CURTIS ELECTROMUSIC SPECIALTIES

C E M 3 3 8 9

VOLTAGE CONTROLLED SIGNAL PROCESSOR

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The CEM 3389 is a general purpose audio signal processing device intended for use in multi-channel systems. Included on-chip are a wide range four-pole low-pass voltage controlled filter with voltage controllable resonance, and three high quality voltage controlled amplifiers, two of which pan the output signal of the third between two outputs.

All three VCAs feature low noise and low control 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 at all three VCA outputs. Thus, the outputs of multiple 3389's may be combined together without excessive noise buildup.

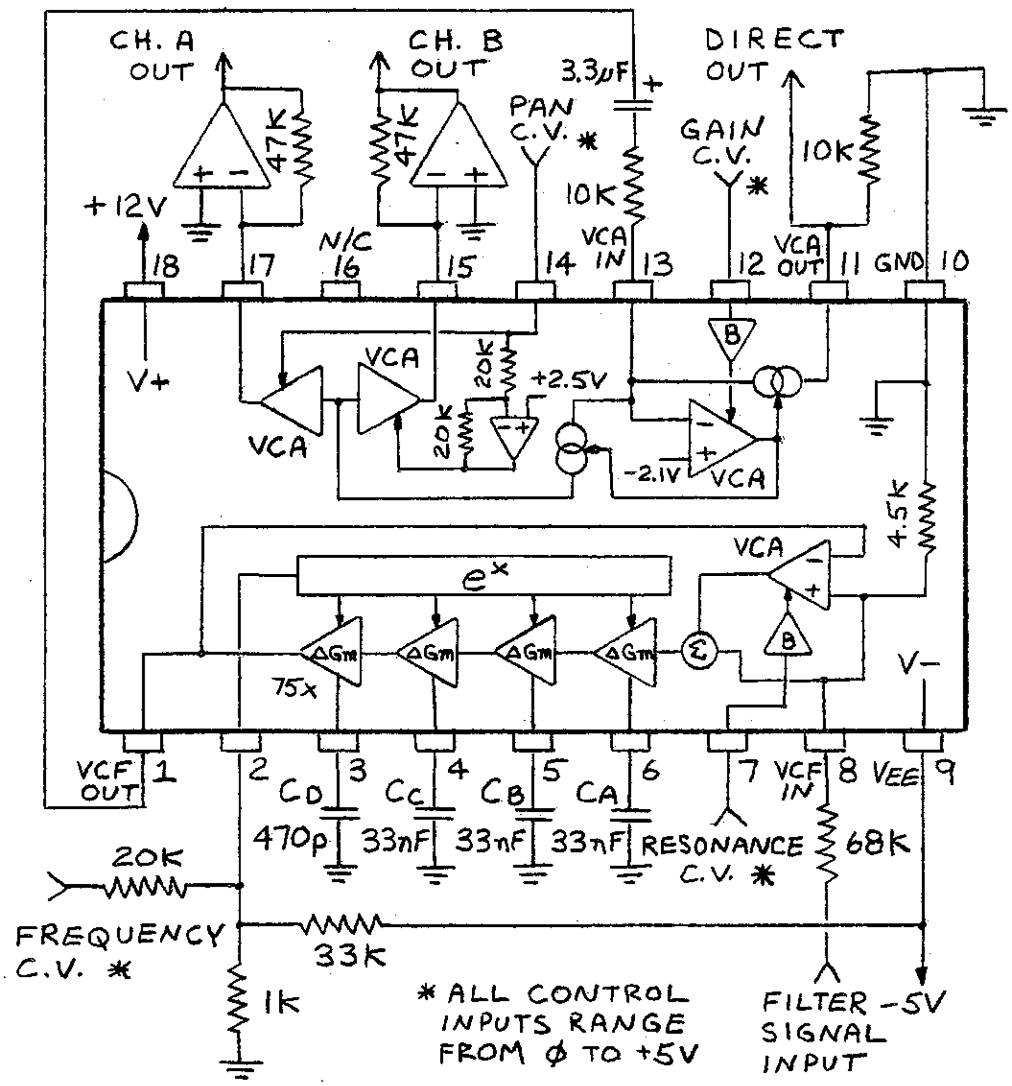
The VCF is the same patented filter used in other Curtis products, designed for good sonic characteristics and no output loss with increasing resonance. With the exception of filter frequency, all control inputs range from 0 to +5v and provide moderately high impedance for minimal system loading; the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

The CEM 3389 is pin-for-pin compatible with the CEM 3379, and may usually be dropped into existing PC boards with only a few component value changes.

Able to operate over a wide supply range and requiring a bare minimum of external components, the CEM 3389 offers low noise signal processing at low cost in stereo output systems.

Features

* Low Cost
* VCF and 4 VCAs On a Single 18 Pin Chip
* Separate Inputs and Outputs for the VCF and VCA Blocks Allowing Unique Signal Processing Configurations
* Rich Sounding VCF Design
* Constant Amplitude v.s. Resonance VCF Characteristic
* Low Noise, Low Distortion VCAs
* Very Low Control Feedthrough Without Trimming
* Completely Noiseless Pan Outputs when Channel is Off
* Operation Down to ± 5V



CEM3389 BLOCK & TYPICAL CONNECTION DIAGRAM

VCC = +12V VEE = -5V TA = 20°C				
Parameter	Minimum	Typical	Maximum	Units
VC FILTER				
Input Signal for 1% THD	---	360	---	mV.P.P.
Passband Signal Gain, VRES=0	6.8	7.5	8.3	
VRES=+2	3.4	3.8	4.2	
Signal Input Resistance	3.6	4.5	5.6	Kohm
Frequency Control Range	14	---	---	octaves
Frequency Control Voltage for 14 Octave Range	---	-155 to +110	---	mV
Frequency Control Scale	+17.5	+19.0	+20.5	mV/octave
Exponential Scale Error, Midrange	---	0.3	1.0	%
Initial Frequency at VFREQ=0 (CA=CB=CC=0.033 uF; CD=470 pF)	650	1000	1650	Hz
Frequency Control Input Bias	-0.2	-0.6	-2.0	uA
Resonance Control Range	Q =0dB	---	oscillation	
Resonance Control Voltage Required for Oscillation	+2.2	+2.8	+3.4	V
Resonance Control Input Bias Current	-0.2	-0.5	-1.5	uA/V
DC Output Shift Over 10 Octave Range (-130mV < VFREQ < +60mV)	---	100	250	mV.P.P.
Output Noise, Filter Wide Open	---	90	---	uV.R.M.S.
Maximum Output Swing	4.5	5.0	5.5	V.P.P.
Quiescent DC Output Voltage	-0.5	0	+0.5	V
Output Sink Current	-0.4	-0.5	-0.6	mA
Output Source Drive Current	---	---	+3.0	mA
INPUT VCA				
Gain Control Range	90	120	---	dB
Maximum Signal Current Gain	0.80	0.93	1.10	
Control Voltage for Max. Gain	4.5	5.0	5.5	V
Maximum Attenuation	90	120	---	dB
Control Voltage for Maximum Attenuation	+30	+85	+140	mV
Control Input Bias Current	-0.1	-0.3	-1.0	uA/V
Voltage at Signal Input Summing Node	-2.3	-2.1	-1.9	V
Output Voltage Compliance	-0.8	---	VCC-1	V

Maximum Recommended Signal Input Swing	---	---	±200	uA
Maximum Possible Signal Input Swing	±0.4	±0.5	±0.6	mA
Output Noise at Max Gain	---	---	2.0	nA.R.M.S.
THD at ±200uA Input	---	0.5	1.5	%
DC Output Offset at Maximum Attenuation	---	---	1.0	nA
DC Output Shift from Maximum Attenuation to Maximum Gain	---	±0.4	±1.8	uA
OUTPUT PAN VCA'S				
Channel A Output (Pin 15)				
Max Gain @ VPAN=0	-8	-7	-6	dB
Max Attenuation @ VPAN=5	86	100	120	dB
Channel B Output (Pin 17)				
Max Gain @ VPAN=5	-8	-7	-6	dB
Max Attenuation @ VPAN = 0	86	100	120	dB
DC Control Feedthrough	---	±0.4	±1.8	uA
Output Noise at Max Gain	---	---	2.0	nA.R.M.S.
THD at ±200uA Input	---	0.5	1.5	%
Pan Control Input Impedance	16K	20K	25K	ohm
Output Voltage Compliance	-0.2	---	VCC-1	V
GENERAL				
Positive Supply Range	+4.75	---	+16	V
Negative Supply Range	-4.75	---	-16	V
(Maximum Supply Across Chip is 25V)				
Supply Current	5.8	7.3	9.1	mA

Power Supplies

The maximum supply allowed across either device is 25 volts. The positive supply may range from +4.75V to +16V while the negative supply may range from -4.75V to -16V; thus, +12V/-12V, +15V/-5V, and +12V/-5V are all acceptable power supplies. Since the maximum positive output swing of the filter is 2.9V below the positive supply, some loss in maximum VCF output will occur at a +4.75 volt supply. For best performance with low power dissipation, +9V to +12V and -5V supplies are recommended.

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 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 that the peak-to-peak output level remains the same when the output waveform rings from added resonance.

The VCF input signal will most likely require attenuation down to the nominal 36Ø mV.P.P. input level. As there is an internal 4.5K (nominal) resistor to gound, this is easily accomplished with a single series resistor to the input pin (pin 8), where the amount of attenuation is given by 1 + (Rinput/4.5K). However, due to the ±25% tolerance of the 4.5K internal resistor, a chip-to-chip VCF output variation of approximately ±2.5dB can be expected worst case. Lower variation can be obtained by adding an external shunt resistor from the VCF input to ground. A 1.3K shunt resistor, for example, will reduce the input resistance to 1K and the output variation caused by internal resistor tolerance to ±Ø.5dB; attenuation is now given by 1 + (Rinput/1K). For best performance, the signal applied to the filter input should have no D.C. component (at least < ±5Ø mV).

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 transconductor:

$$f = Gm/2\pi C$$

Since the transconductance of the last stage is only 1/75th that of the first three stages, its capacitor (pin 3) should always be 1/75th the value of the other three capacitors (pins 4, 5, and 6). Best sweep performance is obtained over a transconductance range of 1 umho to 4 mmho. For a desired frequency range of 5Hz - 2ØKHZ, CA, CB, and CC are thus chosen to be 33nF and CD becomes 47ØpF. (Note that the frequency can be swept at least 1 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 = 200 exp(Vfreq/VT)

where VT is approximately 28.5 mV at 20 C and has a temperature coefficient of +3300 ppm. Note that when Vfreq = 0, the transconductance is nominally 200 umho, resulting in a cut-off frequency of around 1KHZ with C = 33nF. The low frequency of 5HZ is 7.6 octaves below this zero C.V. frequency, and will therefore occur with around -150mV applied to the frequency control pin; the upper frequency of 20KHZ is 4.3 octaves above the zero C.V. frequency, and will occur at a control voltage of around +90 mV.

In the usual case, the system frequency control voltage must be attenuated with a resistor divider down to these levels. If the system C.V. ranges only from 0 volts to a positive value (+5V for instance), then an additional resistor between the control pin and negative supply is needed to produce a negative voltage on the pin (-150mV for instance) to set the lowest desired filter frequency. For best results, the input impedance to the control pin should be kept below several Kohms. Although the transconductors themselves have been internally temperature compensated, the control scale still has a temperature coefficient of -3300 ppm due to VT. This control scale TC may be substantially reduced by use of +3300 ppm TC resistor (such as Tel Labs Q81) in the C.V. 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, Ro, may be connected between the output and the negative supply. The minimum load which may be driven is then:

RLmin (Kohm) = 2.5/(.4 + Vee/Ro (Kohm))

The output is not short circuit protected; therefore, if this pin is connected to outside of the equipment, it is recommended that a minimum of 470 ohm be placed in series with the output pin.

Input VCA

The input VCA is a low noise, low control feedthrough design which does not require any trimming to null control voltage feedthrough; hence it is well suited for being controlled by fast transistion 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; thus the value of input resistor is:

Rin = Vinput (V.P.P.)/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 ±5Ø to ±1ØØuA at the expense of slightly lower signal-to-noise ratio and larger relative control feedthrough. Distortion also increases the lower the input signal voltage; therefore the input signal voltage should be kept above about 1 V.P.P.

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 pans VCAs. Thus the maximum output current swing is one half the input current swing.

The control scale is exponential from Ø to approximately +2ØØmV, controlling the current gain from -1ØØdB nominal to about -3ØdB. Thereafter the current gain increases in a linear fashion until it reaches the maximum of -6dB 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 the direct output has limited negative output voltage compliance (-1V maximum), 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 2 V.P.P., the current-to-voltage conversion may be accomplished simply with a resistor from the output pin (pin 11) to ground. The maximum voltage gain at a +5V control is approximately 1/2 the ratio of the feedback resistor (or output resistor) to input resistor. More precisely, it is:

$$Amax = Rf/2(Rin + .6K)$$

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.

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 may be combined without excessive noise buildup; and 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 the noise is also zero. This ensures extremely quiet sustem 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 +.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 VCA output(s) also have a limited negative output voltage compliance (-Ø.2V), they must be fed to a virtual ground summing node of an op amp for large output voltage swings. However, in cases where the outputs(s) drive 3Ø8Ø type VCA or the input to a VCF, where the voltage swing is less ±2ØØ mV.P., the output current may be converted to the required voltage simply with a resistor connected from the output pin(s) to ground.

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

Compatability with CEM 3379

The CEM 3389 is pin-for-pin compatible with the CEM 3379. If an existing design using the 3379 simply drives the input of the pan VCAs with the output of the final VCA, either directly or with only amplification or 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 values for the current-to-voltage conversion resistors for all three 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 as 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 (2ØK nominal for 3389).