Improving VCA Performance I

VCA off isolation

Though this discussion is specifically about off isolation, the conclusions can be applied to other signals coupled into the summing node of the VCA's output trans-impedance amplifier.

Say for instance that we want to achieve 100 dB of off isolation with a VCA circuit. The VCA specifications seem to indicate that this should be possible, but lab measurements show poorer isolation, particularly with increasing frequency. The cause of this anomaly is usually a parasitic capacitance, Cp, shown in the diagram below.

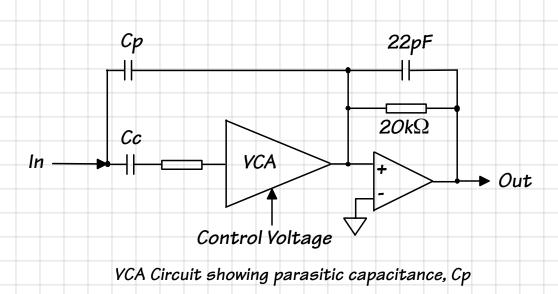The corner frequency resulting from the 22 pF capacitor and the 20 kΩ resistor is

$$f_C = \frac{1}{2\,p \times (2 \times 22 \times 10^{-12}) \times 20k\Omega} = 360kHz$$

Therefore, we know that the 22 pF capacitor is having minimal effect at 20 kHz. To achieve 100 dB isolation, we can see by observation that the gain at 20 kHz that results from Cp and the 20 kΩ resistor must be less than

$$A_V = 10^{\left(\frac{-100}{20}\right)} = \frac{1}{100,000}$$

For this to be the case, the reactance of the capacitor Cp at 20 kHz must be greater than 100,000 times the 20 kΩ resistor, or

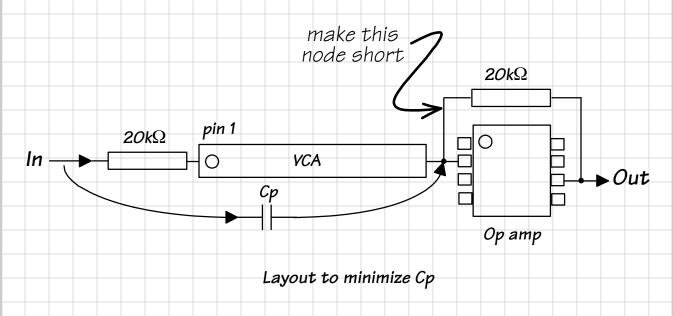$$C_P = \frac{1}{2\,p \times 100,000 \times 20k\Omega \times 20kHz} = 4 \times 10^{-15} = 0.004\ pF$$

VCA Circuit showing parasitic capacitance, Cp

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This is, in fact, a VERY small capacitance, but the layout of the VCA helps in minimizing problems associated with the parasitic component. The drawing below demonstrates how the SIP package, when utilized properly, inherently minimizes the parasitic capacitance.

Layout to minimize Cp

Since capacitance is a 1/d function, any other arrangement that reduces the distance between the input and the trans-impedance amplifiers summing node will reduce off isolation. Area is an issue as well. Most implementations use an electrolytic capacitor for DC isolation at the input. Putting this device right at the summing node will keep this device at virtual ground, and minimize coupling from it to the output trans-impedance amplifier. It will also act as a shield, further reducing capacitance from the input to the output, but it unfortunately also reduces the phase margin of the VCA's input amplifier and acts as an antenna to pick up other stray signals. Other devices, such as bypass capacitors, that are at a DC potential, can be used to create a three dimensional shield around the summing node of the VCA's output trans-impedance amplifier, but make sure that these devices do not also couple noise into the output.

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