Amplifier External Noise Analysis
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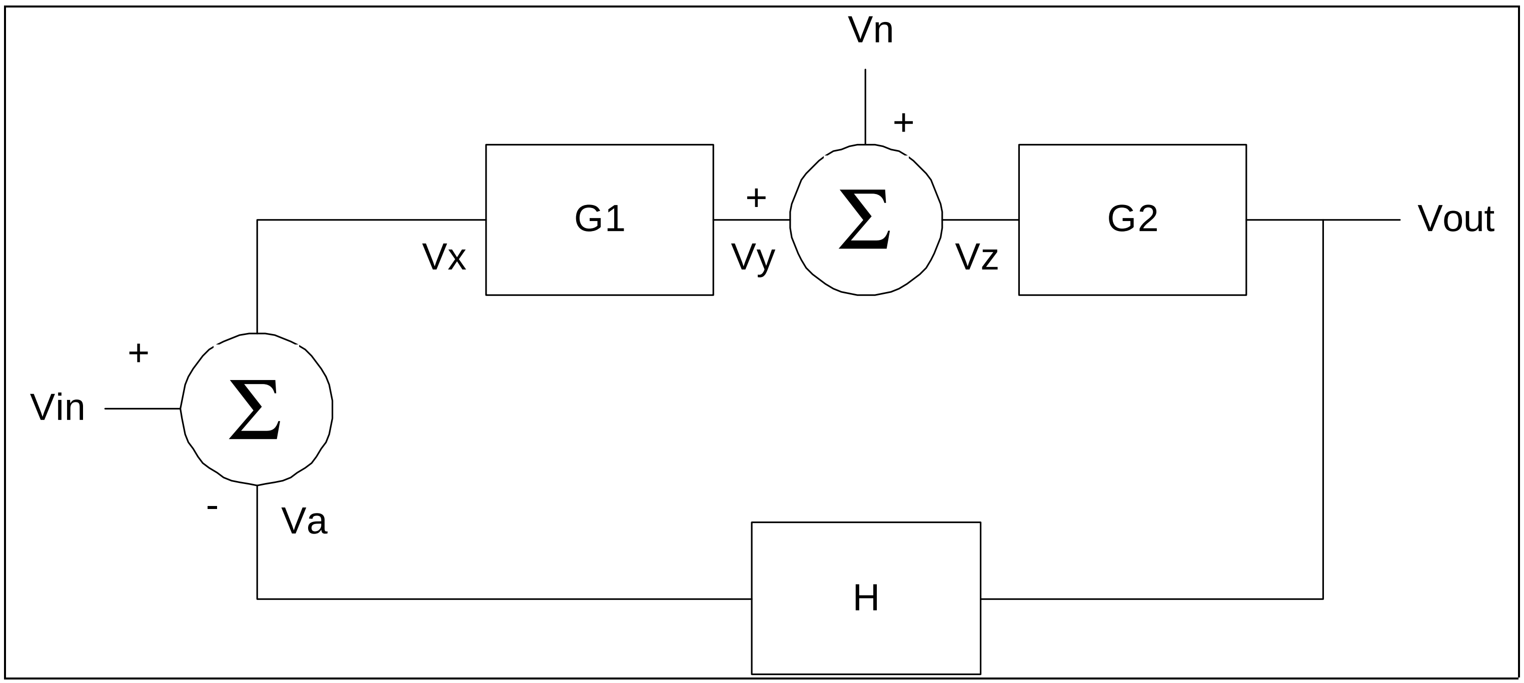

It is often necessary to evaluate the effect of external noise sources on an amplifier's performance. It turns out that an amplifier's sensitivity to noise depends on a number of factors, not the least of which is where the noise enters the signal path. The above diagram illustrates a noise voltage (Vn) entering the loop at a point within the forward signal path of the amplifier. The question naturally arises as to the noise amplitude at the circuit output. The following analysis will develop expressions to answer that question.

$Va = H \cdot Vout$

$Vx = Vin - Va$

$Vy = G1 \cdot Vx$

$Vz = Vn + Vy$

$Vout = G2 \cdot Vz$

Therefore:

$Vout = G2 \cdot [\, Vn + G1 \cdot (Vin - H \cdot Vout)\,]$ Substituting from all of the above expressions

$Vout = G2 \cdot Vn + G1 \cdot G2 \cdot Vin - G1 \cdot G2 \cdot H \cdot Vout$ Completing the indicated multiplications

$$Vout = \left(\frac{G2}{1 + G1 \cdot G2 \cdot H}\right) \cdot Vn + \left(\frac{G1 \cdot G2}{1 + G1 \cdot G2 \cdot H}\right) \cdot Vin$$

Collecting coefficients of Vout, Vn and Vin and then simplifying the expression.

$$Vout = \frac{1}{G1 \cdot H} \cdot \left(\frac{G1 \cdot G2 \cdot H}{1 + G1 \cdot G2 \cdot H}\right) \cdot Vn + \frac{1}{H} \cdot \left(\frac{G1 \cdot G2 \cdot H}{1 + G1 \cdot G2 \cdot H}\right) \cdot Vin$$

Placing the expression in a low entropy forn that illustrates circuit behavior. It can be seen that if G2 is small compared to G1*G2 the noise signal is attenuated relative to the input signal. As long as G1*G2*H>>1, the gain applied to Vin is 1/H. However, in this same case, the gain applied to Vn is 1/(G1*H) and the additional attenuation is clear.

$$\frac{\Delta Vout}{\Delta Vn} = \frac{1}{G1 \cdot H} \cdot \left(\frac{G1 \cdot G2 \cdot H}{1 + G1 \cdot G2 \cdot H}\right) \qquad \frac{\Delta Vout}{\Delta Vin} = \frac{1}{H} \cdot \left(\frac{G1 \cdot G2 \cdot H}{1 + G1 \cdot G2 \cdot H}\right)$$

Taking derivatives of Vout with respect to the two inputs to form the two gain expressions

Now the actual input signal times its' gain determines its' amplitude at the circuit output and the same applies to the noise signal. The ratio of these output signal component amplitudes will give the signal to noise ratio at the output. It must be remembered that the relative magnitudes of the various frequency components of the input signal (and of the noise signal) and their respective gain vs frequency functions (defined above) will need to be included in this analysis. The result is a signal to noise ratio that is a function of frequency. Further analysis of the highlighted equation above reveals that signal to noise ratio is improved (for a given total forward path gain: G1*G2) by moving as much gain as possible to the G1 block that precedes the noise entry point. It must be pointed out that the amplifier is a source of noise all by itself. Low noise applications, especially, must carefully consider internally generated noise but that is a seperate analysis topic.