

Compensation Notes

Compensation is a very important requirement for amplifier design. When feedback is applied to an amplifier, the possibility for instability is inherently introduced.

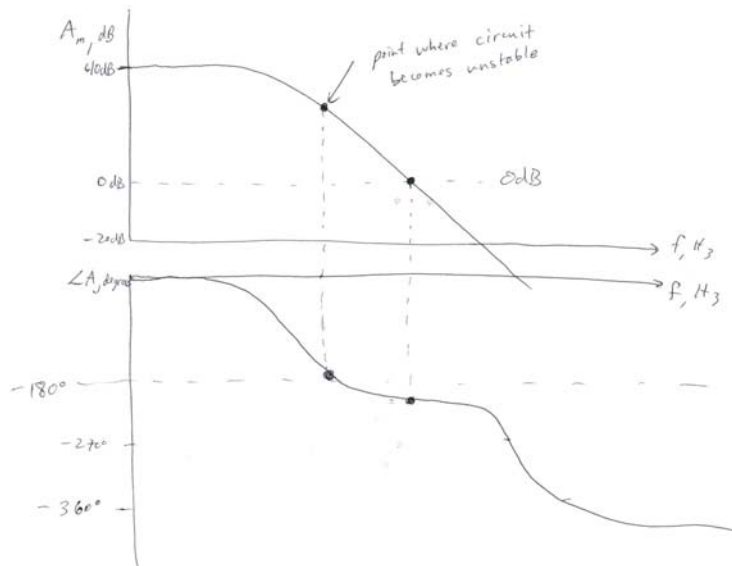
Compensation is a means for controlling the location of poles, by inserting a *dominant pole*, and thus guaranteeing the stability of the amplifier.

Instability refers to the chance that the output changes sign so that the output actually adds to the input, instead of subtracting. This will cause the output to grow without bound and saturate the amplifier.

The problem occurs when the phase delay decreases too slowly relative to the gain. The phase reaches a value of -180 degrees before the gain drops to 0 dB or less. If there is positive gain and -180 degrees of phase, the output will add to the input and since there is positive gain, the output will continue to increase without bound.

To fix this problem, the circuit has a dominant pole added to guarantee that the gain will be 0 dB or less before the phase reaches -180 degrees. In practice, to insure stability, the gain should reach 0 dB before -120 degrees, leaving a conservative 60 degree margin. This distance an amplifier's phase is from -180 degrees at 0 dB gain is called the *phase margin*.

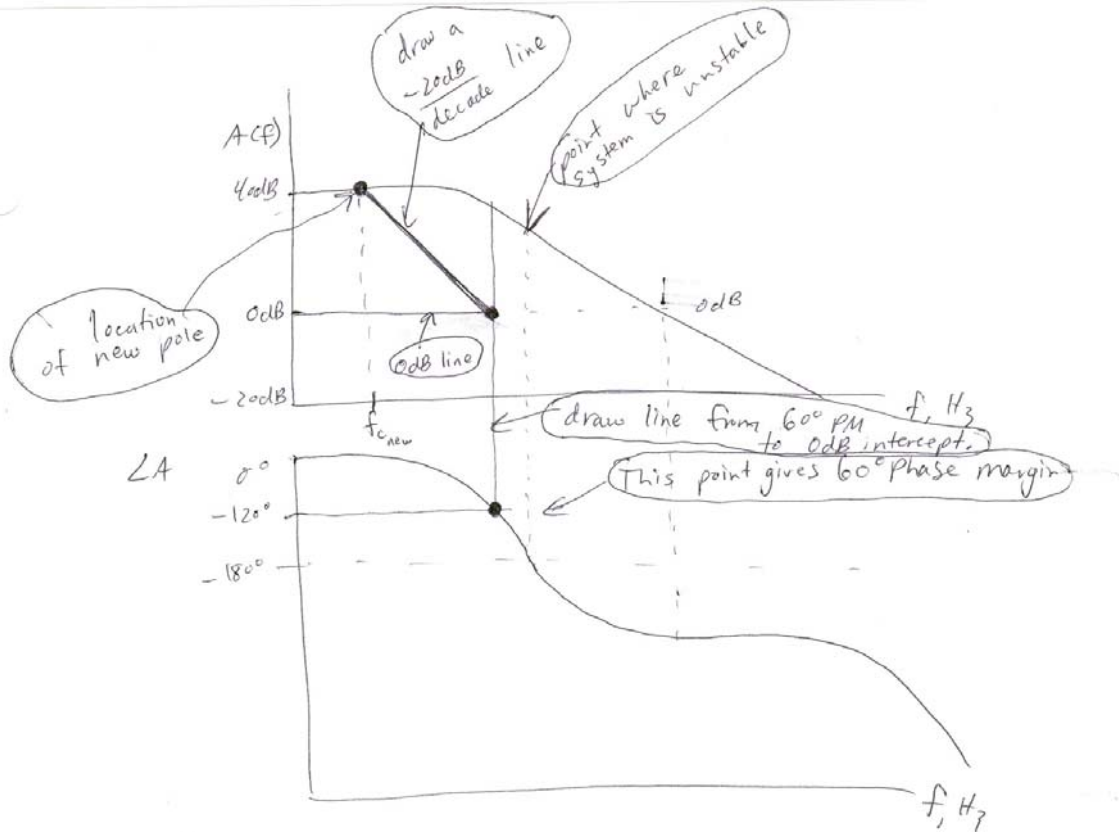
The procedure is best seen by looking at a bode plot of the unstable system first:



To make the circuit stable, a pole needs to be moved to a lower frequency so that the gain will drop below 0dB before the unstable phase of -180 degrees is reached. The calculation for moving the pole can be done graphically. To do so, the phase margin of 60 degrees is located and a line is drawn vertically from this point to the intercept with the 0 dB line on the magnitude curve. A line with a slope of $-20dB/decade$ (one pole's

worth of gain loss), is drawn from this new 0 dB intercept until it reaches the original gain curve. This new intercept is the new corner frequency of the stable system. If an expression for the corner frequency is known and/or the transfer function is known, components can be adjusted to move the pole as desired to the lower frequency.

The ideas are summarized graphically (see also pp. 849-850 in the textbook):



Note that not all systems will be compensated in this manner. Many circuits don't have a dominant pole and one must be added, such as a capacitor to ground or a capacitor between input and output, etc. This will be covered in a later class. This introduction is only meant to help you with Lab 3.