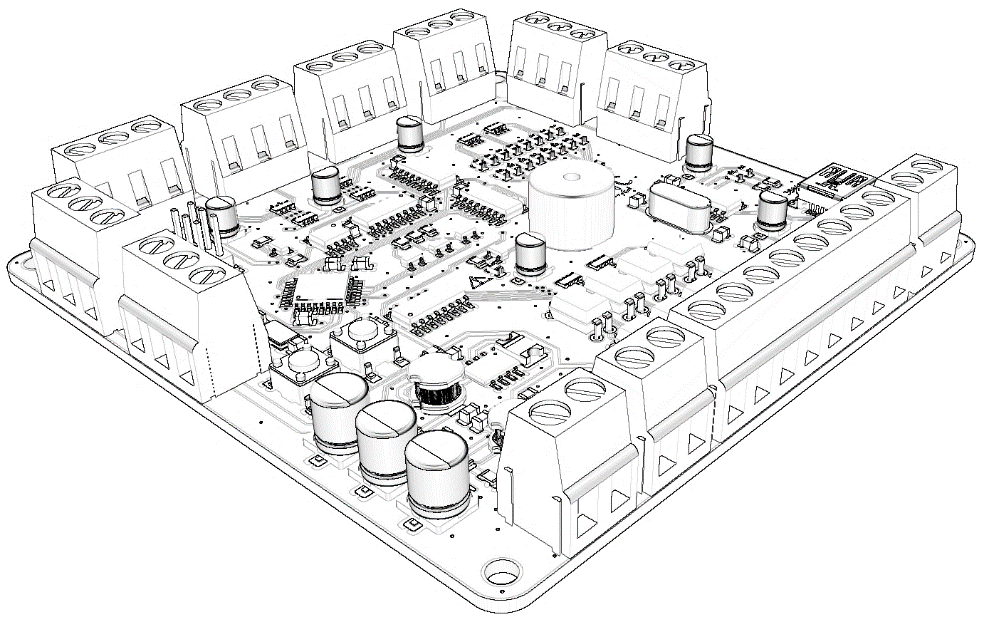
USER GUIDE



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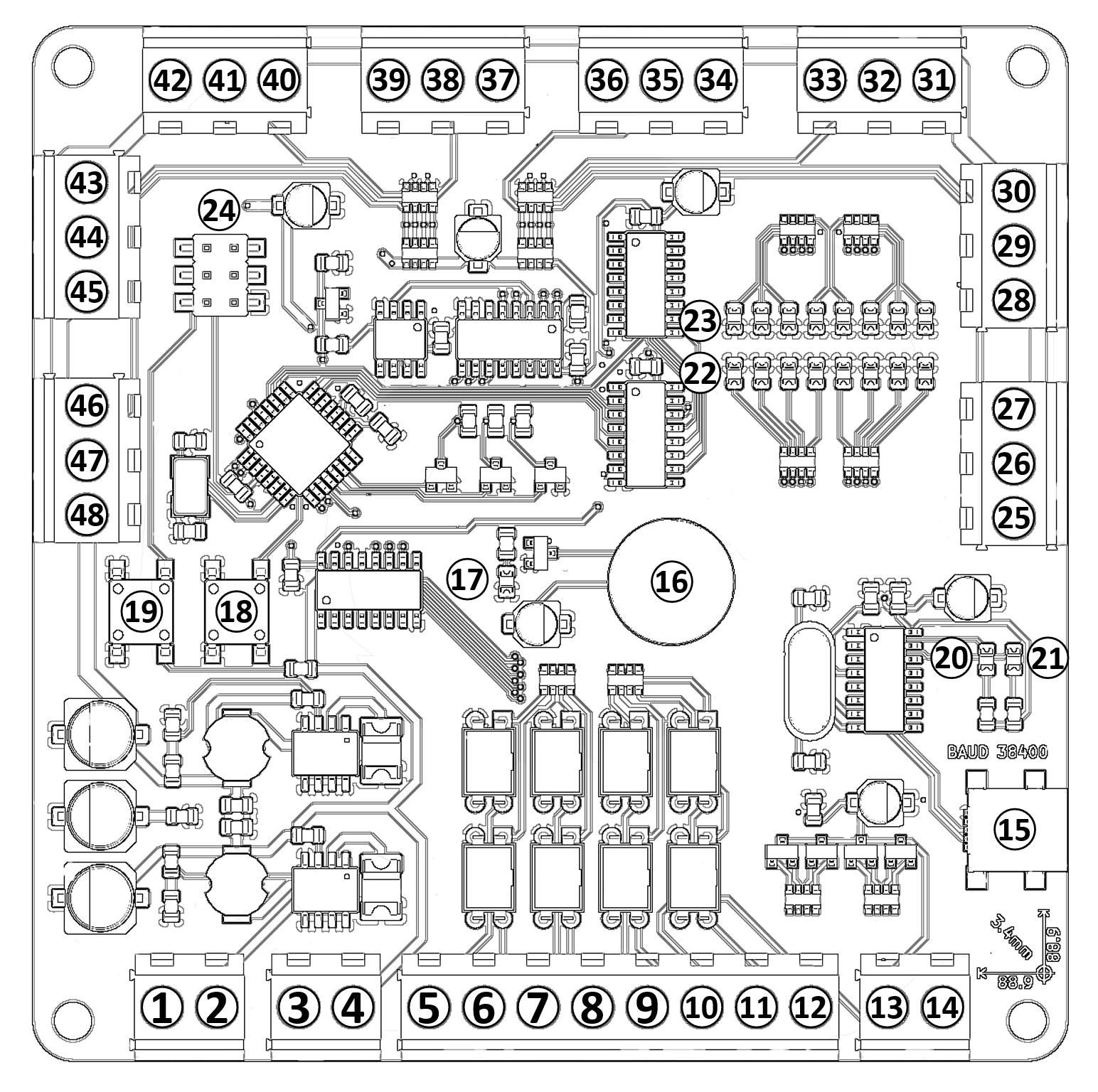
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# Features

* Supports 12V NPN/PNP Proximity sensors, NO/NC switches, 0-12V analog signals
* Optically isolated active Low/High open collector outputs
* Simple programmable Boolean logic
* Remappable outputs
* Programmable input threshold and hysteresis
* Acoustic signals and alarms
* +12V and +5V outputs with up to 2A each
* Simple serial interface
* 10 Kilohertz sampling rate per input
* Isolated configuration and run modes

# Board overview



## Connectors and indicators

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | +16 to +24V | 25 | GND |
| 2 | GND | 26 | Input: H |
| 3 | +12V | 27 | +12V |
| 4 | +5V | 28 | GND |
| 5 | Output: A | 29 | Input: G |
| 6 | Output: B | 30 | +12V |
| 7 | Output: C | 31 | GND |
| 8 | Output: D | 32 | Input: F |
| 9 | Output: E | 33 | +12V |
| 10 | Output: F | 34 | GND |
| 11 | Output: G | 35 | Input: E |
| 12 | Output: H | 36 | +12V |
| 14 | Ext. Voltage | 37 | GND |
| 14 | Ext. Ground | 38 | Input: D |
| 15 | USB Mini-B Serial | 39 | +12V |
| 16 | Buzzer | 40 | GND |
| 17 | Alarm | 41 | Input: C |
| 18 | Config | 42 | +12V |
| 19 | Reset | 43 | GND |
| 20 | RX | 44 | Input: B |
| 21 | TX | 45 | +12V |
| 22 | Output Indicators | 46 | GND |
| 23 | Input Indicator | 47 | Input: A |
| 24 | ISP header | 48 | +12V |

# Powering the board

The board can be powered with 16V to an absolute maximum of 30V (1), the total current draw for all input sensors should not exceed 2A. If the 12V output is used to power external devices their current must be summed with the current of all connected sensors.   
TL;DR A 2A 18V or 24V power supply should work in most cases.

# Connecting Inputs

Diagram, schematic

Description automatically generated

Unconnected or open inputs are pulled to 50%/+6V. The maximum input voltage must never exceed +15V.

## Supported input devices

Diagram, schematic

Description automatically generated

* Switches
* Capacitive or inductive sensors
* Variable resistors
* Open collector outputs
* +12V logic outputs

Since all inputs can be inverted, it doesn’t matter if the connected device is normally closed or normally open.

# Connecting Outputs

Diagram

Description automatically generated

Outputs need to be supplied with an external voltage source or can be connected to the +5V/+12V outputs provided by the board.

All outputs are isolated so Ext.GND must always be connected to the ground of the target device.

## Using internal pull-Up resistors

Diagram

Description automatically generatedIf the target device does not have pull-up resistors on its own and all voltage levels are the same, Ext.VCC can be used to replace external resistors.

## Using external pull-up resistors

Diagram, schematic

Description automatically generated

If two or more target devices with different voltage levels are connected each output requires its own resistor.

# Serial Connection

A serial connection can be established via the USB Port (15), on Windows this requires the correct driver to be installed.

## Serial Settings

|  |  |
| --- | --- |
| Chip | CH340G |
| Baud rate | 38400 |
| Data | 8bit |
| Parity | None |
| Stop bits | 1 |
| Flow Control | None |
| Connector | USB Mini B |

The serial connection is independent and isolated from the rest of the board. When powered through USB the TX Indicator (21) should light up briefly, even if the board is not powered.

Compatible driver: CH341SER.   
Compatible terminal software: [Tera Term](https://ttssh2.osdn.jp/), [Putty](https://www.putty.org/), etc.

# Serial Commands

After powering up the board will immediately switch into run mode and not respond to normal serial commands. There are 2 ways to switch into configuration mode.

1. Enter “$C” and confirm with enter
2. Push config (18)

All valid changes are saved immediately and take effect after the next power cycle, reset or mode switch.

## Command overview

|  |  |  |  |
| --- | --- | --- | --- |
| **$** | Show help | - | R |
| **$P** | Switch to run mode | - | R |
| **$C** | Switch to configuration mode | - | R |
| **$$** | View settings | - | R |
| **$S** | View input status | - | R |
| **$RST** | Reset | $,S,I,O,E | W |
| **$100** | Serial output | 1/0 | RW |
| **$101** | Buzzer | 1/0 | RW |
| [**$2N0**](#_I/O_control) | Input N threshold | 0-100 | RW |
| [**$2N1**](#_I/O_control) | Input N hysteresis | 0-100 | RW |
| [**$2N2**](#_I/O_control) | Input N inverted | 1/0 | RW |
| [**$3N0**](#_I/O_control) | Output N active | 1/0 | RW |
| [**$3N1**](#_I/O_control) | Output N expression | Expr. | RW |

## System Commands

### Help “$”

Displays a list of commands and examples.

### Switch to run mode “$P”

This command causes the board to unload the current context, to reset and switch into run mode.  
Only available while in configuration mode.

### Switch to configuration mode “$C”

Causes the board to switch into configuration mode.   
Only available while in run mode.

### View Settings “$$”

Displays current configuration values.

### View input status “$S”

Reads all input pins and displays their current state in a semicolon separated list.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| A | B | C | D | E | F | G | H |
| 100; | 100; | 100; | 100; | 100; | 100; | 100; | 100; |

### Reset “$RST”

Resets the selected configuration.

$ - Restore global defaults and reboot

S - Restore system defaults and reboot

I - Restore input defaults and reboot

O - Restore output defaults and reboot

E - Restore expression defaults and reboot

After a reset the board starts up in run mode.

### Serial debug output “$100”

Enables the continues serial output of input states.  
This option is only meant for configuring/debugging and will affect the sampling drastically.

### Acoustic signals “$100”

Enable acoustic feedback whenever an output is triggered.  
Errors still trigger alarms.

## I/O Commands

I/O commands control the behavior of each input or output. The first digit of an I/O command describes the port, the second the target pin and the third digit the selected register. All I/O registers are read/write which means they can be individually written to or read back.

|  |  |  |  |
| --- | --- | --- | --- |
| $20X | Input: A | $30X | Output: A |
| $21X | Input: B | $31X | Output: B |
| $22X | Input: C | $32X | Output: C |
| $23X | Input: D | $33X | Output: D |
| $24X | Input: E | $34X | Output: E |
| $25X | Input: F | $35X | Output: F |
| $26X | Input: G | $36X | Output: G |
| $27X | Input: H | $37X | Output: H |

Operation: “$310=1” Enable output B  
Port: Output  
Pin: B  
Property: active  
Parameter: 1  
Response: OK

|  |  |  |
| --- | --- | --- |
| $310=1 | | |
| 3 | 1 | 0 |
| Output | B | Active |
| OK | | |

Operation: “$310” Get the status of output B  
Command: $310  
Port: Output  
Pin: B  
Property: active   
Response: 1

|  |  |  |
| --- | --- | --- |
| $310 | | |
| 3 | 1 | 0 |
| Output | B | Active |
| 1 | | |

### Input Threshold “$2N0”

Get or set the input threshold of a specific input pin.  
The default value of 70% is set up for normally open switches connected to +12V.

|  |  |  |
| --- | --- | --- |
| $200=1 | | |
| 3 | 0 | 0 |
| Input | A | Threshold |
| OK | | |

### Input Hysteresis “$2N1”

Get or set the hysteresis of a specific input pin.  
The default value of 10% should cover most sensors and switches.

|  |  |  |
| --- | --- | --- |
| $211=5 | | |
| 3 | 0 | 0 |
| Input | B | Hysteresis |
| OK | | |

### Input Inverted “$2N2”

Get or set if a specific input pin should be inverted internally. This is useful for NC switches and sensors.

|  |  |  |
| --- | --- | --- |
| $232=0 | | |
| 3 | 0 | 0 |
| Input | C | Inverted |
| OK | | |

### Output Active “$3N0”

Enable or disable an output pin completely.

|  |  |  |
| --- | --- | --- |
| $300=1 | | |
| 3 | 0 | 0 |
| Output | A | Active |
| OK | | |

### Output Expression “$3N1”

Get or set the logic expression specific to an output pin.

|  |  |  |
| --- | --- | --- |
| $301= ($A & ~$B) | (~$A & $B) #XOR | | |
| 3 | 0 | 1 |
| Output | A | Expression |
| OK | | |

|  |  |  |
| --- | --- | --- |
| $301 | | |
| 3 | 0 | 1 |
| Output | A | Expression |
| ($A & ~$B) | (~$A & $B) #XOR | | |

# Configuration

To configure the board, make sure the correct driver is installed and the board is powered up and connected.   
  
(See [Serial connection](#_Serial_Connection).)

## Inputs

Diagram

Description automatically generated

Each input pin can be configured with individual values for their trigger [threshold](https://ivybit-my.sharepoint.com/personal/alexander_ivybit_de/Documents/$2N0#_Input_threshold_) (0-100%), [hysteresis](https://ivybit-my.sharepoint.com/personal/alexander_ivybit_de/Documents/$2N1#_Input_hysteresis_) (0-100%) and active [low/high](https://ivybit-my.sharepoint.com/personal/alexander_ivybit_de/Documents/$2N2#_Input_inverted_) state (0/1).   
  
If a connected device pulls an input pin towards +0V or +12V and the trigger threshold is reached the internal variable is updated and the assigned [expression](https://ivybit-my.sharepoint.com/personal/alexander_ivybit_de/Documents/$3N1#_Output_expression_) reevaluated.   
  
The new state is held until the input falls below or rises above the configured off point.

If for some reason an input/sensor triggers falsely check the captured value with [$S](#_View_input_status) and try raising/lowering the trigger [threshold](https://ivybit-my.sharepoint.com/personal/alexander_ivybit_de/Documents/$2N0#_Input_threshold_) and [hysteresis](https://ivybit-my.sharepoint.com/personal/alexander_ivybit_de/Documents/$2N1#_Input_hysteresis_).  
  
(See [I/O commands](#_I/O_commands).)

### Active High Trigger

High: Input >= Threshold  
Low: Input <= Threshold – Hysteresis

Threshold

Hysteresis

high

low

100%

active

Diagram, schematic

Description automatically generated

Input: F (5)  
Direction: Towards +12V  
Type: Switch normally open.  
Normal: 50% - 60%  
Activated: 85% - 90%

Settings:

|  |  |
| --- | --- |
| $250 = 80 | F: Threshold - 80% |
| $251 = 10 | F: Hysteresis - 10% |
| $252 = 0 | F: Inverted - 0 |

### Active Low Trigger

High: Input <= Threshold  
Low: Input >= Threshold + Hysteresis

Hysteresis

Threshold

high

low

100%

active

A picture containing text, clock

Description automatically generated

Input: F (5)  
Direction: Towards +0V  
Type: Switch normally open.  
Normal: 50% - 60%  
Activated: 0% - 15%

Settings:

|  |  |
| --- | --- |
| $250 = 15 | F: Threshold - 15% |
| $251 = 10 | F: Hysteresis - 10% |
| $252 = 1 | F: Inverted - 1 |

## Outputs

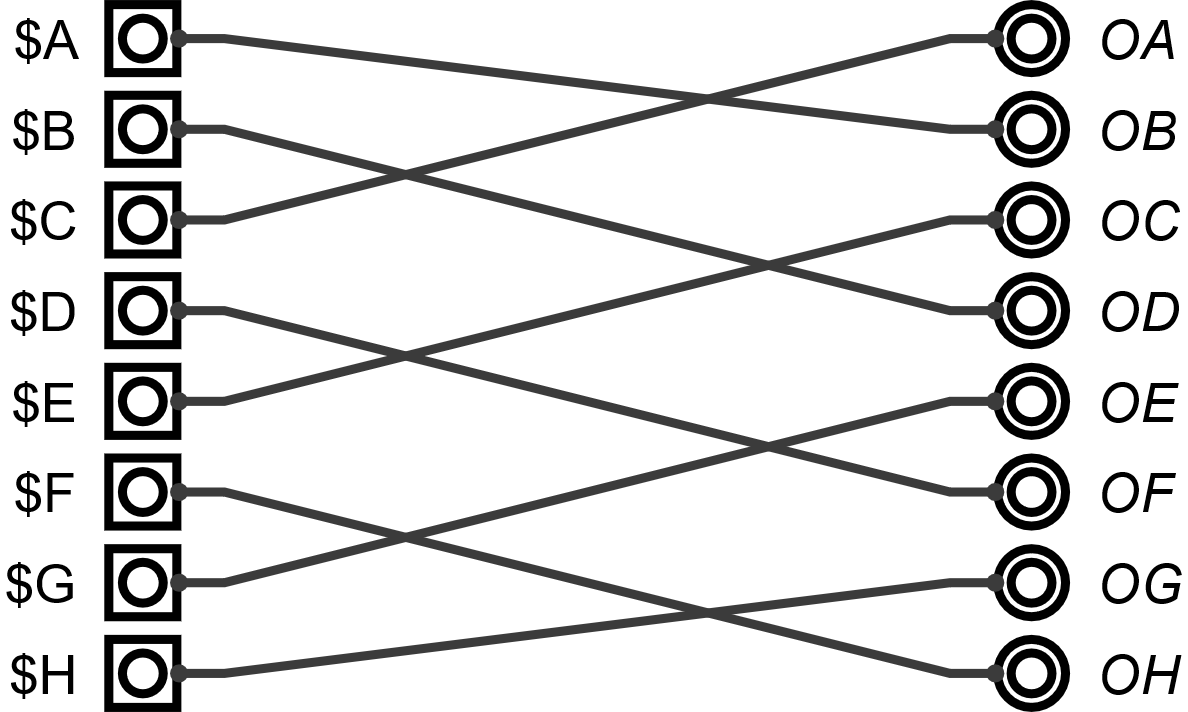
### Enable/disable outputs

Diagram, schematic

Description automatically generatedUnused outputs can be disabled to reduce noise and power consumption.

Command: $3N0 = 1/0  
  
Output A: $300 = 0  
.  
.  
Output H: $370 = 0

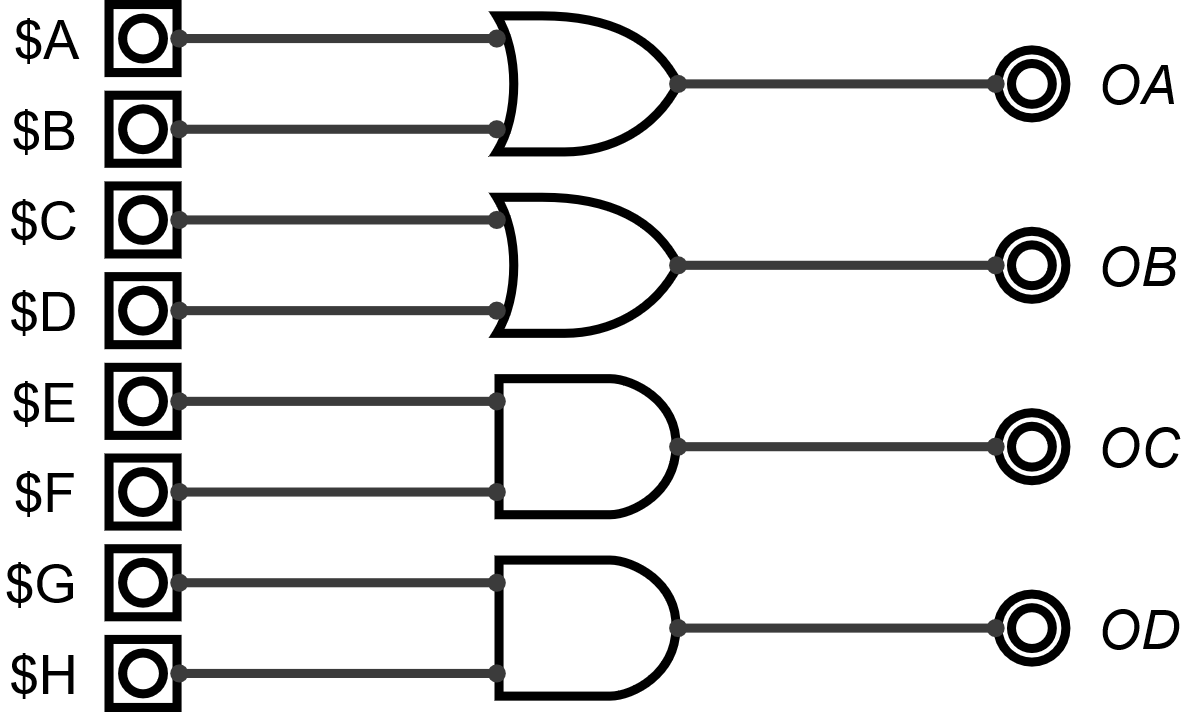
### Remapping outputs

If no special condition is required outputs can be reassigned by simply changing their corresponding expression.

OA: $301 = $C   
OB: $311 = $A  
OC: $321 = $E …

This way wiring can be greatly simplified or changed after the installation is already completed.

### Combining outputs



Many controllers expect two or more limit sensors to be connected to a single input.  
While switches can be simply connected in series or parallel, this is not easily possible with active capacitive or conductive sensors.

Standard limit switches often require additional circuitry or that devices of the same type are used (NC/NO).  
Diagram, schematic, box and whisker chart

Description automatically generated

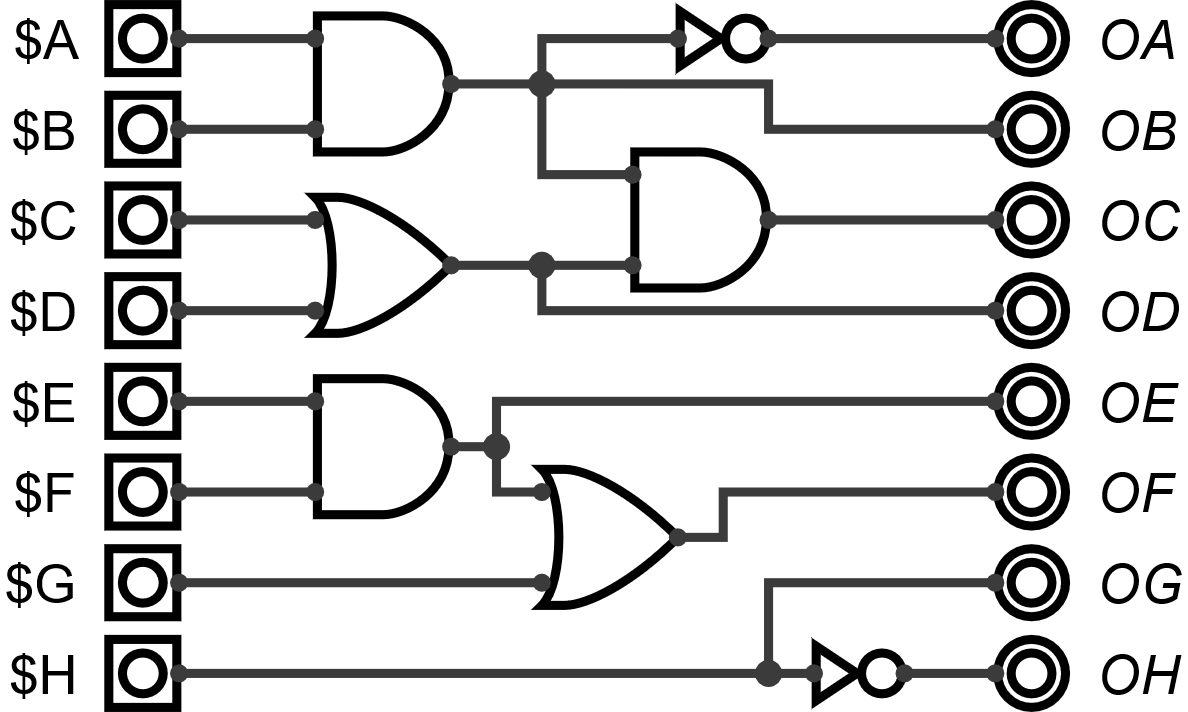
By configuring each input individually almost all combinations of switches and sensors can be realized.

Diagram, schematic

Description automatically generated

OA: $301 = $A | $B # A or B - NO  
OB: $311 = $C | $D # C or D - NO  
OC: $321 = $E & $F # E and F - NC  
OD: $331 = $G & $H # G and H - NC

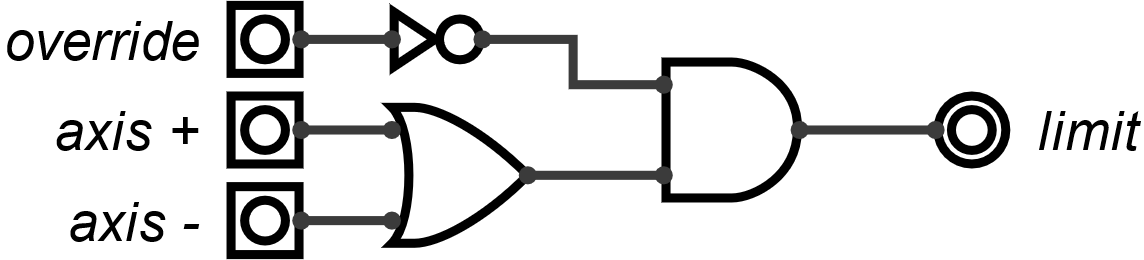
### Complex Expressions

More complex [expressions](#_Logic_expressions) make the implementation of features possible that the target system would normally not support.  
Some examples are security overrides for door switches, axis locks or emergency stops.

Example with two limit and one override switch.

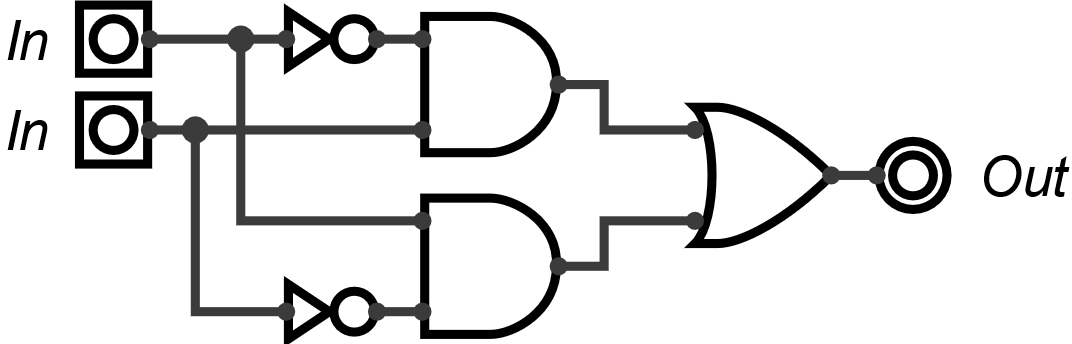
Diagram, schematic

Description automatically generated  
Input-A: PNP NO  
Input-B: PNP NO  
Input-C: SW NO



$301 = ($A | $B) & ~$C # A or B and not C

# Logic expressions

Expressions give the board it’s flexibility and allow it to replace external components, save wiring or expand the input capabilities of a connected device.

[$301](https://ivybit-my.sharepoint.com/personal/alexander_ivybit_de/Documents/$3N1#_Output_expression_) = ($A & ~$B) | (~$A & $B) #XOR

## Operands

All eight inputs are represented with a $ followed by their letter and are either TRUE (1) or FALSE (0).

|  |  |
| --- | --- |
| $A – Input: A | $E – Input: E |
| $B – Input: B | $F – Input: F |
| $C – Input: C | $G – Input: G |
| $D – Input: D | $H – Input: H |

By default, inputs are assigned to the output with the same name. $301 = $A; $311 = $B; $321 = $C; …

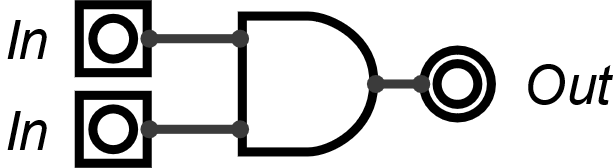
## Operators

The following Boolean operators are supported:  
And (&), Or (|), Not (~), Equals (=),   
Nand (~&), Nor (~|), Xor (~=)

Comments beginning with # are also saved to eeprom.

### Operator And &

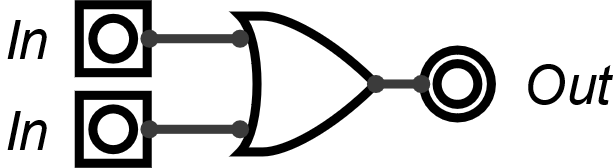
Only true if both inputs are true.

$A & $B

|  |  |  |
| --- | --- | --- |
| A | B | Out |
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

### Operator Or |

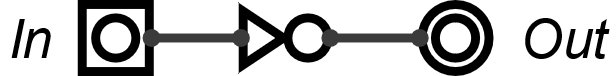
True if one or more input is true.

$A | $B

|  |  |  |
| --- | --- | --- |
| A | B | Out |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

### Operator Not ~

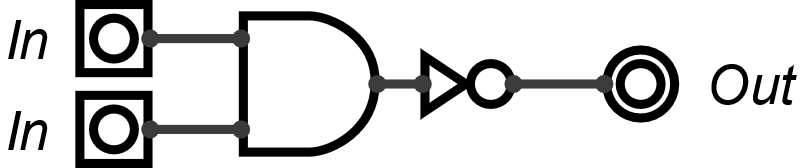
Only true if the input is false.

~$A

|  |  |
| --- | --- |
| A | Out |
| 0 | 1 |
| 1 | 0 |

### Operator Nand ~&

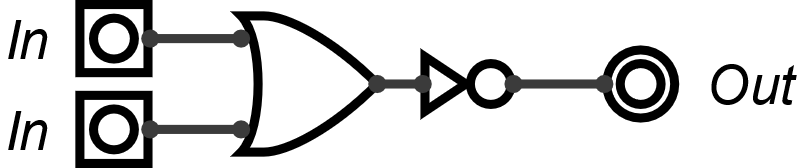
False if both inputs are true.

 $A ~& $B

|  |  |  |
| --- | --- | --- |
| A | B | Out |
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

### Operator Nor ~|

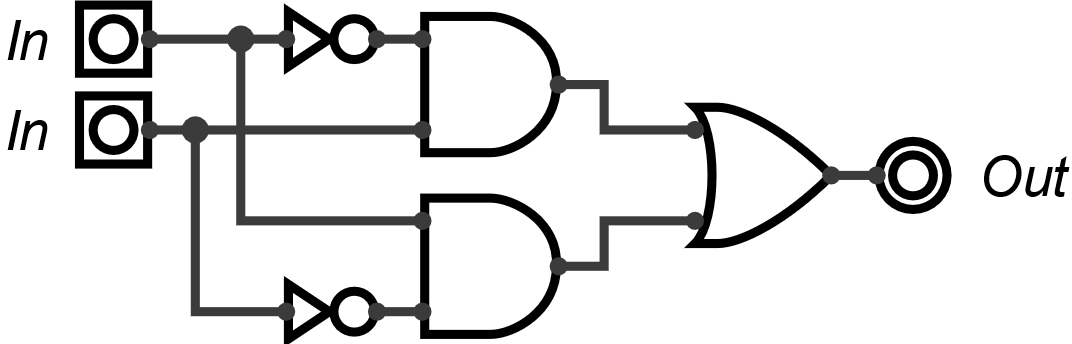
Only true if both inputs are false.

 $A ~| $B

|  |  |  |
| --- | --- | --- |
| A | B | Out |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

### Operator Xor ~=

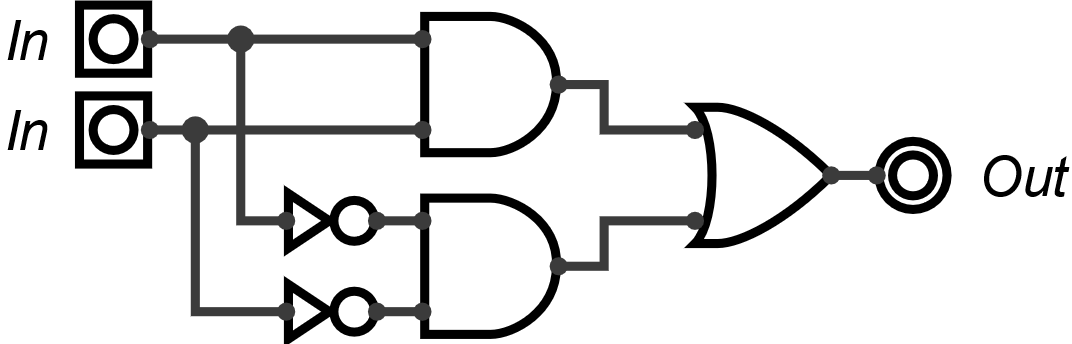
Only true if one input is true and the other false.

 $A ~= $B

|  |  |  |
| --- | --- | --- |
| A | B | Out |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

### Operator Equals =

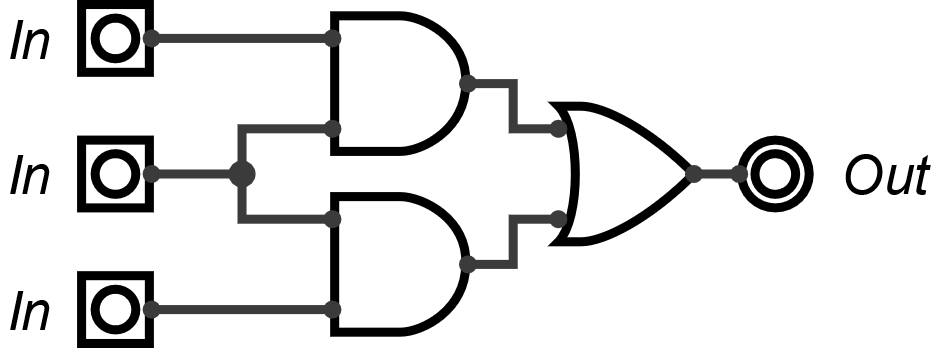
Only true if both inputs are true or both inputs are false.

 $A = $B

|  |  |  |
| --- | --- | --- |
| A | B | Out |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

### Operator Group ()

Group expressions into subexpressions.

($A & $B) | ($B & $C)

|  |  |  |
| --- | --- | --- |
| EXP | EXP | Out |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

## Operator precedence

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | NOT |  |  |
| 2 | AND | NAND | EQ |
| 3 | OR | NOR | XOR |

(NOT) > (AND = NAND = EQ) > (OR = NOR = XOR)

Parentheses override the default operator precedence.