LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
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Phase noise analysis of the Coherent Audio/Locking Fields for squeezing characterization

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1 New Layout

By adjusting the injection site of the CAF, the actuation on the CLF-B VCO can then also drive the CAF frequency, imprinting the pump phase and the CLF-fiber phase into the CAF signal. An additional mixer is needed as the CAF must now be referenced from the 203 MHz squeezer signal. As far as I can tell, all workable alternative configurations also need the extra mixer and phase reference to the 3.125MHz master oscillator.

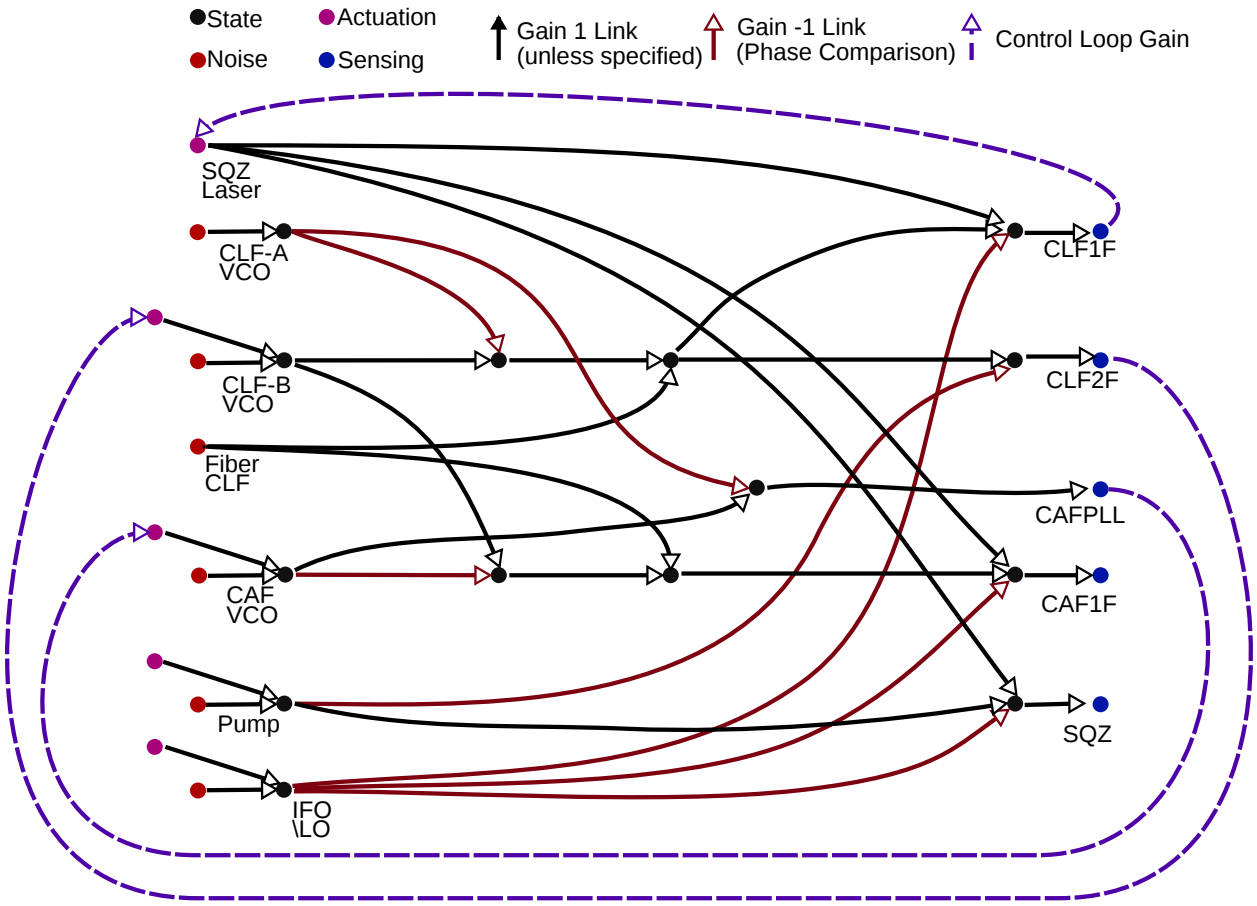

Figure 1: Signal Flow analysis of phase noise in the CLF and CAF loops with the modified CAF layout.

Which corresponds to the open loop couplings (only CAF has changed).

$$S_{\mathrm{CLF1F}} = \hat{N}_{\mathrm{CLF\text{-}B}} + A_{\mathrm{CLF\text{-}B}} - \hat{N}_{\mathrm{CLF\text{-}A}} + \hat{N}_{\mathrm{CLF\text{-}F}} - \hat{N}_{\mathrm{IFO}} + A_{\mathrm{SQZ}} \tag{1}$$

$$S_{\mathrm{CLF2F}} = \hat{N}_{\mathrm{CLF\text{-}B}} + A_{\mathrm{CLF\text{-}B}} - \hat{N}_{\mathrm{CLF\text{-}A}} + \hat{N}_{\mathrm{CLF\text{-}F}} - \hat{N}_{\mathrm{pump}} \tag{2}$$

$$S_{\mathrm{CAFPLL}} = -\hat{N}_{\mathrm{CLF\text{-}A}} + \hat{N}_{\mathrm{CAF}} + A_{\mathrm{CAF}} \tag{3}$$

$$S_{\mathrm{CAF1F}} = \hat{N}_{\mathrm{CLF\text{-}B}} + A_{\mathrm{CLF\text{-}B}} + \hat{N}_{\mathrm{CLF\text{-}F}} - \hat{N}_{\mathrm{CAF}} - A_{\mathrm{CAF}} - \hat{N}_{\mathrm{IFO}} + A_{\mathrm{SQZ}} \tag{4}$$

$$S_{\mathrm{SQZ}} = \hat{N}_{\mathrm{pump}} - \hat{N}_{\mathrm{IFO}} + A_{\mathrm{SQZ}} \tag{5}$$

Now skipping to the closed loop equations:

$$S_{\mathrm{CAFPLL}} = \frac{1}{1+G_{\mathrm{CAF}}}(-\hat{N}_{\mathrm{CLF\text{-}A}} + \hat{N}_{\mathrm{CAF}}) \tag{6}$$

$$S_{\mathrm{CAF1F}} = +\hat{N}_{\mathrm{CLF\text{-}B}} - G_{\mathrm{2F}}S_{\mathrm{CLF2F}} + \hat{N}_{\mathrm{CLF\text{-}F}} - \hat{N}_{\mathrm{CAF}} + G_{\mathrm{CAF}}S_{\mathrm{CAFPLL}} - \hat{N}_{\mathrm{IFO}} - G_{\mathrm{1F}}S_{\mathrm{CLF1F}} \tag{7}$$

$$\tag{8}$$

which in the limit of infinite G_{2F}, becomes

$$S_{\mathrm{CAFPLL}} = \frac{1}{1+G_{\mathrm{CAF}}}(-\hat{N}_{\mathrm{CLF\text{-}A}} + \hat{N}_{\mathrm{CAF}}) \tag{9}$$

$$S_{\mathrm{CAF1F}} = \hat{N}_{\mathrm{CLF\text{-}A}} - \hat{N}_{\mathrm{CAF}} + G_{\mathrm{CAF}}S_{\mathrm{CAFPLL}} - G_{\mathrm{1F}}S_{\mathrm{CLF1F}} + \hat{N}_{\mathrm{pump}} - \hat{N}_{\mathrm{IFO}} \tag{10}$$

or, fully reduced:

$$S_{\mathrm{CAF1F}} = \frac{1}{1+G_{\mathrm{CAF}}}(\hat{N}_{\mathrm{CLF\text{-}A}} - \hat{N}_{\mathrm{CAF}}) + \frac{1}{1+G_{\mathrm{1F}}}(\hat{N}_{\mathrm{pump}} - \hat{N}_{\mathrm{IFO}}) \tag{11}$$

which properly shows the residual noise in the interferometer loops, as desired for the CAF.