A simple, effective soft-knee compressor / limiter

The circuits within this application note feature THAT4301 Analog Engine® to provide the essential elements of voltage-controlled amplifier (VCA) and rms-level detector (RMS), or the THAT2180C (VCA) and 2252 (RMS). Since writing this note, THAT has introduced several new models of Analog Engines, as well as new VCAs. With minor modifications, these newer ICs are generally applicable to the designs shown herein, and may offer advantages in performance, cost, power consumption, etc., depending on the design requirements. We encourage readers to consider the following alternatives in addition to the parts shown in the note:

- Low supply voltage and power consumption: 4320

- Low cost, supply voltage, and power consumption: 4315

- Low cost and power consumption: 4305

- High-performance (VCA only): 2180-series, 2181-series

- Dual (VCA only): 2162

For more information about making these substitutions, please contact THAT Corporation's technical support group at apps_support@thatcorp.com

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The schematic shown in Figure 1 is a basic soft-knee compressor/limiter circuit that can be used as-is or as the basis for a more sophisticated design. The circuit consists of a THAT2180C VCA, a THAT2252 RMS level detector, a few op-amps, and a handful of passive components. An alternative would be to use a single THAT4301 (which comprises the VCA, RMS-Detector, and three general purpose opamps) and some passive components, as shown in Figure 2.

Referring to Figure 1, the design is a variation on a classic soft knee compressor. The RMS detector, U4, has a 20 Ω resistor, R18, connecting the symmetry port and the RMS input, which is held at virtual ground by feedback in the current rectifier. This resistor replaces, for simplicity, the potentiometer normally used to reduce ripple asymmetry in the output of the detector. This connection will result in slightly more ripple asymmetry, but should be acceptable in most applications.

Otherwise, the RMS detector is configured according to the recommended practices in the THAT2252 datasheet. The circuit shown programs the detector to have 0 V out at an input level of 0.5 Vrms (this reference level is usually set to correspond with the average expected signal level). The various device currents in the THAT2252 are inter-related, so use the following design procedure to set its operating parameters:

Define $V_{CC} := 15V;\ V_{EE} := -V_{CC} := -15V;\ V_d := 0.7V;\ V_t := 26mV;$ **and**

$V_{in_{REF}} = 0.5\ Vrms \approx -6\ dBV.$

Further define KGAIN := 6.1 mV/dB, the gain control voltage constant for the THAT2252.

First, set the timing current, It, equal to the recommended value of 7.5 µA. This yields a timing resistor value of

$R7 = \frac{V_{EE} + 2\,V_d}{I_t}$, **or** $R7 \approx 2.2\ M\Omega$

Then set the detector's release rate. We have found over the years that a value of approximately 120 dB per second provides the best sound without introducing noticable distortion. So, defining RelRate := 120 dB/second, the rate of change required of the detector's output voltage becomes:

$VC = KGAIN \times RelRate = \left(6.1 \times 10^{-3}\right) \times 120 = 732\ mV/s$

The timing capacitor, C4, becomes $C4 = \frac{I_t}{V_c} \approx 10\ \mu F$

Now, to obtain the proper input signal level scaling, we let IBIAS = 24 µA, the recommended value from the datasheet. The bias resistor R17 then becomes

$R17 = \frac{|V_{EE}| - 2.1}{I_{BIAS}} \approx 536\ k\Omega$

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The input reference current, again from a formula in the datasheet, is

$$I_{in_{REF}} = \sqrt{\frac{I_{BIAS} \times I_t}{2.9}} \approx 4.6\,\mu A$$

The input resistor, is calculated as $\quad R1 = \dfrac{V_{in_{REF}}}{I_{in_{REF}}} = \dfrac{0.5}{4.6 \times 10^{-6}} \approx 107\,k\Omega$

The threshold in this circuit is determined by linREF of the RMS detector, since the output of the threshold amplifier cannot cause a reduction in gain until the detector output goes above 0 VDC. The gain potentiometer VR2 sets the gain of the VCA below threshold, and the connection through R4 to the threshold amplifier keeps the threshold at a fixed level referenced to the output.

VR3 adjusts the compression ratio. At one end of the potentiometer, the compressor acts like an above-threshold limiter, while at the other end, there is no compression.

The VCA is configured according to the THAT2180 datasheet recommendations.
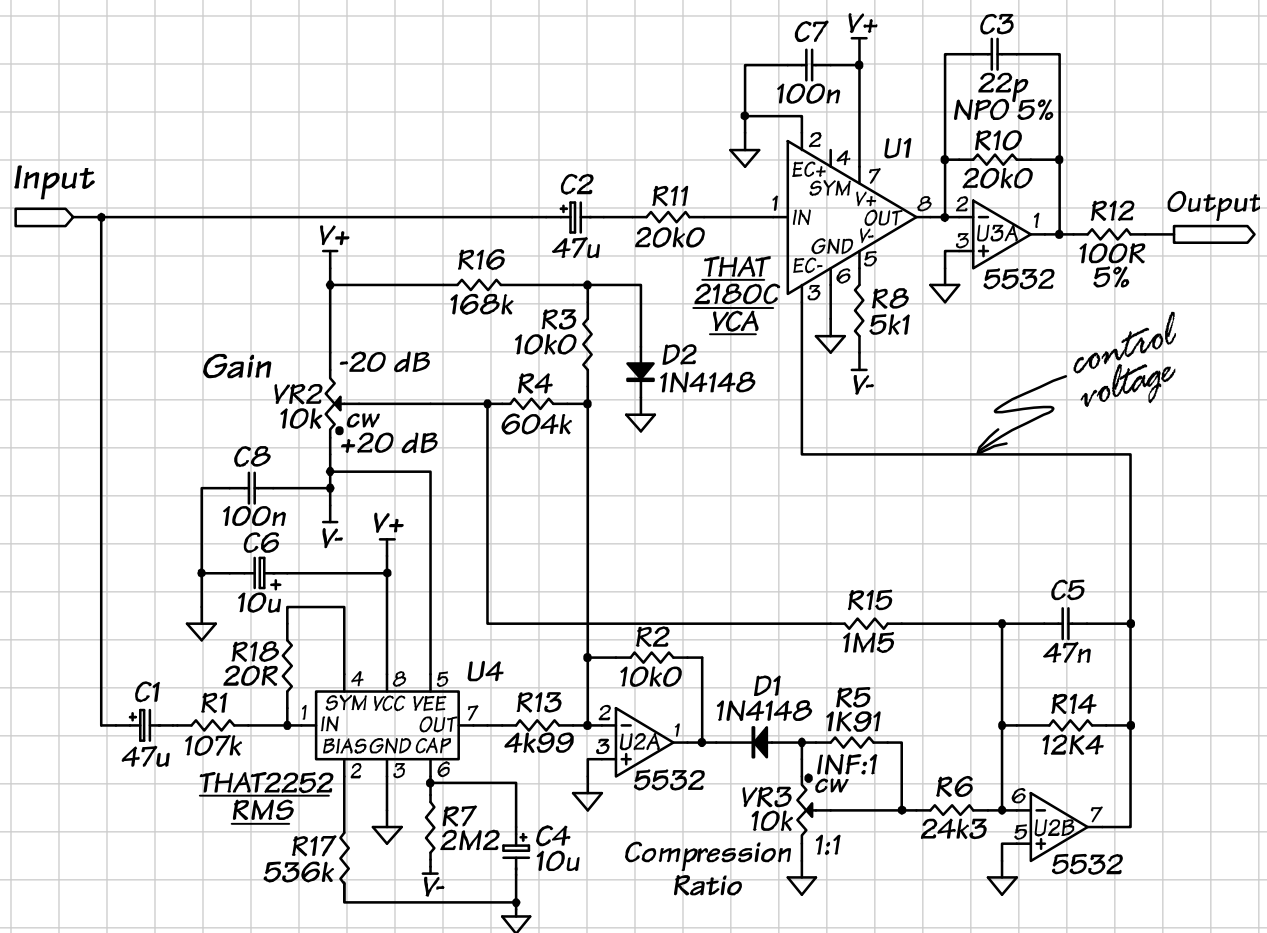
Figure 1. Basic soft-knee compressor / limiter circuit

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A similar circuit based on the THAT4301 is shown in Figure 2. An obvious advantage to the use of the 4301 is the reduced parts count and board space. One disadvantage is the requirement that the symmetry be trimmed on the 4301. This is not a difficult step, but it has to be done to guarantee acceptable performance. Otherwise, the circuit should perform admirably, and it is very simple to implement. Note that there are some slight differences in the calculated values due to differences in the devices. For complete specifications see the THAT4301 datasheet
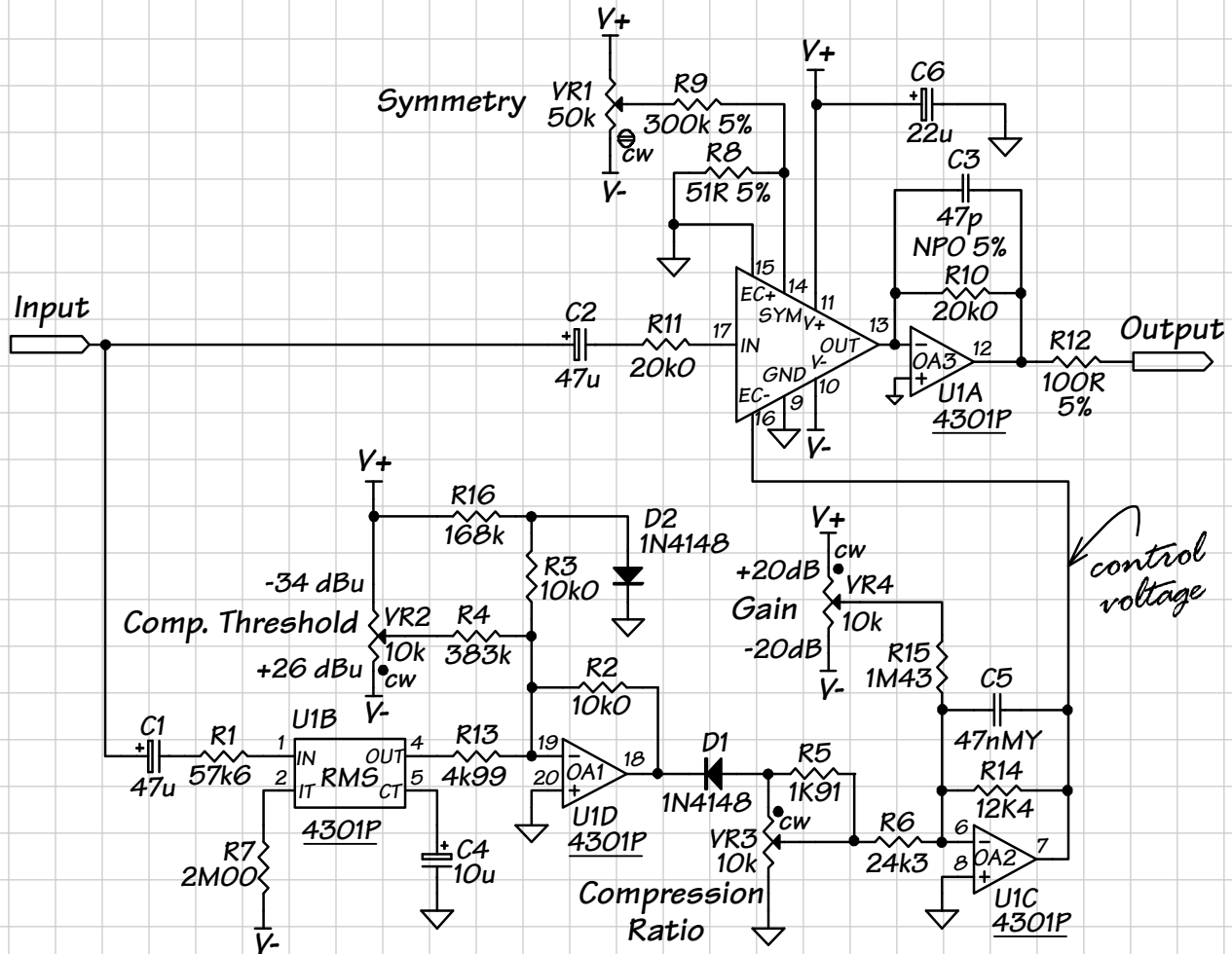

Figure 2. Soft-knee compressor / limiter using the THAT 4301

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