PLL GAIN AND RESPONSE

The goal is to demodulate the FM signal coming from the tunnel diode LC oscillator that encodes the thickness modulations. If the oscillator is used as the voltage controlled oscillator and phase locked to a reference oscilator, the error signal for the phase lock feedback is the demodulated signal.

FM deviation amplitude (Hz) $\Delta f := 10$

The tunnel diode oscillator has a feedback port that shifts its frequency with an input voltage and has a one pole low pass equivalent...

TDO feedback response (Hz/V) $S := 19250$

TDO feedback rolloff $L_f := 40000$

The TDO signal and the reference signal are mixed to DC (phase detection), amplified, and DC fed back to the voltage control port. The mixed signal is also AC amplified for recovery of the modulations.

mixer conversion amplitude - the amplitude of an AC downconverted output signal $V_m := .006$

DC Feedback Amp:	gain	$G_1 := -100$
	low pass	$L_1 := 1000$
AC Signal Amp	gain	$G_2 := 100$
	low pass	$L_2 := 3000$
	hi pass	$H_2 := 30$

The stability of the PLL is determined by the undriven loop solutions, found by the solutions to

$$i \cdot \omega \cdot \left(1 + i \cdot \frac{\omega}{\omega_f}\right) \cdot \left(1 + i \cdot \frac{\omega}{\omega_1}\right) - S \cdot V_m \cdot G_1 = 0 \qquad \left(e^{i \cdot \omega \cdot t}\right)$$

Negative imaginary parts of ω are unstable, and the condtion can be determined...

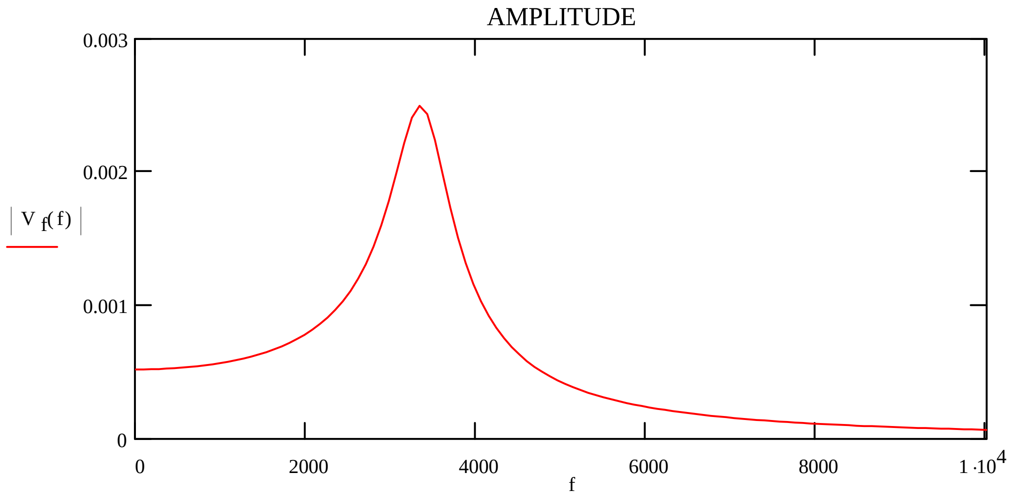
$$\beta := \frac{S \cdot V_m \cdot G_1}{\sqrt{L_1 \cdot L_f}} \qquad \beta = -1.82622 \qquad \alpha := \sqrt{\frac{L_1}{L_f}} + \sqrt{\frac{L_f}{L_1}} \qquad \alpha = 6.48267$$

$$\beta_0 := \frac{\alpha}{27} \cdot \left(9 - 2 \cdot \alpha^2\right) + \frac{2}{27} \cdot \sqrt{\alpha^2 - 3} \cdot \left(\alpha^2 - 3\right) \qquad \beta_0 = 0.03904$$

if $\beta < -\beta_0 < 0$ then there are three exponentially decaying transients.

For our set-up, the AC response to a fixed frequency deviation looks like this:

$$V_f(f) := \frac{\Delta f}{\dfrac{i \cdot f \cdot \left(1 + i \cdot \dfrac{f}{L_1}\right)}{V_m \cdot G_1} - \dfrac{S}{1 + i \cdot \dfrac{f}{L_f}}} \qquad f := 10, 100 .. 10000$$



The signal is just the AC amplified voltage at the mixer:

$$V_s(f) := \frac{G_2}{\left(1 - i \cdot \frac{H_2}{f}\right) \cdot \left(1 + i \cdot \frac{f}{L_2}\right)} \cdot \frac{\Delta f}{\left[\frac{i \cdot f}{V_m} - \frac{G_1}{1 + i \cdot \frac{f}{L_1}} \cdot \frac{S}{1 + i \cdot \frac{f}{L_f}}\right]}$$

AC Response to a signal - the final demodulated signal...