

# Zoxnoxious 3340 VCO

## FEATURES

- Alfa Rpar AS3340 VCO
- Microcontroller interface via I<sup>2</sup>C and SPI
- DAC control for all VCO parameters
- Switching controls for signal routing
- External signal inputs allow for modulation, controlled via VCA
- Two VCO outputs with VCA control for pulse, sawtooth, triangle waveforms
- Four modes of sync with phase modulation
- Board identifier via ROM
- Eurorack power levels

## APPLICATIONS

- Electronic music
- Hardcore techno
- Ambient electronica
- Beyond obnoxious noise
- Folding laundry or space

## GENERAL DESCRIPTION

Built around an Alfa Rpar AS3340 VCO, the Zonxnoxious 3340 provides a digital interface over Serial Peripheral Interface (SPI) and Inter-Integrated Circuit (I<sup>2</sup>C) for all control elements. A 2x20 header includes power, digital control, analog inputs, and analog outputs. The 2x20 header is common among Zoxnoxious devices.

VCO control signals are generated via an Analog Devices AD5328 12-bit DAC. Control signals include exponential frequency control (1 V/octave), linear frequency control, pulse width, VCA levels for both external input

modulation and triangle output, and sync phase are controlled by the DAC. Switched control elements interface with a On Semicon PCA9555 GPIO. Switched controls include external signal selection, routing the external signal to positive sync, negative sync, exponential frequency modulation, linear frequency modulation, output signals and levels.

A M24C02 ROM allows query and identification of the Zoxnoxious 3340 over I<sup>2</sup>C.

A dedicated output pin for the pulse is provided. This is intended to be read back to a microcontroller to allow for tuning.

Functions controlled via 12-bit DAC over SPI:

- Exponential frequency @ 1V/oct
- Linear control voltage
- Pulse Width
- Sync phase
- External modulation attenuation
- Mix1 Triangle output level
- Mix1 Sawtooth output level
- Mix1 Pulse output level

Functions controlled via GPIO over I<sup>2</sup>C:

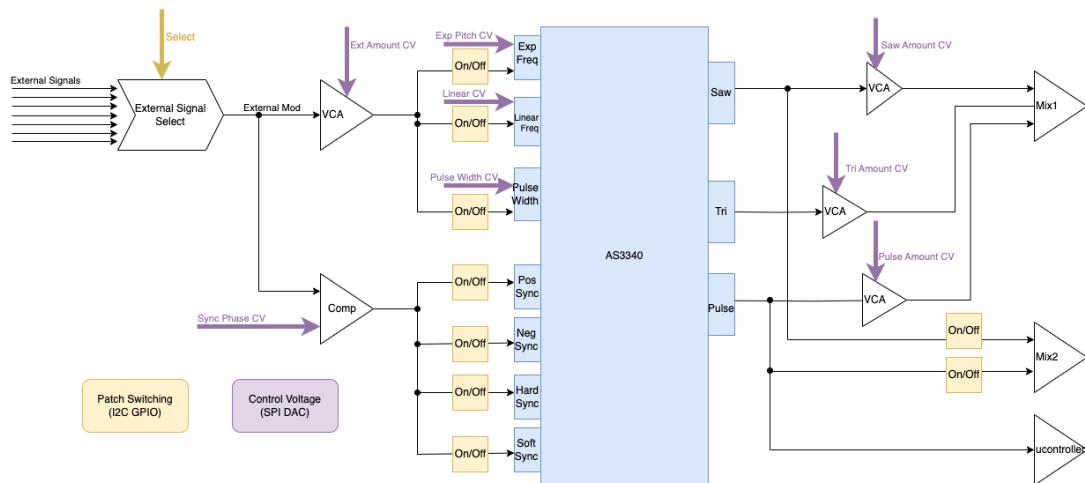
- External signal select from 13 inputs
- External signal to exponential frequency
- External signal to linear frequency
- External signal to pulse width
- Traditional hard sync
- Soft sync
- Positive hard sync
- Negative hard sync
- Mix2 Pulse output on/off
- Mix2 Saw output on/off

## FUNCTIONAL DIAGRAM

The significant blocks of the Z3340 is shown below highlighting functions controlled for SPI and I<sup>2</sup>C.

### Zoxnoxious 3340 Block Diagram

An odd mixture of useful and questionably useful features on a single board. I<sup>2</sup>C is used for patch control / switching. A SPI DAC is used for control voltage signals.



## SPECIFICATIONS

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$V_{CC} = +12V$ ;  $V_{DD} = +5V$ ;  $V_{EE} = -12V$

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Parameter	Typical	Units
<b>Power Supply</b>		
$V_{CC}$	34	mA
$V_{DD}$	5	mA
$V_{EE}$	35	mA
<b>Digital Input<sup>1</sup></b>		
Logic levels	5V logic <sup>2</sup>	
Logic High ( $V_{IH}$ )	3.5	V
Logic Low ( $V_{IL}$ )	1.5	V
I <sup>2</sup> C frequency	400	kHz
SPI frequency	24	MHz
<b>Digital Output</b>		
GPIO Module Output Upper Level	5.0	V
GPIO Module Output Lower Level	0.0	V
<b>Analog Input</b>		
External Signal Recommended High Voltage	5.0	V
External Signal Recommended Low Voltage	-5.0	V
External Signal Input Impedance (selected)	100 k	$\Omega$
External Signal Input Impedance (unselected) <sup>3</sup>	High	$\Omega$
<b>Analog Output<sup>4</sup></b>		
Frequency	27.5 – 7040	Hz
Mix1 Pulse	-2.7 – +2.7	V
Mix1 Saw	-1.8 – +1.8	V
Mix1 Triangle	-2.0 – +2.0	V
Mix2 Pulse	0.0 – +3.6	V
Mix2 Saw	0.0 – +3.7	V
Mix1 Output Impedance	51	$\Omega$
Mix2 Output Impedance	51	$\Omega$

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<sup>1</sup>I<sup>2</sup>C: refer to PCA9555 and M24C02 specs for detailed info. SPI: refer to AD5328 spec for detailed info.

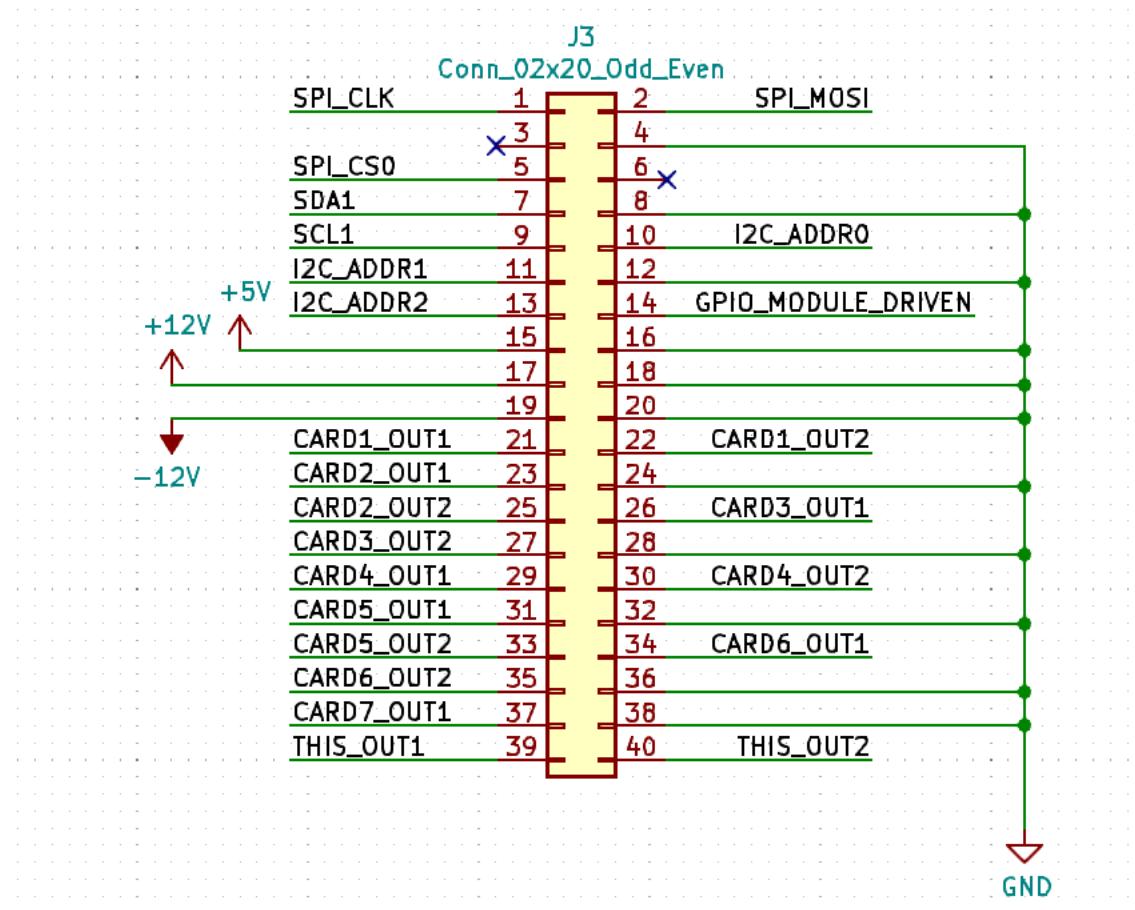
<sup>2</sup>While all digital ICs are 3.3V tolerant, the design is verified against 5V logic only.

<sup>3</sup>Off leakage current 0.01 nA per DG406 datasheet.

<sup>4</sup>Mix1 is AC coupled; Mix2 is unipolar.

## Z-CARD BUS PIN CONFIGURATION AND DESCRIPTION

The diagram and table below specifies the 2x20 header that is common to all Zoxnoxious boards. This is referred to as the “Z-Card Bus” or “Zoxnoxious Bus”.



Pin	Mnemonic	Description
1	SPI_CLK	Serial (SPI) clock for AD5328
2	SPI_MOSI	Serial (SPI) serial in for AD5328
3	SPI_MISO	Not used / no connect for Zoxnoxious 3340
4	GND	Ground
5	SPI_CS0	Active low chip select for AD5328
6	SPI_CS1	Not used / no connect for Zoxnoxious 3340
7	SDA1	I <sup>2</sup> C data for PCA9555 and M24C02. Requires external pullup.
8	GND	Ground
9	SCL1	I <sup>2</sup> C clock for PCA9555 and M24C02. Requires external pullup.
10	I2C_ADDR0	I <sup>2</sup> C address bit for PCA9555 and M24C02

11	I2C_ADDR1	I <sup>2</sup> C address bit for PCA9555 and M24C02
12	GND	Ground
13	I2C_ADDR2	I <sup>2</sup> C address bit for PCA9555 and M24C02
14	GPIO_MODULE_DRIVEN	AS3340 Pulse wave
15	$V_{DD}$	+5V power
16	GND	Ground
17	$V_{CC}$	+12V power
18	GND	Ground
19	$V_{EE}$	-12V power
20	GND	Ground
21	CARD1_OUT1	Input signal selectable as a modulation source
22	CARD1_OUT2	Input signal selectable as a modulation source
23	CARD2_OUT1	Input signal selectable as a modulation source
24	GND	Ground
25	CARD2_OUT2	Input signal selectable as a modulation source
26	CARD3_OUT1	Input signal selectable as a modulation source
27	CARD3_OUT2	Input signal selectable as a modulation source
28	GND	Ground
29	CARD4_OUT1	Input signal selectable as a modulation source
30	CARD4_OUT2	Input signal selectable as a modulation source
31	CARD5_OUT1	Input signal selectable as a modulation source
32	GND	Ground
33	CARD5_OUT2	Input signal selectable as a modulation source
34	CARD6_OUT1	Input signal selectable as a modulation source
35	CARD6_OUT2	Input signal selectable as a modulation source
36	GND	Ground
37	CARD7_OUT1	Input signal selectable as a modulation source
38	GND	Ground
39	THIS_OUT1	Output signal Mix1
40	THIS_OUT2	Output signal Mix2

## THEORY OF OPERATION

### I<sup>2</sup>C Addresses

Both I<sup>2</sup>C chips, the M24C02 and PCA9555, take the last 3 bits their I<sup>2</sup>C address from the Z-Card Bus 2x20 connection header (J3). Pins 13, 11, and 10 provide the lowest 3-bits of I<sup>2</sup>C address for the M24C02 and PCA9555. Assuming Z3340 cards are given unique addresses, this allows up to 8 instances of Zoxnoxious compatible cards to be used together. The I<sup>2</sup>C addresses for the M24C02 and PCA9555 are shown below based on Z-Card pins 13, 11, 10.

Pins 13, 11, 10	M24C02 Addr	PCA9555 Addr
000	0x50	0x20
001	0x51	0x21
010	0x52	0x22
011	0x53	0x23
100	0x54	0x24
101	0x55	0x25
110	0x56	0x26
111	0x57	0x27

Pins 13, 11, and 10 should set to  $V_{DD}$  or ground at system start. Changing the address state of during operation is undefined behavior.

I<sup>2</sup>C requires external pullup resistors. No pullup resistors are included on the Z3340 board.

### ROM Query

The Zoxnoxious 3340 VCO can be distinctly identified from other Zoxnosious boards by querying an 8-bit value at byte address zero on the M24C02 ROM. A factory value of “0x02” is set at byte address zero of the M24C02 ROM by the Zoxnoxious elves. For normal operation the read of byte address zero is the only action ever required from the ROM. Refer to the M24C02 datasheet for I<sup>2</sup>C protocol.

By default writes are disabled. Jumper J2 to enables EEPROM writes.

### GPIO Setup and Operation

On startup, two I<sup>2</sup>C writes should be issued to configure outputs on both the PCA9555 ports.

Set Port 0 as output <i2c addr> 0x06 0x00

Set Port 1 as output <i2c addr> 0x07 0x00

Patch setup is then a matter of an I<sup>2</sup>C command for the desired switching shown below.

Switch	Port	Bit(s)
Traditional Hard Sync	Port 0	XXXXXXXX1
Ext Mod to PW	Port 0	XXXXXXX1X
LED (active low)	Port 0	XXXX0XXX
Sync Negative	Port 0	XXX1XXXX
Soft Sync	Port 0	X1XXXXXX
Sync Positive	Port 0	1XXXXXXX
Ext Mod to Linear Freq	Port 1	XXXXXXX1
Mix2 Saw	Port 1	XXXXXX1X
Mix2 Pulse	Port 1	XXXXX1XX
Ext Mod to Exp Freq	Port 1	XXXX1XXX
Card A Out1	Port 1	0000XXXX
Card A Out2	Port 1	0001XXXX
Card B Out1	Port 1	0010XXXX
Card B Out2	Port 1	0011XXXX
Card C Out1	Port 1	0100XXXX
Card C Out2	Port 1	0101XXXX
Card D Out1	Port 1	0110XXXX
Card D Out2	Port 1	0111XXXX
Card E Out1	Port 1	1000XXXX
Card E Out2	Port 1	1001XXXX
Card F Out1	Port 1	1010XXXX
Card F Out2	Port 1	1011XXXX
Card G Out1	Port 1	1100XXXX

Value “X” implies don’t care; in this instance the meaning should be “maintain state” with the previous value. Details on PCA9555 commands are available in the PCA9555 datasheet.

## DAC Setup and Operation

The AD5328 enable is active low through SPI\_CS0 chip select. SPI mode 1 is used for data transfer, MSB first. On power up, two SPI writes should be issued to initialize the DAC. The first write is for a full reset of device, sending 0xF0 0x00 via SPI. A second SPI command to power on all DACs with 1x gain and use Vref is sent with a payload of 0x80 0x00.

Setting DAC lines on the AD5328 via SPI is two bytes of data with the upper four bits being the address of the DAC line and the lower 12 bits being the data bits to convert to analog.

Supporting DAC circuitry is designed around a sampling rate of up to 8 kHz. A simple RC filter is used for low pass filtering DAC outputs with the approximate corner frequencies listed below.

Description	DAC Addr	Cutoff (Hz)
Sync level	0x0	1600
Exp Freq Control	0x1	1600
Mix1 Pulse VCA	0x2	400
External Mod VCA	0x3	400
Mix1 Triangle VCA	0x4	400
Mix1 Saw VCA	0x5	400
Pulse Width	0x6	700
Linear Freq Control	0x7	1300

## VCO Frequency Scaling

Properly tuned (see TUNING below), the VCO has a range greater than 27.5 Hz – 7040 Hz. If using a CPU autotuning calibration routine during runtime, the manual tuning should ensure this range is exceeded. This allows the CPU autotune calibration to cover the range.

In use the VCO frequency follow the Exp Freq Control DAC. This assumes the Linear Freq Control DAC is set mid-level (0x07ff). Then the VCO frequency should follow:

$$VCO_{freq} = 2^{\frac{ExpFreqControl}{512}} \times 27.5\text{Hz}$$

where ExpFreqControl is a 12 bit value from 0 – 4095.

## GPIO Module Output

The AS3340's pulse wave drives a switch with a high level of  $V_{DD}$ . The intent with this output is to allow a microcontroller to read the pulse wave for frequency counting or tuning. This may be best done in an offline tuning routine so that the pulse width can be set to a fixed 50% values and Linear Freq Control set mid-level.

## EXTERNAL MODULATION

The Zoxnoxious bus provides thirteen signals from seven cards. The Zoxnoxious 3340 gives access to any of these signals; one may be selected as a modulation source via an I<sup>2</sup>C transaction to the GPIO. The modulation destinations can also be enabled/disabled via I<sup>2</sup>C transactions to the GPIO.

## TEST POINTS

The following test points are available on the Zoxnoxious 3340 board:

Test Point	Description
TP1	High Freq Tracking
TP2	Soft Sync Input
TP3	VCO Saw Out
TP4	Hard Sync Input
TP5	Sync Comparator
TP6	VCO Tri Out
TP7	External Mod Post-VCA

## TUNING

As a reference, the CEM3340 datasheet provides info on tuning. The AS3340 does not provide tuning info. For the Zoxnoxious 3340, the steps are:

1. Adjust RV2 such that High Freq Tracking (TP1) reads 0 Volts
2. Set exponential frequency control DAC to 1024 (2 V)
3. Note frequency. Ideally this should be 110 Hz.

4. Set exponential frequency control DAC to 1536 (3 V)
5. Note frequency. Ideally this should be 220 Hz.
6. Adjust RV1 towards 1 Volt per octave: DAC 1024 to 1536 should give a 1 octave interval.
7. Repeat DAC setting, adjusting RV1 to 1 Volt per octave
8. Increase frequency to highest frequencies: DAC to 3583.
9. Note frequency
10. Set exponential frequency control DAC to 4095.
11. Repeat DAC setting and adjust RV2 to achieve 1 Volt per octave

## BOARD INFORMATION

Todo: dimensions, pic, layout