AS3365 - multi-functional VCA blocks (Fader/Panner)

AS3365D
SOIC-16 (150 Mil)

Features

- simplifies the design of voltage controlled audio crossfaders and panners
- three VCA blocks (each contains two 2-quadrant multipliers connected in serial)
- two linear controls for each VCA
- simple signal mixing
- can combine high impedance outputs
- provides high attenuation (-100 dB)
- low current consumption of 3 mA typ at ±12V

Application

Voltage controlled mixing for audio mixers and music synthesizers:
crossfading, panning, ring modulation, stereo panning, audio switching, control signal processing, audio compression with side-chain function, etc.

General description

AS3365 contains three VCA blocks, which are intended for use in musical synthesizer applications (VCA blocks, faders, panners, multiplexers, ring modulators etc.). VCA1 and VCA2 implement function of controlling amplification. A direct signal CVMix1 is supplied to the VCA1 control, an inverted CVMix2 signal is supplied to the VCA2 control. Using two amplifiers VCA1 and VCA2 together, you can implement the function of stereo panning of the input signal. Additional control input Vcntrl controls attenuation of output current - thus realizing function of double multiplication input signal on two control signals. VCA3 block has additional feature – possibility of control/mixing of two input signals.

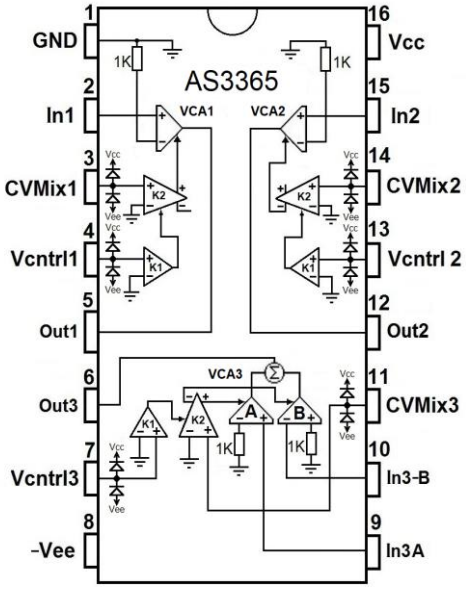
Vast opportunities in designing new synth solutions:

- panner and crossfader designs can use the same single CV signal, because the CV input on VCA2 works in the inverse direction of the CV input on VCA1;
- possibility to use the four-quadrant VCA3 to generate a correction curve for equal loudness (RMS) panning and fading;
- voltage controlled processing and inversion of control voltage signals, like envelope and LFO signals;
- when signal inputs are DC-coupled then both audio signals and low frequency modulation CV signals can be processed with the same circuit;
- normalization on audio input and output connectors can switch between a panning or a crossfading function, depending on how signals are plugged in.

Pin information

SOIC-16	Pin Name	Description
1	GND	Ground
2	In1	Input VCA1
3	CVMix1	Control Input Mixer VCA1
4	Vcntrl1	Control Input VCA1
5	Io1	Current Output VCA1
6	Io3	Current Output VCA3
7	Vcntrl3	Control Input VCA3
8	Vee	Negative Supply
9	In3A	Input VCA3_A
10	In3-B	Input VCA3_-B
11	CVMix3	Control Input Mixer VCA3
12	Io2	Current Output VCA2
13	Vcntrl2	Control Input VCA2
14	CVMix2	Control Input Mixer VCA2
15	In2	Input VCA2
16	Vcc	Positive Supply

Circuit Block Diagram



Absolute Maximum Ratings

Voltage between Vcc and Vee pins	30V
Voltage between Vcc and GND pins	+3V to +16V
Voltage between Vee and GND pins	-3V to -16V
Control voltage range CVMix	-3V to +3V
Control voltage range Vcntrli	-3V to +3V
Vinx	-1V to +1V

Electrical Characteristics

Vcc = + 12V Vee = -12V Tamb = +20°C

Parameter	Min.	Typ.	Max.	Units
Total harmonics distortion(THD) 1) Input voltage (±17 mV) Input voltage (±28 mV) Input voltage (±40 mV)		 0,7 2 4		%
Total harmonic distortion	-	4	6	%
Maximum output current (Vin=±40 mV)		±110		µA
Maximum amplification		2,5		µA/mV
Input bias current		1		µA
Bandwidth	8,0	10	-	MHz
Output current slew rate 3)	700	1000	-	µA/µsec
Crosstalk between VCA (10 kHz)	-80	-90	-	dB
Feedthrough CVMix trimmed	-0,3		+0,3	µA
Feedthrough CVMix untrimmed	-1,5		+1,5	µA
Maximum input current (for CVMix)	-	-3	-	µA
Maximim input current (Vcntrlx)	-	1	-	µA
Output impedance 3)		10	-	MOhm
Maximum voltage range for Outx	-200	-	+200	mV
Positive supply range Vcc	+5	12	+16	V
Negative supply range Vee	-5	-12	-16	V
Current consumtion Icc	2,5	3,3	4,5	mA
Current consumption Iee	2,2	2,8	3,5	mA
VCA1, 2				
Control voltage range CVMix, linear range 2)	-1,75	-	+1,75	V
Control voltage CVMix for maximum amplification VCA1		2		V
Control voltage CVMix for maximum amplification VCA2		-2		V
Control voltage Vcntrl linear range 2)	-1,65	-	+1,65	V
Control voltage Vcntrl for maximum VCA output current		2		V
Vcntrl maximum attenuation level (turn "OFF" VCA current)		-2		V
Attenuation (Vcntrl=-2V)		100		dB
Feedthrough Vcntrl		60		dB
VCA3				
Control voltage CVMix3 for maximum amplification In3A		2		V
Control voltage CVMix3 for maximum amplification In3-B		-2		V
Control voltage CVMix for balance amplification In3A and In3-B	-20	0	20	mV
Maximum output offset (Vin=0)	-2	-1	+1	µA

Note 1. THD is independent from CVMix or Vcntrl
Note 2. Out of these range control is exponential
Note 3. Output current is ±100 µA

Application information

General information

IC consists of 3 VCA blocks, which are controlled by voltage with maximum output current till ±100 μA each. Outputs of VCA can be connected together, allowing current summing from different VCA's. Maximum output voltage on each VCA can't exceed ±200 mV. If higher voltage is needed - IU converter must be used.

VCA1 and VCA2 each has one input signal. VCA3 has two input signals IN3A and IN3-B. Maximum voltage on these inputs can't exceed ±40mV, thus attenuator must be used with 1k resistor connected to GND.

Each VCA has two control inputs CVMix and Vcntrli, with input voltage ranging from -2V to +2V. Control voltages CVMix allows to change amplification on the VCA output. Vcntlr control voltages allow you to change the maximum output current at the VCA output until the current is completely turned off.

For VCA1:
If CVMix = +2V -> VCA output = maximum signal
If CVMix = -2V -> VCA output = "zero" output

For VCA2:
If CVMix = +2V -> VCA output = "zero" output
If CVMix = -2V -> VCA output = maximum signal

CVMIix3 of VCA3 controls mixing of input signals IN3A and IN3-B:
If CVMix3 = +2V -> VCA output = maximum amplification from input IN3A,
If CVMix3 = -2V -> VCA output = maximum amplification from input IN3-B,
If CVMix3 = 0V -> VCA output = "zero" output (IN3A - IN3-B).

Vcntrl1,2,3 – controls output currents of VCA1,2,3 to attenuation -100dB:
if Vcntrlx = +2V -> VCA provides maximum current to output,
if Vcntlrx = 0V -> VCA provides approximately 50% of maximum current,
if Vcntlrx = -2V -> turns "OFF" output current.

For VCA1 and VCA2 mathematical equations are (assume CVMix maximum amplitude is relative "1"):

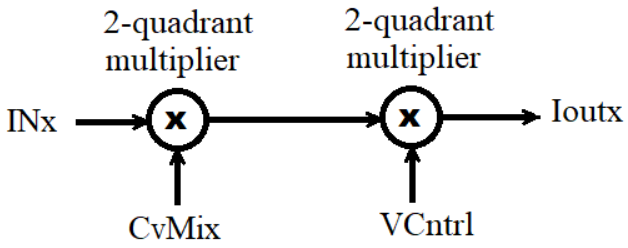
VCA1 : Iout1 ~ In1 * CVMix1 * Vcntlx1

VCA2 : Iout2 ~ In2 * (1-CVMix2) * Vcntlx2

For VCA3 mathematical equation is:

Iout3 ~ (In3A *CVMix3 - In3-B *(1- CVMix3)) * Vcntl3)

Simplified structure of each VCA block can be described as - 2-quadrant multiplier followed by 2- quadrant multiplier.



Simplified VCA structure

Panning & Crossfading

The AS3365 contains three flexible voltage controlled amplifier functions.
The two functions VCA1 and VCA2 are identical in architecture, but VCA1 has a 'positive going' CVMix to control loudness while the second has its CVMix 'internally inverted'. This means that when both VCA1 and VCA2 get the same CV on their CVMix inputs then VCA1 opens while VCA2 closes, which is a requirement when panning or crossfading while using the same CV signal.
Both channels feature an additional Vctrl signal which can set the overall loudness for each of the two channels. This extra Vctrl input can be used to e.g. temporarily mute a channel or to apply a correction curve to change the panning or crossfading curve to an equal loudness curve where the midpoint is at -3dB instead of the -6dB when a linear curve is used. The equal loudness curve is essential when two differently pitched audio signals are panned to stereo or crossfaded to mono and the overall perceived loudness needs to remain the same.
The AS3365 is ideal for two-channel audio processing, e.g. combining two channels in one (crossfading), one channel in two (panning) or controlling a stereo signal (stereo panning). In music synthesizers the principle of crossfade mixing is ideal to mix two or more signals: in essence one can mix n channels with n-1 knobs in a multi-crossfader mixer setup, where the mix output is automatically kept 'equally loud', and at least one channel is always audible. So, while performing on a stage the instrument can never become accidentally silent because all VCO wave mixer knobs are accidentally closed. Additionally, voltage controlled crossfading between two waveforms can significantly add to the expression in the play of the synthesizer.

Ring modulator

The VCA3 is in essence a bipolar VCA, meaning that when the two inputs receive the same signal a negative control voltage on the VMix3 input will invert the phase of the output signal and when VMix3 is at 0V the output will be silent. This results in the four quadrant multiplication needed for e.g. a ring modulator. When DC-coupling its inputs this four quadrant multiplication can be used for 'analog computing' techniques, e.g. to generate a correction curve to approximate RMS behaviour of the VCA1 and VCA2 for an equal loudness mixing contour.

Audio-level control

Combined with an extra envelope follower circuit the AS3365 can be used for automated audio level control on one audio channel, with a side-chain function (ducking) on a second channel. This is useful for e.g. automated mixing of a music track and one of several narrative vocal tracks in different languages for movies or documentaries. Two AS3365s can do a full stereo compressor with side-chaining on two separate stereo channels.

Mixers

Three AS3365s can be combined in a quadrophonic mixer setup with quadrophonic equal loudness behavior, featuring one CV for the X-direction and a second CV for the Y-direction, controllable by e.g. a joystick. In either a 'four inputs to one output' or a 'one input to four outputs' setup.

To implement voltage controlled mixing functions the VCA1 and VCA2 are normally used in parallel, much like the parallel mixer channels on an audio mixing desk. This gives three basic possibilities:
A - the two parallel channels receive the same input signal but have separate outputs, which results in panning;
B - the two parallel channels receive two different input signals but their outputs are tied together, which results in crossfading;
C - the two parallel channels receive two different input signals and their outputs are kept separate, which results in e.g. panning of a stereo input signal to a stereo output signal.

Note:
When using audio connectors with built-in normalization switches these three basic functions can in essence be chosen by how signals are plugged into the connection sockets. Both 1/4" jack connectors and 1/8" mini-jack connectors with normalization switches are widely available for this purpose. Some extra buffering opamps on both inputs and outputs are highly recommended with such a connector normalization scheme.

"Traditional" VCAs

Next to the more complex combined functions both VCA2 And VCA2 can be used as two separate traditional VCAs controlled by the CVMix input, plus an extra overall loudness level CV or mute switch by additional use of the VCtrl input. Please keep in mind that for traditional VCA use the CVMix curve for VCA2 is 'inverted'.

MIDI parameters

The Vctrl input is also useful when a traditional VCA in a music synthesizer needs the MIDI velocity to set the individual loudness of each note played on a keyboard with velocity sensing. Other MIDI parameters like Aftertouch and Expression can also be used on the Vctrl inputs.

"X-X^2" curve (equal loudness)

VCA3 can be used to implement a "X-X^2" curve, when a control voltage between -2V and +2V is applied to both the signal input and the VMix3 input. This results in a 'dome shaped' signal in the negative domain, which can then be shifted into the positive domain by adding a fixed positive voltage in a way that the resulting output voltage is 0V for a -2V and for a +2V control signal and at a positive voltage of around +1V when the CV voltage X is at 0V. When adding this voltage in an equal proportion to both the Vctrl inputs of VCA1 and VCA2 the mixing curve will closely approximate an RMS equal loudness contour.

Adding a switch to turn this correction CV on or off allows for a user to either choose for a linear curve, which may be better for mixing CV signals, or an equal loudness curve that is needed for the crossfading or panning of two audio signals. Note that when two audio signals are mixed together the attenuation of the two signals needs to be -3dB and not -6dB for the result to be perceived as equally loud by the human ear.

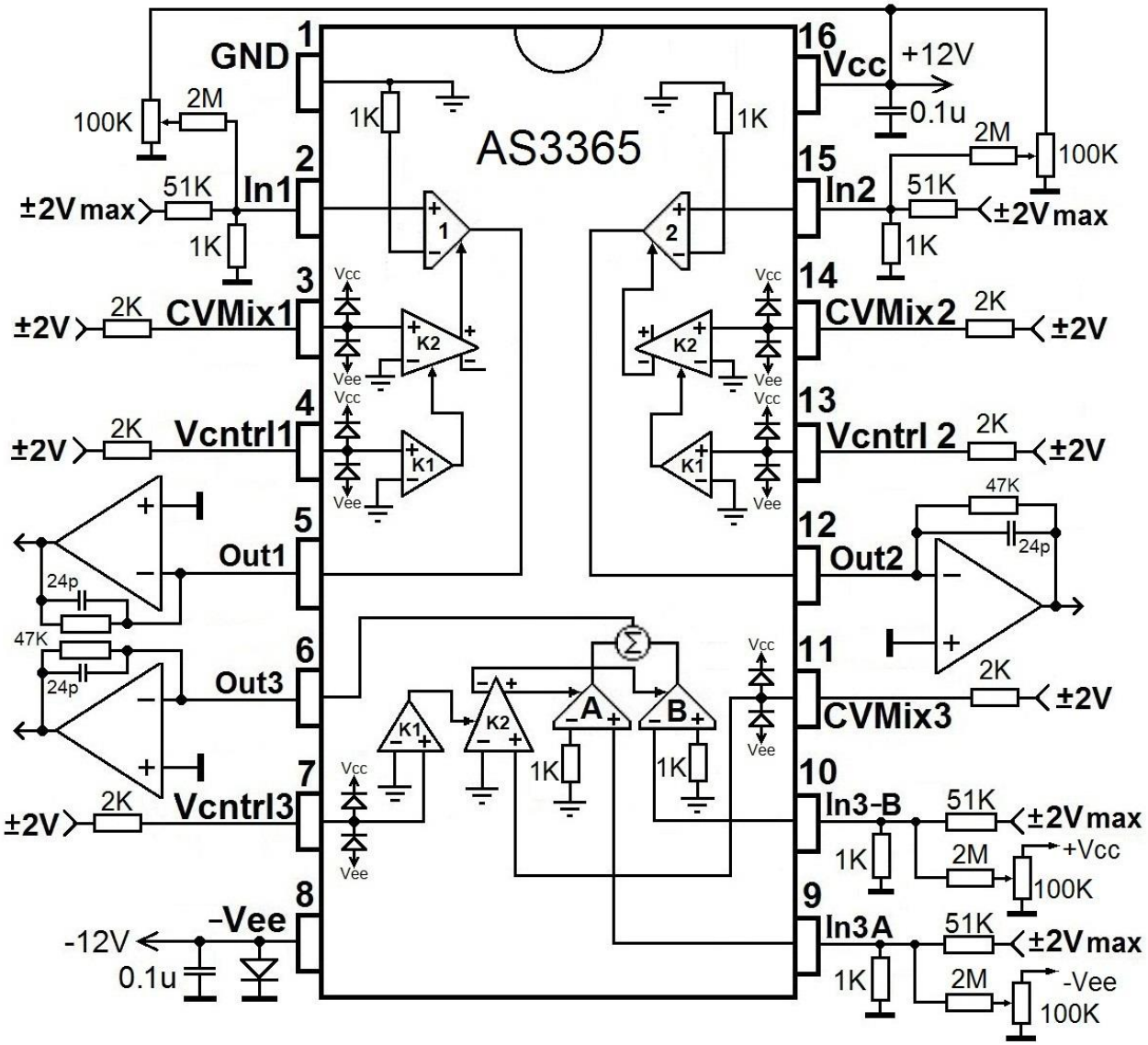
This is very important when e.g. panning a signal between the left and right speakers with a triangle wave LFO signal. But it also often applies to the mixing of two different VCO waveforms as well, especially when one waveform is one or more octaves down.

So, when this "X-X^2" curve is added to both channels the more or less +1V of the curve when in the middle position will boost the amplification of both VCAs by +3dB (use a trimmer to set this extra amplification), while at the 'left' and 'right' side this correction voltage is 0V and thus will not add extra amplification. The result is a close approximation of a true RMS curve, with a smooth 'left to right' angle transition at a loudness perceived as equal for each left<>right position angle in the stereo field. Note that in comparison a linear panner CV curve gives a significant drop in the perceived loudness in the middle position.

Other control applications

VCA3 is also ideal to process control voltage signals in music synthesizers.

E.g. when an envelope signal is modulating a filter sweep VCA3 can modulate the depth of the filter sweep under voltage control. And, as it is a true four-quadrant multiplier, it can also invert the sweep direction. The CV to control VCA3 itself could be the MIDI-velocity parameter or come from a combination of a LFO and a S&H (e.g an ALFA RPAR 1100CK2, K1100CK2 or KP1100CK2 http://www.alfarzpp.lv/eng/sc/1100CK2.php) where the S&H is triggered by the keyboard or sequencer gate signal. The rhythmic variations that would result can greatly add to the expressiveness of e.g. sequenced music.



Application diagramm

Package Information

Device type	Package
AS3365D	SOIC-16 (150 Mil)

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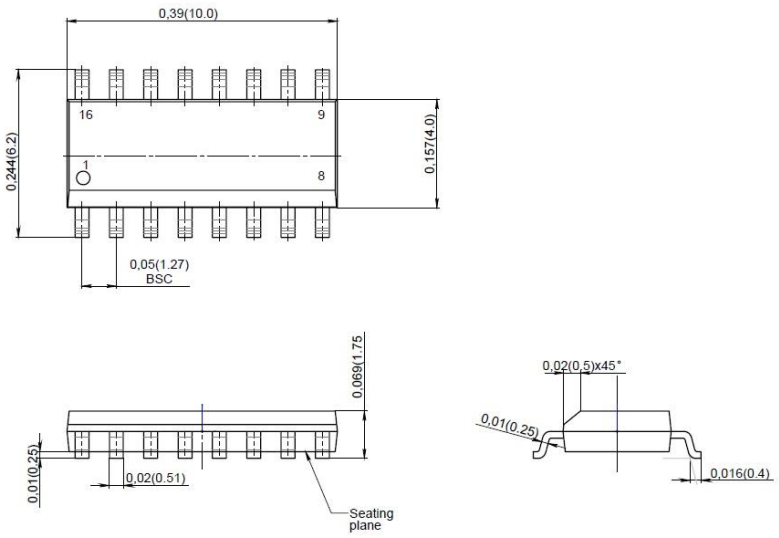

Revision history

Date	Revision	Changes
04-Apr-2020	**1**	Initial version
13-Oct-2020	**2**	Minor changes
10-Dec-2020	**3**	Trimming circuit added ,