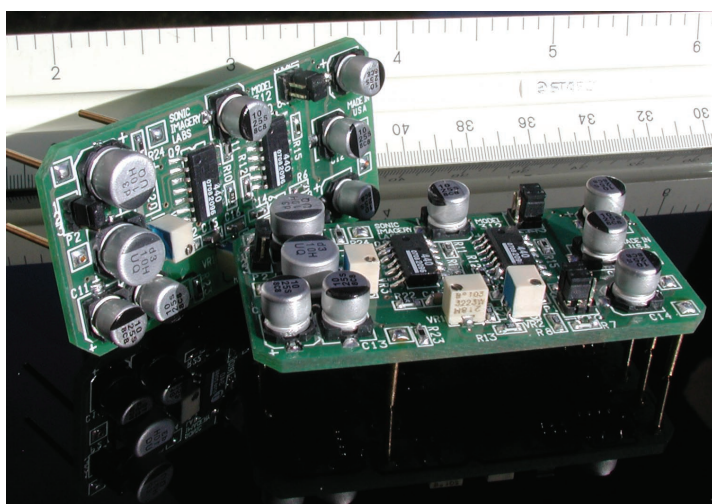




Model 312A Discrete VCA-EGC Module

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 feedthrough 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.

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.

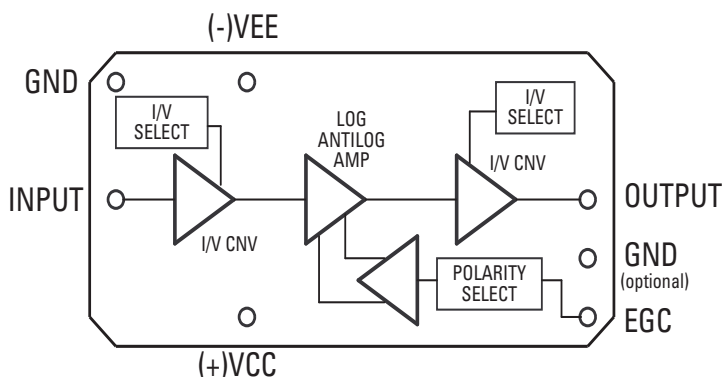
Features:

- 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)

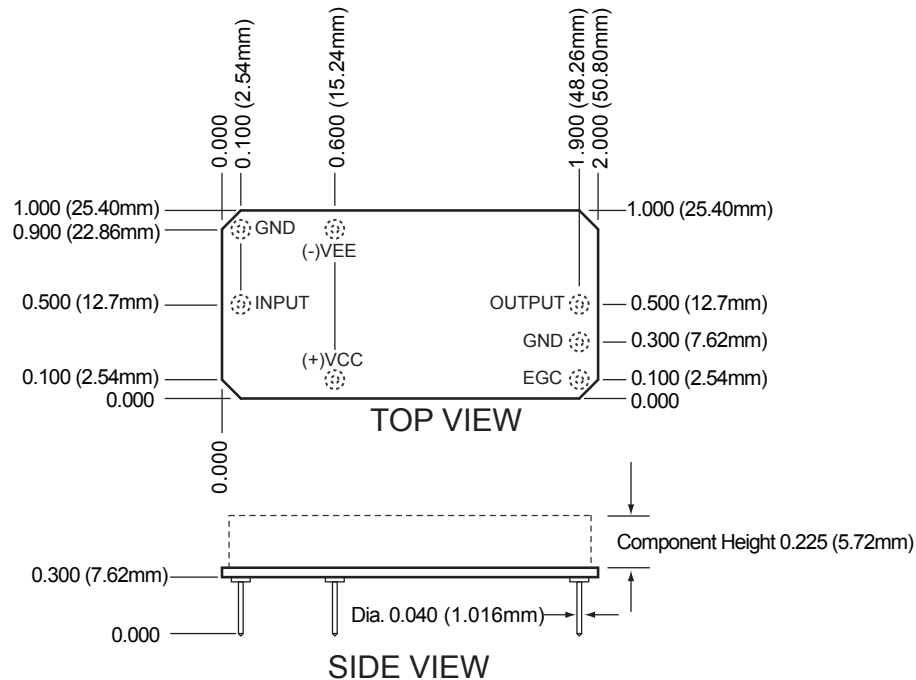
Connection Diagram (Top View)





Model 312A Discrete VCA-EGC Module

Package Diagram:



Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only; the functional operation of the device at these or any other conditions above those indicated in the operational sections is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Absolute Maximum Ratings:

Positive Supply Voltage	VCC	+19.5V
Negative Supply Voltage	VEE	-19.5V
Supply Current (either)	Ic	55mA
Operating Temperature Range	T _{OPR}	-10 to +70°C
Storage Temperature Range	T _{STG}	-60 to +150°C
Maximum EGC Voltage	EGCv	±15V
Power Dissipation (Pd) (Ta=+70C)	Pd	560mW

Recommended Operating Conditions:

Positive Supply Voltage	VCC	+15V
Negative Supply Voltage	VEE	-15V
Signal Current (current-in mode)	Iin	2 uA



Model 312A Discrete VCA-EGC Module

DC Electrical Characteristics (Ta=25°C, Vs=±15V unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V _{CC}	Positive Supply Voltage	-	-	15	16.5	V
V _{EE}	Negative Supply Voltage	-	-	-15	-16.5	V
I _{CCQP}	Quiescent Current Positive	Vout=0V, Vin=0V	-	35	37	mA
I _{CCQN}	Quiescent Current Negative	Vout=0V, Vin=0V	-	34	36	mA
I _{BIAS}	Input Bias Current	Vout=0V	41	30	500	nA
I _{OS}	Input Offset Current	Vout=0V	38	35	400	nA
V _{OM}	Output Voltage Swing	Vs=±15V, R _L =600Ω, 0.1%THD	-	26.5	26.7	V _{pp}
V _{OFF0}	Output Offset Voltage	0dB gain, Vin=0V	-	1	1.5	mV
V _{OFF+20}	Output Offset Voltage	20dB gain, Vin=0V	-	3.5	4	mV
V _{OFF-20}	Output Offset Voltage	-20dB gain, Vin=0V	-	0.3	0.4	mV
V _{CM-IN}	Input Common-Mode Range	Vs=±15V R _L =600Ω	-	24	25.5	V _{pp}
CMRR	Common-Mode Rejection Ratio	R _L =600Ω	88	98	-	V
PSRR	Power Supply Rejection Ratio	-	-	>85	-	dB
EGC+	Gain Control Constant	-60dB<gain <+40dB	-	50	-	mV/dB
EGC-	Gain Control Constant	-60dB<gain <+40dB	-	50	-	mV/dB
A _{VL}	Gain Control Linearity	-	-	0.7	-	dB

AC Electrical Characteristics (Ta=25°C, Vs=±15V unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
SR	Slew Rate	R _L =2KΩ	18	19	20	V/uS
SR	Slew Rate	R _L =600Ω	18.5	19	19.5	V/uS
GBW	Gain Bandwidth Product	20Hz to 100kHz	-	>50	-	MHz
I _{out}	Maximum Peak Output Drive Current	R _L =2KΩ	-	24	-	mA

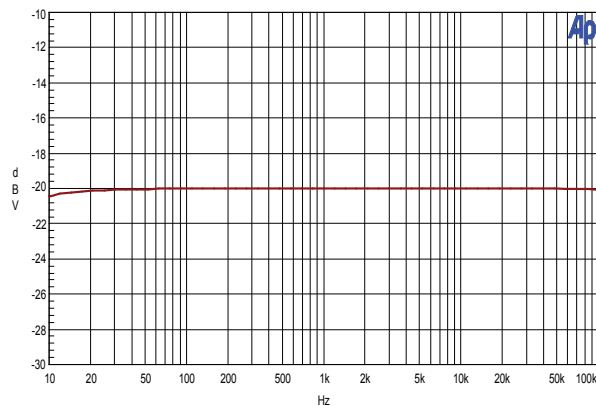
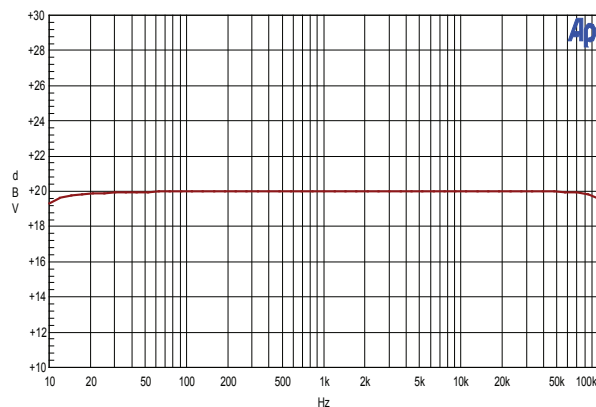
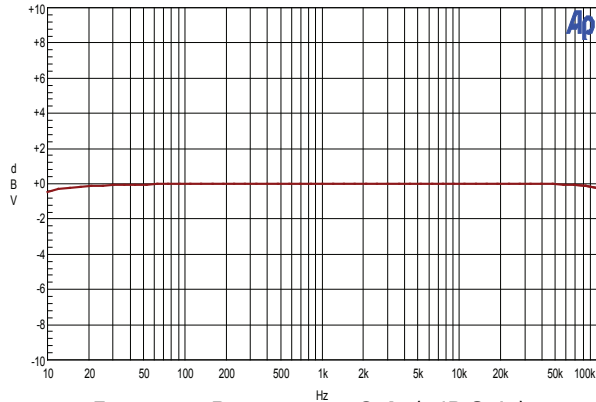
Design Electrical Characteristics (Ta=25°C, Vs=±15V unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
THD	Distortion+Noise (+10dBV input)	R _L =2KΩ Unity Gain @1kHz	-	0.004	-	%
THD	Distortion+Noise (-10dBV input)	R _L =2KΩ 20dB Gain @1kHz	-	0.006	-	%
THD	Distortion+Noise (+10dBV input)	R _L =2KΩ -20dB Gain @1kHz	-	0.006	-	%
e _n	Input Referred Noise Voltage	Input shorted to ground	-	4.4	-	nV√ Hz
i _n	Input Referred Noise Current	f=1kHz	-	<20.0	-	pA√ Hz
f _U	Unity Gain Frequency	Small-signal BW at unity gain (ft)	-	13.5	-	MHz
ZinEGC	Input Resistance	-	-	>10M	-	Ω
e _{n(out)}	Output Noise Unity Gain	22-22kHz, R _L =600Ω	-	-104	-	dBV
e _{n(out+20)}	Output Noise 20dB Gain	22-22kHz, R _L =600Ω	-	-95	-	dBV

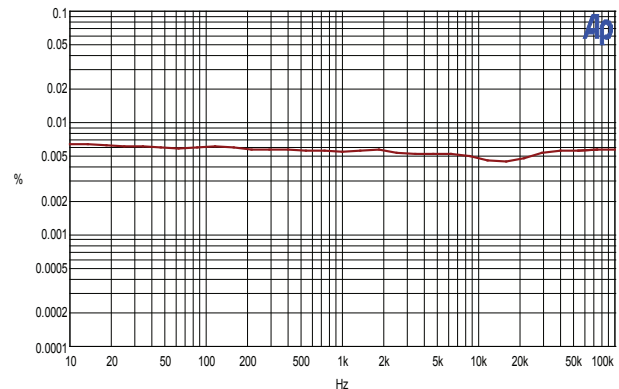
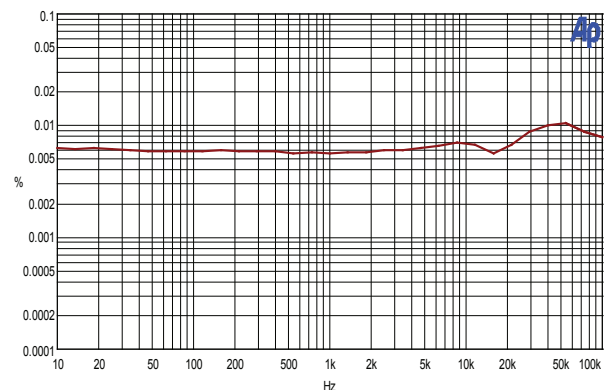
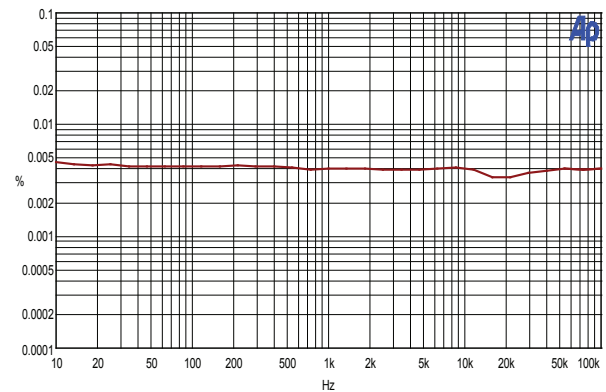


Model 312A Discrete VCA-EGC Module

Frequency Response Characteristics ($T_a=25^\circ\text{C}$, -10dBV in, $V_s=\pm 15\text{V}$, $R_L=2\text{K}$) (unless otherwise noted)



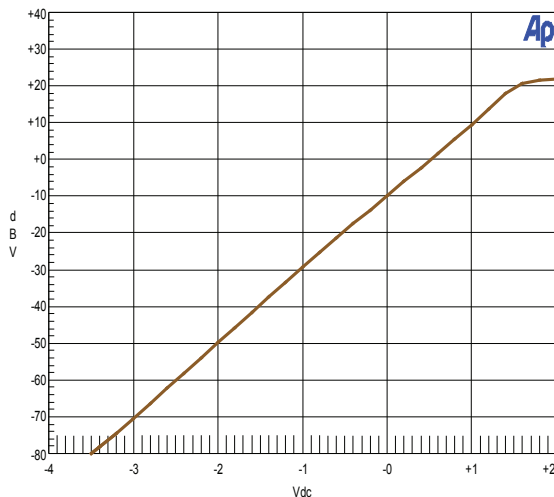
THD+N Characteristics ($T_a=25^\circ\text{C}$, $V_s=\pm 15\text{V}$, $R_L=2\text{K}$) (unless otherwise noted)



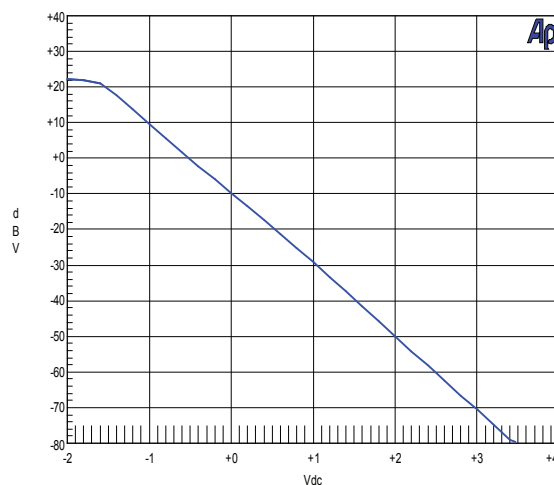


Model 312A Discrete VCA-EGC Module

Gain versus EGC Voltage Characteristics ($T_a=25^\circ\text{C}$, $V_{in}=-10\text{dBV}$, $V_s=\pm 15\text{V}$, $R_L=2\text{K}$) (unless otherwise noted)

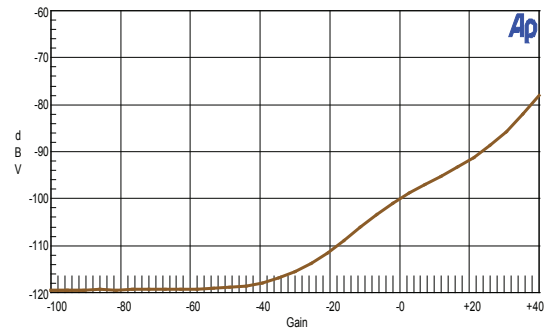


Non-inverting Mode (-10dBV in)



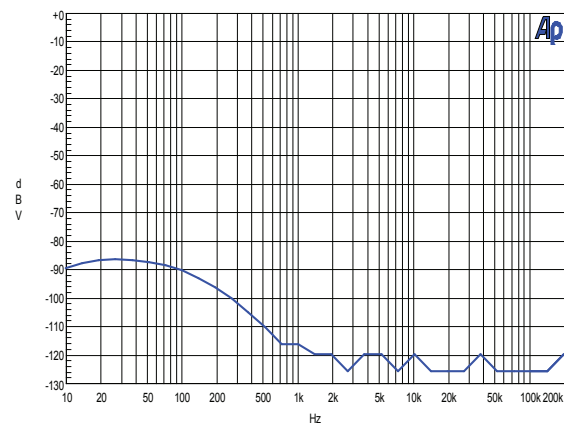
Inverting Mode (-10dBV in)

Noise versus Gain Characteristics ($T_a=25^\circ\text{C}$, $V_{in}=0$, $V_s=\pm 15\text{V}$, $R_L=2\text{K}$) (unless otherwise noted)

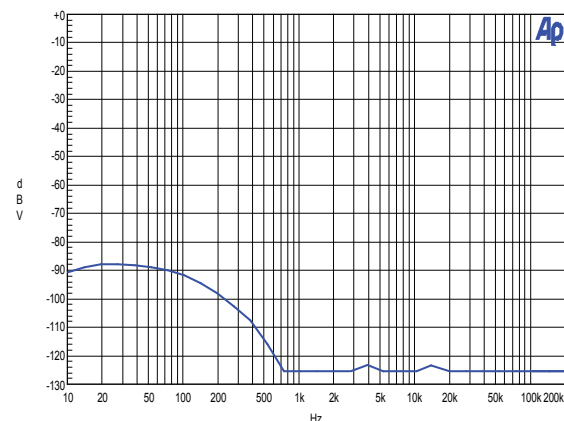


Model 312A Noise (22hz-22kHz NBW) versus Gain

Power Supply Rejection (PSRR) Characteristics ($T_a=25^\circ\text{C}$, $V_{in}=0$, $V_s=\pm 15\text{V}$, $R_L=2\text{K}$) (unless otherwise noted)



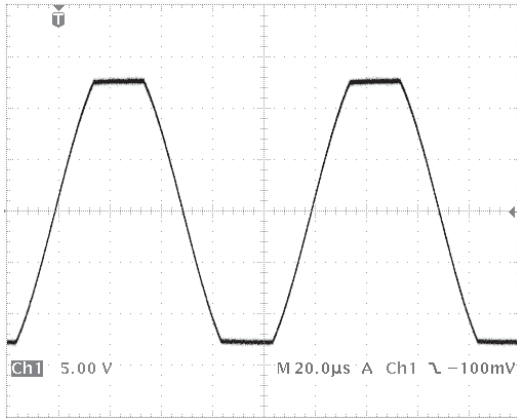
VCC Supply versus Frequency (+0dB Gain)



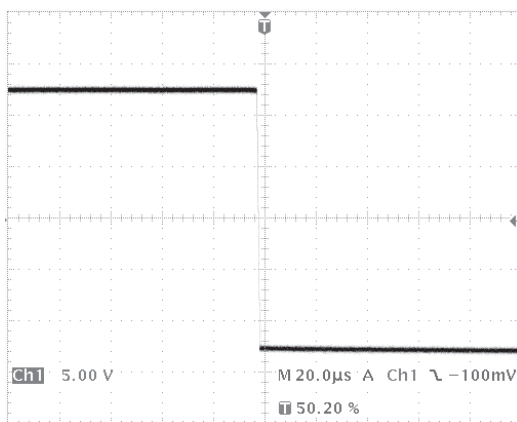
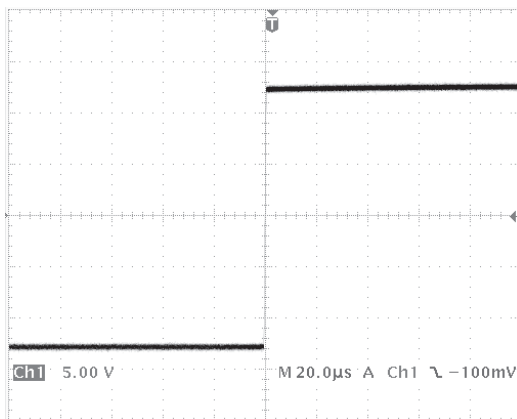
VEE Supply versus Frequency (+0dB Gain)



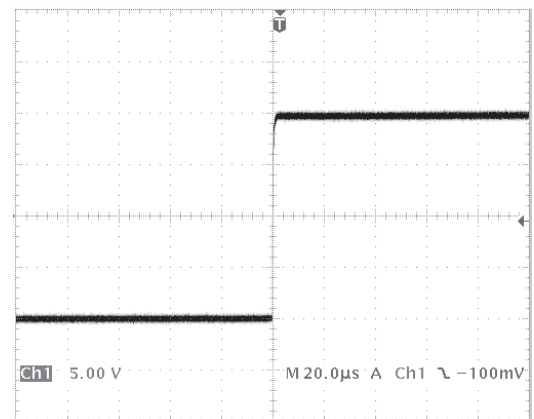
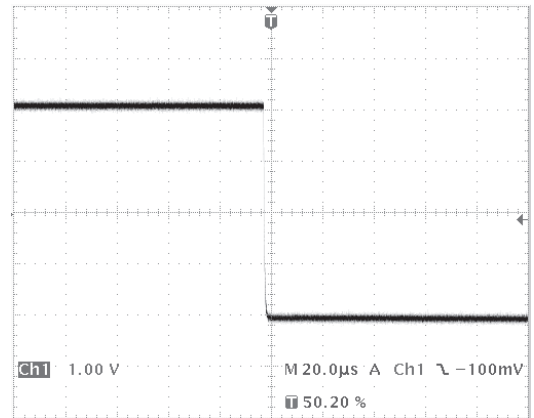
Model 312A Discrete VCA-EGC Module



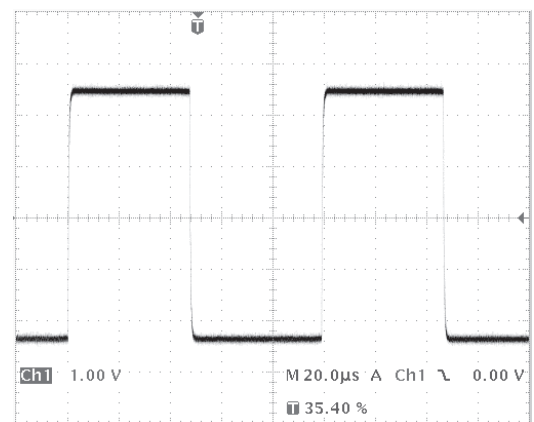
Large Signal Clipping Overload Recovery Response



Large Signal Pulse Response



Small Signal Pulse Response (+20dB Gain)



Small Signal Pulse Response (22kHz +20dB Gain)



Model 312A Discrete VCA-EGC Module

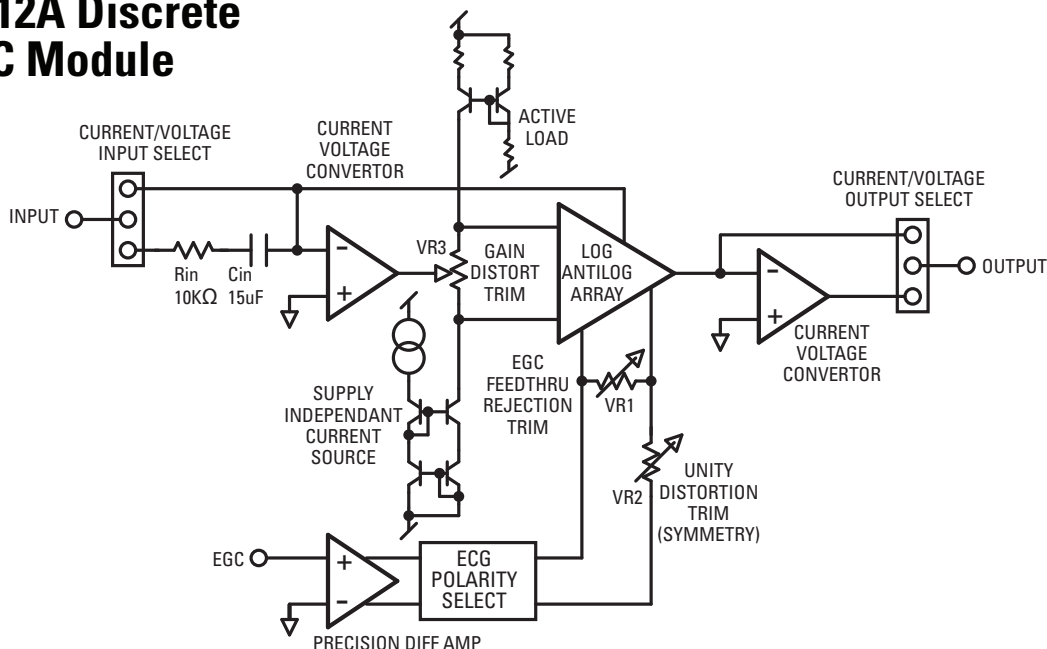


FIGURE 1. Simplified Block Diagram of the Sonic Imagery Labs Model 312A VCA-EGC Module.

EGC Pin

This input pin controls gain with applied voltage. 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. Due to the exponential function, the control voltage sets the gain linearly in decibels. **Figure 3.** shows the decibel voltage gain verses the voltage at the EGC pin when the device is configured with EGC polarity set to non-inverting and P2 and P3 set to voltage-in and voltage out operation.

EGC Input Impedance

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.

EGC Polarity Selection

The proper installation of the shunt jumpers on **pin block P1** selects the EGC voltage polarity. For the non-inverting control function as illustrated in **Figure 3.** place the shunt across PINS 1 and 3 and the

second shunt across PINS 2 and 4. To configure the 312A module in the inverting gain function as illustrated in **Figure 4.** install the shunt across PINS 3 and 5 and the second shunt across PINS 4 and 6.

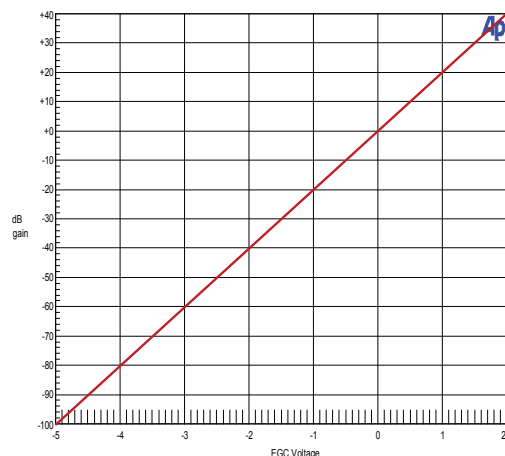


FIGURE 3. above, illustrates the theoretical ideal decibel voltage gain verses the voltage at the EGC pin when the device is configured with EGC polarity set as non-inverting and voltage-in and voltage out operation.



Model 312A Discrete VCA-EGC Module

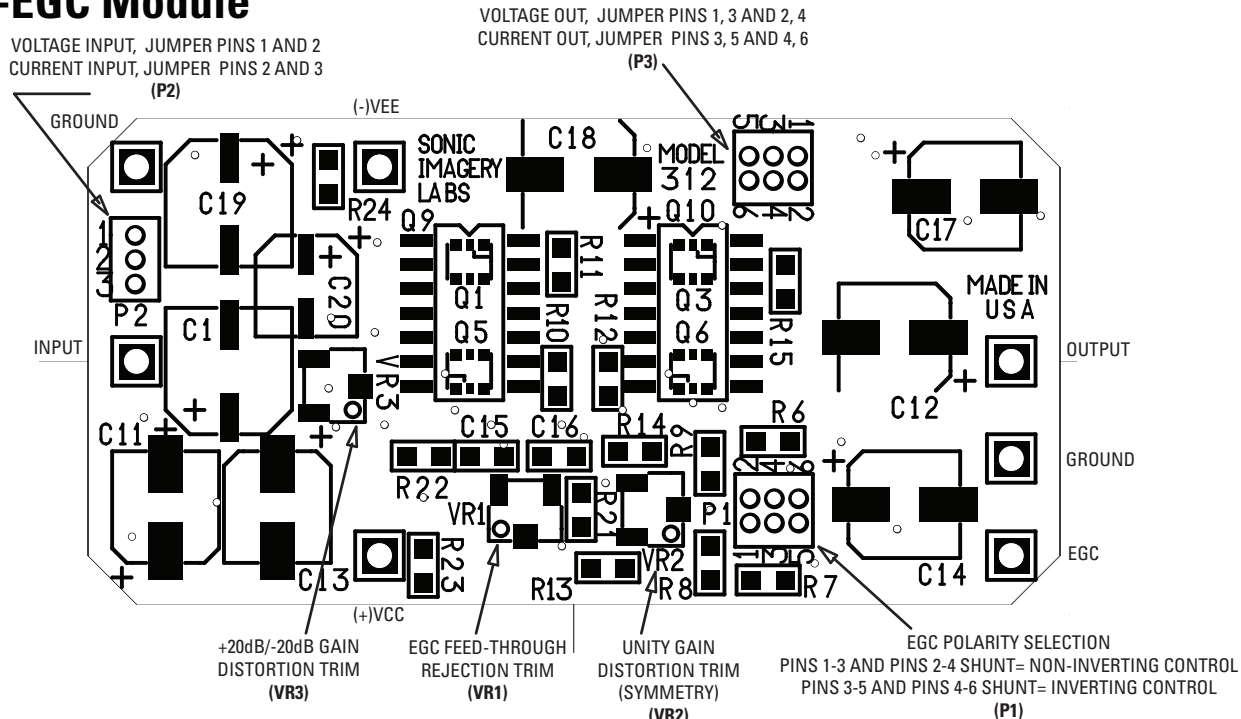


FIGURE 2. Connections, adjustments and mode options locations for the Sonic Imagery Labs Model 312A VCA-EGC Module.

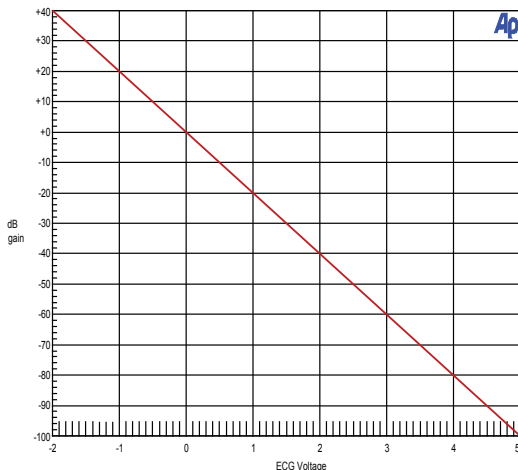


FIGURE 4. above, illustrates the theoretical ideal decibel voltage gain versus the voltage at the EGC pin when the device is configured with EGC polarity set as inverting and voltage-in and voltage out operation.

Audio Input Pin (Current-In Mode)

With shunt jumper placed across PINS 2 and 3 of pin block P2, the Model 312A is configured as a current input device. While this might cause some conceptual difficulty for designers first exposed to this convention, the current input/output mode provides great flexibility in application. The audio input pin is a virtual ground with negative feedback provided internally in this mode. The input resistor (shown as 10K Ω in **Figure 5**) can be scaled to convert the ac input voltage to a current within the linear range of the 312A module. For example, if RX is changed to 4.99K Ω the exponential control is shifted by 6dB of gain. See **Figure 6.** for additional values.

Audio Input Pin (Voltage-In Mode)

With shunt jumper placed across PINS 1 and 2 of pin block P2, the Model 312A is configured as a voltage input device. The resistor and input coupling capacitor shown in **Figure 5** are not needed because they are now in line with the voltage input mode path of the input pin. See simplified block diagram, **Figure 1.** The onboard input resistor is 10K Ω and the coupling capacitor is 15 μ F.



Model 312A Discrete VCA-EGC Module

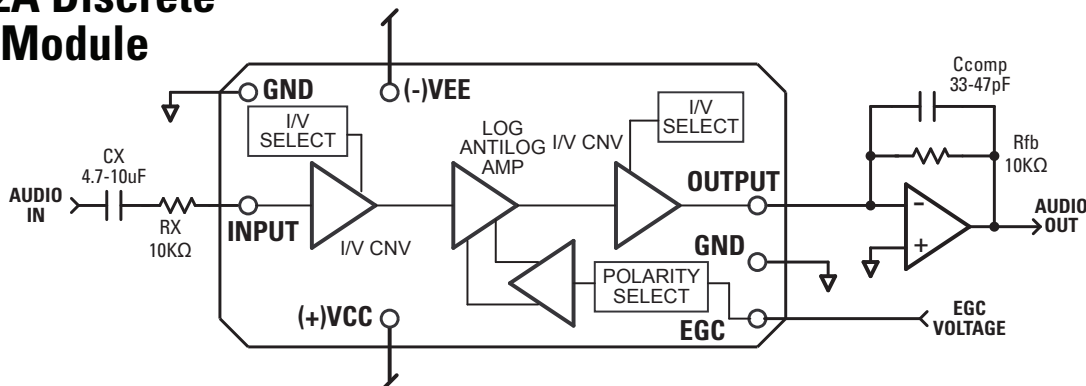


FIGURE 5. illustrates connections and typical current-in and current out mode of operation.

Audio Input Pin (Voltage-In Mode) (continued)

No additional components are required to drive the input and the ability to switch the input from current to voltage allows the user to retrofit or upgrade older vintage equipment.

Summing Multiple Audio Inputs

Multiple signals may be summed via multiple resistors, just as with any inverting op-amp configuration. In such an application, a single coupling capacitor may be located next to the input pin rather than multiple capacitors at the driven ends of the summing resistors.

Audio Input High Frequency Performance

The choice of input resistor has a subtle effect on distortion. Since the open-loop gain naturally rolls off at high frequencies, setting the gain to high will lead to increased high-frequency distortion. For optimum results, RX should be kept to 20KΩ or less. In effect, this resistor controls the offset of the gain slope shown in **Figure 3** and **Figure 4**.

Audio Input Offset

The quiescent dc voltage level at the input (input offset voltage) is typically 130uV, but, as in many typical gain blocks, this can drift with temperature. Any DC input currents will cause DC in the output which will be modulated by the EGC gain setting. If the input is DC coupled, DC input currents may be generated due to the input offset voltage of the 312A itself, or due to the offsets in the stages preceding the 312A module. Therefore, capacitive coupling is almost mandatory for quality audio applications. Choose a quality capacitor and a value which will give proper low frequency performance for the application.

Rx VALUE	MODULE GAIN/LOSS
20.0K	-6 dB
15.0K	-3.5 dB
10.0K	0 dB (unity)
4.99K	6 dB
2.49K	12 dB
1.24K	18 dB

FIGURE 6. The value of Rx controls the offset of the gain slope when the EGC is at 0 volts.

Audio Output Pin (Current-Out Mode)

With shunt jumper placed across PINS 3-5 and PINS 4-6 of pin block P3, the Model 312A is configured as a current output device. In this mode, the output is intended to be connected to a virtual ground node, so that current flowing in it may be converted to a voltage. Choose the external op-amp for optimal audio performance. The feedback resistor should be chosen based on the desired current to voltage conversion constant. Since the resistor (Rin) determines the V to I conversion at the input, the familiar ratio of Rfb/Rin for an inverting opamp will determine the overall voltage gain when the 312A module is set for 0dB current gain. Since the 312A module is optimized for performance at unity gain, setting Rfb to 10KΩ will set the complete circuit shown in **Figure 5** to 0dB with the EGC at 0 volts DC. This essentially sets the tilt of the gain/loss slope shown in **Figures 3** and **4**.

A small feedback capacitor (Ccomp) around the output op-amp shown in **Figure 5** is required to cancel the output capacitance of the 312A module when in current-out mode.



Model 312A Discrete VCA-EGC Module

Audio Output Pin (Current-Out Mode) (continued)

Without it, this capacitance will destabilize most op-amps. The capacitance looking into the OUTPUT pin while in current-out mode is typically 12 to 18pF.

Audio Output Pin (Voltage-Out Mode)

With shunt jumper placed across PINS 1-3 and PINS 2-4 of pin block P3, the Model 312A is configured as a voltage output device. In this mode, the output of the log-antilog amplifier array is buffered similarly to the typical application shown in **Figure 5**. The output buffer can sink and source 24mA and drive loads down to 600Ω

Positive and Negative Power Supplies

The positive supply pin (+VCC) and negative supply pin (-VEE) is connected directly to the supply rails of the application. The 312A module includes a small series resistance and a high quality 10uF capacitor on board so no special bypassing is necessary, but it is good practice to include a small 0.1uF ceramic capacitor at the power supply pins. Performance is not dependant on supply decoupling or supply voltage. The highest permissible supply voltage is fixed by on board devices. ±18V is the nominal limit. Lower supply voltages can also be used but the designer should be aware of the maximum expected output and reduced dynamic range.

Grounds

The input ground pin is used as the ground reference for the VCA. The internal opamps and portions of the internal bias networks and current sources also reference ground, as does the log-antilog amplifier array. It may not be used as an additional input pin. The output ground pin is provided for convenience and new design applications. If the user is upgrading or retrofitting older equipment, it is permissible to remove the output ground pin without affecting module performance.

Noise Considerations

It is the nature among good audio designers to consider the effects of noisy devices on the signal path. Less well known, however, is the effect of noisy circuitry and high impedance levels in the EGC path of voltage-control circuitry.

The 312A module, like all VGAs, act like multipliers: when no signal is present at the signal input, noise at the control input is rejected. So, when measuring noise in the absence of signal, often even very noisy control circuitry goes unnoticed. However, noise at the EGC pin will cause noise modulation of the signal. This can become significant if care is not taken to drive the control ports with quiet signals.

Stray Signal Pickup

It is also common practice among audio designers to design circuit boards to minimize the pickup of stray signals within the signal path. As with noise in the EGC control path, program material signal pickup in the control path can adversely effect the performance of an otherwise good VCA. Because it is a multiplier, the 312A module produces second harmonic distortion if the audio signal itself is present at the control port. Only a small voltage at the control port is required: as little as 25-100 uV of signal can increase distortion to over 0.01%. This can frequently be seen at high frequencies, where capacitive coupling between the signal and control paths can cause stray signal pickup.

Since the signal levels involved are very small, this problem can be difficult to diagnose. One useful technique is to temporarily bypass the control port to ground via a modest-sized capacitor (e.g., 10 uF). If the distortion diminishes, the likely cause is signal pickup in the control path.

No Symmetry Pin

The 312A VCA module contains 3 multi-turn trim potentiometers. These pots are set at the factory for optimum audio performance and do not typically require adjustment. The potentiometer labeled VR2 is the Unity Gain Distortion trim. It is also referred to as the SYMMETRY adjustment on older equipment. Older equipment usually has this adjustment off the VCA module and on the motherboard connected through a pin called SYMMETRY. By incorporating this trim on the Model 312A, the adjustment node is less susceptible to noise pickup, temperature and drift errors.



Model 312A Discrete VCA-EGC Module

Adjustments

The 312A VCA module contains 3 multiturn trim potentiometers. These pots are set at the factory for optimum audio performance and do not typically require adjustment.

Unity Gain Distortion Trim

This trim should be adjusted for minimum harmonic distortion. It is most simply done with the 312A module configured as a voltage-in/voltage-out mode. A distortion analyzer (either THD or IMD) is required for proper adjustment. This is usually done by applying a middle-level, middle frequency signal (e.g. 1kHz at 1V) to the audio input, setting the EGC pin to 0dB gain, and adjusting VR2 trim while observing THD at the output.

VCA Gain/Loss Distortion Trim

This trim should be adjusted for minimum harmonic distortion. It is most simply done with the 312A module configured as a voltage-in/voltage-out mode. A distortion analyzer (either THD or IMD) is required for proper adjustment. This is usually done by applying a middle-level, middle frequency signal (e.g. 1kHz at 1V) to the audio input, setting the EGC pin to either 20dB gain or 20dB attenuation, and adjusting VR3 trim while observing THD at the output.

Control Feedthrough Rejection Trim

Adjustment of VR1 trims for minimum feedthrough of the EGC signal into the audio output path. This is also called DC Feedthrough because a small DC error term flows out the audio output. When gain is changed, the DC term changes. This control voltage feedthrough is more pronounced with gain. Set the 312A module configured as a voltage-in/voltage-out mode. Ground the audio input (through a capacitor). Apply a 10Hz signal to the EGC pin. While monitoring the audio output with an oscilloscope or level meter, increase the level until the 10Hz signal can be seen at the audio output. Adjust VR1 for the smallest 10Hz signal at the audio output.

Table 1. Compatible Upgrade Table

The Model 312A can be used to upgrade and/or replace these obsolete or end-of-life discrete VCA-EGC amplifiers. This list is by no means comprehensive. Contact Sonic Imagery Labs for additional information. Some pin out modification may be required. This typically entails removing the output ground pin from the Model 312A. Some technical knowledge of how older vintage gear operates is important to upgrading successfully.

dbx 202XL Voltage Controlled Amplifier
dbx 202X Voltage Controlled Amplifier
dbx 202 Voltage Controlled Amplifier
dbx 202C Voltage Controlled Amplifier
dbx 2001 Voltage Controlled Amplifier

These modules below are not drop-in compatible but one can remove the Model 312A's mounting pins and the module can be carefully "wired in."

Allison Research ECG-101
Valley International TA101
Valley International TA104
Assorted Symetrix Modules EGC101

In all upgrade cases, the concept to remember is to identify the operating mode correctly, either voltage-in/voltage-out, current in/current out, voltage-in/current out or current in/voltage-out mode. Over the years there have been many variations and generations of gear produced. When below THRESHOLD and with COMPRESSION/LIMITING not activated, the user will have to confirm that with a 0dBV signal input to upgraded gear still produces a 0dBV signal at the output. If this is not the case after upgrading, this indicates that the offset of the compression slope is different. By referring to **FIGURES 5 and 6** and adjusting/replacing the series input resistor (RX) in the unit being upgraded to the appropriate value, one should be able to bring the unit to better than original factory specification, particularly in areas of noise, distortion, speed and bandwidth.



Model 312A Discrete VCA-EGC Module

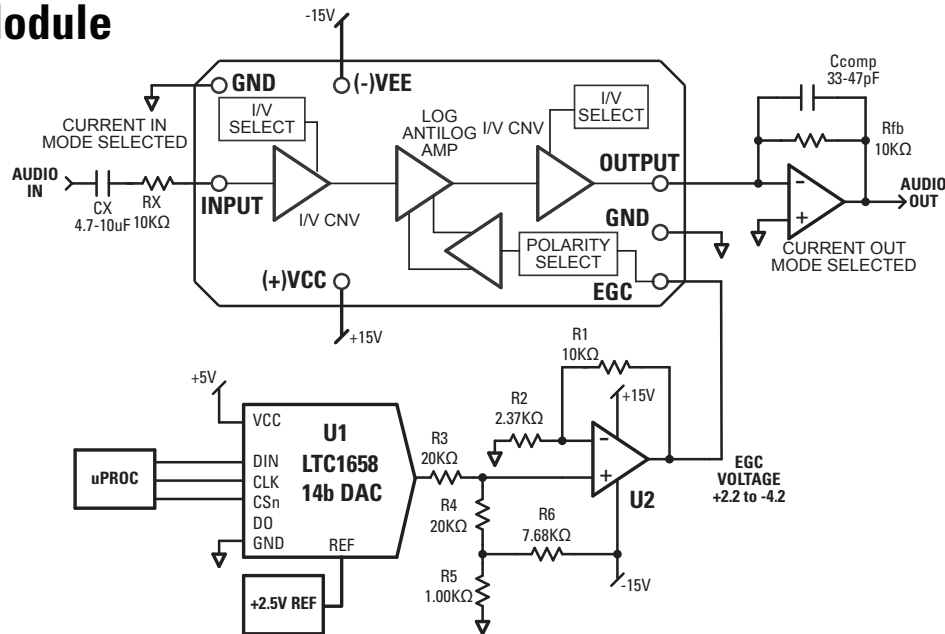


FIGURE 7. Simple microprocessor/DAC controlled gain stage.

Applications: Digital Interfacing

Be sure to download and read **Application Note AN-15** for more technical information regarding this application. 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 versatile building block with applications ranging from radio AGC to microprocessor controlled faders and its application is merely limited to the designers imagination.

FIGURE 7. illustrates a 14bit DAC (U1) driven by a SPI digital port from a microcontroller. A low cost 2.5V reference sets the DAC output voltage range. In this case the output of the DAC is 0 to 2.5V. Any reference will work as long as final EGC voltage is scaled and offset appropriately for the gain/attenuation range required. Scaling and offset is performed by U2. Any low noise precision op-amp can perform this duty. Slewing rate of DAC step changes can be controlled by placing a capacitor across R1. This reduces the bandwidth of the U1. This is generally a good idea as noise and spurious signal at the output of U1 will modulate the program material of the 312A VCA module. Using the values shown in **FIGURE 7.**, the Model 312A VCA-EGC module has a gain range of +44dB at 2.2V and -84dB at -4.2V. With a 14 bit DAC, each DAC step is equivalent to a 0.007dB change in gain/attenuation.

Applications: Digital Interfacing (continued)

Other bit resolution DACs, voltage references and scaling operational amplifier circuits can be implemented depending on the final application and needs of the designer.

Applications: Panning

Be sure to download and read **Application Note AN-14** for more technical information regarding this application. Having the ability to move the apparent position of one microphone input between two output channels often is required in typical recording studio mixing consoles. Such a circuit is called a panning circuit (short for panoramic control circuit) or a pan pot. **FIGURE 8.** illustrates a simple topology which one pot is used to control the panning control. The Model 312A VCA-EGC modules are configured as voltage-in/voltage out devices. The upper 312A VCA's EGC control port is configured to be positive voltage gain control and the lower 312A VCA's EGC control port is configured to be negative voltage gain control. Normally panning requires two oppositely wired control pots ganged together, however the circuit shown in **FIGURE 8 and 9.** provides accurate panning with only one linear taper potentiometer. With the wiper of R1 at center position, 0 volts is applied to the VCA's inputs and each of the outputs are at unity gain. As the wiper is moved to the positive direction, channel 1's gain increases at a 20dB/volt rate.



Model 312A Discrete VCA-EGC Module

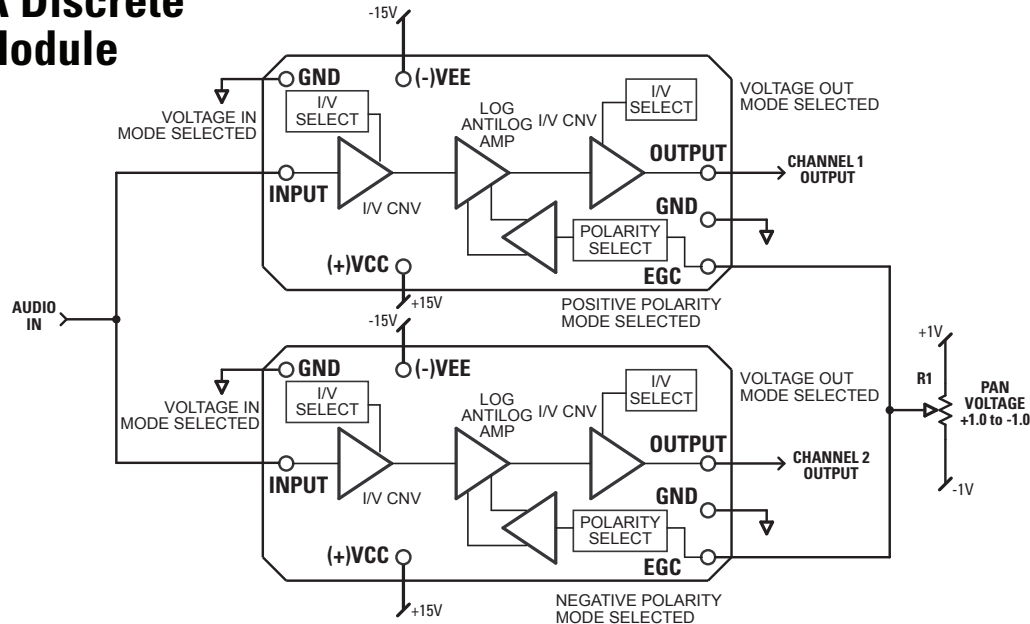


FIGURE 8. Simple topology for a two channel panner.

Applications: Panning (continued)

Conversely, channel 2's gain is reduced at the same 20 dB /volt rate. Moving the wiper to the negative end of the pot, channel 1's gain decreases at a 20dB/volt rate while channel 2's gain increases at same rate. The circuit as shown in **FIGURE 8.** is more akin to a vibrato or tremolo because as the gain is reduced in one channel, it increases in the other channel.

A standard stereo or mixing board panning circuit is required to have unity gain at each extreme of control (pot) travel. All input signal is delivered to one output channel with the other channel at full attenuation. Additionally both channels should have -3dB gain from each output with the pan-pot at center position. (Equal power at each output). **FIGURE 8** and **9.** does not achieve the -3dB gain from each output requirement but does retain the single linear potentiometer as the control input. U1 and U2 are configured as inverting and non-inverting gain of 2.5 clamp at 0 volts opamps. The gain of 2.5 provides approximately 50dB attenuation at the extreme ends of the pan pot travel. The gain could be increased or decreased depending on the application and designers needs. With the pot at the full negative direction, U2's output goes positive and clamps at 0V (unity gain for CHANNEL 1) and U2 will be at -2.5V (-50dB attenuation). Conversely, with the pot at full positive direction U2's output will go negative (attenuation for CHANNEL 1) and U1 will be at 0V (unity gain for CHANNEL 2).

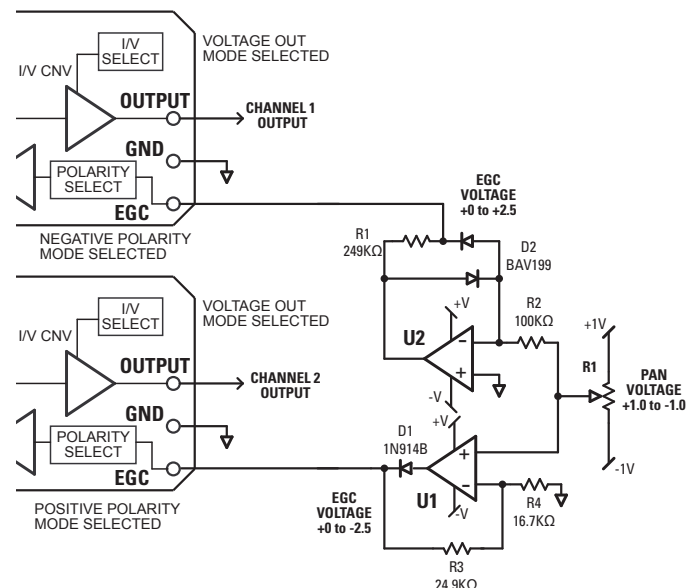


FIGURE 9. Clamp at unity circuit for a two channel panner.



Model 312A Discrete VCA-EGC Module

Applications: Simple Compressor Limiter

The Sonic Imagery Labs Model 312A Voltage-Controlled Amplifier (VCA), makes an ideal controller pair for audio compressor/limiter designs. An rms detector provides a dc output in logarithmic (decibel-scaled) format, and the 312A VCA accepts gain control commands in exponential format (also decibel-scaled). The combination of an rms detector and a 312A VCA makes it possible to construct a variety of compressors and/or limiters with ease, freeing the design engineer to concentrate on the functional requirements of a design, rather than on the methods to achieve this functionality.

Audio Path:

The audio signal flows only through the 312A VCA module making the signal path short enough to locate it entirely around the input and output jacks on a PC board. Input signals are coupled to the 312A VCA module through Cx and Rx. Since the input of the 312A VCA module is a virtual ground when configured as a current input device, Rx determines the gain of the input (current) to the 312A VCA. The 10.0K resistor shown is optimum for input voltages of up to about 10 VRMS, or +20 dBV. Cx (along with Rx) sets the low-frequency limit in the audio path. ($f_c = 1/2\pi R_x C_x$)

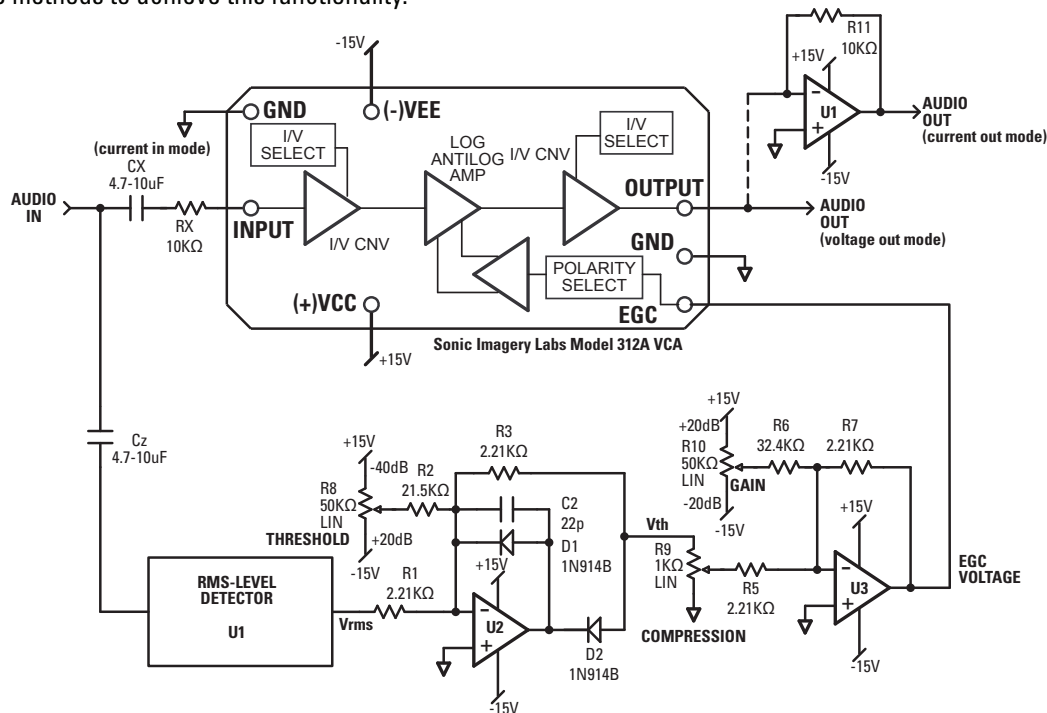


FIGURE 10. Simple over-threshold compressor schematic

Over-Threshold Compressor:

FIGURE 10. shows a basic above-threshold compressor utilizing an rms detector and the 312A VCA. This design offers independent control over threshold, compression ratio, and after compression gain. Time constants are handled by the rms detector. The design exploits the highly predictable behavior of the 312A VCA module to make possible a simple, effective and versatile feedforward approach to gain control.

The 312A VCA module produces an output current signal which is a replica of the input signal, scaled (in decibels) by the voltage at the EGC pin. U1 converts this current back to a voltage based on its feedback resistor, R11. For $R_x = R_{11}$, as shown, V_{in} will equal V_{out} whenever the EGC pin (the control port) is at 0 V (this is unity gain, or 0 dB gain). For every 50 mV increase in the voltage at the EGC pin, the gain decreases by 1 dB. For every 50 mV decrease in voltage, the gain increases by 1 dB. Therefore, the output signal level depends only on the input signal and the control voltage applied to the EGC pin.



Model 312A Discrete VCA-EGC Module

Applications: Simple Compressor Limiter (continued)

RMS-Level Detector. The technical aspects of RMS detectors are beyond the scope of this application note. The detector shown as U4 is simply a black box that the designer can either purchase monolithically or build discretely. In either case the output simply needs to meet the following requirements described below.

The input signal is applied to an rms detector through Cz. The rms detector needs to be configured to provide 0 volts at its output (V_{rms} in **FIGURE 10**.) when approximately 316 mV rms (-10 dBV) is present at the circuit input. As the input signal varies, the rms detector output voltage will vary. For each 1 dB of increase in input level, its output increases by 50 mV. Every 1 dB decrease in input causes a 50 mV decrease in dc output.

Threshold Detector Section: The output of the RMS-Level Detector is connected to U2, which is configured as an inverting, half-wave operational rectifier. Ignoring the effect of R2 and R8, when V_{rms} is negative, the output of U2 will be positive, and D2 blocks this voltage from reaching V_{th} . Therefore, $V_{th} = 0$ for $V_{rms} < 0$. However, when V_{rms} is positive, the output of U2 goes negative, and V_{th} follows V_{rms} with a gain of -1. Therefore, $V_{th} = -V_{rms}$ for $V_{rms} > 0$.

Again neglecting the effects of R2 and R8, U2 and its associated circuitry only passes information when the input signal is above the input level which causes $V_{rms} = 0$ V (the threshold). No information passes for signals below this threshold. The transition below to above threshold is sharp, because the operational rectifier used as the threshold detector linearizes the diode's exponential V-I characteristic curve. R2 and R8 provide a means of adjusting the threshold. For supply rails of ± 15 V, R8 adjusts the threshold over +2.5V. This is equivalent to ± 30 dB at 50 mV/dB. With the wiper of R8 towards V_+ , V_{th} will respond for any $V_{rms} > -2.5$ V, or $V_{in} > -40$ dBV. With the wiper of R8 towards V_- , V_{th} will respond for $V_{rms} > +2.5$ V or $V_{in} > +20$ dBV. This adjusts the threshold over the range +20 dBV to -40 dBV.

Note that a linear-taper potentiometer should be used for R8, the THRESHOLD control. This is because the signal at the RMS-Level detector output represents the log of the input signal level - it has already been converted to decibels. A linear change in threshold voltage corresponds to a linear change in decibel threshold. V_{th} therefore represents the decibel level of the input signal above THRESHOLD. See **FIGURE 11** for a plot of V_{th} vs. V_{in} .

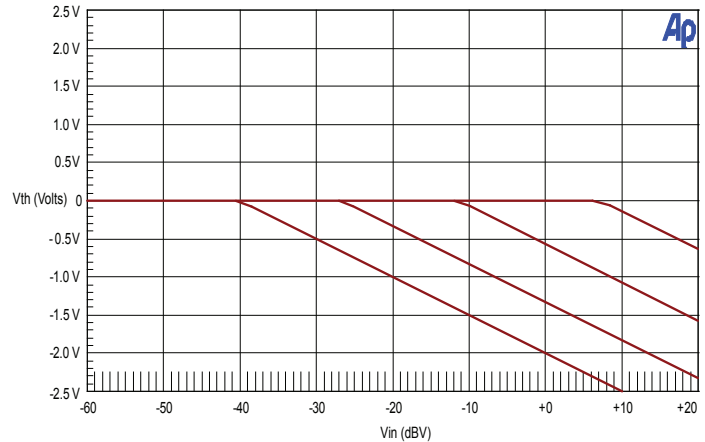


FIGURE 11. V_{th} versus V_{in} for various THRESHOLD settings.

R9, the COMPRESSION control, allows the user to scale V_{th} before it is passed on to the rest of the circuitry. Ignoring the action of R10 and R6, when the wiper of R9 is at its ground end, no signal is passed on to U3. When the wiper is at the opposite end (the maximum), the output of U3 (EGC Voltage) exactly mirrors V_{th} . For settings in between, the EGC Voltage will be a mirror image of some fraction of V_{th} , with the fraction determined by the setting of the COMPRESSION control pot.

When COMPRESSION is at maximum, EGC Voltage = V_{th} , so EGC Voltage in turn represents V_{in} above threshold at 50mV/dB. But, EGC Voltage is applied to EGC pin of the 312A VCA, which controls gain at the rate of -50 mV/dB. For every 1 dB increase (above threshold), EGC Voltage increases by 50 mV and the gain of the VCA decreases by 1 dB. Therefore, at maximum COMPRESSION, the signal gain decreases in exact proportion to signal level increases above threshold, preventing any increase in output level above the threshold.

For intermediate settings of the COMPRESSION control, the decrease in signal gain is proportional to, but less than, the increase in signal level above threshold. For example, at the electronic halfway point for R9, signal gain will decrease by 0.5 dB for each 1 dB increase in input signal above threshold. This will result in an increase in output signal of 0.5 dB for each 1 dB increase in input signal.

The Compression Ratio is a measure of the increase in output signal for increases in input signal above threshold. It is defined as **RATIO = $\Delta V_{in} / \Delta V_{out}$** , where ΔV_{in} is the decibel change in input signal and ΔV_{out} is the decibel change in output signal.



Model 312A Discrete VCA-EGC Module

Applications: Simple Compressor Limiter (continued)

The compression ratio is **infinity:1** when the COMPRESSION control is at its maximum, and 1:1 at its minimum. For settings in between, the ratio is determined by the setting of R9, taking into account the loading effect of R5. If the electrical setting of the COMPRESSION control is expressed as a ratio R relative to full scale (i.e., maximum is 1.0, 50% of full scale is 0.5, etc.), then the compression ratio is determined by the setting of the COMPRESSION control as follows: $RATIO = 1/1-R$. In the circuit shown in **FIGURE 10**, 2:1 compression will occur at slightly more than the halfway point in the pot's rotation, due to the loading of R5. It is not uncommon in this sort of design to add a resistor between the top of R9 and its wiper, in order to set 4:1 compression at the 50% rotation point. Approximately 249 ohms is recommended. **FIGURE 12** plots EGC voltage versus V_{in} , for several settings of the COMPRESSION control, at a fixed THRESHOLD setting.

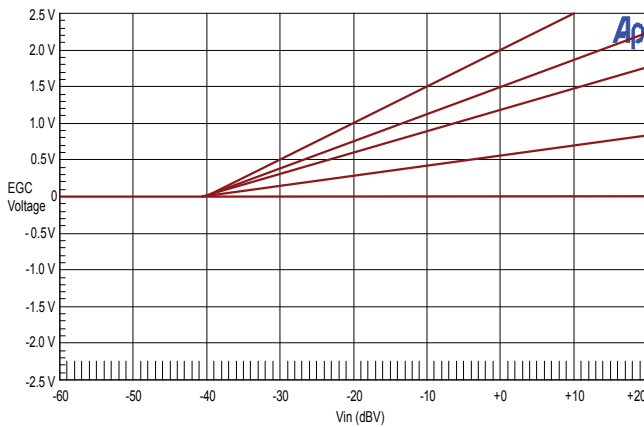


FIGURE 12. EGC voltage versus V_{in} for various COMPRESSION settings.

Setting Output Gain: The action of R10 and R6, neglected in the foregoing analysis, is to add a dc offset to the EGC voltage. This causes a static gain or loss in the signal path, at the familiar constant of 50 mV/dB. As shown, with ± 15 V supply rails, varying R10 (the GAIN control) will cause EGC voltage to vary over ± 1 V. This corresponds to approximately ± 20 dB of gain change. This variation is useful in making up for level lost during compression. **FIGURE 13**, plots EGC vs. V_{in} for various settings of the gain control at constant COMPRESSION and THRESHOLD settings.

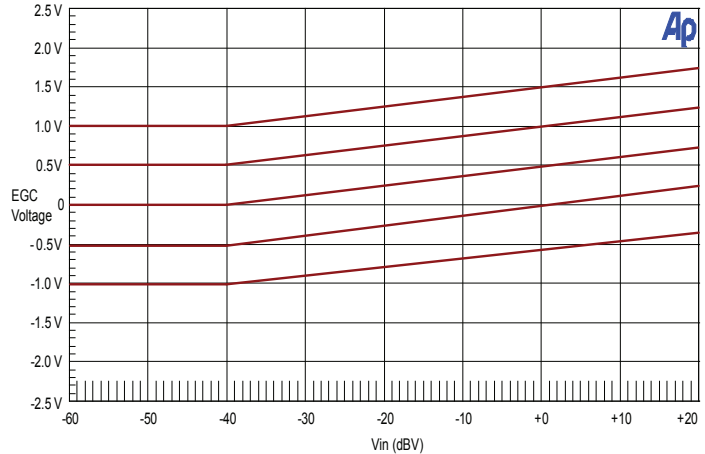


FIGURE 13. EGC voltage versus V_{in} for various GAIN settings.

Compression Character:

The circuit of **FIGURE 10** produces a family of input vs. output characteristic curves as shown in **FIGURE 14**. Note that the onset of compression (the bend in the curves) is sharp, deriving from the sharp rectification characteristic of the operational rectifier used in the threshold detector circuit. Also note the similarity of the previous curves showing EGC control voltages versus V_{in} to the plots of V_{out} versus V_{in} . This follows from the fact that the rms detector produces a decibel representation of the input signal, and that the Sonic Imagery Labs Model 312A Voltage-Controlled Amplifier module responds directly to decibel gain commands.

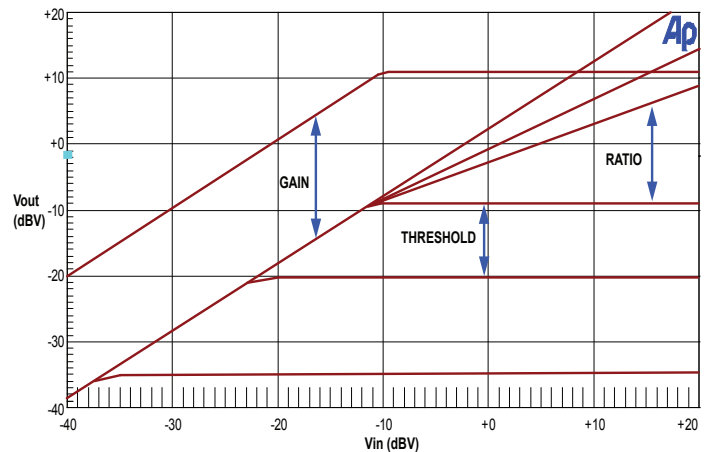


FIGURE 14. Input voltage versus output voltage for various control settings.



Model 312A Discrete VCA-EGC Module

PCB Sockets for 312A VCA-EGC Module

It is highly recommended that the user not solder the pins directly to the mating printed circuit board. Overheating the pin creates a cold solder joint at the other end. Permanent soldering of the pin prevents easy removal of the 312A VCA-EGC module. Lastly, soldering prevents one from servicing components which may lie underneath the module. Many types of sockets for 0.040" diameter pins are available from several manufacturers. Sonic Imagery Labs uses and stocks the sockets from all three listed manufacturers below. These sockets can be soldered or swaged in your printed circuit board. Additionally, users can purchase a set of six from Sonic Imagery Labs.com online.

Mill-Max
190 Pine Hollow Road,
PO Box 300
Oyster Bay NY 11771

Part Number 0344-2-19-15-34-27-10-0

Wearnes Cambion Ltd
Peperial House
Mill Bridge, Castleton
Hope Valley S33 8WR
United Kingdom

Part Number 450-3756-02-03

Concord Electronics Corp
33-00 47th Ave
Level 1A
Long Island City, NY 11101

Part Number 09-9035-2-03

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