LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
-LIGO-

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

51107539

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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licomotor controller chassis LIGO DCC#	<u>D1100323-v1</u>	
ltherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #		<u>51107539</u>
Test Engineer:	Zach	6
Test Date:	11/22/1	1
Overall picomotor chassis testing:	[L]PÁSS	[ ] FAIL
Signature/Initials:		

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20 Controller

#### **Testing Schedule:**

- Front panel LEDs
   Step sizes
   Speeds

- 4. Temperature5. Output terminals



### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

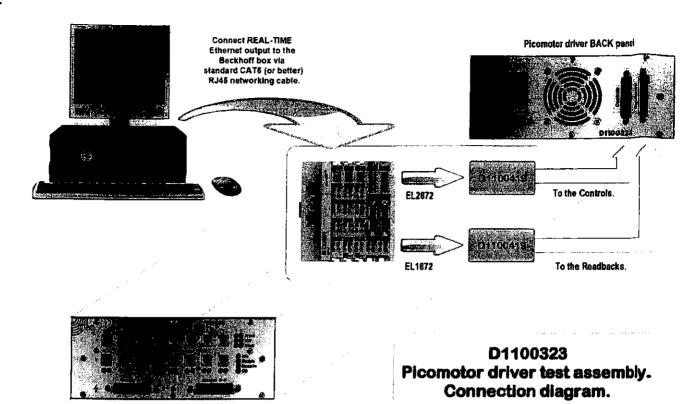
#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

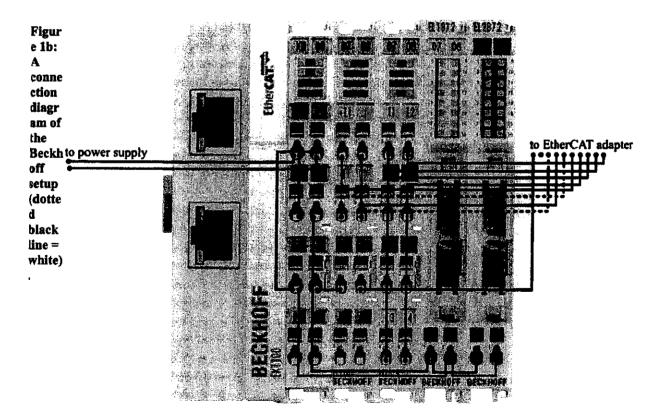
## Setting up

#### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on



Picomotor driver FRONT panel
Figure 1a: A connection diagram of the picomotor setup.



# Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the pieomotor and the PLC controls are set up:

[ ]	Check that the "ON" LED is lit if the power cable is connected and the power switch
	is on, and that it goes off when the power switch is off.

heck that the "ON" indicator on the visualization also responds to the power switch.

Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

Before the next step, check that the fan (rear panel) is off.

Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	50	off	m
STARTING UP	off	on	flashes	flashes	off	σn	on
READY	off	on	off	off	off	$\sim$	00
Check if passed:	[4	H	[ ]				

Table 1: LED response to picomotor status

[ Y Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED		
	Left	Right	
1	[4]	. [4]	
2	[4]	[4]	
3	14	[4]	
4	[4]	U/	
5	W	[4]	
6	M/	U/	
7		$\mathbf{I}$	
8	[]	[4	

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4]	[+	[1]	[]

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

#### 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
VERY SMALL (1)	M	Ŋ,	
MEDIUM (100)	[ ]	$\mathbf{M}_{\mathbf{p}}$	
MAGNUM (10000)	[4	[4	

# 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	N	[-]	
JOG (50Hz)	[ ]	IJ	
SPRINT (500Hz)	[]	U/	

# 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	28,03	21.90	
2	24.03	28.99	
3	30.03	30.12	
4	30.96	31.10	
5	31.75	32.01	
Check if passed:	[4]	[Y	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[9]	[1]		
2		[1		
3	[1]	H		
4	[]	[/		
5	[1]	[1]		
6	1/	[]		
7	[1]	[1]		
8		[1		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	[/]	[]	
2		[1	
3	[8]	[/	
4		[1]	
5	[]	[1	
6	[1]	[X	
7	[ ]	11	
8	[1	[ ]	

# **Testing Summary**

For each test, indicate the results in the table below:

Front panel LEDs	[ Y Pass	[ ] Fail	
Sep sizes	Pass	[ ] Fail	
Speeds	[ ] Pass	[ ] Fail	
Output terminals	[ ]Pass	[ ] Fail	
Overall picomotor driver testing:	[ ]Pass	[ ] Fail	

Test Engineer: Z. J. G

Test Date: 11/72/11

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

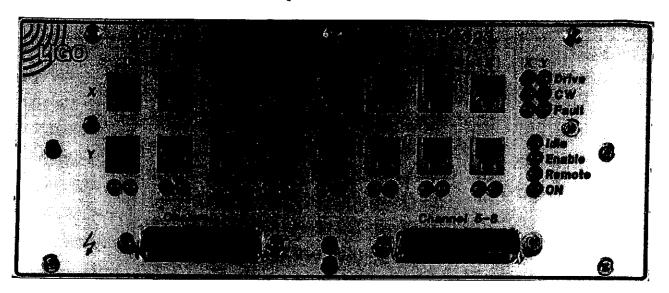


Figure 3: Picomotor driver chassis rear panel

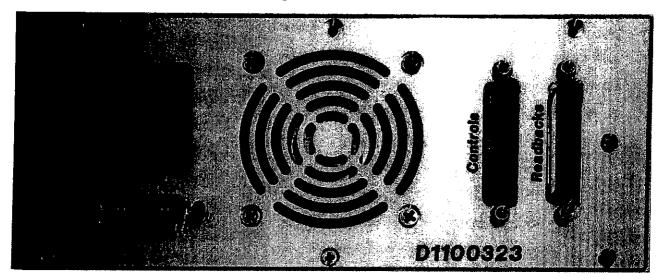
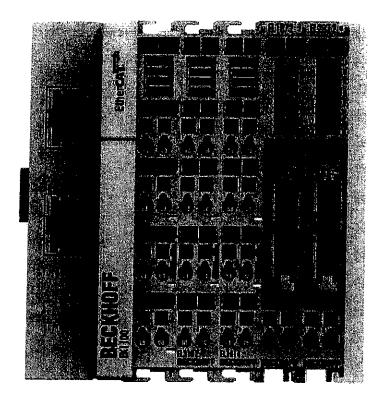


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

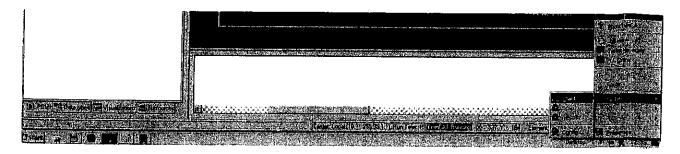
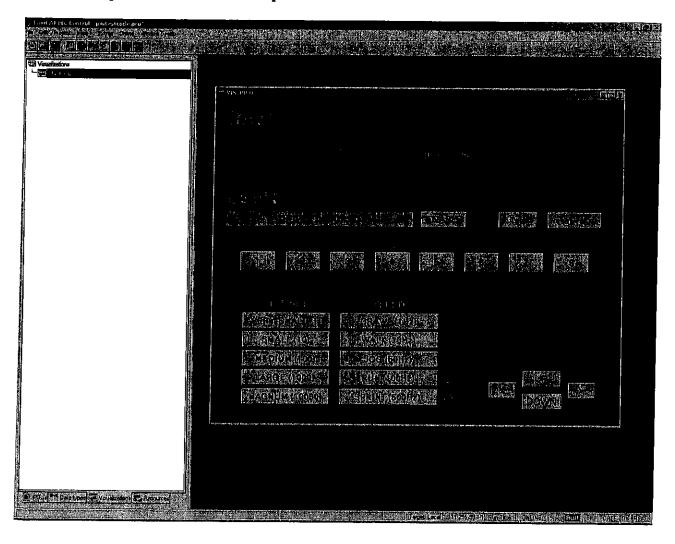


Figure 6: Step 5 of PLC controls setup



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WWW: http://www.ligo.caltech.edu

<u>D1100323-v1</u>
D1100419-v3
5/1 5/107540
Zach 6
1/21/1
[ ] FAIL

# Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals



#### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551



### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

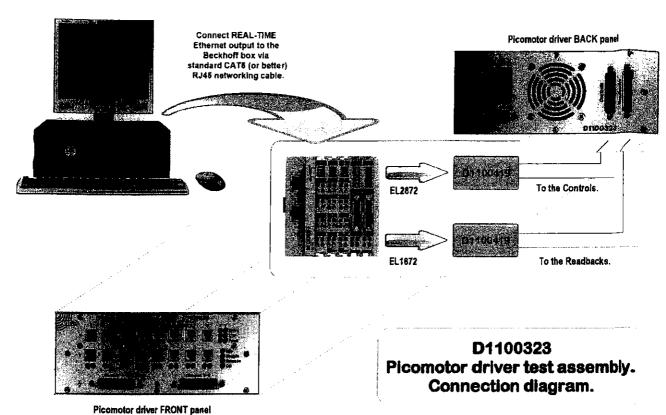
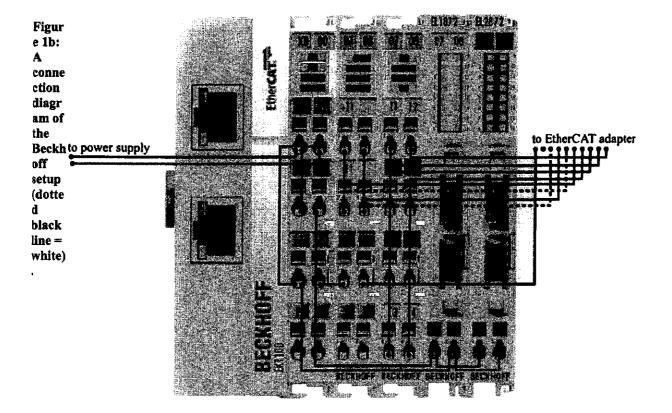


Figure 1a: A connection diagram of the picomotor setup.





#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ Check that the "ON" indicator on the visualization also responds to the power switch.
- [ ] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	<b>Chassis Front Panel LEDs</b>			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	$\infty$	086	M
STARTING UP	off	on	flashes	flashes	S	on	on
READY	off	on	off	off	SF	on	on
Check if passed:	[4]	[4	[4]	[]	H	[4	4-}-

Table 1: LED response to picomotor status

- [ Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [ ] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

TAGO

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	ED
	Left	Right
1	[4]	N
2	[4]	[4]
3	M	[ ]
4	[1]	[4]
5	[4]	[1]
6	[1	/ H/
7		
8	H	[4

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[+	[-]	[]	[]	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

### 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
VERY SMALL (1)	[]	i T	
MEDIUM (100)	[4]	[4	
MAGNUM (10000)	[4]	19	

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	[ 9	14	
JOG (50Hz)	[4	19	
SPRINT (500Hz)	[4	17	

# 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	30,61	27.32		
2	31.76	28.47		
3	32.93	29.66		
4	33.92	30.72		
5	34.90	31.68		
Check if passed:	[4]	W		

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[/]	[9		
2	[J	[9		
3	[/	[4]		
4	[4]	[4]		
5	[1]	[Y		
6	N	14		
7		[ ]		
8	[4]	[]		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[1]	[4		
2	(V)	[4		
3	[ ]	[1/		
4	$\overline{}$	[4]		
5	[4]	14		
6	[9]	[4		
7	[ 9	[4]		
8	[4]	[3		

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[ ] Fail
Output terminals	[ ] Pass	[ ] Fail
Speeds	[ ] Pass	[ ] Fail
Step sizes	[ Pass	[ ] Fail
Front panel LEDs	[YPass	[ ] Fail

Test Engineer: Zach Co
Test Date: 1/21/11

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

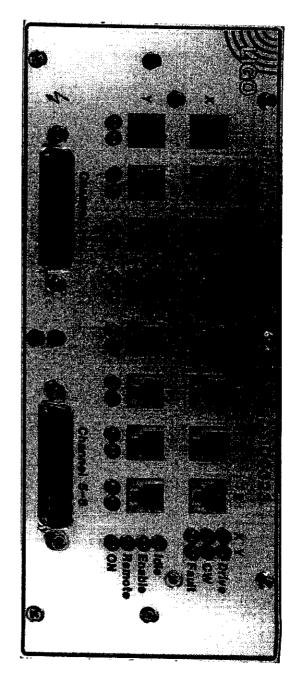


Figure 3: Picomotor driver chassis rear panel

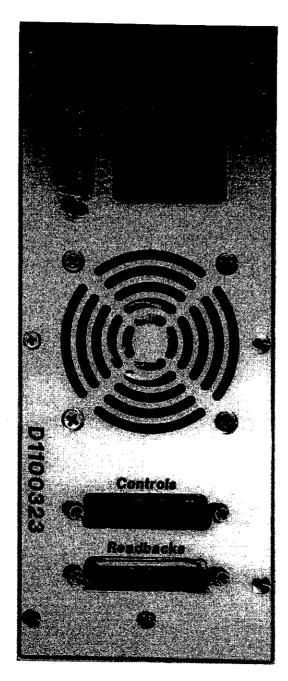
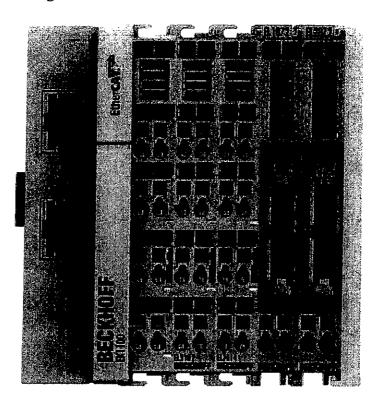




Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

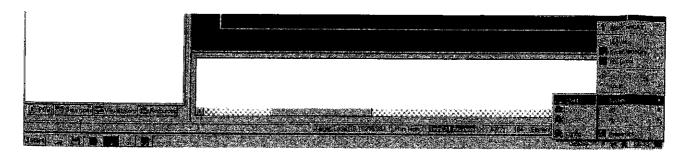
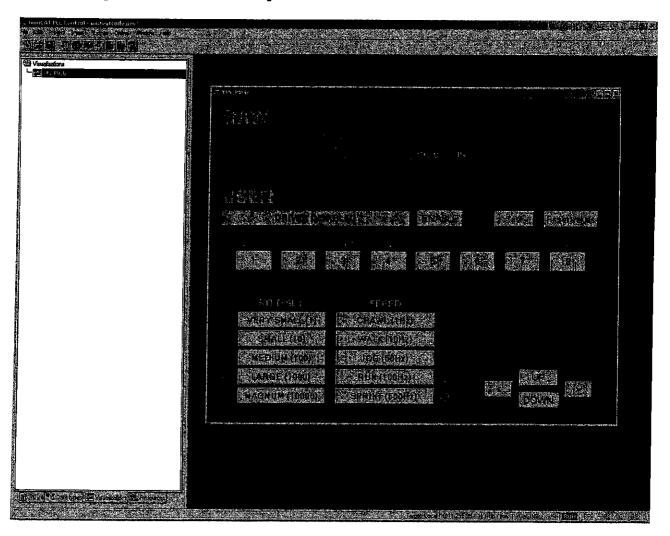


Figure 6: Step 5 of PLC controls setup





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WWW: http://www.ligo.caltech.edu

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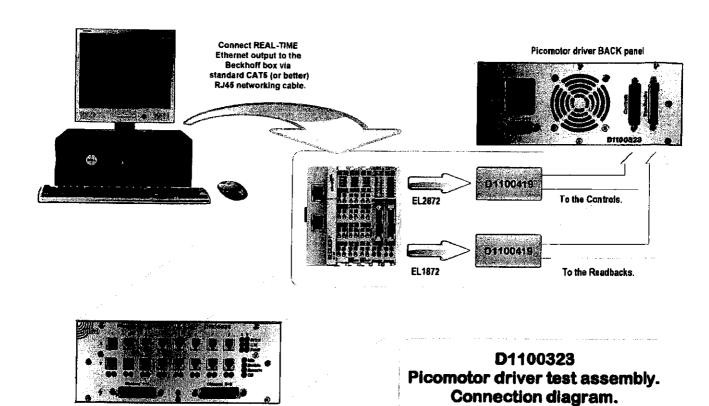
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551



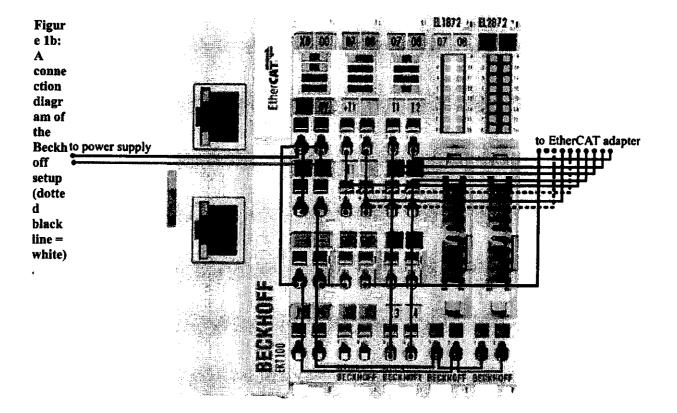
## **Setting up**

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on



Picomotor driver FRONT panel
Figure 1a: A connection diagram of the picomotor setup.



#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:
 "No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- [/] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	54
STARTING UP	off	on	flashes	flashes	686	52	cn
READY	off	on	off	off	6 fg	on	51
Check if passed:	M	[1]	[4]	H	+1	[]	[4

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.



- [ ] Check that the fan is running and blowing air out of the box (rear panel).
- [] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED		
	Left	Right	
1	[4]	M	
2	[4]	[ ]	
3	[4]	[1]	
4	19	[1]	
5	14	14	
6	W	14	
7	M	14	
8	[4]	<u>[1</u>	

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under [] "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CW Y	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[V]	[4]	H	[4]	

Table 2: LED response to picomotor direction

- (while motor is running)
- (stays on after motor is finished running, until opposite direction is selected)

#### 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
VERY SMALL (1)	[1]	[Y		
MEDIUM (100)	[4]	[4//		
MAGNUM (10000)	[Y	[9		

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
CRAWL (1Hz)	[U	14		
JOG (50Hz)	[4]	(Y		
SPRINT (500Hz)	[]	[1]		

## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature				
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	29.44	27.67			
2	30.62	26.78			
3	31.75	25.93.			
4	32.79	30.98			
5	33.60	31.83			
Check if passed:	V	14			

Check the "pass" box for each above if the temperature increases over time.



#### 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	W	[4			
2	[4]	$\mathbb{N}$			
3	[4]	[4			
4	[1]	[4]			
5	N/	M			
6	[A]	M			
7	[Y]	[4]			
8	[4]	rí			

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[4]	[1]				
2	[Y]	[1]				
3		[1]				
4	[4]	[1]				
5	[4]	[1				
6	[1]	[ <i>X</i>				
7						
8	[ ]	[1				



## **Testing Summary**

For each test, indicate the results in the table below:

Front panel LEDs	[M] Pass	[ ] Fail
Step sizes	[ 4] Pass	[ ] Fail
Speeds	[^] Pasts	[ ] Fail
Output terminals	[~] Pass	[]Fail
· · · · · · · · · · · · · · · · · · ·		
Overall picomotor driver testing:	[ ] Pass	[ ] Fail

Test Engineer: Zech G

Test Date: 1/21/11

Additional Comments:



## **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

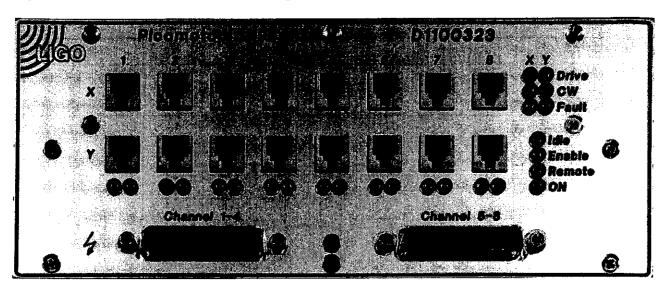
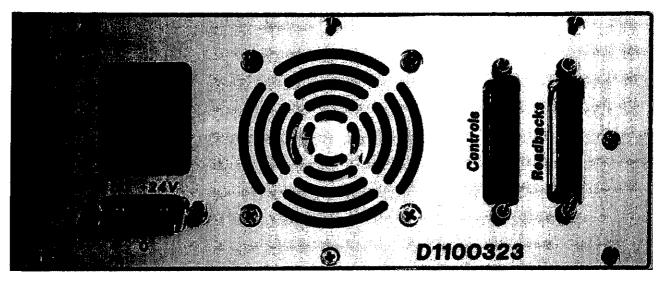
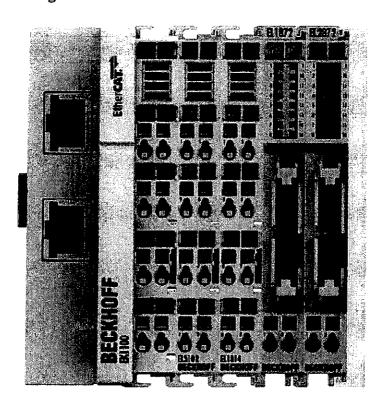


Figure 3: Picomotor driver chassis rear panel



Z GO

Figure 4: EtherCAT configuration



## **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

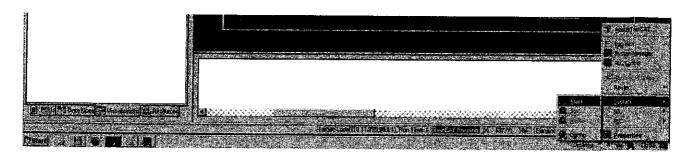
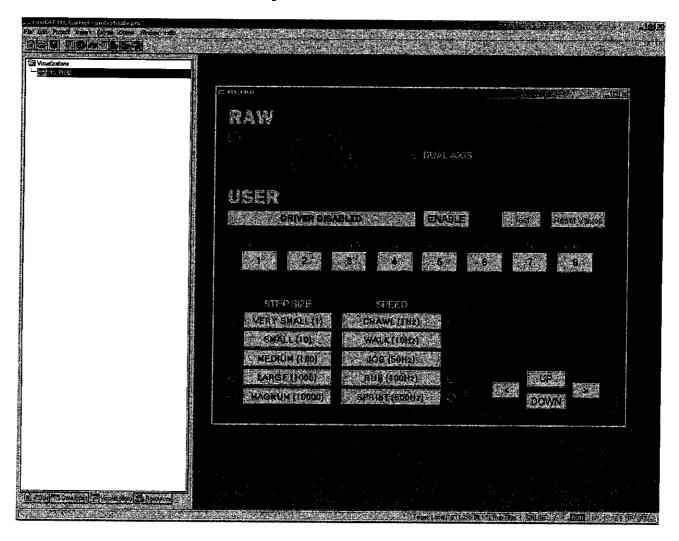


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

| Discomptor controller chassis LIGO DCC# | Discomptor controller chassis LIGO DCC# | Discomptor chassis LIGO DCC# | Discomptor chassis LIGO DCC# | Discomptor chassis testing: | Discompt

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

## **System requirements**

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

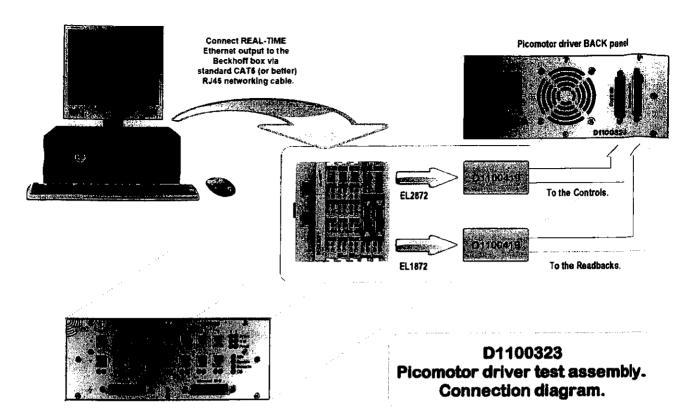
#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

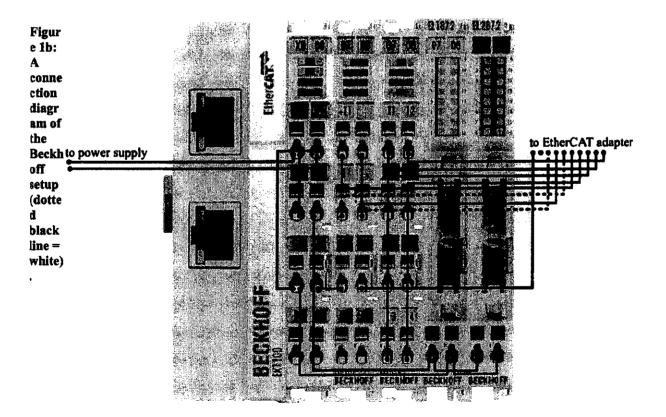
### Setting up

#### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on



Picomotor driver FRONT panel
Figure 1a: A connection diagram of the picomotor setup.



#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:
 "No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on



### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	5	off	9
STARTING UP	off	on	flashes	flashes	OH	on	671
READY	off	on	off	off	off	or	on
Check if passed:	L+	H	[4	[(]	17	11	14

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [ ] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	 LED		
	Left	Right	
1	[4]	[4]	
2	[4]	[}	
3	[1	[1	
4	[]/		
5	[4]		
6	14	[1	
7	[1]		
8	[1]	[/	

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs					
;	Drive X	Drive Y	CW X	CW Y		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	off	off	off		
Check if passed:	1	[4	[4]			

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

## 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[4	[9
MEDIUM (100)	[4	[ ]
MAGNUM (10000)	[9	14

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	[4]	[1]	
JOG (50Hz)	[ ]	[4]	
SPRINT (500Hz)	[ ]	[]	

#### LIGO

### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temp	erature
	X ("<" or ">")	Y ("UP" or "DOWN")
1	28.09	29.87
2	29,17	31.00
3	30.24	32 20
4	31 22	33 . 17
5	32.09	34.16
Check if passed:	M	H

Check the "pass" box for each above if the temperature increases over time.

## 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	M	W/			
2	[4]	(Y			
3	[Y]	[]			
4	[4]	14			
5	M	[4			
6	[4]	[4]			
7	T (Y)	[ ]			
8	۲	[]			

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[i]	[/			
2	[9	[]			
3	i/	[1			
4		[]			
5		[/			
6		[1]			
7	[1]	[1			
8		[1			

# **Testing Summary**

For each test, indicate the results in the table below:

Front panel LEDs	Pass	[ ] Fail
Sep sizes	Pass	[] Fail
Speeds	[ ] Pass	[ ] Fail
Cutput terminals	[ ] Pass	[ ] Fail
A second part of the second part		The state of the s
Overall picomotor driver testing:	Pass	[ ] Fail

Test Engineer: Zab Co

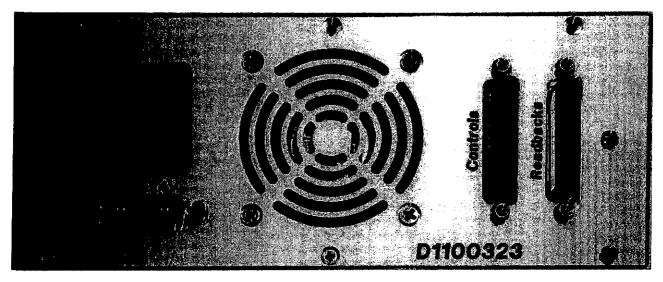
Additional Comments:

## **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

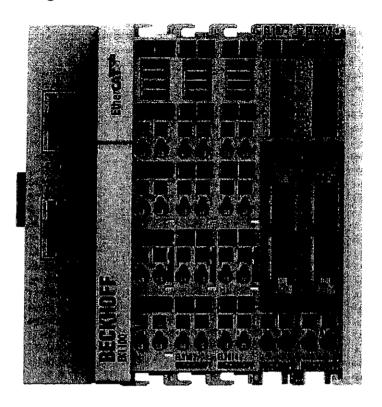


Figure 3: Picomotor driver chassis rear panel



MGO

Figure 4: EtherCAT configuration



## **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

13GO

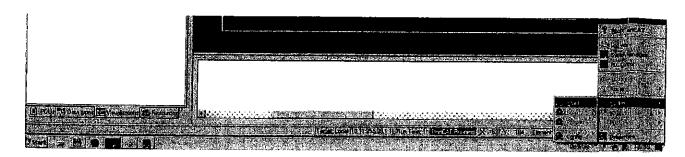
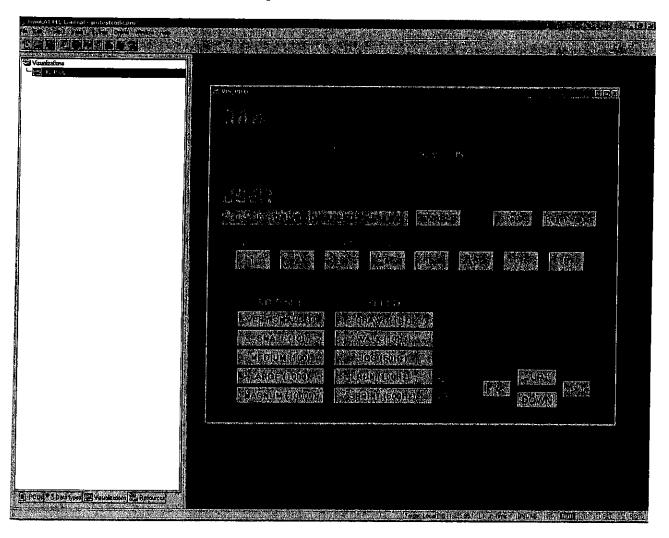


Figure 6: Step 5 of PLC controls setup





# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu



Picomotor controller chassis LIGO DCC#

D1100323-v1

**EtherCAT Adapters LIGO DCC#** 

D1100419-v3

Controller Serial #

**Test Engineer:** 

**Test Date:** 

11/21/11

Overall picomotor chassis testing:

[ ] FAIL

Signature/Initials:

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals



#### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### **Software:**

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

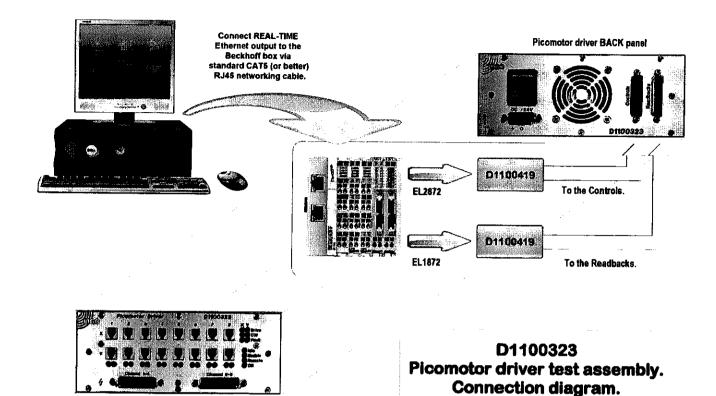


#### Setting up

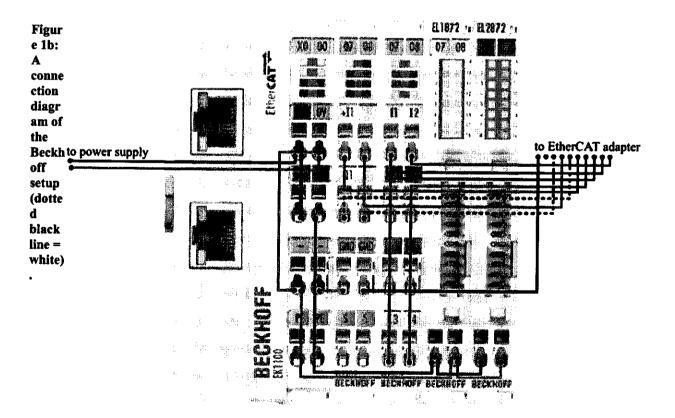
#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on





Picomotor driver FRONT panel
Figure 1a: A connection diagram of the picomotor setup.





#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on



## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ Check that the "ON" indicator on the visualization also responds to the power switch.
- [ ] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- [/ Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off			
STARTING UP	off	on	flashes	flashes			
READY	off	on	off	off	<u> </u>		
Check if passed:	[]		[]	[]	[]	<del>  [</del> ]	[]

Table 1: LED response to picomotor status

- [Y Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.



Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

- [ ] Check that the fan is running and blowing air out of the box (rear panel).
- [ ] Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal		ED
	Left	Right
1	[4]	[1
2	[ <i>Y</i>	1
3		[1
4		[/]
5		[1
6	[1]	[1]
7	_ [1]	[1]
8	[1]	[1]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4]	[]	[1]	[1

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)



#### 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	<u> </u>	[ ]
MEDIUM (100)	[4]	[Y
MAGNUM (10000)	[1	[}

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	<u> </u>	[]	
JOG (50Hz)	[4	[1]	
SPRINT (500Hz)	[1	[1	



#### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
F	X ("<" or ">")	Y ("UP" or "DOWN")	
1	22.67	22.84	
2	24.07	24.28	
3	25.25	95.55	
4	26.42	26.78	
5	27.42	29.81	
Check if passed:		[4]	

Check the "pass" box for each above if the temperature increases over time.



## 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1		[4]
2	M	[4]
3	M	[4/
4	[1	[1]
5	[J	1
6		[1]
7	[]	[1]
8		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
	[1]	
2		
3		11
4		11
5		[1]
6	[]	[1]
7 — — —	[8]	[1]
8	 [1	ιſ



## **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	Pass	[ ] Fail
Output terminals	[ ] Pass	[ ] Fail
Outrook to a six 1	r	
Speeds	[ / Pass	[ ] Fail
Step sizes	[ Pass	[ ] Fail
Front panel LEDs	[ ] Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/21/11

Additional Comments:



## **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

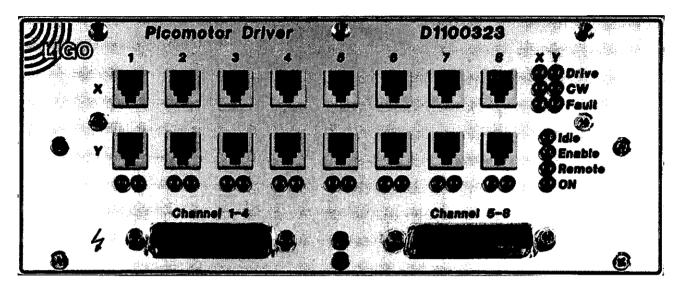


Figure 3: Picomotor driver chassis rear panel

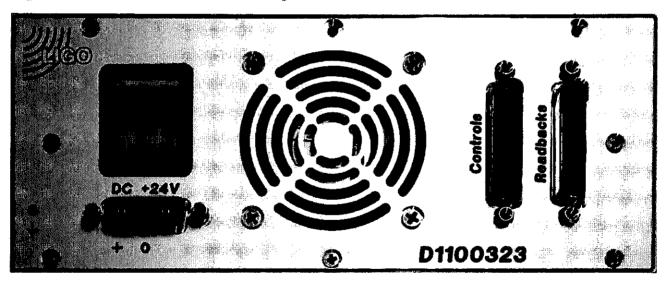
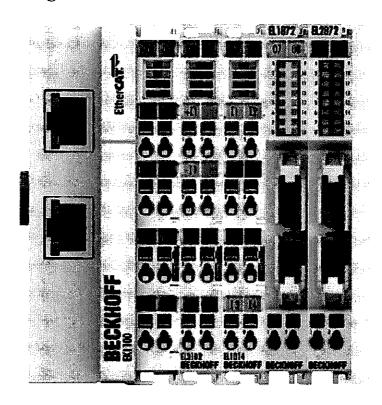




Figure 4: EtherCAT configuration





## **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

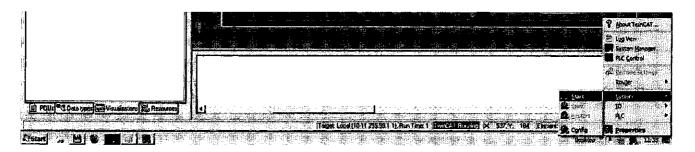
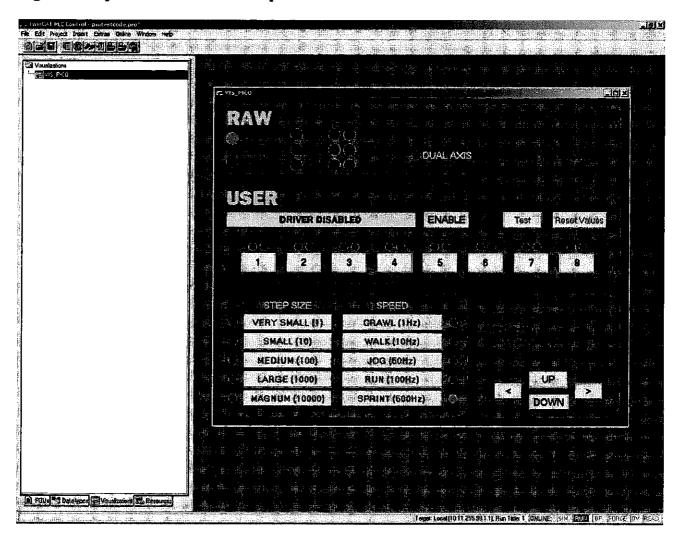


Figure 6: Step 5 of PLC controls setup



## LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

-LIGO-

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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WWW: <a href="http://www.ligo.caltech.edu">http://www.ligo.caltech.edu</a>

licomotor controller chassis LIGO DCC#	D1100323-v1
ItherCAT Adapters LIGO DCC#	D1100419-v3
Controller Serial #	<del>203</del> 51107544
Test Engineer:	Zach G
Test Date:	1/21/11
Overall picomotor chassis testing:	[JPASS []FAIL
Signature/Initials:	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- Front panel LEDs
   Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals



## System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551



### **Setting up**

#### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

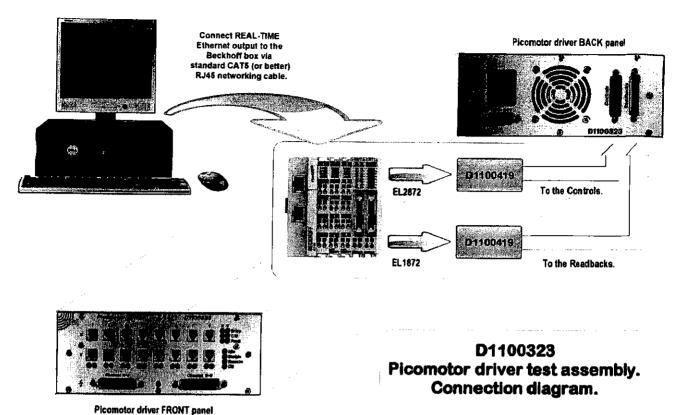
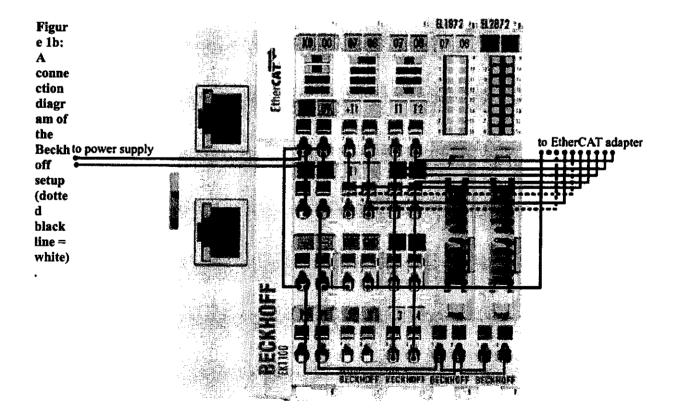


Figure 1a: A connection diagram of the picomotor setup.





### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

Check that the "ON" LED is lit if the power cable is connected and the power switch	L
is on, and that it goes off when the power switch is off.	
is on, and that it goes off when the power switch is off.	

[ ] Check that the "ON" indicator on the visualization also responds to the power switch.

Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

Before the next step, check that the fan (rear panel) is off.

Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	$\sigma$	686	07
STARTING UP	off	on	flashes	flashes	off	SN	9
READY	off	on	off	off	085	σ^	on
Check if passed:	[4]	M	[4	[J	[4	W	[4

Table 1: LED response to picomotor status

Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

[V] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.



Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED		
	Left	Right	
1	[4]	[4]	
2	[4	[4]	
3		[1]	
4	[1	[]	
5	[1]	[1	
6	[1]	[1]	
7	[1	1	
8	[1]	[1]	

Select output terminal 1 and do the following:

[4]

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:		[ ]	[4]	M	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)



On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
VERY SMALL (1)	[4]	[4]		
MEDIUM (100)	[4	ĺν		
MAGNUM (10000)	[4]	14		

## 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	d Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
CRAWL (1Hz)	[7	14		
JOG (50Hz)	A	19		
SPRINT (500Hz)	[/	[1		



## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	28.55	28.77		
2	29.65	29.90		
3	30.66	31.02		
4	31.60	32.00		
5	32.49	32.99		
Check if passed:	W	L)		

Check the "pass" box for each above if the temperature increases over time.



Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[4]	[4]		
2	[4]	[1]		
3	[9]	[4]		
4	[4]	[1]		
5	- M	[4		
6	[1	[4		
7	[]	[]		
8	[1	[1		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[1	[]			
2		[ ]			
3	[1	[1			
4					
5		1/			
6	[1	11			
7		[]			
8					



## **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[ ] Fail
Output terminals	[ ] Pass	[ ] Fail
Speeds	[]Pass	[ ] Fail
Step sizes	[ ] Pass	[ ] Fail
Front panel LEDs	[ Pass	[ ] Fail

Test Engineer: Zach C

Test Date: 11/21/11

Additional Comments:



## **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

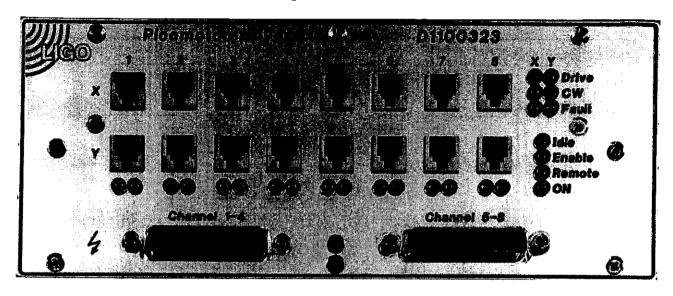


Figure 3: Picomotor driver chassis rear panel

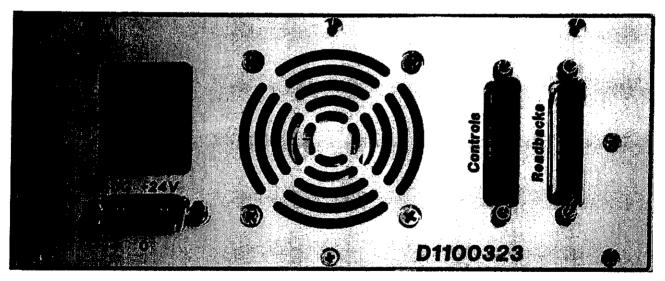
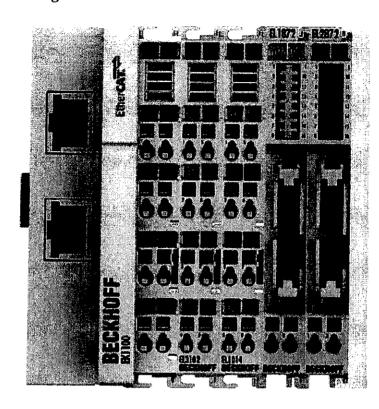




Figure 4: EtherCAT configuration



## **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

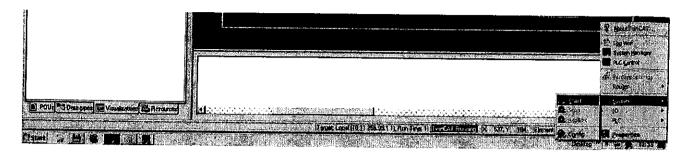
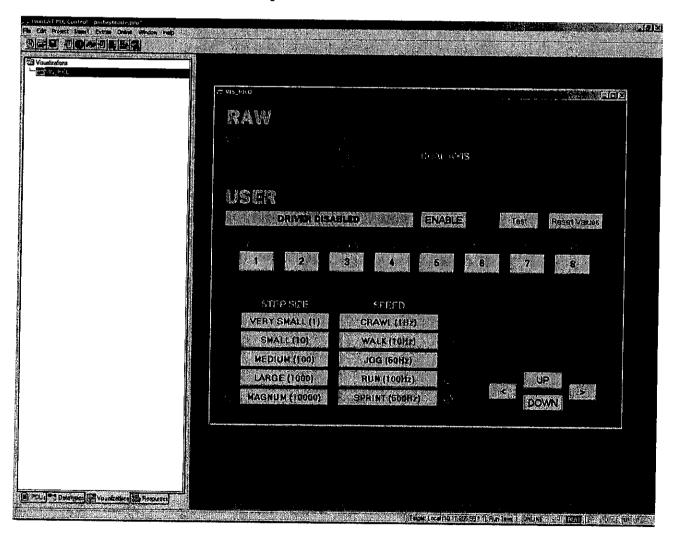


Figure 6: Step 5 of PLC controls setup



## LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals



## System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551



## Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

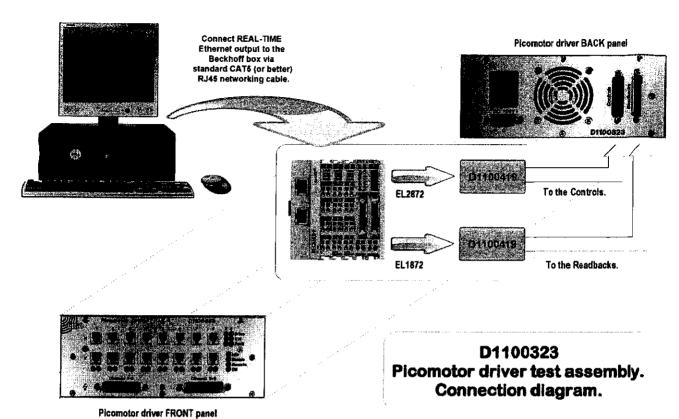
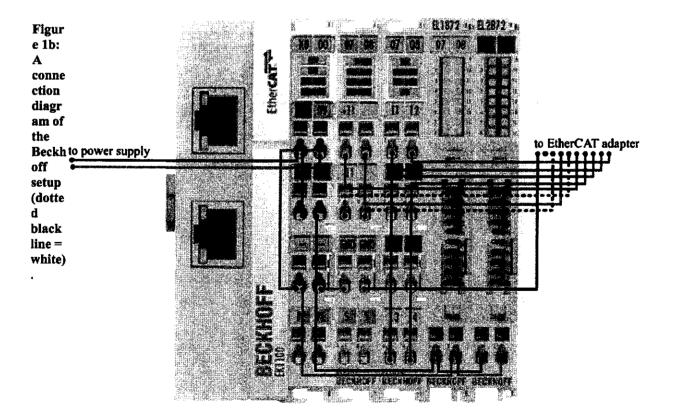


Figure 1a: A connection diagram of the picomotor setup.





## Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)

Click "Yes" at the dialog:

"No program on the controller! Download the new program?"

Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- [ 4 Before the next step, check that the fan (rear panel) is off.
- [ ] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	(77)
STARTING UP	off	on	flashes	flashes	08-8	C2 ,	94
READY	off	on	off	off	off	ch	04
Check if passed:	[4	[]	[]	[վ	[-]	-11	[-

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.



Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[ Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal		LED	
	Left	Right	
1		[1	
2	[1	[1	
3	[/	H	
4	- I		
5	[ <i>Y</i>	[1]	
6	[1	[/	
7	[1		
8	[/]	$\overline{11}$	

#### Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off -	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4]	[4	[4]	[]

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)



## 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
VERY SMALL (1)	[Y	14	
MEDIUM (100)	[4	[4	
MAGNUM (10000)	[4]	آ	

## 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	[4	[9]	
JOG (50Hz)	[]		
SPRINT (500Hz)		[]	



## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	26.60	2 590
2	29.68	26.96
3	30.75	29.99
4	31.68	<b>29</b> .97
5	32.59	29.89
Check if passed:	[4	W

Check the "pass" box for each above if the temperature increases over time.

## 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[4]	M		
2		[4]		
3	[1	[/		
4		[1]		
5	[y	[1]		
6	[J	[1]		
7	[Y	[ ]		
8	[4]	[1		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	[1]	[1]	
2		[1	
3			
4		[]	
5		[/	
6	[1]	[1	
7	[1]	[1]	
8	[1	[1	



## **Testing Summary**

For each test, indicate the results in the table below:

Front panel LEDs	[ Pass	[ ] Fail
Step sizes	[ ] Pass	[ ] Fail
Speeds	[ Pass	[ ] Fail
Output terminals	[ / Pass	[ ] Fail
· —		
Overall picomotor driver testing:	[ ] Pass	[ ] Fail

Test Engineer: 21/11

Additional Comments:



## **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

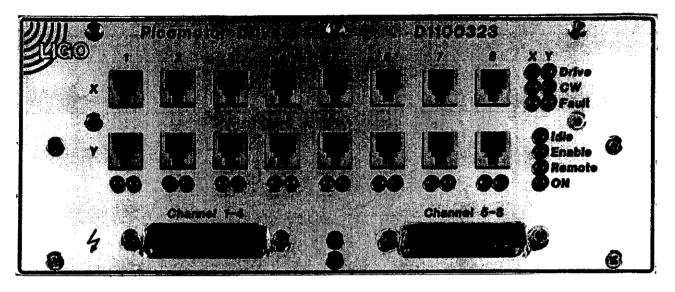


Figure 3: Picomotor driver chassis rear panel

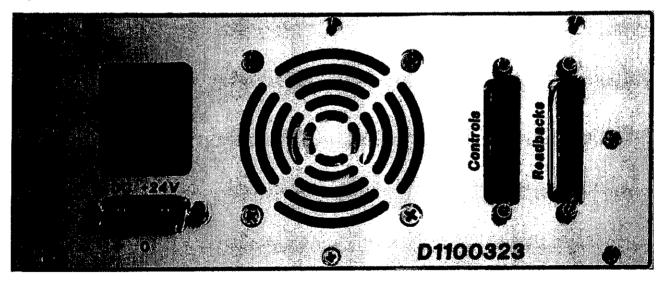
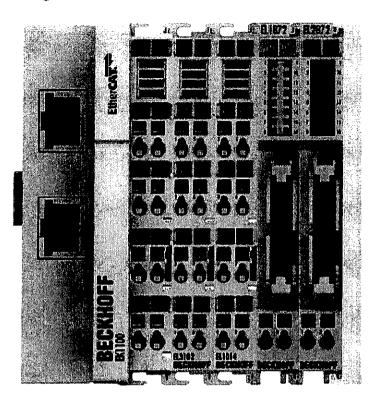




Figure 4: EtherCAT configuration





## **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

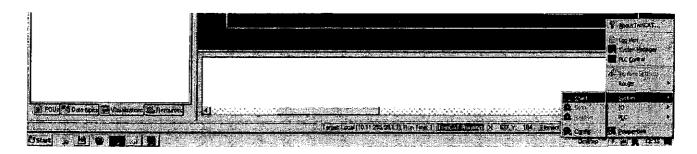
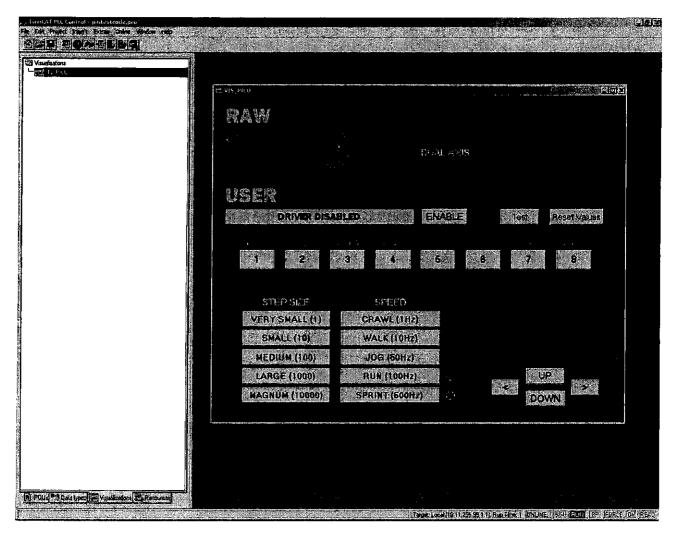


Figure 6: Step 5 of PLC controls setup



## LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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Phone (212) 854-8209 Fax (212) 854-8121

E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	<u>D1100323-v1</u>
ltherCAT Adapters LIGO DCC#	D1100419-v3
Controller Serial #	S1107546
Test Engineer:	Zach
Test Date:	1/21/11
Overall picomotor chassis testing:	[ ] PASS [ ] FAIL
Signature/Initials:	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- Front panel LEDs
   Step sizes
   Speeds

- 4. Temperature
- 5. Output terminals



## **System requirements**

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

#### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

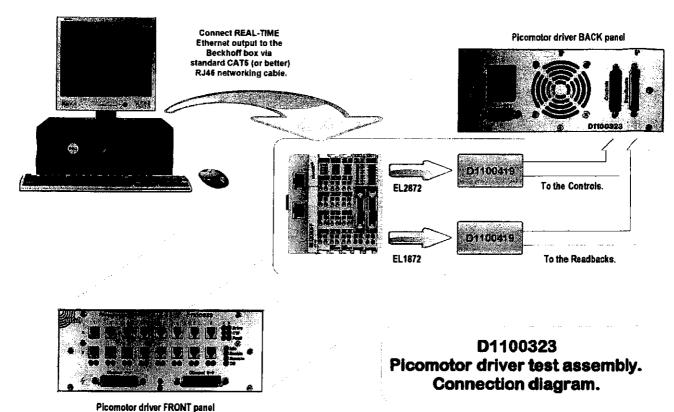
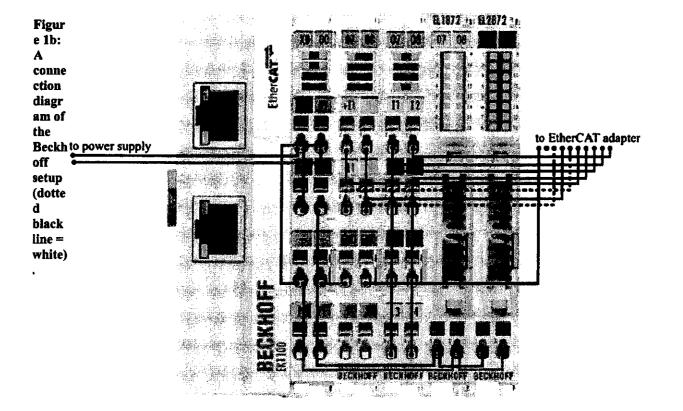


Figure 1a: A connection diagram of the picomotor setup.





#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	(30)	068	9
STARTING UP	off	on	flashes	flashes	9	on	on
READY	off	on	off	off	\$	ON	6n
Check if passed:	[]	[]	[]	[]		[]	[]

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED		
	Left	Right	
1	M	[4]	
2	[4]	_ [4]	
3	M		
4		. [1]	
5		[1	
6	M M	[1]	
7			
8		[1	

#### Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction		Ds		
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4]	[1]	[4]	[/

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

#### 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
VERY SMALL (1)	U _	[4]		
MEDIUM (100)	[4]	IX,		
MAGNUM (10000)	[J	[4]		

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
CRAWL (1Hz)	[4]	[4]		
JOG (50Hz)	[4]	[4]		
SPRINT (500Hz)	[ 🗸	[ U		

#### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	27.01	27.98		
2	27.54	29,12		
3	28.85	30,15		
4	24.85	31.13		
5	30.66	31 90		
Check if passed:	[4	[4		

Check the "pass" box for each above if the temperature increases over time.



## 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under 'SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[4]	[4]				
2	M	14				
3	[4]	[J				
4	[4]	[J/				
5	[J	[4]				
6	[Y	[J				
7		[Y]				
8	[1]	[4				

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[Y]	
2	N	[1
3	[4]	[4]
4	u/,	M
5	[4]	[4/
6	[1]	IJ
7	[4]	14
8	[4	[4

# **Testing Summary**

For each test, indicate the results in the table below:

Front panel LEDs	[4] Pass	[ ] Fail
Step sizes	Pass	[] Fail
Speeds	[JPass	[ ] Fail
Output terminals	[ Pass	[ ] Fail
Overall picomotor driver testing:	[ ] Pass	[]Fail

Test Engineer:

Test Date:

Additional Comments:



## **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

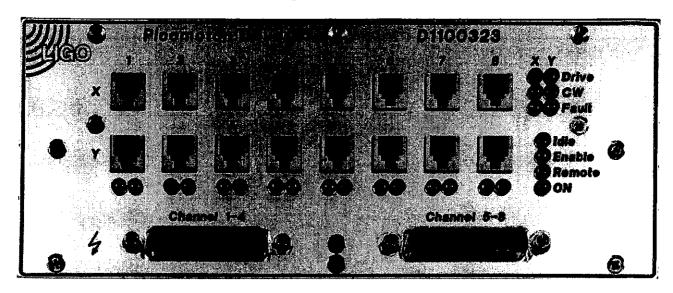


Figure 3: Picomotor driver chassis rear panel

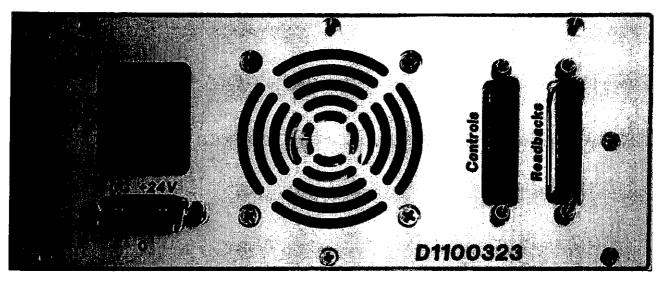
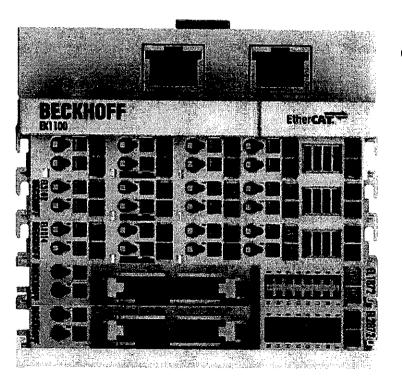


Figure 4: EtherCAT configuration





#### **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

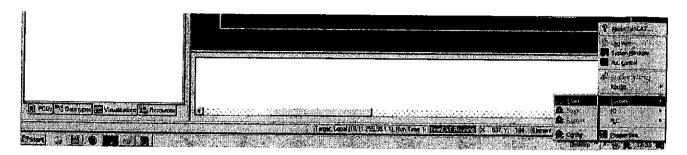
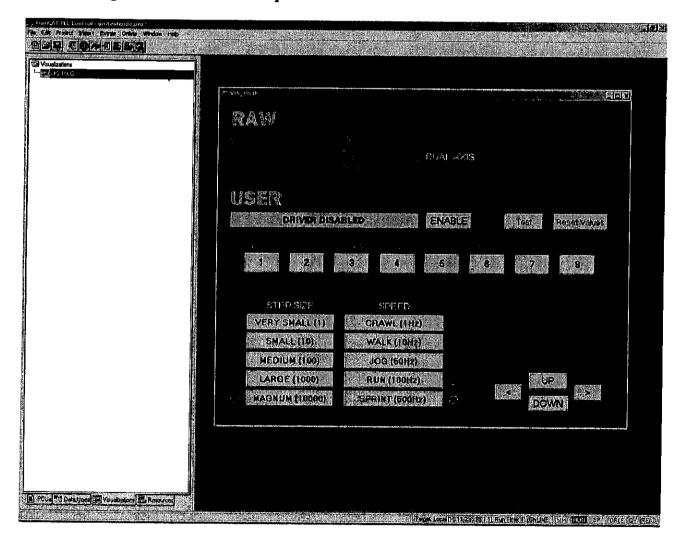


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

#### **System requirements**

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551



#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

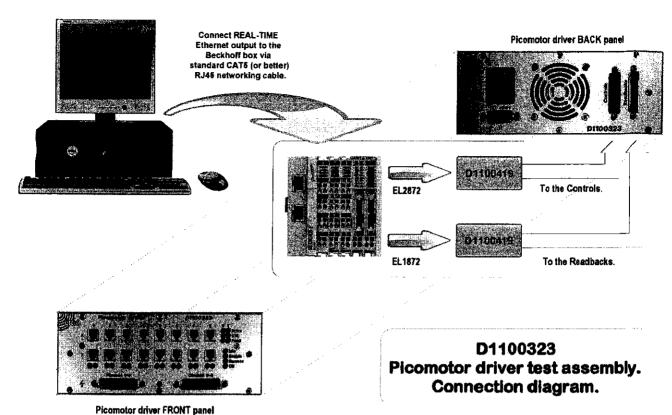
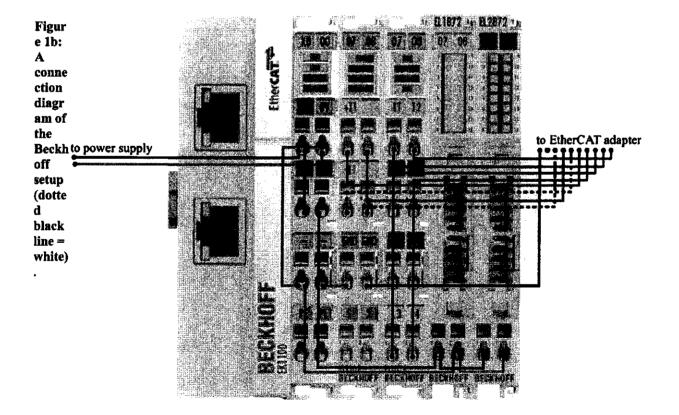


Figure 1a: A connection diagram of the picomotor setup.





#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

#### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ W Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	086-	on
STARTING UP	off	on	flashes	flashes	086	Sn	on
READY	off	on	off	off	088	on	on
Check if passed:		[1]	[1]	N	H	1	

Table 1: LED response to picomotor status

- [4] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[/] Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED		
	Left	Right	
1	[1]	[/]	
2	[1]	[1]	
3	[4]	[1]	
4		[A]	
5	[1	[1]	
6	[1]	[1]	
7		[ /ʃ/	
8	[ ]	[ / ]	

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	Ŋ	[4	[4]	[+	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

#### 2. Testing the step sizes

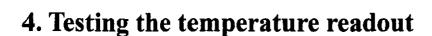
On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
VERY SMALL (1)	[1]	[4	
MEDIUM (100)	[1]	[ <del>Y</del> /	
MAGNUM (10000)	[4	(4	

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	[4]	W.	
JOG (50Hz)	$\mathbf{M}$	[4]	
SPRINT (500Hz)	[7]	[4	



On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	27.43	27.18	
2	28.49	2850	
3	29.58	29.53	
4	30.57	30.65	
5	31.42	31.51	
Check if passed:	[]	. [4]	

Check the "pass" box for each above if the temperature increases over time.

## 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[Y	[-]			
2		[]			
3	[4]	[4]			
4	[4]	[]/			
5	[1]	[]/			
6	[4]	[]			
7	[4/	[ ]			
8	[1	[/			

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[4]	[]
2		[/
3	[ ]	
4	[ ]	[}
5		[]
6	[ ]	[}
7		[]
8	[1	

## **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[] Fail
Output terminals	[ ] Pass	[] Fail
Speeds	[ ]Pass	[ ] Fail
Step sizes	[ ] Pass	[ ] Fail
Front panel LEDs	[ ] Pass	[ ] Fail

Test Engineer: Zach C
Test Date: 1/21/11

Additional Comments:

## **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

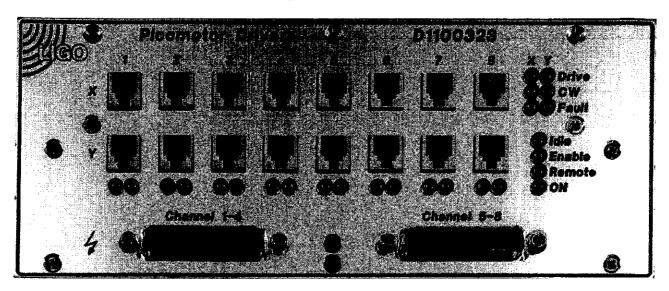


Figure 3: Picomotor driver chassis rear panel

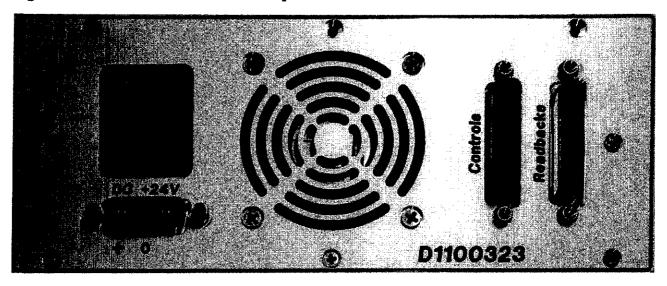
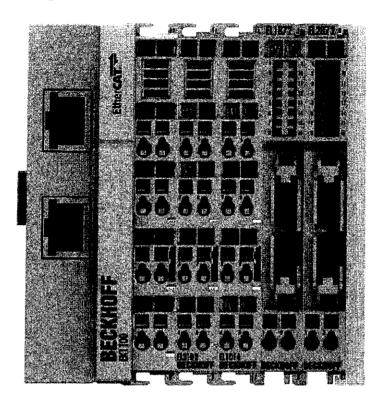


Figure 4: EtherCAT configuration



## **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

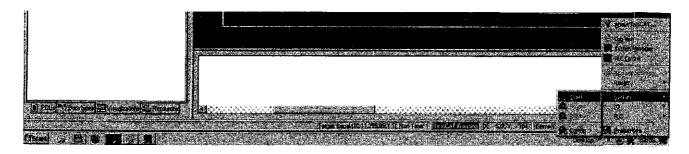
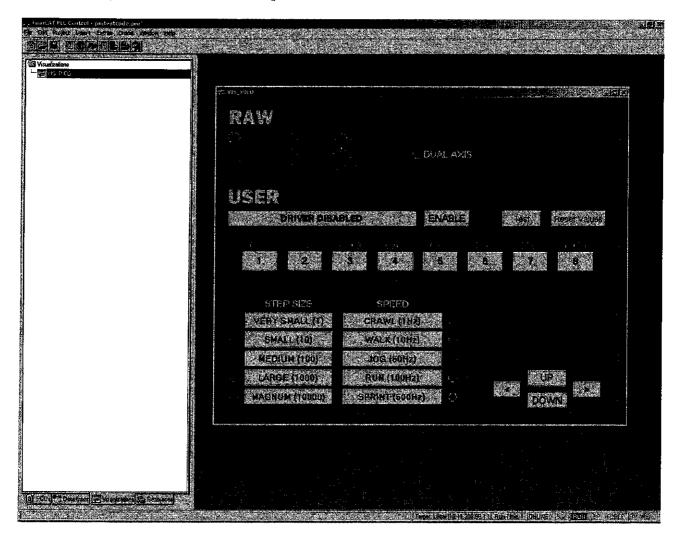


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

## CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	<u>D1100323-v1</u>
ltherCAT Adapters LIGO DCC#	<u>D1100419-v3</u>
Controller Serial #	S1107548
Test Engineer:	Zach C
Test Date:	<u> 1/22/11</u>
Overall picomotor chassis testing:	PASS []FAIL
Signature/Initials:	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### Testing Schedule:

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

#### 14G0

## **System requirements**

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

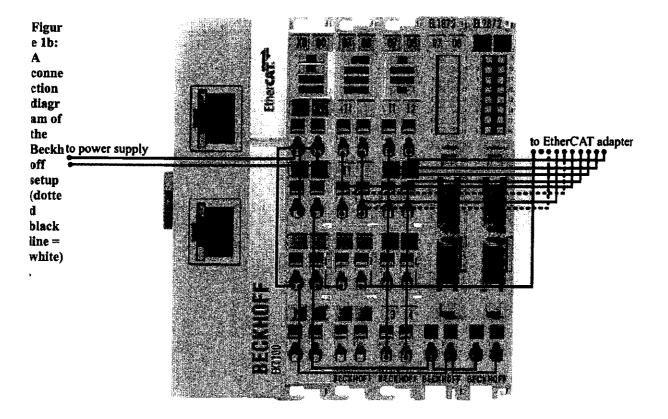


### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

Picomotor driver FRONT panel
Figure 1a: A connection diagram of the picomotor setup.



## **Setting up**

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:
 "No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ Check that the "ON" indicator on the visualization also responds to the power switch.
- [ Y Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Cl	Chassis Front Panel LEDs			Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	e8F	CSV
STARTING UP	off	on	flashes	flashes	68	SN	on
READY	off	on	off	off	of	on	on
Check if passed:	[7]	[4]	N	M	14	14	W

Table 1: LED response to picomotor status

- [ ] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [ ] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	ED
	Left	Right
1	[4]	M
2	- W	· (4)
3	[4]	[4]
4	W/	[4]
5	[J	[4]
6		[4]
7		[-]/
8	[-]	[√]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[ 4	[ ]	[]	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

## 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[U]	
MEDIUM (100)	M	[ ]
MAGNUM (10000)	[1	[]

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	ľ	IX ,	
JOG (50Hz)	[]	[1]	
SPRINT (500Hz)	[]	[1	

# 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	36.67	29.93	
2	31.01	30.93	
3	31.89	31.82	
4	32.71	32.70	
5	33.51	33.50/	
Check if passed:	[4	[4]	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[]	[,]/		
2	[4]	Ĭ.		
3	W/			
4	[4]			
5	[4]	[4		
6	W W	[4]		
7	[4]	[4]		
8	[4	M		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[N]	U		
2	T IY	[4]		
3	[4]	[4]		
4	[4]	[]		
5		[4]		
6	[]	[]		
7	[4/	[]		
8		H		

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	Pass	[ ] Fail
Output terminals	[] Pass	[]Fail
Speeds	[ Pass	[ ] Fail
Step sizes	[] Pass	[ ] Fail
Front panel LEDs	[YPass	[ ] Fail

Test Engineer: Zach C

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

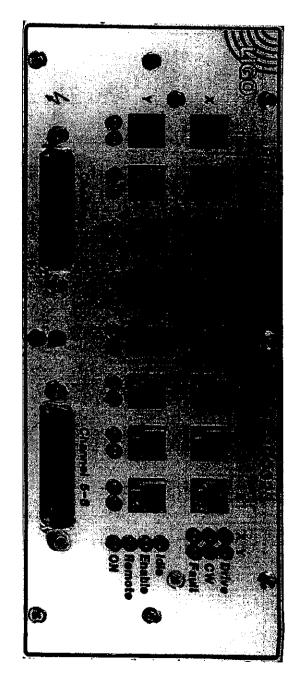


Figure 3: Picomotor driver chassis rear panel

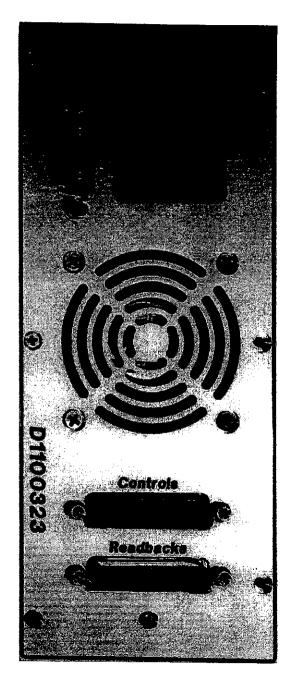
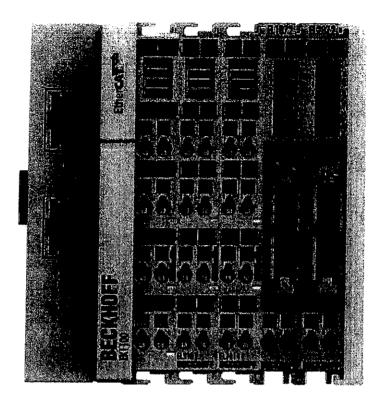


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

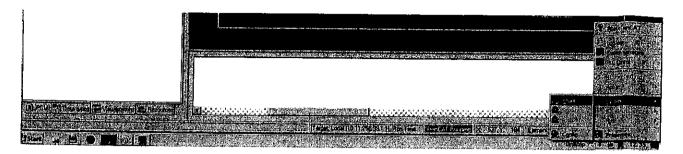
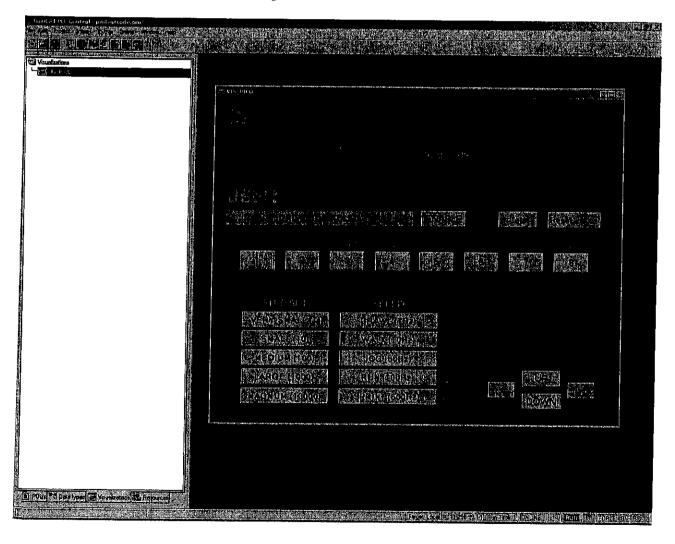


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: <a href="http://www.ligo.caltech.edu">http://www.ligo.caltech.edu</a>

licomotor controller chassis LIGO DCC#	D1100323-v1		
ItherCAT Adapters LIGO DCC#	D1100419-v3		
Controller Serial #	<u> 5 110</u>	7549	
Test Engineer:	Zach	G	
Test Date:	11/22/	<u> </u>	
Overall picomotor chassis testing:	[4PASS	[ ] FAIL	
Signature/Initials:			
			***************************************

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- Front panel LEDs
   Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

## System requirements

#### <u>Hardware:</u>

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

# Setting up

#### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

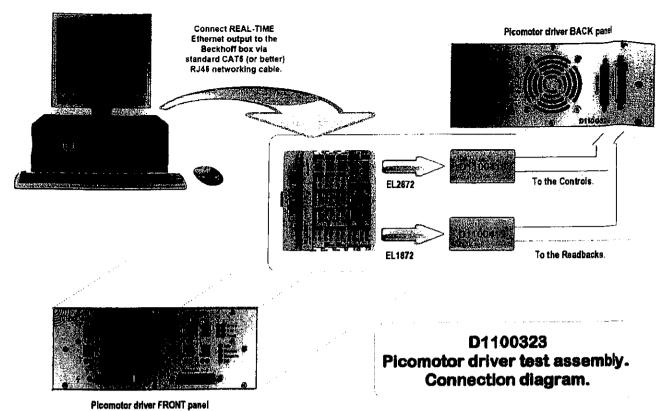
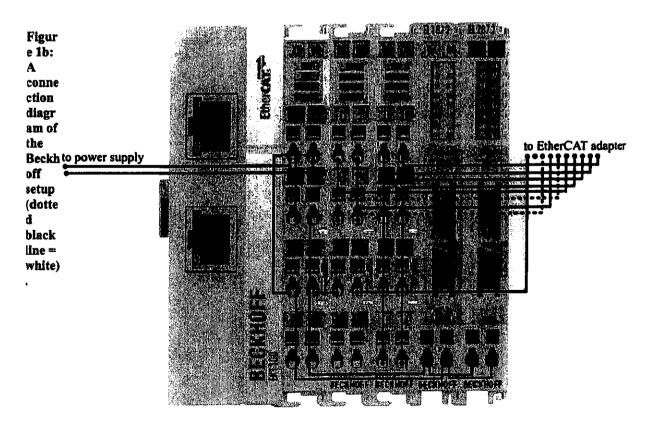


Figure 1a: A connection diagram of the picomotor setup.



#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

# 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	C	Chassis Front Panel LEDs			Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	M	08	071
STARTING UP	off	on	flashes	flashes	2	d)	m
READY	off	on	off	off	05	9	On
Check if passed:	[1	[9]	[1		[4]	[4	[]

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [ ] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LI	ED
	Left	Right
1	[4]	[4]
2	[Y	[4]
3	[J	[4]
4	[4]	[4]
5	[J	[4]
6	[J]	H
7		H
8	[4]	[]

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[4	[4]	[4	M	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

#### DST.

# 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a set size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

	<u>/t]</u>	(00001) MUNDAM
[ بلر	<u>√</u> 61	<b>MEDIUM</b> (100)
	<u>_</u> 61	AEKK SWYLL (1)
X ("Nb., or "DOWN")	X ("<" or ">")	
sixA		Step Size

### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

SPRINT (500Hz)	<i>[</i> -}	<u></u>
10G (50Hz)	[A]	لير
CKAWL (1Hz)	<i>[</i> *1]	h
	$(^{n}<^{n}$ to $^{n}>^{n})$ X	X ("UP" or "DOWN")
Speed		sixA

# 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	26.90	28.70	
2	27.98	29,65	
3	29.12	30-87	
4	30.05	31.83	
5	30-99	32.7	
Check if passed:	H	[4]	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	M	[1		
2	[4]	[4]		
3	[4	U,		
4	[4]	[4		
5		[]		
6	[4]	[]		
7		[4]		
8	[4]	[]		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[4	[4		
2	[ <del>]</del>	H		
3		[-		
4	H	[]		
5		[4		
6		4		
7	[4]	[ ]		
8	[1			

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	Pass	[ ] Fail
Output terminals	Pass	[ ] Fail
Speeds	[ Pass	[ ] Fail
Step sizes	[ Pass	[] Fail
Front panel LEDs	[ Pass	[ ] Fail

Test Engineer: Zad Test Date: 1/22/11

**Additional Comments:** 

# **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel



Figure 3: Picomotor driver chassis rear panel

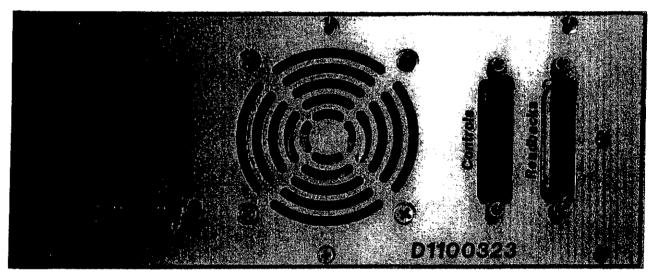
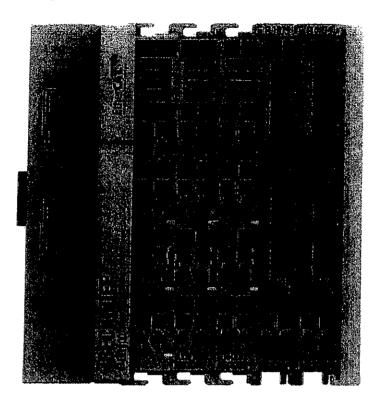


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

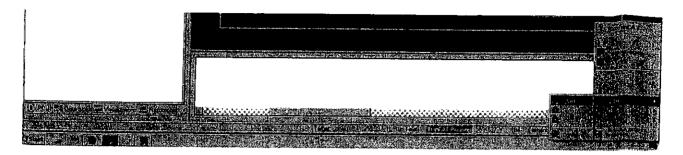
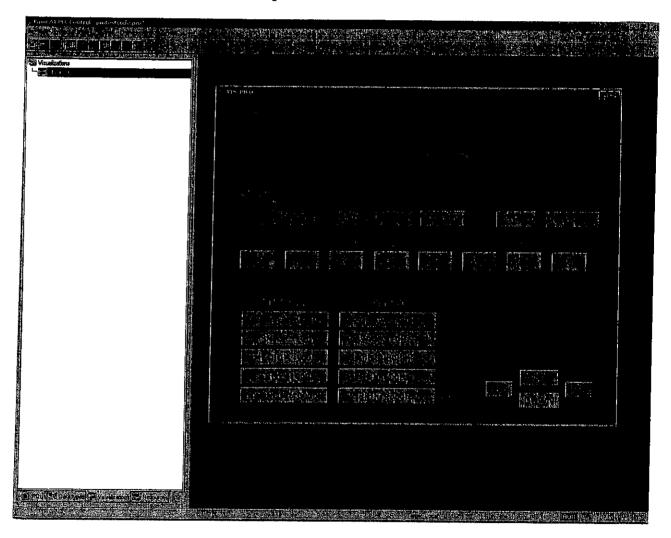


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

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Phone (212) 854-8209 Fax (212) 854-8121

E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	<u>D1100323-v1</u>
ItherCAT Adapters LIGO DCC#	D1100419-v3
Controller Serial #	51107550
Test Engineer:	Zach G
Test Date:	11/22/11
Overall picomotor chassis testing:	[4] PASS [ ] FAIL
Signature/Initials:	
TATABAT HARRISTAN (SANTANIA) PROBERTIAN (SANTANIA) PROBERTIAN IN THE MANAGEMENT OF THE SANTANIA STATEMENT AND THE SANTANIA STATEMENT OF THE SANTANIA	and the fine of the first of th

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

# System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551



#### Setting up

#### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

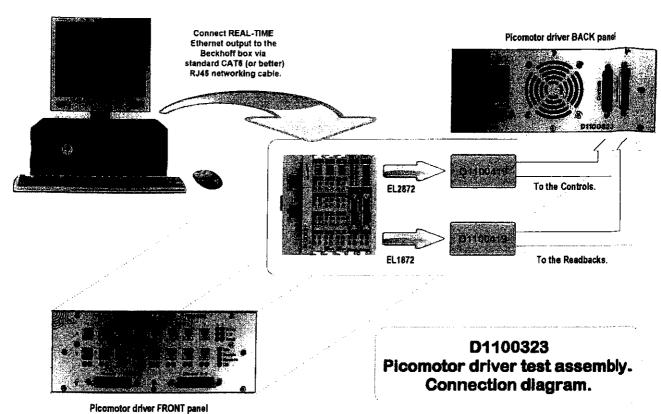
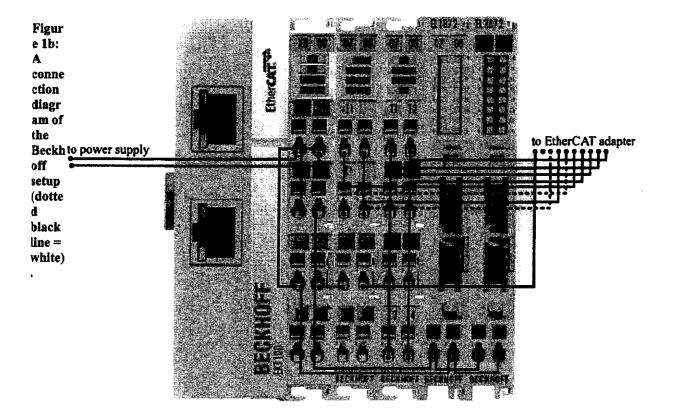


Figure 1a: A connection diagram of the picomotor setup.



#### MGO

#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	On	380	on
STARTING UP	off	on	flashes	flashes	off	on	or'
READY	off	on	off	off	64	on	on
Check if passed:	W	[4]	14	H	H	14	[4]

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	I	ED
	Left	Right
1	H	H
2	[1	[7
3	[Y	[]
4	门	17
5		[1
6		[}
7	[/	[1]
8	[1	[1

Select output terminal 1 and do the following:

[4] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[十	[+	[/	[-]-

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

# 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
VERY SMALL (1)	[X]	14	
MEDIUM (100)	[4]	14	
MAGNUM (10000)	[4]		

# 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	M	[4]	
JOG (50Hz)	[ ]	17	
SPRINT (500Hz)	[]	11	



# 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	25.87	28.51	
2	27.14	29.97	
3	28.20	31-22	
4	29.35	32.41	
5	30.23	33.45	
Check if passed:	H	[4]	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[4-	[4		
2	[4	[4]		
3	[4	[]		
4	[4]	[+]		
5	[ 9	H		
6	[]	[]		
7		[1		
8	<u> </u>	[1		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[1]	[/		
2		[1		
3				
4	[1]	[1		
5		[/		
6	[1	[}		
7		[/]		
8	[1	17		

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[YPass	[]Fail
Output terminals	[ Pass	[]Fail
Speeds	[ the Pass	[ ] Fail
Step sizes	[ ] Pass	[] Fail
Front panel LEDs	[ 9 Pass	[ ] Fail

Test Engineer: Zah G
Test Date: 11/22/11

Additional Comments:

# **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

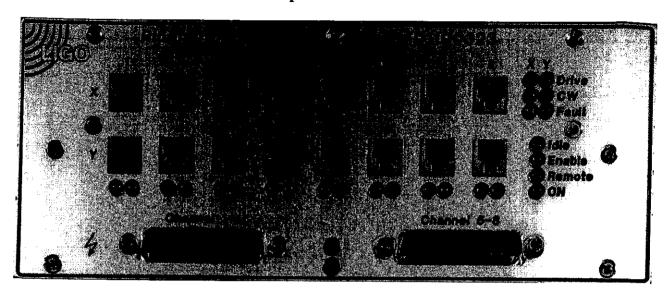
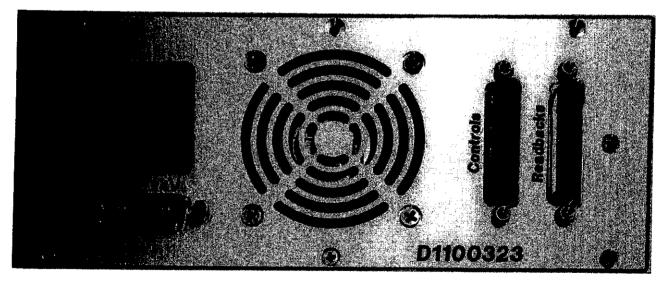
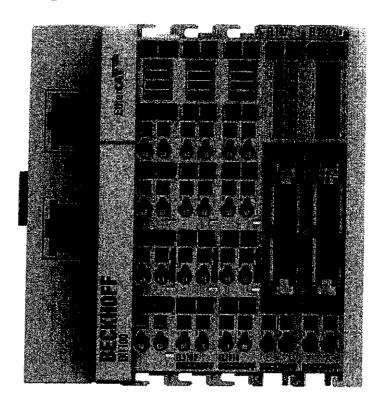


Figure 3: Picomotor driver chassis rear panel



JAGO!

Figure 4: EtherCAT configuration



### **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

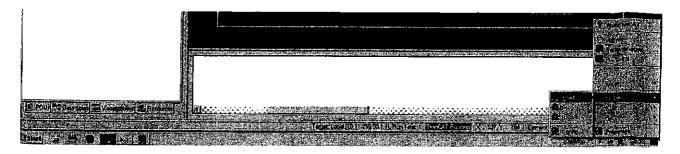
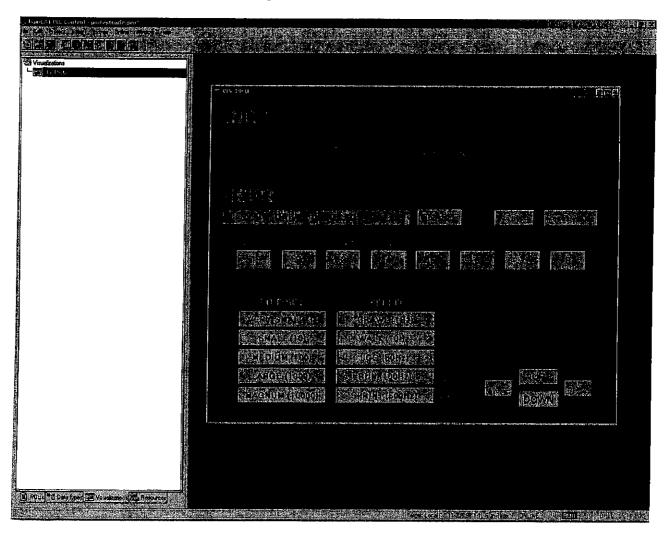


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

icomotor controller chassis LIGO DCC#	D1100323-v1	
htherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	31107551	
Test Engineer:	Zach G	
Test Date:	11/22/11	
Overall picomotor chassis testing:	[ ] FAIL	
Signature/Initials:		

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- Front panel LEDs
   Step sizes
   Speeds

- 4. Temperature5. Output terminals

#### **System requirements**

#### <u>Hardware:</u>

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

#### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

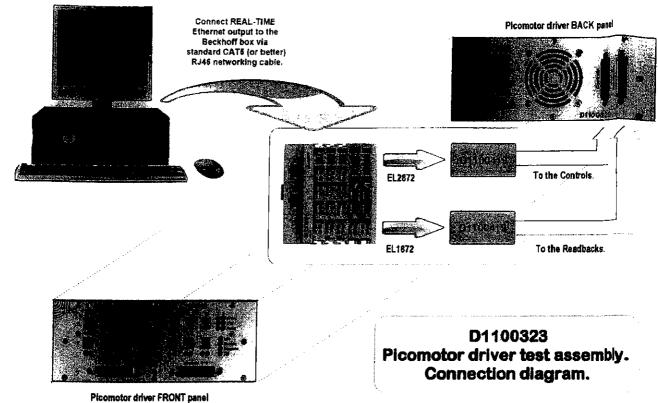
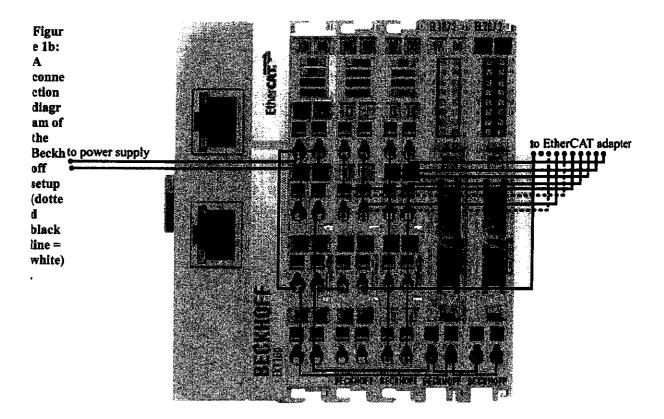


Figure 1a: A connection diagram of the picomotor setup.



#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:
"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- [ Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Cl	Chassis Front Panel LEDs			Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	SM	off	m
STARTING UP	off	on	flashes	flashes	off	on	m
READY	off	on	off	off	off	on	on
Check if passed:	[4]		[]	[-}	[9	[]	

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

- Check that the fan is running and blowing air out of the box (rear panel).
- Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	Ll	ED
	Left	Right
1	[V]	M
2	[4]	[4
3	[4	[4
4	[+]	14
5	[]	[]
6	[1	[1
7		[1]
8	N	[/

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off off	off	off
Check if passed:	[]	[]	1	[]

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

# l. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and thete visualization screen, make sure then select "SPRINT (500Hz)" under "SPEED". Select a select that output terminal I is selected, then select "SPRINT (500Hz)" under "SPEED". Select a set is size and then a direction. Check that the motor runs for a longer time (the motor clicks and furns when it runs) as you increase the step size for each axis (X and Y):

	/6]	(10000) WUNDAM
<i>[</i>		MEDIUM (100)
[ 7:1	المر	VERY SMALL (1)
Y ("UP" or "DOWN")	X ("<" or ">")	
sixA		Step Size

# 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE", Select a speed and then a direction, Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

PRINT (500Hz)	<i>[</i> -]	<u></u>
(SH02) DC	[المر	
RAWL (1Hz)	<i>[</i> -]	[ ]
	X ("<" or ">")	Y ("UP" or "DOWN")
beeq		sixA

### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	25.25	26.20	
2	26.43	27.65	
3	27.57	28.83	
4	28.72	29.7	
5	29.65	31.62	
Check if passed:	[4	12/	

Check the "pass" box for each above if the temperature increases over time.

## 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[4	[7
2	[4	[1
3	[X	[ <del>]</del>
4	[4	[.]
5		[1/]
6	T (1)	[]
7	[1]	[1]
8	[ ]	[1

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[4	[1]
2	14	И
3		[/
4		[4]
5	[4]	[]
6	[1]	[1]
7		IX.
8		

# **Testing Summary**

for each test, indicate the results in the table below:

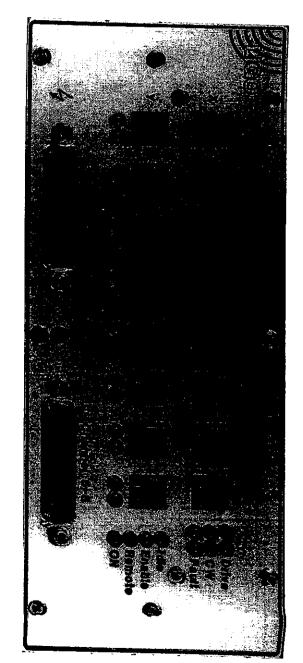
Overall picomotor driver testing:	[YPass	[ ] Fail
Output terminals	[-]Pass	[ ] Fail
Speeds	[ Pass	[ ] Fail
Sep sizes	[ Pass	[ ] Fail
Front panel LEDs	[ Pass	[ ] Fail

Test Engineer: Zoch 6
Test Date: 11/22/11

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel



Mgure 3: Picomotor driver chassis rear panel

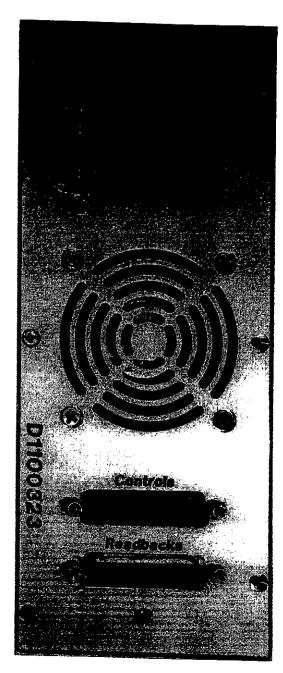
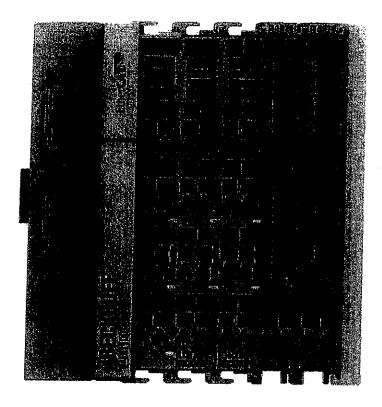


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

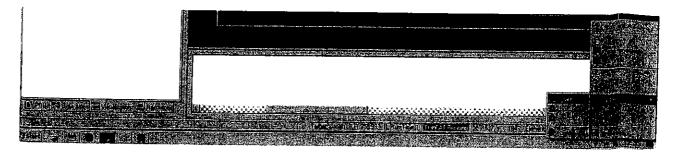
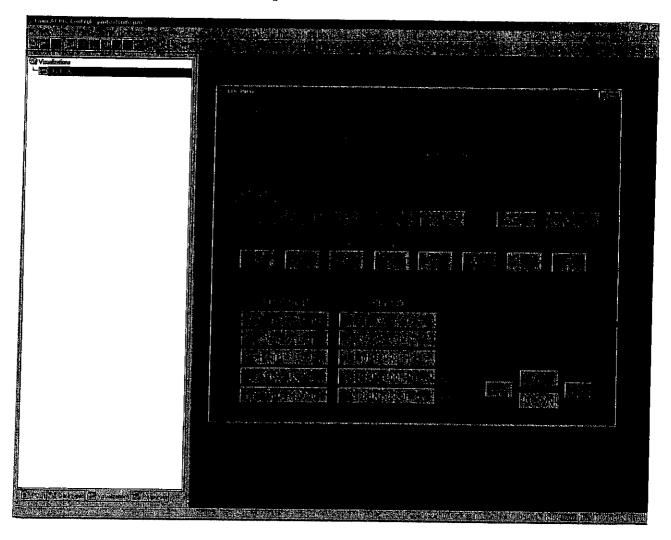


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: <a href="http://www.ligo.caltech.edu">http://www.ligo.caltech.edu</a>

hicomotor controller chassis LIGO DCC#	D1100323-v1	
htterCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	S107552	
Test Engineer:	Zado C	
Test Date:		Y22/11
Overall picomotor chassis testing:	YASS	FAIL
Signature/Initials:		

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

## System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

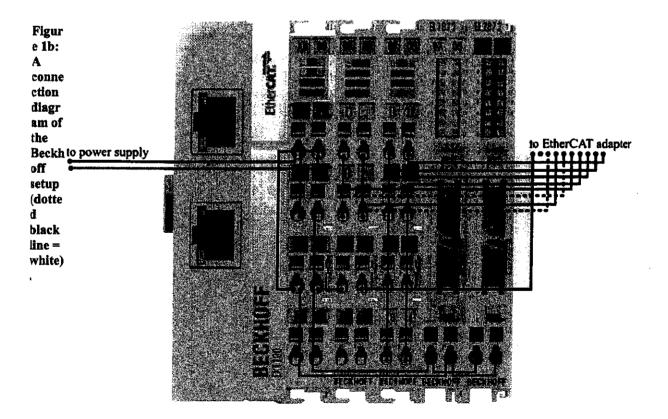
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

#### Setting up

#### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

Picomotor driver FRONT panel
Figure 1a: A connection diagram of the picomotor setup.



#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:
 "No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	C1	Chassis Front Panel LEDs			Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	AF.	6n
STARTING UP	off	on	flashes	flashes	Off	622	on6
READY	off	on	off	off	of	en	on
Check if passed:	М	N	[4]	<u> </u>	[1]	[]	[-]

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	ED
	Left	Right
1	M	4
2	[4]	[4]
3	[4	[]
4	[Y	[4]
5	[4]	[1]
6	[4	[1]
7		[4]
8	[1	1

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	M	[4	[1	M

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

#### 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
VERY SMALL (1)	[1]		
MEDIUM (100)	$\omega$	1	
MAGNUM (10000)	[4	[]	

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	[4]	[1]	
JOG (50Hz)	[1	rs (	
SPRINT (500Hz)	[ ]	[1	

# 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	29.33	27.19	
2	30.32	29.29	
3	31.46	29.43	
4	32.37	30 31	
5	33.30	31.28	
Check if passed:	[4]	[4]	

Check the "pass" box for each above if the temperature increases over time.

#### 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DQWN")		
1	[Y	[U]		
2	[4]	[4		
3	[4]	[4]		
4	[4]	[4]		
5	[4]	[-}		
6	[4]	[4]		
7		[/		
8		[/		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	[]	[1	
2		[1	
3		[/]	
4	[1	[1]	
5	[/	[1]	
6	[1]	[1	
7	[1]	[1]	
8	[/]	[1	

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[ ] Fail
Output terminals	[ ] Pass	[ ] Fail
Speeds	[ ] Pass	[ ] Fail
Sep sizes	[ ] Pass	[ ] Fail
Front panel LEDs	[   Pass	[ ] Fail

Test Engineer: Z. C

Test Date: 1/24/1

Additional Comments:

# **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

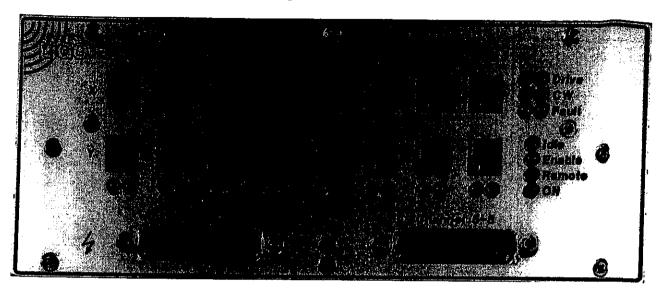


Figure 3: Picomotor driver chassis rear panel

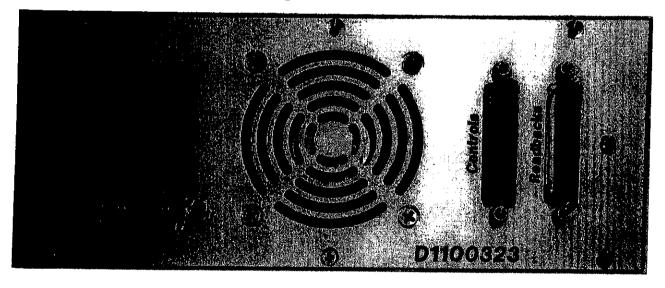
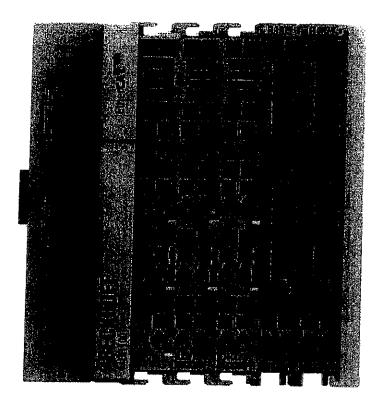


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

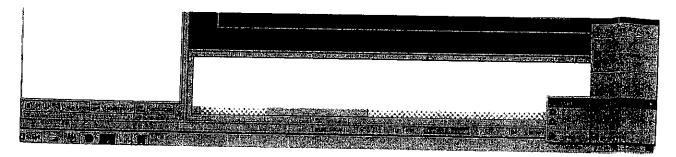
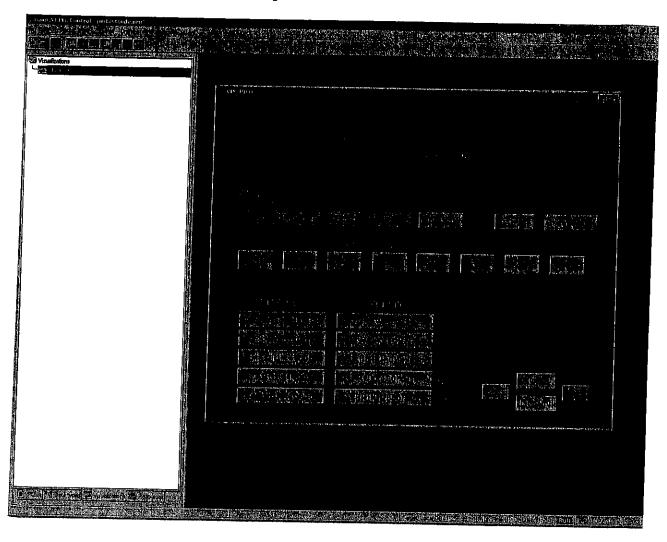


Figure 6: Step 5 of PLC controls setup



LSU

# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1	
ItherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	51107:	553
Test Engineer:	Zach	G
Test Date:	1/22/1	
Overall picomotor chassis testing:	[JPASS	[]FAIL
Signature/Initials:		

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- Front panel LEDs
   Step sizes

- 3. Speeds4. Temperature
- 5. Output terminals

#### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- **5** DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

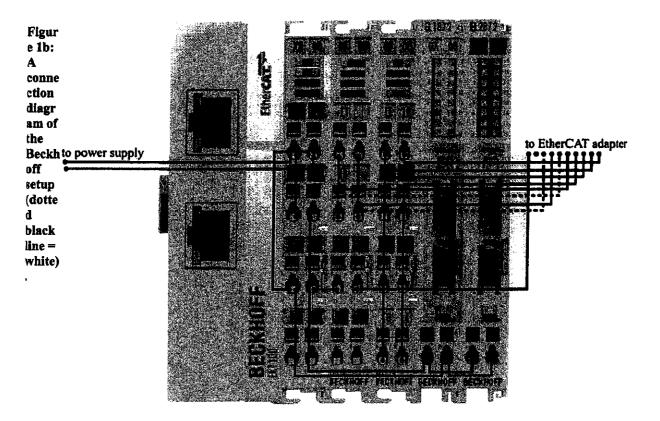
- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

#### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

Picomotor driver FRONT panel
Figure 1a: A connection diagram of the picomotor setup.



### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

	Check that the "ON" LED is lit if the power cable is connected and the power switch
,	is on, and that it goes off when the power switch is off.

Check that the "ON" indicator on the visualization also responds to the power switch.

[ \int Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[ ] Before the next step, check that the fan (rear panel) is off.

Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	00	0 F	on
STARTING UP	off	on	flashes	flashes	off	con	m
READY	off	on	off	off	off	01	57
Check if passed:	[1]	[-]	H	[]	H		[}

Table 1: LED response to picomotor status

Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[ Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	LED		
	Left	Right		
1	W	[4		
2	[4]	[1		
3	[4	[]		
4	[]	[X]		
5	[4]	[4]		
6	[4]	[1]		
7	[4	[1/		
8	[]	[1		

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:		[-]	M	[1]

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

# 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and there that output terminal I is selected, then select "SPRINT (500Hz)" under "SPEED". Select a set is size and then a direction. Check that the motor runs for a longer time (the motor clicks and rurns when it runs) as you increase the step size for each axis (X and Y):

<i>F</i> 1	<i>[</i> 1]	(10000) MUNDAM
المر	[الحر	MEDIUM (100)
[ ]	[المر	VERY SMALL (1)
Y ("UP" or "DOWN")	$X^{(n < n \text{ of } n > n)}$	
sixA	Step Size	

# 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

sixA		Speed
Y ("UP" or "DOWN")	("<" 10 ">") X	
<u>[</u>	<u> [4]</u>	CRAWL (1Hz)
/ <u> </u>	<b>/</b> -1	JOG (50Hz)
<u></u>	<i>[</i> -1]	SPRINT (500Hz)

### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	31.55	30.02	
2	32.61	31.19	
3	33.77	32.40	
4	34.81	33.50	
5	35.72	34.47	
Check if passed:	[4]	W	

Check the "pass" box for each above if the temperature increases over time.

### 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[Y]	[17]
2	[4]	[4
3		$[\mathcal{X}]$
4	[4]	[ ]
5	[1]	[ 1
6	[4]	[1]
7	[4]	[1]
8	[4]	[1

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	[4]	[]	
2	T	[ <del>]</del>	
3	[4	[4]	
4	[4]	[4	
5		[]	
6	[4]	[9]	
7	[]	[4]	
8		[4]	

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[.] Pass	[] Fail
Output terminals	[ ] Pass	[ ] Fail
Speeds	[ ] Pass	[ ] Fail
Step sizes	[ /Pass	[ ] Fail
Front panel LEDs	Pass	[ ] Fail

Test Engineer: Zach G
Test Date: 11/22/11

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

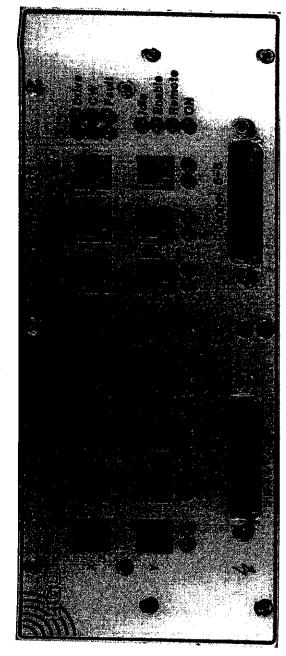


Figure 3: Picomotor driver chassis rear panel

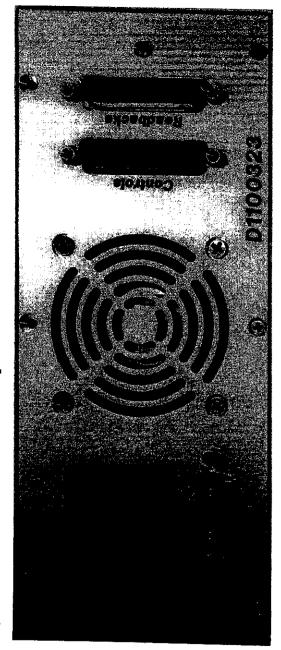
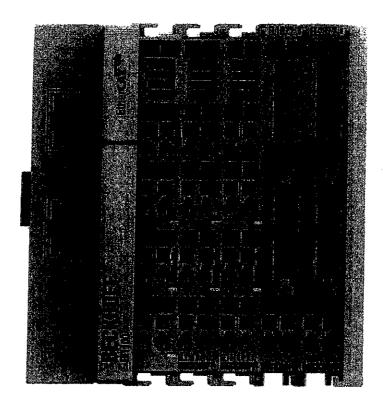


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

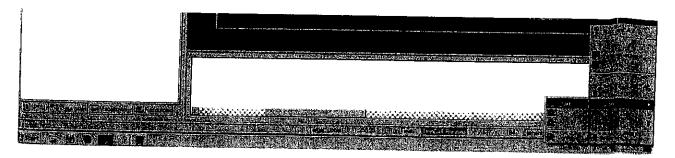
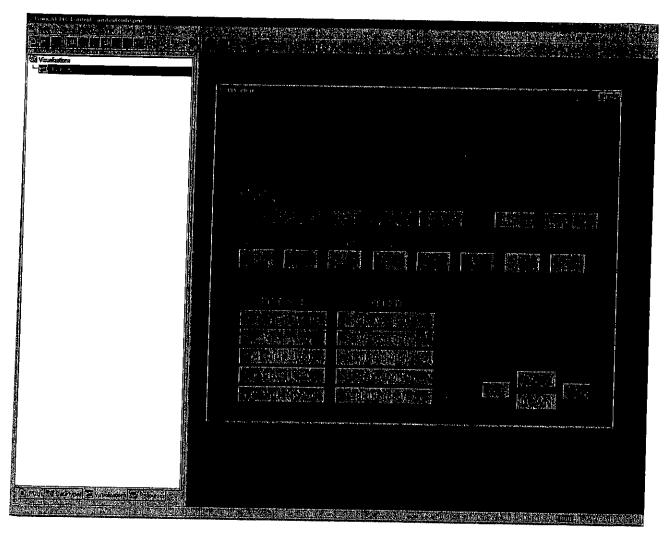


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1		
ItherCAT Adapters LIGO DCC#	D1100419-v3		
€ontroller Serial #	5110	7 554	
Test Engineer:	Zac	h 6	
Test Date:	11/22	/11	
Overall picomotor chassis testing:	[YPASS	[ ] FAIL	
Signature/Initials:			

### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

### **Testing Schedule:**

- Front panel LEDs
   Step sizes
- 3. Speeds
- 4. Temperature
  5. Output terminals

## System requirements

### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- Hook-up wiresBrown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

### Setting up

### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

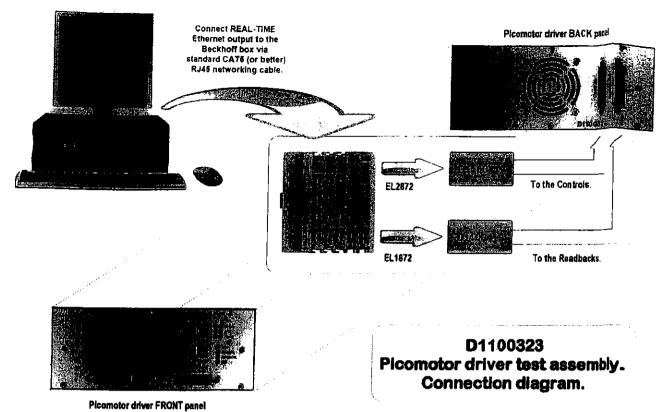
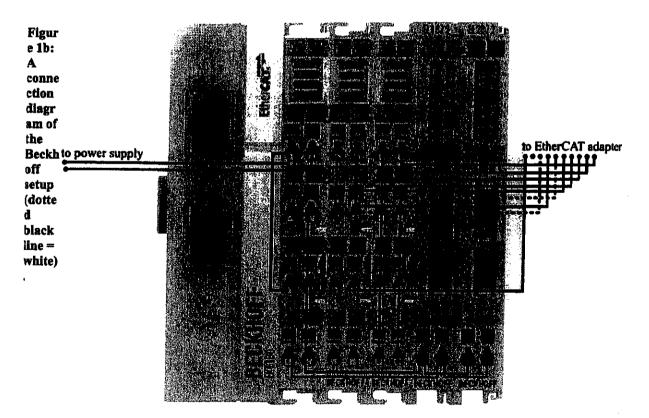


Figure 1a: A connection diagram of the picomotor setup.



### Setting up

### Steps for setting up the PLC controls:

Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

# 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

Check that the "ON" LED is lit if the power cable is connected and the power switch
is on, and that it goes off when the power switch is off.

Check that the "ON" indicator on the visualization also responds to the power switch.

Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

Before the next step, check that the fan (rear panel) is off.

Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	571	df	611
STARTING UP	off	on	flashes	flashes	aff	(DY	W
READY	off	on	off	off	off	5	55
Check if passed:	[4]	[-]	[]	[/	11	[/]	17

Table 1: LED response to picomotor status

Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	I	ED
	Left	Right
1	[4	[ 4/
2	[Y	W
3	[]	[]
4	[4	[4]
5	[ ]	[4]
6		[4/
7	[1]	[X]
8	[-]	[1

Select output terminal 1 and do the following:

[] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4]	[1]	W	[4

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

## 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
VERY SMALL (1)	[4]	[4	
MEDIUM (100)	[4	14	
MAGNUM (10000)	[Y	i.	

### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[4	14
JOG (50Hz)	[9	ĬŢ.
SPRINT (500Hz)	[]	i d

### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	34.57	33.77	
2	35.56	34.89	
3	36.44	35.81	
4	37.21	36.64	
5	37.91	37.40	
Check if passed	: [4	[Y	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[4]				
2	["]	[ ]			
3	[4]	[1			
4		[ <del>/</del>			
5	[]	[ 1			
6		il			
7		ił			
8		11			

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[1	[1				
2	[1	[1				
3	[1	[1				
4	[]	[/				
5		1 1				
6	[1]	[}				
7		[1/				
8		[ ]				

# **Testing Summary**

For each test, indicate the results in the table below:

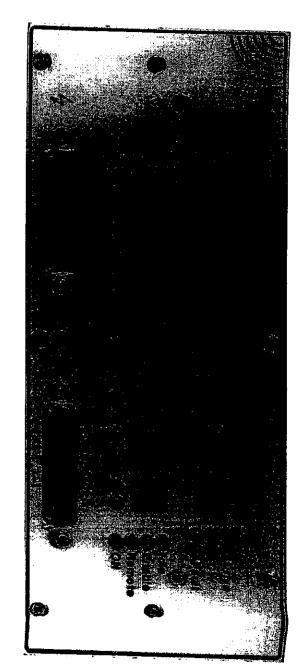
Front panel LEDs	Pass	[ ] Fail
Step sizes	[ Pass	[ ] Fail
Speeds	[   Pass	[]Fail
Output terminals	Pass	[ ] Fail
	AND AN IN MATERIAL SERVICES AND THE PARTY OF	
Overall picomotor driver testing:	[ ] Pass	[ ] Fail

Test Engineer: Zah 6
Test Date: 1/22/11

Additional Comments:

# Appendix A: Physical Components

figure 2: Picomotor driver chassis front panel



Mgure 3: Picomotor driver chassis rear panel

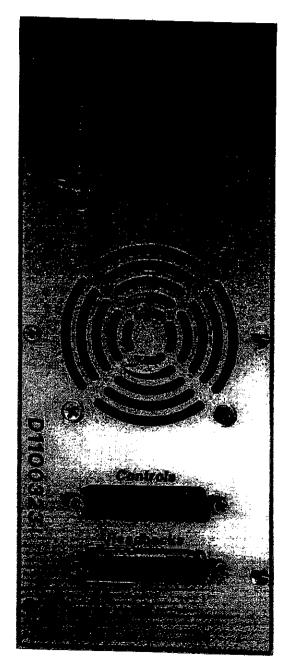
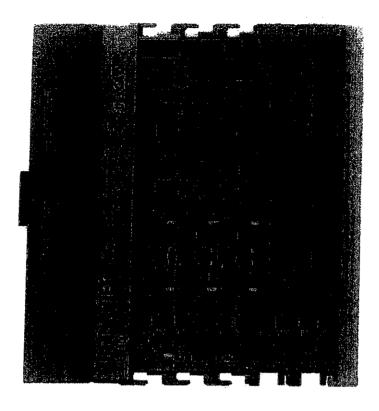


Figure 4: EtherCAT configuration



### **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

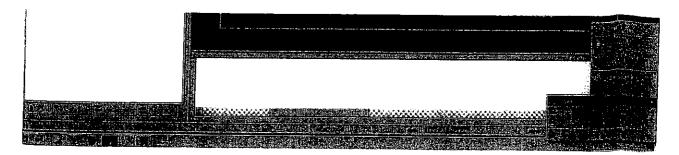
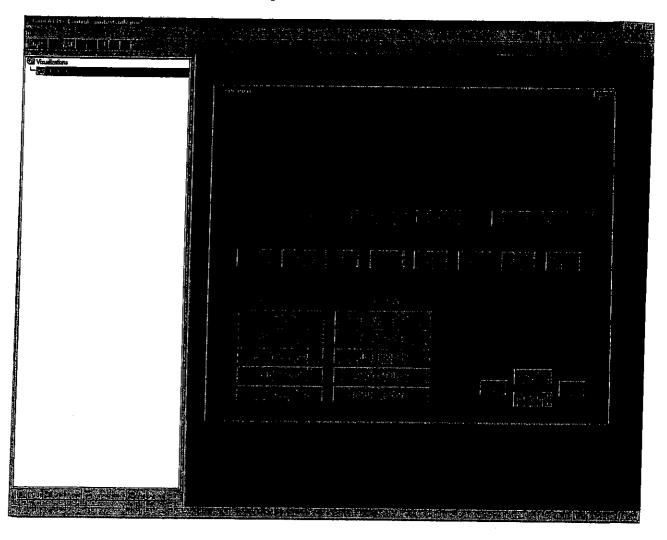


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

### CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

icomotor controller chassis LIGO DCC#	<u>D1100323-v1</u>
ItherCAT Adapters LIGO DCC#	D1100419-v3
Controller Serial #	51107555
Test Engineer:	Zach G
Test Date:	W22/11
Overall picomotor chassis testing:	[YPASS []FAIL
Signature/Initials:	

### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

### Testing Schedule:

- Front panel LEDs
   Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

### System requirements

### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

### Setting up

### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

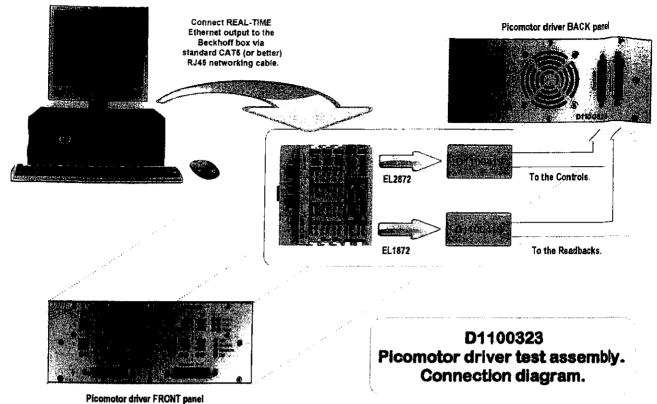
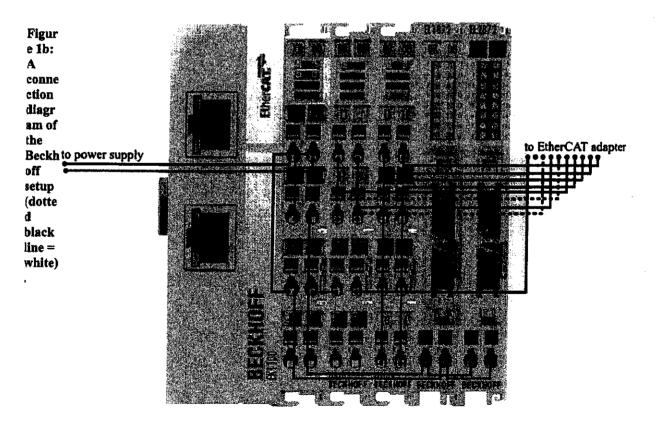


Figure 1a: A connection diagram of the picomotor setup.



### Setting up

### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ ] Check that the "ON" indicator on the visualization also responds to the power switch.
- [ 1 Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	C	Chassis Front Panel LEDs			Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	$\infty$	A	Gn
STARTING UP	off	on	flashes	flashes	off	M	on
READY	off	on	off	off	of	5	on.
Check if passed:		[]	[7	[/]	ľ	[1]	17

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	Ll	ED
	Left	Right
1	[ ]	[1]
2	[4]	14
3	[4]	[}
4	[4]	[1]
5	[]	[/
6		[/]
7	[-]	1/
8	[]	[1]

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[ ]	[]	[]	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

### l. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and thetek that output terminal I is selected, then select "SPRINT (500Hz)" under "SPEED". Select a set is size and then a direction. Check that the motor runs for a longer time (the motor clicks and rurns when it runs) as you increase the step size for each axis (X and Y):

<u></u>	۲)	(10000) MUNDAM
المر	[کمر	<b>WEDIOM</b> (100)
[-]	<i>[</i> *]	VERY SMALL (1)
Y ("UP" or "DOWN")	$X (^{n} <^{n} or ^{n} >^{n})$	
sixA		Step Size

### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

SPRINT (500Hz)	[7]	
10G (20Hz)	<i>[</i> k]	[4
CRAWL (1Hz)	[~]	[A]
	X ("<" or ">")	Y ("UP" or "DOWN")
Speed	sixA	

### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	27.94	27.99	
2	28.40	28.48	
3	28.86	28.91	
4	29.35	29.40	
5	29.77	25.77/	
Check if passed:	[4	[4]	

Check the "pass" box for each above if the temperature increases over time.

### 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[Y	[1]		
2	M/	[1		
3		$\mathcal{A}$		
4	[1	[1		
5		ſΊ		
6	[1]	1/		
7	[1			
8		[1		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[4]	[1]		
2	[4]	[1		
3	[-	[1		
4		[]		
5		[1		
6	[/	[1]		
7	[1]			
8	[1	[1]		

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ]Pass	[ ] Fail
Output terminals	[ ] Pass	[ ] Fail
Speeds	[   Pass	[ ] Fail
Step sizes	[ / Pass	[ ] Fail
Front panel LEDs	[ ] Pass	[ ] Fail

Test Engineer: Zall

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

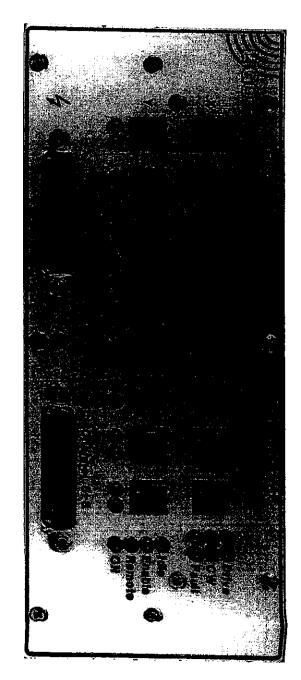


Figure 3: Picomotor driver chassis rear panel

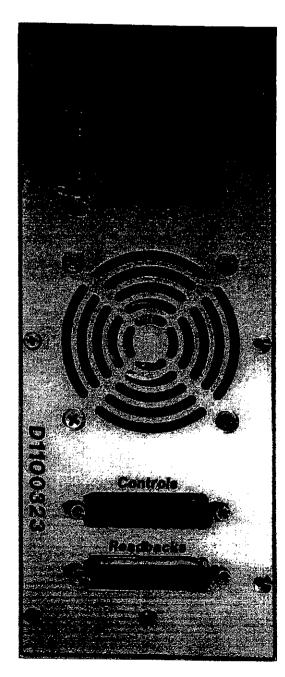
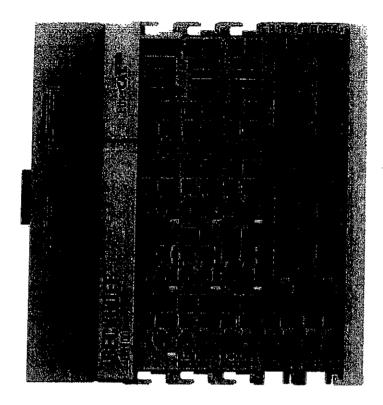


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

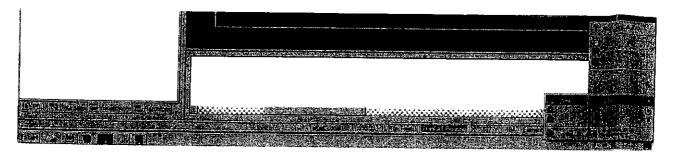
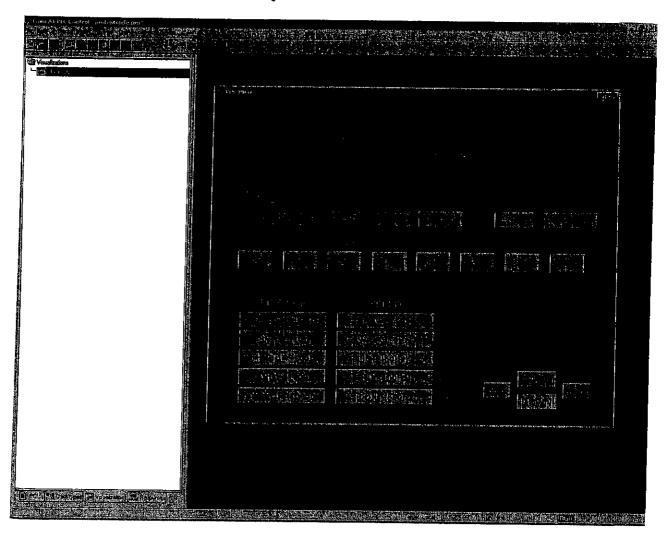


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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Phone (212) 854-8209

Fax (212) 854-8121

E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1	
ItherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	51107556	
Test Engineer:	Zach 6	
Test Date:	11/22/11	
Overall picomotor chassis testing:	[ ] FAIL	
Signature/Initials:		
	**************************************	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20 Controller

#### **Testing Schedule:**

- Front panel LEDs
   Step sizes
- 3. Speeds
- 4. Temperature5. Output terminals

# **System requirements**

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

## Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

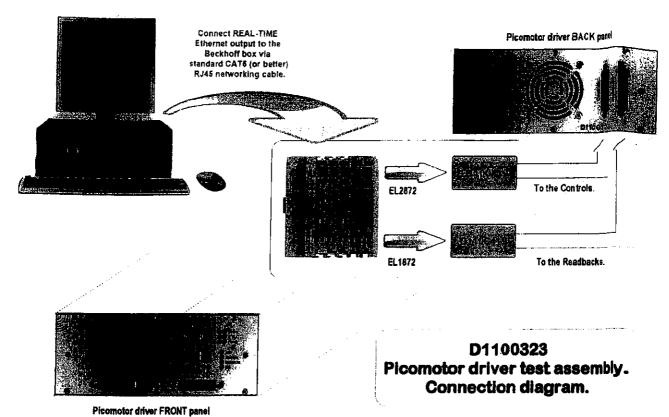
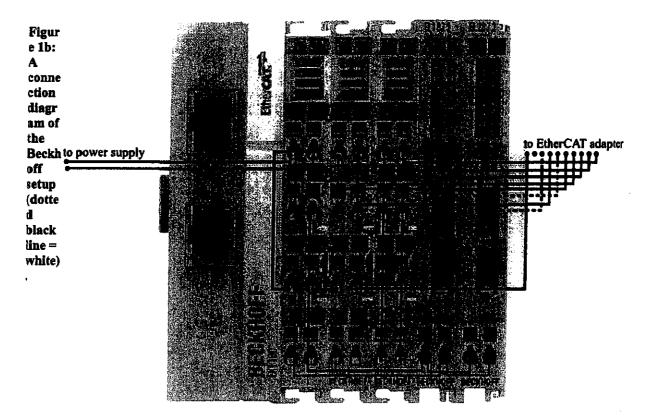


Figure 1a: A connection diagram of the picomotor setup.



## Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:
 "No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

# 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	(3)F	on
STARTING UP	off	on	flashes	flashes	285	on	on
READY	off	on	off	off	6SF	on	57
Check if passed:	W	W	[4	[4]	[4]	[]	[4]

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	LED		
	Left	Right		
1	[4]	H		
2	[4]	[4]		
3		[4]		
4	M	[4]		
5	[1]	[]		
6	[1]			
7		1/		
8	[ <b>1</b>	[X]		

#### Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	M	[]		[-]	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

# 2. Testing the step sizes

On the visualization sereen, make sure the picomotor is enabled and that the status is "READY", and thetek that output terminal I is selected, then select "SPRINT (500Hz)" under "SPEED". Seled a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and furns when it runs) as you increase the step size for each axis (X and Y):

[7]	[1]	(10000) MAGNUM
	<i>[</i> ]	<b>MEDINM</b> (100)
[ کمر	[طر	VERY SMALL (1)
Y ("UP" or "DOWN")	X ("<" or ">")	
sixA	,	Step Size

# 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

SPRINT (500Hz)	[عر	J.l
(zH0c) ĐO1	/rl	J-1
CRAWL (1Hz)	<b>[</b>	المر
	$X (^{n} <^{n} \text{ or }^{n} >^{n})$	Y ("UP" or "DOWN")
Speed		sixA

## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	32.47	29.61		
2	33.54	30.69		
3	34.57	31.72		
4	35.46	32.69		
5	36.30	33.45		
Check if passed:	[4	M		

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[4]	[]			
2	M				
3	[/	[1			
4	[4]	[ <del>]</del>			
5	[1]	[/			
6	[1	[1			
7		[1/.			
8					

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[1]	[1				
2						
3		[]				
4		[/				
5	[1	11				
6						
7		17				
8		[ ]				

# Testing Summary

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[/] Pass	[ ] Fail
Output terminals	[   Pass	[] Fail
Speeds	[   Pass	[ ] Fail
Step sizes	[ J Pass	[ ] Fail
Front panel LEDs	[4] Pass	[ ] Fail
Front panel LEDs	[42 Page	f less

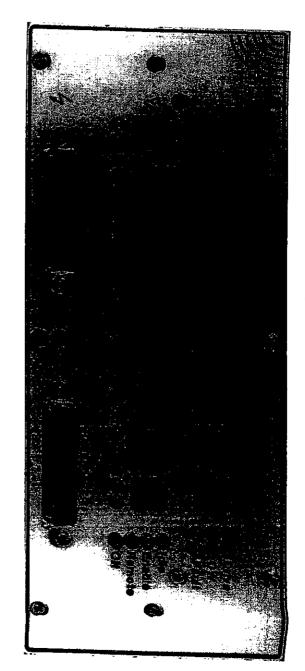
Test Engineer: Zad C

Test Date: 11/23/11

Additional Comments:

# Appendix A: Physical Components

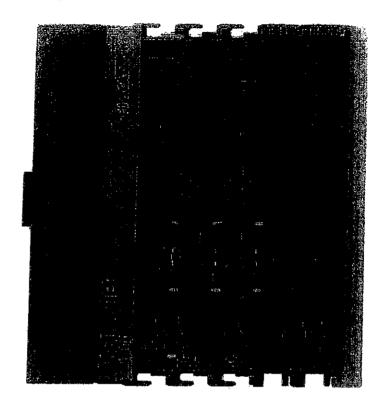
Figure 2: Picomotor driver chassis front panel



Mgure 3: Picomotor driver chassis rear panel



Figure 4: EtherCAT configuration

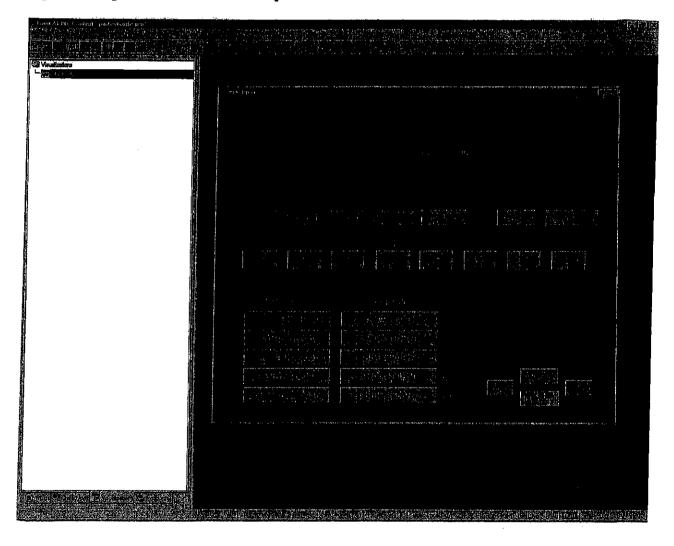


# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup



Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

icomotor controller chassis LIGO DCC#	D1100323-v1	
ItherCAT Adapters LIGO DCC#	<u>D1100419-v3</u>	
Controller Serial #	51107557	
lest Engineer:	Zach G	
Test Date:	1/22/11	
Overall picomotor chassis testing:	[YPASS	[ ] FAIL
Signature/Initials:		

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- Front panel LEDs
   Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

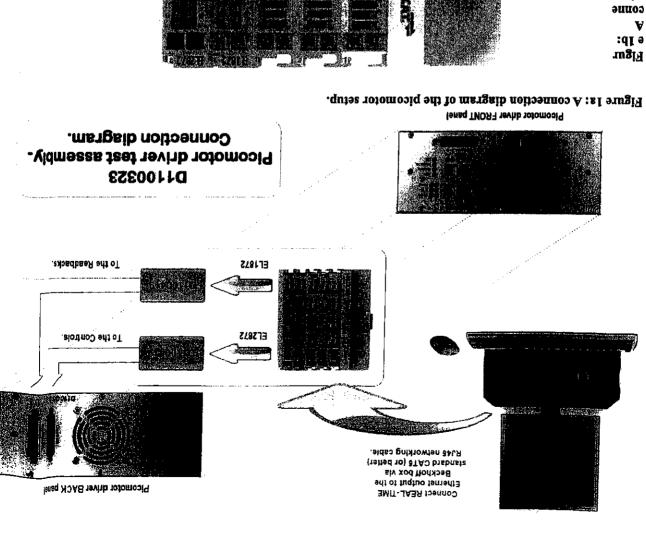
#### **Software:**

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

# Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on



white)

Seck to power supply

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Seck to power supply

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A

fine

# Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	971	off	on
STARTING UP	off	on	flashes	flashes	04	02	on
READY	off	on	off	off	off	500	00
Check if passed:	[4]	[1]	[4	[-]	[4		[-

Table 1: LED response to picomotor status

- [ Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[V] Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal		LED Left Right		
1		M	[4]	
2		W.	14	
3		M	[]	
4		M	[4]	
5		M	[4]	
6		[4]	M	
7		[4]	[4]	
8		[4	4	

#### Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	M	[ ]	[]	[]

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

# 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and there that output terminal I is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and furms when it runs) as you increase the step size for each axis (X and Y):

[h]		(00001) MUNDAM
[1	/h]	MEDIUM (100)
	Jh]	VERY SMALL (1)
Y ("UP" or "DOWN")	("<" to ">") X	
sixA	7	Step Size

# 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

SPRINT (500Hz)	/1	<u></u>
(SH02) DOI	<i>[</i> *]	H
CRAWL (1Hz)	[بر]	۴ì
	X (" < "	Y ("UP" or "DOWN")
Speed	sixA	

# 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	29.36	27.29	
2	29.54	28.52	
3	30.67	29.71	
4	31. (do	30.69	
5	32.6	31.49	
Check if passed:	- iv	[4]	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	W	[/		
2		[1		
3		$\square$		
4	[4	[1		
5		[1		
6		[]		
7	[1]			
8		1		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	N	[/		
2	1	[1		
3	[/	[ ]		
4	[/	[/		
5	[/			
6		[]		
7		[1		
8		[1		

# Testing Summary

For each test, indicate the results in the table below:

Front panel LEDs [ ] Pass [ ] Fail  Step sizes [ ] Pass [ ] Fail  Speeds [ ] Pass [ ] Fail  Output terminals [ ] Pass [ ] Fail	Overall picomotor driver testing:	[ ] Pass	[ ] Fail
Step sizes [ ] Fail	Output terminals	Pass	[ ] Fail
Step sizes [ ] Fail	Speeds	[   Pass	[ ] Fail
Front panel LEDs [ ] Fail	Step sizes	£/3	[] Fail
	Front panel LEDs	[ ] Pass	[ ] Fail

Test Engineer: Zach G
Test Date: 11/24/11

Additional Comments:

# **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

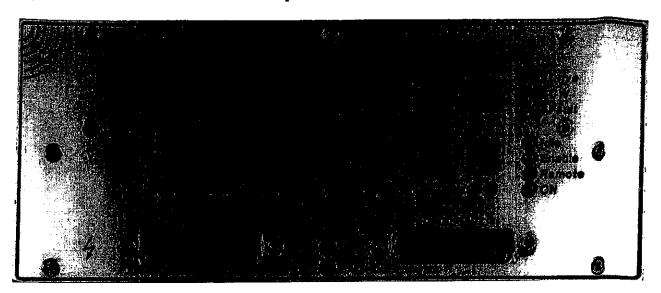


Figure 3: Picomotor driver chassis rear panel

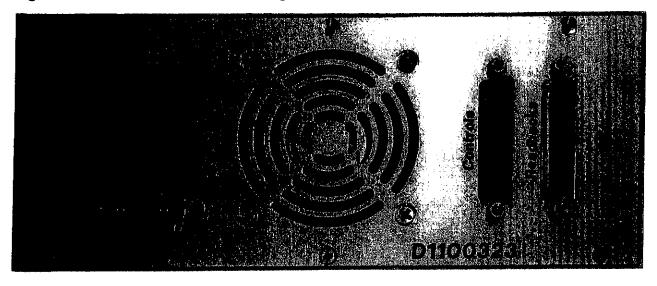
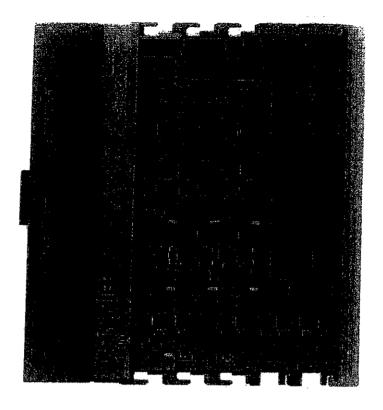


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

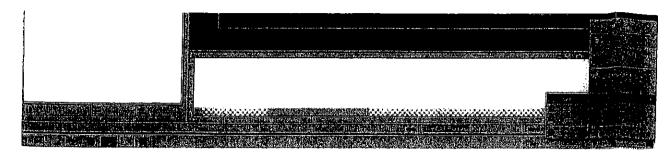
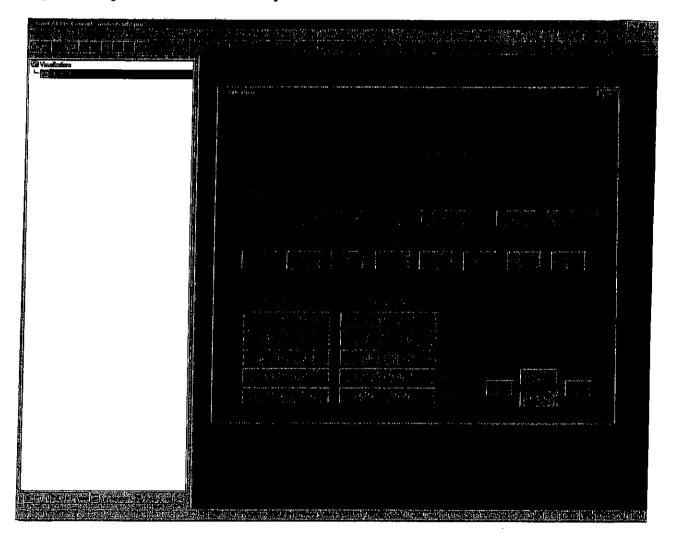


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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Fax (212) 854-8121

E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1		
ItherCAT Adapters LIGO DCC#	D1100419-v3		
Controller Serial #	511075	58	
Test Engineer:	Zach	6	
Test Date:	11/22/11		
Overall picomotor chassis testing:	[ YPASS	[ ] FAIL	
Signature/Initials:			
уу г түй тоой тоон шишин шашин үй дүүнөө төөнө шашышушуу да үй мүнүнүн тоон бүй Мүнүн тоон тоон тоон тоон тоон тоон тоон		The state of the s	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature5. Output terminals

# System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

## Setting up

#### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

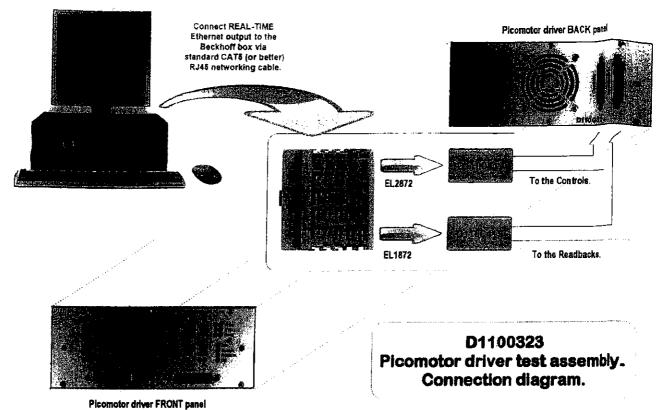
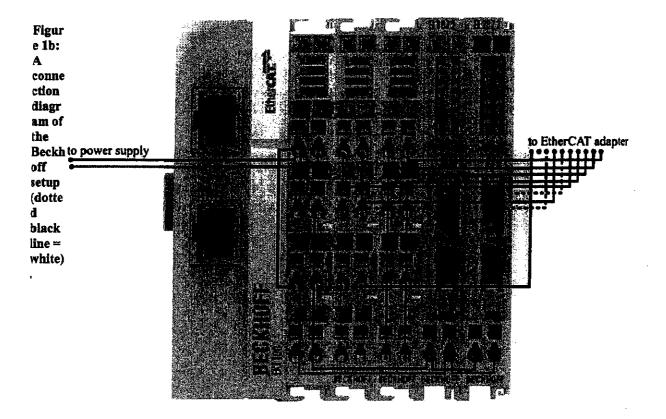


Figure 1a: A connection diagram of the picomotor setup.



## Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:
 "No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	C	hassis Front	Panel LEI	Os	Software Readback		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	01	280	on
STARTING UP	off	on	flashes	flashes	off	100	on
READY	off	on	off	off	<i>6</i>	on	on
Check if passed:	[4]	[]	[1]	[/	[9	[]	[9]

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	1	LED
	Left	Right
1	[4/	[4]
2		, H
3	- M	[ ]
4	[1]	$\mathbf{H}_{\mathbf{A}}$
5	[1]	[4]
6	[/]	[1]
7	[1]	[1]
8	[/]	[1]

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[]	[]	[]	[1]	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

## 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and there visualization screen, make sure the picomotor is enabled and that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

[ الر	<u>[1</u>	(00001) MUNDAM
[ \f\	(1)	MEDIUM (100)
h	Æ]	VERY SMALL (1)
Y ("UP" or "DOWN")	X ("<" or ">")	
sixA	sixA	

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

SPRINT (500Hz)	<i>J</i> -1	<u>[</u> ]		
10G (50Hz)	\\P\]	<b>[</b> ]		
CKAWL (1Hz)	<i>\f</i> !			
-	X ("<" or ">")	Y ("UP" or "DOWN")		
Speed	sixA			

## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	33.30	34.41		
2	33.99	35.24		
3	34.77	36.05		
4	35.57	36.86		
5	36.16	37.53		
Check if passed:	[]	H		

Check the "pass" box for each above if the temperature increases over time.

## 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	M	[4				
2	[4]	[ ]				
3	[1	[4				
4	[]	[]				
5	[4]	[]				
6	[1]	[1]				
7	[]	[]				
8						

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	M	[4]			
2	[4]	[1			
3	[9]	[1			
4	[4]	[1			
5	[4	[ ]			
6	[4]	[1			
7		[1			
8		ſΊ			

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ †Pass	[ ] Fail
Output terminals	[]Pass	[ ] Fail
Speeds	[ Pass	[ ] Fail
Step sizes	[ ] Pass	[ ] Fail
Front panel LEDs	[ YPass	[ ] Fail

Test Engineer: Z. L. C.
Test Date: 11/2 7/11

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

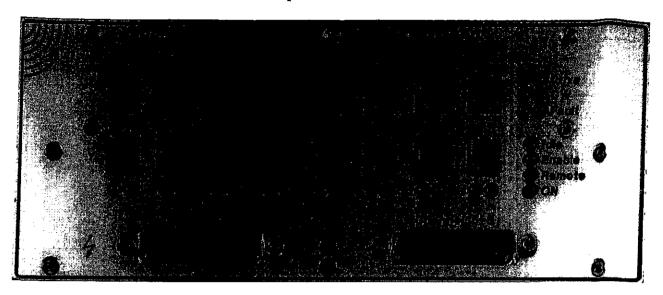


Figure 3: Picomotor driver chassis rear panel

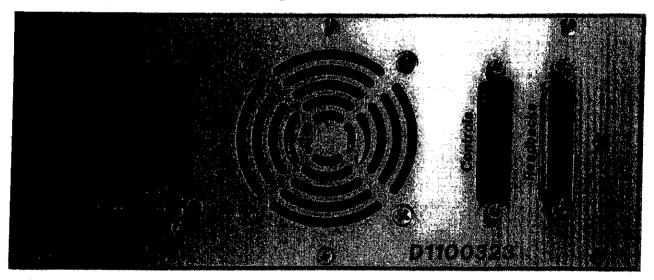
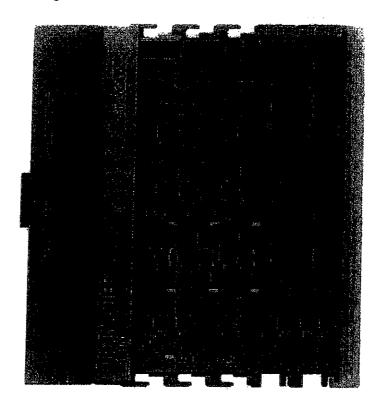


Figure 4: EtherCAT configuration



## **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

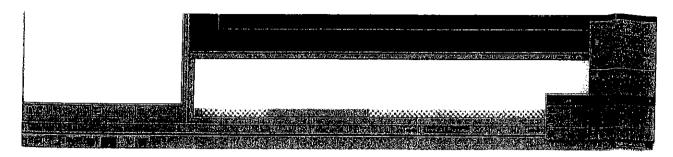
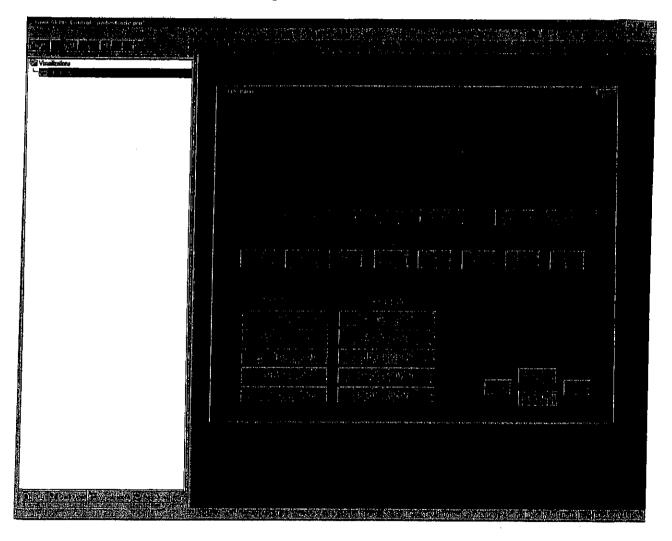


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1		
ItherCAT Adapters LIGO DCC#	D1100419-v3		
Controller Serial #	51107559		
lest Engineer:	Zach G	<del></del>	
Test Date:	1/22/11		
Overall picomotor chassis testing:	[ YPASS [ ] FAI	Ĺ	
Signature/Initials:			

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### Testing Schedule:

- Front panel LEDs
   Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

#### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1)
  (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

#### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

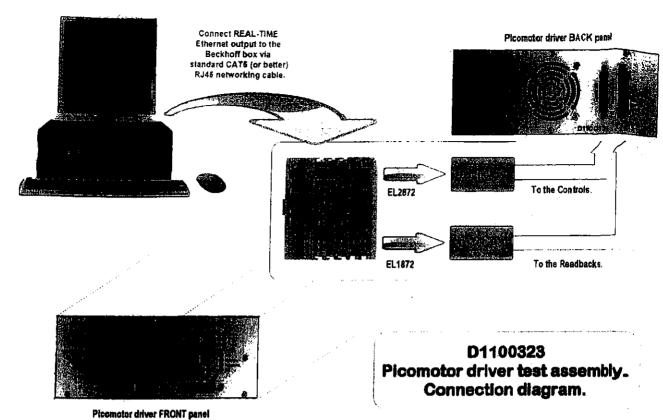
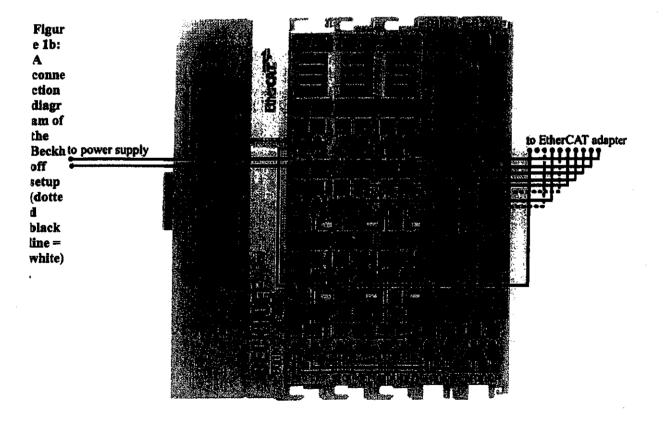


Figure 1a: A connection diagram of the picomotor setup.



## Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:
 "No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- [ d Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Softw	Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	001	Off	621
STARTING UP	off	on	flashes	flashes	SE	on	90
READY	off	on	off	off	DO	m	on
Check if passed:	[1]	[]	W	1	[]	19	17

Table 1: LED response to picomotor status

- [ Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [ ] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the vicomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal		LED		
		Left	Right	
1		[4	M	
2		4	4	
3		14	[4]	
4		4	H	
5		[U/	1	
6		M	[1]	
7		M	/ H/	
8	-	[4	[1]	

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction		LE	Ds	
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4]	[1	[ ]	[/

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

#### 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	M	i I
MEDIUM (100)	[4]	M
MAGNUM (10000)	M	19

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[9]	[1]
JOG (50Hz)	[4]	19
SPRINT (500Hz)	[]	14

## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Tem	perature
	X ("<" or ">")	Y ("UP" or "DOWN")
1	27.41	27.26
2	20.55	28.41
3	29. 82	29 63
4	30.77	30.66
5	31.74	31.57
Check if passed:	[Y	

Check the "pass" box for each above if the temperature increases over time.

## 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	H	N/
2	H	[ 9
3	[4]	U/
4		
5	[1]	[7]
6	1	[1]
7		[/
8	[1]	[]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[1]	19
2		[]
3		[ ]
4		[]
5	[1]	[]
6	[1	
7	[1	
8		[]

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[ ] Fail	and distribution of the second
Output terminals	[]Pass	[ ] Fail	
Speeds	[ Pass	[ ] Fail	
Step sizes	[ YPass	[ ] Fail	
Front panel LEDs	Pass	[ ] Fail	

Test Engineer: Zech Co
Test Date: 11/22/11

Additional Comments:

## **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

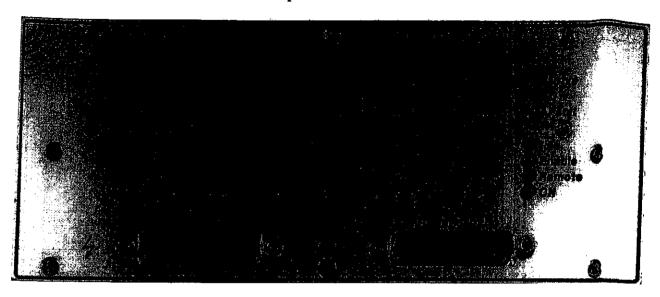


Figure 3: Picomotor driver chassis rear panel

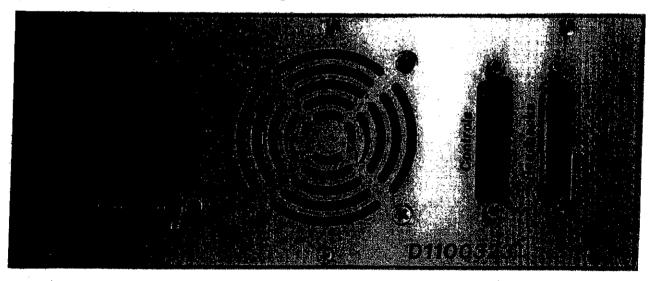
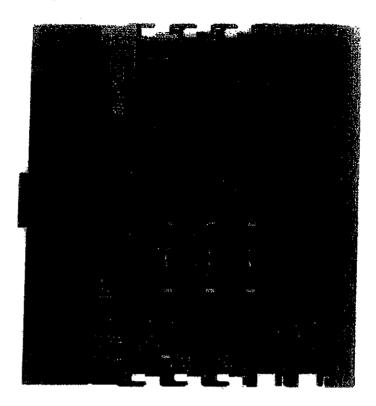


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

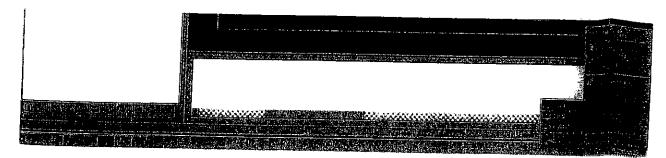
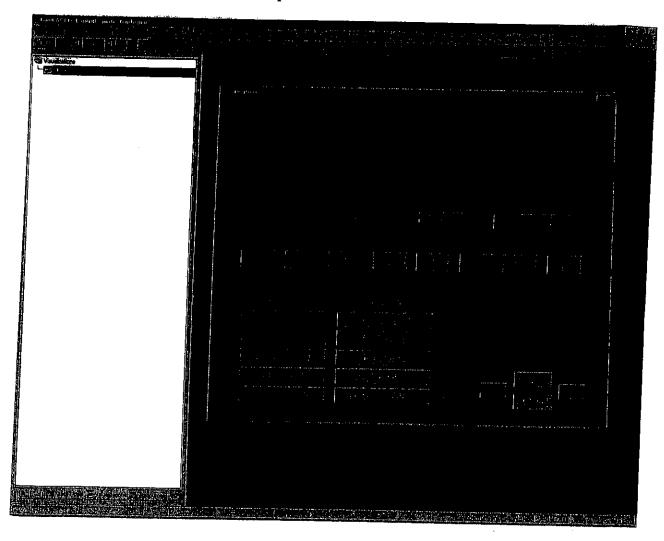


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

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This is an internal working note of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

icomotor controller chassis LIGO DCC#	D1100323-v1	
EtherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	51107560	
lest Engineer:	Zech C	
Test Date:	11/22/11	
Overall picomotor chassis testing:	[/]PASS []FAIL	
Signature/Initials:		

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### Testing Schedule:

- Front panel LEDs
   Step sizes
   Speeds
   Temperature
   Output terminals

## System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- **5** DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

## Setting up

#### <u>Steps for setting up the picomotor:</u>

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

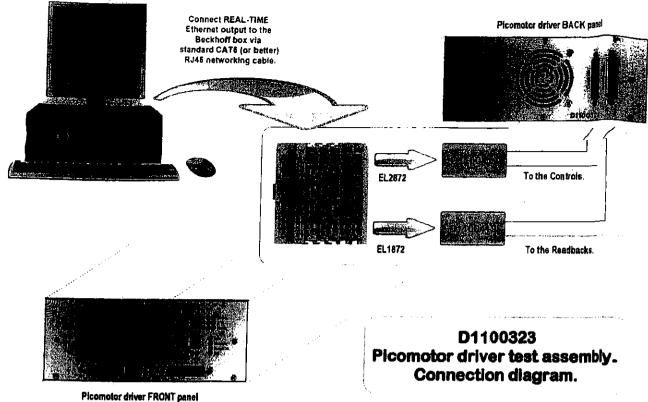
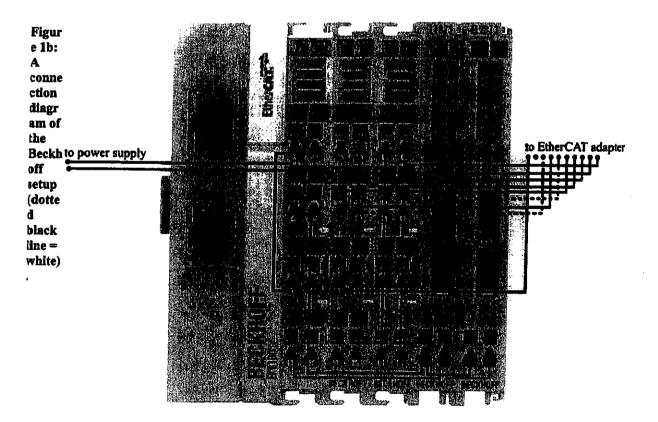


Figure 1a: A connection diagram of the picomotor setup.



## Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

#### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	C	hassis Front	Panel LEI	)s	Softw	are Read	backs
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	df	021
STARTING UP	off	on	flashes	flashes	off	200	551
READY	off	on	off	off	off	200	on
Check if passed:	H	[-]	[]	[]	[-]	[]	

Table 1: LED response to picomotor status

- [ ] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED
	Left Right
1	MM
2	[Y] [Y]
3	M H
4	
5	I H
6	$\square$ $\bowtie$ $\bowtie$
7	[1]
8	

#### Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction		LE	Ds	
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[1]	[1]	[1]	[]

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

## l. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and there is terminal I is selected, then select "SPRINT (500Hz)" under "SPEED". Select a sep size and then a direction. Check that the motor runs for a longer time (the motor clicks and fulting when it runs) as you increase the step size for each axis (X and Y):

MAGNUM (10000)	<u></u>	
<b>MEDIUM</b> (100)	\\ \\	<i>[</i> -]
VERY SMALL (1)	/h]	
	("<" to ">") X	Y ("UP" or "DOWN")
Step Size		sixA

## 3. Testing the speeds

SPRINT (500Hz)	/[]	[]
OG (SOHz)	<i>[</i> †]	<b>/</b> €]
CRAWL (1Hz)		<b>1</b>
	$X (^{n} <^{n} \text{ or }^{n} >^{n})$	Y ("UP" or "DOWN")
Speed	sixA	

### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	24.48	24.76	
2	25.80	26.16	
3	27.01	27.48	
4	28.17	28.76	
5	29.09	29.79/	
Check if passed:	N	ľ	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	W,	[4]
2	[4]	H,
3		[/
4	H	[1
5		
6	i1	1
7		[/
8		[1

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[Y	H
2	T IY	[1
3	T IY	[Y
4	[4'	H
5	[J	
6	[1/	[}
7	[4]	
8		[1]

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ Pass	[ ] Fail
Output terminals	[ ] Pass	[ ] Fail
Speeds	[JPass	[ ] Fail
Step sizes	[ ] Pass	[ ] Fail
Front panel LEDs	[ UPass	[ ] Fail

Test Engineer:

Test Date:

Zah 6

Additional Comments:

# **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

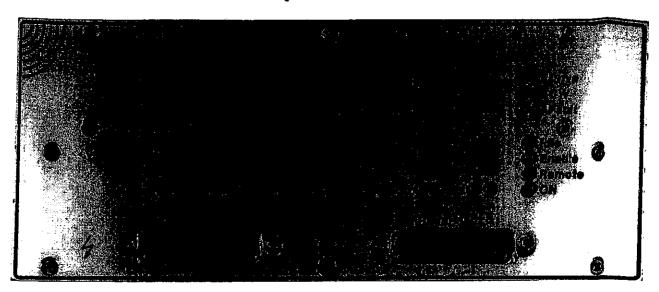


Figure 3: Picomotor driver chassis rear panel

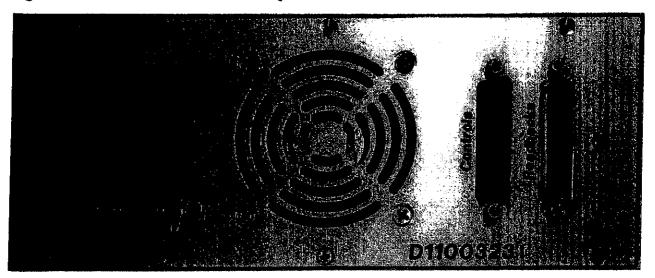
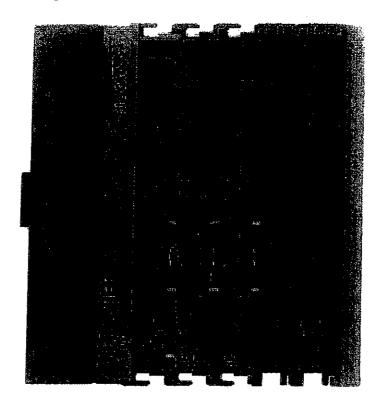


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

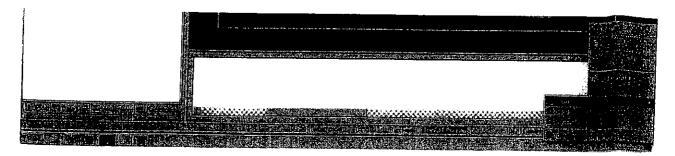
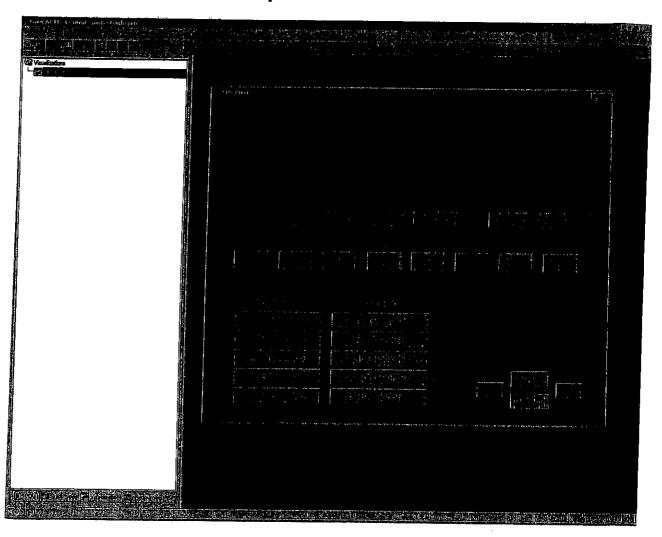


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

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New York NY 10027
Phone (212) 854-8209

Fax (212) 854-8121 E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	<u>D1100323-v1</u>
ItherCAT Adapters LIGO DCC#	D1100419-v3
Controller Serial #	51107561
lest Engineer:	Zech G
Test Date:	11/20/11
Overall picomotor chassis testing:	[ ] FAIL
Signature/Initials:	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- Front panel LEDs
   Step sizes
   Speeds

- 4. Temperature
  5. Output terminals

### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
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#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

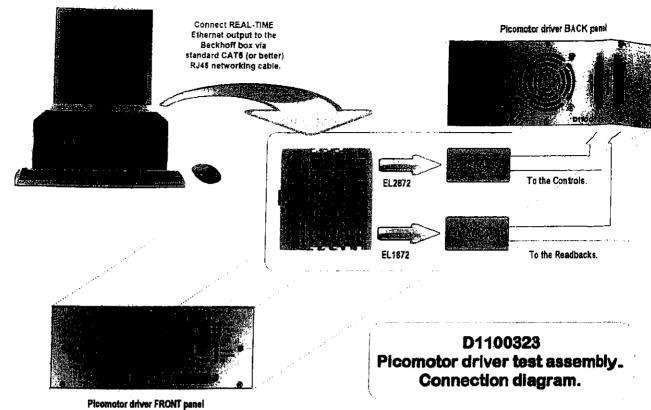
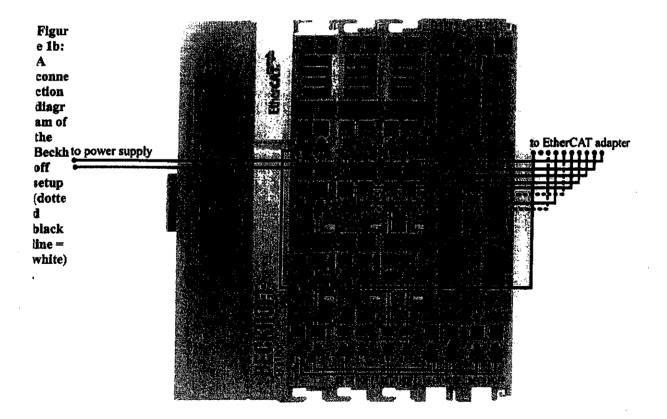


Figure 1a: A connection diagram of the picomotor setup.



### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ ] Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	C	Chassis Front Panel LEDs			Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	ON	off	8
STARTING UP	off	on	flashes	flashes	200	ON	on
READY	off	on	off	off	off	3	57
Check if passed:	[]	[4]	IJ	[]	[]	[-]	[]

Table 1: LED response to picomotor status

- [ \( \) Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [ ] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal		LED		
		Left	Right	
1		W/	[1]	
2		[]/	[1]	
3		1/	[1]	
4		[1]	11	
5		[X]	[X]	
6		[]	[1]	
7		[1]	[1	
8	-	[]	[]	

#### Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[1]	[1]	[/	1]

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

### desting the step sizes.

On the visualization screen, make sure the picomotor is enabled and that the status is "READ", and thete visualization screen, make sure then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns) as you increase the step size for each axis (X and Y):

المر	[طر	(10000) MUNDAM
المر	[1]	MEDIUM (100)
المر	/h]	AEKA SWYTT (1)
Y ("UP" or "DOWN")	("<" 10 ">") X	
sixA	7	Step Size

### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

In select a speed for each axis (X and Y):  $(X = 10^{-1})^{-1}$ 

SPRINT (500Hz)	<i>[</i> ]	<u>[]</u>
10G (50Hz)	<b>₹</b> ]	
CKAWL (1Hz)	[r]	H
_	X ("<" or ">")	Y ("UP" or "DOWN")
Speed		sixA

### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	23.92	23.89	
2	25.43	25.44	
3	26.76	26.88	
4	27.92	28.08	
5	26.98	29.29	
Check if passed:	[1]	H	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[Ų	[4		
2				
3	[4	[]		
4	T (y)	[1		
5	14	[Y]		
6	H	[1		
7	T H	[1]		
8	[3/	[4]		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	U/	[]		
2	11/	[V]		
3	[Y	[/		
4		[X		
5	[1	[ }		
6	[1]	[1		
7		[1]		
8	[4]			

## **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ]Pass	[ ] Fail
Output terminals	[ ] Pass	[ ] Fail
Speeds	[ LPass	[ ] Fail
Step sizes	[ ] Pass	[] Fail
Front panel LEDs	[ Pass	[ ] Fail

Test Engineer: Zach C

Test Date: 11/77/11

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

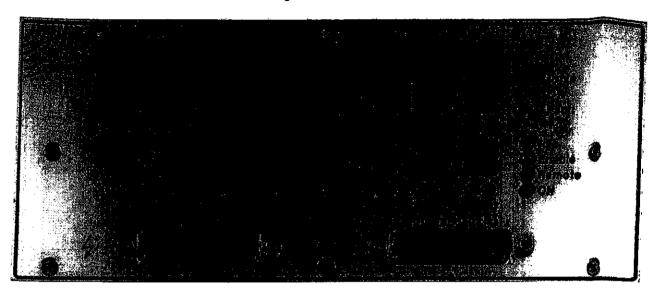


Figure 3: Picomotor driver chassis rear panel

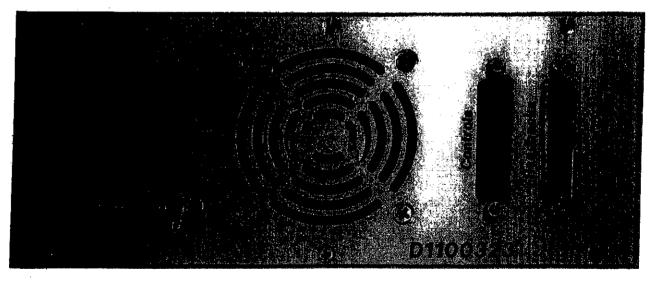
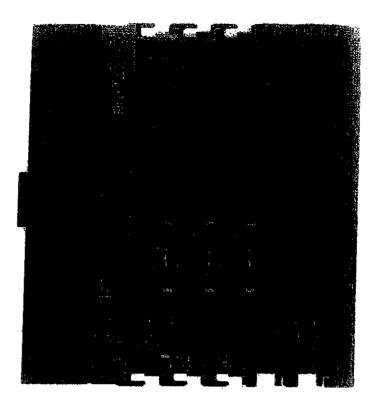


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

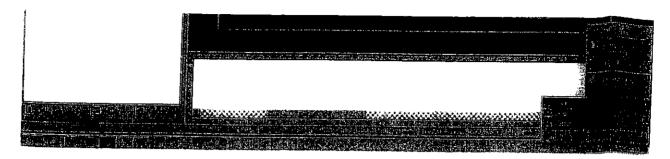
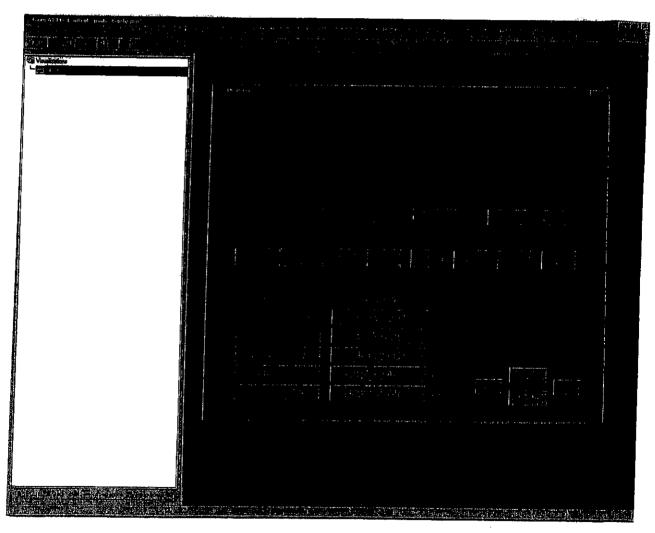


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1	
EtherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	<u> 5110756</u>	2
lest Engineer:	Zach	6
lest Date:	11/22/	<u> </u>
Overall picomotor chassis testing:	[YPASS	[ ] FAIL
Signature/Initials:		

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### Testing Schedule:

- Front panel LEDs
   Step sizes
   Speeds

- 4. Temperature
- 5. Output terminals

### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

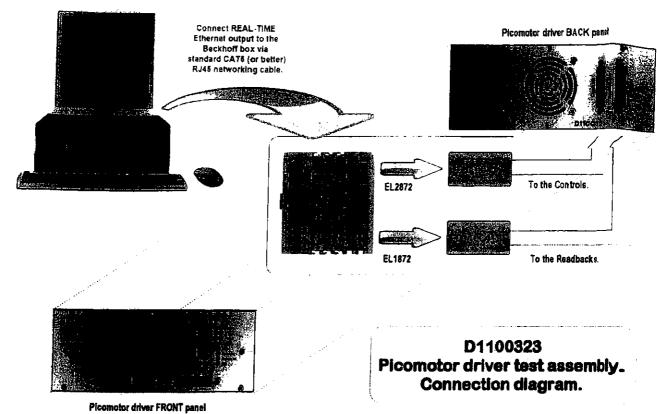
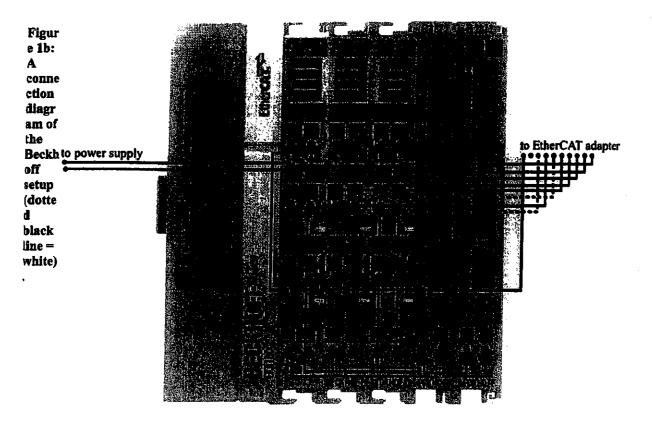


Figure 1a: A connection diagram of the picomotor setup.



### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)

Click "Yes" at the dialog:

"No program on the controller! Download the new program?"

Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

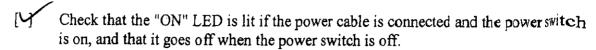
in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:



[4	Check that the "ON" indicator on the visualization also responds to the power switch.
----	---

[4	Check that the "Remote" LED turns off if the EtherCAT adapter for controls is
	disconnected.

[4	Before the next step, check that the fan (rear panel) is off
----	--

Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	atus Chassis Front Panel			Os	Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	KM	O.T	cm
STARTING UP	off	on	flashes	flashes	de	on	m
READY	off	on	off	off	of_	57	(27)
Check if passed:	[U	[4	[4]	[J	W	U	11

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [ ] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	LED		
	Left	Right		
1	[4]	[4]		
2	[J			
3	[4	[4		
4	LY	[]		
5	[4	[4]		
6		[4]		
7		[4]		
8		_[ <u>}</u>		

#### Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	U	[ 9	[4]	7	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

### 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[4]	[]
MEDIUM (100)	[]	H
MAGNUM (10000)	[4	[]

### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Selecta speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[]	[]
JOG (50Hz)	[-]	[]
SPRINT (500Hz)	[]	[]

### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	27.64	27.46		
2	28.82	28.77		
3	36.00	29.97		
4	31.00	31.05		
5	31-91	32.01		
Check if passed:	[9]	14		

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	[4]	Ŋ	
2	[4]	H	
3		[]	
4	II II	[1	
5	[9	[1]	
6	H		
7	[14]	[/	
8	T U	[1	

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	[1]	[]	
2	1	11	
3		W.	
4	()	ĺ	
5		W.	
6	W	[1]	
7			
8		, , , , , , , , , , , , , , , , , , ,	

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[]Fail
Output terminals	[ ] Pass	[ ] Fail
Speeds	[ ] Pass	[ ] Fail
Step sizes	[ ] Pass	[ ] Fail
Front panel LEDs	[ Pass	[ ] Fail

Test Engineer: Z. C.
Test Date: 1/22///

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

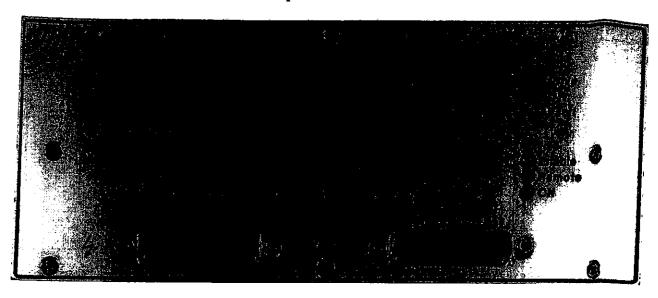


Figure 3: Picomotor driver chassis rear panel

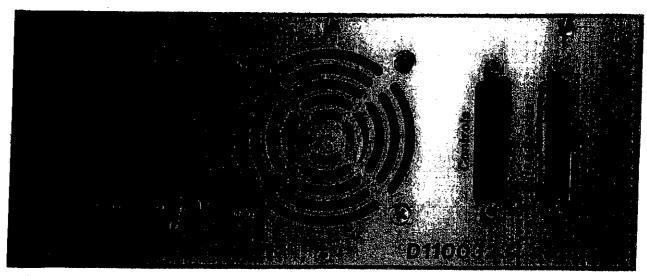
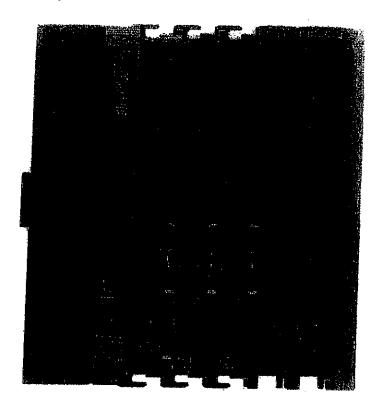


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

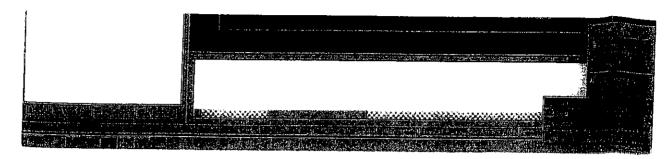
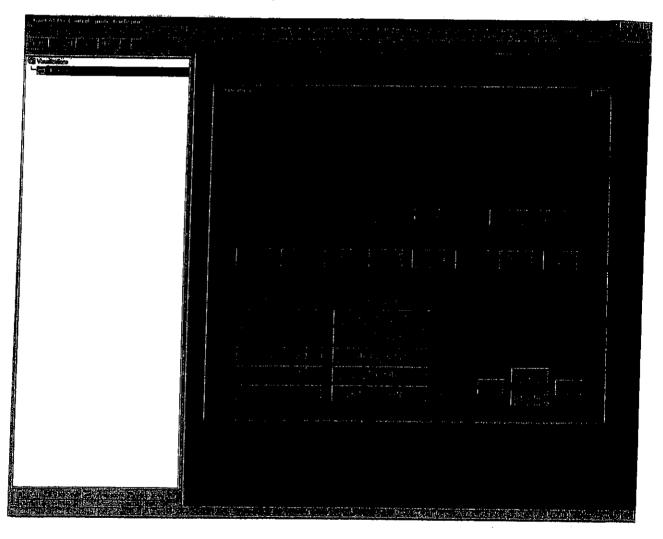


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

## CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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Fax (212) 854-8121

E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	<u>D1100323-v1</u>	
ItherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	5/107	563
Test Engineer:	Z.J.	6
Test Date:	11/28/	<u>'</u>
Overall picomotor chassis testing:	[4PASS	[]FAIL
Signature/Initials:		

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

### **Testing Schedule:**

- Front panel LEDs
   Step sizes
   Speeds

- 4. Temperature
  5. Output terminals

## System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

## Setting up

#### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

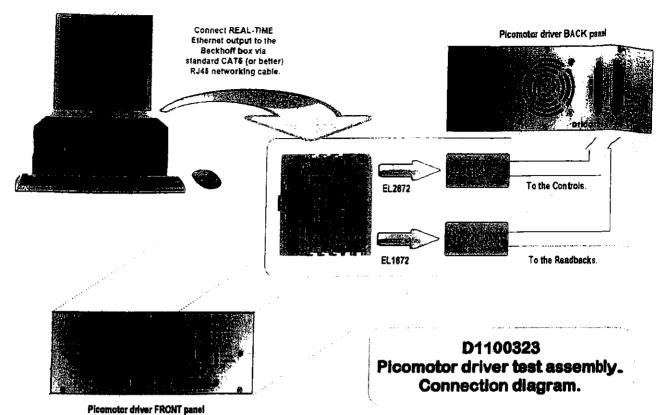
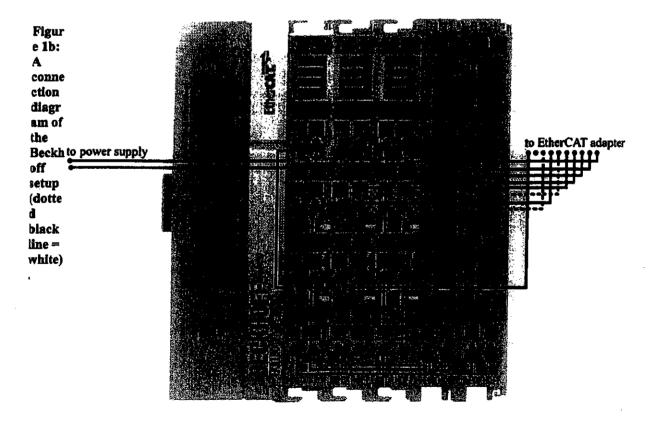


Figure 1a: A connection diagram of the picomotor setup.



## Setting up

### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

[i]	Check that the "ON" LED is lit if the power cable is connected and the power switch
	is on, and that it goes off when the power switch is off.

Check that the "ON" indicator on the visualization also responds to the power switch.

[ Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

[ ] / Before the next step, check that the fan (rear panel) is off.

Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	(57)	68	SU
STARTING UP	off	on	flashes	flashes	5 Pt	on	(2)
READY	off	on	off	off	A	S	
Check if passed:	[1]		[]	11		[]	1

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	ED
	Left	Right
1	[U]	M
2	[4]	M
3		1
4		1
5	[]	[1
6		[/]
7	[-]	[]
8	[1	[]

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[4]	M	[]		

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

## 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
VERY SMALL (1)	[1]	19	
MEDIUM (100)	[4]	H	
MAGNUM (10000)	[4	[]	

## 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	[4]	[]	
JOG (50Hz)	IY/	M	
SPRINT (500Hz)	[-]	1	

## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Tem	perature
	X ("<" or ">")	Y ("UP" or "DOWN")
1	26.75	24.88
2	28.03	26.23
3	29.19	27.99
4	30.24	28.63
5	31.18	29,61
Check if passed:	[4]	[]

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	[]	[4	
2	W.	[ ]	
3	[9]		
4	[9		
5			
6	[ ]	[1	
7		[/	
8		11	

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[1/	[1
2		[]
3	[1	11
4		[X
5		i/
6	[1	[ <i>X</i>
7	И	1.7
8		[/

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[ ] Fail	
Output terminals	[ ] Pass	[ ] Fail	
Speeds	[ ] Pass	[ ] Fail	
Step sizes	[ ] Pass	[ ] Fail	
Front panel LEDs	Pass	[ ] Fail	

Test Engineer: Zeb 6
Test Date: 1/28/11

Additional Comments:

## **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

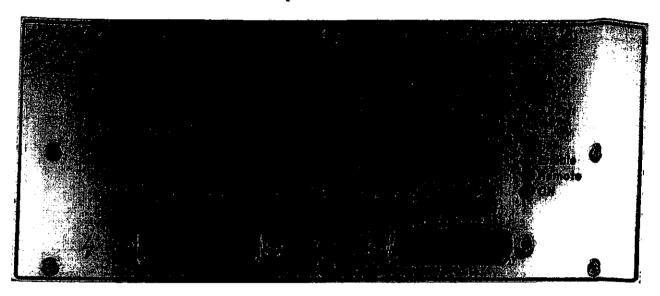


Figure 3: Picomotor driver chassis rear panel

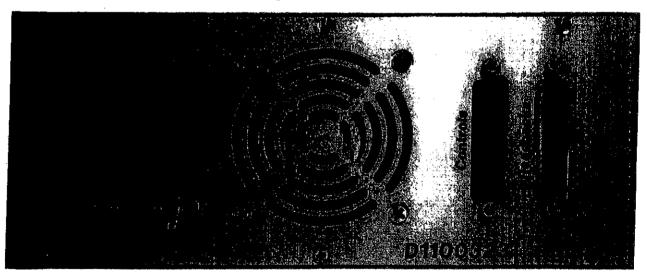
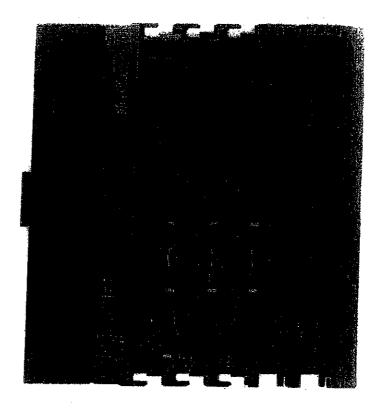


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

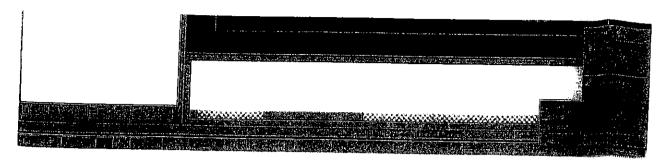
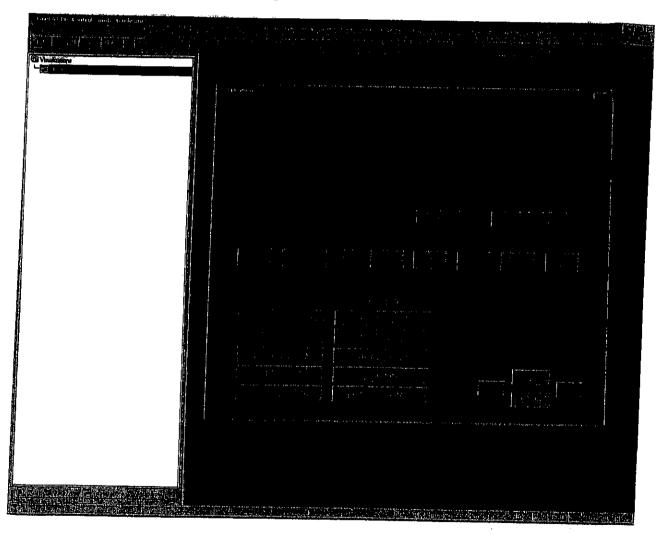


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1		
ltherCAT Adapters LIGO DCC#	D1100419-v3		
Controller Serial #	511075	69	
lest Engineer:	Zuch	C=	
Test Date:	1/28/11		
Overall picomotor chassis testing:	PASS	[ ] FAIL	
Signature/Initials:			

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

### Testing Schedule:

- Front panel LEDs
   Step sizes
   Speeds

- 4. Temperature
- 5. Output terminals

## System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1)
  (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

## Setting up

### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

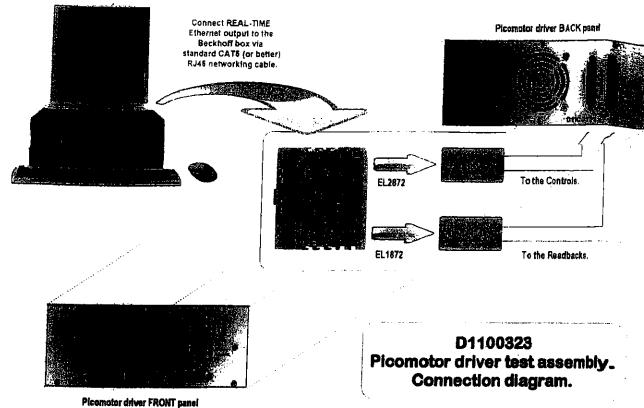
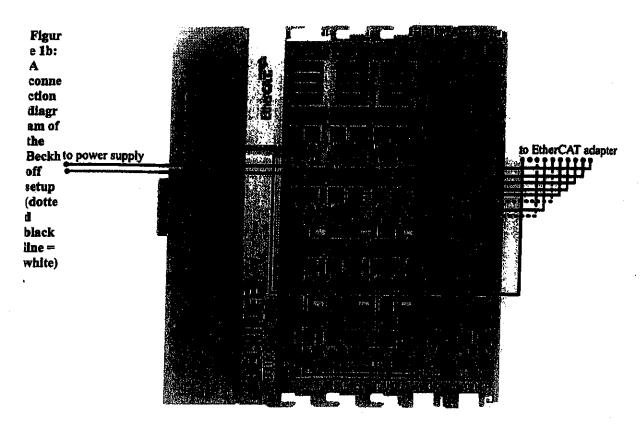


Figure 1a: A connection diagram of the picomotor setup.



## Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- [ ] Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	Onc	off	021
STARTING UP	off	on	flashes	flashes	08	CM	02
READY	off	on	off	off	G	5	(51)
Check if passed:	[1]	[1	1	[1]	[1	1	H

Table 1: LED response to picomotor status

- [ ] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- ['] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the icomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED		
	Left	Right	
1	[4	[4]	
2	14	[4]	
3	[1]	[4]	
4	[4 <sup>'</sup>	[4	
5	[4]	[4]	
6	I I I	W	
7		[4]	
8	[]	[1]	

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4]	[1]	[]	[9

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

## 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and sheck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
VERY SMALL (1)	[]	[]	
MEDIUM (100)	[ }_	[]	
MAGNUM (10000)	[1	[]	

### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	[4]	· ·	
JOG (50Hz)	[]	[]	
SPRINT (500Hz)	[-]	19	

## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	23,92	25.16	
2	25.22	26.56	
3	26.40	27.90	
4	27.44	28.94	
5	28, 42	30.02	
Check if passed:	H	H	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[4]	N		
2	[4]	F4		
3				
4		[2]		
5	[19]			
5	M.	(1/		
7		19		
3		14		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal 1	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
	[4]	14		
2	[4]	[ <del>]</del>		
3	[4]	1/		
4	[4]	17		
5	14			
6	11/	17		
7				
3		11		

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ / Pass	[]Fail	
Output terminals	[ ] Pass	[ ] Fail	
Speeds	[ ] Pass	[ ] Fail	
Step sizes	[ ] Pass	[ ] Fail	
Front panel LEDs	[ ] Pass	[ ] Fail	

Test Engineer: Zah C
Test Date: 1/28///

Additional Comments:

## Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

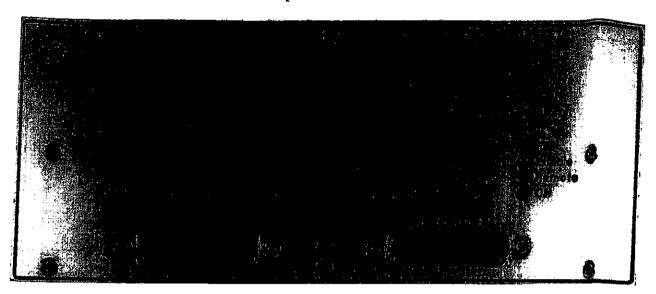


Figure 3: Picomotor driver chassis rear panel

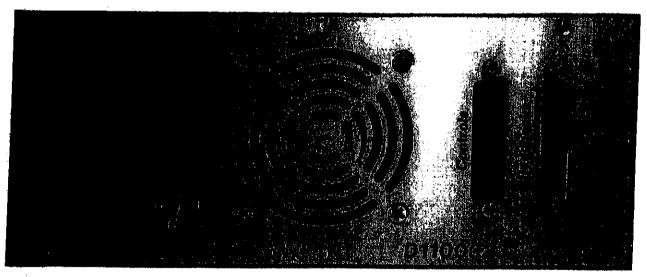
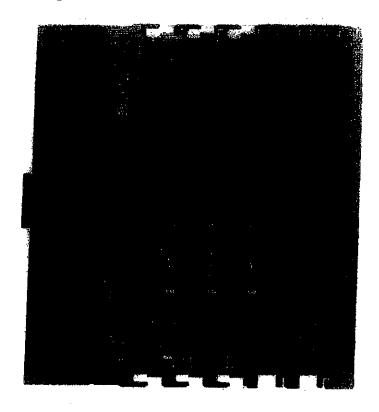


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

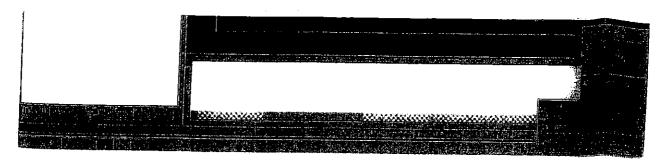
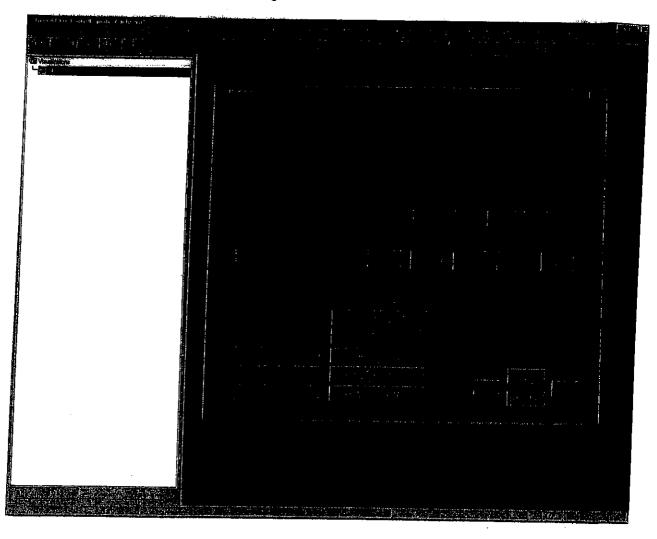


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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Fax (212) 854-8121

E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1	
ltherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	51107565	
lest Engineer:	Zach G	<del></del>
lest Date:	11/28/11	
Overall picomotor chassis testing:	[ ] PASS	[ ] FAIL
Signature/Initials:		

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20 Controller

#### Testing Schedule:

- Front panel LEDs
   Step sizes
- 3. Speeds
- 4. Temperature5. Output terminals

## System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1)
  (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

## Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear partel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

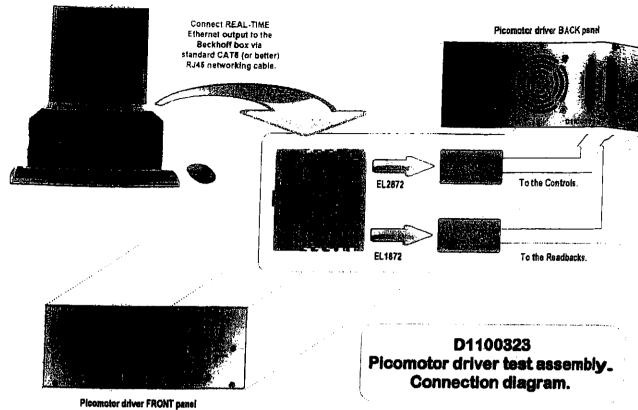
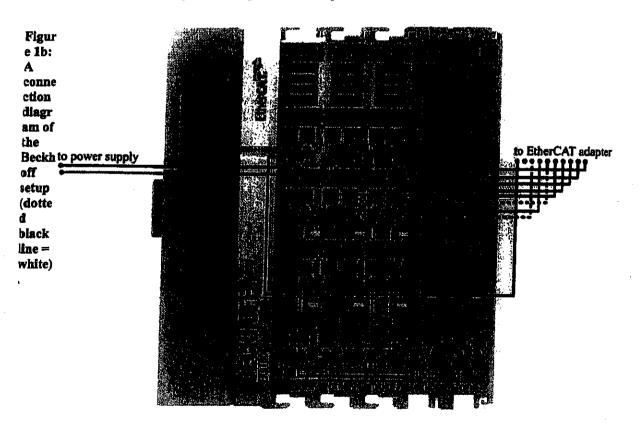


Figure 1a: A connection diagram of the picomotor setup.



## Setting up

### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

# 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	04	(M
STARTING UP	off	on	flashes	flashes	OF.	on	OM
READY	off	on	off	off	off	on	(7)
Check if passed:	[1]	[]	[1]				

Table 1: LED response to picomotor status

- [ ] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	ED
	Left	Right
1	[4]	[4
2	[4	[-]
3	[4]	[1
4	[]	1
5	[Y	[1]
6		[1
7	[4]	[1
8	[}	[1

### Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs					
	Drive X	Drive Y	CW X	CWY		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	off	off	off		
Check if passed:	[4]	[]	[]	[]		

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

# 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and there is terminal I is selected, then select "SPRINT (500Hz)" under "SPED". Select a tep size and then a direction. Check that the motor runs for a longer time (the motor clicks and  $tu_1n_2$ ) when it runs) as you increase the step size for each axis (X and Y):

	<u></u>	(10000) MUNDAM
<i>[</i>	[H	MEDIUM (100)
[1]	$\mathcal{H}$	AEKA ZWYLT (1)
Y ("UP" or "DOWN")	("<" 10 ">") X	
sixA	,	Step Size

# 3. Testing the speeds

SPRINT (500Hz)	[F]	XI
(SH08) ĐOU	<i>[</i> -	المر
CKAWL (IHz)	<b>1</b>	
-	X ("<" or ">")	Y ("UP" or "DOWN")
Speed	,	sixA

# 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	24.76	24.21		
2	26.00	25.62		
3	27.31	26.89		
4	28.49	28.09		
5	29.43	29.19		
Check if passed:	[4	M		

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	W				
2	W	[1]			
3	[4]				
4	[4]	[7]			
5	[Y]	17			
6	[4]	11			
7	[1]	[1			
3		ī <b>1</b>			

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[1	[/				
2	[1	11				
3	[/]	11				
4	[1	11				
5	[X	ĺ				
6		11				
7		11				
8	[1					

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[]Pass	[ ] Fail
Output terminals	[ ] Pass	[ ] Fail
Speeds	[ ] Pass	[ ] Fail
Step sizes	[ ] Pass	[ ] Fail
Front panel LEDs	Pass	[ ] Fail

Test Engineer: Zoh Co
Test Date: 1/28/11

Additional Comments:

# Appendix A: Physical Components

Mgure 2: Picomotor driver chassis front panel

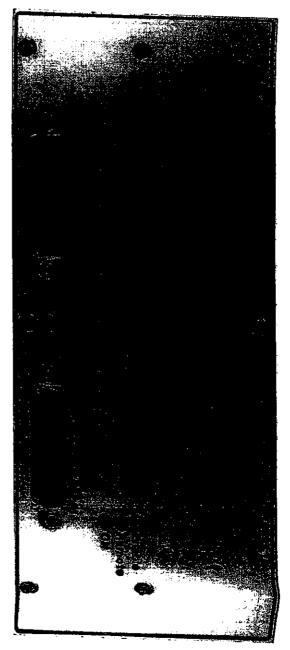
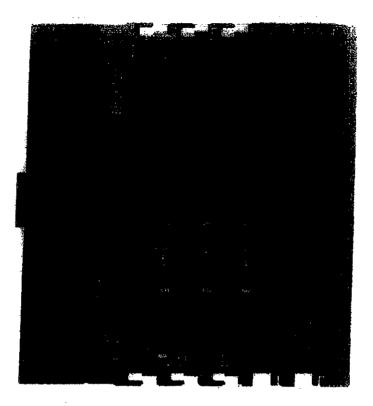


Figure 3: Picomotor driver chassis rear panel



Figure 4: EtherCAT configuration



# Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

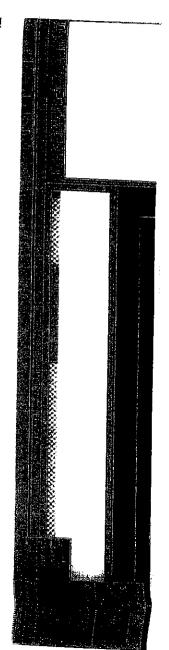
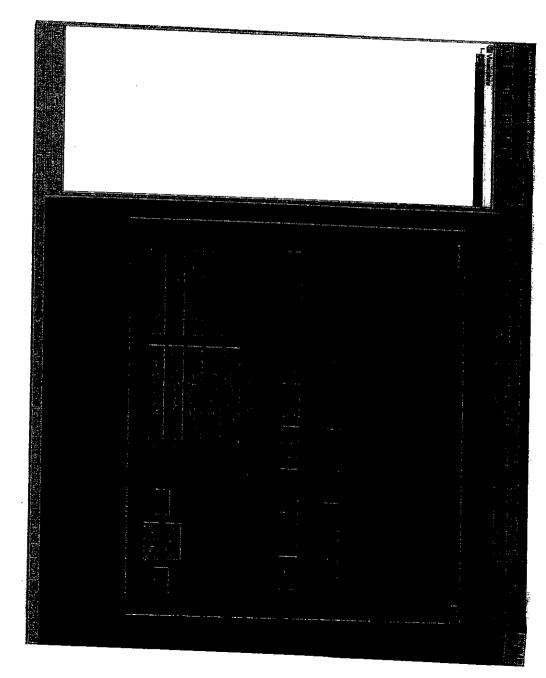


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

<u>D1100323-v1</u>
D1100419-v3
511075ldo
Zech G
11/28/11
MPASS []FAIL
,

### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

### **Testing Schedule:**

- Front panel LEDs
   Step sizes
- 3. Speeds
- 4. Temperature
  5. Output terminals

# System requirements

### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

# Setting up

### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

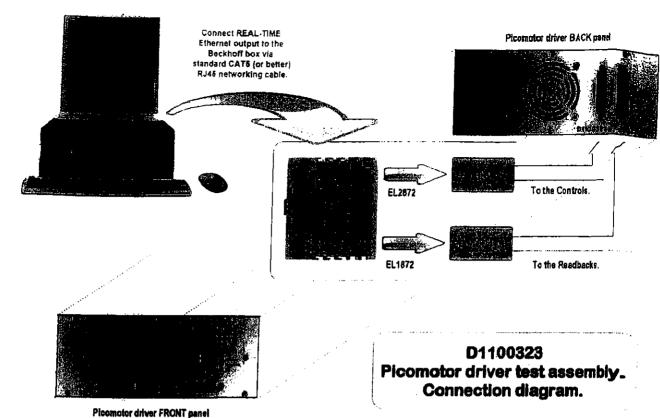
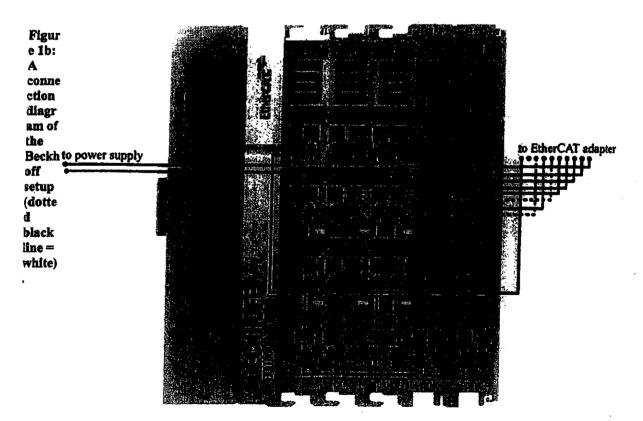


Figure 1a: A connection diagram of the picomotor setup.



# Setting up

### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:
 "No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

# 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [4] Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	571
STARTING UP	off	on	flashes	flashes	off	on	مرن
READY	off	on	off	off	off	on	97
Check if passed:	[4	[1	[1	ľ	[4]	1/	11

Table 1: LED response to picomotor status

- [ ] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Inable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED		
	Left	Right	
1	[4]	[ ]	
2	[4		
3	[1]		
4		[1]	
5	[1	[1]	
6		[1]	
7	[1	17	
8	[/]	[1]	

### Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[1]	[1	[]	[]	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

# 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a tep size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
VERY SMALL (1)	[Y	[ <del>-]</del>	
MEDIUM (100)	[4]	19	
MAGNUM (10000)	14	ij	

### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	IJ	[4
JOG (50Hz)	H/	W.
SPRINT (500Hz)	[4	11

# 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	23.74	24.43	
2	24.91	25.67	
3	26.13	26.95	
4	27.12	28.07	
5	28.12	29.09	
Check if passed:	[+	19	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1		[/
2	[1]	
3		
4		11
5		17
	[/	17
		17
		11

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[Y	1/
2	[4]	11
3	[4]	 [X
4	[4]	IΧ
5		1/
6		ſχ
7	T W	
3		r 1⁄

# Testing Summary

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[YPass	[] Fail
Output terminals	Pass	[ ] Fail
Speeds	[ ) Pass	[ ] Fail
Sep sizes	[] Pass	[ ] Fail
Front panel LEDs	Pass	[ ] Fail

Test Engineer: Zach 6

Test Date: 1/28///

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

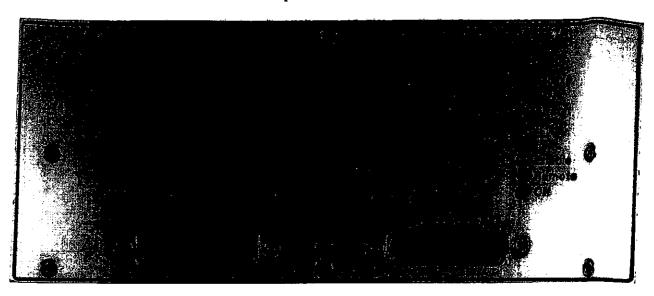


Figure 3: Picomotor driver chassis rear panel

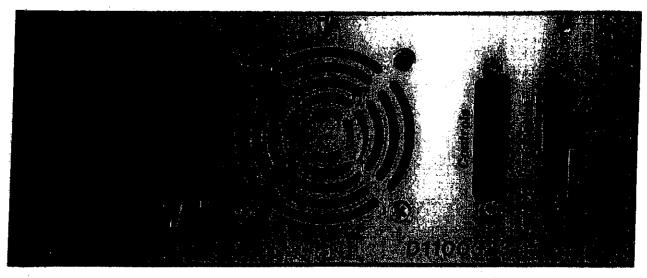
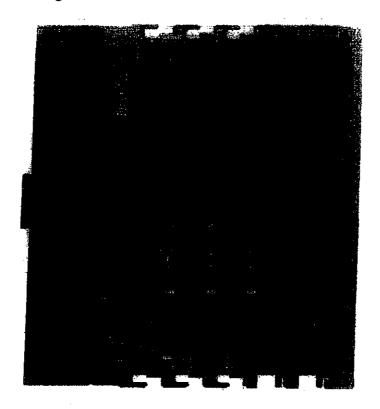


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

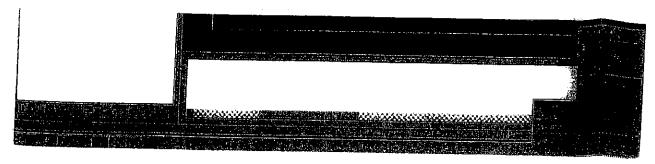
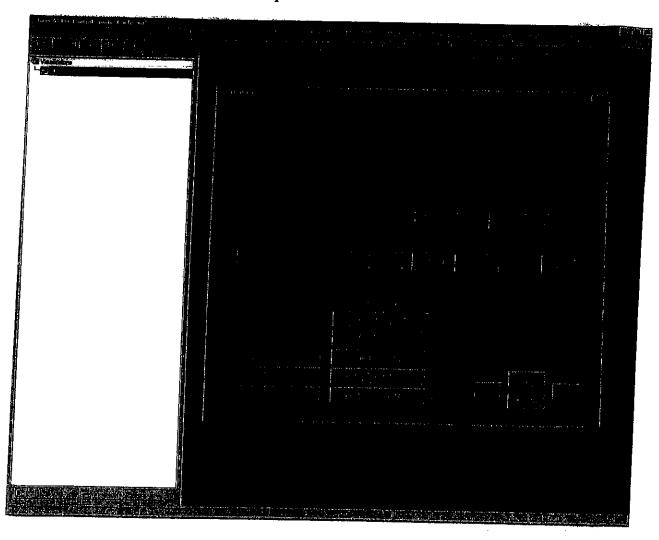


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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Fax (212) 854-8121

E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

icomotor controller chassis LIGO DCC#	D1100323-v1	
ltherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	51107567	
lest Engineer:	Zach	6
Test Date:	1/28/11	
Overall picomotor chassis testing:	[]PASS	[ ] FAIL
Signature/Initials:		

### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

### Testing Schedule:

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

# System requirements

### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

# Setting up

### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear pariel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

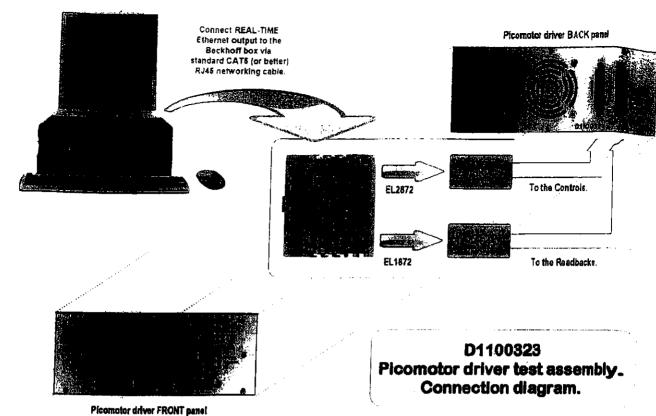
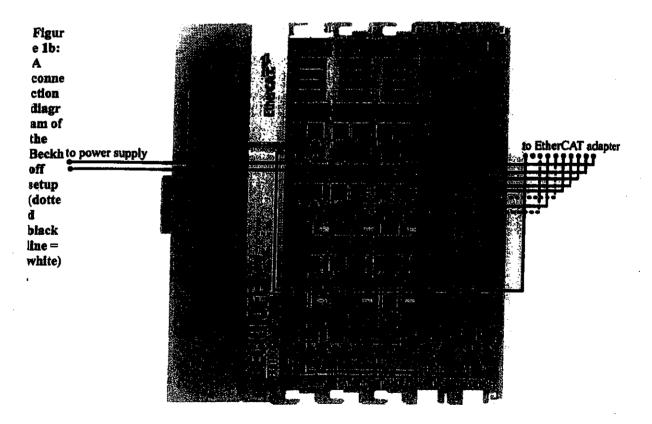


Figure 1a: A connection diagram of the picomotor setup.



# Setting up

### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

# 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Cl	Chassis Front Panel LEDs			Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	OM	Off	GM
STARTING UP	off	on	flashes	flashes	off	SM	on
READY	off	on	off	off	of	on	07
Check if passed:	[-]		1		[/]	[]	W

Table 1: LED response to picomotor status

- [ ] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the accomptor status is "READY", then do the following:

[ Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LED		
	Left	Right	
1	 [4]	[1]	
2	[4]	[1]	
3	M		
4	1	11	
5	[1]	[ ]	
6	[1]	[1	
7	[1]	[1]	
8	[1	[]	

### Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:		[ ]	[]	[]	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

# l. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and there is tune the motor runs for a longer time (the motor clicks and tune) as you increase the step size for each axis (X and Y):

When it runs) as you increase the step size for each axis (X and Y):

	<i>[</i> +]	(10000) MUNDAM
	$\mathcal{L}$	MEDIUM (100)
	hl	VERY SMALL (1)
Y ("UP" or "DOWN")	("<" 10 ">") X	
sixA	sixA	

# 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

SPRINT (500Hz)	J-1	<u>F</u> I
10G (20Hz)	[بخر	FI
CKAWL (1Hz)	[A]	J. 1
	X ("<" or ">")	Y ("UP" or "DOWN")
Speed	sixA	

# 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	24.46	25.02
2	25.72	26.74
3	26.91	27.67
4	28.12	28.51
5	29.09	29.90
Check if passed:	H	N

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	H	[/
2		[+
3	- W	[}
4	[/	[+
5	[Y	[}
6	[X	
7	[ ]	[/
3	[ ]	[]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[4]	IT
2	[ ]	11
3	[Y	11
4	[4]	11
5	[9	11
6	T I	1,
7		[/
3	1	1

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[] Fail	
Output terminals	Pass	[ ] Fail	
Speeds	[ ] Pass	[]Fail	
%ep sizes	[] Pass	[ ] Fail	
Front panel LEDs	[YPass	[ ] Fail	

Test Engineer: Zach C

Test Date: 11/28/11

Additional Comments:

## Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

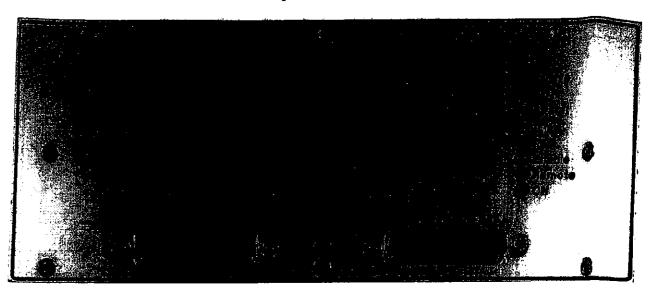


Figure 3: Picomotor driver chassis rear panel

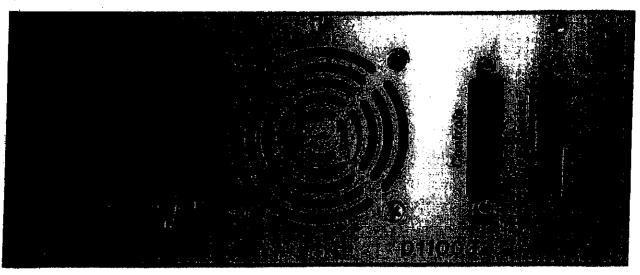
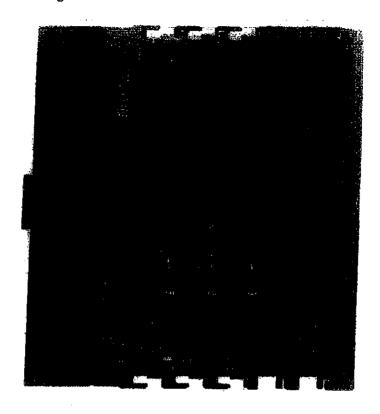


Figure 4: EtherCAT configuration



### **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

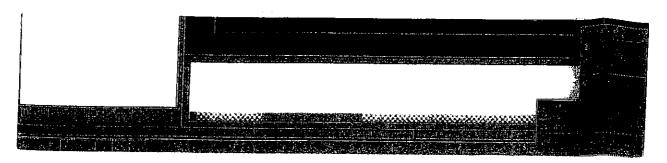
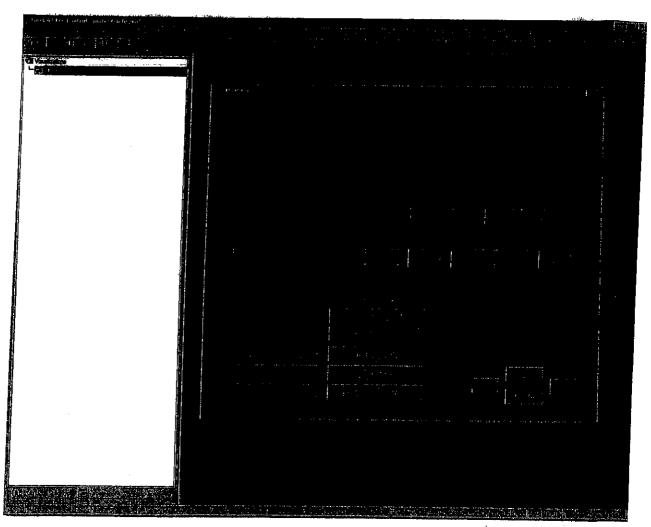


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

## CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

D1100323-v1		
D1100419-v3		
5110	07968	
2dh	G	
11/28/	//	
PASS	[ ] FAIL	
	D1100419-v3 SIIC Zch	D1100419-v3  S1107968  Zech G  11/28/11

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### Testing Schedule:

- Front panel LEDs
   Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

#### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1)
  (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

#### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872

  Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

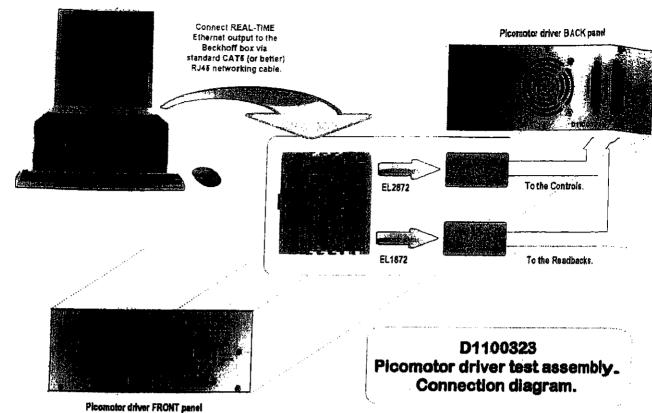
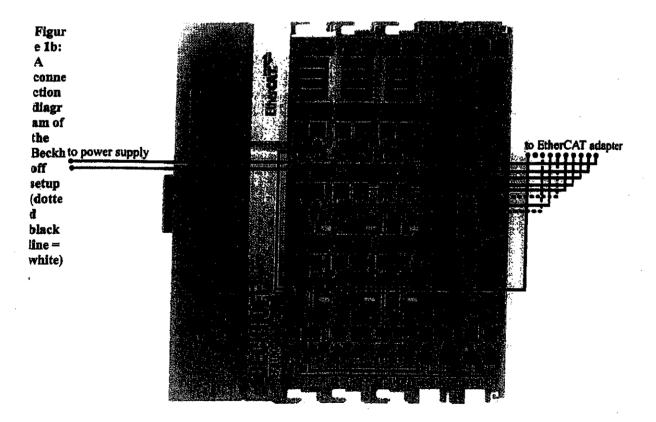


Figure 1a: A connection diagram of the picomotor setup.



#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

#### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	124	(5/1
STARTING UP	off	on	flashes	flashes	01	SN	M
READY	off	on	off	off	off	600	on
Check if passed:	- H	11	[]	[7]	[1]	11	11

Table 1: LED response to picomotor status

- [ ] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [/] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[ Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	ED
	Left	Right
1	[/	V
2	[1	[7
3	[/	[7
4	[/	11
5	[/	H
6	[1	
7		[1]
8	[1]	[1

#### Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[/]		[1	[]	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

## 3. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and there that output terminal I is selected, then select "SPRINT (500Hz)" under "SPEED". Select a fep size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns) as you increase the step size for each axis (X and Y):

المر		(00001) MUNDAM
	<i>[</i> *]	MEDINM (100)
	<b>/</b> ₹]	VERY SMALL (1)
Y ("UP" OF "DOWN")	X ("<" or ">") X	
sixA	7	Size gətz

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

sixA	7	Speed
Y ("UP" or "DOWN")	$(^{n}<^{n})$ Or $^{n}>^{n}$	
<u>/1</u>	[辽	CKAWL (IHz)
<b>J</b> 1	<i>[</i> ]	10G (50Hz)
FI	<i>[</i> ]	SPRINT (500Hz)

#### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Tem	perature
	X ("<" or ">")	Y ("UP" or "DOWN")
1	25.15	26.79
2	26.48	28.25
3	27.76	29.60
4	28.82	30.74
5	29.79	31.81
Check if passed:	[4	14

Check the "pass" box for each above if the temperature increases over time.

## 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	CY.	[V			
2	- [Y				
3		[/			
4		1			
5		17			
6		1/			
7		1/			
3	[4]	11			

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	M	[4]			
2	[4	17			
3	[4	[1]			
4	[4]	11			
5	7 [4	1.7			
6		11			
7	[1]				
3		[ ]			

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[]Fail
Output terminals	[ }Pass	[ ] Fail
Speeds	[ ] Pass	[ ] Fail
Step sizes	[JPass	[ ] Fail
Front panel LEDs	Pass	[ ] Fail

Test Engineer: Zech ()
Test Date: 11/28///

Additional Comments:

## Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

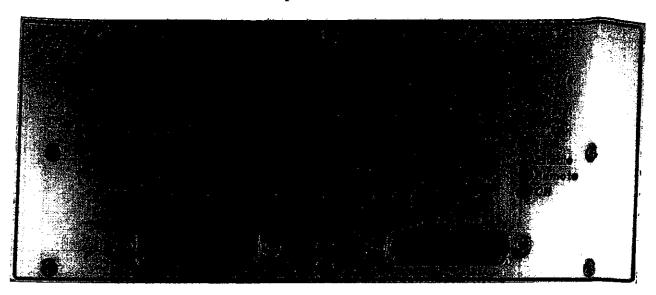


Figure 3: Picomotor driver chassis rear panel

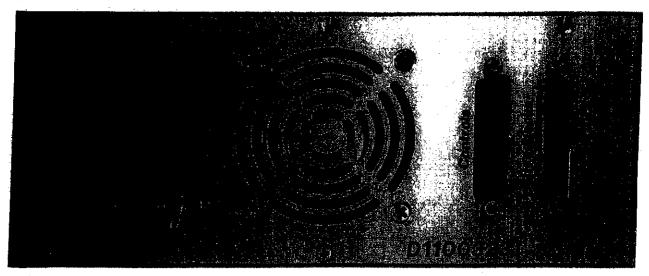
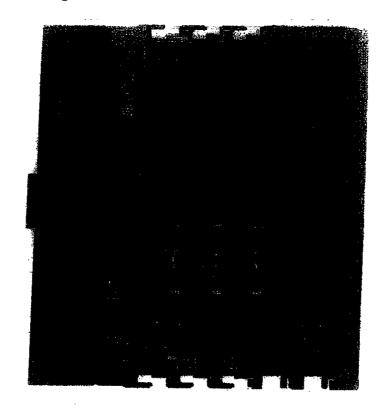


Figure 4: EtherCAT configuration



## **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

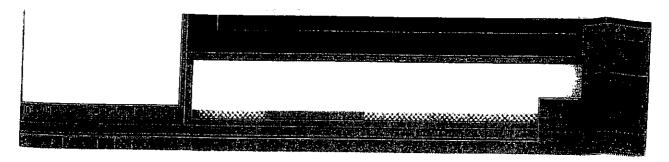
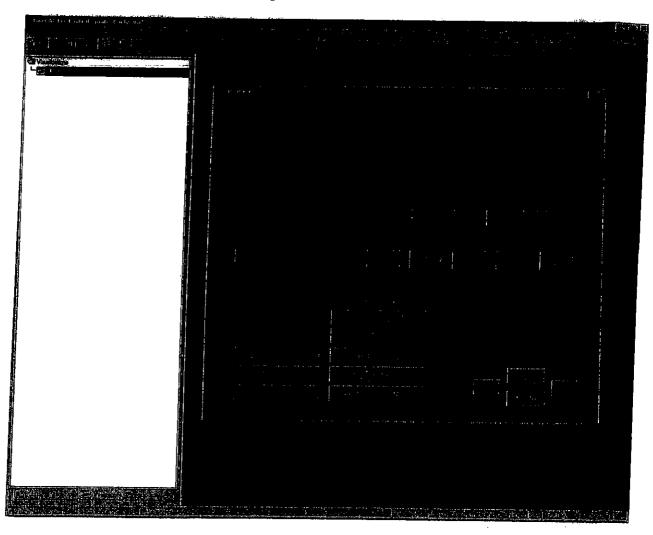


Figure 6: Step 5 of PLC controls setup



## LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

## CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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## LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

## CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

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Fax (212) 854-8121 E-mail: geco.cu@gmail.com

E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1
ItherCAT Adapters LIGO DCC#	D1100419-v3
Controller Serial #	5107569
lest Engineer:	Zach C
Test Date:	11/28/11
Overall picomotor chassis testing:	[ ] FAIL
Signature/Initials:	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### Testing Schedule:

- Front panel LEDs
   Step sizes

- 3. Speeds
  4. Temperature
- 5. Output terminals

#### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### <u>Software:</u>

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

#### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

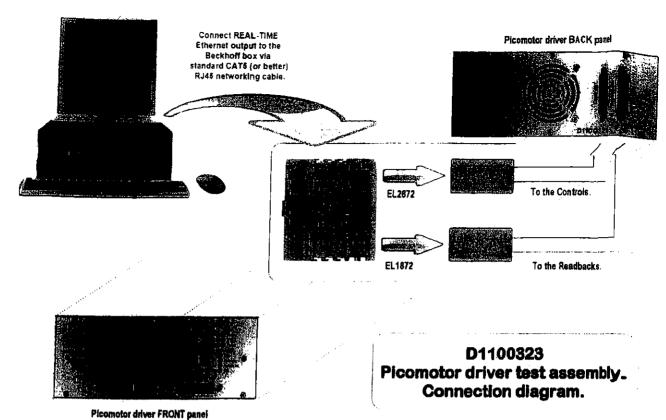
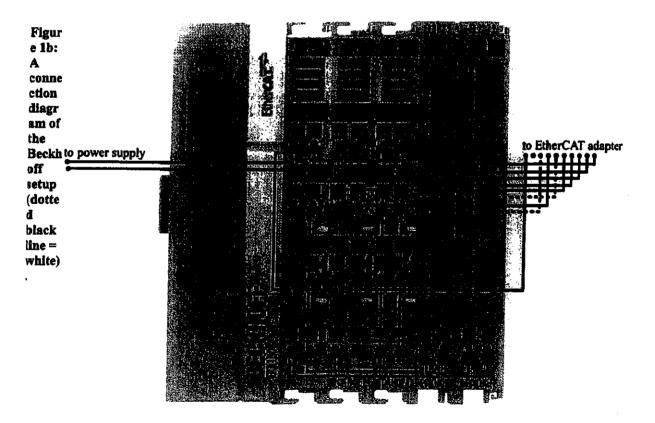


Figure 1a: A connection diagram of the picomotor setup.



#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

#### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Softv	vare Read	backs	
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	of	on
STARTING UP	off	on	flashes	flashes	of	on	(13)
READY	off	on	off	off	off	5	(\sqrt)
Check if passed:	W.	[4]	<del>-</del>	[7]	[]	H	

Table 1: LED response to picomotor status

- [ Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LJ	LED	
	Left	Right	
1	[4]	[J	
2	[4]	[4	
3	[4]	[4	
4	[4]	[4]	
5		[]	
6	[4	[/	
7	W W	[1	
8	[/	[/]	

#### Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	H	[]	[/]	[/

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

#### 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
VERY SMALL (1)	M	M	
MEDIUM (100)	[4	[9]	
MAGNUM (10000)	[4]	19	

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Selecta speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	[4]	[9	
JOG (50Hz)	[4	19	
SPRINT (500Hz)	[Y	19	

### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	35.00	34.64	
2	35 · 83	35.47	
3	36.54	36.27	
4	3716	36.96	
5	37.70	37. 62	
Check if passed:	[1]	19	

Check the "pass" box for each above if the temperature increases over time.

## 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[Y	[4]		
2	[4]	[]		
3	[4]	[4		
4	[-]	[J		
5	[4]	[]		
6	[]	[]		
7	[]	[ ]		
8		[]		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	[1]	[4]	
2	14	14	
3	[4]	[/	
4		1/	
5	[4]	[1	
6	[1]	[/	
7		[7]	
8			

## **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[   Pass	[ ] Fail
Output terminals	[-]Pass	[ ] Fail
Speeds	[ Pass	[ ] Fail
Sep sizes	[ ] Pass	[ ] Fail
Front panel LEDs	[JPass	[ ] Fail

Test Engineer: Zach 6
Test Date: 11/29/1

Additional Comments:

## Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

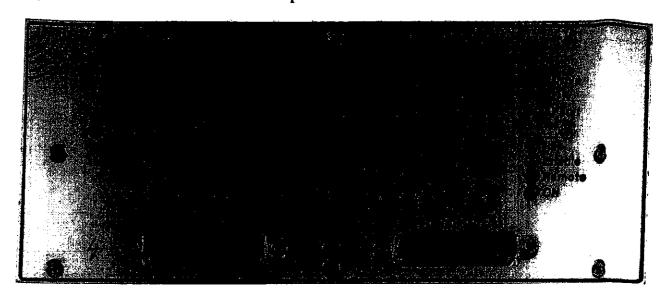


Figure 3: Picomotor driver chassis rear panel

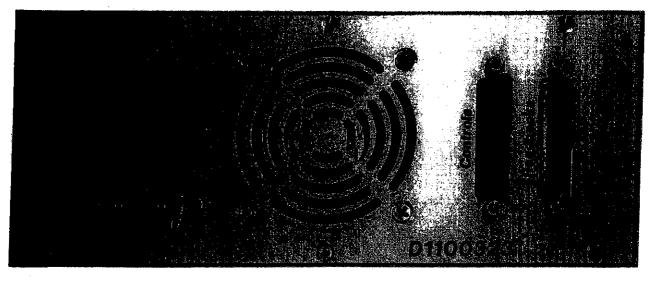
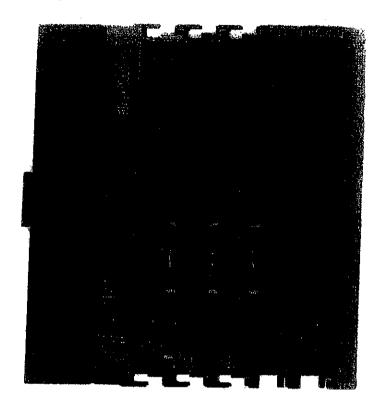


Figure 4: EtherCAT configuration



## **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

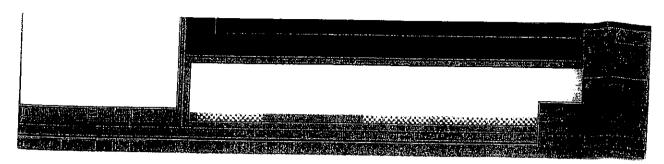
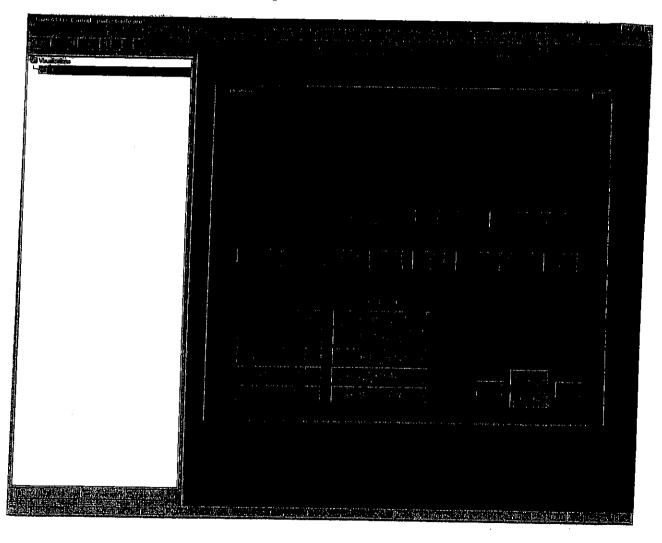


Figure 6: Step 5 of PLC controls setup



## LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

### CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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licomotor controller chassis LIGO DCC#	D1100323-v1		
EtherCAT Adapters LIGO DCC#	<u>D1100419-v3</u>		
Controller Serial #	51107	570	
Test Engineer:	_ Zach	6	
Test Date:		<b>4</b> /11	
Overall picomotor chassis testing:	[4] PASS	[]FAIL	
Signature/Initials:			

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

# **Testing Schedule:**

Reference:

- Front panel LEDs
   Step sizes
   Speeds

- 4. Temperature5. Output terminals

### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1)
  (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- Hook-up wires
   Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

### Setting up

#### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

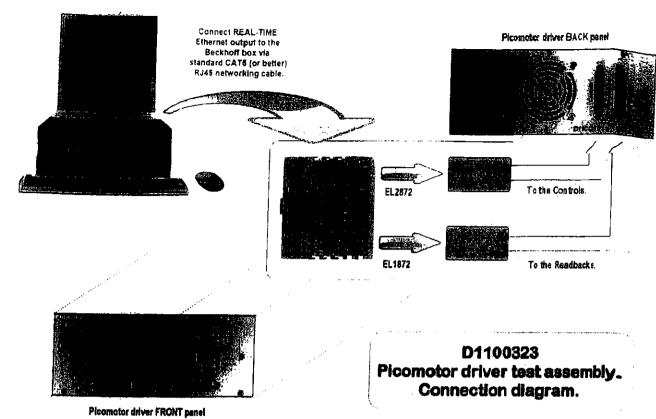
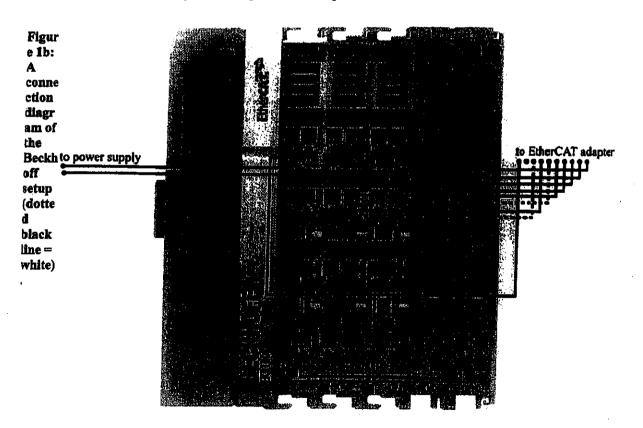


Figure 1a: A connection diagram of the picomotor setup.



### Setting up

#### Steps for setting up the PLC controls:

Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the powerswitch is on, and that it goes off when the power switch is off.
- [ Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	On	Of	on
STARTING UP	off	on	flashes	flashes	64	on	On
READY	off	on	off	off	off	00/	021
Check if passed:	[4]	[4]	[4	[4]	[9]	F	+1

Table 1: LED response to picomotor status

- [ Y Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	ED
	Left	Right
1	[4	[4]
2	[4]	[1]
3		[]
4	[-]	[]
5	H	[]
6		[ 4
7		[-]
8	1 [1	[4]

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CW Y	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[4]	[-]	[}		

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

### 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a tep size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
VERY SMALL (1)	[4]	M		
MEDIUM (100)	[4			
MAGNUM (10000)	[4	19		

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
CRAWL (1Hz)	[4	[1]
JOG (50Hz)	[-]/	il
SPRINT (500Hz)	[ <i>Y</i>	19

### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	25.93	25.70	
2	27.12	27.00	
3	28.35	28.24	
4	29,44	29.44	
5	36.39	36.46	
Check if passed:	H	14	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[4	[4]				
2	[4]	14				
3	[y	19				
4	[4	13				
5	[4	14				
6	T IY	N				
7		11				
3	H	[1				

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[i]	11		
2	14	11		
3	[4]	IT		
4	[4]	11		
5		[}		
6	[1]	11		
7		[]		
3		[-		

# Testing Summary

For each test, indicate the results in the table below:

Overall picomotor driver testing:		
Output terminals [~	Pass [	] Fail
Speeds [V	Pass [	] Fail
Step sizes [	Pass	[] Fail
Front panel LEDs	Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/29/11

Additional Comments:

# Appendix A: Physical Components

Ngure 2: Picomotor driver chassis front panel

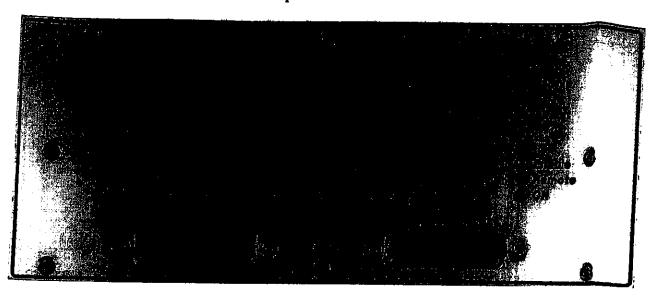
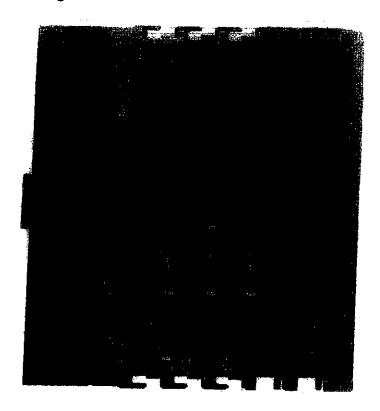


Figure 3: Picomotor driver chassis rear panel



Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

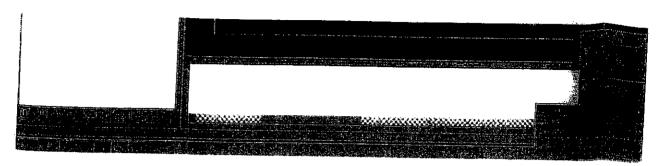
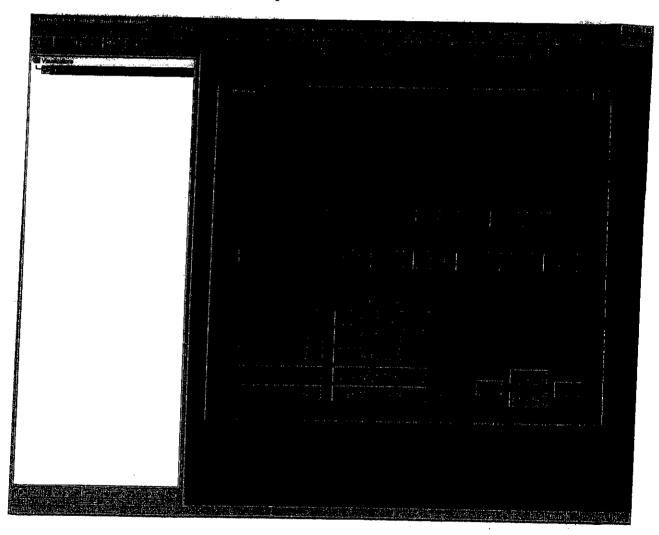


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC#	D1100323-v1	
ItherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	511093	71
Test Engineer:	Zach	9
Test Date:	11/29/4	
Overall picomotor chassis testing:	[4PASS	[]FAIL
Signature/Initials:		
	•	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### Testing Schedule:

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature5. Output terminals

### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

### Setting up

#### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

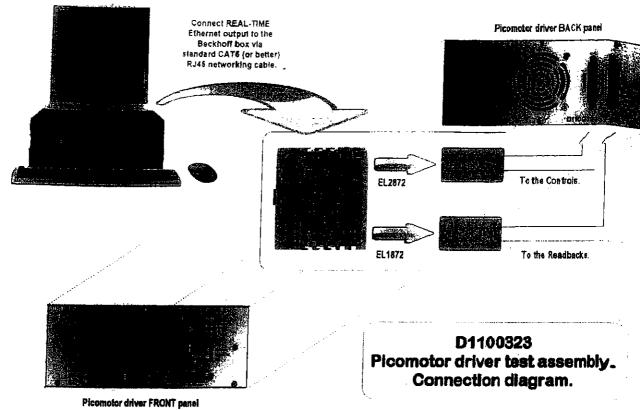
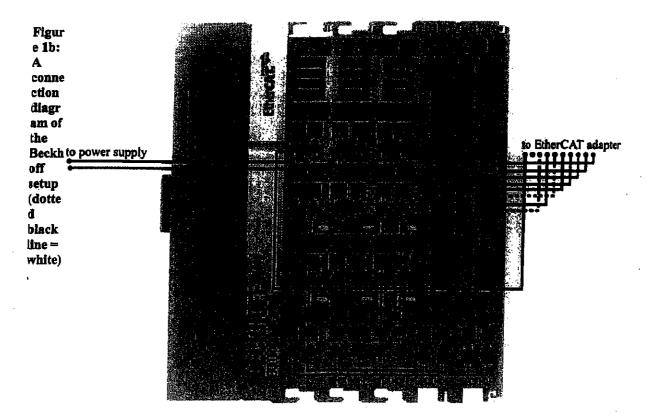


Figure 1a: A connection diagram of the picomotor setup.



### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the powerswitch is on, and that it goes off when the power switch is off.
- [ \ Check that the "ON" indicator on the visualization also responds to the powerswitch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	500	OFF.	97
STARTING UP	off	on	flashes	flashes	6H	on	57
READY	off	on	off	off	04	3	57
Check if passed:	[]	[ ]	[]	[7]	[]	[]	H

Table 1: LED response to picomotor status

- [ T Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [ ] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	ED
	Left	Right
1	[4	[1
2	V	[]
3		[]
4		[1]
5	[/	[1]
6	[] [/	M
7		[1]
8		[1]

#### Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CW Y	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[]	打	[1	[/	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

### 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
VERY SMALL (1)	[4]	11		
MEDIUM (100)	[4			
MAGNUM (10000)		11		

### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
CRAWL (1Hz)	[1	[}		
JOG (50Hz)		11		
SPRINT (500Hz)	[/	ίγ		

### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	22.64	21.41		
2	23 90	22.76		
3	25.15	24.07		
4	26.23	25.21		
5	27.28	26.27		
Check if passed:	[1]	[4		

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[4]				
2	[4]	il			
3	[9]				
1	[1	17			
5		17			
5		11			
		[ <i>Y</i>			
	[1	[ <i>X</i>			

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[1	IT			
2	11	1			
3	[ ]	[1			
4	[1	[1			
5	[1	į. Į.			
6	- IT	[X			
7	[}	[]			
3	1	[X]			

# **Testing Summary**

For each test, indicate the results in the table below:

Front panel LEDs [ ] Fail Step sizes [ ] Fail Speeds [ ] Fail Output terminals [ / Pass [ ] Fail Overall picomotor driver testing: []Fail

Test Engineer: Zach C
Test Date: 1/29/1

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

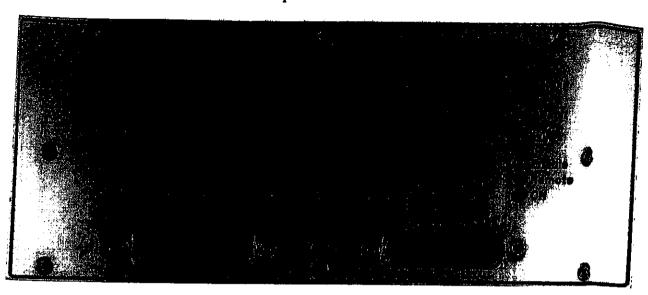


Figure 3: Picomotor driver chassis rear panel

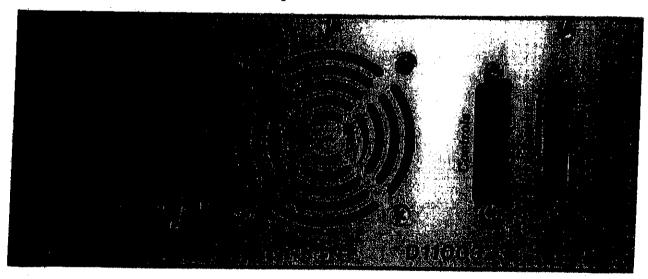
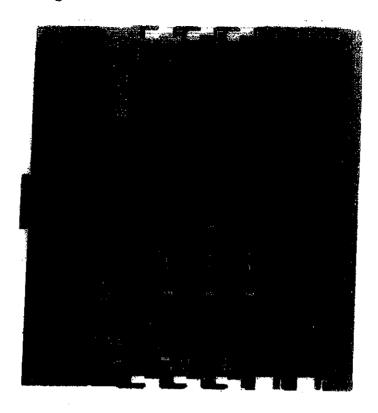


Figure 4: EtherCAT configuration



## **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

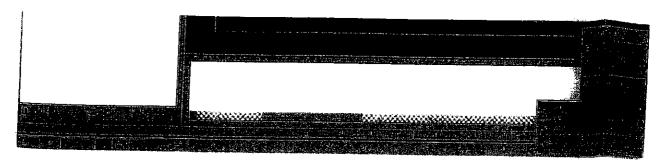
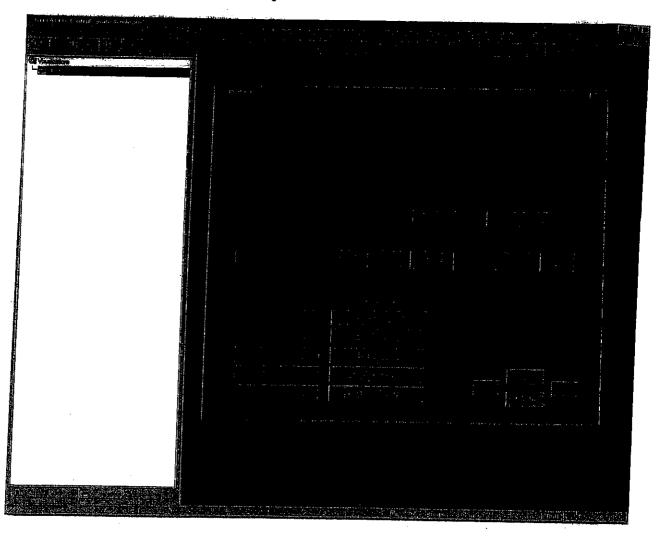


Figure 6: Step 5 of PLC controls setup



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E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1	
ItherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	51107572	
lest Engineer:	Zach C	
Test Date:	11/29/11	
Overall picomotor chassis testing:	[4PASS	[ ] FAIL
Signature/Initials:		
	*	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- Front panel LEDs
   Step sizes
   Speeds

- 4. Temperature
- 5. Output terminals

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- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

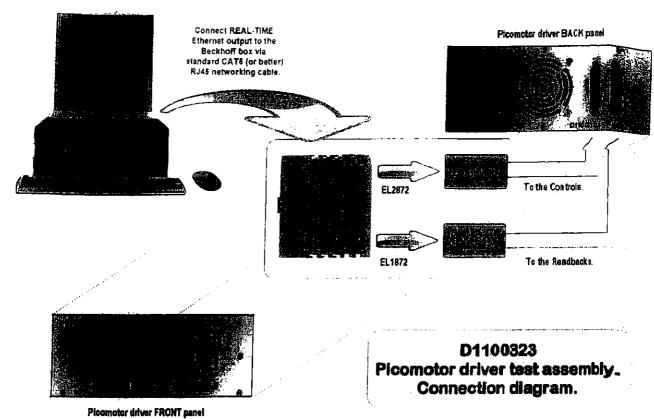
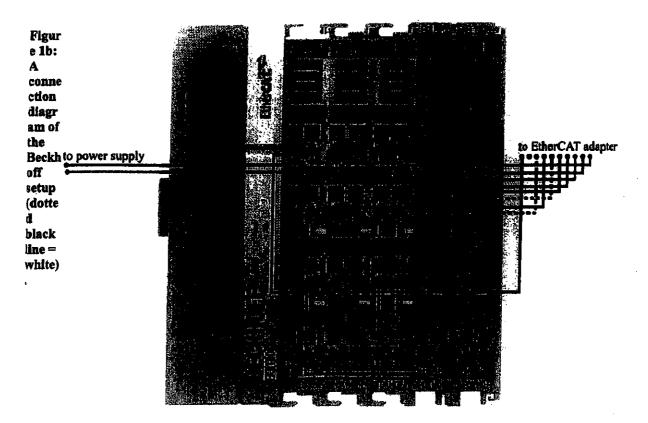


Figure 1a: A connection diagram of the picomotor setup.



### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the powerswitch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the powerswitch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- [ Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	cm	PCD	On
STARTING UP	off	on	flashes	flashes	Off	On	on
READY	off	on	off	off	AF.	m	v n
Check if passed:	[4]	[ 4	[4]	[4]	[4]	[-	-[4]

Table 1: LED response to picomotor status

- [ Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [ ] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal		LED		
	Le	ft	Right	
1	Ĺ	1	[4]	
2	[\	1	W	
3	[(		(1)	
4	[5	1/		
5		3	[]	
6	P	Y	H	
7	[-]		[1]	
8			[]	

#### Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	M	[-]	[]	[]	

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

### l. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and there is that output terminal I is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns) as you increase the step size for each axis (X and Y):

J.	<i>J</i> <sub>1</sub>	(00001) MUNDAM
[]		MEDIUM (100)
	11	<b>NEKL SWALL (1)</b>
Y ("UP" OF "DOWN")	("<" 10 ">") X	
sixA		Step Size

## 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

In the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

[ZH00	/1	SPRINT (500
[/] (2	[7]	10G (20Hz)
[_] (zH)	[ا	CKAWL (1H
o ">") X	X ("<" Or ">")	
		Speed

## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	23.06	22.79	
2	24.52	24.33	
3	25.79	25.77	
4	26.93	26.95	
5	27.92	28.67	
Check if passed:	[4	H	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	[4	[1			
2		[1			
3	[ ]	[]			
4					
5		[1			
6	[1	[ ]			
7	IT	Ħ			
3		EI			

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	V	17			
2	[1	IT			
3	[,}	IT			
4	[1	[ ]			
5	[]	[}			
6	- U	[}			
7	[7	[レ			
3		[ <i>X</i>			

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[] Fail
Output terminals	[ ] Pass	[ ] Fail
Speeds	[ ] Pass	[ ] Fail
Step sizes	[ TPass	[ ] Fail
Front panel LEDs	[ Pass	[ ] Fail

Test Engineer: Zach C
Test Date: 1/29///

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

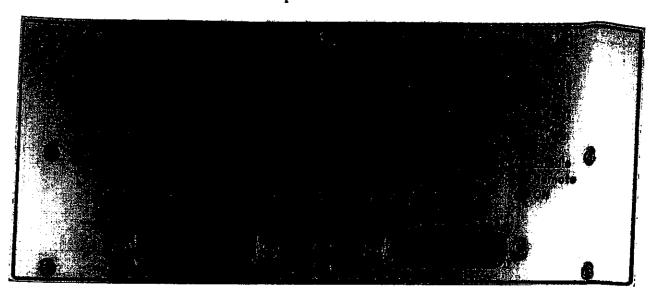


Figure 3: Picomotor driver chassis rear panel

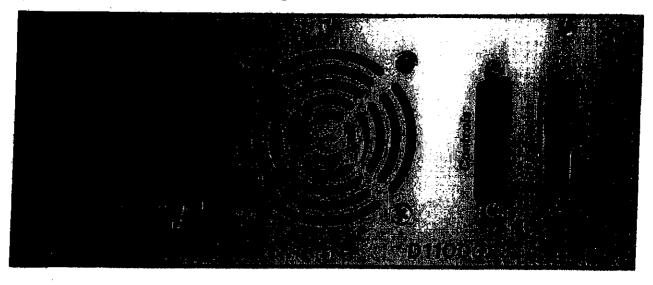
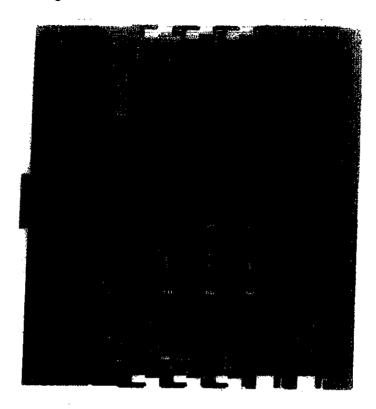


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

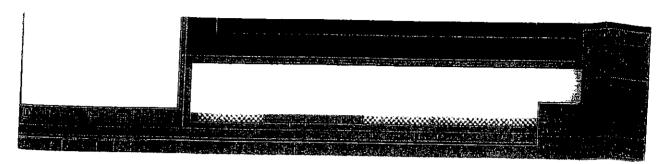
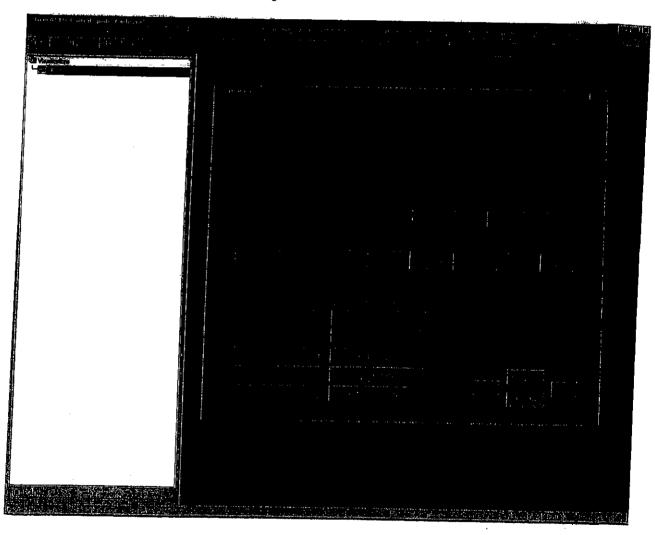


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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Fax (212) 854-8121 E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1
ltherCAT Adapters LIGO DCC#	D1100419-v3
Controller Serial #	51107573
Test Engineer:	Zach G
Test Date:	11/29/11
Overall picomotor chassis testing:	[ PASS [ ] FAIL
Signature/Initials:	
	[ ] FAIL

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### **Testing Schedule:**

- Front panel LEDs
   Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

#### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

## Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

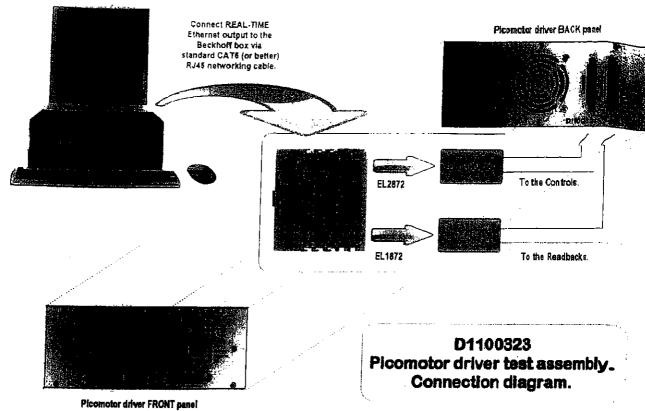
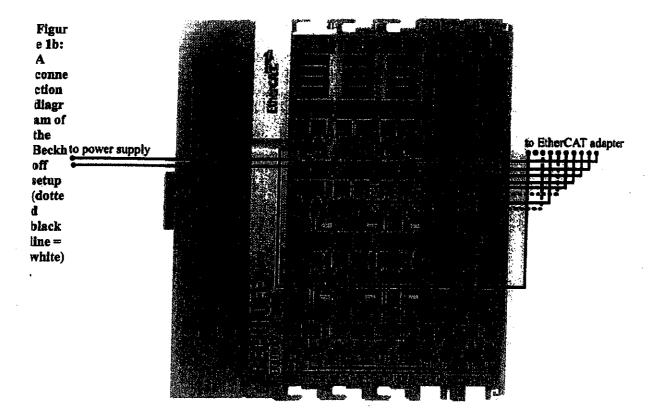


Figure 1a: A connection diagram of the picomotor setup.



#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

4. Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the powerswitch is on, and that it goes off when the power switch is off.
- [ Y Check that the "ON" indicator on the visualization also responds to the powerswitch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	C	Chassis Front Panel LEDs			Software Readbacks		backs
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	9	Ro	(TA)
STARTING UP	off	on	flashes	flashes	Off	(2)	(37)
READY	off	on	off	off	off	(M	(22)
Check if passed:	[]	[]	[]	Ħ	[]	11	11

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the nicomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	ED
	Left	Right
1	W	[4]
2	[4]	[4]
3		[4]
4	[4]	[4]
5		[]
6		[1
7	[1	[1
8	[1	[1

Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4]	[-]	[}	[]

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

## 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[4]	[9
MEDIUM (100)	[4	1
MAGNUM (10000)	[4	1

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	[4]	[]	
JOG (50Hz)	IT	17	
SPRINT (500Hz)	[}	H	

## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	25.85	26.33	
2	27.16	27.77	
3	28.43	29.11	
4	29.51	30.27	
5	30. 59	31.40	
Check if passed:	H	[4]	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	H	[+		
2	[6]	[]		
3	[.]	[7		
4	[]	[7		
5	[X	[1		
5	1	[}		
7	[1	17		
3	[1	ī.*		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	W	11		
2		ij		
3	[4]	IT.		
4	]	IT		
5	I I	[+		
5				
7				
3	1	[1		

# Testing Summary

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[]Fail
Output terminals	[   Pass	[ ] Fail
Speeds	Pass	[ ] Fail
Step sizes	Pass	[ ] Fail
Front panel LEDs	Pass	[ ] Fail

Test Engineer: Zach G

Test Date: 11/24/11

Additional Comments:

# Appendix A: Physical Components

Mgure 2: Picomotor driver chassis front panel

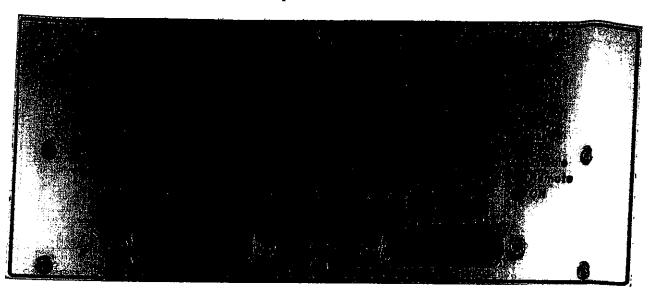


Figure 3: Picomotor driver chassis rear panel

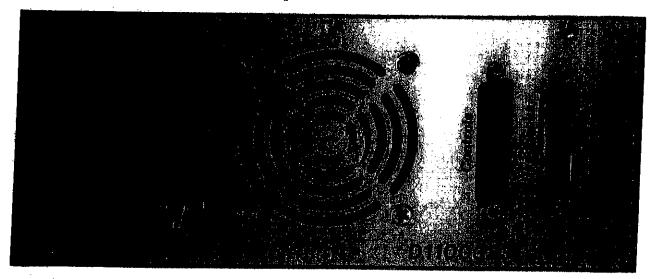
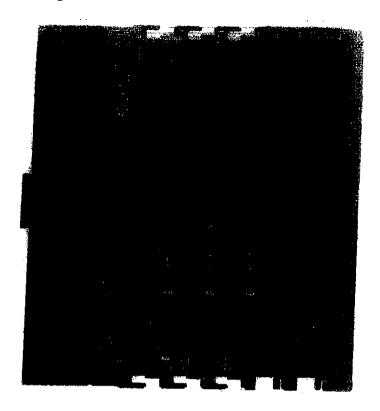


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

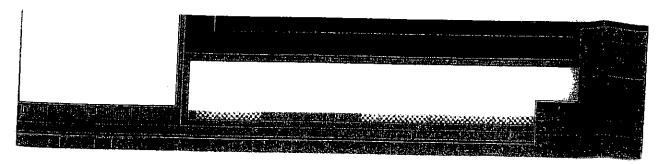
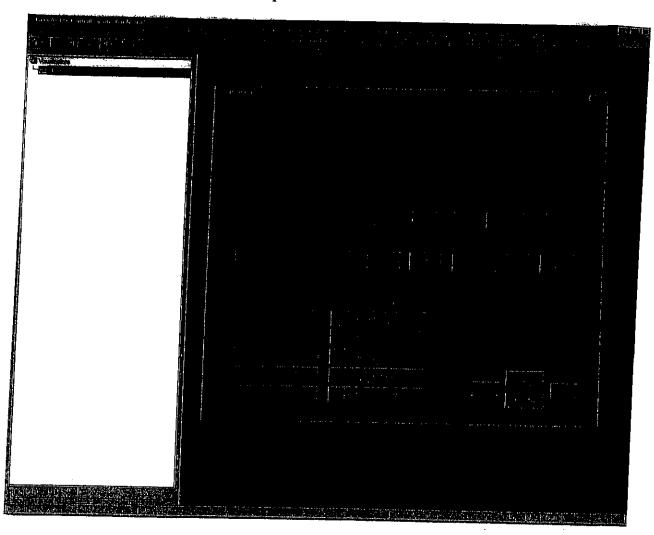


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

## CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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Pupin Hall - MS 5247
New York NY 10027
Phone (212) 854-8209
Fax (212) 854-8121

E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	D1100323-v1	
ItherCAT Adapters LIGO DCC#	D1100419-v3	
€ontroller Serial #	<u></u>	1674
Test Engineer:	Zach	C
Test Date:	11/291	1]
Overall picomotor chassis testing:	PASS	[ ] FAIL
Signature/Initials:		
	•	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### Testing Schedule:

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
  5. Output terminals

## System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- Hook-up wiresBrown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

## Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

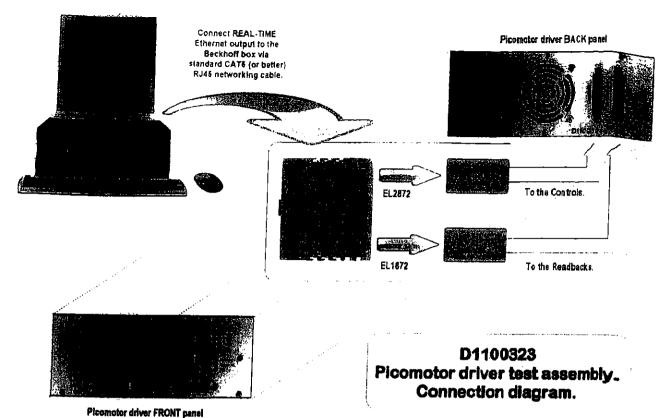
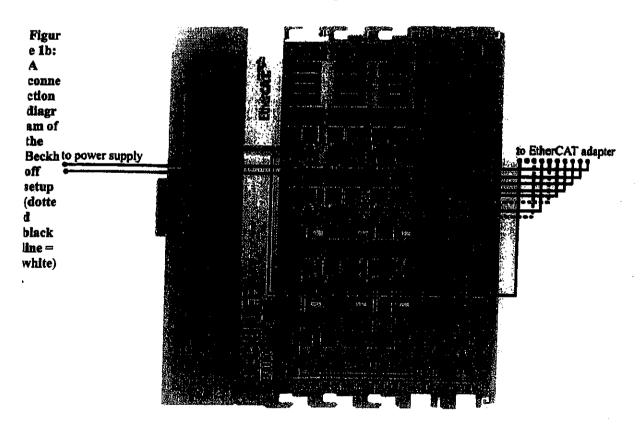


Figure 1a: A connection diagram of the picomotor setup.



## Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

## 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs			Software Readbacks			
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	OF	011
STARTING UP	off	on	flashes	flashes	off.	Sn	571
READY	off	on	off	off	off	ω\	on
Check if passed:	[4]	[4]	[]	[4]	[4	H	17

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LE	ED
	Left	Right
1	[4]	[]
2	[ ]	[/
3	N	[1
4	W	
5	[]	[1]
6	 14	[1]
7	[]	[1]
8	V	[]

#### Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs				
	Drive X	Drive Y	CW X	CWY	
DOWN	off	on *	off	on **	
UP	off	on *	off	off	
>	on *	off	on **	off	
<	on *	off	off	off	
Check if passed:	[-]	H	[/]		

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

## 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
VERY SMALL (1)	[4	11
MEDIUM (100)	[]	11
MAGNUM (10000)		11

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
CRAWL (1Hz)	H	11	
JOG (50Hz)	[]	ΙÍ	
SPRINT (500Hz)	[1	iT	

## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	12.23	22.37	
2	23.54	23.85	
3	24.80	25.20	
4	25.90	26.32	
5	26.90	27.46	
Check if passed:	H	19	

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[4]	[4		
2	[']	19		
3		[]		
4	[ ]	[]		
5	U	13/		
5	[/	[ <i>Y</i>		
7		[X		
3		[ ]		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis	
	X ("<" or ">")	Y ("UP" or "DOWN")
1	N	11
2	[1	11
3	[1	[X
4	[1	[]
5	$\mathcal{C}_{\mathcal{X}}$	[ <i>X</i>
5	[]	[7
7	[1	
		[ <i>7</i>

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ ] Pass	[]Fail
Output terminals	[ YPass	[ ] Fail
Speeds	[ ]Pass	[ ] Fail
Sep sizes	[ ] Pass	[ ] Fail
Front panel LEDs	[JPass	[ ] Fail

Test Engineer: Zoch G
Test Date: 11/29/11

Additional Comments:

# **Appendix A: Physical Components**

Figure 2: Picomotor driver chassis front panel

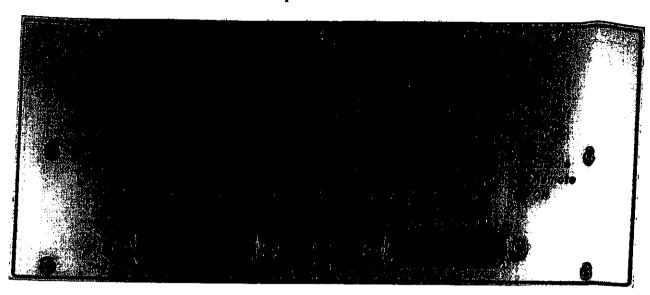


Figure 3: Picomotor driver chassis rear panel

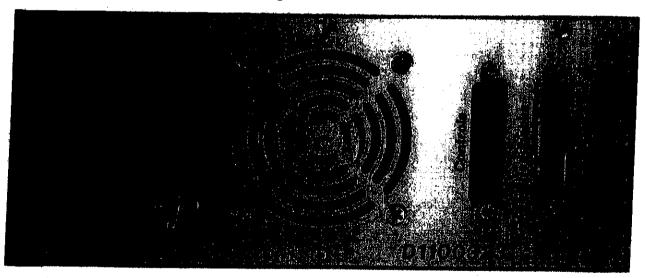
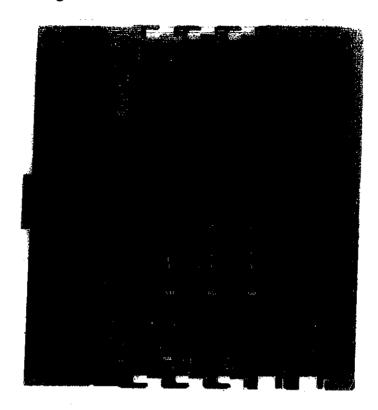


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

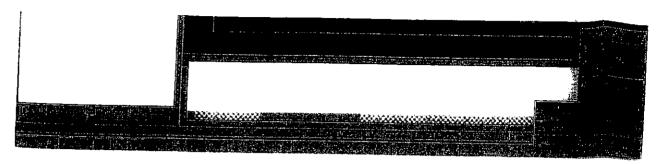
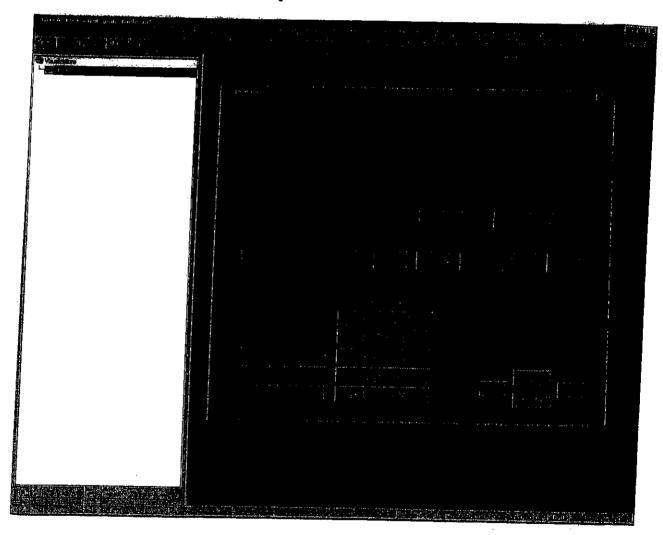


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

## CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**Technical Note** 

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

licomotor controller chassis LIGO DCC#	<u>D1100323-v1</u>
ItherCAT Adapters LIGO DCC#	D1100419-v3
Controller Serial #	S107575
lest Engineer:	Zach G
Test Date:	11/29/11
Overall picomotor chassis testing:	PASS []FAIL
Signature/Initials:	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### Testing Schedule:

- Front panel LEDs
   Step sizes
   Speeds

- 4. Temperature
- 5. Output terminals

#### System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5)
   EK1100, EL3102, EL1014, EL1872, EL2872
   (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

#### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

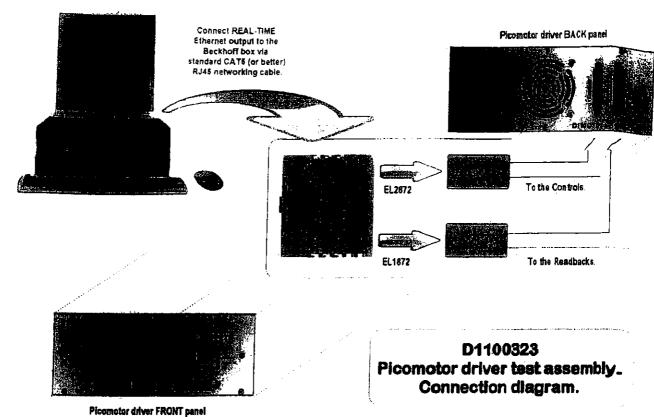
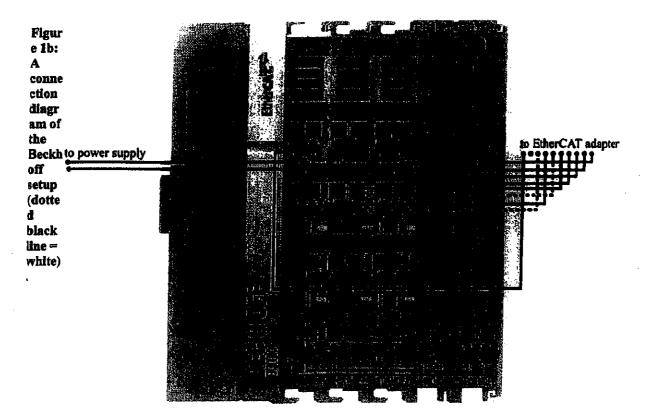


Figure 1a: A connection diagram of the picomotor setup.



#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that pops up, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

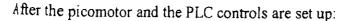
In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

#### 1. Testing the front panel LEDs



Check that the "ON" LED is lit if the power cable is connected and the powerswitch
is on, and that it goes off when the power switch is off.

[4	Check that the "ON" indicator on the visualization also responds to the powerswitch.
----	--

Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.

Before the next step, check that the fan (rear panel) is off.

Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	on	off	on
STARTING UP	off	on	flashes	flashes	off	on	on
READY	off	on	off	off	off	on	5
Check if passed:	W	[4]	[4]			[7]	17

Table 1: LED response to picomotor status

Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.

Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	ED
	Left	Right
1	[4]	[1
2	[4	1
3	[4]	[]
4	[4]	[]
5		[7]
6	[1	[}
7		[]
8	[1]	[1

#### Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs			
	Drive X	Drive Y	CW X	CWY
DOWN	off	on *	off	on **
UP	off	on *	off	off
>	on *	off	on **	off
<	on *	off	off	off
Check if passed:	[4	[1]	[7]	<i>{</i> }

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

## 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and there is time output terminal I is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

[ ]	M	(00001) MUNDAM
-F1	<u>_</u> h]	MEDIUM (100)
المكر	المر	VERY SMALL (1)
Y ("UP" OF "DOWN")	X ("<" or ">")	
six.A	Step Size	

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

sixA	Speed	
Y ("UP" or "DOWN")	( <sup>n</sup> <" or ">") $ X$	
	<u></u>	CKAWL (1Hz)
<i>[</i> ]	<b>★</b> ]	10G (20Hz)
<i>[</i> -]	<u> </u>	SPRINT (500Hz)

#### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature			Temperature	
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	25.48	23.90			
2	26.775	25.14			
3	27.89	26,010			
4	2504	27.57			
5	30.04	28.59			
Check if passed:	[4	[L]			

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
1	[4]	[1		
2	[9]	[7		
3	T M	[7]		
4	[1	[]		
5		11		
6		[1]		
7		И		
3	[ ]	11		

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal	Axis		
	X ("<" or ">")	Y ("UP" or "DOWN")	
1	[1	[8]	
2	[1]	И	
3		11	
4	<b>一</b> [1	IT	
5	[1]	[ }	
6	11	rí	
7		[1	
3	11	rΤ	

# **Testing Summary**

For each test, indicate the results in the table below:

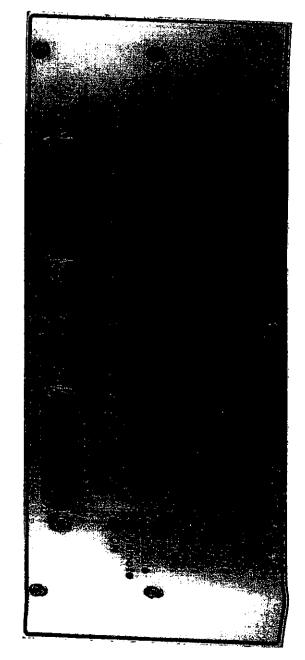
Overall picomotor driver testing:	[ ] Pass	[ ] Fail
Output terminals	[ ] Pass	[ ] Fail
Speeds	[ ] Pass	[ ] Fail
Step sizes	[]Pass	[ ] Fail
Front panel LEDs	Pass	[ ] Fail

Test Engineer: Zach G
Test Date: 11/29/11

Additional Comments:

# Appendix A: Physical Components

Ngure 2: Picomotor driver chassis front panel



Mgure 3: Picomotor driver chassis rear panel

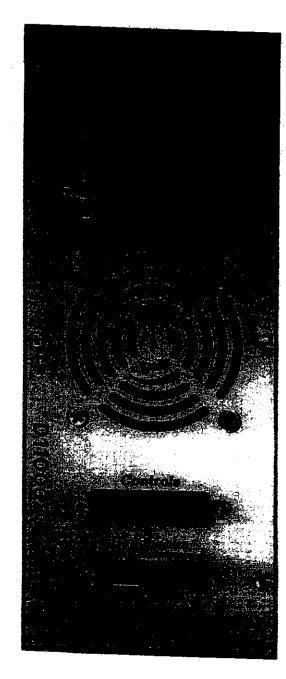
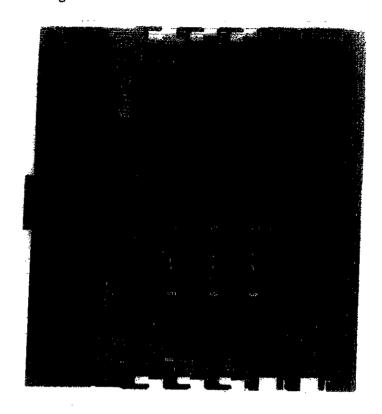


Figure 4: EtherCAT configuration



# **Appendix B: PLC Controls**

Figure 5: Step 3 of PLC controls setup

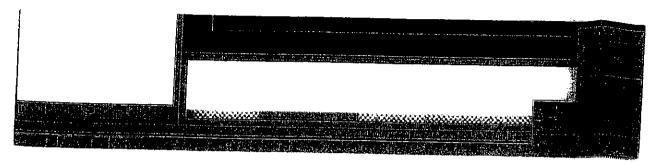
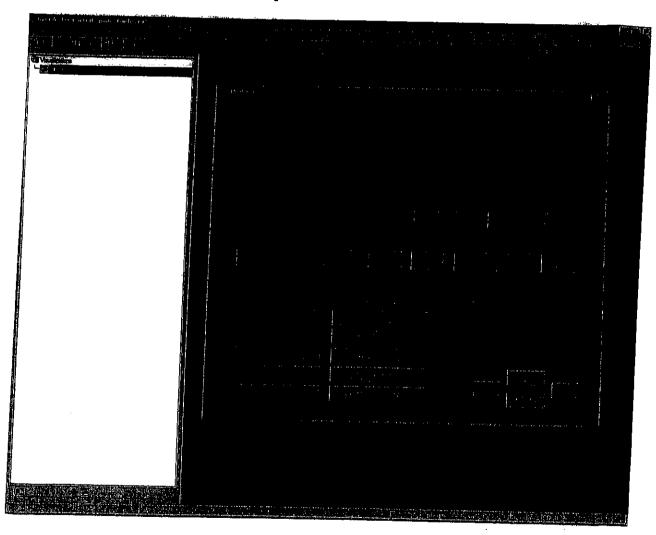


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

#### CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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Columbia University
Columbia Astrophysics Laboratory
Pupin Hall - MS 5247
New York NY 10027
Phone (212) 854-8209
Fax (212) 854-8121

E-mail: geco.cu@gmail.com

WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC#	D1100323-v1		
ItherCAT Adapters LIGO DCC#	D1100419-v3		
Controller Serial #	S		6 7 5 76
Test Engineer:	22		
Test Date:	9PASS	FAIL	
Signature/Initials:			

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### Testing Schedule:

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

## System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1)
  (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- 8 Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- 2 Beckhoff TwinCAT software bundle, v2.11.1551

#### Setting up

#### steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the ELi872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

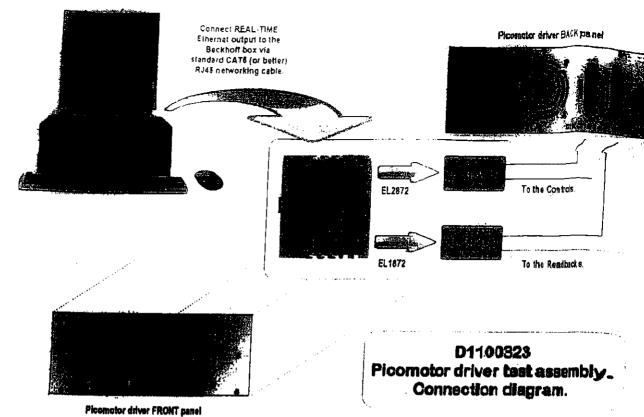
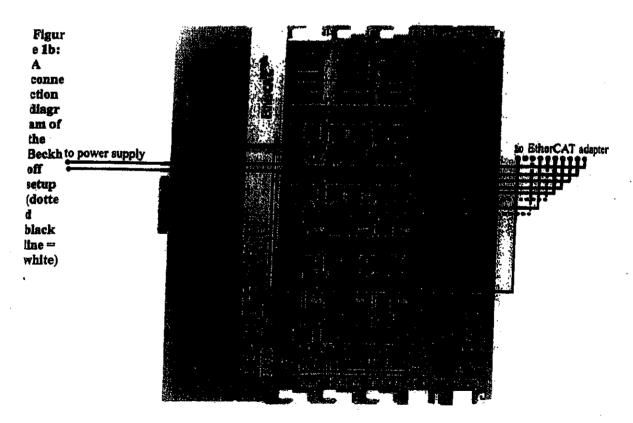


Figure 1a: A connection diagram of the picomotor setup.



#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that popsup, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)
Click "Yes" at the dialog:

"No program on the controller! Download the new program?"
Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

#### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [ Check that the "ON" indicator on the visualization also responds to the power switch.
- [ ] Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- [ ] Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	On	off	On
STARTING UP	off	on	flashes	flashes	08	on	m
READY	off	on	off	off	280	on	on
Check if passed:	[]	[]	N	H	[]	[-]	[+

Table 1: LED response to picomotor status

- [ ] Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [/] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

[ Check that the fan is running and blowing air out of the box (rear panel).

Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	LI	ED
	Left	Right
1	[9	
2	[]	[]
3	[]	
4	[1	[]
5	[]	[]
6	[1]	H
7	[]	
3		

#### Select output terminal 1 and do the following:

[ ] Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs					
	Drive X	Drive Y	CW X	CW Y		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	off	off	off		
Check if passed:	[-]	[]	[]			

Table 2: LED response to picomotor direction

\* (while motor is running)

\*\* (stays on after motor is finished running, until opposite direction is selected)

## 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and theck that output terminal 1 is selected, then select "SPRINT (500Hz)" under "SPEED". Select a step size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns when it runs) as you increase the step size for each axis (X and Y):

Step Size	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
VERY SMALL (1)	[]	N		
MEDIUM (100)		IT		
MAGNUM (10000)		11		

#### 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected, then select "SMALL (10)" under "STEP SIZE". Select a speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

Speed	Axis			
	X ("<" or ">")	Y ("UP" or "DOWN")		
CRAWL (1Hz)	[]	11		
JOG (50Hz)	[]	IT		
SPRINT (500Hz)	[]	[]		

## 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Temperature				
	X ("<" or ">")	Y ("UP" or "DOWN")			
1	23.56	24.45			
2	24.95	25-94			
3	26-27	27.34			
4	27.38	28.62			
5	28.45	29.80			
Check if passed:	H	U			

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[6]	[1				
2	[4]	1				
3						
4						
5	11					
i	11	[/]				

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis				
	X ("<" or ">")	Y ("UP" or "DOWN")				
1	[1]	11				
2	[]	11				
3		1/1				
1						
		[1				
•						
		17				

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	Pass	[]Fail	
Output terminals	[ ] Pass	[] Fail	
Speeds	[ ] Pass	[ ] Fail	
Step sizes	Pass	[] Fail	
Front panel LEDs	Pass	[ ] Fail	

Test Engineer: Zach C
Test Date: 12/21/11

Additional Comments:

# Appendix A: Physical Components

Mgure 2: Picomotor driver chassis front panel

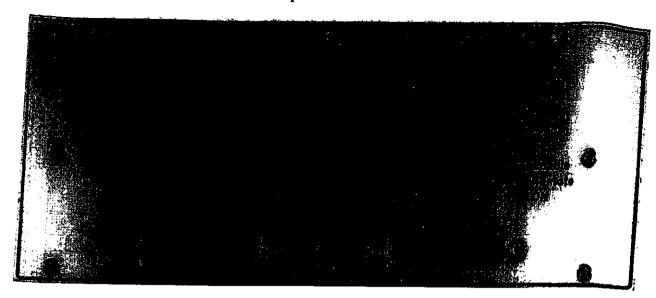
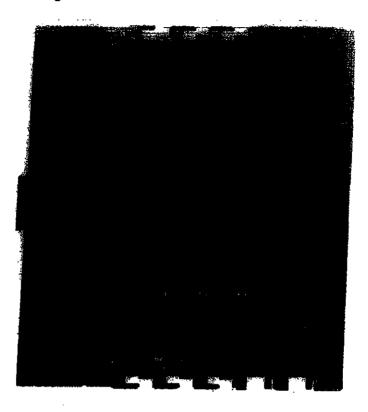


Figure 3: Picomotor driver chassis rear panel



Figure 4: Ether CAT configuration



# Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

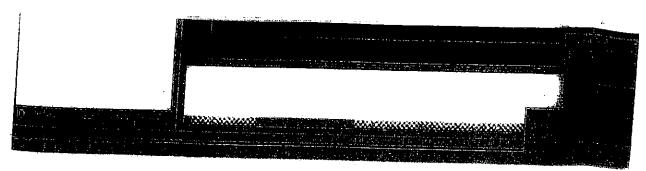
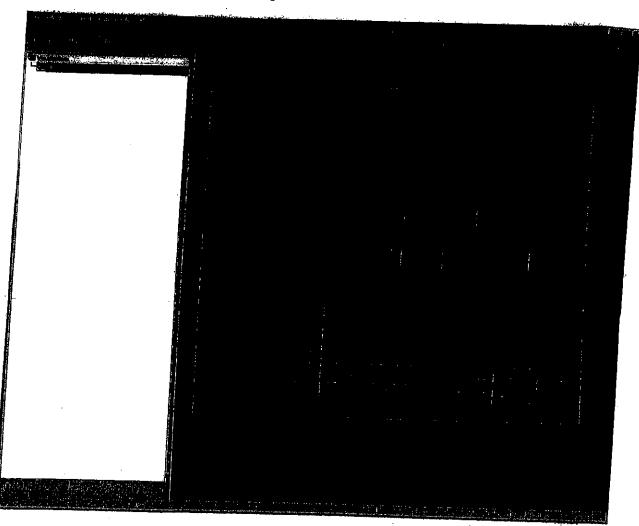


Figure 6: Step 5 of PLC controls setup



# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY -LIGO-

# CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note

LIGO-T1100458-v1

08/26/11

# Testing Procedure for the Picomotor Driver for Advanced LIGO

Maxim Factourovich, Daniel Sigg and Maggie Tse

This is an internal working note of the LIGO Project.

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WWW: http://www.ligo.caltech.edu

Picomotor controller chassis LIGO DCC#	D1100323-v1	
EtherCAT Adapters LIGO DCC#	D1100419-v3	
Controller Serial #	S	107577
Test Engineer:	Zachary	
Test Date:	1/2/11	
Overall picomotor chassis testing:	YPASS [] FAIL	

#### Reference:

https://awiki.ligo-wa.caltech.edu/aLIGO/Picomotor%20Controller

#### Testing Schedule:

Signature/Initials:

- 1. Front panel LEDs
- 2. Step sizes
- 3. Speeds
- 4. Temperature
- 5. Output terminals

## System requirements

#### Hardware:

- Picomotors (2)
  Compatible models: Newport 8302
- Picomotor driver D1100323-v2 (1) (Figures 2 and 3 in Appendix A)
- 3 LIGO standard 24V M-F-M DB3 power cable
- 4 EtherCAT adapter D1100419-v3 (1)
- 5 DB25 F/M cables (2)
- 6 Hook-up wires
  Brown, Green, White, Black, Grey, Purple
- 7 IDC 20-pin cable assemblies (2)
- Beckhoff EtherCAT boxes (5) EK1100, EL3102, EL1014, EL1872, EL2872 (Figure 4 in Appendix A)
- 9 24V power supply for Beckhoff boxes (1)
- 10 Ethernet cable (1)
- 11 Computer equipped with TwinCAT-Intel PCI Ethernet Adapter (100BASE-T)

#### Software:

- 1 MS Windows XP/7, 32-bit
- Beckhoff TwinCAT software bundle, v2.11.1551

#### Setting up

#### Steps for setting up the picomotor:

- 1. Connect the EtherCAT adapter for controls to the left DB25 port on the rear panel of the driver chassis
- 2. Connect the EtherCAT adapter for readbacks to the right DB25 port on the rear panel of the driver chassis
- 3. Using a ribbon cable, connect the EtherCAT adapter for controls to the EL2872 Beckhoff box
- 4. Using a ribbon cable, connect the EtherCAT adapter for readbacks to the EL1872 Beckhoff box
- 5. Connect an Ethernet cable to the X1 IN port on the EK1100 Beckhoff box
- 6. Connect the EK1100 Beckhoff box to a DC power source (24V)
- 7. Connect the other end of the Ethernet cable to the PC through the realtime Ethernet port
- 8. Connect the picomotor driver to a DC power source (24V) and turn the power switch on

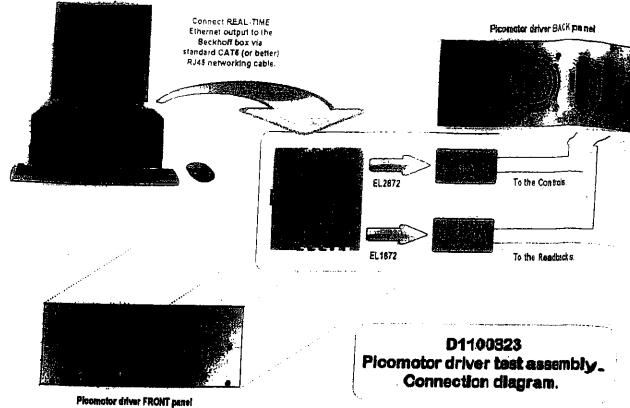
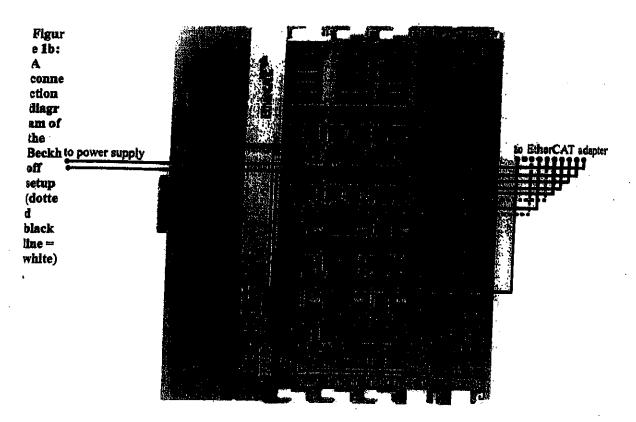


Figure 1a: A connection diagram of the picomotor setup.



#### Setting up

#### Steps for setting up the PLC controls:

1. Open up the TwinCAT System Manager software and go to:

File > Open > Picomotor\_test.tsm

2. Open up the TwinCAT PLC Control software and go to:

File > Open > pmtestcode.pro

3. Go to the system tray, click on the TwinCAT icon and in the menu that popsup, go to: (see Figure 5 in Appendix B for a screenshot)

System > Start

Go to the TwinCAT PLC Control window and go to:

Online > Login (F11)

Click "Yes" at the dialog:

"No program on the controller! Download the new program?"

Online > Run (F5)

5. At the bottom of the left sidebar in the TwinCAT PLC Control window, click on the "Visualizations" tab, and under the "Visualizations" folder, double-click and open "VIS\_PICO", and a visualization window should appear.

(see Figure 6 in Appendix B for a screenshot)

In the "VIS\_PICO" visualization window:

in the "RAW" section, the "IDLE" indicator should be lit in the "USER" section, the status should read "DRIVER DISABLED"

On the controller front panel:

the "IDLE" LED should be lit the "Enable" LED should be off the "ON" LED should be on

#### 1. Testing the front panel LEDs

After the picomotor and the PLC controls are set up:

- Check that the "ON" LED is lit if the power cable is connected and the power switch is on, and that it goes off when the power switch is off.
- [Y Check that the "ON" indicator on the visualization also responds to the power switch.
- Check that the "Remote" LED turns off if the EtherCAT adapter for controls is disconnected.
- Before the next step, check that the fan (rear panel) is off.
- Toggle the "ENABLE" button on the visualization screen and check that the following LEDs respond to the picomotor status according to Table 1:

Status	Chassis Front Panel LEDs				Software Readbacks		
	IDLE	Enable	Fault X	Fault Y	IDLE	Enable	Power
DRIVER DISABLED	on	off	off	off	ms	off	CDA
STARTING UP	off	on	flashes	flashes	off	CD	0.724
READY	off	on	off	off	SF	(5)4	Con
Check if passed:	[4]	[4]	[]		FT	H	[]

Table 1: LED response to picomotor status

- Check that the "DUAL AXIS" indicator on the visualization lights up when the picomotor is enabled.
- [ ] Check that the temperature readouts on the visualization, under the "RAW" section, are positive values near room temperature if motor was previously off.

Enable the picomotor by pressing the "ENABLE" button on the visualization, wait until the picomotor status is "READY", then do the following:

- Check that the fan is running and blowing air out of the box (rear panel).
- [ 9 Check that the two LEDs for each output terminal are lit when that output terminal is selected on the visualization (terminals 1-8 under the "USER" section):

Terminal	L	ED
	Left	Right
1	[4	
2		[]
3		[]
4		[]
5	[]	
5		
7		
3	[]	[]

Select output terminal 1 and do the following:

Select "MEDIUM (100)" under "STEP SIZE" and "SPRINT (500Hz)" under "SPEED" and then click each direction. Check that the following lights respond to the selected direction according to Table 2:

Direction	LEDs					
	Drive X	Drive Y	CWX	CW Y		
DOWN	off	on *	off	on **		
UP	off	on *	off	off		
>	on *	off	on **	off		
<	on *	off	off	off		
Check if passed:	[-]	[]	[]			

Table 2: LED response to picomotor direction

- \* (while motor is running)
- \*\* (stays on after motor is finished running, until opposite direction is selected)

# 2. Testing the step sizes

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and then to output terminal I is selected, then select "SPRINT (500Hz)" under "SPEED". Select a kep size and then a direction. Check that the motor runs for a longer time (the motor clicks and turns) as you increase the step size for each axis (X and Y):

(10000) MUNDAM	<i>X</i> ]	£1
MEDIUM (100)		[,]
VERY SMALL (1)	[1]	1
	X (" < " Or " >")	X ("UP" OF "DOWN")
Step Size	sixA	

## 3. Testing the speeds

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and speed and then a direction. Listening for the 10 clicks, check that the motor runs faster as you increase the speed for each axis (X and Y):

SPRINT (500Hz)		
10G (50Hz)	[]	11
CRAWL (IHz)		£]
	X ("<" or ">")	Y ("UP" or "DOWN")
Speed	sixA	

#### 4. Testing the temperature readout

On the visualization screen, make sure the picomotor is enabled and that the status is "READY", and check that output terminal 1 is selected. Then under the "TEMPERATURE" section, click the "Reset Values" button, then click the "Test" button, which will drive the motors continuously for 5 minutes, and read the temperature every minute for each axis (X and Y). Record the five temperatures in the table below:

Time (minutes)	Tem	perature
	X ("<" or ">")	Y ("UP" or "DOWN")
1	23.55	23-Y3
2	25.00	25.40
3	26-32	26.92
4	29.50	28.18
5	28.59	29.37
Check if passed:	[ ]	IT

Check the "pass" box for each above if the temperature increases over time.

# 5. Testing the output terminals

Make sure the picomotor is enabled and that the status is "READY". Connect the picomotor to one of the 8 terminals, then select "MEDIUM (100)" under "STEP SIZE" and "JOG (50Hz)" under "SPEED". For each terminal, check that the motor runs on each axis (X and Y):

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1		[1]
2	[1	
3	[]	[]
4	[]	[X
5		[]
6		
7	[1	ſΧ
3	[/]	[7]

Repeat the above, but connecting the picomotor(s) through the D-sub connectors instead:

Terminal		Axis
	X ("<" or ">")	Y ("UP" or "DOWN")
1	[1]	11
2	W	11
3		11
4		
5 .	16	
5	1/1	[/]
7		1/
	1	[/]

# **Testing Summary**

For each test, indicate the results in the table below:

Overall picomotor driver testing:	[ Pass	10 M	[]Fail	
Output terminals	Pass		[]Fail	
Speeds	[ ] Pass		[ ] Fail	
Step sizes	[ ]Pass		[ ] Fail	
Front panel LEDs	[ ] Pass		[ ] Fail	

Test Engineer: Z / 21/1/

Additional Comments:

# Appendix A: Physical Components

Figure 2: Picomotor driver chassis front panel

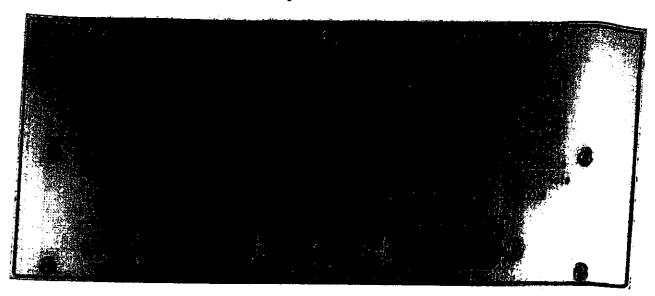


Figure 3: Picomotor driver chassis rear panel

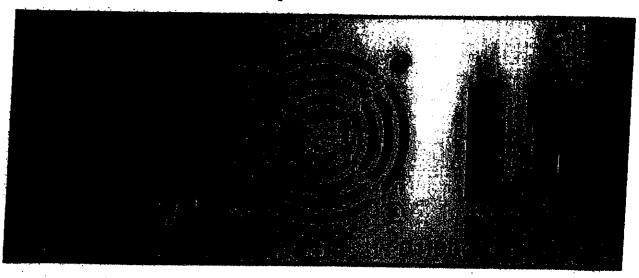
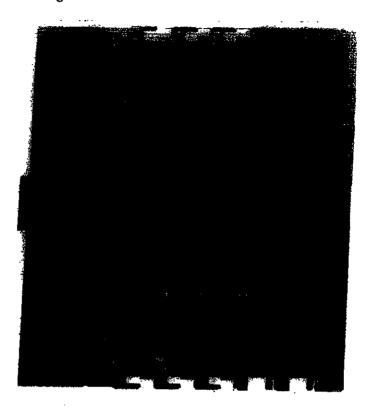


Figure 4: EtherCAT configuration



# Appendix B: PLC Controls

Figure 5: Step 3 of PLC controls setup

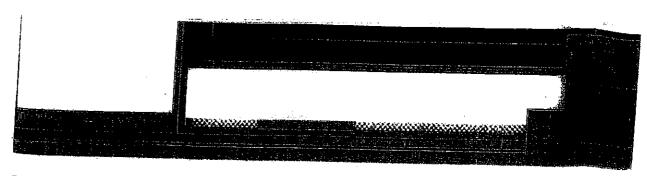


Figure 6: Step 5 of PLC controls setup

