



Upgrading Modular VCAs with the Sonic Imagery Labs 312A Discrete VCA Amplifier

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The 312A VCA module is a very high performance device offering wide range exponential control of gain and attenuation with very low audio program signal distortion. The 312A VCA module is a powerful and versatile building block with applications ranging from radio AGC, compressors, limiters, expanders, to microprocessor controlled faders. Its application is merely limited to the designer's imagination.

The circuits within this application note feature the Sonic Imagery Labs Model 312A to provide the essential function of a voltage-controlled amplifier (VCA). In many cases, a fully analog signal path provides the least compromise to sonic integrity, and ultimately delivers the best sounding audio program material.

The appearance of the first modular VCAs in the late 1960s and early 1970s accelerated the field of fader automation and dynamics control. While the performance of early VCAs is lacking by today's standard specifications, many of the early SSL, Quad-8, Harrison, Sony and MCI consoles built during that era are still in operation. When a channel fails, most operators will need to repair the channel strip rather than replace the entire console. This now presents the problem of how to replace VCA modules that may not have been in production for many years.

The Sonic Imagery Labs Model 312A VCA is a footprint-compatible upgrade to these early VCAs. In most cases, upgrading to the Sonic Imagery Labs Model 312A VCA is simply a matter of altering the components surrounding the old VCA to those of the recommended schematic for the newer higher performance Model 312A VCA module. There are a number of circumstances, however, where the situation is not so straightforward. In order to replace the VCA in these latter implementations, it is beneficial to understand the nuances of the device's operation and the constraints placed on its performance by the technology at the time the older device was designed.

FIGURE 1. shows the basic connections of the Sonic Imagery Labs Model 312A VCA Module. The Model 312A can be shunt jumper configured to be a current in-current out, voltage in-current out device, voltage in-voltage out or current in-voltage out device. Additionally, the gain control input of the Model 312A can be shunt jumper configured to allow either positive or negative (inverting or non-inverting) gain control voltage to control the device.

In the following upgrade situations, the Model 312A is shunt jumper configured to be a current in-current out device. Additionally, the gain control input (EGC VOLTAGE) of the Model 312A is shunt jumper configured to be a negative (inverting) gain control voltage. In this configuration the INPUT of the 312A module is a virtual ground and the OUTPUT drives current into the virtual ground of an external opamp. Refer to the Sonic Imagery Labs Model 312A VCA datasheet for other mode setups.

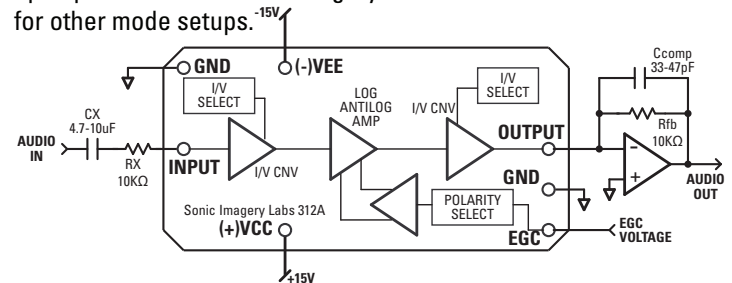


FIGURE 1. Basic connections for current-in and current out mode of operation.

Referring to FIGURE 1., with RX and Rfb set to 10K ohms, a -10dBV input signal at the AUDIO IN node will produce a -10dBV signal at the AUDIO OUTPUT with the EGC VOLTAGE at 0 VOLTS. The Model 312A has a gain constant of 50mV/dB (20dB/Volt). With the EGC polarity set to be negative, when the EGC Voltage is -1.0 volts, the VCA will have 20dB of gain. The -10dBV signal at the AUDIO IN node will produce a +10dBV signal at the AUDIO OUTPUT. Conversely, when the EGC Voltage is +1.0 volts, the VCA will have 20dB of attenuation. The -10dBV signal at the AUDIO IN node will produce a -30dBV signal at the AUDIO OUTPUT.

The EGC input pin is connected directly to the non-inverting input of a single ended to differential voltage to current convertor. The common mode input impedance is typically 100 megaohms or greater. This pin has a leakage current typically of 10 to 50nA. Due to this low leakage and high impedance, the EGC pin does not have to be driven from a near zero output impedance driver as do other VCA modules and monolithic IC VCA's.

Vintage modules have an additional pin called SYM or SYMMETRY. Older equipment has this adjustment off the VCA module and on the mainboard connected through the pin called SYMMETRY. By incorporating this trim on the Model 312A, the adjustment node is less susceptible to noise pickup, temperature and drift errors. It is typically adjusted at the factory. Refer to the datasheet for details.



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VCA Module Upgrade Notes:

FIGURE 2. shows the basic connections of an early VCA module dubbed the dbx 202 "Black Can." It was called the black can because of its glossy black, drawn steel enclosure that encased the electronics. This VCA suffered some technical short comings.

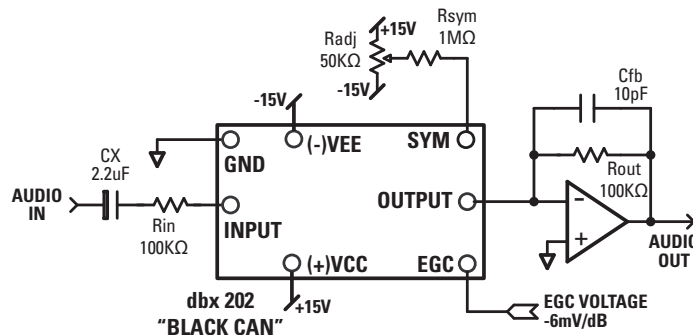


FIGURE 2. The original "Black Can" dbx 202 module basic connections

At high signal levels, and particularly with gain or attenuation, transistor parasitics resulted in distortion which limited the maximum signal current. This in turn limited the modules dynamic range. At low signal levels, the limiting factor was shot noise in the gain cell and the cells quiescent current. Lastly the EGC control voltage sensitivity of the Black Can 202 is -6mV/dB. This low sensitivity makes the program material susceptible to unwanted modulation if the module is in the presence of external noise sources and this noise couples to the EGC line. The circuit shown in FIGURE 3 at the left is designed to drive the "BLACK CAN" 202 with a -6mV/dB control voltage constant.

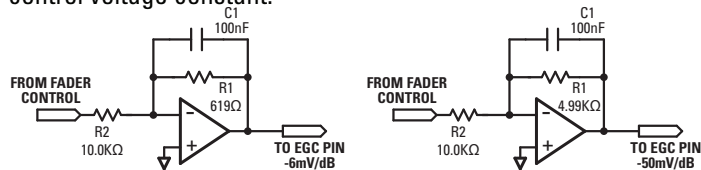


FIGURE 3. Retrofitting and accounting for the change in the control voltage constant.

If upgrading to the Sonic Imagery Labs Model 312A VCA, the user also must increase the gain of the control port drive by a factor of

$A_v = (50\text{mV/dB}) \text{ divided by } (6.1\text{mV/dB}) \text{ for an increase of } 8.2.$

Thus, if the control port buffers feedback resistor was 619 ohm, then the new value would be 4.99K ohm.

This new value is shown in the circuit on the right in FIGURE 3. Changing the gain immediately ahead of the VCAs control port not only scales the control voltage constant correctly, it also correctly scales any offsets that might have been added earlier in the drive circuitry.

FIGURE 4. shows the basic connections of the dbx 202C "Gold Can." It provided better dynamic range than the 202 and the control voltage constant was changed to be -50mV/dB. The -50mV/dB constant became the standard for most VCA modules from this era forward to present day. Error correction circuitry was added to the 202C to reduce the distortion at higher current levels. This also allowed the input and output resistors to be lowered helping the Kv and shot noise.

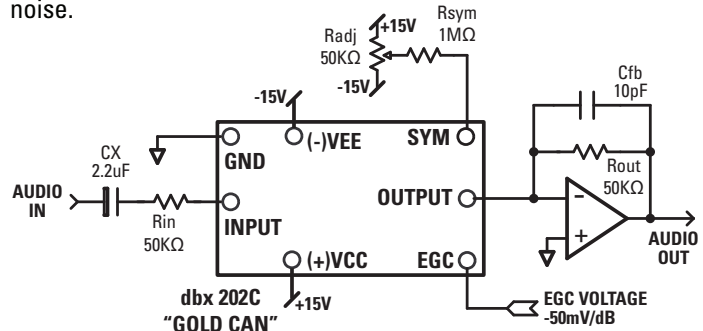


FIGURE 4. The "Gold Can" dbx 202C module basic connections. The 202C had internal correction circuitry

While the 202C "Gold Can" provided a 5X improvement in intermodulation distortion referenced to the standard 202, the change barely kept pace with the development of VCAs elsewhere. Allison Research and Valley People also started manufacturing of Class A VCA modules using different VCA and transistor topologies.

During this time, dbx chose to develop its own Class A VCA, the dbx2001, housed in a silver enclosure. Class A operation resulted in a substantially higher noise floor, resulting from higher currents through the VCA gain cell and the correspondingly higher shot noise. However, some users claimed to prefer the sound of this device because of its lower harmonic distortion. Since the logging elements in the lower and upper halves of the gain cell both contained NPN and PNP transistors, the requirement for a log slope correction was eliminated.



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VCA Module Upgrade Notes:

FIGURE 5. shows the basic connections of the dbx 2001 "Silver Can." The dbx2001 is primarily of interest because, in spite of the fact that it works some what differently from the 202s that came before it, the Sonic Imagery Labs Model 312A VCA can be used to retrofit a console built with dbx2001s without changing the input and output resistors.

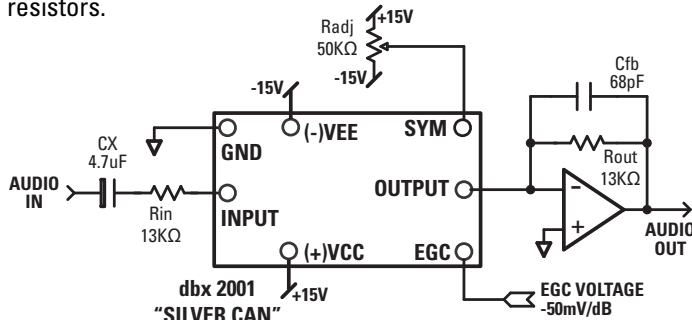


FIGURE 5. The "Silver Can" dbx 2001 module basic connections. The last VCA with equal input and output resistors.

Though ideally the Sonic Imagery Labs Model 312A VCA wants the input and output resistors to be 10K ohm for unity gain with the EGC voltage at 0. Using the values shown in FIGURE 5. shifts the gain slope down 2.3dB while the 13K at the output provides a current to voltage gain of 2.3dB. The dbx2001 was the last VCA module with recommended equal input and output resistor values.

Subsequent modular VCAs from dbx no longer utilized drawn steel cans and equal input and output resistors. The first of these integrated circuit hybrid modules was the dbx202X.

Since there were 8 IC VCAs in this module, and each had a 10K ohm resistor in series, the net internal input resistance was 1.25K ohms. As a result, the input resistance is 1.25K ohms less that of the output resistor. This situation is reflected in the recommended circuit, shown in FIGURE 6. Note that the can was eliminated from this and all subsequent 202 series modules.

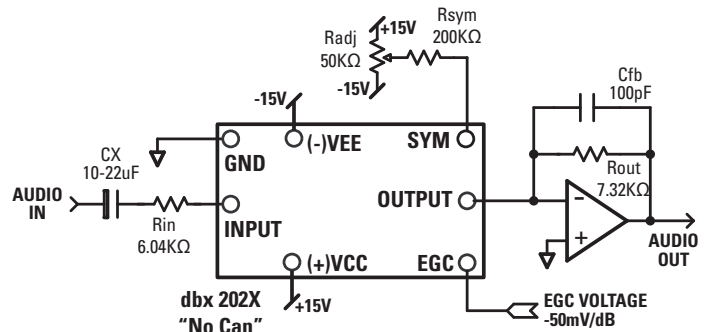


FIGURE 6. The dbx 202X module basic connections. The first hybrid IC VCA.

Integrated circuit fabrication offers some distinct advantages over the use of discrete components, particularly with regards to parametric and thermal matching. The downside is that the designer is typically required to allow for lower performance in certain parameters, particularly minimum transistor beta and maximum device current. In particular, comparatively large parasitic resistance in the transistor collectors affected the way these devices saturated, which in turn resulted in the dbx202X having a noticeable "thump" coming out of mute. FIGURE 7 shows the recommended schematic for the dbx 202XL, the next model in this series of modules. This model used complementary control port drive to mitigate the "thump" problem. Unfortunately, this particular implementation exacerbated another problem which was noise modulation. This effect is the result of the fact that all log/anti-log VCAs are multipliers, and noise on the control port is exponentiated and then multiplied by the output signal. Note that this effect can only be observed in the presence of signal.

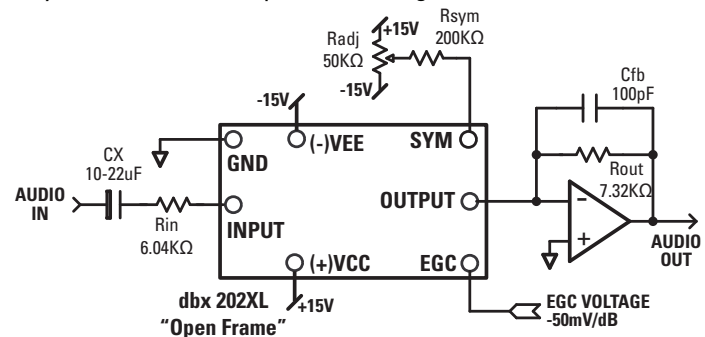


FIGURE 7. The dbx 202XL used complementary control port drive, but suffered from excessive noise modulation.



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Replacement Considerations:

Acquiring an original functioning dbx, Valley People, Allison Research or Symetrix VCA module may be impossible. Once you've identified your particular module to be replaced, retrofitting or replacing one of these older modules is usually a simple matter of updating the circuitry around the VCA to the values appropriate for the Sonic Imagery Labs Model 312A VCA. See **FIGURE 1**. Using the 312A VCA in place of the obsolete or failed module will typically exceed original factory specification especially in the areas of noise floor, dynamic range and harmonic distortion performance.

There are, however, some circumstances where it takes additional thought to replace the VCA. One of these situations is when one needs to maintain an atypical gain structure. All of the recommended schematics in this application note assume zero dB of standby gain. Stand by gain (or loss) is the net gain of the VCA from input to output when the control port is at zero (0V) volts.

If the user requires a standby gain of -6dB, the input resistor (shown as RX, 10K Ω in **FIGURE 1**) can be scaled to convert the ac input voltage to a current within the linear range of the 312A VCA module. For example, if RX is changed to 20.0K Ω the exponential control is shifted by -6dB of gain. See **FIGURE 8**. for additional values.

The output resistor (shown as Rfb, 10K Ω in **FIGURE 1**) can be scaled to convert output current to a voltage with additional gain. For example, if Rfb is changed to 20K Ω the output will have an additional 6dB of gain. This is also sometimes referred to as offset gain. See **FIGURE 9**. for additional values.

Rx VALUE	MODULE GAIN/LOSS
20.0K	-6.02 dB
17.8K	-5.00 dB
16.9K	-4.55 dB
15.0K	-3.52 dB
14.0K	-2.92 dB
11.8K	-1.43 dB
10.0K	0 dB (unity)
8.45K	1.46 dB
6.98K	3.12 dB
5.90K	4.58 dB
4.99K	6.02 dB
2.49K	12.07 dB
1.24K	18.13 dB

FIGURE 8. The value of Rx controls the offset of the gain slope when the EGC is at 0 volts. This is also referred to as stand by gain. Stand by gain is the net gain (or loss) of the VCA from input to output when the control port is at zero (0V) volts.

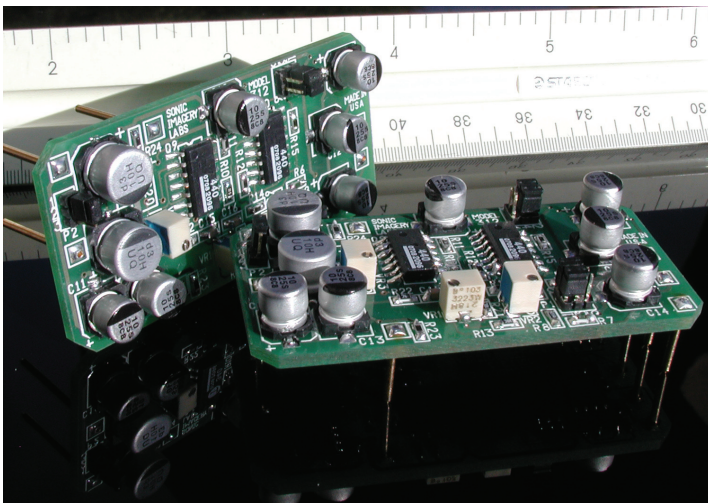
Rfb VALUE	MODULE GAIN/LOSS
20.0K	6.02 dB
17.8K	5.00 dB
16.9K	4.55 dB
15.0K	3.52 dB
14.0K	2.92 dB
11.8K	1.43 dB
10.0K	0 dB (unity)
8.45K	-1.46 dB
6.98K	-3.12 dB
5.90K	-4.58 dB
4.99K	-6.02 dB
2.49K	-12.07 dB
1.24K	-18.13 dB

FIGURE 9. The value of Rfb controls the gain of the output current to voltage convertor. This is also sometimes referred to as offset gain.



Model 312A Discrete Voltage Controlled Amplifier Module

The Model 312A voltage controlled amplifier is a high-performance voltage controlled amplifier or electronic gain control (VCA-EGC) designed for audio or instrumentation applications where low distortion, low noise, low control-voltage feed through and exceptional gain control characteristics are of primary importance. The 312A approaches immeasurably small intermodulation and total harmonic distortion independent of gain, input, or output levels. The 312A has been designed using precision matched pair discrete SMD component technology, resulting in outstanding performance, high reliability, temperature stability and wide dynamic range. It is pinned out for industry compatibility.



The gain versus control voltage characteristics of the 312A are an exponential function (20db/volt) allowing the designer to easily and accurately program the gain in decibels. The all discrete VCA core boasts a gain-bandwidth product of better than 50Mhz, resulting in full audio bandwidth at 60dB of gain without slew rate distortion error.

The Model 312A can be shunt jumper configured to be a current in-current-out, voltage in-current-out device, voltage in-voltage-out or current in-voltage-out device. Additionally, the gain control input of the Model 312A can be shunt jumper configured to allow either positive or negative (inverting or non-inverting) gain control voltage to control the device.

PRODUCT BRIEF

The Model 312A VCA-EGC module can be utilized in voltage controlled automation consoles, filters, gates, compressors, oscillators, test instrumentation, radio AGCs and any other signal modifier circuits where voltage controlled amplification is required.

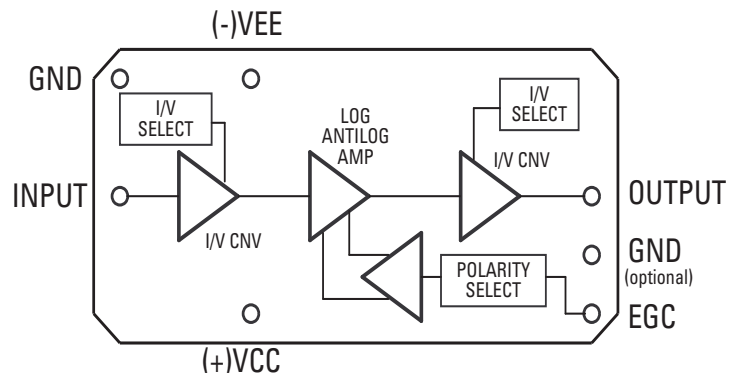
Features:

- Ultra Low Total Harmonic Distortion, 0.005 THD+N @ 1kHz
- Ultra Low Noise <4.4nV/rtHz typical
- Wide Dynamic Range >100dB typical
- Wide Gain Range
- Simplified Standard Retro/Upgrade Footprint
- Operates over $\pm 12V$ to $\pm 16V$ supply rails
- Low Control-Voltage Feedthrough
- I-In, I-Out or V-In, V-Out Selectable Operation
- Selectable Gain Control Operation (pos/neg)
- Particular emphasis on audio performance
- Designed, assembled and produced in the USA
- 3 Year Warranty

Applications:

- Voltage Controlled Faders and Panners
- Voltage Controlled Filters and Equalizers
- Gates and Expanders
- Compressors and Limiters
- Voltage Controlled Oscillators
- Automatic Gain Control (AGC)

Connection Diagram (Top View)





Model 312A Discrete Voltage Controlled Amplifier Module

PRODUCT BRIEF

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This now presents the problem of how to replace VCA modules that may not have been in production for many years.

The Sonic Imagery Labs Model 312A VCA is a footprint-compatible upgrade to these early VCAs. In most cases, upgrading to the Sonic Imagery Labs Model 312A VCA is simply a matter of altering the components surrounding the old VCA to those of the recommended schematic for the newer higher performance Model 312A VCA module. The user is encouraged to read Sonic Imagery Labs application Note AN-16 for more information.

Specifications and audio performance data is published in the Sonic Imagery Labs Model 312A Discrete Voltage Controlled Amplifier Module datasheet.

Package Diagram:

