Adaptive attack and release rates using THAT Corporation RMS detectors (the Non-Linear Capacitor circuit)

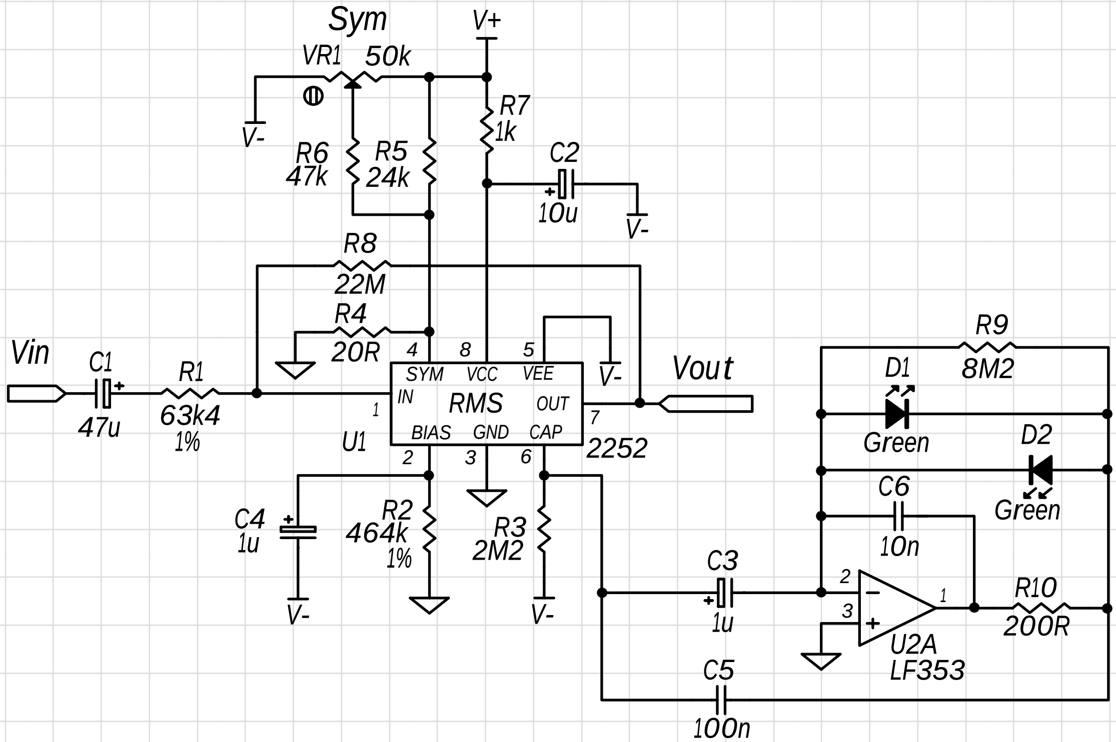
Single-band compressor designs must contend with the trade off between fast detector response (to minimize some compressor artifacts), and low frequency distortion (the result of rectified audio signal on the VCA control port being multiplied by the actual signal in the gain cell). A non-linear capacitor can make this trade-off unnecessary by acting as a large timing capacitor for slow moving signals and as a smaller timing capacitor for fast moving signals. Below is a schematic which shows a THAT2252 RMS detector incorporating a non-linear capacitor circuit.

In this circuit, the RMS detector is configured as a typical detector, but the timing capacitor is replaced with C3, which is connected to the virtual ground at the op-amp's input. The gain of this stage is set by the ratio of C3 and C6. Under conditions where the op-amp's output is not limited by D1 and D2, C5, which is dynamically in parallel with C3, is effectively multiplied by one minus the closed loop gain of the op-amp, which is similar to the well known Miller effect. Under conditions where D1 and D2 limit the output of the op-amp, C5 is simply in parallel with C3, and its effect is negligible.

The simplified transfer functions for this circuit are:

For Steady-State Inputs: $C_{time} = C3 + C5 \times (1 + \frac{C3}{C6})$

For Transient Inputs: $C_{time} = C3 + C5$



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Here are a few tips on fine tuning the values in the circuit:

1. The value of R9, the resistor which provides a return path for the op-amp's bias current, is chosen to produce a minimal DC offset as a result of the bias current. If your diodes are leaky, you may be able to use a much larger value of R9.

2. The value of C6 is chosen so that fc resulting from C6 and R8 is below the audio range.

3. D1 and D2 are green LEDs, which have a forward drop of approximately 2.2V. Red LEDs have a forward drop closer to 1.6V. Anti-paralleled diodes have a forward drop of approximately 0.65V. (All of these voltages depend on the current through the diode.) The limited swing of the op-amp and the maximum permissible short term variation on the RMS detectors output are used to determine the amount of gain needed for proper operation.

4. Assume that you can tolerate 3 dB of short term variation (ripple+RMS output swing) at the output of the RMS detector before the non-linear capacitor switches to fast mode:

$$Av = \frac{2V}{.0065(V/dB) \times 3(dB)} = 102$$

5. In rough terms, for a gain of 100, C3 should be 100 times greater than C6. Thus C3 should be 1 μF.

6. C5 will be multiplied by this gain while the op-amp is not clipping.

$$C5_{effective} \cong Av \times C5$$
$$C5_{effective} \cong 100 \times 100\,nF = 10\,\mu F$$

In other words, for slowly changing signals, the total effective timing capacitance will be

$$C_{time} = C3 + C5_{effective}$$
$$C_{time} = 1\,\mu F + 10\,\mu F = 11\,\mu F$$

Though this design uses a THAT 2252, all of the principles apply to the RMS detector in the THAT 4301 as well.

For a more detailed explanation of the non-linear capacitor, see THAT Corporation application note AN103, page 7, "Extra Credit: The Non-Linear Capacitor."

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