Negative Feedback

In a feedback control system, the output is sampled and a fraction of it is send back to the input. This returning signal combines with the original input, producing remarkable changes in the system performances.

Negative feedback means the returning signal has a phase that opposes the input signal.

In amplifier design, negative feedback is applied to effect the following properties:

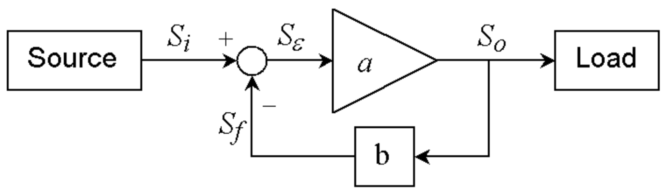
- stabilizing the gain; make the value of the gain less sensitive to variations in the value of circuit components (such is temperature variations);
- reduce nonlinear distortion; make the output proportional to the input (make the gain constant, independent of signal level);
- reduce the effect of noise; minimize the contribution to the output of unwanted electric signal (generated by the circuit components and extraneous interference);
- control the input and output impedance; raise or lower input and output impedance by selecting the appropriate feedback topology;
- Extend the bandwidth of the amplifier.

All of these desirable properties are obtained at the expense of a reducing in gain. The basic idea of negative feedback is to trade gain for other desirable properties.

Under certain conditions the negative feedback can become positive and leads to instability or cause oscillations.

The General Feedback Structure

The signal (S) flow diagram of a negative feedback system is presented in the figure.



S_i, S_ε, S_o and S_f are signals: input, error, output, feedback signals, respectively. The signal S represents either a voltage or a current.

The elements in the diagram are:

- The open-loop amplifier (or the basic amplifier) has a gain a; thus: $S_o = a \cdot S_\varepsilon$;
- The feedback network, fed by the output, produces a sample of the output: $S_f = b \cdot S_o$, where b is the "feedback factor";
- The feedback signal is subtracted from the source signal, to produce the input to the basic amplifier: $S_\varepsilon = S_i - S_f$; The negative feedback reduces the signal that appears at the input of the basic amplifier.

The gain of the feedback amplifier can be obtained:

$S_o = a \cdot S_\varepsilon = a\,(S_i - S_f) = a\,(S_i - b \cdot S_o)$ that gives $S_o\,(1 + ab) = a \cdot S_i$.

The closed-loop voltage gain or the overall gain:

$$A = \frac{S_o}{S_i} \text{ is } A = \frac{a}{1+ab};$$ that is the basic equation of negative feedback.

The quantity (product) "ab" is called the "loop gain". For a positive loop gain ($ab>0$) the gain with feedback is smaller than the open-loop gain "a" by the quantity "$1+ab$", which is called the "amount of feedback".
For the negative feedback to be effective, the designer makes the loop gain much grater than unity: $ab \gg 1$.
From the basic equation of feedback it follows that: $A = \frac{1}{b}$, the gain of the feedback amplifier is almost entirely determined by the feedback network.
Since the feedback network usually consists of passive components, that are precise, the feedback gain is accurate, predictable and stable.
The overall gain, or closed-loop gain, will have very little dependence on the gain of basic amplifier "a" (usually the gain "a" is function of many parameters, some of them with wide variations or tolerances).

Gain De-sensitivity

Reduction of Nonlinearities

Noise Reduction

The Feedback Topologies

Input and Output Impedance of Feedback Amplifiers

Rules to Compute a Practical Feedback Amplifier