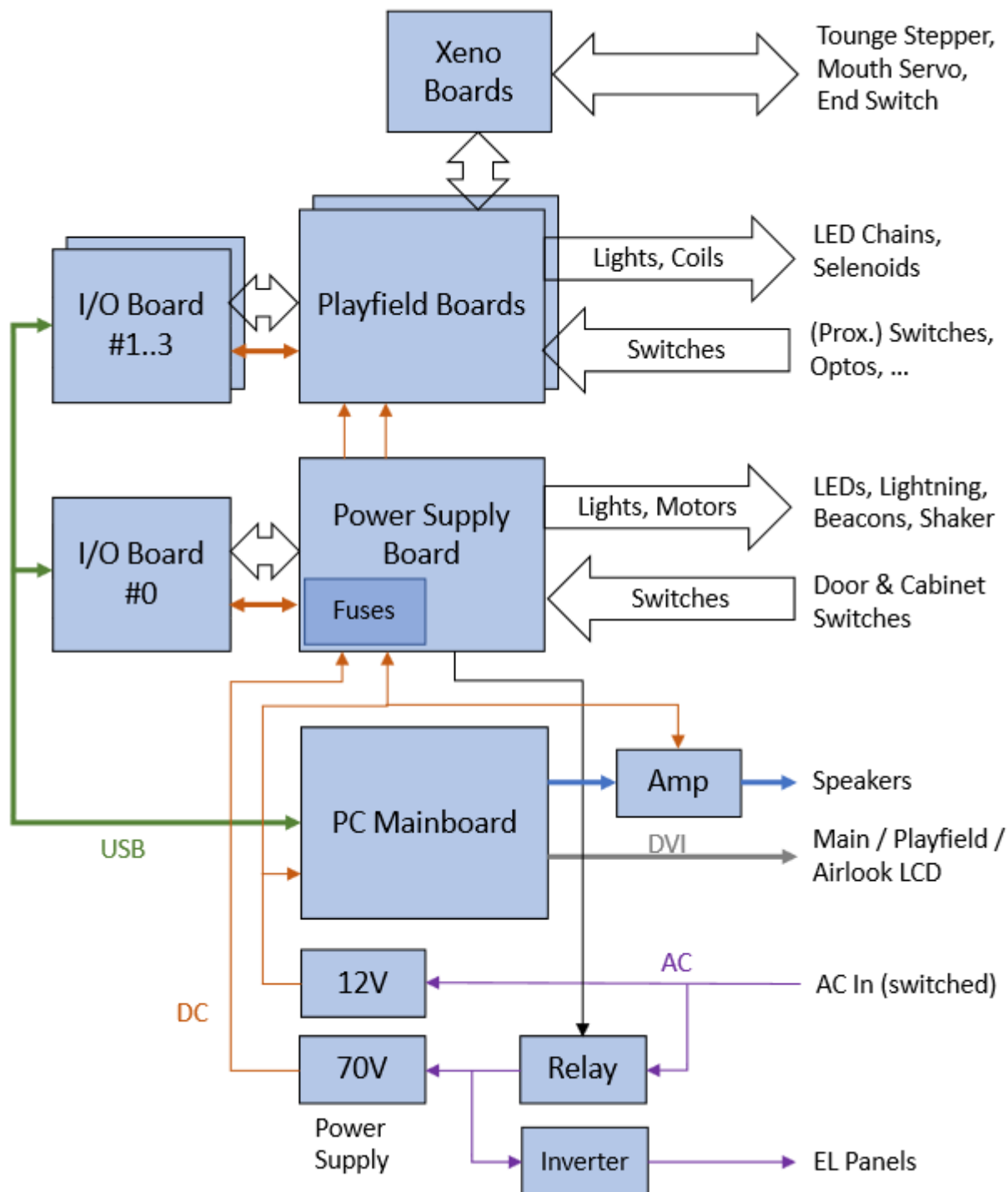


## Alien I/O Board

Version 1.0 created on 01/18/2019 by Per

The Highway Alien pin uses 4 identical I/O-Boards to connect the PC mainboard with the pin hardware (coils, motors, lights, switches etc.) as shown in the following diagram of the Alien pinball electronics.

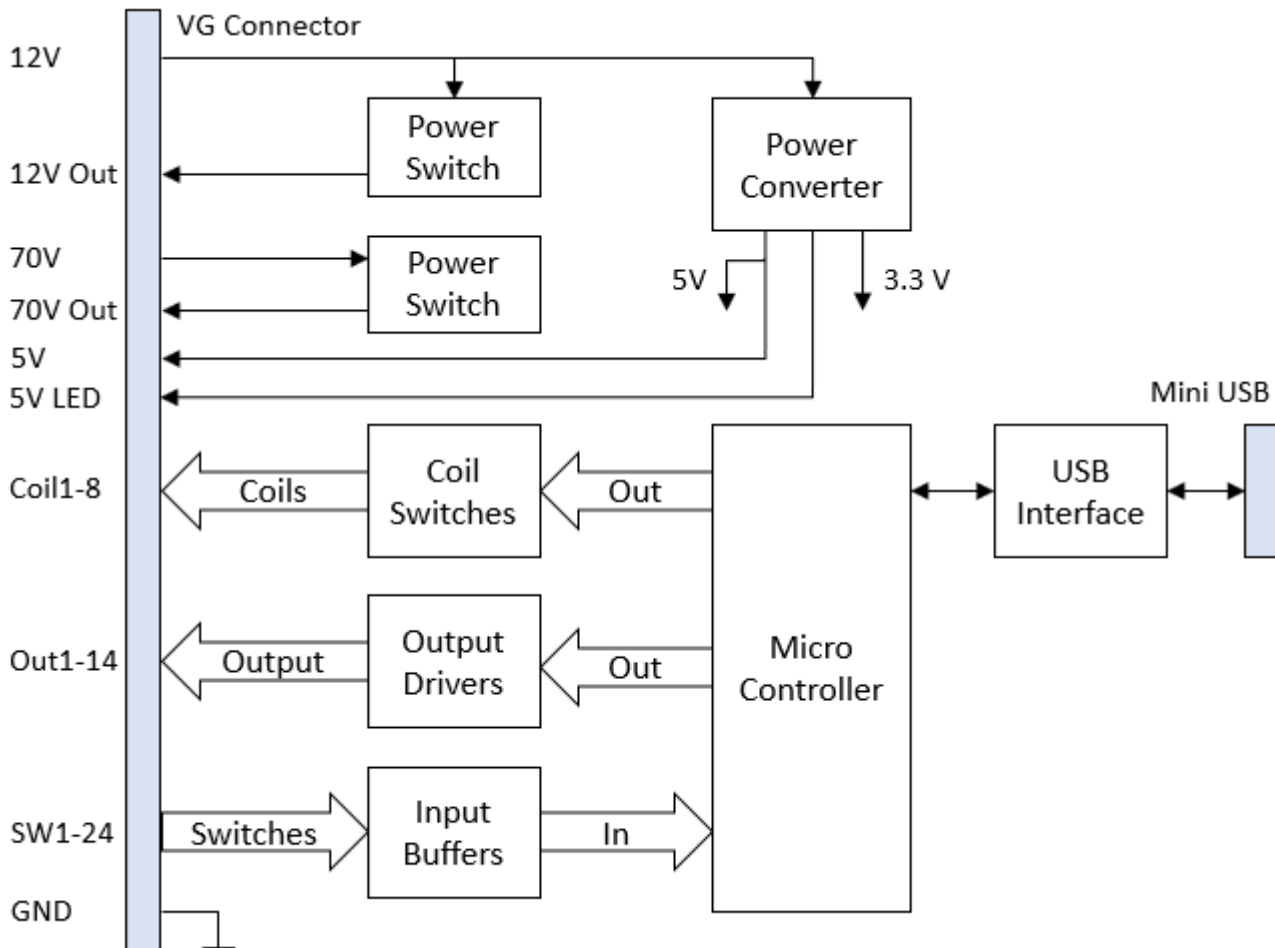


Unfortunately there are no schematics available for the I/O board (as of Jan 2019) but it would be helpful to understand its functionality and circuitry for general maintenance as well as repair purposes. Therefore I inspected the boards for some time and here are my results.

## Overview

The I/O-Board is a multilayer printed circuit (dimensions 10x15cm, close to euroboard size) with a 96 pin male VG connector (DIN 41612, see [https://en.wikipedia.org/wiki/DIN\\_41612](https://en.wikipedia.org/wiki/DIN_41612)). The electronic components – mostly SMD type – are placed on both sides of the board:

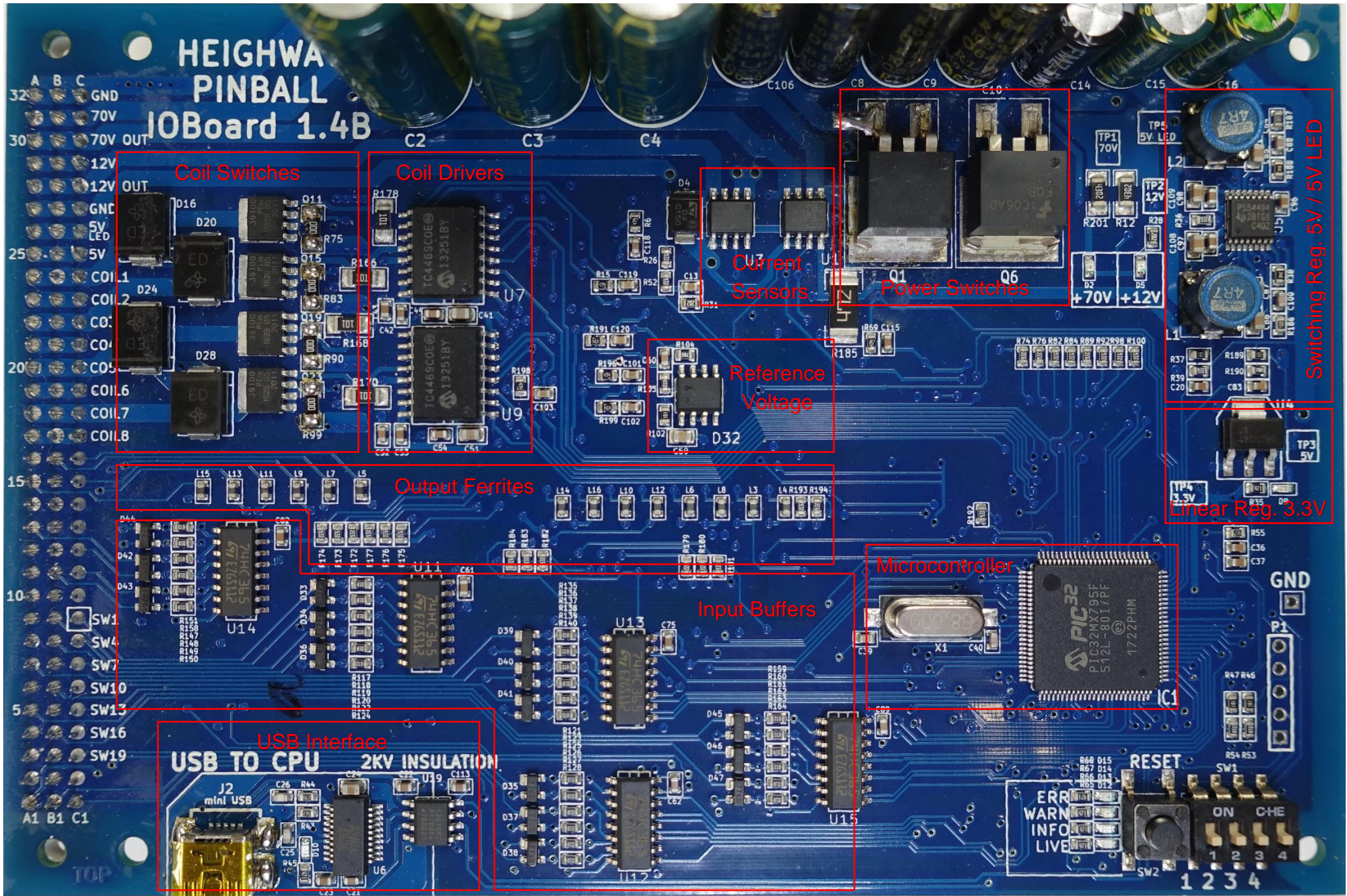
- The heart of every board is a PIC32 MX7 microcontroller (uC) including a CPU, Memory and many I/O channels
- 8 I/O channels toggle the high current coil switches
- 14 more I/O channels are connected to 5 volts output drivers
- 24 I/O channels are used to detect closed switches via buffered inputs
- Each board has its own power supply circuits, converting the 12 volts input to 5 and 3,3 volts for ICs and additional 5 volt for the LEDs.
- There are also two power switches implemented, delivering 12 volt and 70 volts with over-current protection
- Finally there is a USB Interface to connect the uC with the PC mainboard



## Component Map

The following pictures show both sides of the I/O-Board. The labeled red boxes indicate the locations of the main electronic devices.

Note: A few parts are missing on the pictures as I took the photos from a defect board.



# HEIGHWA PINBALL IOBoard 1.4B

Coil Switches

Coil Drivers

Current  
Sensors

Power Switches

Reference  
Voltage

Output Ferrites

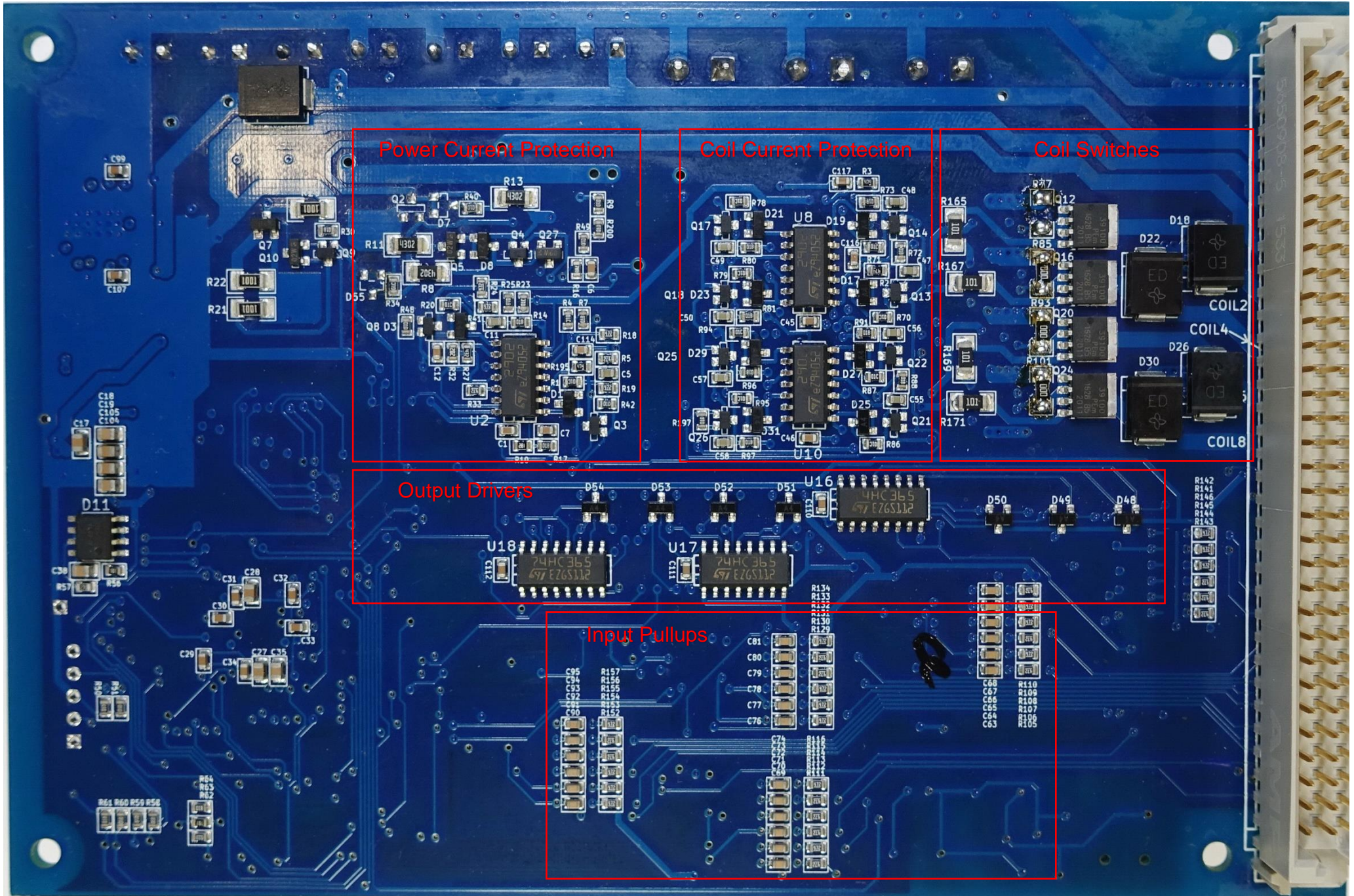
Input Buffers

Microcontroller

USB Interface  
USB TO CPU 2KV INSULATION

Switching Reg. 5V / 5V LED

Linear Reg. 3.3V



Power Current Protection

Coil Current Protection

Coil Switches

Output Drivers

Input Pullups

## Component details

The next sections provide schematic circuit diagrams for most components together with a short explanation and links to datasheets. Several circuits exist multiple times (see overview above) - part numbers (in [...]) are related to one example in these cases.

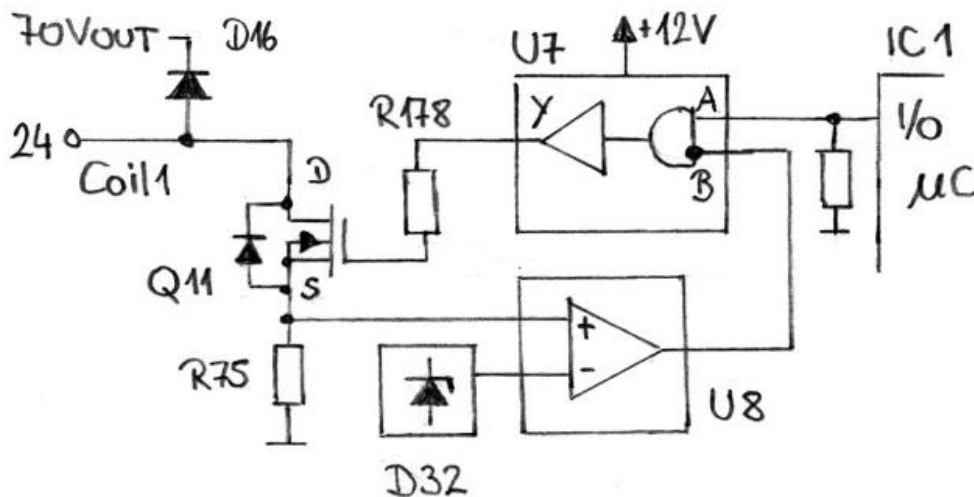
### Microcontroller

The I/O board uses a quite powerful 80 MHz, 32bit microcontroller PIC32MX795F512L-80I/PF manufactured by Microchip [IC1]. Check the [Datasheet](#) for more information.

### Coil Switch

There are 8 coil switches (4 on each side of the board). Each of them uses a n-channel MOSFET PSMN039-100YS (100V, 28A) [Q11, [Datasheet](#)] to connect the corresponding Coil x output to ground (GND). An ES3D diode [D16, [Datasheet](#)] protects the MOSFET against back current from the coil.

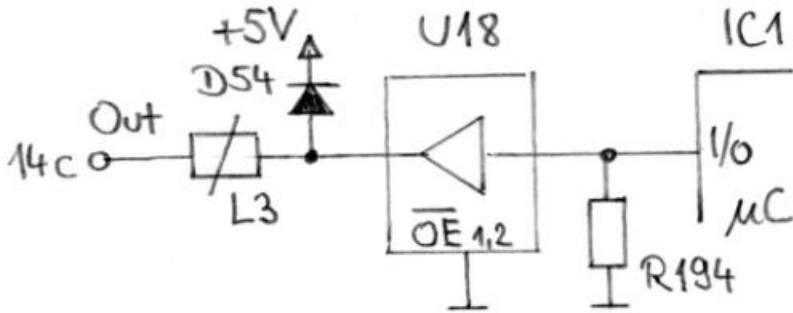
TC4467 drivers [U7, [Datasheet](#)] are used to amplify the PIC32 output signal (12V, 1.2A). The drivers are also controlled by a LM 2902 op amp [U8, [Datasheet](#)] comparing the coil current related voltage drop at resistor [R75, 30mOhm] with a reference voltage [D32, [Datasheet](#)].



Note: The over current protection is disabled for all MOSFETs on current I/O boards by replacing all measuring resistors with 0 Ohm devices and additionally shorting them with a common wire. Obviously this circuitry caused problems, the additional wires could be an indication of some oscillation tendency.

### Output Driver

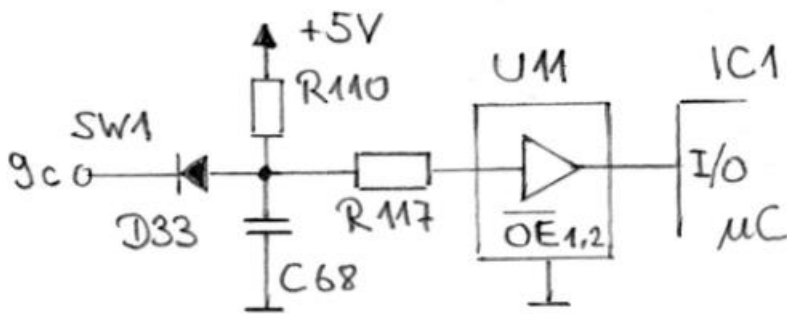
14 outputs are available for 5V logic devices, including the WS2812B LED data inputs [Datasheet]. They are implemented with 74HC365 buffer devices [U18, Datasheet] (5V, 30mA) together with a protection diode [D54] and a ferrite bead [L3] for noise suppression.



Note: Typically there should be a resistor between an output and the first controlled LED (on the playfield boards? **check**). But the ferrite [L3] might also do the job (resistance?).

### Input Buffer

24 pins of the VG connector are attached to microcontroller inputs via 74HC365 buffer devices [U11, Datasheet]. A pull-up resistor [R110] signals 5V (logic high) for open inputs, connected switches should therefore close to ground when active. All other components protect the input [D33] and clean the signal (debouncing).

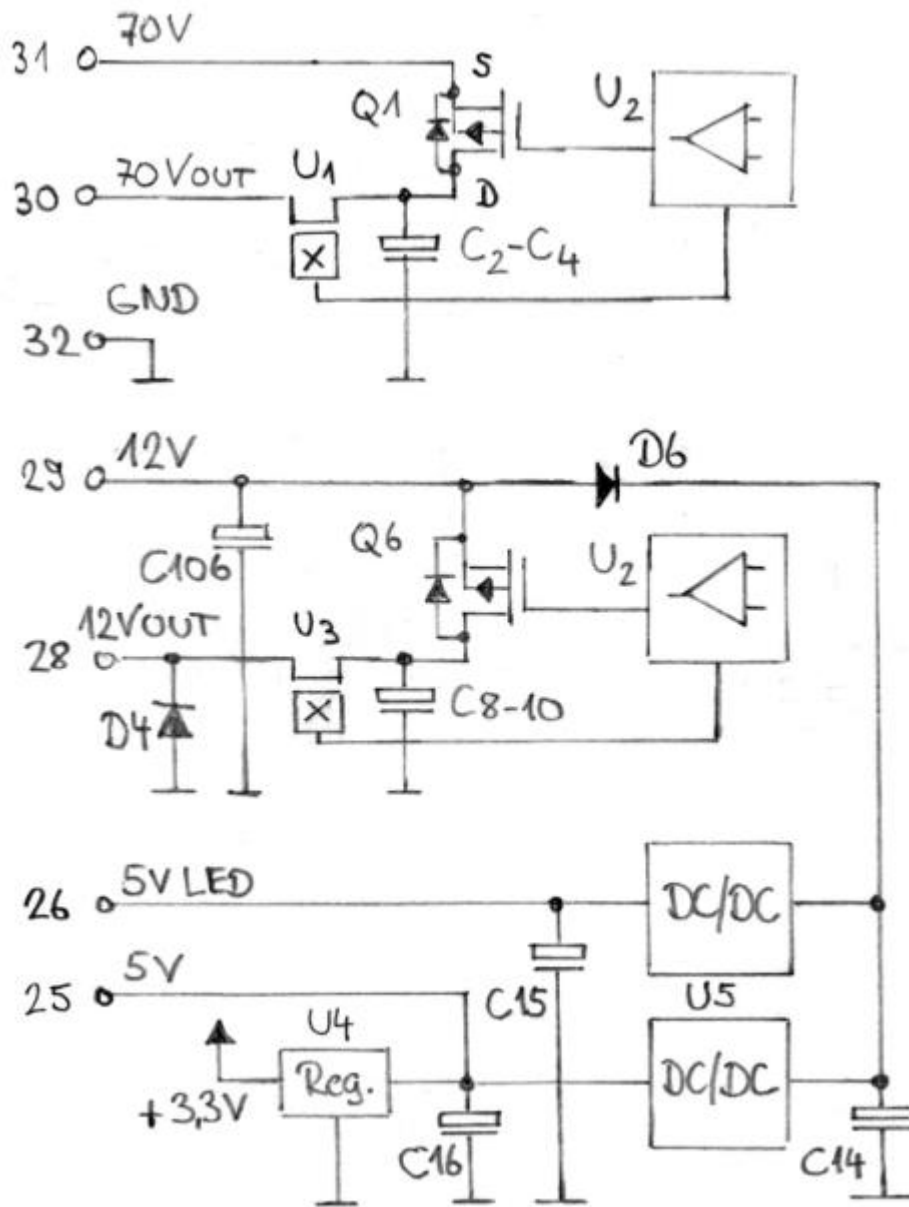


### Power Supply / Switches

The board is working with 12V consuming about 150mA. There are two groups of components for the power supply of the board itself and the attached hardware.

The first group creates 5V and 3.3V operating voltages for the integrated circuits on the I/O board as well as for the LEDs and other attached devices. A TPS54494 dual DC/DC converter [U5, Datasheet] reduces the main 12V supply to 5V and 5V LED. A linear regulator [U4, like LM1117, Datasheet] provides 3.3V out of the 5V line. A series of capacitors smooth the voltages.

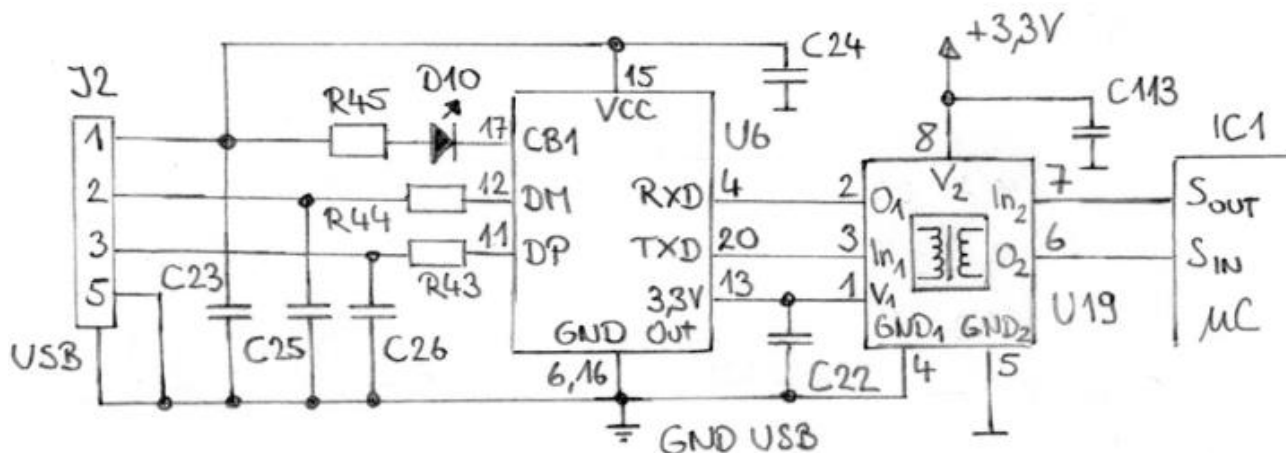
The second group implements 12V and 70V high current outputs with over-current protection. The incoming voltage is switched off with a FQB22P10TM p-channel MOSFET [Q1/Q6, Datasheet] if the current sensor ACS711 KLCTR-12AB [U1/U3, Datasheet] reaches a certain threshold. The current / voltage check is performed by a LM 2902 op amp [U2, Datasheet] and many additional parts (see component map).



Note: I saw some melted 70V MOSFETs (see pictures above). The reason is unclear to me and I ask myself, if a simple fuse could not replace those switches...

### USB Interface

The USB interface uses a FT231X interface device [U6, [Datasheet](#)] with USB bus powered configuration. The serial signal and power separation is accomplished with an additional ADuM 1201 [U19, [Datasheet](#)]. All discrete parts follow exactly the vendor's application example.



## VG Connector pinout

Here is a table of the VG connector pins and corresponding signals. The connector has 32 rows numbered 1 to 32 ab three columns named A, B and C. They pins and many signals are clearly marked on the I/O board, as visible in the component map pictures above.

Pin	Signal	Input/Output
A1	GND	Output
B1	SW 24 / Board Select 2	Input
C1	SW 23 / Board Select 1	Input
A2	SW 22 / Board Select 0	Input
A3, B3, C3	SW 21, 20, 19	Input
B4, B4, C4	SW 18, 17, 16	Input
...	...	Input
A9, B9, C9	SW 3, 2, 1	Input
C10	Out 14	Output
A11	Out 13	Output
A12, B12	Out 12,11	Output
B13, C13	Out 10, 9	Output
B14, C14	Out 8, 7	Output
A15, B15, C15	Out 6, 5, 4	Output
A16, B16, C16	Out 3, 2, 1	Output
A17, B17, C17	Coil 8	Output
A18, B18, C18	Coil 7	Output
A19, B19, C19	Coil 6	Output
A20, B20, C20	Coil 5	Output
A21, B21, C21	Coil 4	Output
A22, B22, C22	Coil 3	Output
A23, B23, C23	Coil 2	Output
A24, B24, C24	Coil 1	Output
A25, B25, C25	5V	Output
A26, B26, C26	5V LED	Output
A27, B27, C27	GND	Input
A28, B28, C28	12V OUT	Output
A29, B29, C29	12V	Input
A30, B30, C30	70V Out	Output
A31, B31, C31	70V	Input
A32, B32, C32	GND	Input

### Remarks:

- The Board Select inputs are used to detect the board address as a binary value:  
1 = open, 0 = GND
- The Out numbers are not specified on the PCB
- The high current connections use 3 pins in parallel (max. 2A / pin allowed)
- Missing pins are unused
- Be careful, the numbering on the connector itself may be different