10. FEEDBACK

In general, a HUGE concept. Remember of course that Harold Black, mentioned in the introduction to this chapter as the inventor of negative feedback, was a WPI EE graduate.

10.1 THE GENERAL FEEDBACK STRUCTURE [804-808]

Very important! Be comfortable with the analysis of Fig. 10.1.
Caution: on p. 806, they say that the "comparison circuit" is also known as a "mixer" - not usually; the term "mixer" is more commonly used for a multiplication function in communications circuits and systems.

Example 10.1 [806]

Good example of op-amp analysis in terms of general feedback theory.

10.2 SOME PROPERTIES OF NEGATIVE FEEDBACK [809-814]

Important to remember the types of problems you will encounter that can be improved with negative feedback.

10.2.2 Bandwidth Extension [810-811]

Note that bandwidth isn't so much "extended" as traded off with gain – as noted on p. 810, gain is reduced by the same factor as bandwidth is increased.

10.2.3 Interference Reduction [811-812]

The issue of reducing power-supply "hum" is considered in a problem on HW set 6.

10.3-10.8 FEEDBACK TOPOLOGIES [814-863]

Don't worry about this material for now – there is way more than we need at this point in ECE3204. For op-amp design, we are usually concerned with the series-shunt configuration, but the material in 10.3-10.8 won't be necessary for the stability analyses we will be doing.

10.9 DETERMINING THE LOOP GAIN [863-868]

VERY IMPORTANT! Be comfortable with idea of breaking the feedback loop to determine the loop gain (loop transmission) as shown in Fig. 10.32. We won't need the techniques of Fig. 10.32(c,d) since with op-amps we will be able to break the loop at a high impedance point (one of the op-amp inputs).
The example chosen in Fig. 10.33 is not the best - including all the resistance terms confuses the issue, in my opinion. Usually by intelligently choosing the point at which to break the loop, the load and source resistance issues that complicate this example are less of a problem.

10.9.2 Equivalence of Circuits from a Feedback-Loop Point of View [866-867]

VERY IMPORTANT for simplifying your life! Very often a given circuit topology (feedback loop) can be used in different ways to perform different functions. Once you've analyzed the basic circuit topology for stability, you don't need to repeat the analysis.

10.10 THE STABILITY PROBLEM [868-870]
EXTREMELY important concept, although not covered here as well as it could be. The ultimate problem we need to be concerned with is preventing the poles of Eq. (10.81) from entering the right half plane. Stability analysis allows you to determine if the poles are in the right half plane without actually solving for the roots of the denominator polynomial, which can be difficult (if not impossible) and gives us more information than we need: we don't need the exact pole locations; if the poles are anywhere in the right half plane then we're in trouble.
Key idea: in a negative feedback situation, the phase shift (phase lag, phase delay) around the loop must not exceed -180° at the frequency for which the loop gain has dropped to unity.

10.10.2 The Nyquist Plot [869-870]
Not that important, in my opinion - I think the Bode plot method gives more insight. (The Nyquist plot is really just the Bode plot wrapped around the origin; the stability criterion is the same).

10.11 EFFECT OF FEEDBACK ON THE AMPLIFIER POLES
10.11.1 Stability and Pole Location [871-872]
VERY IMPORTANT! Be comfortable with the s-plane and corresponding time domain representations of the natural modes (poles) of a system.

10.11.2 Poles of the Feedback Amplifier [872]
Important idea: feedback changes the pole locations - must make sure the new pole locations are still stable.

10.11.3 Amplifier with Single-Pole Response [873-874]
VERY IMPORTANT! Amplifier is unconditionally stable - that is why op-amps are made with a "dominant pole", so they will be stable with any (resistive) feedback. Note that the plot in Fig. 10.36(b) expresses the gain-bandwidth product relationship for the op-amp.

10.11.4 Amplifier with Two-Pole Response [873-877]
10.11.5 Amplifiers with Three or More Poles [877-879]
Don't spend too much time on these subsections - we will examine the multiple pole feedback stability problem in the context of a single-pole amplifier and a reactive feedback network that introduces one or more poles.

10.12 STABILITY STUDY USING BODE PLOTS
10.12.1 Gain and Phase Margins [879-880]
HUGE! We'll cover this in class, too - be sure you understand this!

10.12.2 Effect of Phase Margin on Closed-Loop Response [880-881]
The important point is that less phase margin moves the amplifier closer to instability.

10.12.3 An Alternative Approach [881-883]
HUGE! VERY IMPORTANT! Especially for op-amp design, where A is fixed (determined by the op-amp) and we want to see what feedback configurations (β networks) will result in a stable amplifier.

10.13 FREQUENCY COMPENSATION [884-889]
Not needed right now in ECE3204 – these issues are covered in ECE4902 when we do design of the internal op-amp circuit.