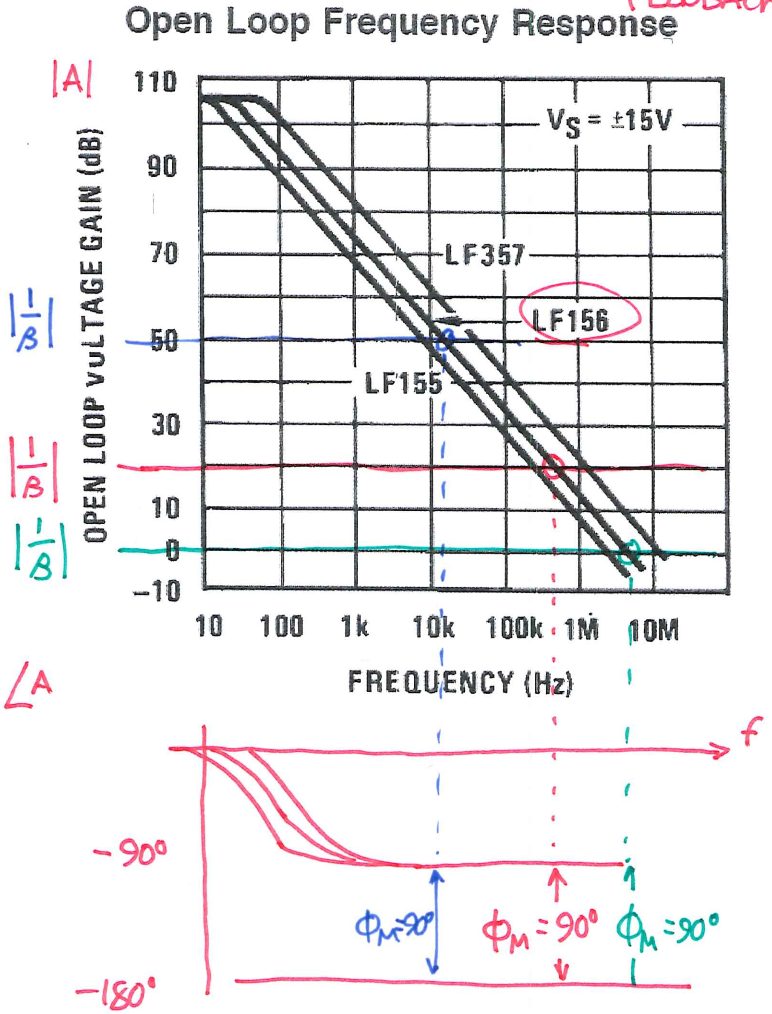
ECE3204 Lecture 24

Dominant Pole Compensation

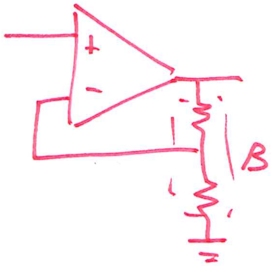
Revisit: Transimpedace amplifier (Lab 1)

Why does op-amp Open Loop Gain look like this?

UNCONDITIONALLY STABLE WITH RESISTIVE ($\angle\beta = 0$) FEEDBACK



PLOT $\left|\frac{1}{\beta}\right|$ ON SAME AXES AS $|A|$



$\beta = 0.1$

CLOSED LOOP GAIN = 10

RESISTIVE FEEDBACK (NO ϕ SHIFT IN β)

FIND f_1

CONDITION $|A\beta| = 1$

$$|A|\,|\beta| = 1 \Rightarrow |A| = \left|\frac{1}{\beta}\right|$$

One-Minute Quiz Op-Amp

$$A(s) = \frac{v_{out}}{v_{id}} = \frac{100\,000}{\left(1+\frac{s}{2\pi(\underbrace{100kHz}_{10Hz})}\right)\left(1+\frac{s}{2\pi(3MHz)}\right)\left(1+\frac{s}{2\pi(100MHz)}\right)}$$

"DOMINANT POLE" COMPENSATION

ANALYSIS: GIVEN A, β, FIND ϕ_M

OP-AMP DESIGN (ECE4902)

CHOOSE ϕ_M WE WANT

DESIGN FOR A TRANSFER FUNCTION

WANT 60° ϕ_M (STABLE) WITH UNITY GAIN FEEDBACK

FIND −120° LAG (ϕ_M=60°) ON ∠A

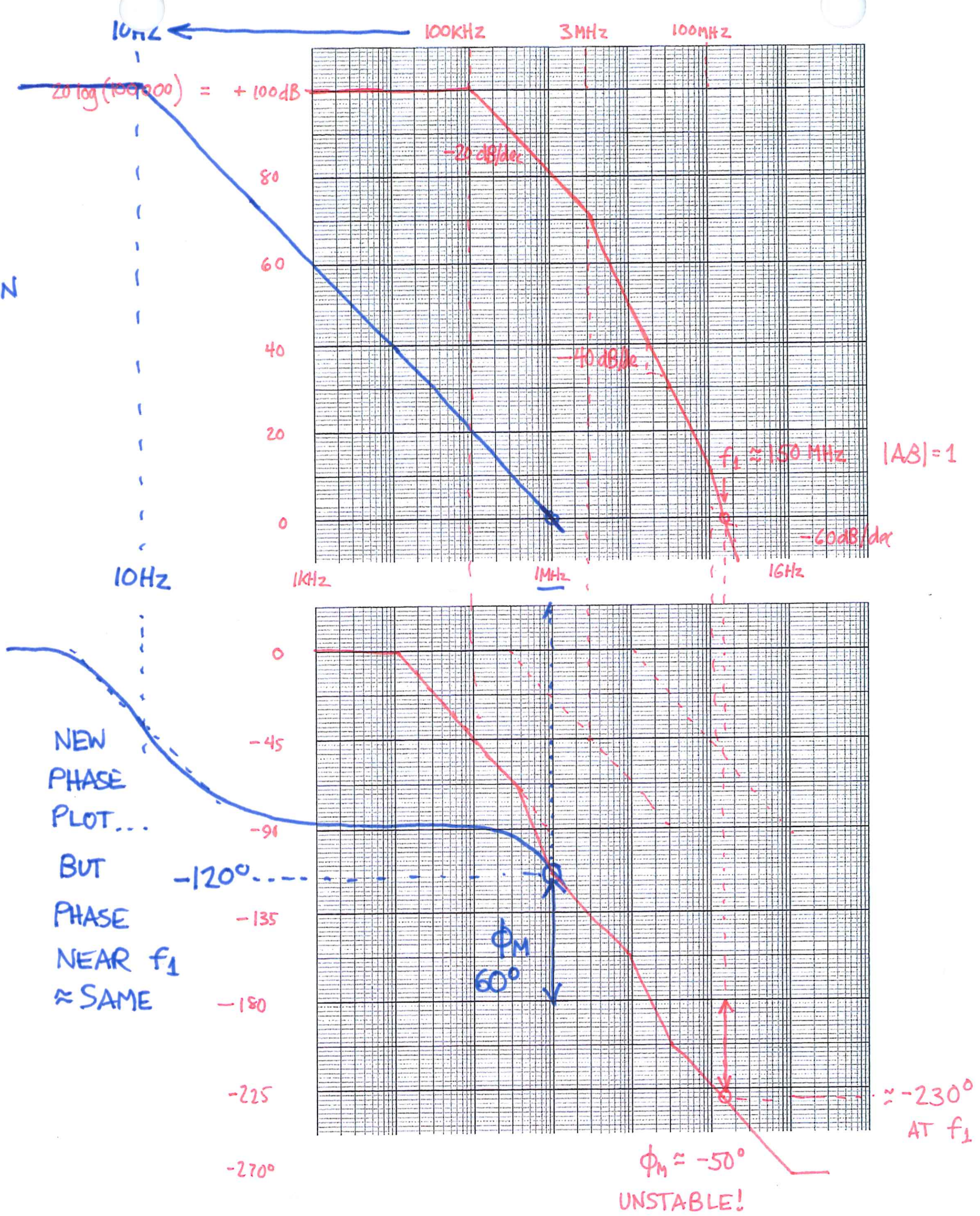
THIS WOULD BE f_1 IF A WAS WHAT WE WANTED

THAT FREQUENCY SHOULD BE OUR f_1

WORK BACK TO DC GAIN WITH 20 dB / DECADE SLOPE

NEED TO MOVE 100KHz POLE TO 10 Hz

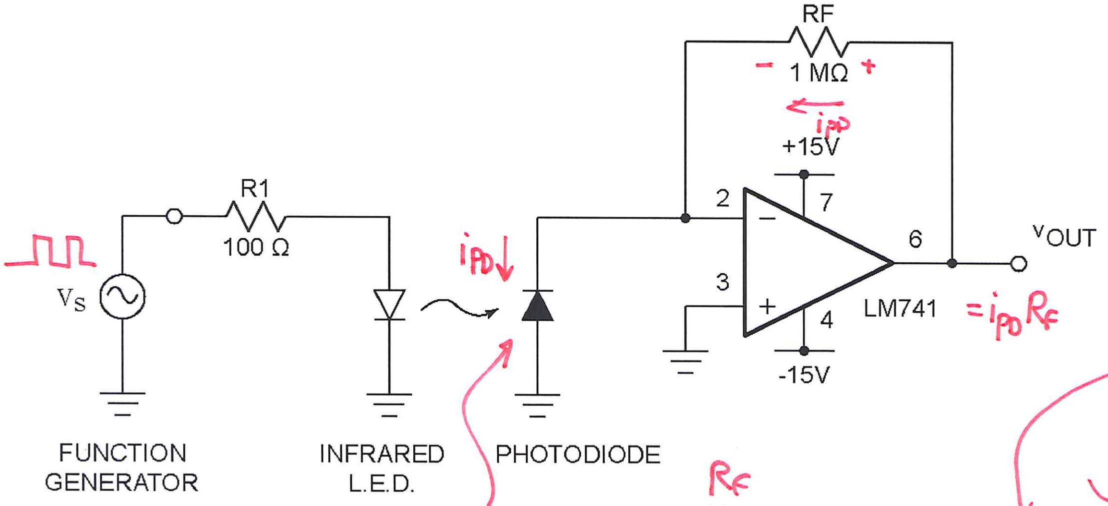
HOW: SEE ECE4902

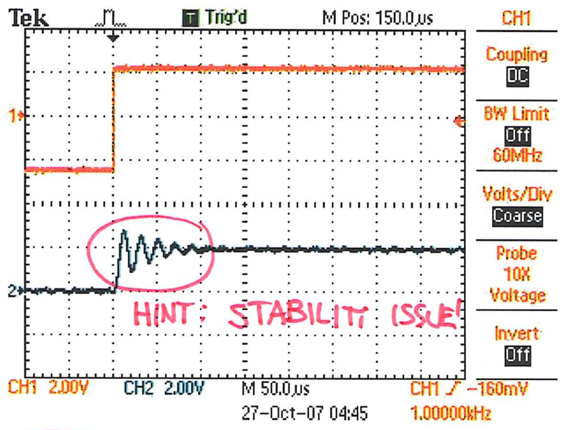


NEW PHASE PLOT...

BUT PHASE NEAR f_1 ≈ SAME

Transimpedance Amplifier (Lab 1)





M Pos: 150.0µs

CH1

Coupling DC

BW Limit Off 60MHz

Volts/Div Coarse

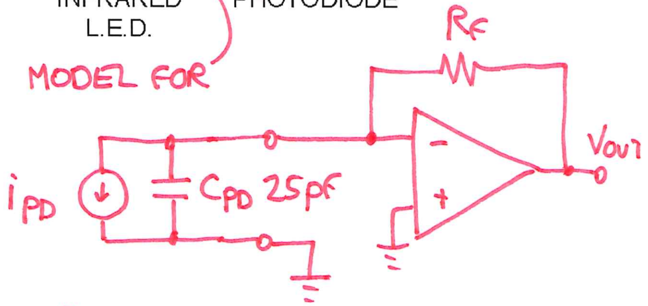
Probe 10X Voltage

Invert Off

CH1 2.00V CH2 2.00V M 50.0µs CH1 ƒ -160mV

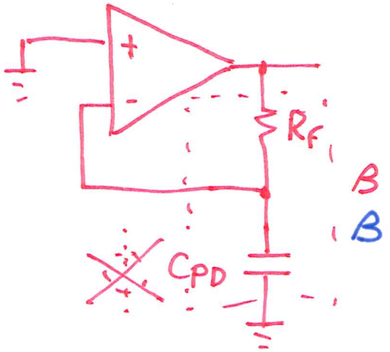
27-Oct-07 04:45 1.00000kHz

MODEL FOR



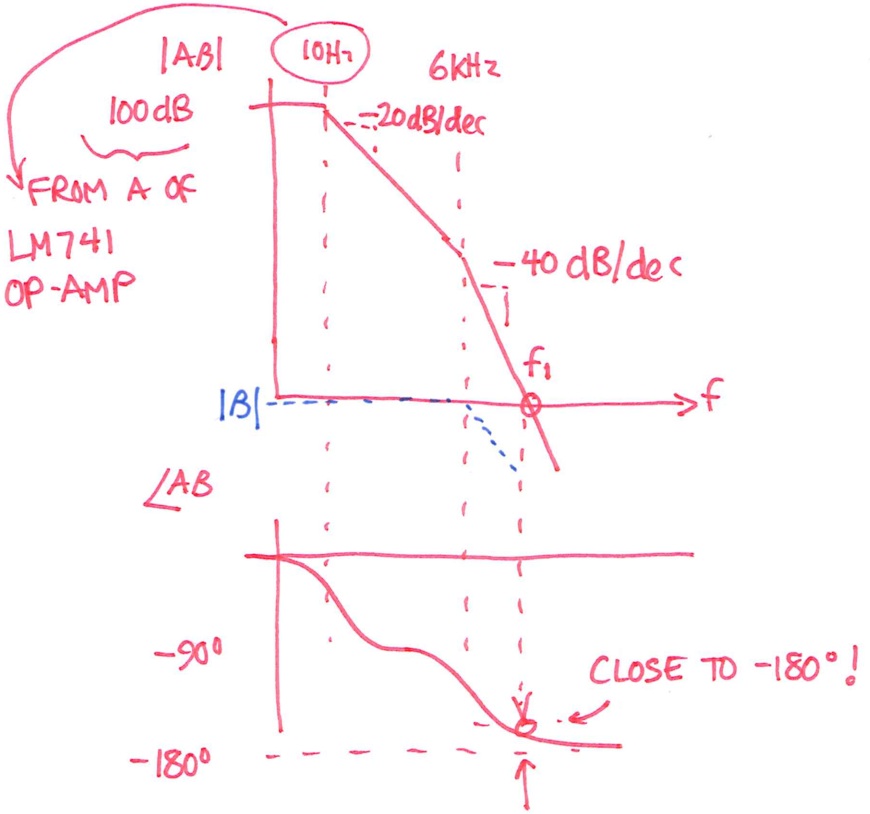
TURN OFF i_{PD} ⇒ OPEN CIRCUIT

REDRAW TO SHOW β



$$\beta = \frac{\frac{1}{sC_{PD}}}{R_F + \frac{1}{sC_{PD}}} = \frac{1}{sR_FC_{PD}+1}$$

$$f_p = \frac{1}{2\pi(1M\Omega)(25pF)} = 6kHz$$

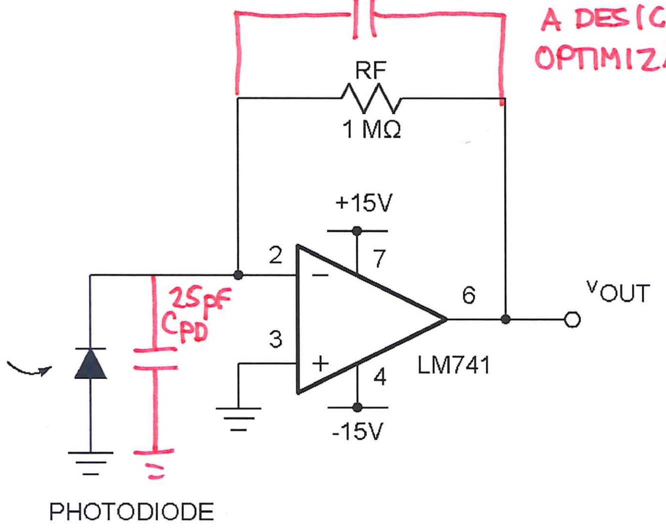


$\phi_M \simeq 15°$

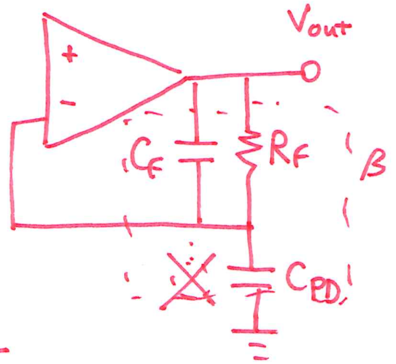
MARGINALLY STABLE!

Stability Fix: Transimpedance Amplifier

$C_F = 5pF$ * CHOOSE IN A DESIGN OPTIMIZATION



ANALYSIS FOR β



$$\beta = \frac{\frac{1}{sC_{PD}}}{\frac{1}{sC_{PD}} + \frac{R_F}{1+sR_FC_F}}$$

$$= \frac{1+sR_FC_F}{1+sR_FC_F+sR_FC_{PD}} = \frac{1+sR_FC_F}{1+sR_F(C_F+C_{PD})} \begin{array}{l} \}\ \text{30KHz ZERO} \\ \}\ \text{POLE 5KHz} \end{array}$$