CEM3389 Voltage Controlled Signal Processor

The CEM3389 is a general purpose audio signal processing device intended for use in multi-channel systems. Included on-chip are a wide-range four-pole lowpass VCF with voltage controlled resonance, and three high quality VCAs, two of which pan the output signal of the third between two outputs.

All three VCAs feature low noise and low control voltage feedthrough without trimming. In addition, the three VCAs are structured such that when the input VCA is off, no currents flow in the two output pan VCAs, resulting in absolutely no noise in the outputs. Thus, the output of multiple 3389s may be combined together without excessive noise buildup.

The VCF is the same patented filter used in other Curtis products, designed for good sonic characteristics and no output loss with increasing resonance. With the exception of filter frequency, all control inputs range from 0 to +5V and provide moderately high impedance for minimal system loading. The filter frequency control voltage ranges from -150mV to +100mV, allowing easy control voltage mixing and all parameters to be conveniently controlled with a single polarity DAC.

The CEM3389 is pin-for-pin compatible with the CEM3379, and may usually dropped into existing designs with only a few component value changes.

Able to operate over a wide supply range and requiring a bare minimum of external components, the CEM3389 offers low noise signal processing at low cost in stereo output systems.

FEATURES

- Low Cost
- VCF and 4 VCAs on a single 18 pin DIP
- Separate inputs and outputs for each function
- Rich Sounding VCF
- Constant Amplitude versus Resonance VCF Design
- Low Noise, Low Distortion VCAs
- Very Low Control Voltage Feedthrough without trims
- Completely noiseless Pan Outputs when channel is Off
- Operation down to +-5V

CEM3389 Electrical Characteristics
(VCC = +12V   VEE = -5V   Ta = 25C)

PARAMETER	MINIMUM	TYPICAL	MAXIMUM	UNIT
OUTPUT PAN VCAs				
Max Gain @ Vpan = 0 volts	-8	-7	-6	dB
Max Attenuation @Vpan = 5V	86	100	120	dB
DC Control Feedthrough	---	0.4	1.8	uA
Balance Control Input Bias	-0.2	-0.6	-2.0	uA
Pan Control Input Impedance	16K	20K	25K	ohms
Output Voltage Compliance	-0.2	---	VCC-1	V
VC FILTER				
Input signal for 1% THD				
Passband Signal Gain Vres=0V	---	360	---	mV PP
Input Resistance	6.8	7.5	8.3	
Frequency Control Range	3.6	4.5	5.6	KOhm
Frequency Control Voltage	14	---	---	octaves
Frequency Control Scale	-155	---	110	mV
Exponential Scale Error	17.5	19.0	20.5	mV/octave
Initial Frequency (Ca-Cc=0.033uf)	---	0.3	1.0	%
Frequency Control Input Bias	650	1000	1650	Hz
Resonance Control Range	-0.2	-0.6	-2.0	uA
Resonance Control Voltage @osc	Q = 0dB	---	self-osc	
Resonance Control Input Bias	2.2	2.8	3.4	V
DC Output Shift over 10 Octaves	-0.2	-0.5	-1.5	uA/V
Output noise	---	100	250	mV pp
Maximum Output Swing	---	90	---	uVrms
Quiescent DC Output Voltage	4.5	5.0	5.5	Vpp
Output Sink Current	-0.5	0.0	0.5	V
Output Source Drive Current	-0.4	-0.5	-0.6	ma
	---	---	3.0	ma
INPUT VCA				
Gain Control Range				
Maximum Signal Current Gain	90	120	---	dB
Control Voltage for Max Gain	0.80	0.93	1.10	
Control Voltage for Min Gain	4.5	5.0	5.5	V
Control Input Bias Current	30	85	140	mV
Voltage at Signal Input Node	-0.1	-0.3	-1.0	uA/V
Output Voltage Range	-2.3	-2.1	-1.9	V
Maximum Input Signal Swing	-0.8	---	Vcc-1	V
Output Noise	-200	---	200	uA
THD @ +-200uA Input Swing	---	---	2.0	nA rms
DC Output Offset at Min Gain	---	0.5	1.5	%
DC Output Offset Range	---	---	1.0	nA
	---	+-0.2	+-1.2	uA
GENERAL				
Supply Voltage Range	+-4.75	---	+-16	V
Supply Current per Chip	5.8	7.3	9.1	mA

POWER SUPPLIES

The maximum supply allowed across either device is 25 volts. Due to internal voltage regulators, the supplies do not have to be balanced: +5/-12 is allowed, as would be +12/-5. Since the maximum positive output swing of the filter is 2.9 volts below the positive supply, some loss in maximum VCF output will occur at +4.75 volt supply. For best performance with low power dissipation, use +9/-5 or +12/-5 supply voltages.

OUTPUT PAN VCAs

The two output pan VCAs have the same characteristics of low noise and low control feedthrough as the input VCA. The low noise makes the 3389 ideally suited for use in multi-channel systems, where the outputs of many 3389s many be combined. The low feedthrough allows rapid modulation of the pan function without annoying “pops” and “clicks”.

In addition, the current through each pan VCA is merely the output current of the input VCA. Thus, when it is off, all currents through the pan VCAs are zero and hence the input current noise is zero. This ensures extremely quiet system outputs when all channels are off.

The gains of the two VCAs are complementary, being equal and half their maximum gain at a nominal control voltage of +2.5V. The control scales are linear between 0.5V and 4.5V, becoming logarithmic beyond these extremes.

The maximum gain at either pan output is exactly the same as the direct output, and may be calculated in the same manner. Since the pan output(s) have a limited negative output voltage compliance (-0.2V max.), they must be fed into a virtual ground summing node of an op amp for large output voltage swings. However, in cases where the output(s) drive 3080-type VCA or the input to a VCF section, the output current may be converted to the output voltage with a resistor connection to ground.

All three VCA outputs may be combined with corresponding outputs from other 3389s simply by connecting the output pins together before converting to a voltage.

FILTER

The voltage controlled filter (VCF) is the standard musical 4 pole low pass with internal feedback through a VCA to add resonance or sustained oscillation at the cut-off frequency. A portion of the input signal is applied to the resonance VCA, so that as the amount of resonance is increased, the passband gain drops by only 6dB instead of the normal 12dB without this technique. This choice of a 6dB drop ensures the peak-to-peak output level remains the same when the output waveform rings from added resonance.

If the VCF input signal comes from a source other than the mixer output, it will most likely require attenuation down to the nominal 360mv pp level. This is easily accomplished with a single series resistor to the input pin (Pin 8). The amount of attenuation is given by:

$$1 + (Rin/4500)$$

However, the internal 4500 ohm resistor has a 25% tolerance, so a chip-to-chip +-2.5dB variation is to be expected. Lower variation can be obtained by adding a shunt resistor to ground. A 1.3K shunt resistor will reduce the input resistance to 1K and the output variation caused by the 4.5K will be reduced to +-0.5dB. For best performance, the signal applied to the filter input should have < 50mv DC component.

The cut-off frequency of the filter (which is defined as the oscillation frequency at maximum resonance or the -9dB point at no resonance) is determined by the transconductance and associated capacitance of each of the 4 stages as:

fc = Gm/(2 x pi x C)

Since the transconductance of the last stage is 1/75th of the other 3 stages, the capacitor value is 1/75th of the other capacitors. Best sweep performance is obtained over a transconductance range of 1umho to 4 mmho. For a desired frequency range of 5Hz to 20KHz, Ca, Cb, and Cc are chosen to be 33nF and Cd becomes 470pF. Note that the frequency can be swept one octave above and below these frequencies.

The transconductance is varied in an exponential manner with the control voltage, and is given in umhos by

Gm = 200exp (Vfreq/VT)

where VT is approximately 28.5mv at 20C and has a temperature coefficient of +3300ppm. Note that when Vfreq = 0, the transconductance in nominally 200 umho, resulting in a cutoff frequency of around 1KHz with the capacitors given. The lower frequency of 5Hz is 7.6 octaves below the zero control voltage. This requires a -150mv signal. The upper limit of 20Khz requires a 90mv control voltage signal.

In the usual case, the system frequency control voltage must be attenuated with a resistor divider down to these levels. If the system CV ranges from 0 to a positive value (most likely), then an additional resistor between the control pin and the negative supply voltage is need to produce a negative voltage for the lower cutoff frequencies. For best results, the input impedance to the control pin should be <2K. Although the transconductors themselves have been internally temperature compensated, the control scale still has a -3300ppm factor due to TC. Therefore, a +3300ppm temperature compensation resistor is used in the CV attenuation network.

The VCF output (Pin 1) is a low impedance output capable of driving loads down to 6.8K. If more drive is required, a resistor Rout may be connected between the output and the negative supply. The minimum load which may be driven is:

Rload (Kohm) = 2.5/(0.4 + Vee/Rout)

where Rout is in Kohms. The output is not short circuit protected. Therefore, if this pin is connected to outside of the equipment, a series resistor of 470 ohms in series with the output pin is needed.

INPUT VCA

The input VCA is a low noise, low control voltage feedthrough design which does not require any trimming to null. Hence it is well suited for being controlled by fast transition envelopes without producing “pops” or “clicks”.

The VCA signal input is a current summing input at a voltage of -2.1V, requiring an external series capacitor and resistor between the input signal voltage and input pin (Pin 13). The maximum input current should be limited to +-200uA. The value of input resistor is therefore:

Rin = Vin/400uA

The series capacitor is then chosen to give the desired -3dB low frequency corner with the selected resistor.

Somewhat lower distortion can be obtained with a lower maximum input current of +-50 to +-100uA at the expense of slightly lower signal-to-noise ratio and larger relative control feedthrough. Distortion also increases the lower input signal voltage; therefore the input signal voltage should be kept about 1Vpp.

The output of this VCA splits into two paths, one half routed to the direct output (Pin 11) and the other half driving the input to the two pan VCAs. Thus the maximum output current swing is ½ of the input current swing.

The control scale is exponential from 0 to approx. 200mv, controlling the current gain from -100dB to about -20dB. Thereafter the current gain increases in a linear fashion until it reaches 0dB at +5V nominal. This slight rounded knee at the scale bottom allows an envelope to decay to zero with a natural exponential sound regardless of the small variations in VCA turn-on threshold.

As this VCA also has limited negative output voltage compliance (-1v max.), it is best to convert the output current to a voltage with a virtual ground summing op amp. Of course, if the output voltage needs to be no greater than 2V pp, the current-to-voltage conversion may be accomplished with a resistor to ground. The maximum voltage gain at +5V control is approximately ½ the ratio of the feedback resistor (or output resistor) to input resistor:

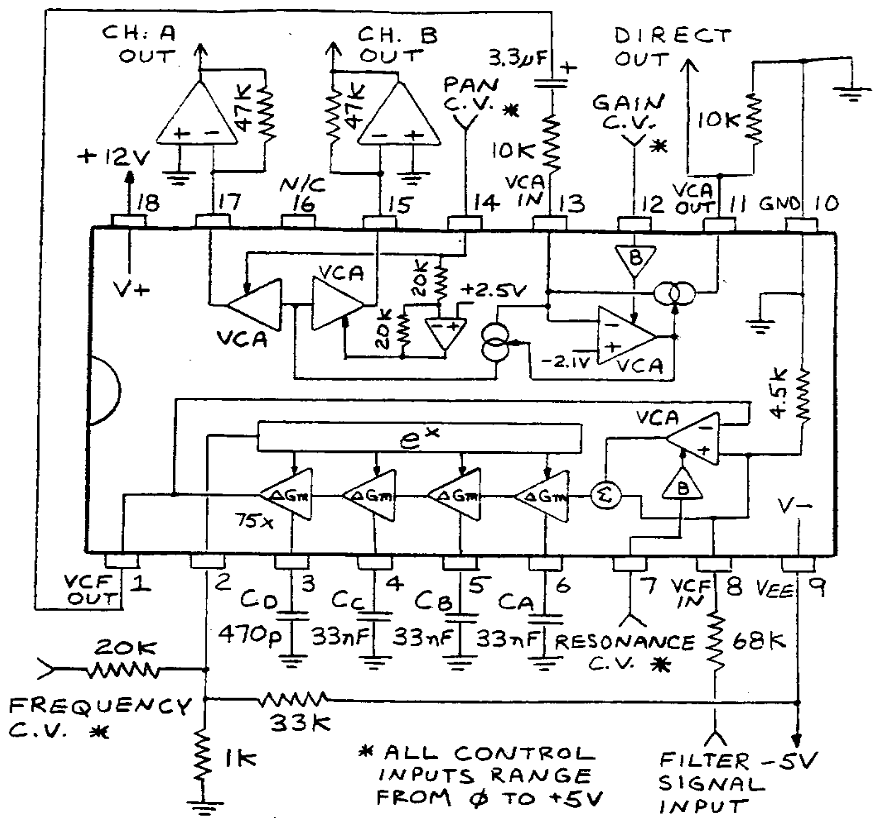
Amax = Rf/2 x (Rin + 0.6K)

If the direct output is not used, it should be connected to ground, or otherwise ensured that it does not go more negative than -1V, as this will disturb the pan outputs.

COMPATIBILITY WITH THE 3379

The 3389 is pin-for-pin compatible with the 3379. If an existing 3379 design simply drives the input of the pan VCAs with the output of the final VCA, either directly or with only amplification/buffering in between, then the 3389 may be used in the existing pc board. Since Pin 16 on the 3389 is not connected anywhere internally, any signal applied there from the existing pc board layout is harmless. The only changes which must be made are the resistor values for the current-to-voltage conversion for the 3 VCAs. The feedback/output resistor for the direct output must be doubled, and those for the pan outputs must be recalculated to keep all the output levels the same in the existing design.

The only other differences (which may or may not affect the system) are that the control voltage required for panning to the same output pin is reversed, and the input impedance to the pan control input is significantly lower (20K for the 3389).



CEM3389 BLOCK & TYPICAL CONNECTION DIAGRAM