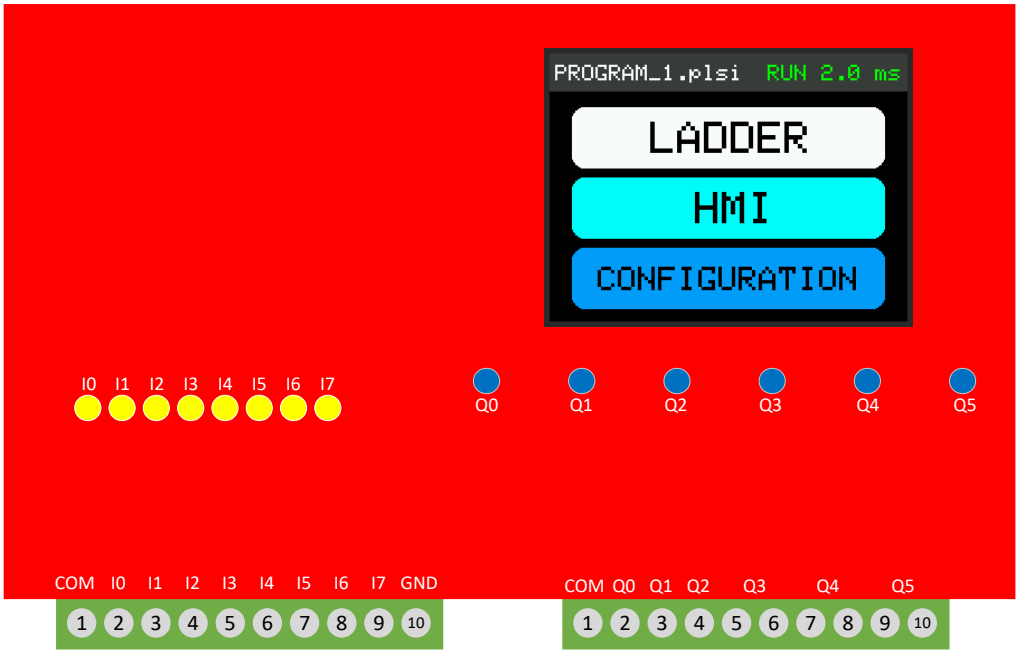
PLsi v0

Hardware Manual



Project page:

https://github.com/ElPercha/PLsi

GPL Free Software
Free as in Freedom

Purpose of this document

This PLsi manual provides you with information to build a PLsi v0 unit, it comprises the board assembly, firmware download and a series of tests to validate the main functionalities. For wiring, configuration and programming information use the "PLsi v0 User Manual" instead.

Please, create an issue in the PLsi repository if you see that this manual is not clear enough or has opportunities to improve.

Document information

Manual Name: **PLsi_v0_Hardware_Manual**

Revision: **A**

Date: **January 20, 2021**

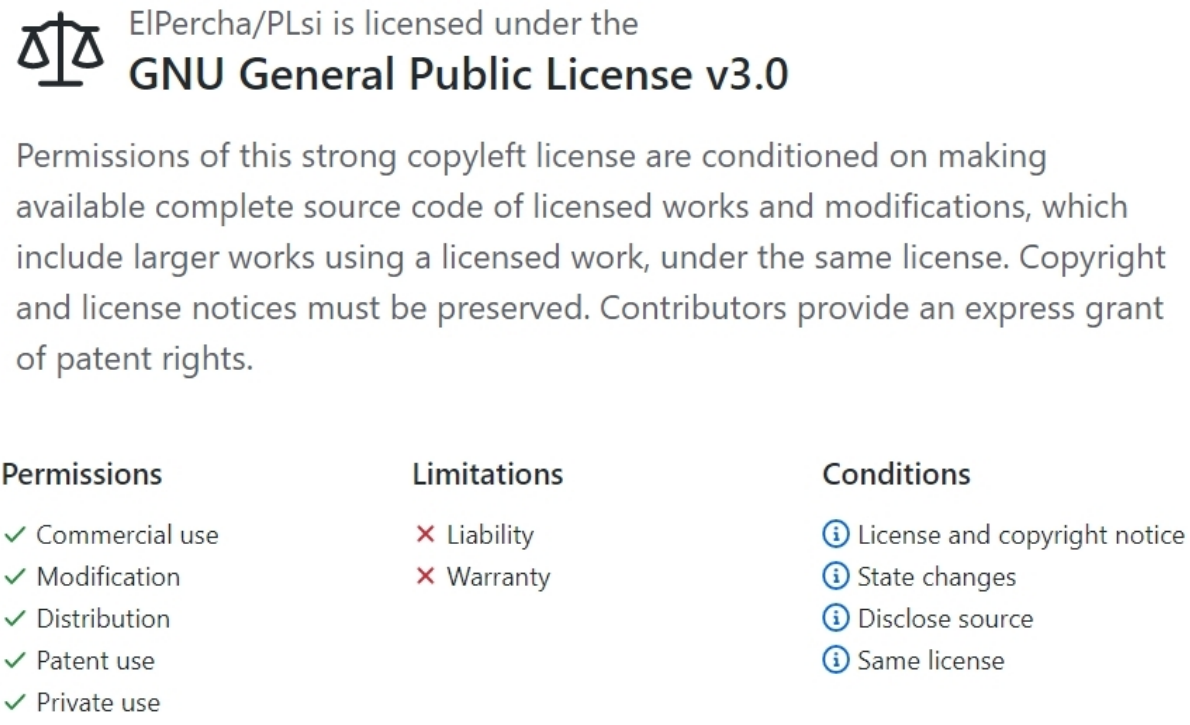
Revision history

Revision	Date	Description
A	March 20, 2021	First Revision

License

The complete PLsi Project is under GPL v3.0 license.

This includes Hardware, Software, Documentation and all related contributions:



A full copy of the License is included on the Master branch of the project for reference:

https://github.com/ElPercha/PLsi/blob/master/LICENSE

Original copy with useful FAQ:

https://www.gnu.org/licenses/gpl-3.0.html

Disclaimer

Safety Guidelines

All applicable local and national codes that regulate the installation and operation of your equipment shall be followed in order to minimize the risk of potential safety issues.

PLsi is not fault-tolerant and must not be used to control equipment in hazardous environments where the failure of the system could lead to death, people injury, or severe environmental damage. Refers to the Disclaimer notice for more information.

This manual contains 3 levels of hints:

WARNING:
Death, serious harm to health or equipment damage can result if the stated measures are not followed !

CAUTION:
Harm to health or equipment damage can result if the stated measures are not followed

TIP:
Important information that requires your special attention

Table of Contents

1. Introduction

The objective of the PLsi project is to create a PLC & HMI with the following main characteristics:

- To not require external systems such us Laptops or Cellphones to be programmed
- To be used on Classroom for educational purposes, IOT applications or industrial low risk applications
- Software and Hardware with Industrial performance and features
- Open Source and Open Hardware
- Focus on Low Cost

The hardware version 0 of PLsi system is designed to be cheap and easy to build. It does not have SMD components, what makes the building process easy, fast and feasible using basic tools. The components selection was oriented to use easy to get and cheap elements.

The PLsi v0 is mainly composed by:

- Main board
- ESP32 module
- TFT 2.8" SPI Display module with touchscreen
- Terminal blocks and common electronic components

The PLsi v0 board is designed to support different input output configurations. This manual will cover the 2 main suggested configurations. For that reason, before to start, you have to select which version are you going to build, these are the 2 main options:

1. Digital version:
    - 8 digital inputs (5 to 26VDC)
    - 6 relay outputs (10A max per PLsi, external fuse required)
2. Analog version:
    - 6 digital inputs (5 to 26VDC)
    - 4 relay outputs (10A max per PLsi, external fuse required)
    - 2 Analog Inputs (0-5V)
    - 2 Analog Outputs (0-5V)

This definition will modify your component list. The details of which component is required on each version is covered on the following chapters.

1.1 Project documentation

The PLsi project is hosted on GitHub:

https://github.com/ElPercha/PLsi

The tree structure is divided in 3 main folders:

1. **doc**: Contains project documentation and auxiliary tools
2. **firm**: Contains the Firmware, it is designed using PlatformIO + Visual Studio
3. **hard**: Contains the Hardware documentation, mainly:
    - Circuit schematic
    - Component list
    - Board fabrication details
    - 3D Printed housing fabrication details
    - 3D Printed Din Rail support fabrication details

The most updated information is located on the master branch (link provided above), but it also might contain nightly builds of the firmware, hardware or any document. For this reason, it is recommended to use the “releases”, they are a more trustworthy information source.

Each release contains a snapshot of the full project site by the moment of his creation, plus the required binaries to flash the ESP32 module.

By the time this document was created, the latest revision available is the “v0.00.03”.

It is recommended to use the latest available release to build your PLsi unit.

https://github.com/ElPercha/PLsi/releases

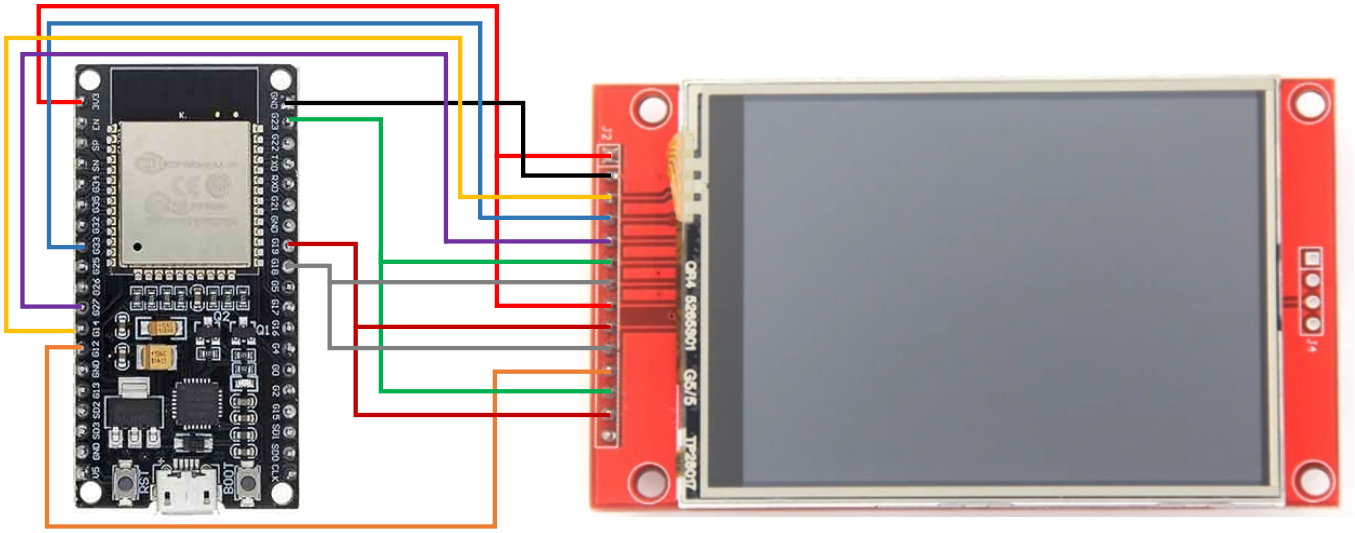
The details on how to use the binary files to flash your PLsi are going to be covered during the next chapters.

1.2 Minimum system

The easiest way to build a PLsi v0 is using the board designed for it, but for PLsi CPU testing purposes (with no Inputs Outputs) a limited system can be easily built.
It consist of:

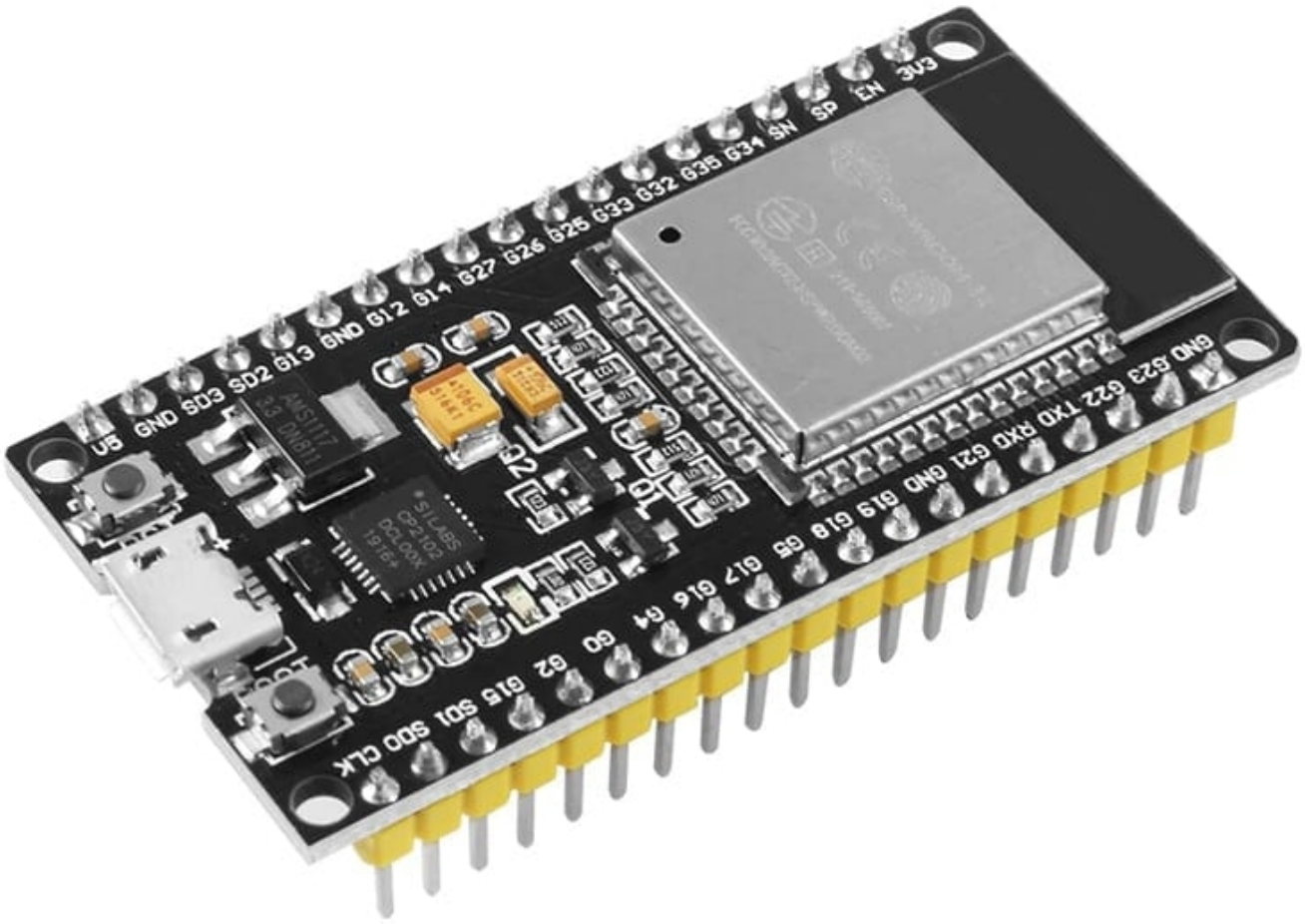
- ESP32 WROOM module
  - 38 pins version
  - They typically have yellow pin terminals
  - For test purposes you can use another ESP32 module as long as it has dual core, but the described model is required if you use the PLsi v0 board.
- 2.8" 320x240 SPI TFT Display – LcdWiki info
  - Driver ILI 9341
  - Touchscreen driver XPT2046
  - For test purposes you can use another display, as long as it has the same interface, resolution and drivers, but the described model is required if you use the PLsi v0 board.
- 9 Jumper cables for the ESP32 ← → Display connections.
- Micro USB cable and adapter with 1A capacity (recommended 2A)
  - This fed the ESP32 module and it is the main incoming supply voltage of the PLsi v0

Required ESP32 ← → Display connections for minimal system:

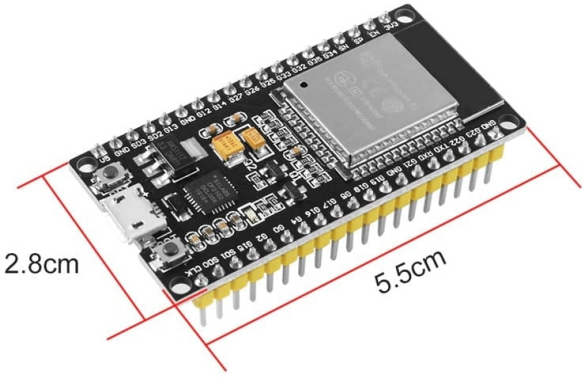


In the above sketch the minimal connections are shown.
The only pending activity to have a functional CPU will be the ESP32 Firmware download. This procedure is detailed in the Firmware Download chapter.

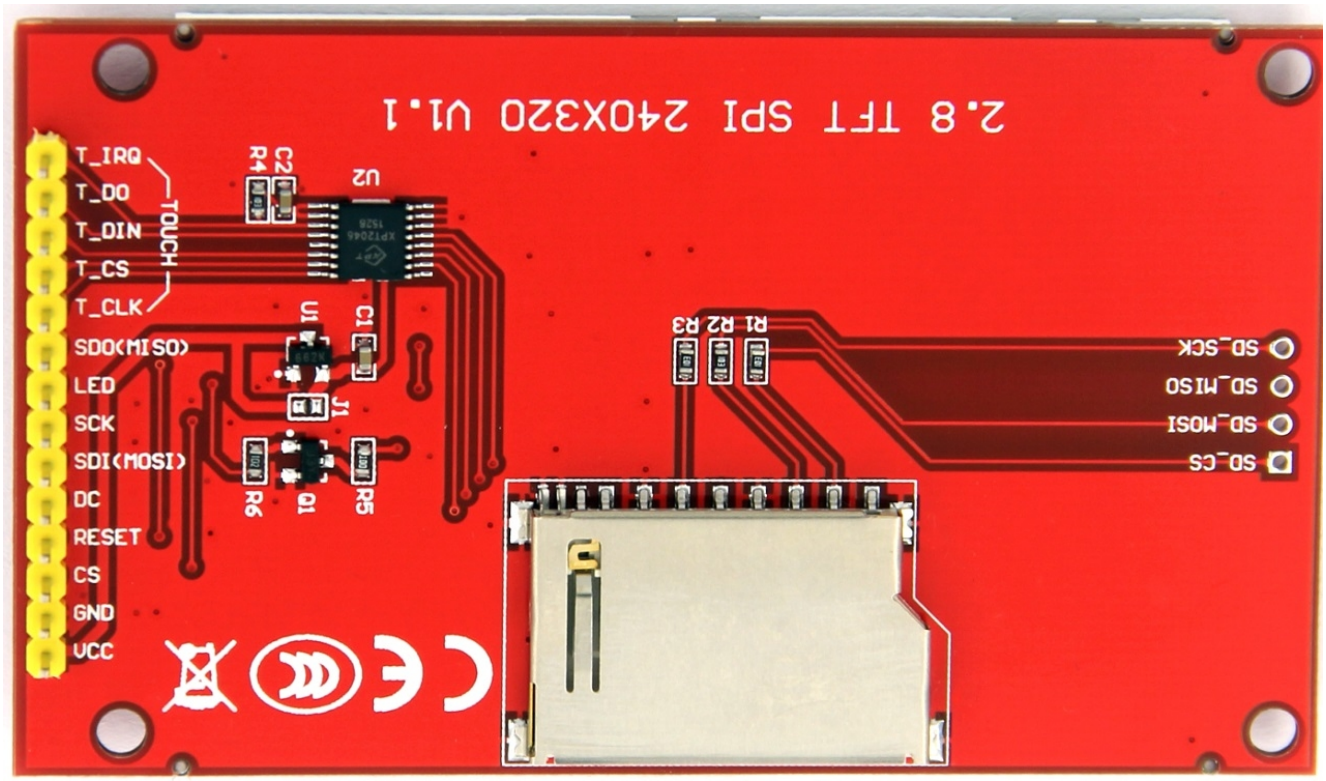
Required ESP32 Module



Dimensions:



Required display:

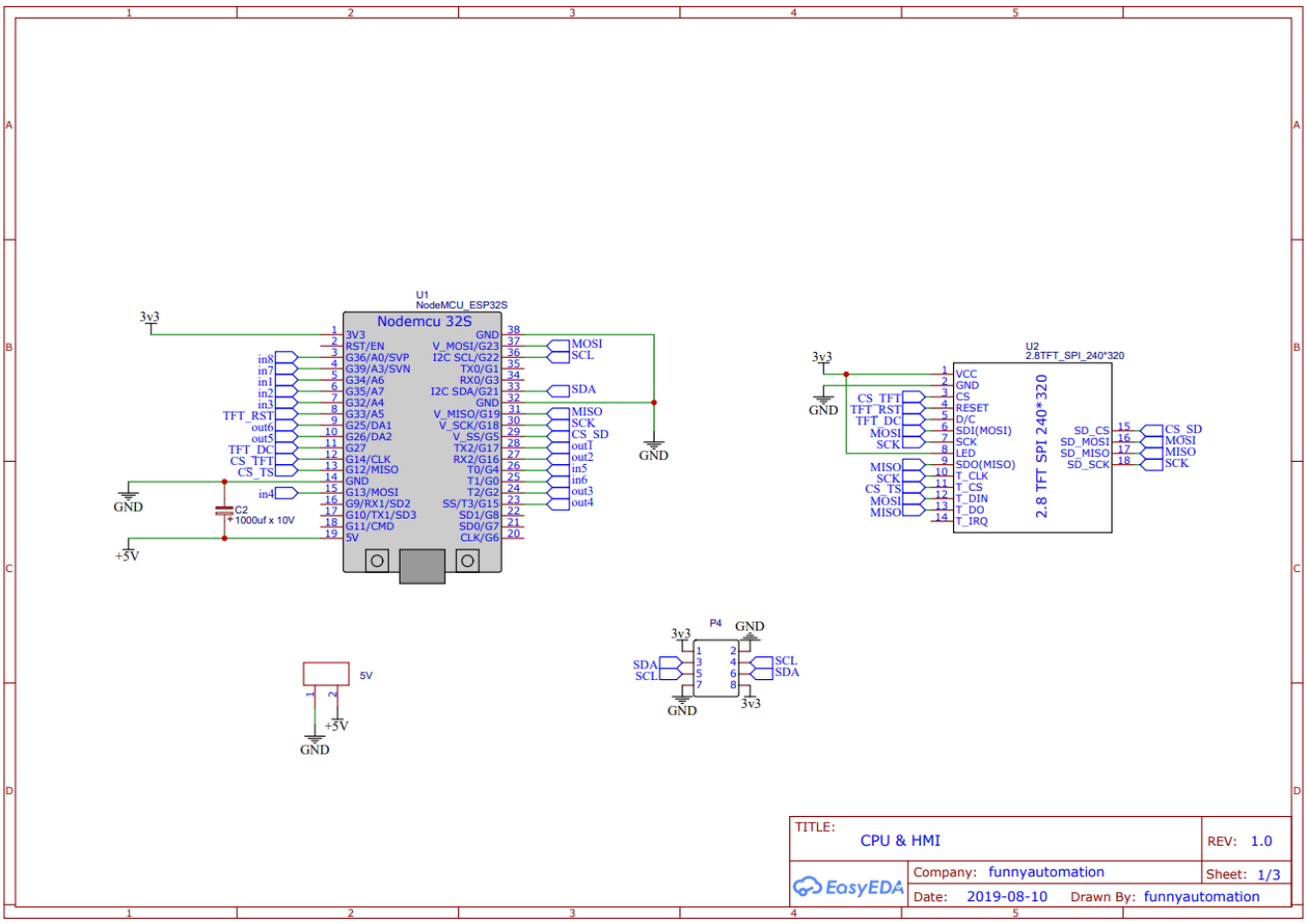


1.3 Drawing

The drawing was created using the free editor EasyEDA.
You can access the project following this link.
The schematic is also stored on GitHub, in the folder hard/CPU/v0/schematic

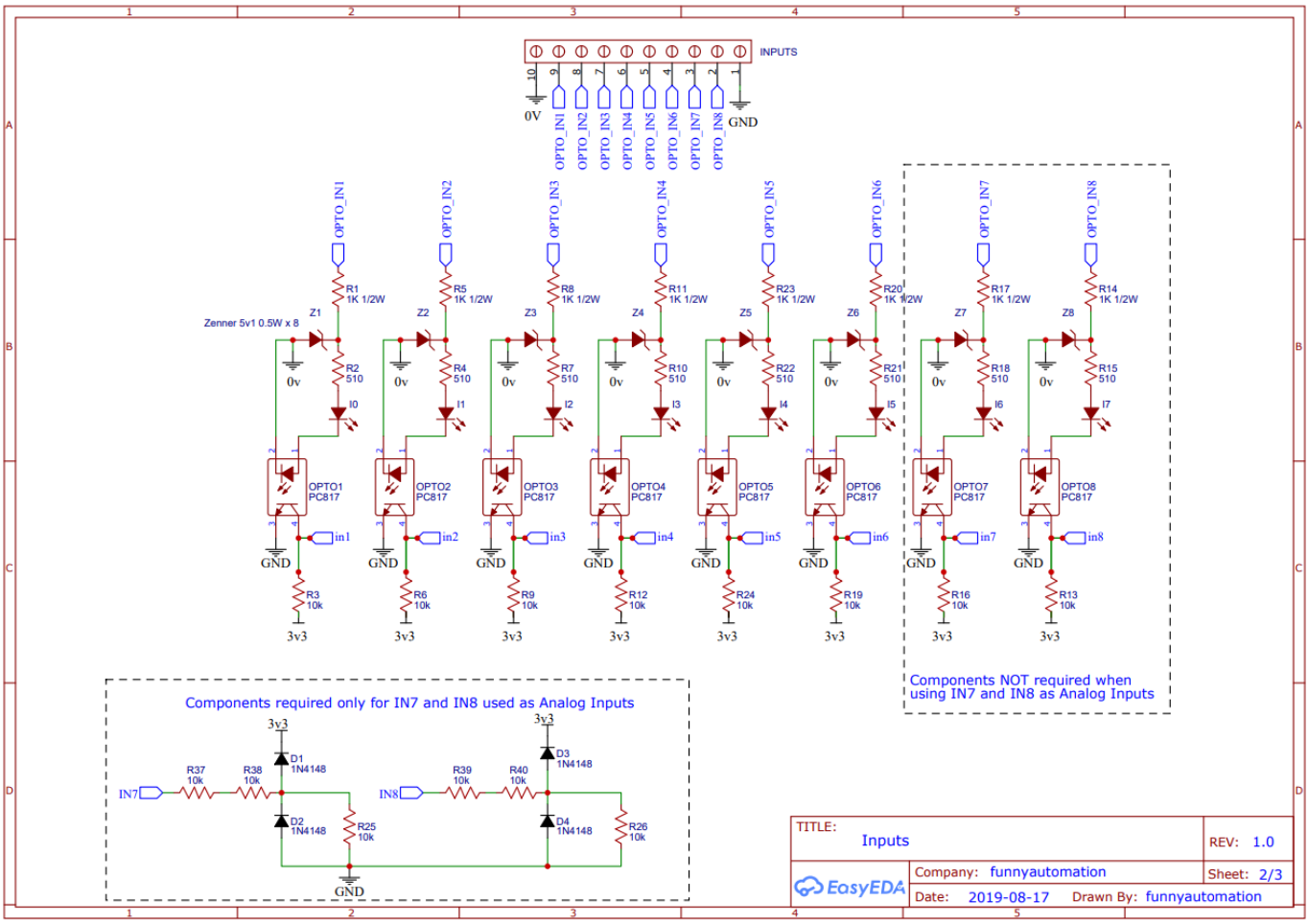
The drawing is composed by 3 pages:

- CPU & HMI
- Inputs
- Outputs



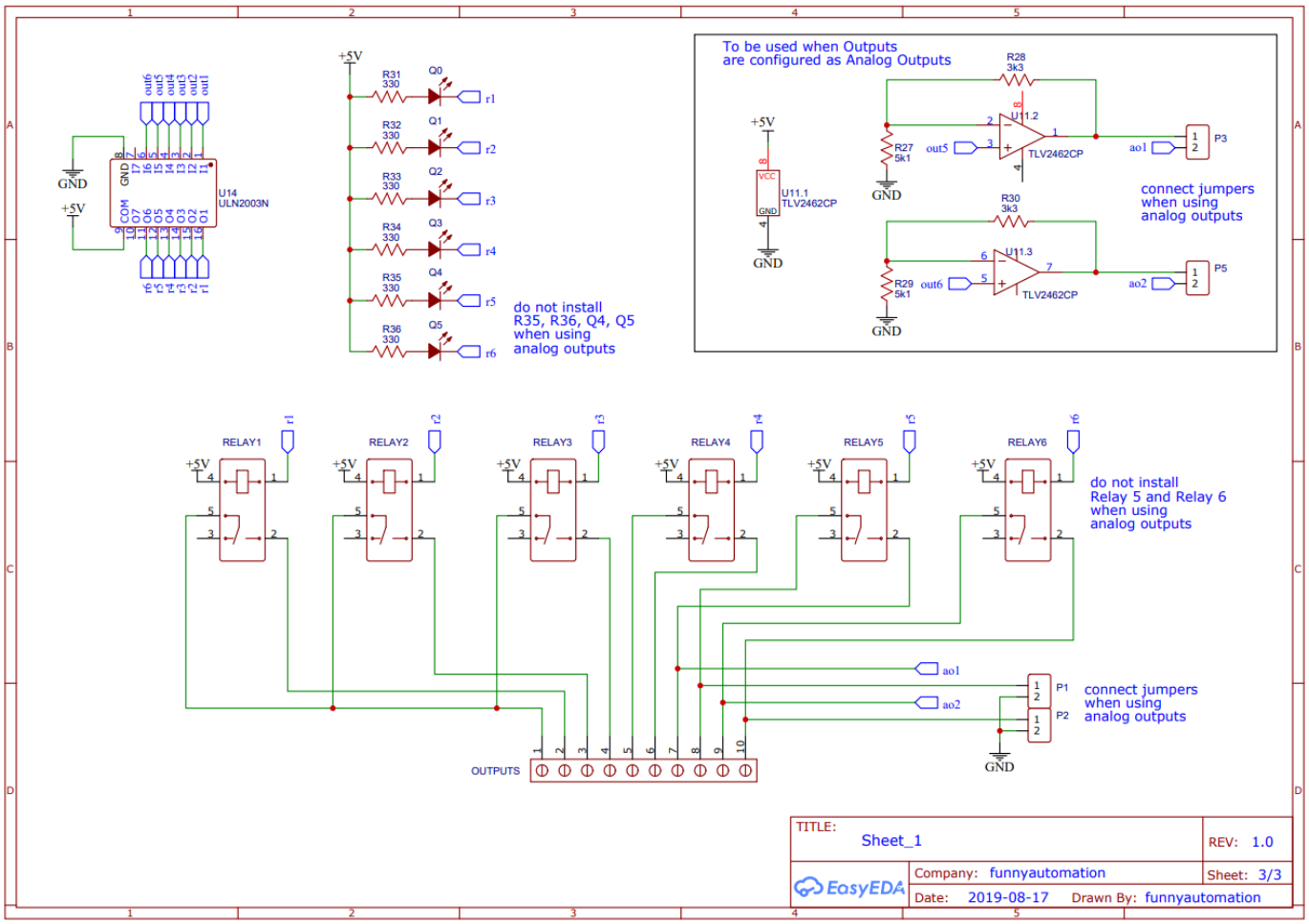
All the components shown in the above schematic are required for any PLsi v0 version, analog or digital.

Digital & Analog inputs schematic:



Note that not all components are required.
The components list for Analog or Digital version is detailed over the next chapters

Digital & Analog outputs schematic:



Note that not all components are required.
The components list for Analog or Digital version is detailed over the next chapters

2. Board Assembly

The recommended way to build your PLsi is using the board designed for it.
All the required files to build the board are stored on Github. Each PLsi hardware version has his own folder.

PLsi v0 board link.

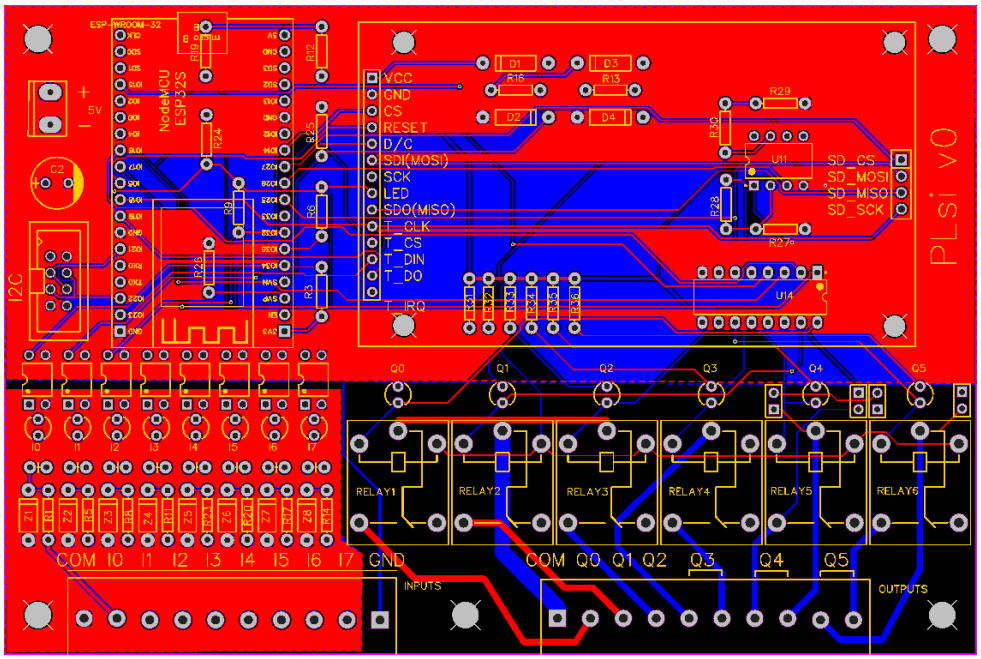
Folder content:

- Gerber Files
- EasyEDA source
- Altium source (it is a beta export option of the EasyEDA platform, not tested)
- Schematic
- BOM

The EasyEDA project is also public, you can directly clone the project, download or open the files from here.

The Boards used to prototype the PLsi v0 were ordered to:

https://jlcpcb.com/



2.2 Digital version

The Digital version of PLsi hardware v0 will have:

- 8 digital inputs (5 to 26VDC)
- 6 relay outputs (10A max per PLsi, external fuse required)

2.2.1 Component list

The following table has the list of components required to build your Digital PLsi v0:

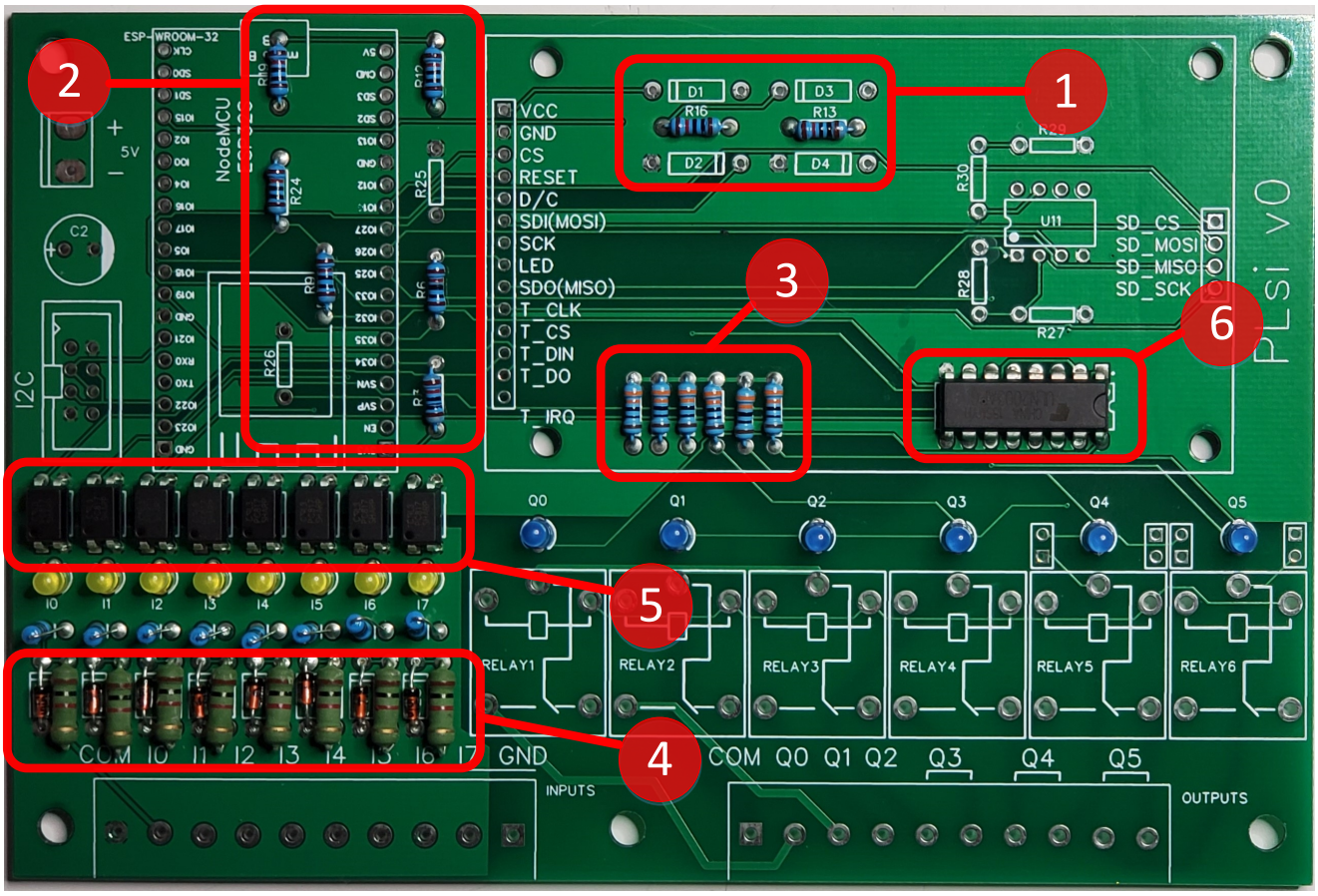
Item	Component TAG	Description	Quantity
1	U1	NodeMCU_ESP32S	1
2	U2	Touch Screen Display	1
3	U14	ULN2003N	1
4	INPUTS, OUTPUTS	5.08 x 10 Terminal block	2
5	U2 – SD Card connection pins	Dupont 2.54mm Male strip	4 pins
6	U1 and U2 - Socket	Dupont 2.54mm Female strip	2 x 40 pins
7	5V	Dupont 3 pins male	3 pins
8	P4	HDR-IDC-2.54-2X4P	1
9	C2	Capacitor 1000uF 9V	1
10	OPTO1, OPTO2, OPTO3, OPTO4, OPTO5, OPTO6, OPTO7, OPTO8	Optocoupler PC817	8
11	Z1, Z2, Z3, Z4, Z5, Z6, Z7, Z8	Diode 5v1 – Zenner 1w	8
12	I0, I1, I2, I3, I4, I5, I6, I7	Leds 3mm Color 1	8
13	Q0, Q1, Q2, Q3, Q4, Q5	Leds 3mm Color 2	6
14	R3, R6, R9, R12, R13, R16, R19, R24	Resistor 10k	8
15	R1, R5, R8, R11, R14, R17, R20, R23	Resistor 1K x 1/2W	8
16	R2, R4, R7, R10, R15, R18, R21, R22	Resistor 510 ohms	8
17	R31, R32, R33, R34, R35, R36	Resistor 330 ohms	6
18	RELAY1, RELAY2, RELAY3, RELAY4, RELAY5, RELAY6	SRD-05VDC-SL-C	6

The latest version of the BOM (Bill of Materials) file, is stored in this Folder.

2.2.2 Assembly

This section will recommended a step by step sequence to facilitate the assembly process, starting with the smaller components and finishing with the bigger ones.

For each step, the indicated Item number can be found on the previous table (Section 2.2.1) to get more information about the component.



Step 1 - Weld quantity 2 x 10K Resistors – Item 14

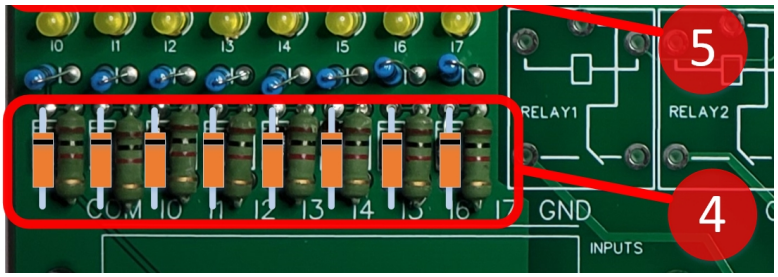
Step 2 - Weld quantity 6 x 10K Resistors – Item 14

Step 3 - Weld quantity 6 x 330 ohm Resistors – Item 17

Step 4 - Weld quantity 8 x 1K x 1/2W Resistors – Item 15

Weld the 8 x Zenner Diodes 5.1V x 1W – Item 11

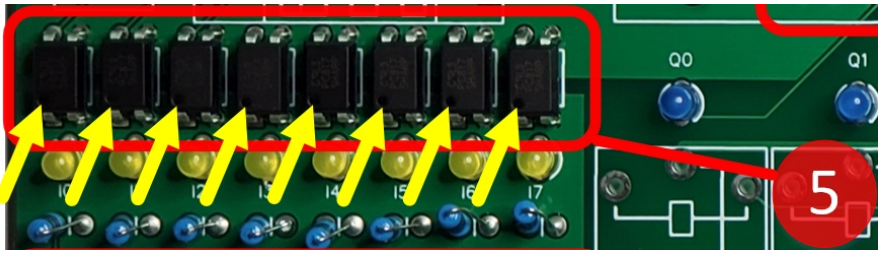
Pay special attention to the Zenner diodes polarity:



Do not use components with less power of what is suggested.
1/2W for Resistors and 1W for Zenner Diodes

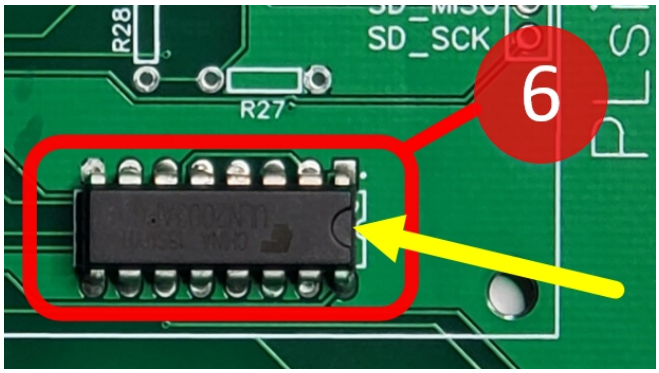
Step 5 - Weld quantity 8 x PC817 Optocouplers – Item 10

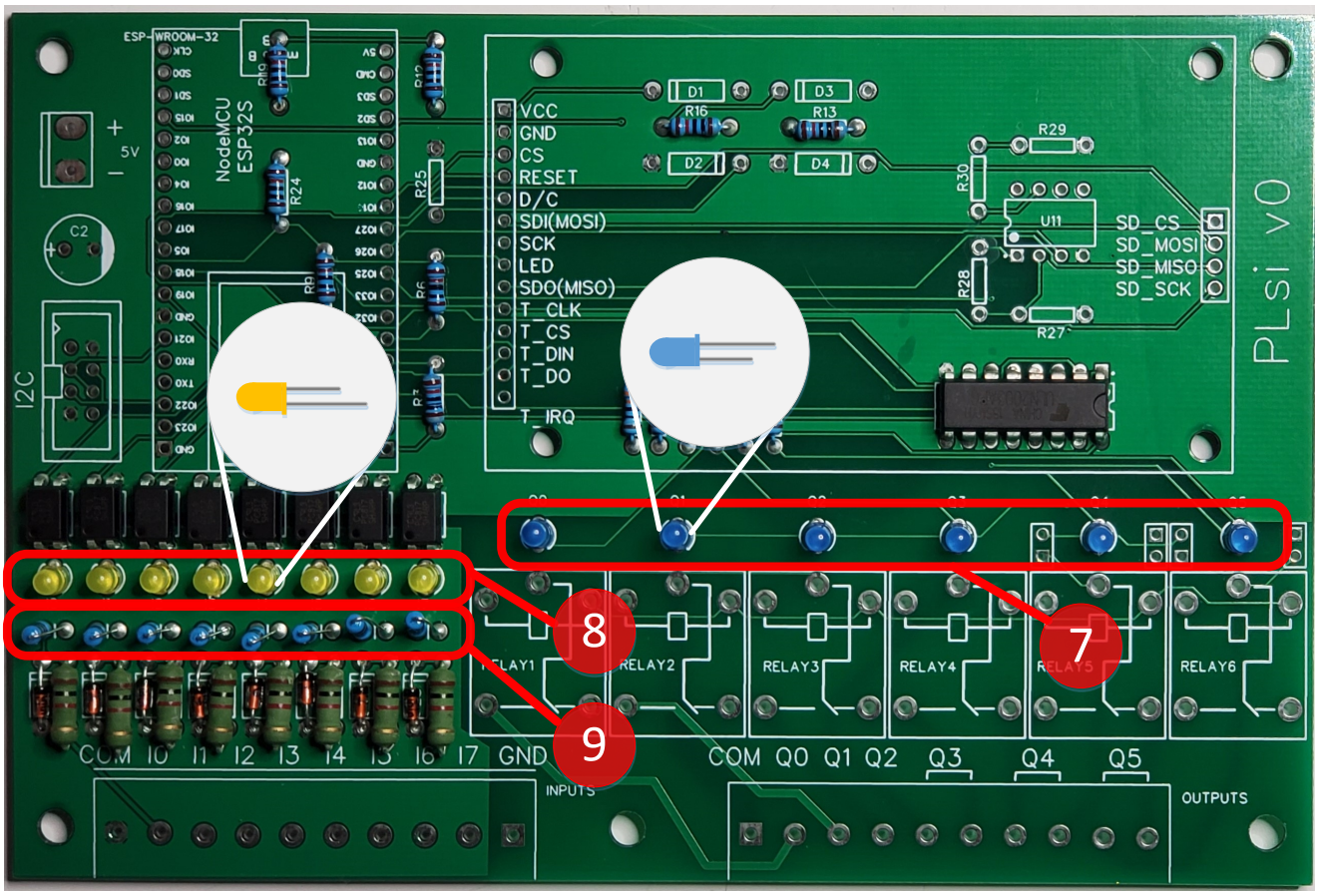
Pay special attention to the orientation mark on the Chip



Step 6 - Weld quantity 1 x UNL2003N driver – Item 3

Pay special attention to the orientation mark on the Chip





Step 7 - Weld quantity 6 x 3mm Leds of your favorite color – Item 13

It is recommended to avoid using red and green since they are typically used to indicate failures and OK statuses respectively.

Pay special attention to the polarity (Long leg/Short leg)

Recommended color: Yellow

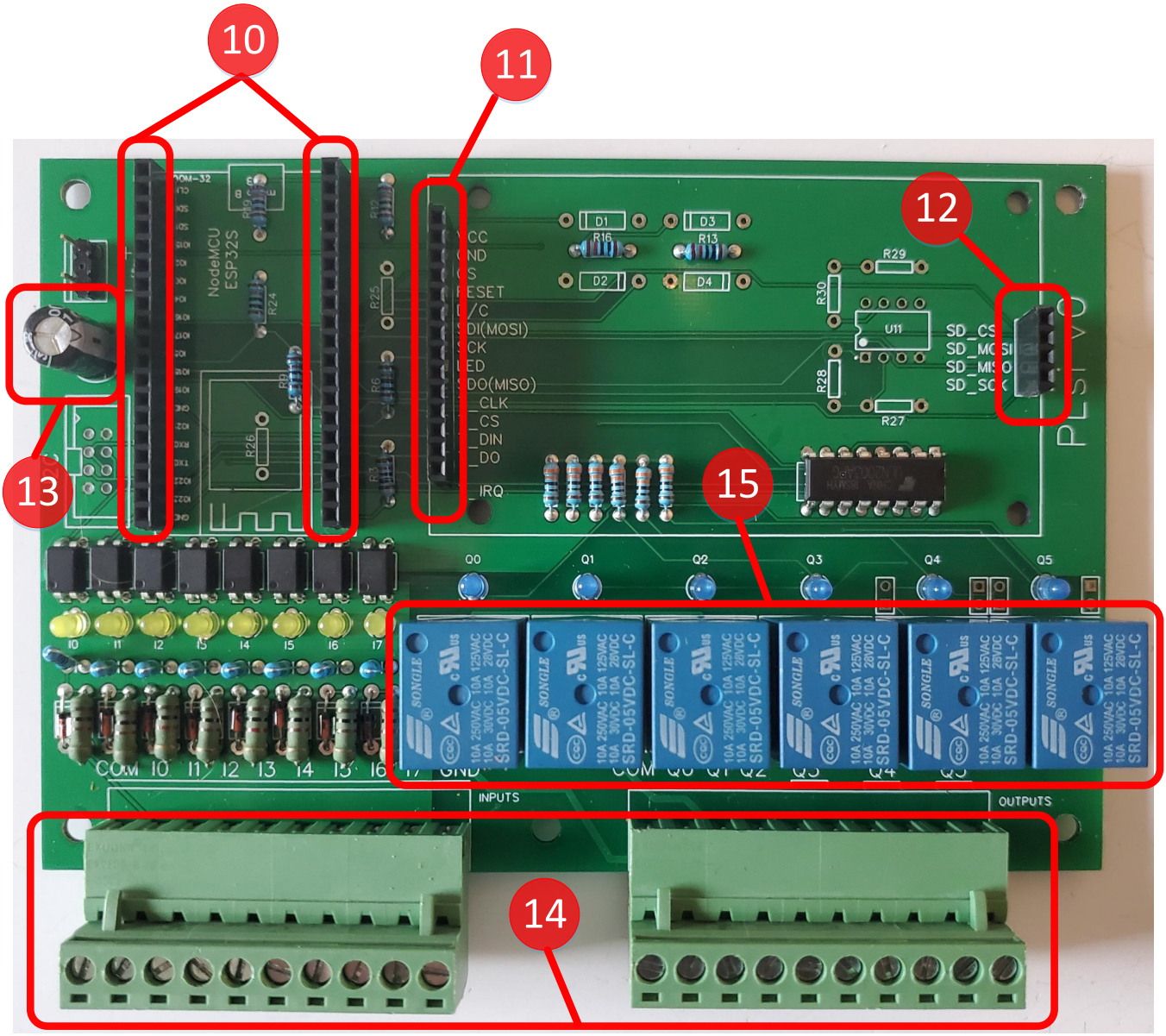
Step 8 – Weld quantity 8 x 3mm Leds of your favorite color – Item 12

It is recommended to avoid using red and green since they are typically used to indicate failures and OK statuses respectively.

Pay special attention to the polarity (Long leg/Short leg)

Recommended color: Blue, Purple, Yellow

Step 9 - Weld vertically quantity 8 x 510 ohms Resistors – Item 16



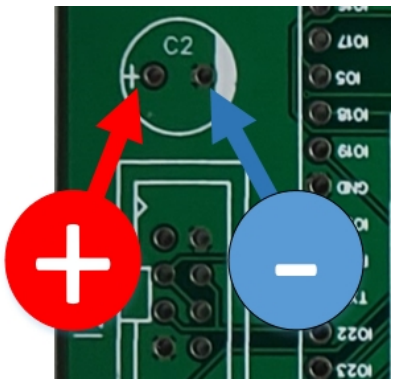
Step 10 – Weld quantity 2 x 18 pins Female Dupont headers (2.54mm) – Item 12

Step 11 - Weld quantity 1 x 14 pins Female Dupont header (2.54mm) – Item 12

Step 12 - Weld quantity 1 x 4 pins Female Dupont header (2.54mm) – Item 12

Step 13 - Weld quantity 1 x Capacitor 1000uF 9V

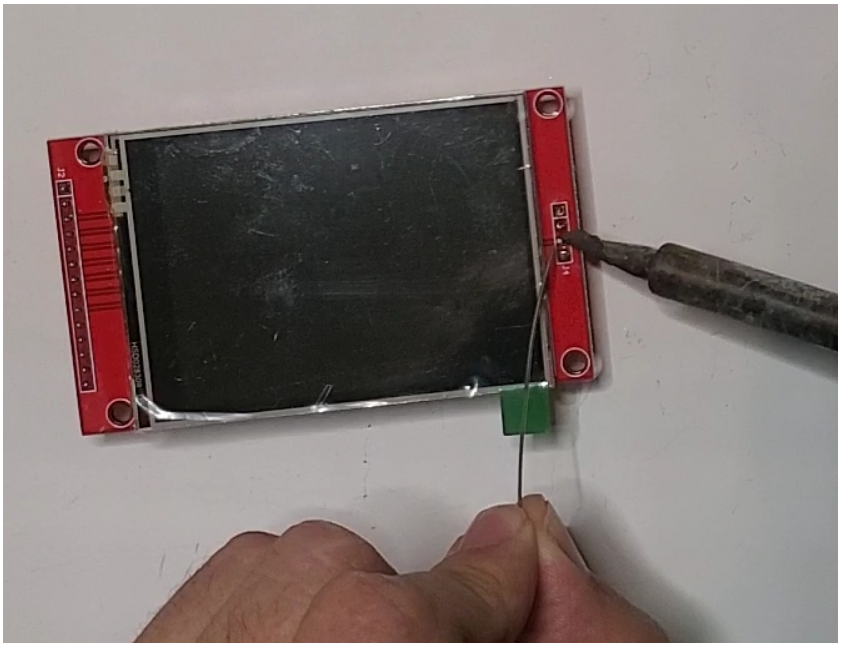
Observe the Polarity detail:



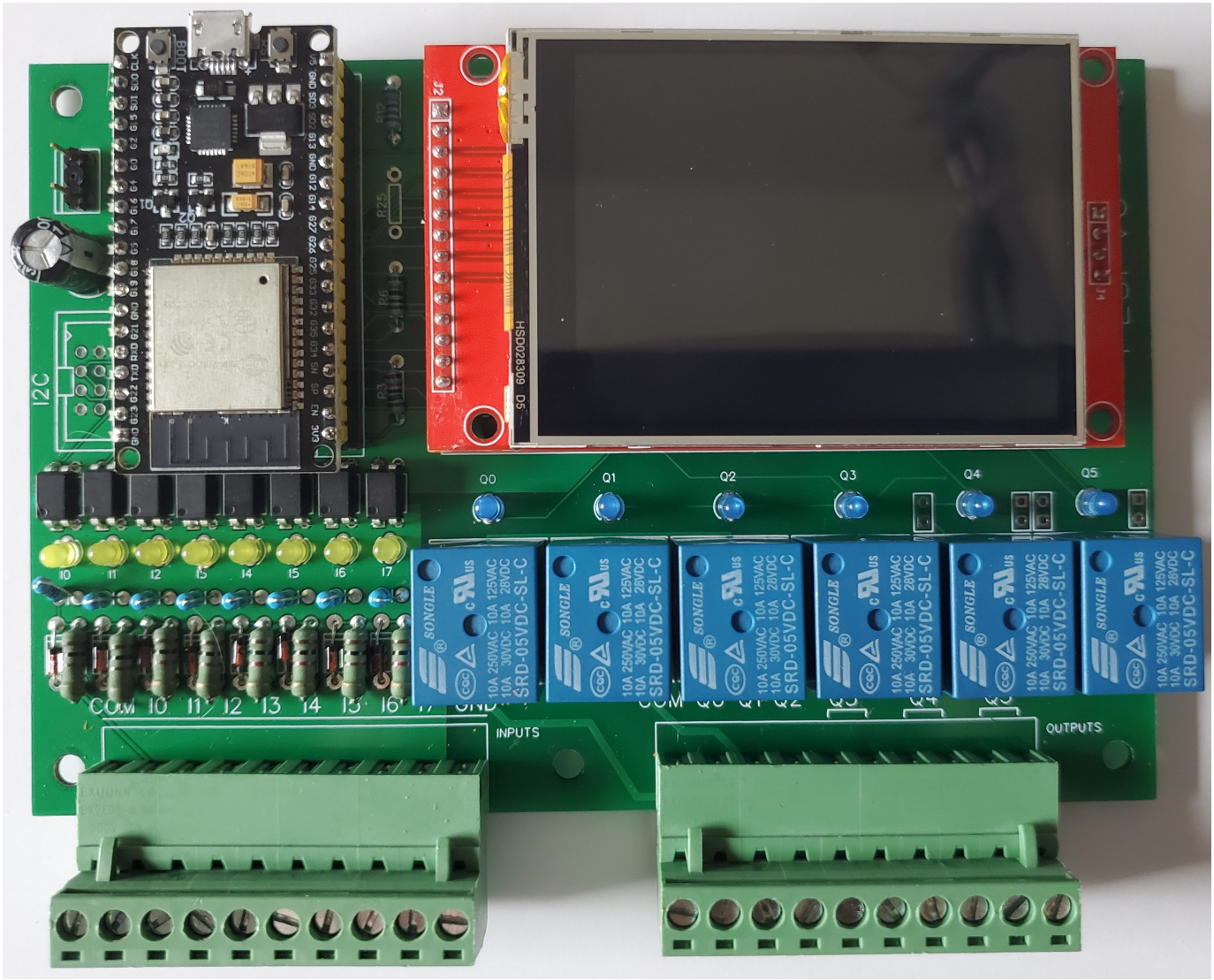
Step 14 - Weld quantity 2 x Header 10 pins 5.08mm – Item 4

Step 15 - Weld quantity 6 x Relay 10Amps Coil 5vdc – Item 18

Step 16 – Weld the 4 pin header right side of the Display as indicated in the following picture:



Step 17 – Insert ESP32 Module and Display



You have now completed the PLsi v0 hardware assembly.

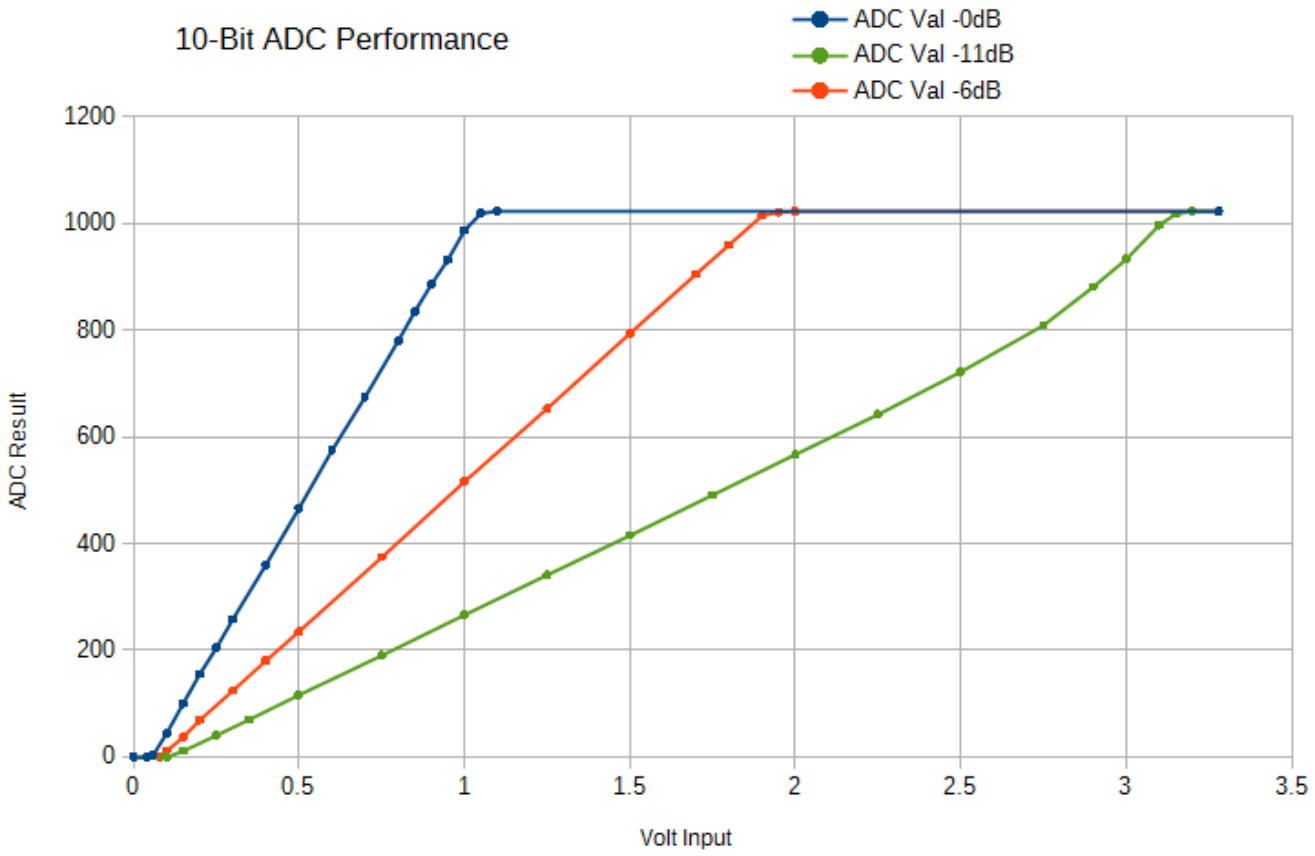
Jump to Chapter 3 to proceed with the Firmware Download procedure.

2.3 Analog version

The Analog version of PLsi hardware v0 will have:

- 6 digital inputs (5 to 26VDC)
- 4 relay outputs (10A max per PLsi, external fuse required)
- 2 Analog inputs 0-5VDC range (non isolated)
- 2 Analog outputs 0-5VDC range (non isolated)

The analog inputs in the ESP32 doesn't have a good linear response and they have a considerable zero drift. The firmware implement a couple of corrections to improve the linear response of the ADC. The ADC is configured at -6dB:



If high precision analog readings are required an external I2C or Wi-Fi expansion is suggested.

2.3.1 Component list

The following table has the list of components required to build your Analog PLsi v0:

Item	Component TAG	Description	Quantity
1	U1	NodeMCU_ESP32S	1
2	U2	Touch Screen Display	1
3	U14	ULN2003N	1
4	INPUTS, OUTPUTS	5.08 x 10 Terminal block	2
5	U2 – SD Card connection pins	Dupont 2.54mm Male strip	4 pins
6	U1 and U2 - Socket	Dupont 2.54mm Female strip	2 x 40 pins
7	5V	Dupont 3 pins male	3 pins
8	P4	HDR-IDC-2.54-2X4P	1
9	C2	Capacitor 1000uF 9V	1
10	OPTO1, OPTO2, OPTO3, OPTO4, OPTO5, OPTO6	Optocupler PC817	6
11	Z1, Z2, Z3, Z4, Z5, Z6	Diode 5v1 – Zenner 1w	6
12	I0, I1, I2, I3, I4, I5	Leds 3mm Color 1	6
13	Q0, Q1, Q2, Q3	Leds 3mm Color 2	4
14	R3, R6, R9, R12, R19, R24	Resistor 10k	6
15	R1, R5, R8, R11, R20, R23	Resistor 1K x 1/2W	6
16	R2, R4, R7, R10, R21, R22	Resistor 510 ohms	6
17	R31, R32, R33, R34	Resistor 330 ohms	4
18	RELAY1, RELAY2, RELAY3, RELAY4	SRD-05VDC-SL-C	4
19	D1, D2, D3, D4	Diode 1N4148	4
20	R25, R26, R37, R38, R39, R40	Resistor 10k 1%	6
21	R27,R29	Resistor 5k1	2
22	R28,R30	Resistor 3k3	2
23	U11	TLV2462CP	1

The latest version of the BOM (Bill of Materials) file, is stored in this Folder.

2.3.2 Assembly

PLsi is not fault-tolerant and must not be used to control equipment in hazardous environments where the failure of the system could lead to death, people injury, or severe environmental damage. Refers to the Disclaimer notice for more information.

3. Firmware Download

PLsi is not fault-tolerant and must not be used to control equipment in hazardous environments where the failure of the system could lead to death, people injury, or severe environmental damage. Refers to the Disclaimer notice for more information.

3.1 Required files

PLsi is not fault-tolerant and must not be used to control equipment in hazardous environments where the failure of the system could lead to death, people injury, or severe environmental damage. Refers to the Disclaimer notice for more information.

0x1000 - bootloader_dio_40m.bin
0x8000 - partitions.bin
0xe000 - boot_app0.bin
0x10000 - firmware.bin
https://www.espressif.com/en/products/socs/esp32/resources

3.2 Espressif download tool

PLsi is not fault-tolerant and must not be used to control equipment in hazardous environments where the failure of the system could lead to death, people injury, or severe environmental damage. Refers to the Disclaimer notice for more information.

https://www.espressif.com/en/products/socs/esp32/resources

3.2 Downloading the Firmware

PLsi is not fault-tolerant and must not be used to control equipment in hazardous environments where the failure of the system could lead to death, people injury, or severe environmental damage. Refers to the Disclaimer notice for more information.

4. Hardware Validation

This step is optional but recommended……..

4.1 Digital Inputs validation

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4.2 Digital Outputs validation

PLsi is not fault-tolerant and must not be used to control equipment in hazardous environments where the failure of the system could lead to death, people injury, or severe environmental damage. Refers to the Disclaimer notice for more information.

4.3 Analog Inputs validation

PLsi is not fault-tolerant and must not be used to control equipment in hazardous environments where the failure of the system could lead to death, people injury, or severe environmental damage. Refers to the Disclaimer notice for more information.

Show configuration of Analog input

4.4 Analog Outputs validation

PLsi is not fault-tolerant and must not be used to control equipment in hazardous environments where the failure of the system could lead to death, people injury, or severe environmental damage. Refers to the Disclaimer notice for more information.