Interchanging the THAT2181Lx and the THAT215x series of VCAs

Introduction

THAT Corporation offers its trimmable voltage-controlled amplifiers (VCAs) in two different series: the venerable 215x series and the more recent 2181 series. We recommend use of the 2181 for new designs primarily because of its superior distortion performance, particularly at gain, cut, and at higher input levels, and because of its extended frequency response. Also, unlike the 215x, the 2181 version is available in a surface mount package.

Like so many other components, however, the 2181 series is subject to spot shortages and long lead times during periods of high demand or when supplies are low. At such times, the 215x series can act as a second source, at least for users of the single-inline-package (SIP) versions of the 2181. This paper discusses what must be done to allow either VCA to be used interchangeably in a given product.

Circuit and layout changes

The THAT2181Lx ('L' designates the SIP version) and the THAT 215x are not 100% drop-in compatible, though the differences are minor and easily accommodated in new designs. The following are the differences that must be taken into account so that your design can accept either the 215x or the 2181Lx series.

- The various grades of 215x and 2181Lx are distinguished primarily by their THD specifications. Please check the datasheets of each product to determine the proper grade of each series suitable for your application.
- The 215x series requires an additional 51Ω resistor between the EC+ and SYM pins as discussed later in this paper.
- The compensation capacitor around the external current-to-voltage op-amp at the output of the VCA must be increased when using a 215x to avoid oscillation.
- The values of the external trimming components (connected to the SYM pin) are changed to accommodate for differences in the trimming characteristics of the two series.
- The supply voltage range for the THAT 215x series is ±5V to ±18V, whereas the supply voltage range for the THAT 2181Lx series is ±4V to ±20V. If the maximum supply voltage is an issue in your design, THAT Corporation's Design Note 123 describes a technique for overcoming a VCA's supply voltage limitations by taking advantage of its "current in / current out" transfer characteristic.

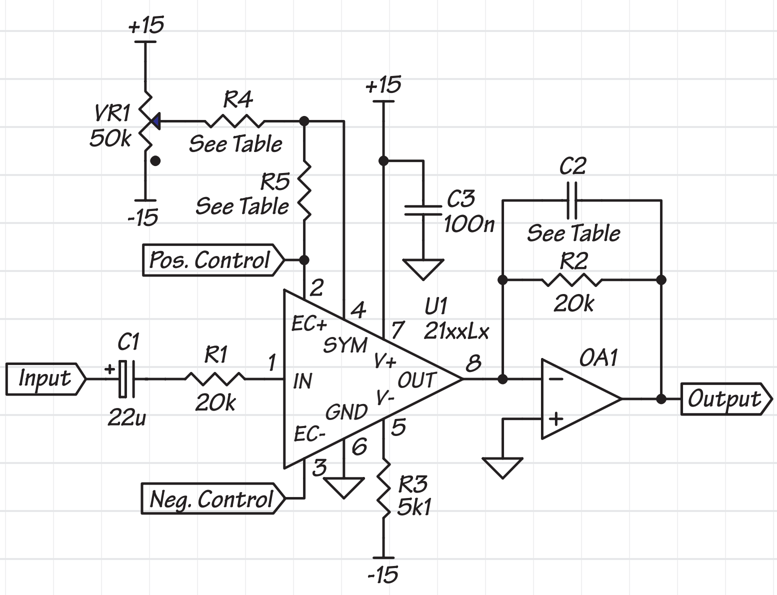

Figure 1: Generic VCA circuit

The circuit in Figure 1 shows a generic VCA circuit that can be adapted for use with all of THAT Corporation's standalone VCAs by the inclusion or omission of different values of components. This circuit allows complementary drive of both control ports, but unidirectional (single-ended) drive of either control port can be achieved by grounding the undriven port.

The components which change from one VCA series to the other are VR1, R4, R5, and C2. Table 1 shows a matrix of the correct component values to use with different THAT Corporation VCAs.

The use of the table is self explanatory, but note that an additional external resistor is required when using the 215x series.

This 51Ω resistor, R5, should be added directly between pins 2 and 4. Not doing so is one of the more common implementation errors with THAT Corporation's VCAs.

VCA	C2	VR1	R4	R5
2151	47p	50 kΩ	470 kΩ	51Ω
2150A	47p	50 kΩ	390 kΩ	51Ω
2155	47p	50 kΩ	300 kΩ	51Ω
2181 LA	22p	50 kΩ	680 kΩ	-
2181 LB	22p	50 kΩ	240 kΩ	-
2181 LC	22p	50 kΩ	150 kΩ	-

Table 1: VCA specific component values

Theoretical considerations

Due to mismatches between certain internal components, both the 215x and 2181Lx VCAs require an external voltage divider network connected to pin 4. When properly adjusted, this divider network injects a voltage which compensates for the internal mismatches and minimizes the 2nd harmonic distortion that can otherwise result.

Figure 2 is taken from the THAT 2181x data sheet and shows a simplified internal schematic of the THAT 2181Lx VCA. One can see from this schematic that the base of lower logging transistor Q3 is cross-coupled to the base of upper anti-logging transistor Q2. Q1 and Q4 are similarly cross-coupled by way of a 27Ω resistor. When it comes to the 215x series, however, this connection is made externally (by R5, with a value of 51Ω).

In either case, the purpose of the resistor connecting the bases of Q1 and Q4 is to allow an external symmetry voltage to be applied to the base of Q4. This symmetry voltage, in turn, compensates for variations between the transistors of the gain cell, thereby minimizing 2nd harmonic distortion. In practice, pins 2 and 4 should never be more than a few millivolts apart.

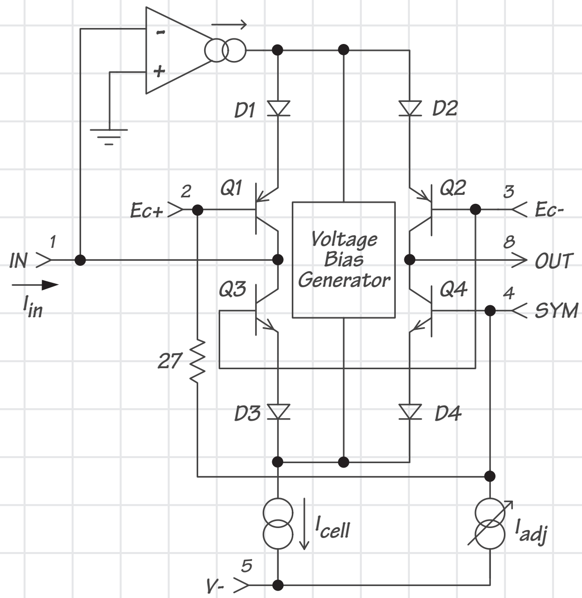

Figure 2: Simplified Internal Circuit Diagram

In addition to reducing distortion, properly setting the symmetry voltage will minimize any DC offset changes ("thumps") that may occur with changes in gain.

As noted previously, when using the 215x series R5 should be connected directly between EC+ (pin 2) and SYM (pin 4), even when EC+ (pin 2) is grounded. This direct connection avoids any significant impedance between pin 2 and ground. Otherwise, any substantial ground currents (such as those which can occur when shield currents or relay drive currents are shunted through ground paths near the VCA) could result in error voltages developing at the control ports, resulting in a performance degradation. A good grounding scheme, of course, makes this concern superfluous, but we feel obligated to mention the issue since we have seen these mistakes in the past.

Summary

With very little effort, engineers can design their products to accept both the 2181Lx and 215x VCA series. Doing so provides some semblance of second sourcing, and helps ensure continued supply of VCAs even when one or the other series is in short supply.

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