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LIGO PROJECT

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SUBJECT Effect of Pockels cell misalignment on frequency suppression

Abstract

Frequency suppression by the primary cavity servo calculated using linear model agrees well with the measured frequency suppression.

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In the model (Fig. 2) the effect of Pockels cell (PC) misalignment is just regarded as the existence of spurious feedback paths (from PC voltages to demodulation signals).

According to the model, if f_1, $f_2 << f_{MC}$'

$$\Delta v_2' = \frac{(D_2 - D_2G_PX_1 + D_1D_2G_CC + D_1G_PX_2)f_{MC}}{\{1 - G_PX_1 + D_1(G_ZZ + G_PP + G_CC)\}(1 + D_2G_2)}$$

Let's define the frequency suppression by the primary cavity servo G as:

$$\Delta v_2'(with\ A1) \equiv \frac{\Delta v_2'(without\ A1)}{1+G}$$

where A1 is the primary cavity servo.

Then we will get:

$$G = \frac{D_1D_2(G_ZZ + G_PP) - D_1G_PX_2}{D_2 + D_1D_2G_CC - D_2G_PX_1 + D_1G_PX_2}$$

The frequency suppression was calculated by measuring or reasonably guessing each component which composes G in the above equation. The ideal frequency suppression without the spurious paths was also calculated. They are shown with the measured frequency suppression in Fig.1.

The result is as follows:

(1) The effect of the PC misalignment can be treated as the existence of the spurious feedback paths.

(2) The frequency suppression is reduced by the PC misalignment effect.

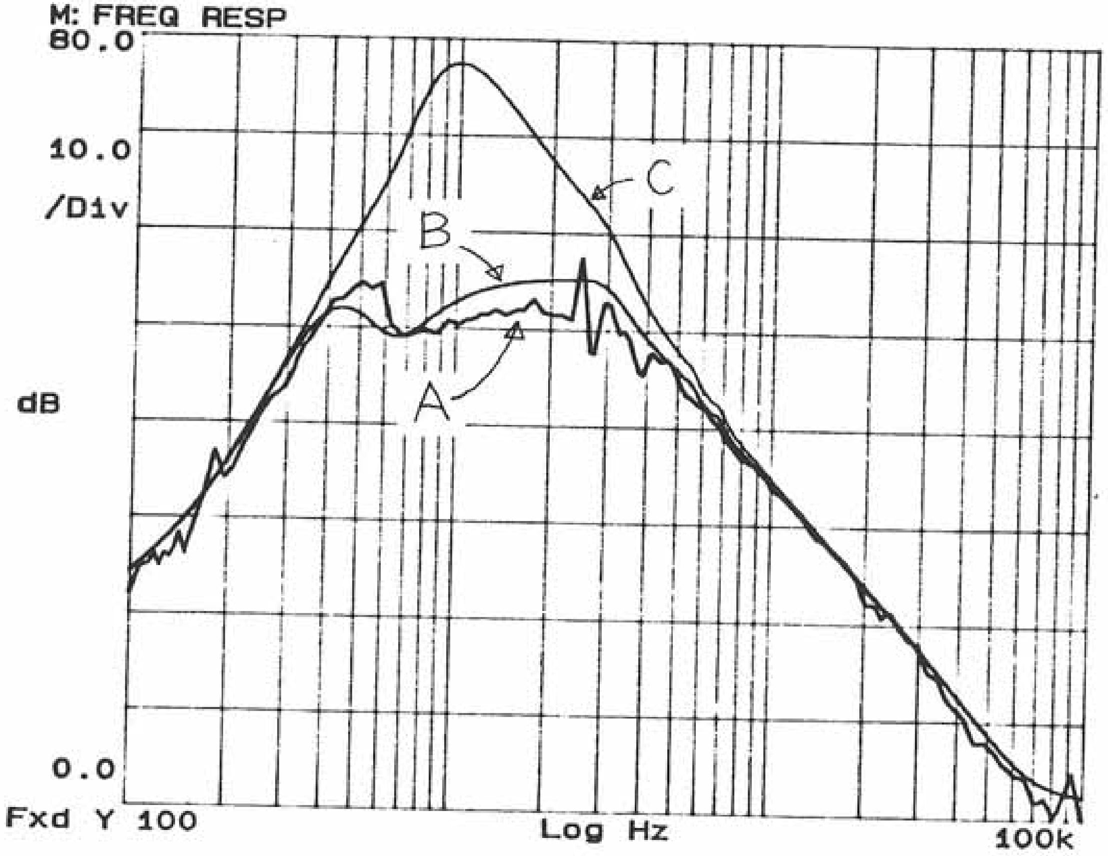

Fig. 1 Frequency suppression of the primary cavity servo.

A : Measured
B : Calculated (with spurious paths)
C : Calculated (without spurious paths)

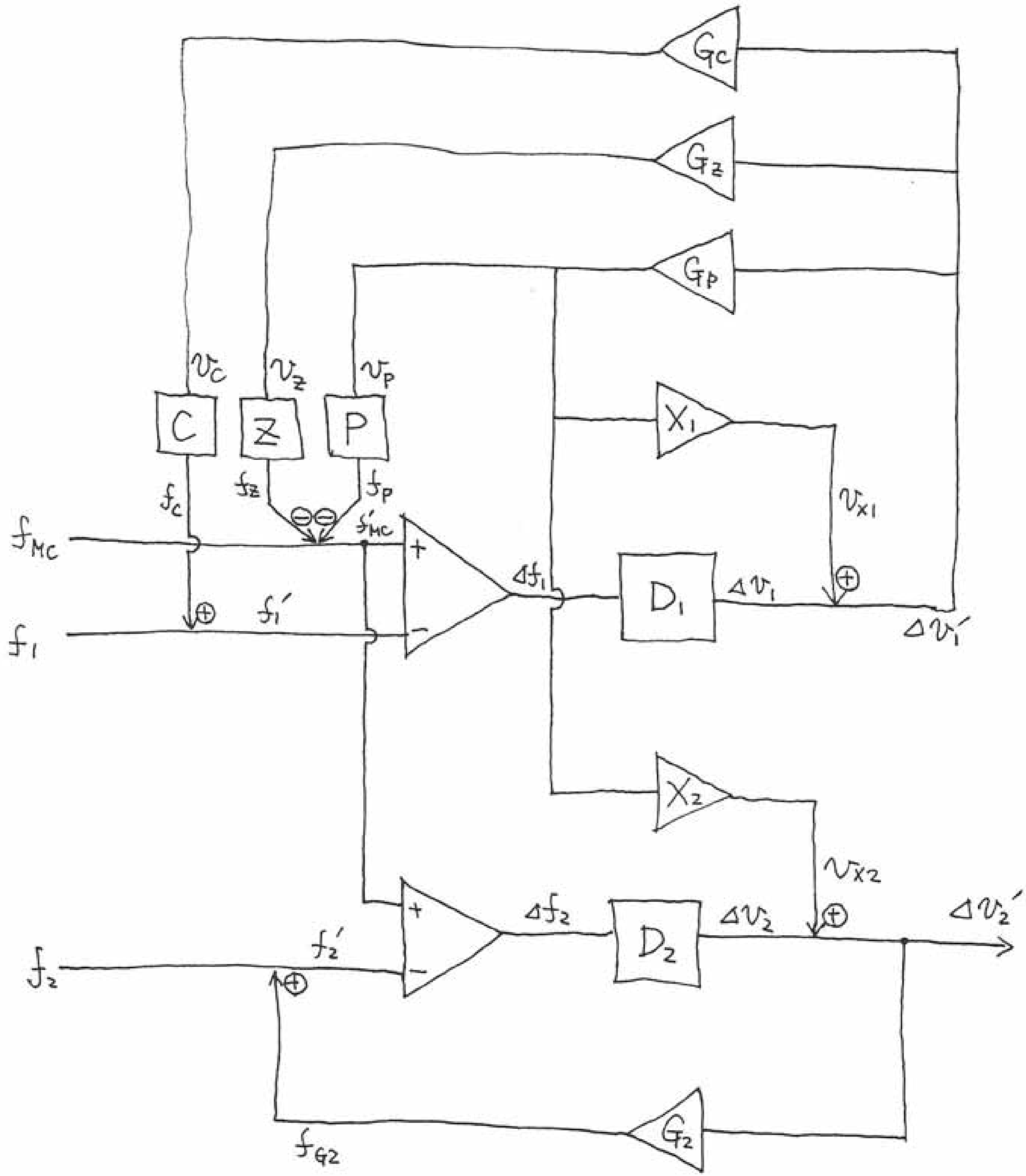

Fig. 2 Linear model of the PC misalignment effect.
(see next page)

f_{MC}: Frequency of the light out of the mode cleaner

f_1: Resonance frequency of the primary cavity

f_{MC}': Stabilized frequency

f_1': Resonance frequency of the primary cavity (when locked)

Δf_1: True frequency deviation (between f_{MC}' and f_1')

D_1: Transfer function from frequency changes to demodulation signal (primary)

Δv_1: Ideal demodulation signal

$\Delta v_1'$: Measured demodulation signal

G_P: Electronics gain of the PC path

v_P: PC feedback voltages

P: PC conversion factor (from voltages to frequencies)

f_P: Equivalent correction frequency of the PC

G_Z: Electronics gain of the PZT path

v_Z: PZT feedback voltages

Z: PZT conversion factor (from voltages to frequencies)

f_Z: Equivalent correction frequency of the PZT

G_C: Electronics gain of the coil path

v_C: Coil feedback voltages

f_C: Equivalent correction frequency of the coil

X_1: Transfer function from PC feedback voltages to demodulation signal (primary) due to PC misalignment

v_{X1}: False demodulation signal due to PC misalignment

f_2: Resonance frequency of the secondary cavity

f_2': Resonance frequency of the secondary cavity (when locked)

Δf_2: True frequency deviation (between f_{MC}' and f_2)

Δf_2': Measurable frequency deviation (between f_0 and f_2')

D_2: Transfer function from frequency changes to demodulation signal (secondary)

Δv_2: Ideal demodulation signal

Δv_2': Measured demodulation signal

G_2: gain of the coil path (from demodulation signals to frequencies)

f_{G2}: Equivalent correction frequency of the coil (secondary)

X_2: Transfer function from PC feedback voltages to demodulation signal (secondary) due to PC misalignment

v_{X2}: False demodulation signal due to PC misalignment