

# Zoxnoxious 3372 Analog Signal Processor

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## FEATURES

- Alfa Rpar AS3372 Analog Signal Processor
- 4-pole lowpass filter with resonance
- White noise source available pre-filter
- Two selectable sources for mixing and modulation
- Panning control over output
- Microcontroller interface via I<sup>2</sup>C and SPI
- DAC control over eight parameters
- Switching controls for signal routing
- Board identifier via ROM
- Eurorack power levels

## APPLICATIONS

- Electronic music
- Detroit techno
- Ambient electronica
- Beyond obnoxious noise

## GENERAL DESCRIPTION

Built around the Alfa Rpar AS3372 Analog Signal Processor, the Zoxnoxious Z3372 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 and plugs into the Zoxnoxious Signal Bus.

The Z3372 control signals are generated via an Analog Devices AD5328 12-bit DAC. Control signals include filter cutoff frequency, resonance amount, VCA control for two inputs, VCA control for modulation amount,

noise level, output level, and pan control. Switched control elements interface with a On Semicon PCA9555 GPIO. Switched controls include selection of two different input signal from the Zoxnoxious Signal Bus, and enable/disabling modulation routing to filter cutoff, resonance, output level, and panning.

A M24C02 ROM allows query and identification of the Zoxnoxious Z3372 over I<sup>2</sup>C.

A digital output is provided to allow for calibration.

Functions controlled via 12-bit DAC over SPI:

- Signal one input VCA
- Signal two input VCA
- White noise level
- Filter cutoff
- Resonance amount
- Modulation amount
- Output VCA
- Panning mix1/mix2

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

- Input Signal one select from 8 inputs
- Input Signal two select from 8 inputs
- Filter cutoff modulation
- Resonance modulation
- Output VCA modulation
- Panning modulation

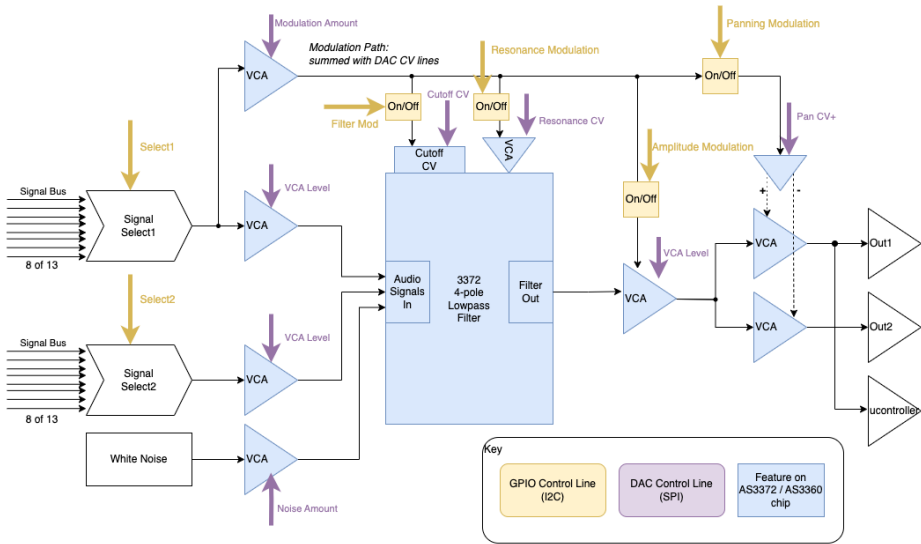
FUNCTIONAL DIAGRAM

The significant blocks of the Z3372 is shown below highlighting functions controlled for SPI and I<sup>2</sup>C.

Zoxnoxious Z3372 Block Diagram

The Zoxnoxious 3372 is a voltage controlled 4-pole lowpass filter with voltage controlled resonance, amplifier control, and stereo panning to provide analog signal processing for audio signals. Two muxes on the frontend allow for signal selection to mix two signals from the Zoxnoxious audio bus. The first signal is available both on the audio path and can also be used as a modulation source. Modulation destinations include filter cutoff, resonance, amplitude modulation, and panning modulation. A white noise source with its own VCA is included as an additional audio source, pre-filter.

All VCAs, filter cutoff, and resonance are under DAC control. DAC lines are summed with modulation lines where relevant.

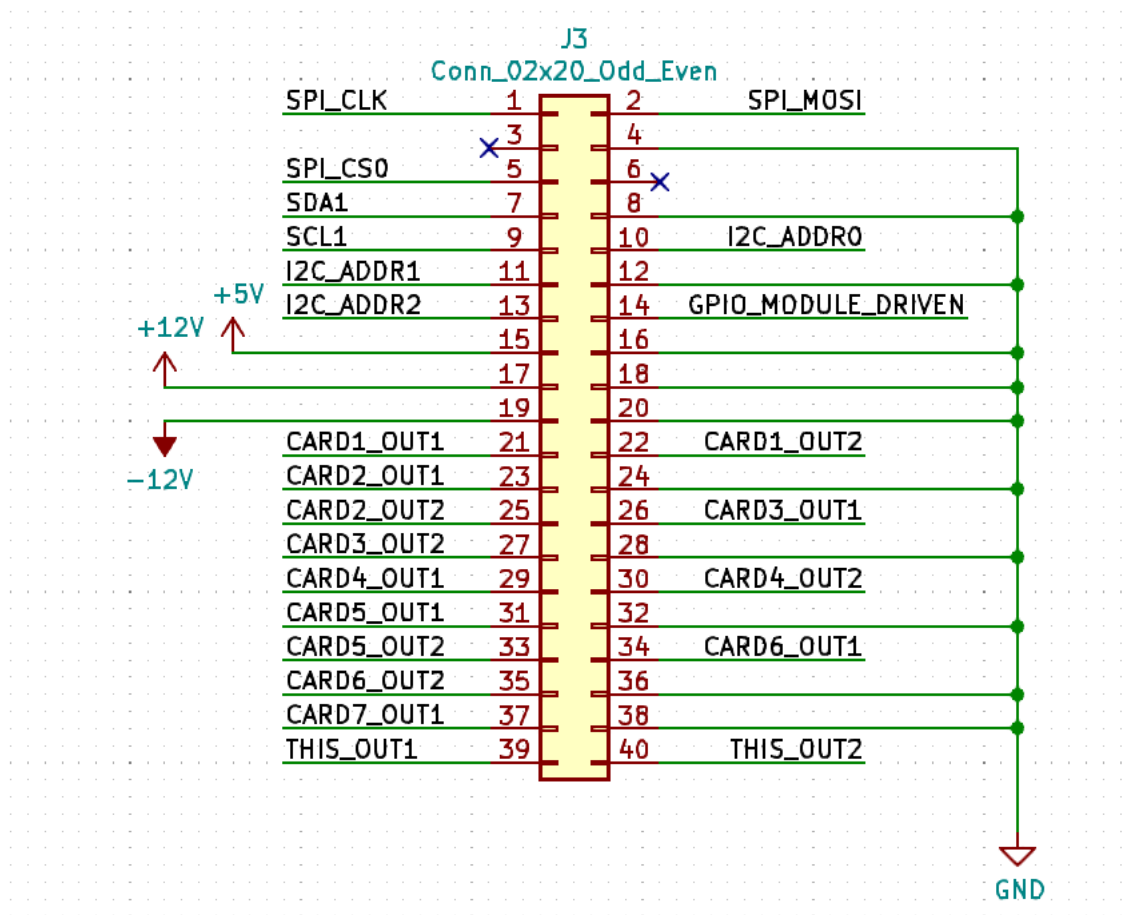


## SPECIFICATIONS

| $V_{CC} +12V$ , $V_{DD} +5V$ , $V_{EE} -12V$ |          |           |
|--|----------|-----------|
| Parameter                                    | Typical  | Units     |
| Power  |          |           |
| $V_{CC}$                                     | TBD      | mA        |
| $V_{DD}$                                     | TBD      | mA        |
| $V_{EE}$                                     | TBD      | mA        |
| Digital Input <sup>1</sup>                   |          |           |
| Logic levels                                 | 5V logic |           |
| I <sup>2</sup> C frequency                   | 400      | kHz       |
| SPI frequency                                | 12       | MHz       |
| Digital Output                               |          |           |
| GPIO Module Output Upper Level               | 5.0      | V         |
| GPIO Module Output Lower Level               | 0.0      | V         |
| Analog Input                                 |          |           |
| External Signal Recommended High Voltage     | 5.0      | V         |
| External Signal Recommended Low Voltage      | -5.0     | V         |
| External Signal Input Impedance (selected)   | 100k     | $\Omega$  |
| External Signal Input Impedance (unselected) | High     | $\Omega$  |
| Analog Output                                |          |           |
| Frequency control range                      | 10       | Octaves   |
| Frequency at min control                     | < 13.75  | Hz        |
| Frequency at max control                     | > 14080  | Hz        |
| Resonance control for oscillation            | 0x0CFF   | DAC Value |
| Mix1 Output Impedance                        | 51       | $\Omega$  |
| Mix2 Output Impedance                        | 51       | $\Omega$  |

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

## PIN CONFIGURATION AND DESCRIPTION



| 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                               |
| 4   | GND       | Ground  |
| 5   | SPI_CS0   | Active low chip select for AD5328                   |
| 6   | SPI_CS1   | Not used / no connect                               |
| 7   | SDA1      | I <sup>2</sup> C data for PCA9555 and M24C02        |
| 8   | GND       | Ground  |
| 9   | SCL1      | I <sup>2</sup> C clock for PCA9555 and M24C02       |
| 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 | logic switched from Out1               |
| 15 | V <sub>DD</sub>    | +5V power                              |
| 16 | GND                | Ground                                 |
| 17 | V <sub>CC</sub>    | +12V power                             |
| 18 | GND                | Ground                                 |
| 19 | V <sub>EE</sub>    | -12V power                             |
| 20 | GND                | Ground                                 |
| 21 | CARD1_OUT1         | Input selectable as Source1 or Source2 |
| 22 | CARD1_OUT2         | Input selectable as Source1 or Source2 |
| 23 | CARD2_OUT1         | Input selectable as Source2            |
| 24 | GND                | Ground                                 |
| 25 | CARD2_OUT2         | Input selectable as Source1 or Source2 |
| 26 | CARD3_OUT1         | Input selectable as Source1            |
| 27 | CARD3_OUT2         | Input selectable as Source2            |
| 28 | GND                | Ground                                 |
| 29 | CARD4_OUT1         | Input selectable as Source2            |
| 30 | CARD4_OUT2         | Input selectable as Source1            |
| 31 | CARD5_OUT1         | Input selectable as Source1            |
| 32 | GND                | Ground                                 |
| 33 | CARD5_OUT2         | Input selectable as Source2            |
| 34 | CARD6_OUT1         | Input selectable as Source2            |
| 35 | CARD6_OUT2         | Input selectable as Source1            |
| 36 | GND                | Ground                                 |
| 37 | CARD7_OUT1         | Input selectable as Source1            |
| 38 | GND                | Ground                                 |
| 39 | THIS_OUT1          | Output signal Left                     |
| 40 | THIS_OUT2          | Output signal Right                    |

## THEORY OF OPERATION

### I<sup>2</sup>C Addresses and SPI Chip Enable

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 J3 2x20 connection header. Provided cards are given unique addresses, this allows up to multiple instances of the same Zoxnoxious Z3372 card or other Zoxnoxious compatible cards to be used together. The I<sup>2</sup>C addresses for the M24C02 and PCA9555 are shown below based on J3 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         |

Changing the state of J3 pins 13, 11, or 10 during operation is undefined behavior.

### ROM Query

The Zoxnoxious Z3372 Analog Signal Processor 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 “0x03” is set at byte address zero 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.

Writes are enabled via a jumper. Typical operation is expected to be read-only.

### 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)   |
|--------------------------|--------|----------|
| LED (active low)         | Port 0 | XXXXXXX0 |
| Signal1 to VCF mod       | Port 0 | XXXXX1XX |
| Signal1 to Resonance mod | Port 0 | XXXX1XXX |
| Signal1 to VCA mod       | Port 0 | XXX1XXXX |
| Signal1 to Panning mod   | Port 0 | XX1XXXXX |
| Signal1 Enable           | Port 1 | XXXXXXX1 |
| Card 1 Out1              | Port 1 | XXXX1111 |
| Card 1 Out2              | Port 1 | XXXX1101 |
| Card 2 Out2              | Port 1 | XXXX1011 |
| Card 3 Out1              | Port 1 | XXXX1001 |
| Card 4 Out2              | Port 1 | XXXX0111 |
| Card 5 Out1              | Port 1 | XXXX0101 |
| Card 6 Out2              | Port 1 | XXXX0011 |
| Card 7 Out1              | Port 1 | XXXX0001 |
| Signal2 Enable           | Port 1 | XXX1XXXX |
| Card 1 Out1              | Port 1 | 1111XXXX |
| Card 1 Out2              | Port 1 | 1101XXXX |
| Card 2 Out1              | Port 1 | 1011XXXX |
| Card 2 Out2              | Port 1 | 1001XXXX |
| Card 3 Out2              | Port 1 | 0111XXXX |
| Card 4 Out1              | Port 1 | 0101XXXX |
| Card 5 Out2              | Port 1 | 0011XXXX |
| Card 6 Out1              | Port 1 | 0001XXXX |

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. 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 2X gain and use Vref is sent with a payload of 0x80 0x30.

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 assuming a 4 kHz sampling rate. A simple RC filter is used for low pass filtering DAC outputs with the approximate corner frequencies listed below.

| Description    | DAC Addr | Cutoff (Hz) |
|----------------|----------|-------------|
| Noise VCA      | 0x0      | 285         |
| Pan VCA        | 0x1      | 340         |
| Resonance      | 0x2      | 400         |
| Output VCA     | 0x3      | 360         |
| VCF Cutoff     | 0x4      | 800         |
| Signal1 VCA    | 0x5      | 1000        |
| Signal2 VCA    | 0x6      | 1000        |
| Modulation VCA | 0x7      | 285         |

### GPIO Module Output

The `This_Out1` output is used to drive a transistor for digital output to `GPIO.Module.Driven`. The digital output will toggle with the input signal.

Frequency counting can be used as part of a tune routine for the VCF. With resonance set high and inputs signals muted (VCAs to zero), the cutoff frequency can be set to characterize the frequency response.

### EXTERNAL INPUT

The Z3372 card allows two inputs to be tapped from the thirteen signals the Zoxnoxious signal bus provides. The Signal1 input can be used for filtering and/or modulation. The Signal2 input can be used for filtering only. Two 8:1 muxes front each input, so a limited number of the Zoxnoxious signal bus is available to each input. See the GPIO section of how to set each input. The modulations available are described below.

**VCF mod** Signal1 is added to the VCF cutoff. This modulates the filter cutoff point at an audio rate from Siganl1.

**Resonance mod** Signal1 is inverted and added to the resonance amount. This will be out of phase from VCF mod, as that produces the most interesting results.

**VCA mod** Signal1 is added to VCA4 for amplitude modulation. Given the function is addition, this may work best with the output VCA tuned down a bit.

**Panning mod** Signal1 is added to Panning signal. This has a similar effect to amplitude modulation, but for each left/right channel and in opposite phases.

The **Modulation VCA** controls the modulation amount for all destinations. All modulations are DC-coupled.

### TEST POINTS

The following test points are available on the Zoxnoxious Z3372 board:

| Test Point | Description              |
|------------|--------------------------|
| TP1        | Resonance CV             |
| TP2        | White Noise              |
| TP3        | VCA 1/2 Out              |
| TP4        | Pan CV                   |
| TP5        | VCF Out Post-Cap         |
| TP6        | VCF CV                   |
| TP7        | VCA4 Out                 |
| TP8        | Modulation VCA Out       |
| TP9        | VCA4 CV                  |
| TP10       | GPIO Out Transistor Base |
| TP11       | Input to Resonance VCA   |

### BOARD INFORMATION

Todo: dimensions, pic, layout