Project:	CTA Calibration Flasher (V2)
Doc. Title:	User Manual
Doc. No.:	CfAI.CTA.CHECFLA.003
Issue:	D1
Date:	14/03/2019

	Name:	Signature & Date:
Prepared By:	Paul Clark	
Checked By:	Anthony Brown	
Approved By:	Paula Chadwick	

Change Record

Issue:	Date:	Sections:	Description of Change:
D1	14/03/19	All	First Draft

Table of Contents

1 Introduction

1.1 Scope of the document

This document defines the user manual for **Version 2** of the Cherenkov Telescope Array Calibration Flasher, incorporating:

- Calibration Flasher:
  - Controller Board
  - Timing Board
  - LED Board
- FlasherCtl:
  - UDP software stack based extensively on Felix Werner's ServoCtl (RD1)
    - C code for the Controller Board (compiled and programmed via the Arduino IDE)
    - Python utilities (to be run on a laptop computer or similar)

2 Applicable Documents

AD#	Document Title	Doc. No.
AD1		
AD2		

3 Reference Documents

RD#	Document Title
RD1	ServoCtl Manual, Felix Werner, August 25 2015

4 Abbreviations

ADC	Analogue to Digital Converter
BGA	Ball Grid Array
CfAI	Centre for Advanced Instrumentation
CHEC	Compact High Energy Camera
COTS	Commercial Off The Shelf
CS	(SPI) Chip Select
CTA	Cherenkov Telescope Array
DC	Direct Current
DI	(SPI) Data In
DO	(SPI) Data Out
EMI	Electro Magnetic Interference
FIFO	First In First Out
FR4	Flame Retardant 4 (glass-reinforced epoxy laminate PCB material)
GCT	Gamma Cherenkov Telescope
IC	Integrated Circuit
IIC or I2C	Inter-Integrated Circuit
LED	Light Emitting Diode
MISO	(SPI) Master In Slave Out
MOSI	(SPI) Master Out Slave In
N/C	Not Connected
PCB	Printed Circuit Board
POE	Power Over Ethernet
PSoC	Programmable System on Chip
PWM	Pulse Width Modulation
RTC	Real Time Clock
RTS	Request To Send
SCK	(SPI) Serial Clock
SPI	Serial Peripheral Interface
TQFP	Thin Quad Flat Package
UART	Universal Asynchronous Receiver / Transmitter
UDP	User Datagram Protocol
USB	Universal Serial Bus
UV	Ultraviolet
w.r.t.	with respect to

5 Overview

Version 2 of the Calibration Flasher comprises:

- LED Board:
  - Housing ten 3mm UV LEDs and drive electronics
- Timing Board:
  - Configures which of the ten LEDs will flash
  - Provides *digital* control of the LED pulse width, adjustable in 0.25 ns increments up to a maximum of 62 ns.
  - Provides accurate (16-bit) temperature measurement
  - Incorporates a unique digital serial number
  - Provides two General Purpose Output pins for pointing LEDs or similar
  - The timing board has the same physical outline as the LED board and mounts directly underneath it
- Controller Board:
  - Accepts configuration information and provides diagnostic information via UDP over Ethernet
  - Distributes power, configuration information and trigger signals to up to four timing boards (three being 'slaves' connected via ribbon cable – see Figure 4)
  - Accepts an external trigger signal via an SMA connector, but can also generate on-board test pulses in response to UDP messages for stand-alone use or testing
  - The controller board has the same physical outline as the timing board and can be mounted directly underneath it

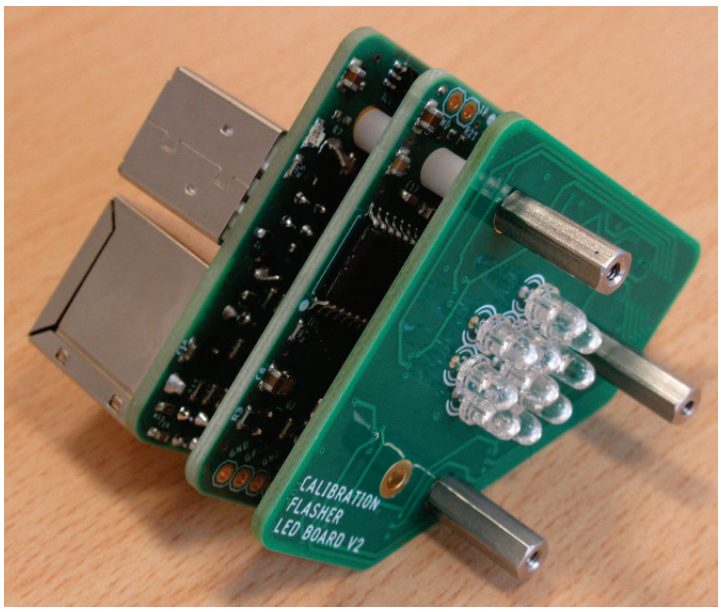


Figure 1: Calibration Flasher: Controller, Timing and LED Boards (Front View)

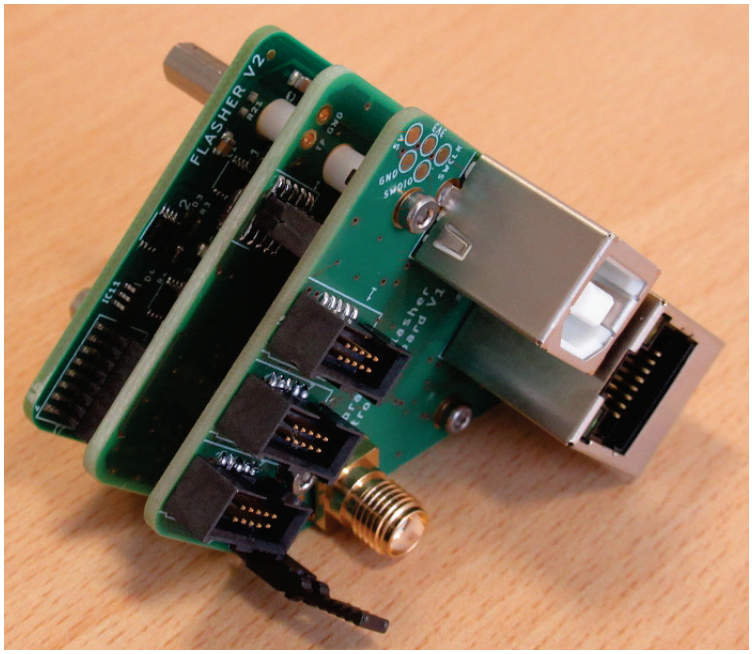


Figure 2: Calibration Flasher: LED, Timing and Controller Boards (Rear View)

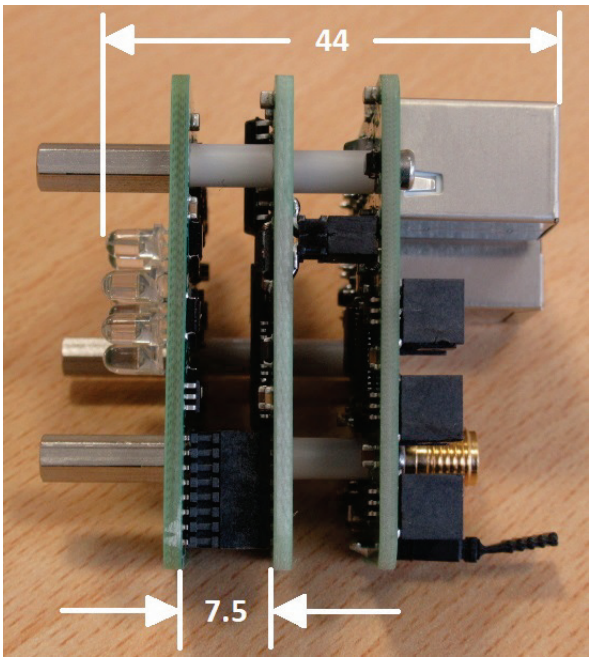


Figure 3: Calibration Flasher: LED, Timing and Controller Boards (Side View)

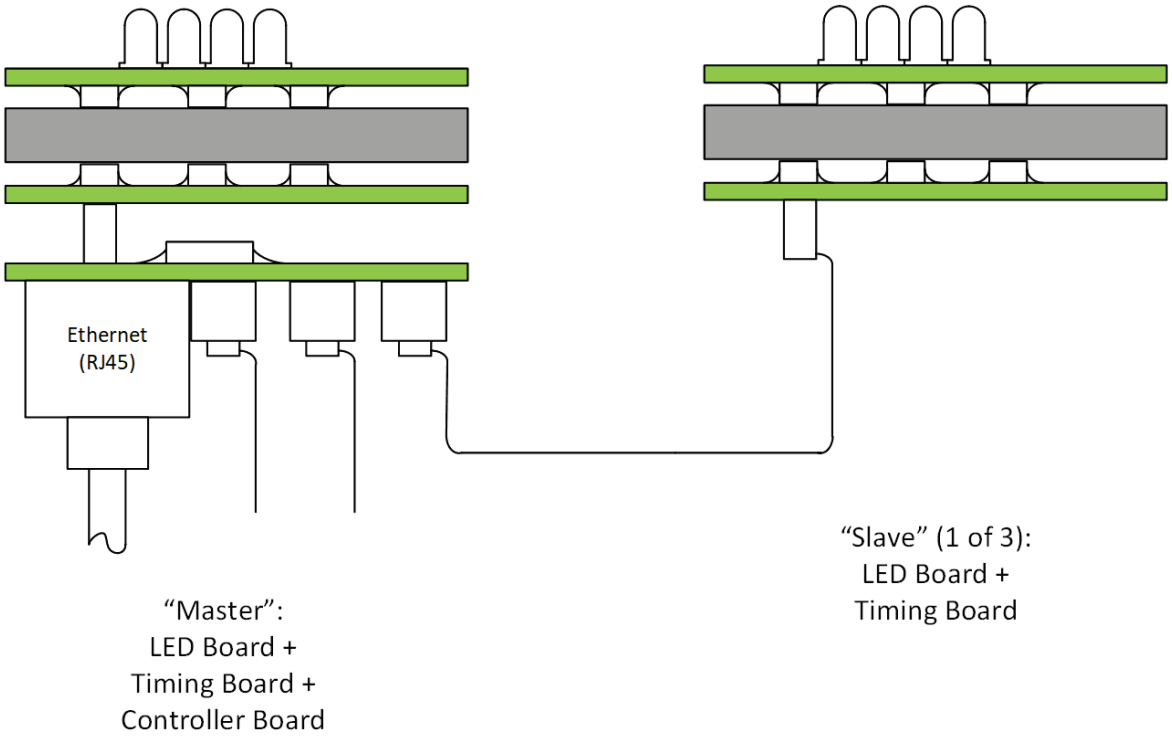


Figure 4: LED, Timing and Controller Boards (Master and Slave)

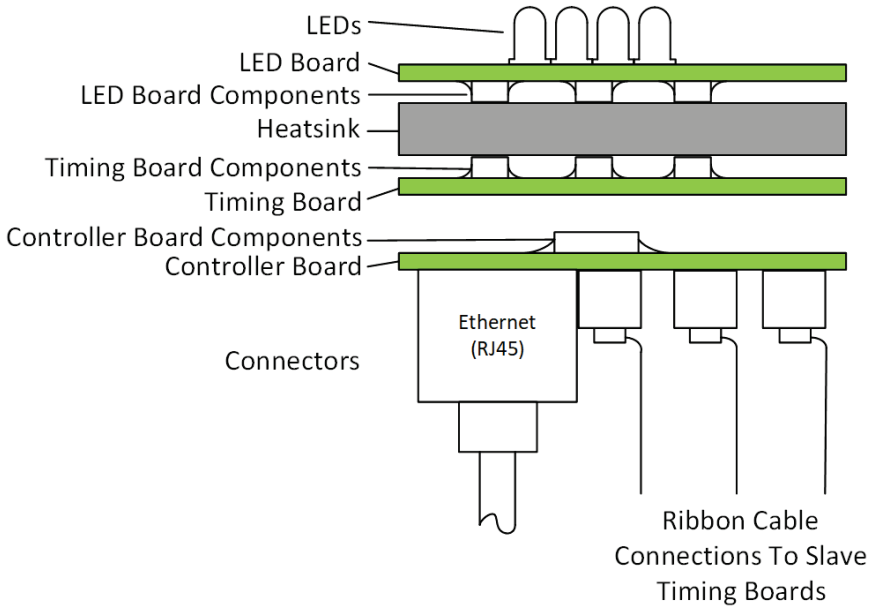


Figure 5: Flasher Board Stack-Up

5.1 Updates for Version 2

Version 1 of the flasher system has several drawbacks:

- The Cypress PSoC 1 CY8C244 23A-24LT is obsolete
- The potentiometer-controlled pulse width generation circuit is very difficult to adjust accurately for short pulse widths and is thermally unstable
- It is very difficult to ensure the pulse width from each of the four flashers is the same
- The BGA packages of the NOT and NOR gates used on the LED board are difficult to assemble. Assembly by hand soldering is impossible. Inspection is difficult. The lead-free ball solder joints have failed on occasion.
- The serial daisy-chain (FIFO) architecture used to configure the four flashers is not intuitive
- Each PSoC board needs to be individually programmed with its sequence number within the serial daisy-chain
- There are concerns regarding the long-term reliability of the COTS Arduino boards (although these could be largely ameliorated by having similar boards made to the same open-source design but using a managed and controlled manufacturing process and subject to failure mode analysis)

Version 2 offers the following improvements:

- The design of the LED board has not changed substantially, however:
    - All of the LED drive ICs have been moved to the underside the board, allowing them to be bonded to a heatsink ensuring thermal uniformity (see Figure 5). The LEDs are the only components mounted on the top layer of the PCB
    - The BGA packages have been replaced with small outline packages which can be inspected by eye and soldered by hand if required
    - The timing pulse distribution fan-out has been improved from 1:10 to 1:5
    - The PCB is now four-layer (version 1 is two-layer)
- The timing board (previously called the PSoC Board) has been substantially re-designed:
    - The board allows the LED pulse width to be *digitally* controlled in 0.25 ns increments up to a maximum of 62 ns. The analogue, potentiometer-controlled pulse generation circuit has been removed completely
    - A 16-bit temperature sensor has been included
    - A digital serial number IC has been included which allows each timing board + LED board pair to be uniquely identified during characterisation and use
    - All of the ICs are located on the top of the PCB allowing them to be bonded to the same heatsink as the LED board ICs (see Figure 5)
    - The board does not require programming or configuration before use. The PSoC used on version 1 has been removed
    - The serial (UART) “daisy chain” architecture used on version 1 has been replaced with SPI, each timing board having its own dedicated SPI interface
    - The PCB is now four-layer
- The controller board completely replaces the Arduino Leonardo Ethernet and driver shield used by version 1 of the flasher:
    - The board has the same outline as both LED and timing boards

- The board is based around a Microchip Technology Inc. (formerly Atmel) ATSAMD21G18A Cortex-M0+ processor
- 10/100 Mbps Ethernet interface is provided by a Wiznet W5500 IC; connection is via a robust screened connector with built-in magnetics
- A robust USB 2.0 Type-B screened connector is used to provide 5V power; the USB interface is used to programme the SAMD processor, configure the Ethernet MAC address and provide diagnostic messages
- The external trigger signal from the camera backplane is connected via an SMA connector. The controller board can generate its own test pulses if required (if a two-pin header has been installed and the pins linked; by default the test pulse pins are disconnected)
- The PCB is six layer however the inner layers are power and ground only; all signal traces have been routed using the top and bottom layers only
- Communication between the controller board and the timing board(s) is via 3.3V SPI

5.2 Definitions

The ***Timing Pulse*** is the nanosecond pulse generated by the timing board and used to illuminate one or more LEDs on the LED board.

The ***Trigger Signal*** is the signal provided by the camera backplane which triggers an LED flash; the timing pulse is generated on the rising edge of the trigger signal.

6 LED Board

The LED board schematic is provided on page 62; the PCB component positions and layers are shown on pages 63 to 69; the Bill Of Materials is provided on page 70.

6.1 Dimensions

The dimensions of the LED board are shown in Figure 6 - Figure 8. When compared to version 1: an additional mounting hole has been included (to avoid a collision with the Ethernet connector on the controller board); the LEDs are optimally packed (the outer diameter of the LED cluster is 15.25mm compared to 16.0mm for version 1).

The dimensions shown in Figure 6 and Figure 7 have been reverse-engineered from the Gerber files used to manufacture version 1 of the LED boards. Conversion between inches and mm, coupled with rounding errors, may have introduced some inaccuracy in the quoted dimensions and hole positions.

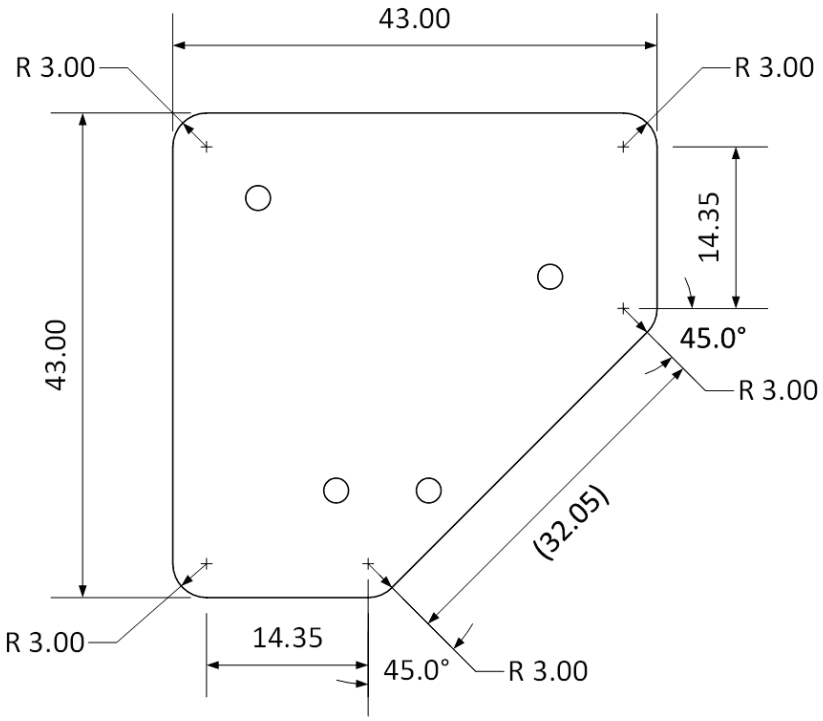


Figure 6: Board Dimensions

LED and Timing Board Mounting Holes:

4 x Ø2.2mm Through Holes

Spaced as shown on a circle of radius 15.6mm which is centred on (18.618, 24.435)

Hole coordinates are:
(7.569, 35.458)
(33.503, 28.473)
(14.503, 9.500)
(22.733, 9.500)

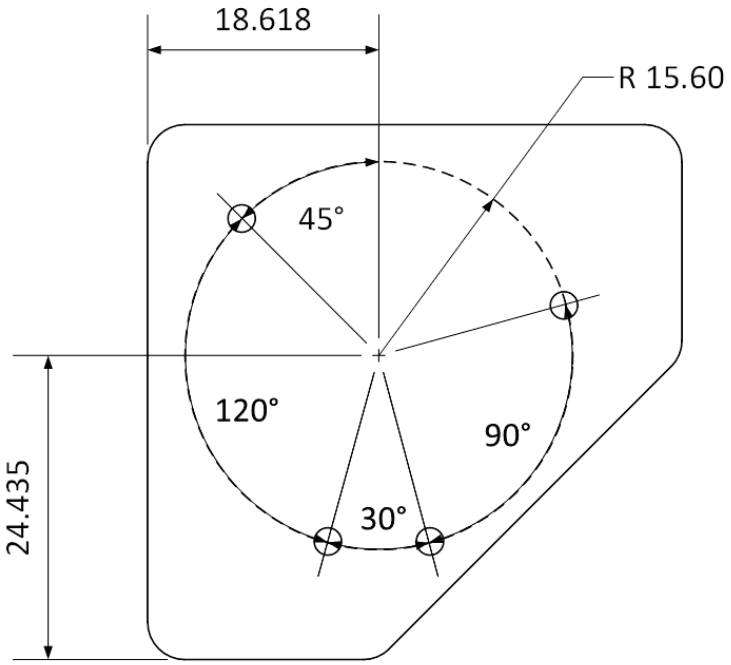


Figure 7: LED and Timing Board Mounting Hole Positions

LED positions:

LED pattern is centred on (18.618, 24.435)

LED1: (17.567, 29.962)
LED2: (21.506, 29.263)
LED3: (23.984, 26.124)
LED4: (23.751, 22.131)
LED5: (20.922, 19.302)
LED6: (16.929, 19.069)
LED7: (13.790, 21.547)
LED8: (13.091, 25.486)
LED9: (17.058, 25.995)
LED10: (19.887, 23.166)

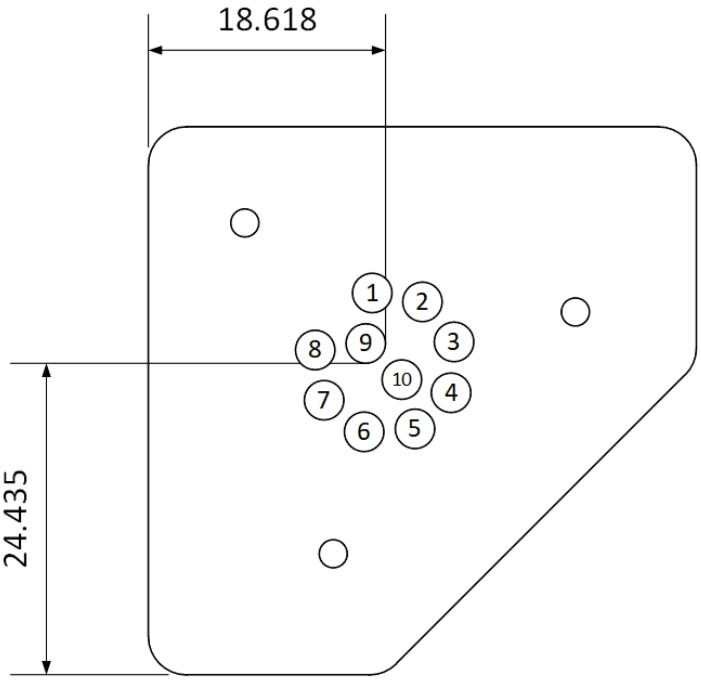


Figure 8: LED Board LED Positions

6.2 Layer Stack-Up

Version 2 of the LED board PCB is four-layer. The layer stack-up is:

- Top Layer: Signals
- Layer 2: Power (5V)
- Layer 3: Ground (0V)
- Bottom Layer: Signals

(Version 1 of the LED board is two-layer.)

6.3 Component Positioning

The LEDs are the only components mounted on the top layer of the PCB. All drive electronics and the multi-way connector are mounted on the bottom layer. This arrangement will allow a bespoke heatsink to be machined and adhered to the drive electronics, permitting thermal stabilisation, as shown in Figure 5.

(Version 1 of the LED board has both the drive electronics and LEDs mounted on the top layer.)

6.4 Component Packages

Only small-outline IC packages are used. All resistors, capacitors and diode packages are 0805 or 0603.

(Version 1 of the LED board uses BGA packages for the NOT and NOR gates.)

6.5 Electrical Interface

The electrical interface for the LED board is as follows:

- The LED Board is powered by 5V DC (defined by the 3.4V – 3.8V forward voltage of the UV LEDs)
- Ten 5V logic signals act as enable signals to define which LEDs will illuminate when the timing pulse is high. These signals are:
    - single ended
    - referenced to 0V
    - active low (0V = LED will be illuminated when the timing pulse is high)
- A 5V logic signal timing pulse controls the illumination of the LEDs. This pulse is:
    - single ended
    - referenced to 0V
    - active high (5V = the enabled LEDs are illuminated)
    - has nanosecond pulse width (generated by the Timing Board)

A 16-way Samtec FTSH-108-02-L-DV 1.27mm x 1.27mm surface mount pin header is mounted on the bottom of the PCB; this mates with a matching 16-way Samtec FLE-108-01-G-DV socket on the Timing Board. The pin allocations are defined in
Table 1.

Pin	Signal
1	5V
2	0V
3	LED7 Enable
4	LED8 Enable
5	LED6 Enable
6	LED9 Enable
7	LED10 Enable
8	LED1 Enable
9	LED5 Enable
10	LED2 Enable
11	LED4 Enable
12	LED3 Enable
13	Timing Pulse
14	0V
15	5V
16	0V

Table 1: LED Board Connector Pin Allocations

The pin allocations were chosen to ease routing of each LED enable signal to the associated driver. Figure 9 shows the connector orientation.

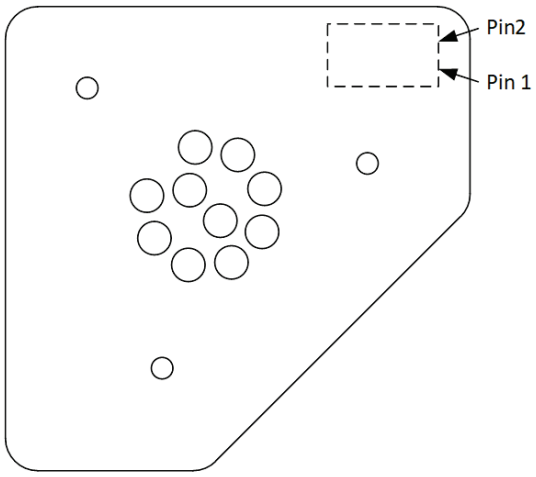


Figure 9: LED Board Connector Orientation
(Viewed from above. The connector is mounted on the bottom of the PCB)

6.6 UV LEDs

Version 2 of the LED board uses the same Bivar UV3TZ-400-15 400nm 15° LED as used by version 1:

- The diode has a maximum (continuous) forward current of 20mA but can tolerate a peak forward current of 100mA at 10% duty cycle with a pulse width of ≤ 0.1msec

- The typical forward voltage is: 3.4V at 20mA; 3.8V at 90mA

6.7 LED Drive Electronics

The LED drive circuit used on version 1 of the LED board has been retained. The schematic for one LED is shown in Figure 10.

- Each LED is driven by both halves of a SN74LVC2G02 dual NOR gate
- The LED current is defined by resistors between each NOR gate and the LED
- Schottky diodes are included to improve the turn-off time of the LED
- Each NOR gate can deliver a maximum of 50mA
- Using 80R resistors, the total LED current will be approximately 30mA (taking into account the V_{OH} of the NOR gate at V_{CC} = 5V with an I_{OH} of ~15mA)

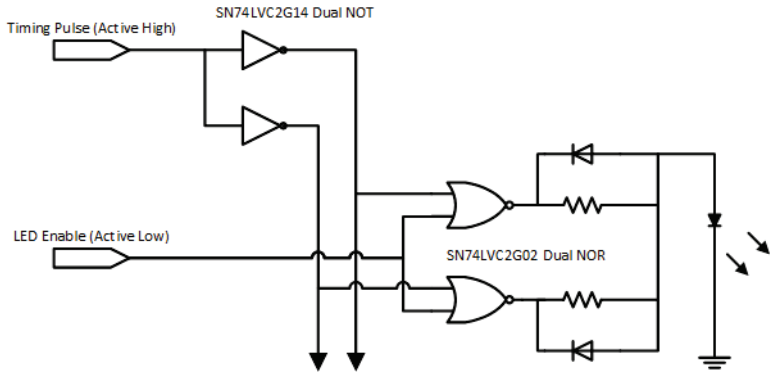


Figure 10: LED Drive Circuit

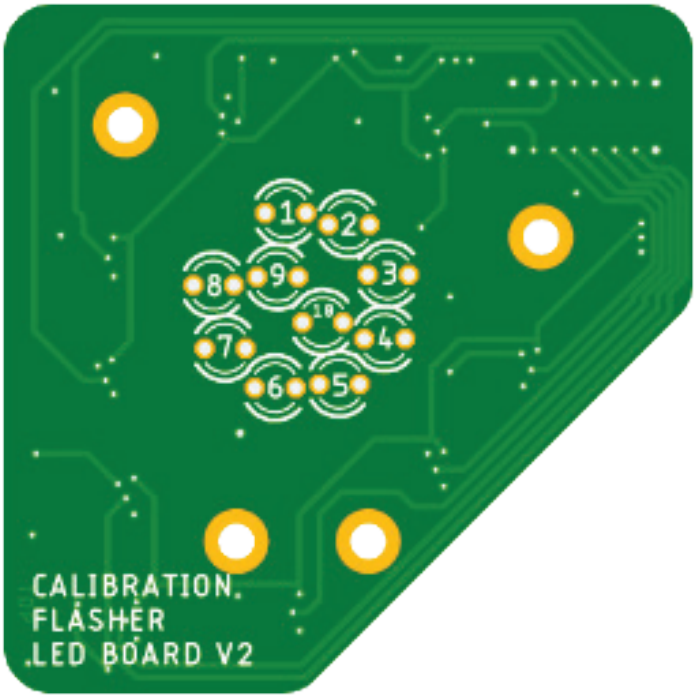


Figure 11: LED Numbering

The LED series resistances are:

- LED3, LED4, LED5, LED6, LED10 = 80R6
- LED7 = 100R
- LED2 = 110R
- LED8 = 120R
- LED1 = 130R
- LED9 = 140R

Note: the LED numbering in terms of brightness has changed substantially compared to version 1.

7 Timing Board

The timing board schematic is provided on page 53; the PCB component positions and layers are shown on pages 54 to 60; the Bill Of Materials is provided on page 61.

The Timing Board has two main functions:

- It configures which LEDs will be illuminated by the timing pulse
    - A 16-bit SPI port expander is used to generate the ten LED enable signals minimising the number of connections between the controller board and the timing board
- It converts the rising edge of the trigger signal into digitally adjustable naosecond timing pulse for the LED Board
    - A second 16-bit SPI port expander is used to create the eight programming bits which set the duration of the pulse

The timing board also provides:

- Accurate (16-bit) temperature measurement
- A unique (48-bit) digital serial number

The timing board has no pre-programmed ‘identity’. All timing boards operate identically without the need for individual configuration or programming.

7.1 Timing Pulse Generation

The timing pulse generation circuit is based on the Dallas Semiconductor / Maxim IC DS1023 8-bit Programmable Timing Element (Digital Delay Line) (IC5 on page 53)

The DS1023-25 provides two outputs: one with a variable delay of 0 to 63.75 nsec in 0.25 nsec steps; and one with a fixed (reference) delay of 1.5nsec. Using two NOR gates to combine the two outputs, it is possible to generate programmable pulse widths of essentially zero to ~62 nsec as shown in Figure 12.

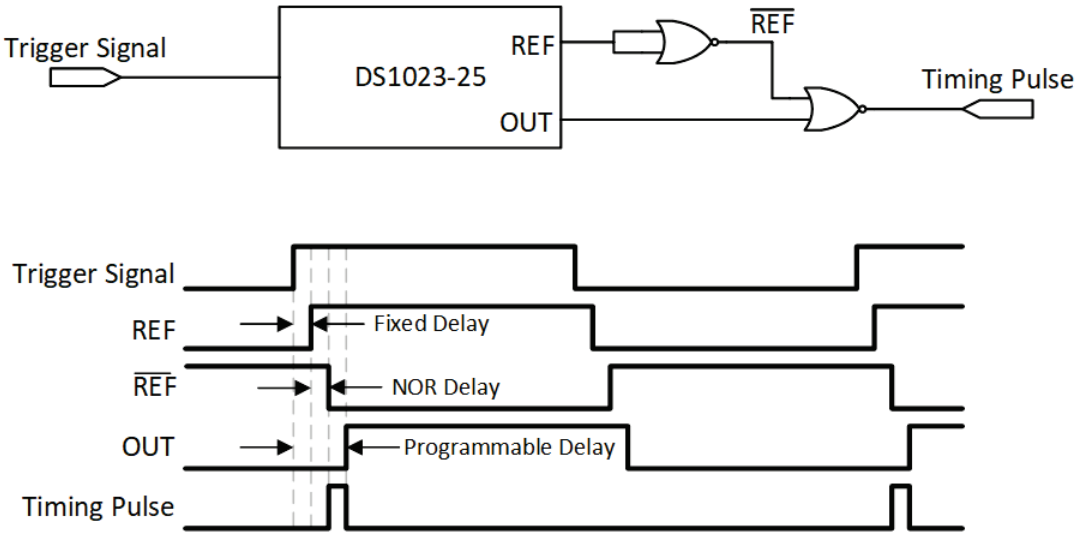


Figure 12: Timing Pulse Generation

The timing pulse output will go high for the programmed duration on the rising edge of the incoming trigger signal.

The DS1023 is an old design in a relatively large small outline (SOIC) package. The original DS1023-25 is obsolete, but the newer DS1023S-25+ is still in production.

The delay can be programmed by parallel or serial interface. As the serial interface is “SPI-like” (not fully SPI compliant), a true SPI port expander is used to create the 8 configurations bits connected to the DS1023 parallel interface.

7.2 SPI Port Expansion

To reduce the pin count between the Controller Board and the Timing Board, an SPI interface is used to transfer data between the two. Two Microchip MCP23S17 (SPI) 16-bit port expanders (IC2 and IC3 on page 53) are used:

- To provide the ten enable signals for the LED board plus the eight programming bits for the timing pulse generator
- The remaining pins are used to: provide two general purpose output pins for pointing LEDs or similar; monitor the trigger signal (from the controller board); create an I2C interface for the digital serial number IC (IC7 on page 53)
- These devices are cascadable and share the SPI bus using a single chip select line; each is given a different hard-wired address.

7.3 Temperature Measurement

An ADT7310 16-bit temperature sensor (IC1 on page 53) is used to measure the temperature of the timing and LED board heatsink. This is an SPI device and shares the SPI bus with the two port expanders, but requires its own chip select line.

7.4 3.3V to 5V Signal Level Shifting

Like the LED board, the timing board is powered by 5V and uses 5V logic signals throughout. As the SPI signals generated by the SAMD processor on the controller board are 3.3V, it is necessary to shift the 3.3V signals to 5V for the port expanders and temperature sensor. A TXB0108 8-bit bi-directional level shifter (IC8 on page 53) performs this function.

7.5 Dimensions

The dimensions of the Timing Board are the same as those of the LED Board as shown in Figure 6 and Figure 7.

7.6 Layer Stack-Up

The timing board PCB is four-layer. The layer stack-up is:

- Top Layer: Signals
- Layer 2: Ground (0V)
- Layer 3: Power (5V)
- Bottom Layer: Signals

7.7 Component Positioning

All electronic components are mounted on the top layer of the PCB. The only component mounted on the bottom layer is the 10-way connector to the controller board. This arrangement allows the electronic components to be placed in thermal contact with the same heatsink as used to stabilise the temperature of the LED Board components as shown in Figure 5

7.8 Component Packages

Only small-outline IC packages are used. All resistor, capacitor and diode packages are 0805 or 0603.

7.9 Electrical Interface

The electrical interface between the Timing Board and the Controller Board is defined as follows:

- The timing board is powered by 5V DC
- A 3.3V SPI interface links the two with the Controller Board acting as the Master and the Timing Board as the Slave
- The 5V trigger signal from the controller board is:

- single ended
- referenced to 0V
- the rising edge of the trigger signal causes the LEDs to flash

A 10-way Samtec FTSH-105-02-L-DV 1.27mm x 1.27mm surface mount pin header is mounted on the bottom of the PCB; this mates with a matching 10-way Samtec FLE-105-01-G-DV socket on the Controller Board. If the timing board is to be used as a slave then a Samtec FFSD-05-D-XX.XX-01-N IDC cable is used to link the two instead. The pin allocations are defined in Table 2.

Pin	Signal
1	5V
2	0V
3	SPI SCK (3.3V)
4	SPI DO (MOSI) (3.3V)
5	SPI DI (MISO) (3.3V)
6	SPI CS1 (3.3V) (Port Expanders)
7	Trigger Signal (5V)
8	SPI CS2 (3.3V) (Temperature Sensor)
9	5V
10	0V

Table 2: Timing Board Connector Pin Allocations

8 Controller Board

The controller board schematic is provided on pages 40 to 42; the PCB component positions and layers are shown on pages 43 to 51; the Bill Of Materials is provided on page 52.

The Controller Board has several functions:

- Accepts configuration information and provides diagnostic information via UDP over Ethernet
- Distributes power, configuration information and trigger signals to multiple timing boards
- Monitors the temperature of the flashers (via sensors on the timing boards)

8.1 Dimensions

The dimensions of the Controller Board are the same as those of the LED Board as shown in Figure 6. Only three mounting holes are provided as shown in Figure 13, allowing space to be allocated for the large Ethernet connector on the bottom of the board.

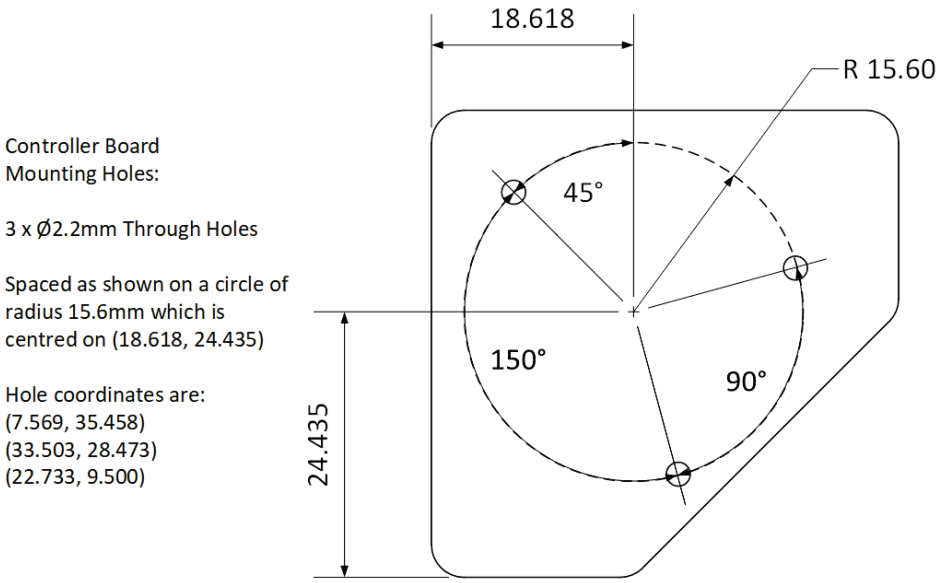


Figure 13: Controller Board Mounting Hole Positions

8.2 Layer Stack-Up

The controller board PCB is six-layer. The layer stack-up is:

- Top Layer: Signals
- Layer 2: Ground (0V)
- Layer 3: Power (5V)
- Layer 4: Power (3.3V)
- Layer 5: Ground (0V)
- Bottom Layer: Signals

8.3 Component Positioning

All electronic components and one timing board connector are mounted on the top layer of the PCB. Only connectors are mounted on the bottom layer. These are:

- Ethernet
- USB 2.0 Type-B (Power, configuration and diagnostics)
- SMA connector for the Trigger Signal from the camera backplane
- Three Samtec SHF-105-01-L-D-SM connectors for ribbon cable connections to the slave timing + LED boards

8.4 Major Components

8.4.1 Microchip Technology (was Atmel) ATSAMD21G18A (IC5 on page 41)

- As used on the Arduino Zero

- 48MHz 32-bit Cortex-M0+ CPU
- 256KB Flash
- 32KB RAM
- 6 SERCOM modules each of which can be configured as SPI, I2C or UART
- RTC
- Built-in ADC
- 48-pin TQFP package (PCB footprint is approx. 10.0mm x 10.0mm)
- No Ethernet physical layer transceiver

The SAMD processor is programmed with a bootloader and the FlasherCtl UDP software stack as described in section 8.6.

8.4.2 WIZnet W5500 Ethernet Physical Layer Transceiver (IC6 on page 42)

- As used on the Arduino Leonardo Ethernet
- Supports 10MB and 100MB Ethernet
  - Support for: TCP, UDP, ICMP, IPv4, ARP, IGMP, PPPoE
  - SPI host interface
  - 48-pin TQFP Package (PCB footprint is approx. 10.0mm x 10.0mm)

8.4.3 Trigger signal level shifting and distribution (IC1-4 and IC7 on page 40)

- Four 74AHCT1G125 non-inverting buffers shift the incoming trigger signal (2.0V Minimum) to 5V and distribute it to the four timing boards
- One additional buffer shifts the 3.3V test pulse from the SAMD processor to 5V

8.5 Test Pulse (Trigger Signal) Generation

The Controller Board can generate its own test pulses (trigger signal) permitting stand-alone testing of the Control Board + Timing Board + LED Board from any Ethernet-capable laptop or similar.

By default, the two Test Pulse pads on the bottom of the controller board are not populated or linked. To enable the test pulses: solder a two-pin 0.1” header into the Test Pulse pads; bridge the pins using a jumper link. The controller board will now generate its own trigger signal in response to calls to flasherctl_test_pulse.py / CMD_TEST_PULSE.

CAUTION! When the test pulse link is installed, the 5V test pulses will be connected to the SMA connector. Take care to ensure the SMA connector is not simultaneously connected to the camera backplane or BAD THINGS WILL HAPPEN!

8.6 LEDs

The controller board has three LEDs:

- A small red LED driven by the LED_BUILTIN pin on the SAMD processor. The LED can be enabled or disabled via UDP command (CMD_LED_BUILTIN). When the SAMD is in bootloader mode, the LED will fade up and down.
- Two LEDs on the Ethernet connector: Yellow (Link) and Green (Activity). These are disabled by default but can be enabled by shorting the solder jumper SJ1 located between the Ethernet connector strain relief pegs, between R16 and R17.

8.7 Configuring the Controller Board

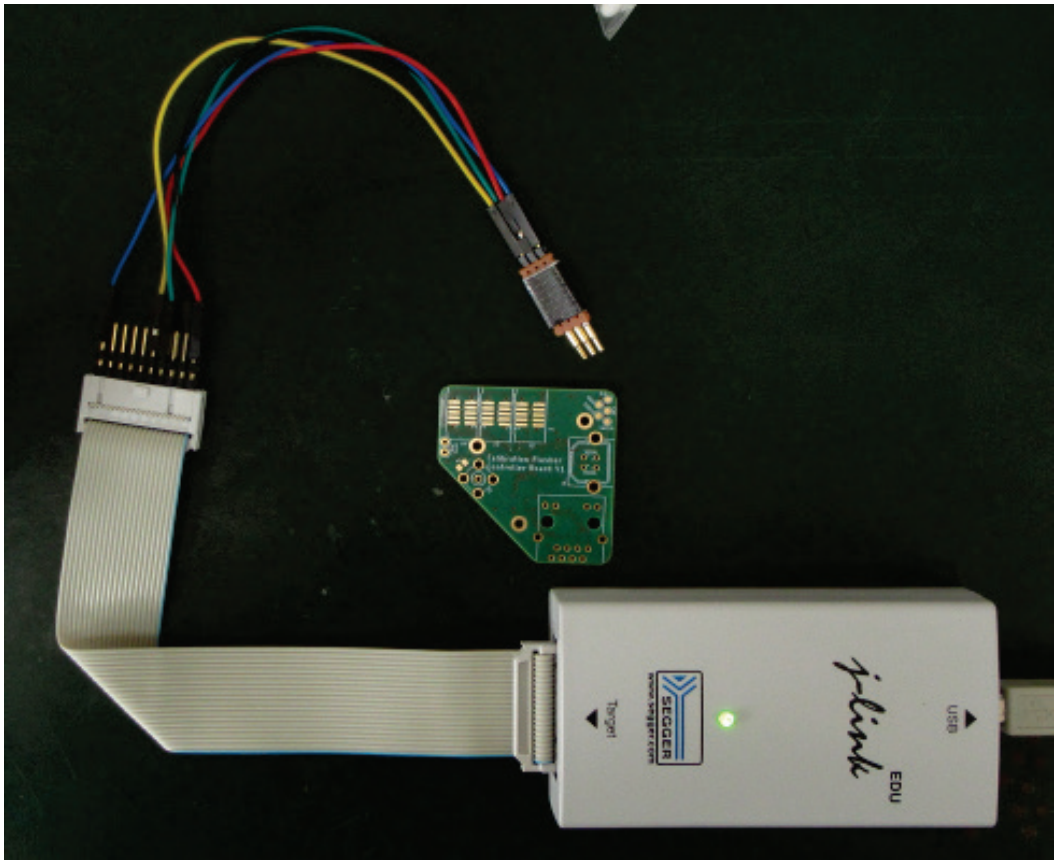
Configuration of the controller board is a three-step process:

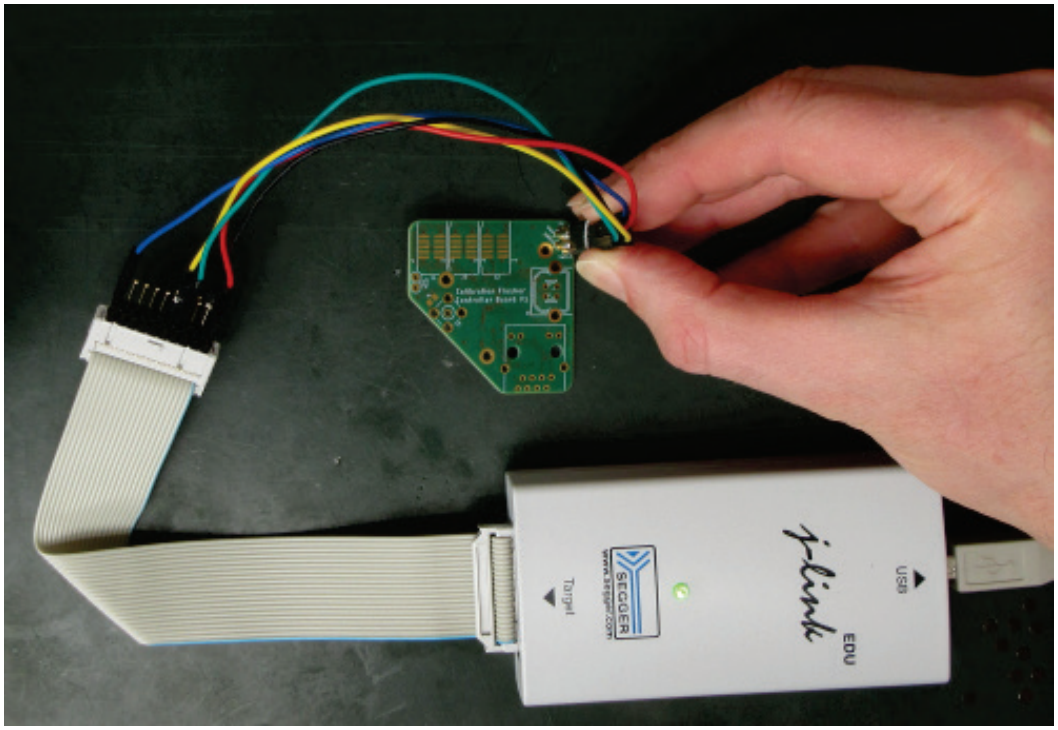
- Installation of the flasher bootloader
- Installation of the FlasherCtl C code via the Arduino IDE
- Configuration of the MAC address via USB serial

8.7.1 Installing the Bootloader

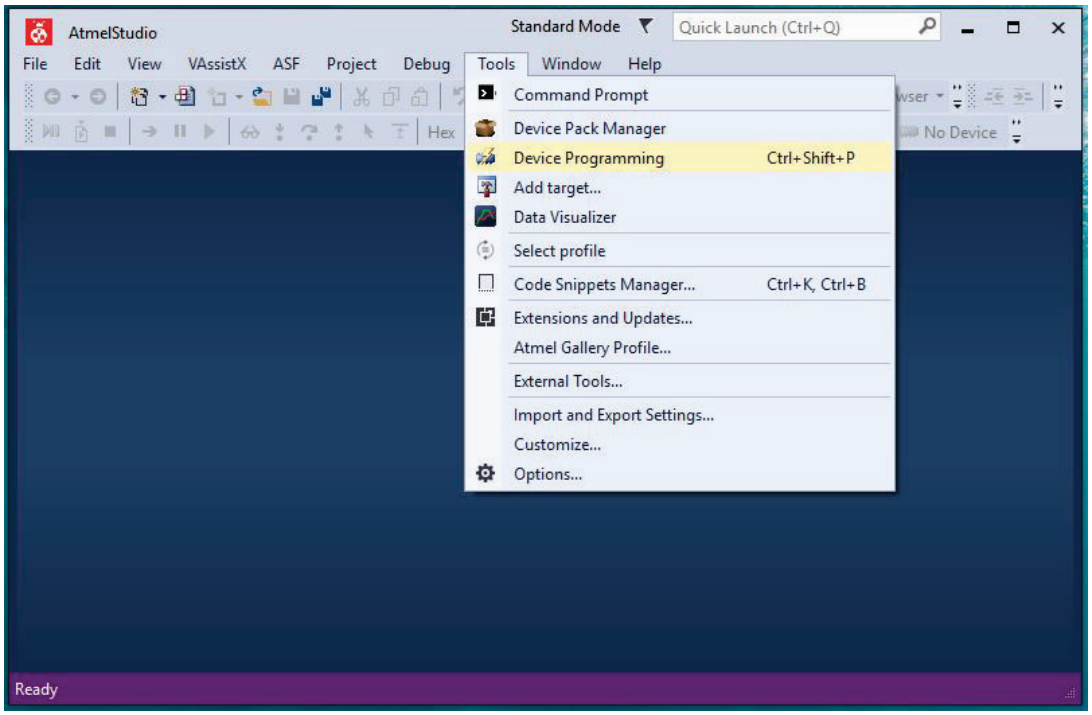
- Download, install and run the Arduino IDE (https://www.arduino.cc/en/Main/Software)
- Open the "Boards Manager" (under Tools\Board), scroll down the list of available boards (or type "SAMD" in the search box), select and install the "Arduino SAMD Boards (32-bits ARM Cortex-M0+) by Arduino"
- Open the File\Preferences menu; in the box next to "Additional Boards Manager URLs:" enter the following:
  https://raw.githubusercontent.com/PaulZC/CTA_Flasher/master/package_PAULZC_FLASHER_index.json
  This will allow the board manager to pick up the custom version of the Arduino Zero board used by the flasher
- Exit and Restart the IDE
- Open the "Boards Manager" again, scroll down the list of available boards (or type "flasher" in the search box), select and install the "Flasher Board – based on Arduino Zero by PaulZC"
- Use the Tools\Board menu to select "Flasher" as the board type (you will need to scroll down to the bottom of the board list to find it)
- Exit the IDE

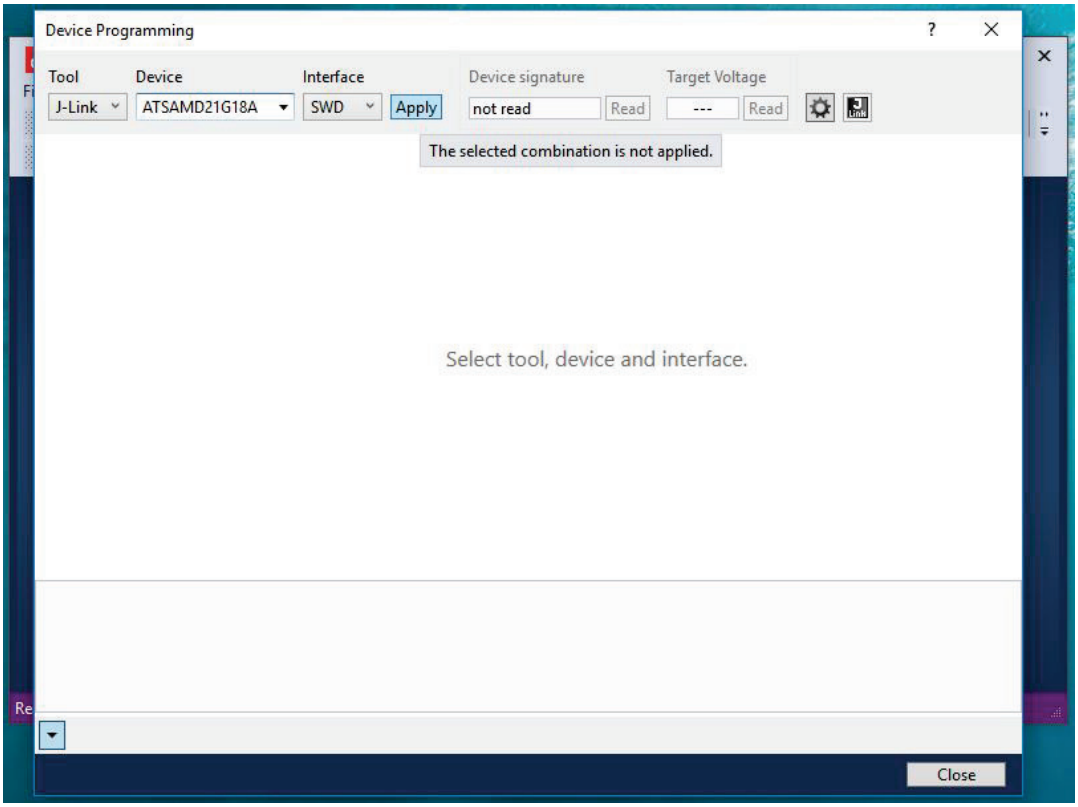
- Download, install and run Atmel Studio 7 (https://www.microchip.com/mplab/avr-support/atmel-studio-7)
- Purchase a Segger J-Link EDU programming tool from (e.g.) Mouser (943-8.08.90) or Farnell / Element14 (2098545)
- Connect the J-Link to your computer
- Assemble the programming adaptor shown on pages 71 to 74 – or use a similar "pogo-pin" adaptor – to connect the J-Link to the five test JTAG pads on the underside of the controller board


Target
SEGGER
www.segger.com
USB
J-Link
EDU


Target
SEGGER
www.segger.com
USB
J-Link
EDU

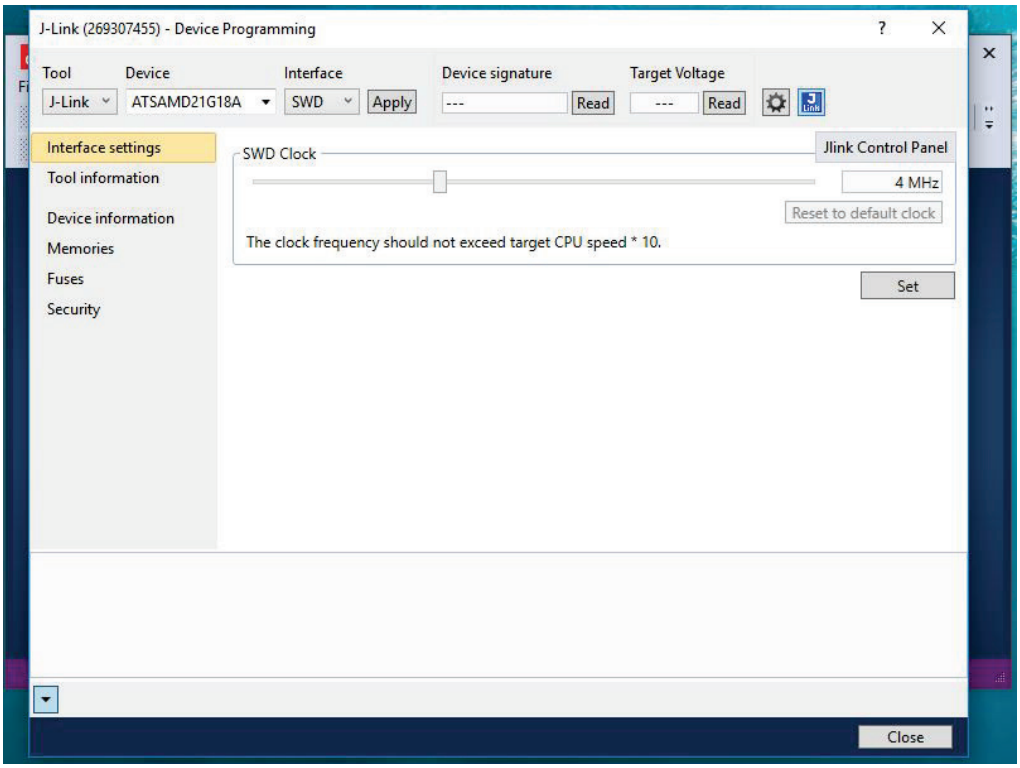
- Select Tools \ Device Programming



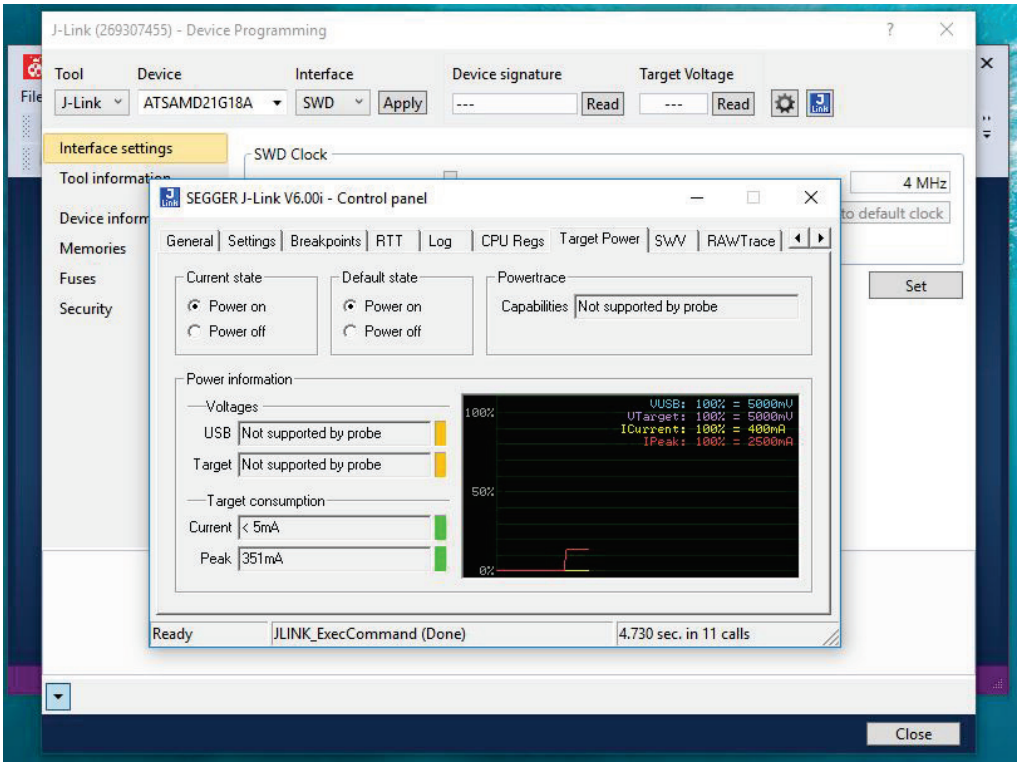


- Select J-Link in the Tool pull-down menu
- Select ATSAMD21G18A in the Device pull-down menu

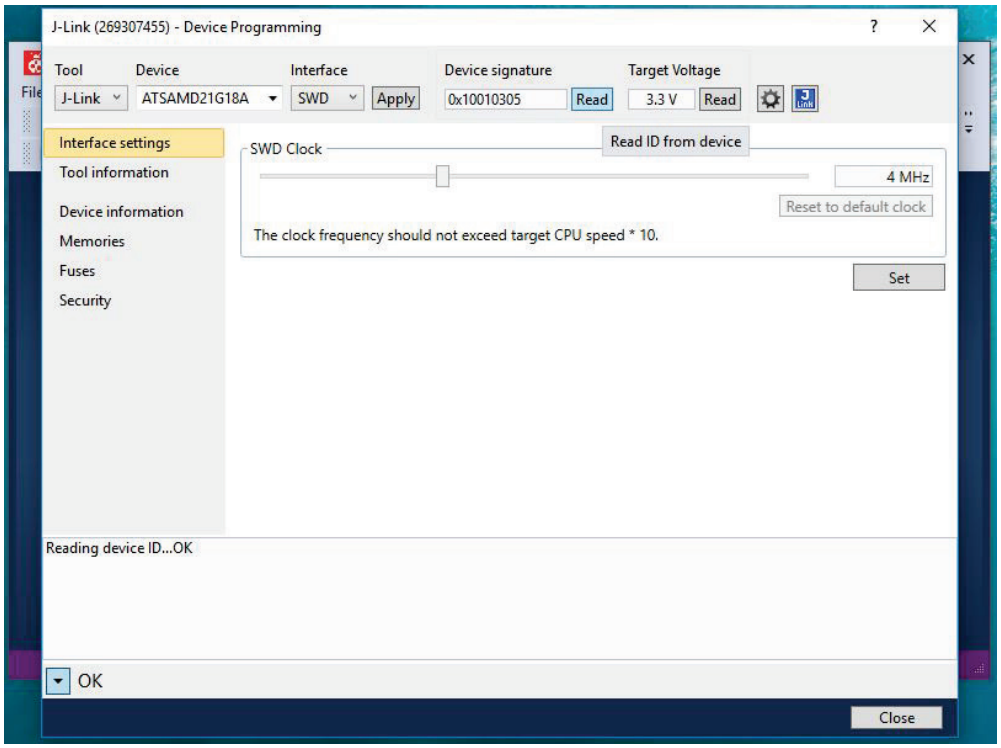
- Select SWD in the Interface pull-down menu
- Then click Apply



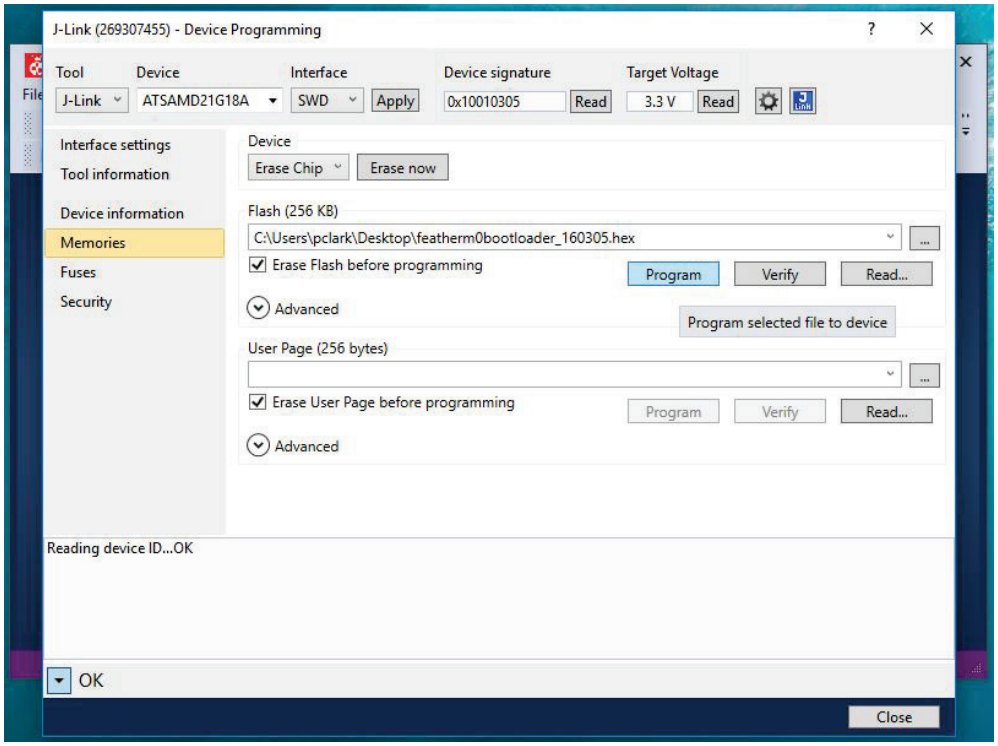
- Click the J-Link icon to apply target power to the flasher



- Select the Target Power tab and set Current State to Power On. This will apply 5V power from the J-Link to the flasher



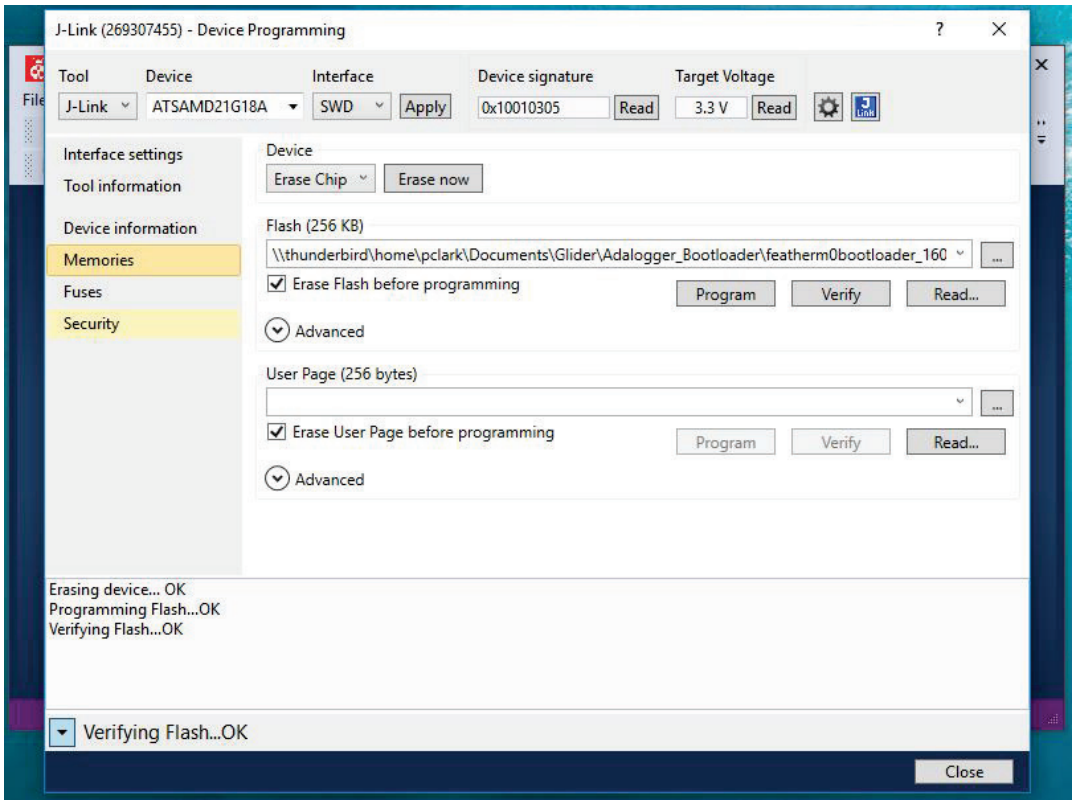
- In the Device Programming window click 'Read' to read the Device Signature and Target Voltage



- Click 'Memories', click the '...' icon to select the bootloader Flash file. You will find the flasher bootloader at:

C:\Users***your_user***\AppData\Local\Arduino15\packages\PaulZCboards\hardware\samd\1.0.2\bootloaders\zero\ flasher_bootloader.hex

- Click Program to erase, program and verify the device
- All being well, the red LED on the controller board should start to fade up/down indicating that the SAMD is in bootloader mode



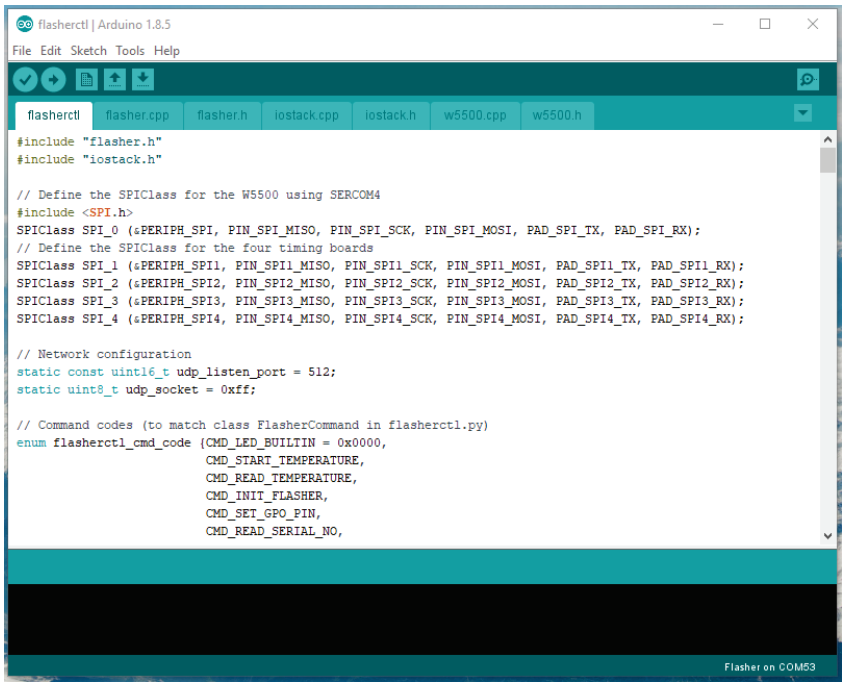
- Return to the the J-Link window, select the Target Power tab and set Current State to Power Off
- Close the J-Link window, the Device Programming window and Atmel Studio itself
- You are now able to configure the Beacon with the Arduino code

8.7.2 Download FlasherCtl

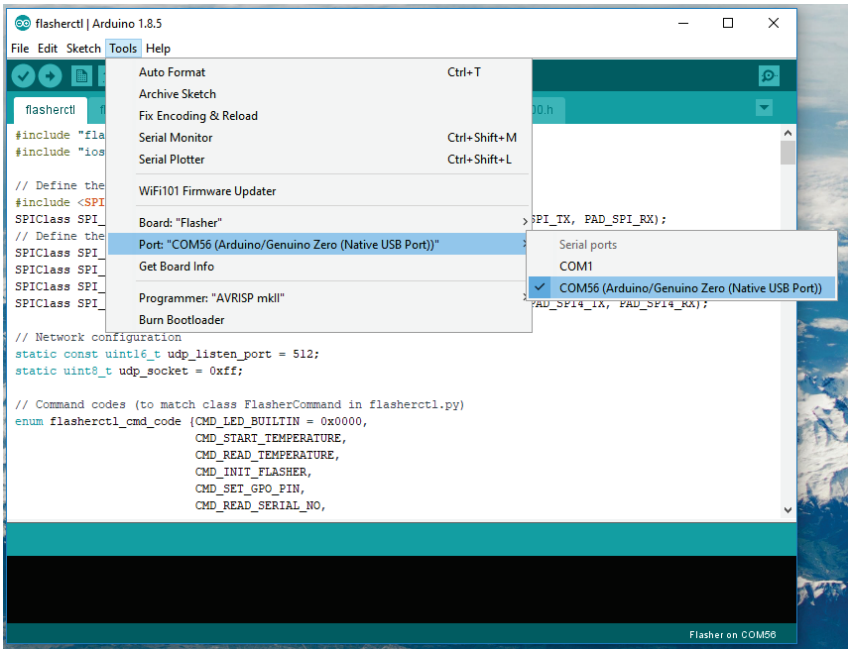
- FlasherCtl can be downloaded from GitHub
  - Open https://github.com/PaulZC/FlasherCtl
  - Download a ZIP copy of the repository using the “Clone or download” button
- Extract the ZIP file
- Copy the flasherctl folder and place it in Documents\Arduino

8.7.3 Installation of the FlasherCtl C code via the Arduino IDE

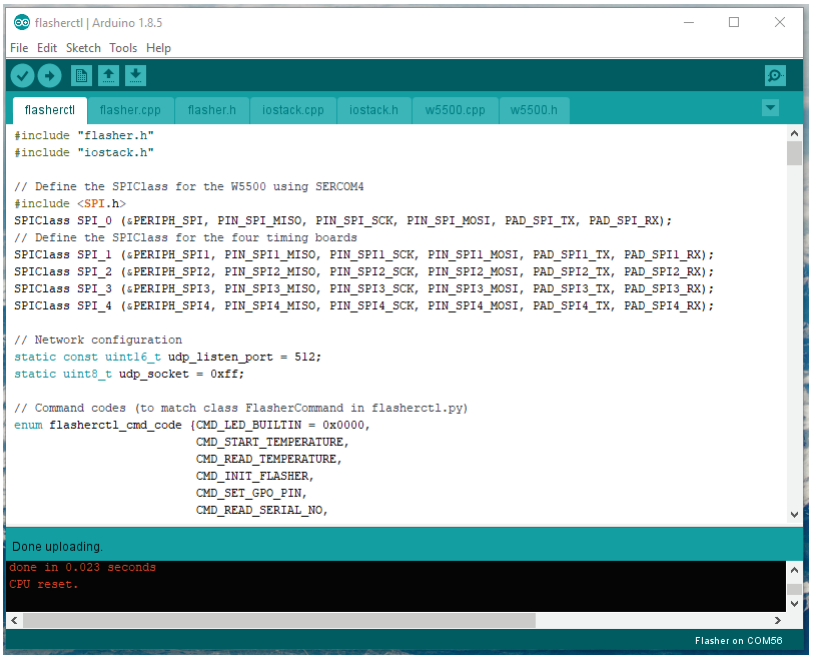
- Connect the flasher to your computer using a USB 2.0 Type-B cable
- Open the Arduino IDE
- Check that “Flasher” is shown in the bottom right corner of the window; if not, use the Tools\Board menu to select Flasher from the scroll list
- Use the File\Open menu to navigate to Documents\Arduino\flasherctl and open flasherctl.ino



- Select the Tools\Port menu and click the entry which says “Arduino/Genuino Zero (Native USB Port)”

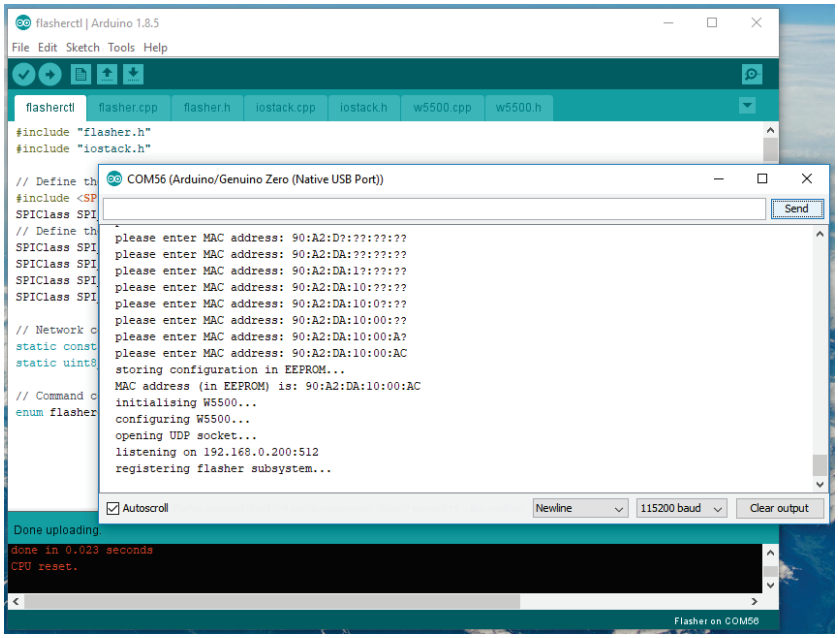


- Click the right arrow below the Edit menu to compile and upload the flasherctl code to the board
- All being well, you should see a “Done uploading” message

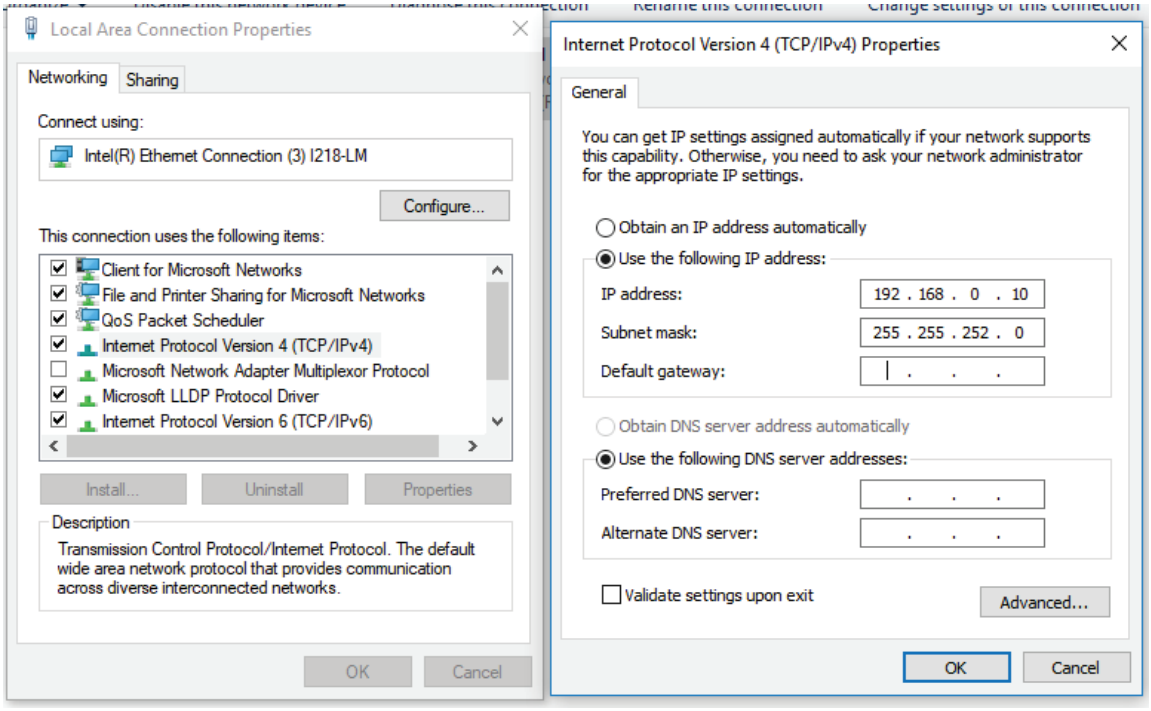


8.7.4 Configuring the MAC address via USB serial

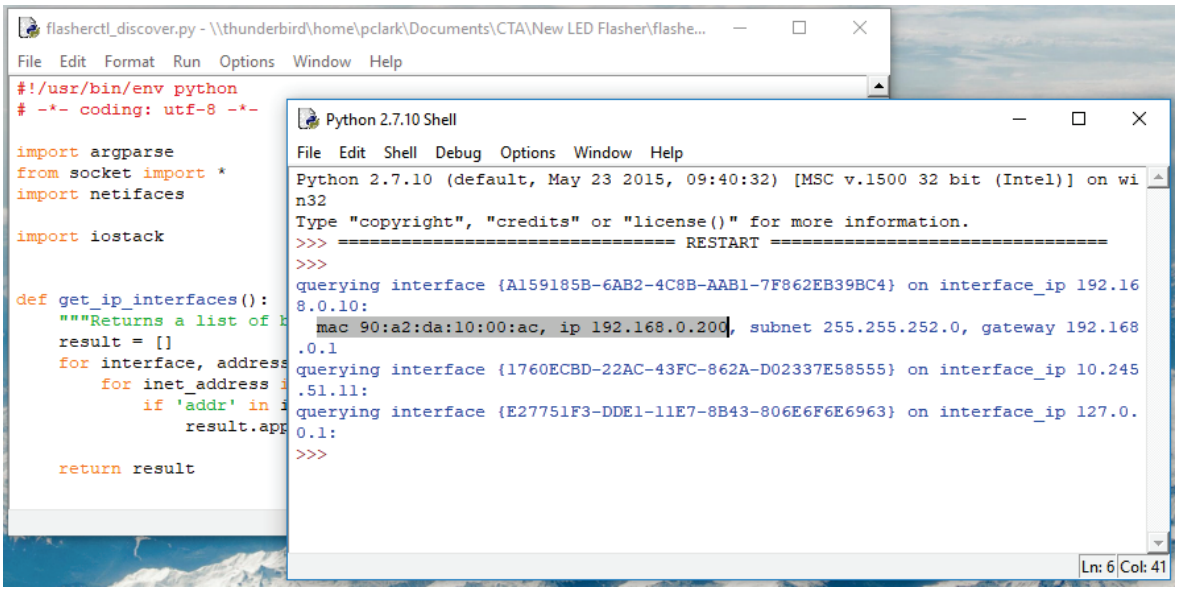
- Use the Tools\Port menu to reselect the “Arduino/Genuino Zero (Native USB Port)” option as the COM port number may have changed
- Open the Tools\Serial Monitor window. You should see messages saying “please enter MAC address”
- Set the line ending box to Newline, type the chosen MAC address into the text box and press send



- The MAC address will be stored in the SAMD's Flash memory
- Connect an Ethernet cable between your computer and the Flasher. The flasher will have an IP address of 192.168.0.200 . You need to set your computer to have an IP address in the same range. Open the Ethernet Adaptor properties, right-click on "Internet Protocol Version 4" and set the IP address to (e.g.) 192.168.0.10



- Navigate to the utils folder in the FlasherCtl ZIP file
- Run flasherctl_discover.py
- All being well, you should see the MAC address and IP number of the flasher being detected



9 FlasherCtl

FlasherCtl is a UDP software stack based extensively on Felix Werner's ServoCtl (RD1). Essentially the Dynamixel functionality has been replaced with commands to communicate with the flashers.

The flashers have been given a subsystem ID of 2 (the servos are 1; and the iostack is 0).

9.1 Initial Setup

Follow the instructions in sections 8.6. Further information can be found in sections 2.1 – 2.3 of the ServoCtl manual (RD1).

9.2 Utilities

Several Python utilities are provided to operate a FlasherCtl device. Each program can be invoked with the "-h" or "—help" switch to show a short description and its list of options.

- flasherctl_discover.py is a copy of servoctl_discover (see section 3.1 of the ServoCtl manual RD1). It returns a list of FlasherCtl devices located on the same physical network as the PC. Devices can be selected by MAC address to change their IP address, subnet mask and gateway address.

- flasherctl_ping.py is a copy of servoctl_ping. It checks the availability and round trip time for communication with a FlasherCtl device.
    - "python flasherctl_ping.py 192.168.0.200" will ping flasher 192.168.0.200 repeatedly until Ctrl-C is pressed
    - ping.py will ping flasher 192.168.0.200 repeatedly until Ctrl-C is pressed

- flasherctl_blink.py performs simple on/off control of the red LED (LED_BUILTIN) on the controller board. flasherctl_blink can be used to perform a simple visual verification that communication with the board is successful.
    - "python flasherctl_blink.py 192.168.0.200 1" will turn the LED on
    - "python flasherctl_blink.py 192.168.0.200 0" will turn the LED off
    - blink.py will cause the LED on flasher 192.168.0.200 to blink on and off repeatedly

- flasherctl_test_pulse.py can be used to set the state of the TEST_PULSE pin on the controller board.
    - "python flasherctl_testpulse.py 192.168.0.200 1" will set TEST_PULSE high
    - "python flasherctl_testpulses.py 192.168.0.200 0" will set TEST_PULSE low
    - "python flasherctl_testpulses.py 192.168.0.200 2" will pulse TEST_PULSE high then low (once)
    - ***Caution: the test pulses will be transmitted to the backplane if the test pulse jumper link is installed and the backplane is connected via the SMA connector.***
    - test_pulses.py will toggle the state of TEST_PULSE and read the state of the trigger signal from all four timing boards on flasher 192.168.0.200 repeatedly

- flasherctl_read_trig.py can be used to read the state of the trigger signal line on the selected timing board
    - “python flasherctl_read_trig.py 192.168.0.200 0” will read the state of the trigger signal on timing board zero (the one connected directly to the controller board, the slaves are boards 1-3)
    - By combining calls to flasherctl_testpulse.py and flasherctl_read_trig.py, correct operation of each timing board can be established. See test_pulses.py for example code
    - test_pulses.py will toggle the state of TEST_PULSE and read the state of the trigger signal from all four timing boards on flasher 192.168.0.200 repeatedly

- flasherctl_read_serial_no.py can be used to read the digital serial number from each timing board
    - “python flasherctl_read_serial_no.py 192.168.0.200 1” will read the serial number from timing board 1 (the first slave)
    - read_serial_numbers.py will read the serial numbers from all four timing boards on flasher 192.168.0.200 repeatedly

- flasherctl_read_temperature.py can be used to read the temperature of each timing board
    - “python flasherctl_read_temperature.py 192.168.0.200 2” will read the temperature from timing board 2 (the second slave)
    - The temperature is read by first starting the temperature conversion (CMD_START_TEMPERATURE) then, at least 0.25 seconds later, reading the temperature (CMD_READ_TEMPERATURE)
    - read_temperatures.py will read the temperatures from all four timing boards on flasher 192.168.0.200 repeatedly

- flasherctl_set_gpo_pin.py can be used to set the state of the two GPO pins on each timing board
    - “python flasherctl_set_gpo_pin.py 192.168.0.200 3 0 1” will set GPO0 on timing board 3 on
    - “python flasherctl_set_gpo_pin.py 192.168.0.200 0 1 0” will set GPO1 on timing board 0 off
    - blink_gpo_pins.py will toggle both GPO pins on timing board zero on flasher 192.168.0.200 repeatedly

- flasherctl_set_LEDs.py can be used to configure which LEDs will flash on each timing board
    - “python flasherctl_set_LEDs.py 192.168.0.200 0 0000000001” will enable (only) LED1 on timing board zero
    - “python flasherctl_set_LEDs.py 192.168.0.200 1 1000000000” will enable (only) LED10 on timing board 1
    - “python flasherctl_set_LEDs.py 192.168.0.200 2 1111111111” will enable all LEDs on timing board 2
    - The LED configuration is supplied as a binary string, MSB first. The MSB is LED10, the LSB is LED1.
    - CMD_SET_LEDS actually expects the LED settings as an integer

- test_LEDs.py will test each LED in turn on all four timing boards on flasher 192.168.0.200 using test pulses. CMD_READ_TRIG is also called to confirm that the pulses are being delivered to each timing board

- flasherctl_set_pulse_width.py can be used to set the timing board pulse width
  - "python flasherctl_set_pulse_width.py 192.168.0.200 0 255" will set the pulse width on board 0 to the maximum of 255 * 0.25 ns
  - The actual pulse width will be slightly shorter than this for the reason explained in section 7.1

9.3 LED Driver Request / Response Structure

The CMD_READ_REG / CMD_WRITE_REG / CMD_INIT / CMD_REPORT_ERROR request / response structure of the Dynamixel servos has been updated for the flashers as shown in Table 3.

Code	Symbol	Description	Request Payload	Response Payload
0	CMD_LED_BUILTIN	Sets the state of the red LED (LED_BUILTIN) on the controller board	uint8_t on_off	
1	CMD_START_TEMPERATURE	Starts a temperature conversion on the selected timing board	uint8_t board	
2	CMD_READ_TEMPERATURE	Reads the result of the temperature conversion from the selected timing board	unit8_t board	float temperature
3	CMD_INIT_FLASHER	Reinitialises the SPI port expander pins on the selected timing board	uint8_t board	
4	CMD_SET_GPO_PIN	Sets the state of the selected GPO pin on the selected timing board	uint8_t board, uint8_t pin, uint8_t on_off	
5	CMD_READ_SERIAL_NO	Reads the serial number from the selected timing board	uint8_t board	uint8_t serial_no[6]
6	CMD_SET_LEDS	Sets the LED enable signals on the selected timing board	uint8_t board, uint16_t led_bits	
7	CMD_SET_PULSE_WIDTH	Sets the timing pulse width on the selected timing board	uint8_t board, uint8_t width	

8	CMD_TEST_PULSE	Sets the state of the TEST_PULSE signal on the controller board	uint8_t on_off	
9	CMD_READ_TRIG	Reads the state of the TRIG signal on the selected timing board	uint8_t board	uint8_t trig

Table 3: Calibration Flasher Request / Response Structure

Code	Symbol	Description
1	ERR_BVALUE	Boolean (on_off) value was not 0 or 1 (for LED_BUILTIN, TEST_PULSE, or SET_GPO_PIN)
2	ERR_FLASHER_ID	Flasher timing board ID was not in the range 0:3
128	ERR_TIMEDOUT	(Unused)
256	ERR_RX_CHECKSUM	(Unused)
512	ERR_MISMATCH	(Unused)
1024	ERR_READ_ONLY	(Unused)
32768	ERR_RX_FSM	(Unused)

Table 4: Calibration Flasher Error Codes

9.4 Python API Description

9.4.1 FlasherCtl Class

The FlasherCtl class is based extensively on ServoCtl

9.4.1.1 Constructor

FlasherCtl.**__init__**(*ip, port=512, timeout=0.2, max_retries=3, verbosity=0, max_packet_size=256, interface_ip=None*)

Connects to the flasher subsystem at the given address.

Parameters

- **ip** (*string*) – Destination IP address
- **port** (*int, optional*) – Destination port (default: 512)
- **timeout** (*float, optional*) – Response timeout in seconds (default: 200 ms)
- **verbosity** (*int, optional*) – Verbosity level (default: 0, silent)
- **max_packet_size** (*int, optional*) – Expected maximum size of replies (default: 256 bytes)
- **interface_ip** (*str, optional*) – IP address of local interface (default: let OS choose)

9.4.1.2 Methods

FlasherCtl.**_init** (*serial_baud_rate=115200*)

Connects to the flasher subsystem at the given address

Parameters

- **serial_baud_rate** (*int*) – Data rate between the LED Driver and the flasher chain (default: 115200 bps)

FlasherCtl.**_LED_BUILTIN** (*on_off*)

Enables or disables the red LED (LED_BUILTIN) on the controller board

Parameters

- **on_off** (*byte*) – LED state: 0 (off) or 1 (on)

FlasherCtl.**_START_TEMPERATURE** (*board*)

Starts a temperature conversion on the selected timing board

Parameters

- **board** (*byte*) – Timing board number (0:3)

FlasherCtl.**_READ_TEMPERATURE** (*board*)

Reads the result of the temperature conversion on the selected timing board

Parameters

- **board** (*byte*) – Timing board number (0:3)

Returns

- **temperature** (*float*) – the temperature of the timing board in C

FlasherCtl.**_INIT_FLASHER** (*board*)

Reinitialises the selected timing board to a known state:
all LEDs are disabled; pulse width is set to zero

Parameters

- **board** (*byte*) – Timing board number (0:3)

FlasherCtl.**_SET_GPO_PIN** (*board, pin, on_off*)

Set the state of the selected GPO pin on the selected timing board

Parameters

- **board** (*byte*) – Timing board number (0:3)
- **pin** (*byte*) – GPO pin number (0:1)
- **on_off** (*byte*) – State (0:off, 1:on)

FlasherCtl.**_SET_LEDS** (*board, leds*)

Configure which of the ten LEDs will flash on the selected timing board

Parameters

- **board** (*byte*) – Timing board number (0:3)

- **led** (*word*) – LED configuration (10 bits, MSB first, '1': LED enabled, '0': LED disabled, LSB = LED1)

FlasherCtl.**_SET_PULSE_WIDTH** (*board, width*)

Configure the timing pulse width on the selected timing board

Parameters

- **board** (*byte*) – Timing board number (0:3)
- **width** (*byte*) – Pulse width (in 0.25 ns increments)

FlasherCtl.**_TEST_PULSE** (*on_off*)

Set the state of the TEST_PULSE pin on the controller board

Parameters

- **on_off** (*byte*) – State: 0 (low), 1 (high), 2 (high then low)

FlasherCtl.**_READ_TRIG** (*board*)

Reads the state of the trigger signal on the selected timing board

Parameters

- **board** (*byte*) – Timing board number (0:3)

Returns

- **trig** (*byte*) – the state of the trigger signal (0:low, 1:high)

FlasherCtl.**_READ_SERIAL_NO** (*board*)

Reads the digital serial number from the selected timing board

Parameters

- **board** (*byte*) – Timing board number (0:3)

Returns

- **serial** (*byte[6]*) – the serial number (MSB first)

9.4.1.3 Example Code

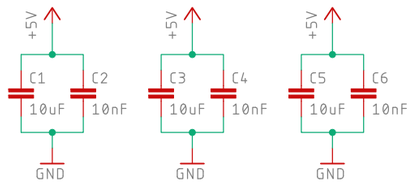
See the flasherctl\utils directory

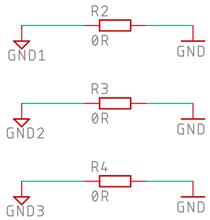
9.4.2 IOStack Class

A copy of the servo IOStack class

Decoupling Capacitors

(Values are nominal)

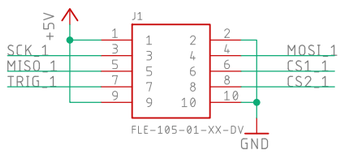




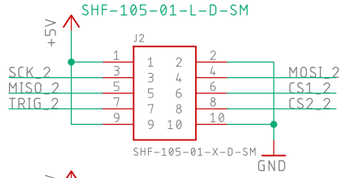
Mounting Hole Grounding

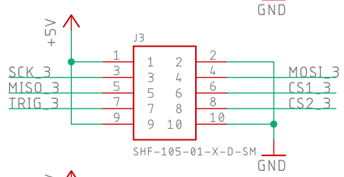
(Can easily be removed if the mounting holes need a robust ground connection for EMI or thermal reasons)

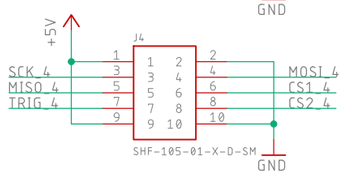
Samtec
FLE-105-01-G-DV



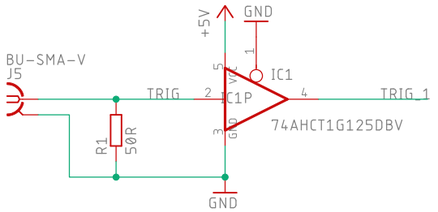
Samtec
SHF-105-01-L-D-SM

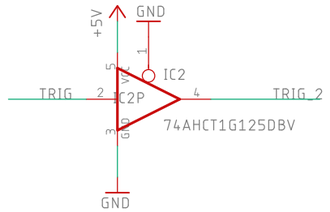




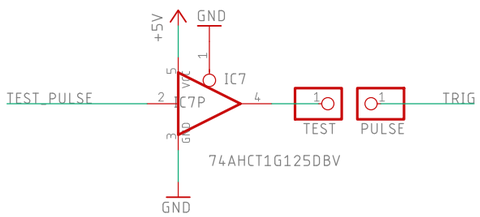


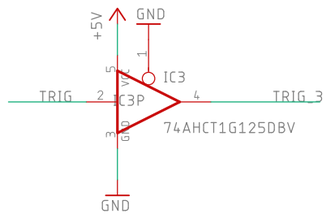
Connectors

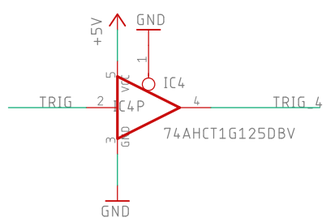




Trigger Signal Distribution







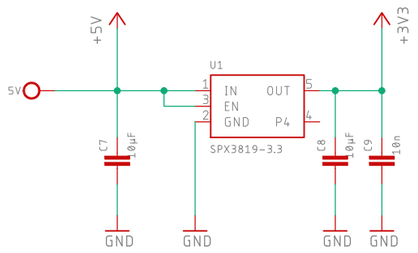
Fiducials

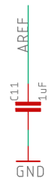
Calibration Flasher Controller Board V1b

Updates for V1b:
Added IC7 to buffer TEST_PULSE
Corrected MISO & MOSI pin selection

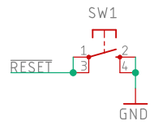
	Flasher_Controller_Board
	15/02/2019 13:34
	Sheet: 1/3

POWER AND FILTERING

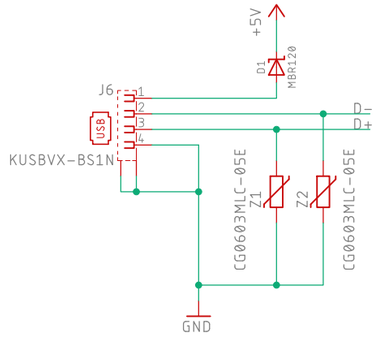




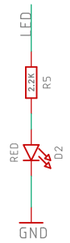
RESET



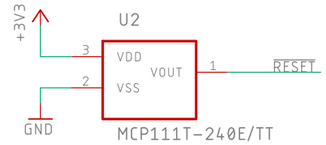
USB

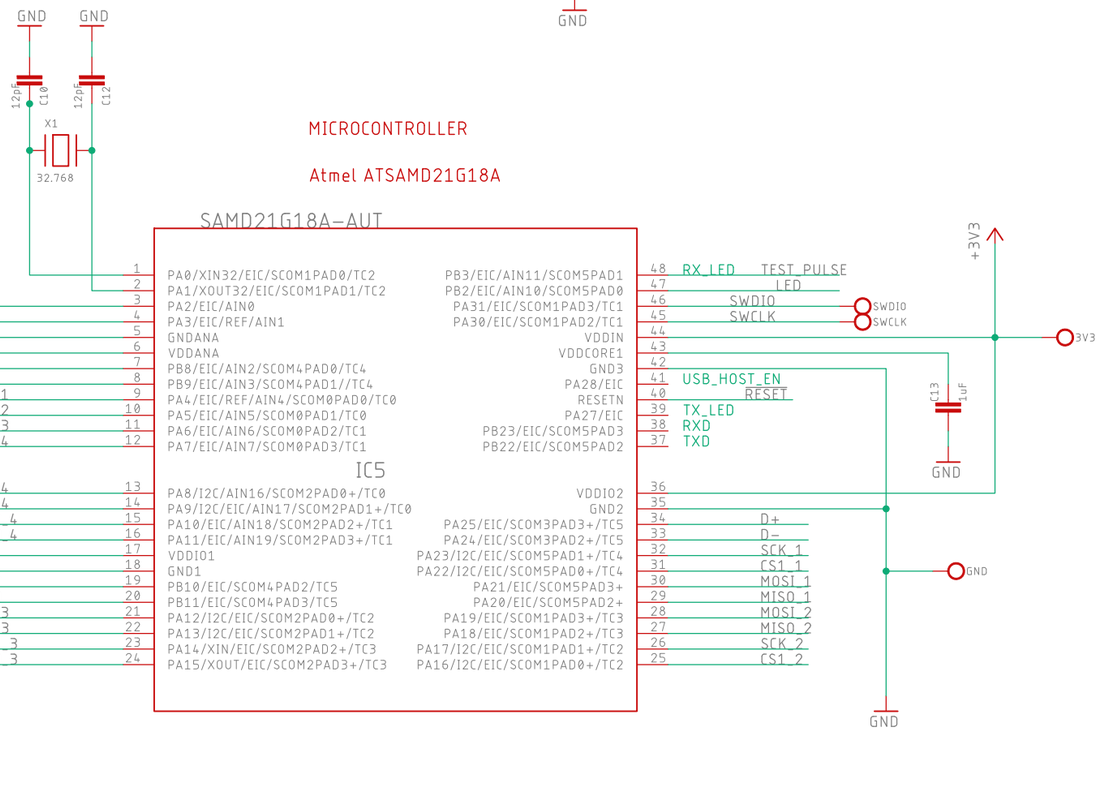


LED



Reset Supervisor



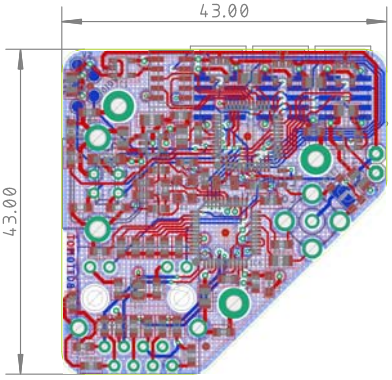


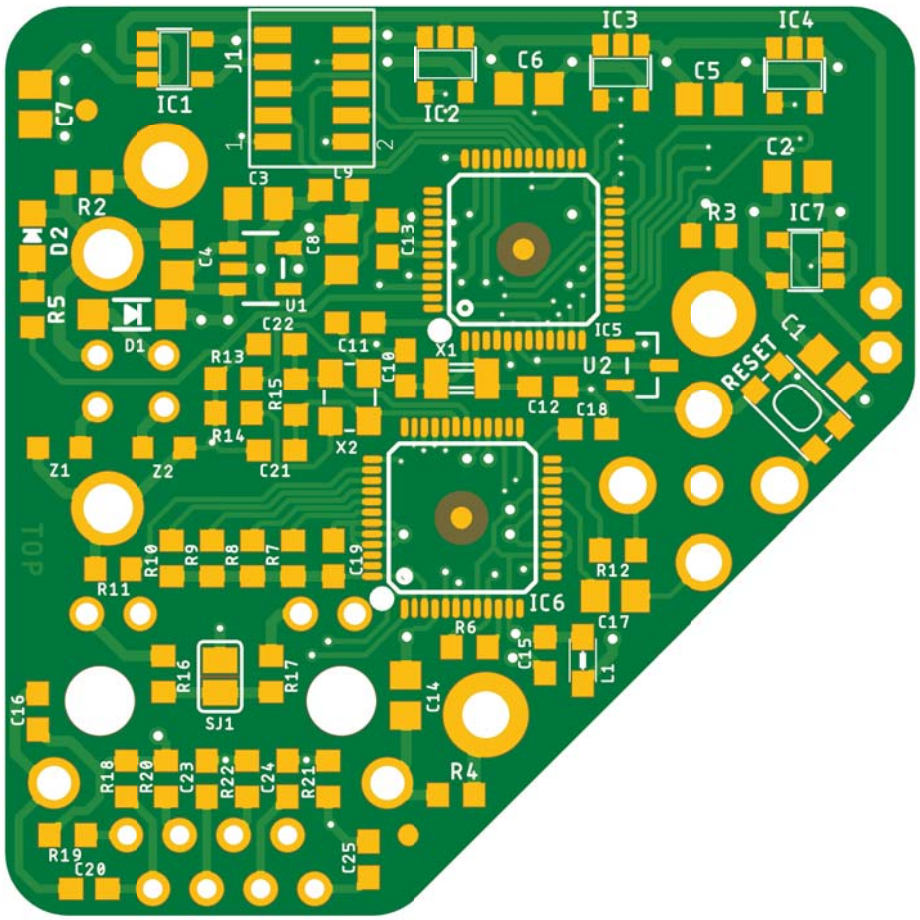
	Flasher_Controller_Board
	15/02/2019 13:34
	Sheet: 2/3

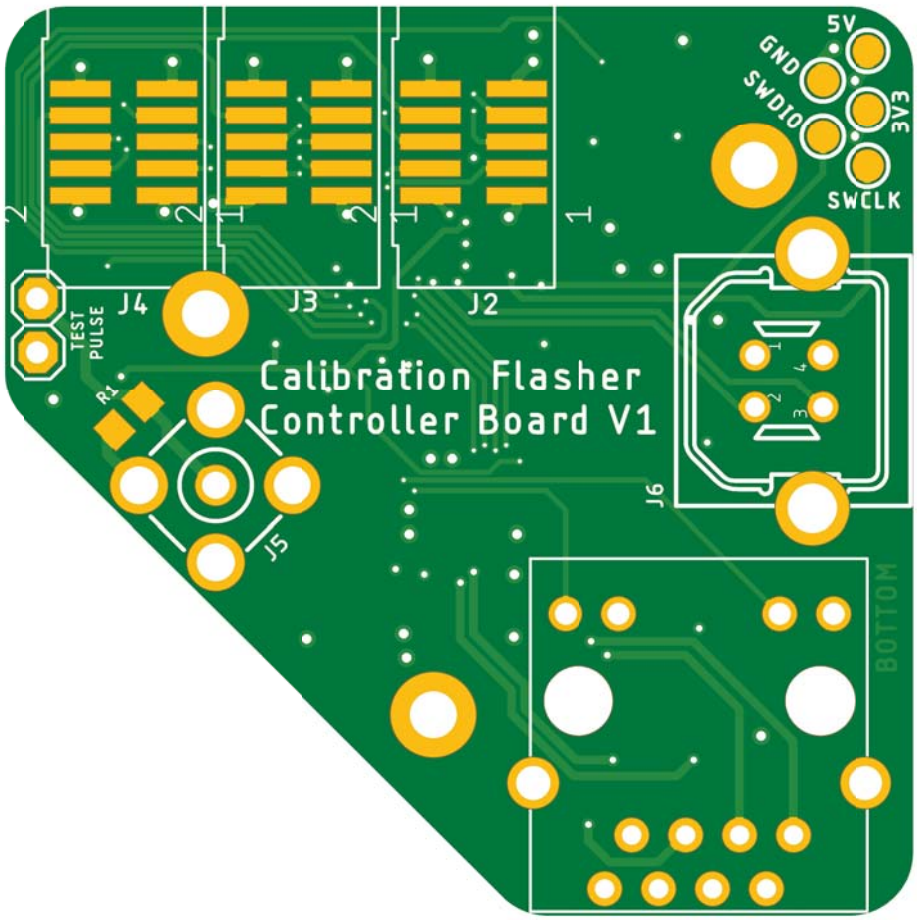
Ethernet
Shielded RJ45 with
10/100Mbps Magnetics
Valcon VSIMJLV-88-FF-GY

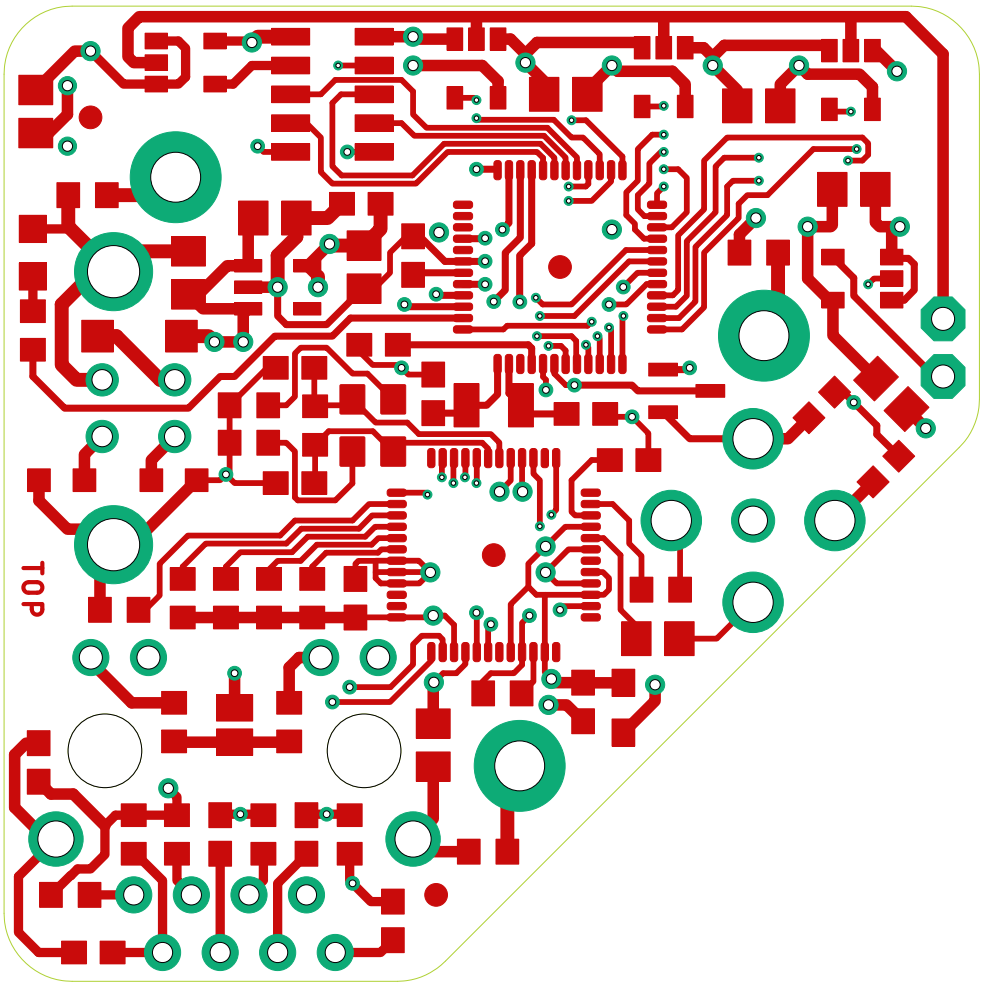
WIZnet W5500

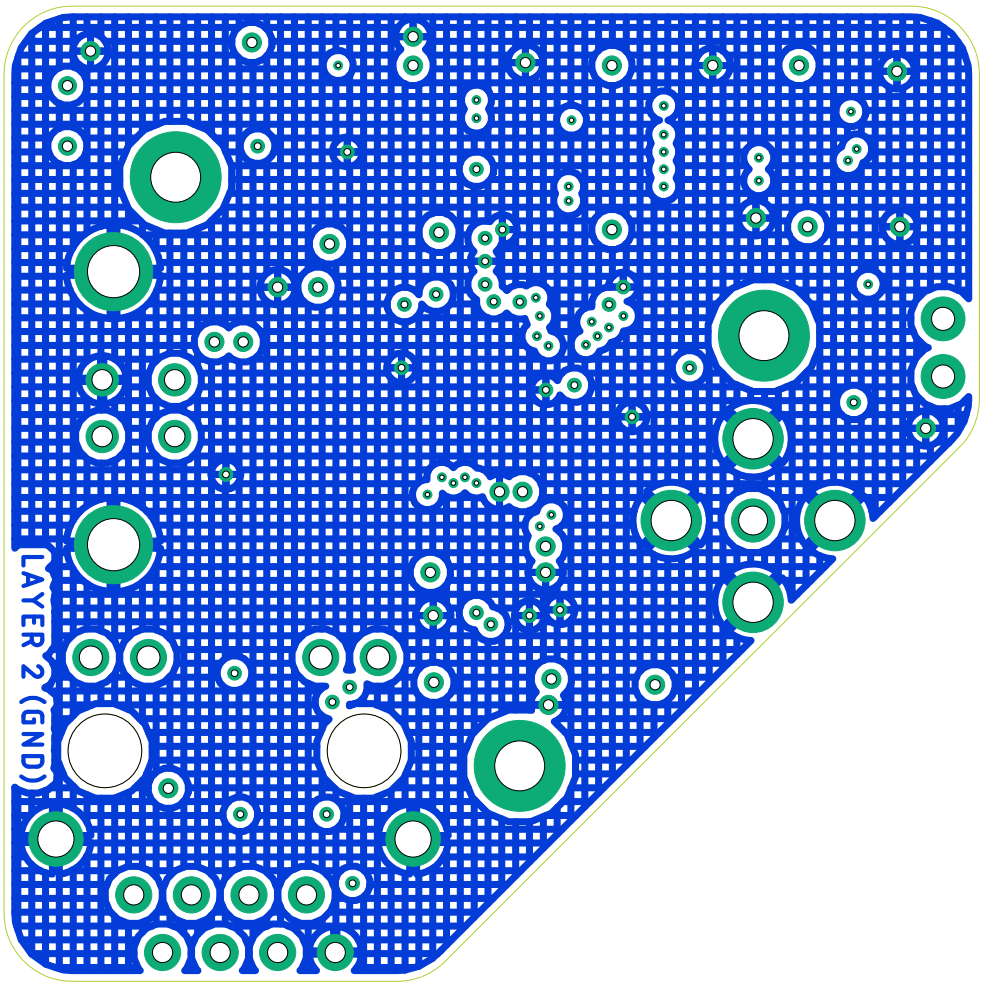
Flasher_Controller_Board	
15/02/2019 13:34	
Sheet: 3/3	

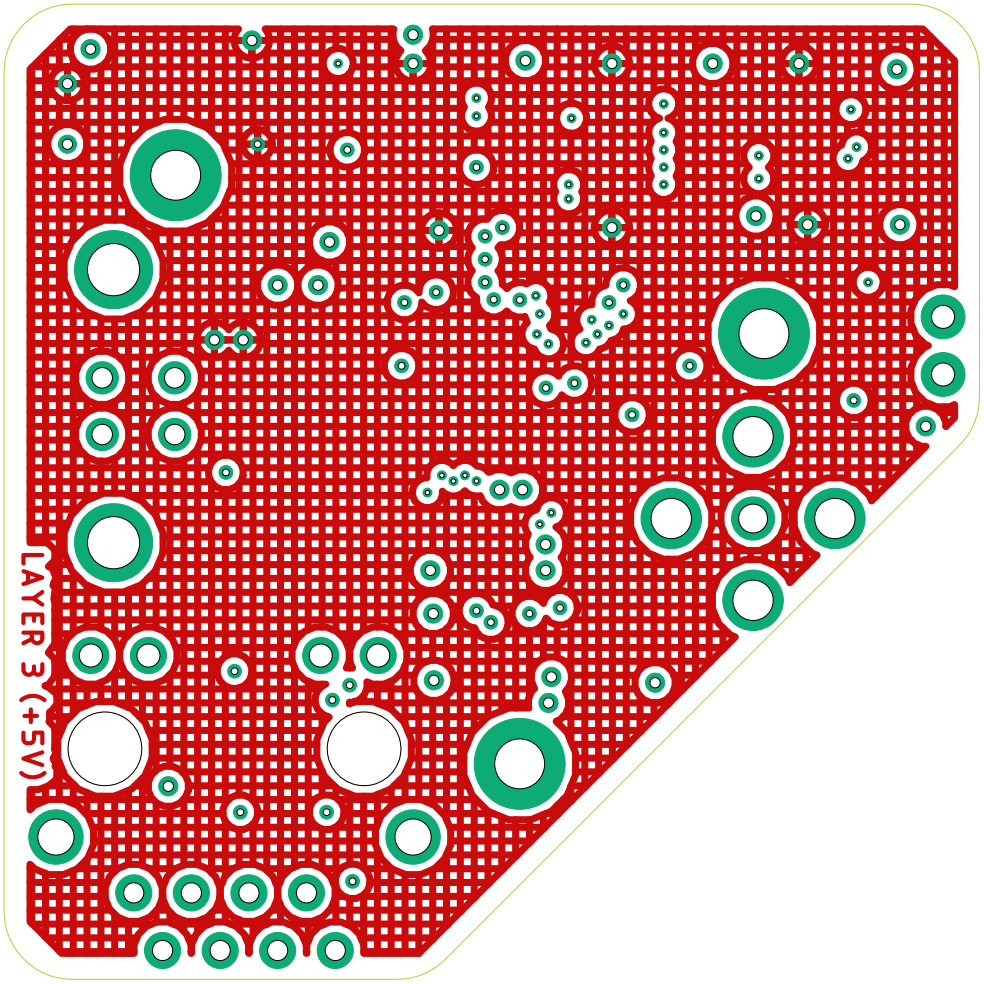

43.00
43.00

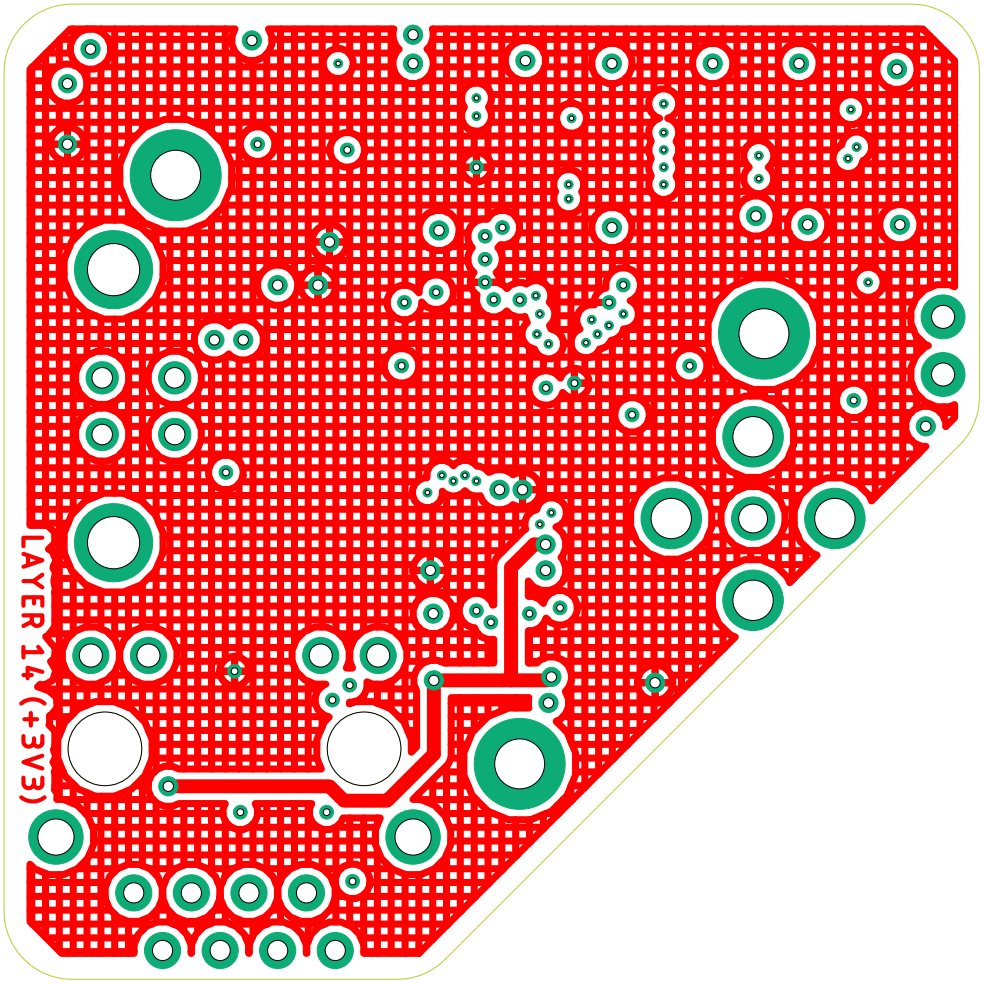

IC1
J1
IC2
C6
IC3
C5
IC4
C7
C3
C9
C2
R2
D2
C4
C8
C13
R3
IC7
R5
V1
C22
D1
IC5
C1
RESET
R13
C11
C10
X1
U2
R15
C12
C18
R14
X2
Z1
Z2
C21
TOP
R10
R9
R8
R7
C19
R12
R11
IC6
R6
C17
C15
L1
R16
R17
SJ1
C16
C14
R4
R18
R20
C23
R22
C24
R21
R19
C20
C25

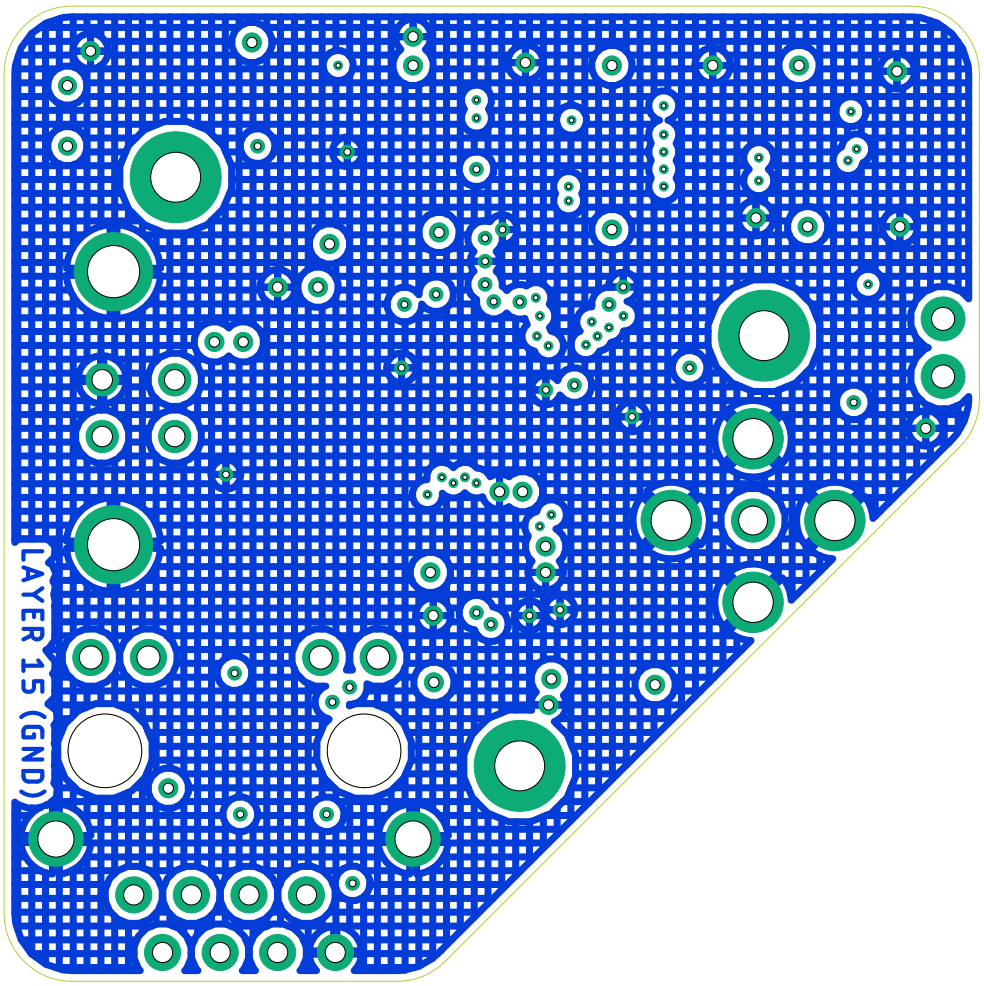

5V
GND
SWDIO
3V3
SWCLK
J4
J3
J2
TEST
PULSE
R1
Calibration Flasher
Controller Board V1
J5
J6
BOTTOM

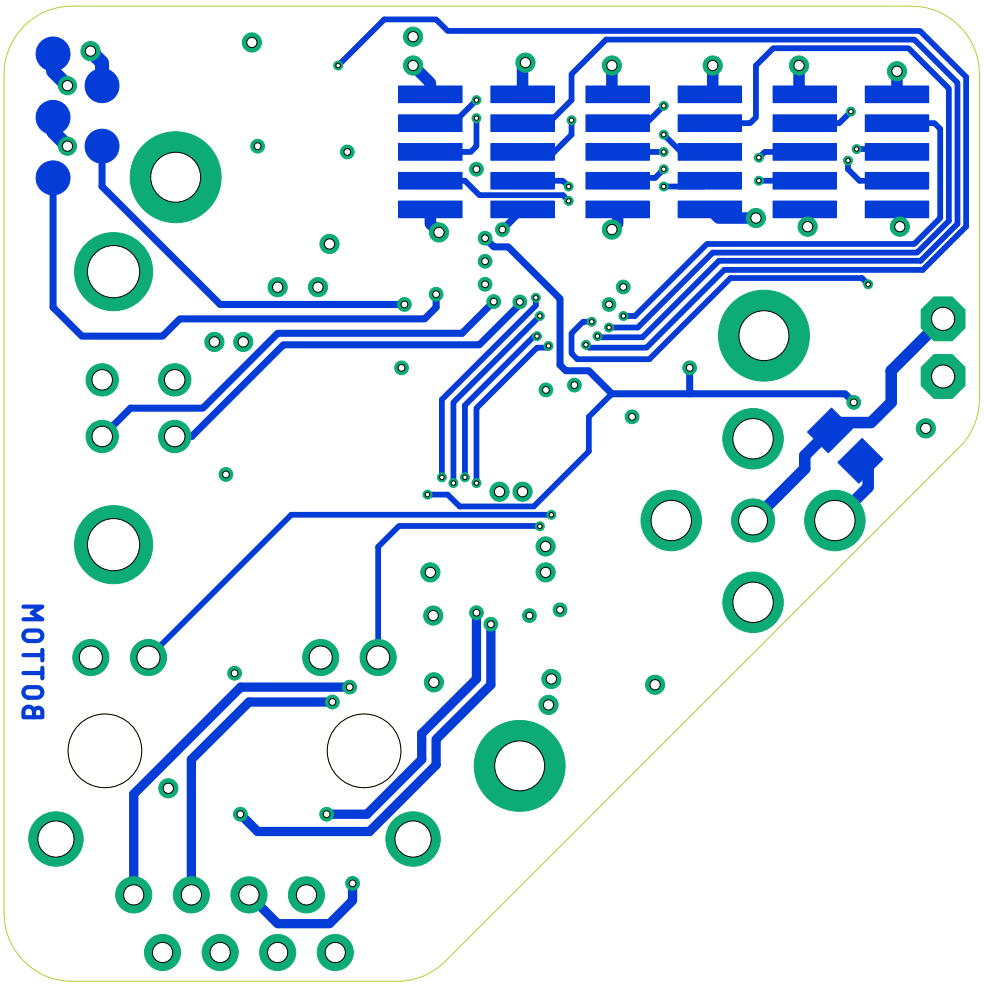

TOP


LAYER 2 (GND)


LAYER 3 (+5V)


LAYER 14 (+3V3)


LAYER 15 (GND)


BOTTOM

Part	X	X (Mirrored)	Y	Angle	Angle (Mirrored)	Package	Value	Manufacturer	Manufacturer Part No	Farnell Part No	Mouser Part No	Description
Dimensions	**43.00**		**43.00**									
Fiducials - for solder paste mask alignment:												
FD1	19.05		3.81	0								Fiducial 1mm
FD2	3.81		38.10	0								Fiducial 1mm
Top Layer Surface Mount Components:												
C1	39.12		25.91	315		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C2	37.47		34.93	0		0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C3	11.94		33.66	0		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C4	8.13		31.24	90		0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C5	33.27		38.61	180		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C6	24.77		39.12	180		0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C7	1.40		38.35	90		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C8	15.88		31.50	270		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C9	15.75		34.29	180		0603	10n	Walsin	0201B103K100CT	2496756		MultiLayer Ceramic Capacitor; 10nF; 10V; 0603; X7R
C10	18.92		25.91	90		0603	12pF	Walsin	0603N120J500CT	2496884		MultiLayer Ceramic Capacitor; 12pF; 50V; 0603
C11	16.51		28.07	180		0603	1uF	Walsin	0603X105K100CT	2496916		MultiLayer Ceramic Capacitor; 1uF; 10V; 0603; X5R
C12	25.65		25.02	0		0603	12pF	Walsin	0603N120J500CT	2496884		MultiLayer Ceramic Capacitor; 12pF; 50V; 0603
C13	18.03		32.00	90		0603	1uF	Walsin	0603X105K100CT	2496916		MultiLayer Ceramic Capacitor; 1uF; 10V; 0603; X5R
C14	18.92		10.41	270		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C15	25.53		12.32	270		0603	10n	Walsin	0201B103K100CT	2496756		MultiLayer Ceramic Capacitor; 10nF; 10V; 0603; X7R
C16	1.52		9.65	90		0603	100nF	Murata	GRM188R71H104JA93D	2688523		MultiLayer Ceramic Capacitor; 0.1uF; 50V; 0603; X7R
C17	28.83		15.11	0		0805	4u7	TDK	C2012X5R1E475K125AB	2309036		MultiLayer Ceramic Capacitor; 4.7uF; 25V; 0805; X5R
C18	27.56		22.99	0		0603	10n	Walsin	0201B103K100CT	2496756		MultiLayer Ceramic Capacitor; 10nF; 10V; 0603; X7R
C19	15.49		16.89	270		0603	100nF	Murata	GRM188R71H104JA93D	2688523		MultiLayer Ceramic Capacitor; 0.1uF; 50V; 0603; X7R
C20	3.94		1.27	0		0603	22nF	Walsin	0603B223K250CT	2496846		MultiLayer Ceramic Capacitor; 22nF; 25V; 0603; X7R
C21	12.83		21.97	180		0603	12pF	Walsin	0603N120J500CT	2496884		MultiLayer Ceramic Capacitor; 12pF; 50V; 0603
C22	12.83		27.05	180		0603	12pF	Walsin	0603N120J500CT	2496884		MultiLayer Ceramic Capacitor; 12pF; 50V; 0603
C23	9.53		6.48	90		0603	10nF	Walsin	0603B103K101CT	2496825		MultiLayer Ceramic Capacitor; 10nF; 100V; 0603; X7R
C24	13.34		6.48	90		0603	10nF	Walsin	0603B103K101CT	2496825		MultiLayer Ceramic Capacitor; 10nF; 100V; 0603; X7R
C25	17.14		2.67	90		0603	10nF	Walsin	0603B103K101CT	2496825		MultiLayer Ceramic Capacitor; 10nF; 100V; 0603; X7R
D1	5.97		28.45	180		SOD-123	MBR120	ON SEMICONDUCTOR	MBR120VLSFT1G	1431044		Schottky Rectifier; 20V; 1A; SOD-123
D2	1.27		32.13	0		2.0x1.25	RED	Wurth Electronik	150080RS75000	2322077	710-150080RS75000	LED; Red; 20mA; 2V; 2.0x1.25mm
IC1	8.01		40.51	270		SOT23-5	74AHCT1G125DBV	Texas Instruments	SN74AHCT1G125DBVR	1105927		Buffer / Line Driver; Single Gate
IC2	20.83		40.25	180		SOT23-5	74AHCT1G125DBV	Texas Instruments	SN74AHCT1G125DBVR	1105927		Buffer / Line Driver; Single Gate
IC3	29.08		39.87	180		SOT23-5	74AHCT1G125DBV	Texas Instruments	SN74AHCT1G125DBVR	1105927		Buffer / Line Driver; Single Gate
IC4	37.34		39.75	180		SOT23-5	74AHCT1G125DBV	Texas Instruments	SN74AHCT1G125DBVR	1105927		Buffer / Line Driver; Single Gate
IC5	24.51		31.50	90		TQFP48-7X7	SAMD21G18A-AFT	Atmel / Microchip	SAMD21G18A-AFT		556-ATSAMD21G18A-AFT	
IC6	21.59		18.80	90		TQFP48-7X7	W5500	WIZnet	W5500		950-W5500	Ethernet ICs 3in1 Enet Controller TCP/IP +MAC+PHY
IC7	37.84		30.99	90		SOT23-5	74AHCT1G125DBV	Texas Instruments	SN74AHCT1G125DBVR	1105927		Buffer / Line Driver; Single Gate
J1	14.48		39.12	90		FLE-105-01-G-DV	FLE-105-01-G-DV	Samtec	FLE-105-01-G-DV	1667672		Board-To-Board Connector, 1.27 mm, 10 Contacts, 2 Rows
L1	27.30		12.07	90		0805	MH2029-300Y	Bourns	MH2029-300Y	2859362	652-MH2029-300Y	Ferrite Bead; 0805; 30 Ohms at 100MHz
R2	3.68		34.67	180		0603	0R	Multicomp	MCMR06X000PTL	2073345		SMD Chip Resistor, 0 ohm, 75 V, 0603, 100 mW
R3	33.27		32.13	180		0603	0R	Multicomp	MCMR06X000PTL	2073345		SMD Chip Resistor, 0 ohm, 75 V, 0603, 100 mW
R4	21.34		5.71	180		0603	0R	Multicomp	MCMR06X000PTL	2073345		SMD Chip Resistor, 0 ohm, 75 V, 0603, 100 mW
R5	1.27		28.70	90		0603	2.2K	Multicomp	MCWR06X2201FTL	2447320		Chip Resistor; Thick Film; 2.2k; 50V; 0603; 100mW
R6	21.97		12.70	0		0603	12K4	Vishay	CRCW060312K4FKEA	1652836		Chip Resistor; Thick Film; 12.4k; 75V; 0603; 100mW
R7	13.59		16.89	270		0603	10K	Multicomp	MCWR06X1002FTL	2447230		Chip Resistor; Thick Film; 10k; 50V; 0603; 100mW
R8	11.68		16.89	270		0603	10K	Multicomp	MCWR06X1002FTL	2447230		Chip Resistor; Thick Film; 10k; 50V; 0603; 100mW
R9	9.78		16.89	270		0603	10K	Multicomp	MCWR06X1002FTL	2447230		Chip Resistor; Thick Film; 10k; 50V; 0603; 100mW
R10	7.87		16.89	270		0603	10K	Multicomp	MCWR06X1002FTL	2447230		Chip Resistor; Thick Film; 10k; 50V; 0603; 100mW
R11	5.08		16.38	180		0603	10K	Multicomp	MCWR06X1002FTL	2447230		Chip Resistor; Thick Film; 10k; 50V; 0603; 100mW
R12	28.96		17.27	180		0603	10K	Multicomp	MCWR06X1002FTL	2447230		Chip Resistor; Thick Film; 10k; 50V; 0603; 100mW
R13	10.79		25.40	0		0603	0R	Multicomp	MCMR06X000PTL	2073345		SMD Chip Resistor, 0 ohm, 75 V, 0603, 100 mW
R14	10.79		23.75	180		0603	0R	Multicomp	MCMR06X000PTL	2073345		SMD Chip Resistor, 0 ohm, 75 V, 0603, 100 mW
R15	13.72		24.51	270		0603	1M	Multicomp	MCWR06X1004FTL	2447285		SMD Chip Resistor, 1Mohm, 50 V, 0603, 100 mW
R16	7.49		11.43	270		0603	1K	Multicomp	MCWR06X1001FTL	2447272		Chip Resistor; Thick Film; 1k; 50V; 0603; 100mW
R17	12.57		11.43	270		0603	1K	Multicomp	MCWR06X1001FTL	2447272		Chip Resistor; Thick Film; 1k; 50V; 0603; 100mW
R18	5.71		6.48	90		0603	10R	Vishay	CRCW060310R0JNEA	2616744		Chip Resistor; Thick Film; 10 ohm; 75V; 0603; 100mW
R19	2.92		3.81	180		0603	49R9	Multicomp	MCWR06X49R9FTL	2447381		Chip Resistor; Thick Film; 49.9 ohm; 50V; 0603; 100mW
R20	7.62		6.48	90		0603	49R9	Multicomp	MCWR06X49R9FTL	2447381		Chip Resistor; Thick Film; 49.9 ohm; 50V; 0603; 100mW
R21	15.24		6.48	90		0603	49R9	Multicomp	MCWR06X49R9FTL	2447381		Chip Resistor; Thick Film; 49.9 ohm; 50V; 0603; 100mW
R22	11.43		6.48	90		0603	49R9	Multicomp	MCWR06X49R9FTL	2447381		Chip Resistor; Thick Film; 49.9 ohm; 50V; 0603; 100mW
SW1	37.46		24.00	315		4.6x2.8	Tactile Switch	Multicomp	MCIPTG23K-V	1605470		Tactile Switch; 4.6x2.8mm; 50mA; 12V
U1	12.07		30.61	270		SOT23-5	SPX3819-3.3	Exar	SPX3819M5-L-3-3/TR		701-SPX3819M5-L-33TR	LDO Voltage Regulator; 500mA; SOT-23-5
U2	30.10		26.04	270		SOT23-3	MCP111T-240E/TT	Microchip	MCP111T-240E/TT	1627192		Reset Supervisor; SOT23-3; 2.40V; Open Drain; Active Low
X1	21.59		25.40	180		3.2x1.5	32.768	Epson	Q13FC13500004	1278036		Crystal; 32.768kHz; 12.5pF; 3.2 x 1.5mm
X2	16.26		24.51	90		CRYSTAL3.2X2.5	FTX25.000M12SM3S	ECS	ECS-250-12-33-AGM-TR		520-250-12-33-AGMT	Crystals 25MHz 12pF 25ppm
Z1	2.54		22.10	180		CT/CN0603	CG0603MLC-05E	Bourns	CG0603MLC-05E	1838966	652-CG0603MLC-05E	ESD Suppressor; 0603; 5 Volts
Z2	7.49		22.10	0		CT/CN0603	CG0603MLC-05E	Bourns	CG0603MLC-05E	1838966	652-CG0603MLC-05E	ESD Suppressor; 0603; 5 Volts
Bottom Layer Surface Mount Components:												
R1	37.08		23.62	45		0805	50R					Leave unpopulated
J2	20.83		36.58	90		SHF-105-01-L-D-SM	SHF-105-01-L-D-SM	Samtec	SHF-105-01-L-D-SM	1885915		Samtec SHF Header; 10 contacts; 2 rows; surface mount
J3	29.08		36.58	90		SHF-105-01-L-D-SM	SHF-105-01-L-D-SM	Samtec	SHF-105-01-L-D-SM	1885915		Samtec SHF Header; 10 contacts; 2 rows; surface mount
J4	37.34		36.58	90		SHF-105-01-L-D-SM	SHF-105-01-L-D-SM	Samtec	SHF-105-01-L-D-SM	1885915		Samtec SHF Header; 10 contacts; 2 rows; surface mount
Non-Surface Mount Components:												
J5							BU-SMA-V	IMS	42.2510.009		**RS: 112-3794**	Straight 50Ω Through Hole SMA Connector
J6							KUSBVX-BS1N	Kycon	KUSBVX-BS1N-B		806-KUSBVX-BS1N-B	USB B-type Receptacle Vertical, 4 Position, Through Hole
J7							VSIMJLV-88-FF-GY	Valcon	VSIMJLV-88-FF-GY		**Toby Electronics**	Valcon VSIMJLV-88-FF-GY RJ45 Vertical with 10/100Mbps Magnetics

Connector to LED Board

Samtec
FLE-108-01-G-DV-K

J1
FLE-108-01-XX-DV

EN7 EN6 EN10 EN5 EN4 TP
EN8 EN9 EN1 EN2 EN3

Connector to Controller Board

Samtec
FW-05-05-x-D

J2
FW-05-05-XX-D

SCK_3V MISO_3V TRIG
MOSI_3V CS1_3V CS2_3V

D4
R6 100K
C14 1uF

3V3 to 5V Level Shifting

IC8
TXB0108
OE VCCA VCCB GND
A1 A2 A3 A4 A5 A6 A7 A8
B1 B2 B3 B4 B5 B6 B7 B8
1.2–3.6V
1.65–5.5V

SCK_3V MISO_3V MOSI_3V CS1_3V CS2_3V
SCK MISO MOSI CS1 CS2

U1
SPX3819-3.3
IN OUT EN GND P4
C13 10µF
C12 10n

R21 R22 R23 0R
GND1 GND2 GND3

Mounting Hole Grounding

(Can easily be removed if the mounting holes need a robust ground connection for EMI or thermal reasons)

Reset Supervisor

IC4
MCP111T-240E/TT
VDD VSS VOUT
R5 10K
RESET

Temperature Sensor

IC1
ADT7310TRZ
SCLK DOUT DIN CS
VDD GND CT INT
SCK MISO MOSI CS2

SPI Port Expanders

IC2
MCP23S17SS
VDD RESET INTA INTB CS SCK SI SO A0 A1 A2 VSS
GPA0 GPA1 GPA2 GPA3 GPA4 GPA5 GPA6 GPA7
GPB0 GPB1 GPB2 GPB3 GPB4 GPB5 GPB6 GPB7

RESET CS1 SCK MOSI MISO
D0 D1 D2 D3 D4 D5 D6 D7
LE GPO0 GPO1

R7 100R
TRIG

IC3
MCP23S17SS
EN1 EN2 EN3 EN4 EN5 EN6 EN7 EN8 EN9 EN10

Timing Pulse Generation

IC5
DS1023-25
Maxim DS1023-25
Programmable Timing Element
(Delay Line)
IN LE Q/P0 CLK/P1 D/P2 P3 P4 GND
VCC OUT/OUT P7S P7 P6 MS P5 REF/PWM

LE D0 D1 D2 D3 D4
D7 D6 D5

IC6P
74AC/VHC02
Quad NOR
IC6D 74HC02D
IC6A 74HC02D
IC6B 74HC02D
IC6C 74HC02D
TP

R8 1K
R11 1K
R9 2K2
R10 2K2
Q3 2N2222
Q4 2N2222

IC7
DS28CM00R-A00+T
SCL GND SDA NC VCC
Serial Number (I2C)

Decoupling Capacitors

(Values are nominal)

C2 C1 C4 C3 C6 C5 C8 C7 C10 C9
10uF 10nF

Q1 Q2
DMG3415U-7
R1 R3 10K
R2 R4 80R6
GPO0 GPO1

GND. GND..

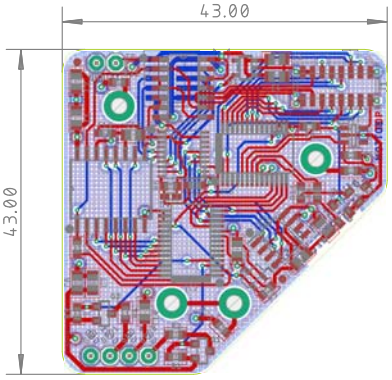
General Purpose Outputs
(for Pointing LEDs)

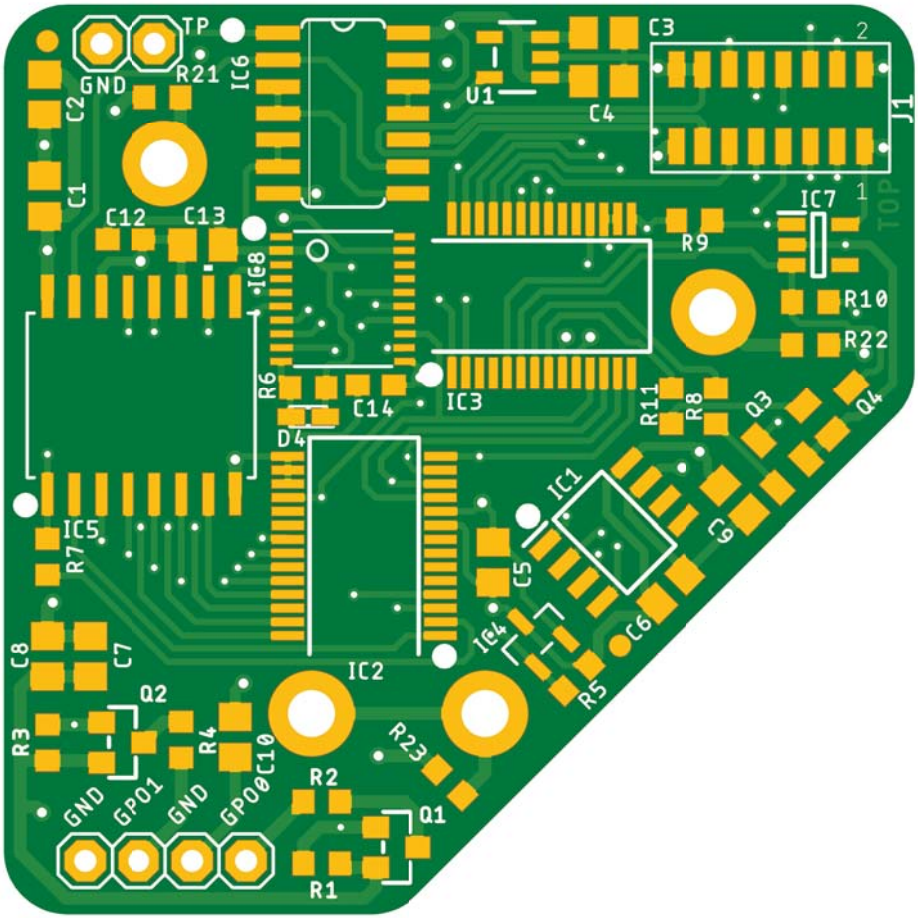
Calibration Flasher Timing Board V2b

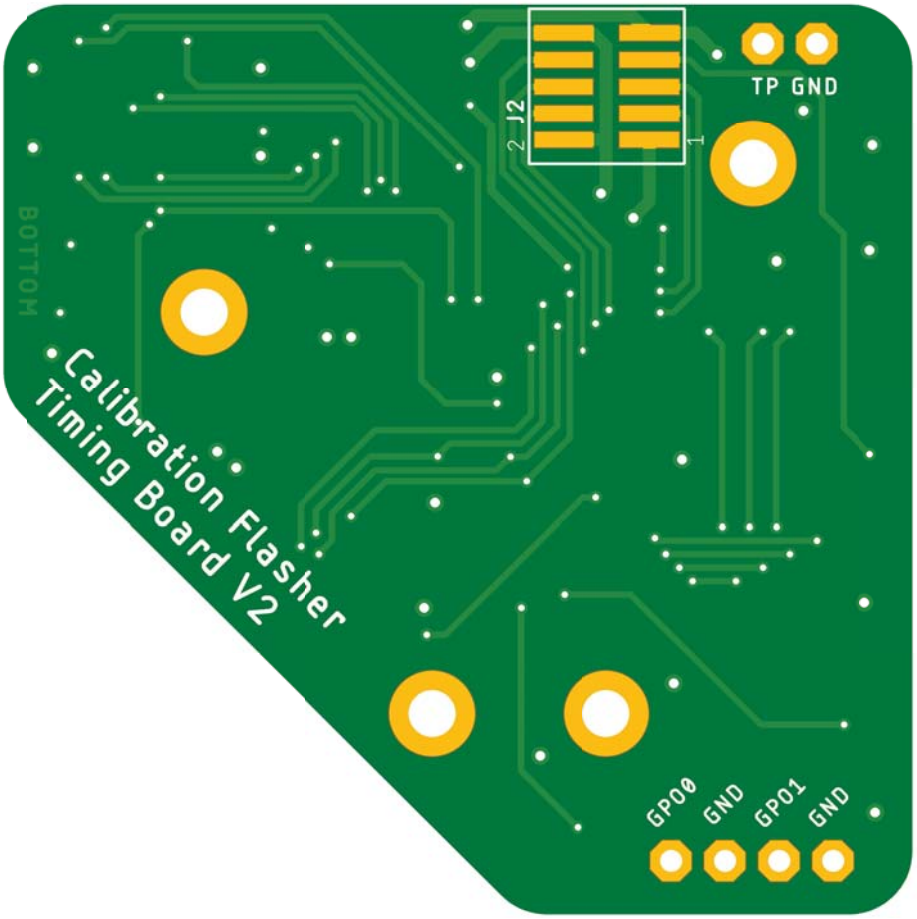
Modifications for V2b:
Added pull-up for RESET
Added IC8 level shifter
Added pull-down transistors for IC7 SDA and SCL

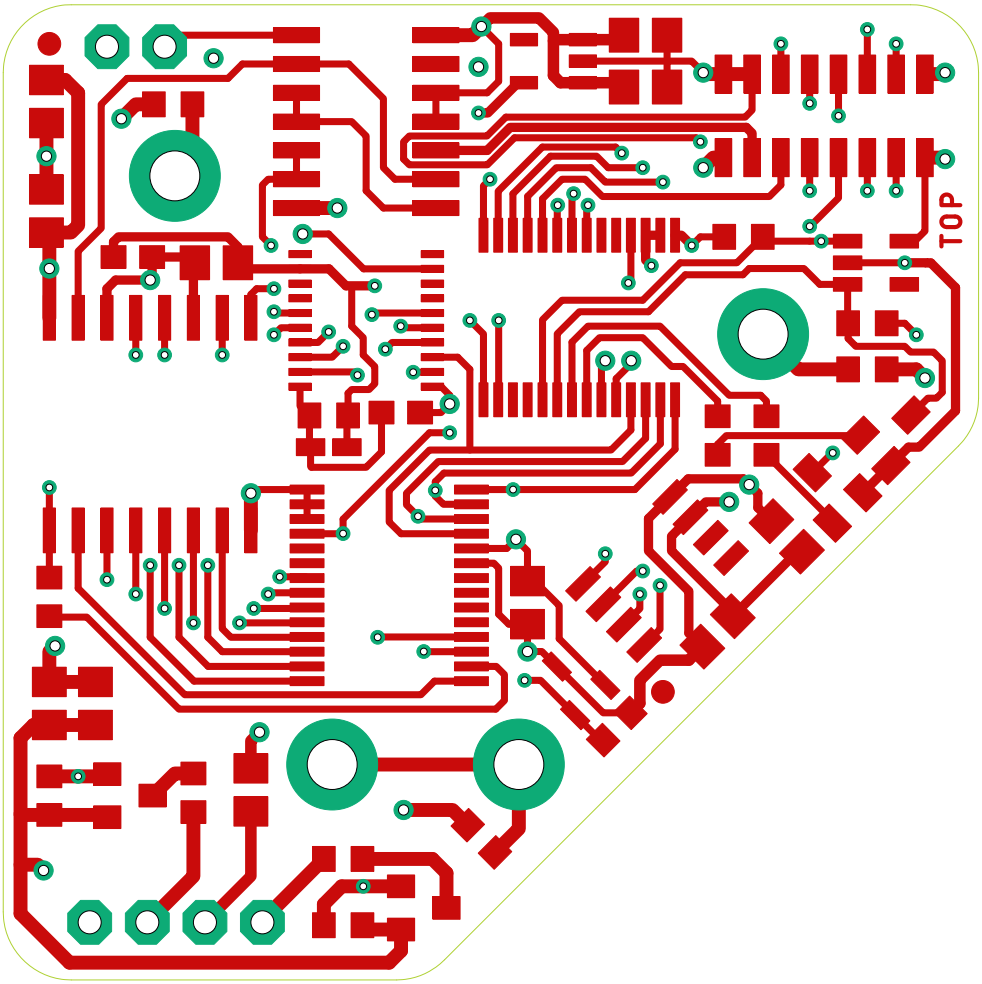
Fiducials

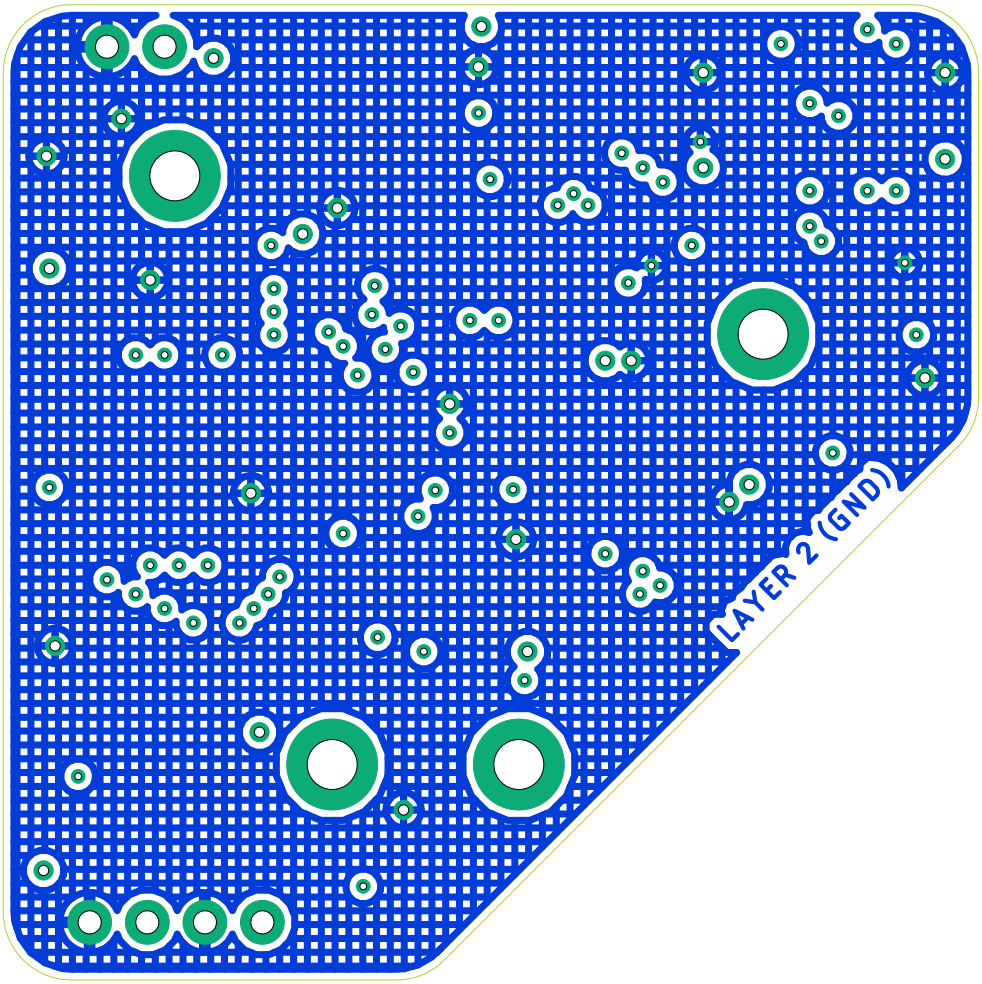
Flasher_Timing_Board	
18/02/2019 12:37	
Sheet: 1/1	

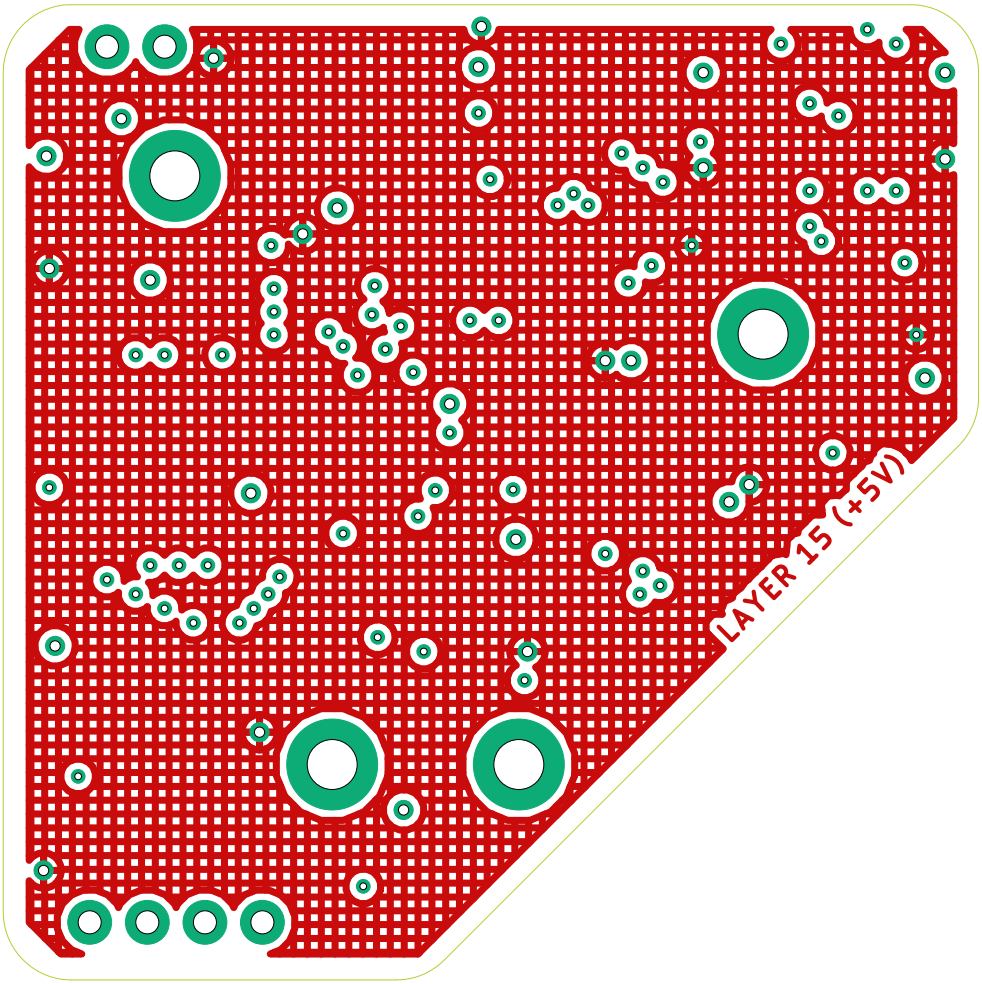

43.00
43.00

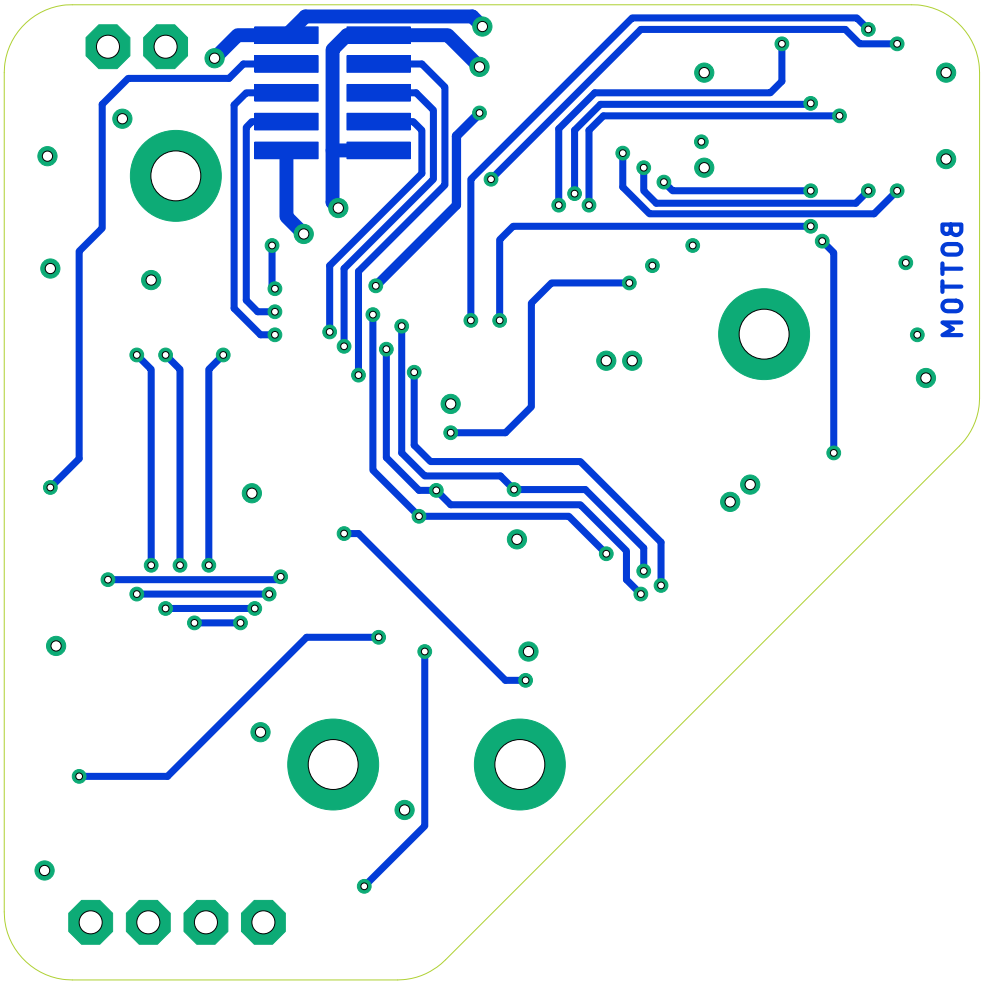

TP
GND
R21
IC6
C2
C1
C12
C13
IC8
R6
C14
IC3
D4
IC5
R7
C8
C7
Q2
R3
R4
C10
GND
GPO1
GND
GPO0
R2
R1
Q1
R23
IC2
IC4
C5
IC1
C9
C6
R5
R11
R8
Q3
Q4
R9
IC7
R10
R22
V1
C4
C3
J1
TOP


TP GND
J2
2
1
BOTTOM
Calibration Flasher
Timing Board V2
GPO0
GND
GPO1
GND


TOP

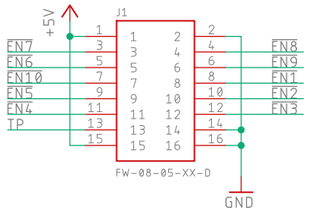

LAYER 2 (GND)


LAYER 15 (+5V)

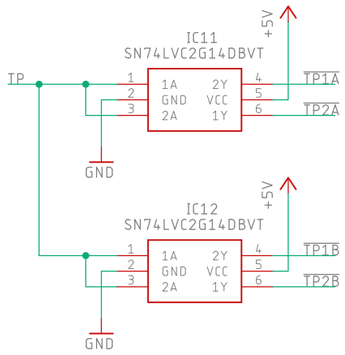

BOTTOM

Part	X	X (Mirrored)	Y	Angle	Angle (Mirrored)	Package	Value	Manufacturer	Manufacturer Part No	Farnell Part No	Mouser Part No	Description
Dimensions	**43.00**		**43.00**									
Fiducials - for solder paste mask alignment:												
FD1	2.03		41.27	0								Fiducial 1mm
FD2	29.08		12.70	0								Fiducial 1mm
Top Layer Surface Mount Components:												
C1	1.91		33.91	90		0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C2	1.91		38.73	270		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C3	28.32		41.66	0		0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C4	28.32		39.37	0		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C5	23.11		16.64	90		0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C6	31.5		15.37	45		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C7	4.06		12.19	90		0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C8	2.03		12.19	90		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C9	34.54		19.56	315		0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C10	10.92		8.38	270		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C12	5.71		31.88	0		0603	10n	Walsin	0201B103K100CT	2496756		MultiLayer Ceramic Capacitor; 10nF; 10V; 0603; X7R
C13	9.4		31.62	180		0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C14	17.53		25.02	0		0603	1uF	Walsin	0603X105K100CT	2496916		MultiLayer Ceramic Capacitor; 1uF; 10V; 0603; X5R
D4	14.35		23.5	180		0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
IC1	28.83		18.03	45		8-Lead SOIC_N (R-8)	ADT7310TRZ	Analog Devices	ADT7310TRZ	2067805	584-ADT7310TRZ-R7	Temperature Sensor IC, Digital, ± 0.5°C, -55 °C, +150 °C
IC2	17.02		17.4	90		SSOP28	MCP23S17SS	Microchip	MCP23S17-E/SS	1467675	579-MCP23S17T-E/SS	I/O Expander, 16 bit, 10MHz
IC3	25.4		29.21	0		SSOP28	MCP23S17SS	Microchip	MCP23S17-E/SS	1467675	579-MCP23S17T-E/SS	I/O Expander, 16 bit, 10MHz
IC4	25.48		12.75	45		SOT23-3	MCP111T-240E/TT	Microchip	MCP111T-240E/TT	1627192	579-MCP111T-240E/TT	Reset Supervisor; SOT23-3; 2.40V; Open Drain; Active Low
IC5	6.48		24.51	90		WSOIC-16	DS1023-25	Maxim	DS1023S-25+	2516605	700-DS1023S-25	Delay Line; 256 taps; 250ps delay/tap; WSOIC-16
IC6	16		37.85	270		SO14	74HC02D	ON Semi	74VHC02M	1014103	512-74VHC02M	Quad NOR Gate; SOIC-15
IC7	38.48		31.62	0		SOT23-5	DS28CM00R-A00+T	Maxim	DS28CM00R-A00+T	2514574	700-DS28CM00R-A00T	Maxim (Dallas Semi) I2C/SMBus Silicon Serial Number
IC8	16		29.08	270		TSSOP20	TXB0108PWR	Texas Inst.	TXB0108PWR	1494945		Voltage Level Translator; 8 Input; TSSOP-20
J1	36.2		38.1	180			FLE-108-01-G-DV	Samtec	FLE-108-01-G-DV	2308518	200-FLE10801GDV	Board-To-Board Connector, 1.27 mm, 16 Contacts, 2 Rows
Q1	18.54		3.18	270		SOT23-WIDE	DMG3415U-7	Diodes Inc.	DMG3415U-7	1843688	621-DMG3415U-7	MOSFET; P Channel; SOT23-WIDE
Q2	5.59		8.13	270		SOT23-WIDE	DMG3415U-7	Diodes Inc.	DMG3415U-7	1843688	621-DMG3415U-7	MOSFET; P Channel; SOT23-WIDE
Q3	36.78		21.25	45		SOT23	2N2222	Fairchild	MMBT2222A	9846700		Bipolar (BJT) Single Transistor, NPN, 40 V, 350 mW, 1 A
Q4	38.91		23.79	315		SOT23	2N2222	Fairchild	MMBT2222A	9846700		Bipolar (BJT) Single Transistor, NPN, 40 V, 350 mW, 1 A
R1	14.99		2.41	0		0603	10K	Multicomp	MCWR06X1002FTL	2447230		Chip Resistor; Thick Film; 10k; 50V; 0603; 100mW
R2	14.99		5.33	0		0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R3	2.03		8.13	270		0603	10K	Multicomp	MCWR06X1002FTL	2447230		Chip Resistor; Thick Film; 10k; 50V; 0603; 100mW
R4	8.38		8.26	90		0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R5	27.05		11.18	225		0603	10K	Multicomp	MCWR06X1002FTL	2447230		Chip Resistor; Thick Film; 10k; 50V; 0603; 100mW
R6	14.35		24.89	180		0603	100K	Multicomp	MCWR06X1002FTL	2447230		Chip Resistor; Thick Film; 10k; 50V; 0603; 100mW
R7	2.03		16.89	270		0603	100R	Bourns	CR0603-FX-1000ELF	2371762		Chip Resistor; Thick Film; 100R; 50V; 0603; 100mW
R8	33.66		24	90		0603	1K	Multicomp	MCWR06X1001FTL	2447272		Chip Resistor; Thick Film; 1k; 50V; 0603; 100mW
R9	32.64		32.77	180		0603	2K2	Multicomp	MCWR06X2201FTL	2447320		Chip Resistor; Thick Film; 2.2k; 50V; 0603; 100mW
R10	38.1		28.96	0		0603	2K2	Multicomp	MCWR06X2201FTL	2447320		Chip Resistor; Thick Film; 2.2k; 50V; 0603; 100mW
R11	31.5		24	90		0603	1K	Multicomp	MCWR06X1001FTL	2447272		Chip Resistor; Thick Film; 1k; 50V; 0603; 100mW
R21	7.49		38.61	180		0603	0R	Multicomp	MCMR06X000PTL	2073345		SMD Chip Resistor, 0 ohm, 75 V, 0603, 100 mW
R22	38.1		26.92	0		0603	0R	Multicomp	MCMR06X000PTL	2073345		SMD Chip Resistor, 0 ohm, 75 V, 0603, 100 mW
R23	21.08		6.22	135		0603	0R	Multicomp	MCMR06X000PTL	2073345		SMD Chip Resistor, 0 ohm, 75 V, 0603, 100 mW
U1	24.26		40.51	90		SOT23-5	SPX3819-3.3	Exar	SPX3819M5-L-3-3/TR		701-SPX3819M5-L-33TR	LDO Voltage Regulator; 500mA; SOT-23-5
Bottom Layer Surface Mount Components:												
J2	14.48	28.52	39.12	90	270		FTSH-105-02-L-DV	Samtec	FTSH-105-02-L-DV-P			Samtec FTSH Header, 1.27mm, 10 pins, 2 rows, pick & place

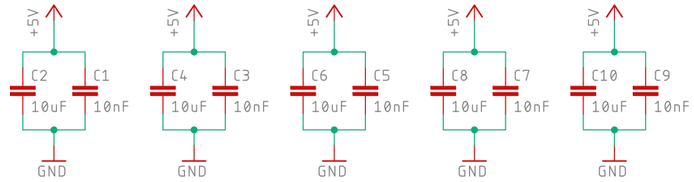
Samtec
FW-08-05-x-D

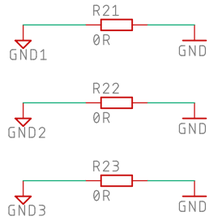


Timing Pulse Distribution

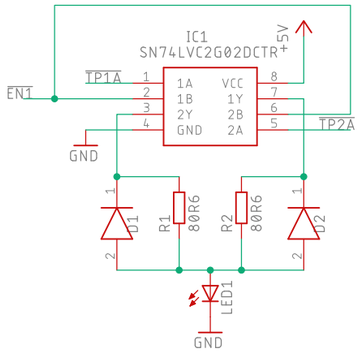


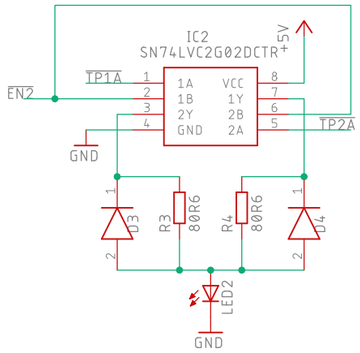
Decoupling Capacitors

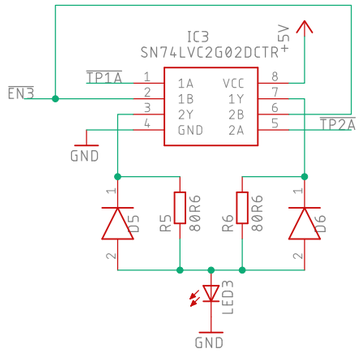


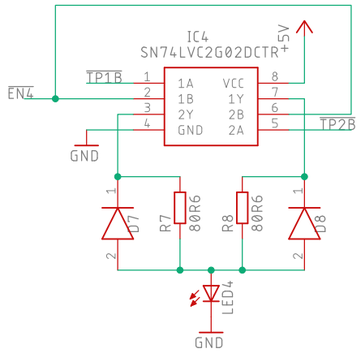


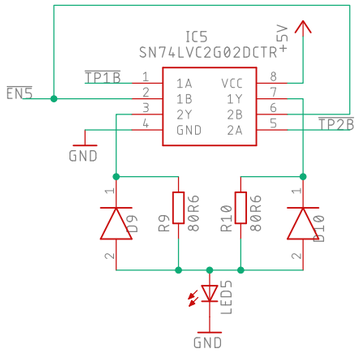
Mounting Hole Grounding

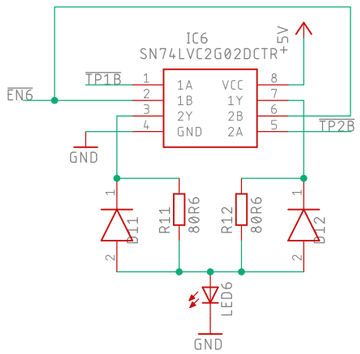


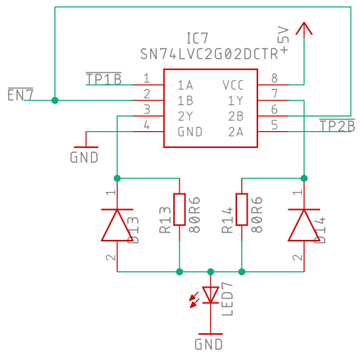


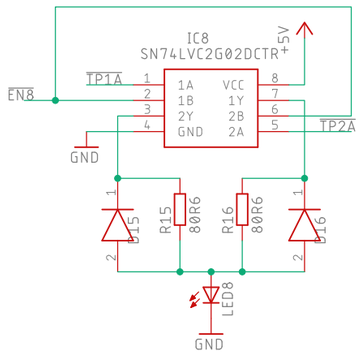


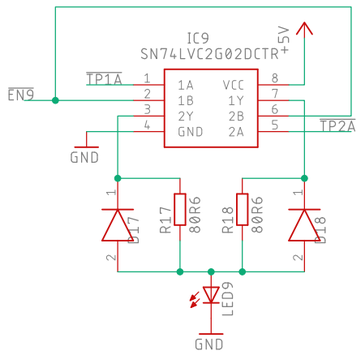


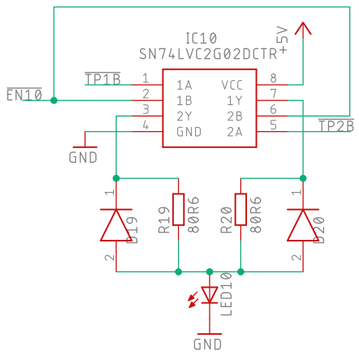








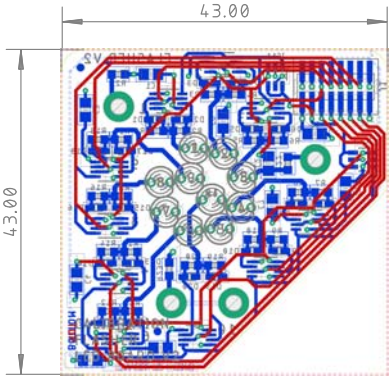


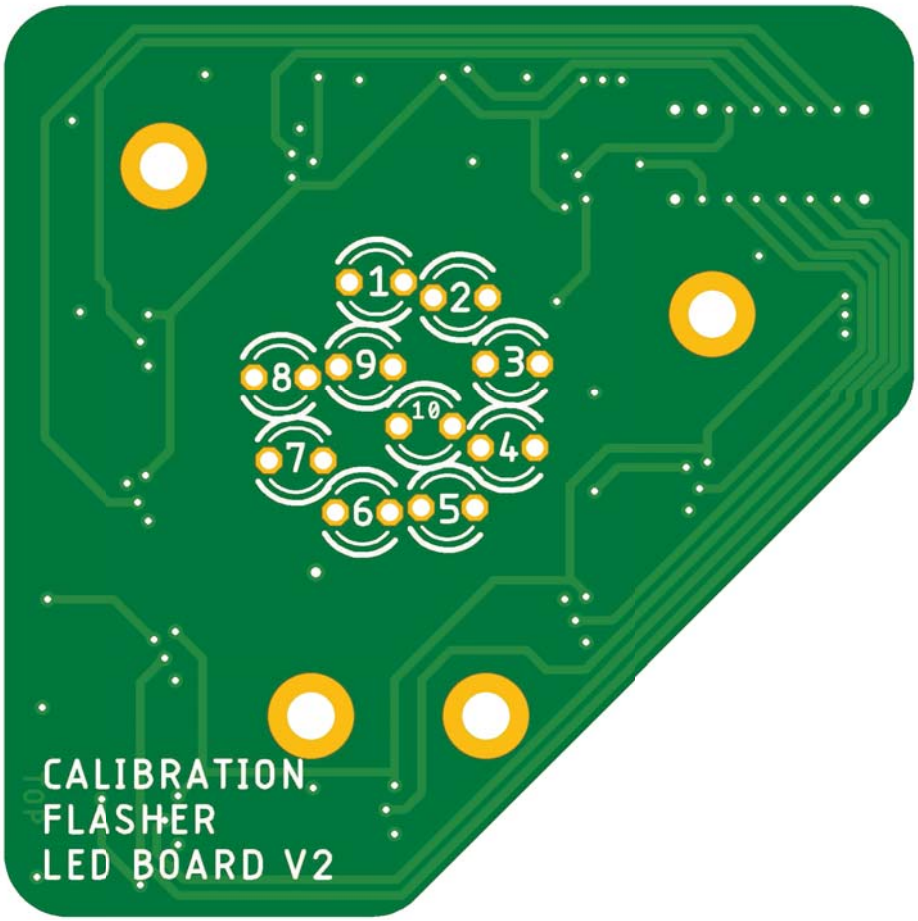


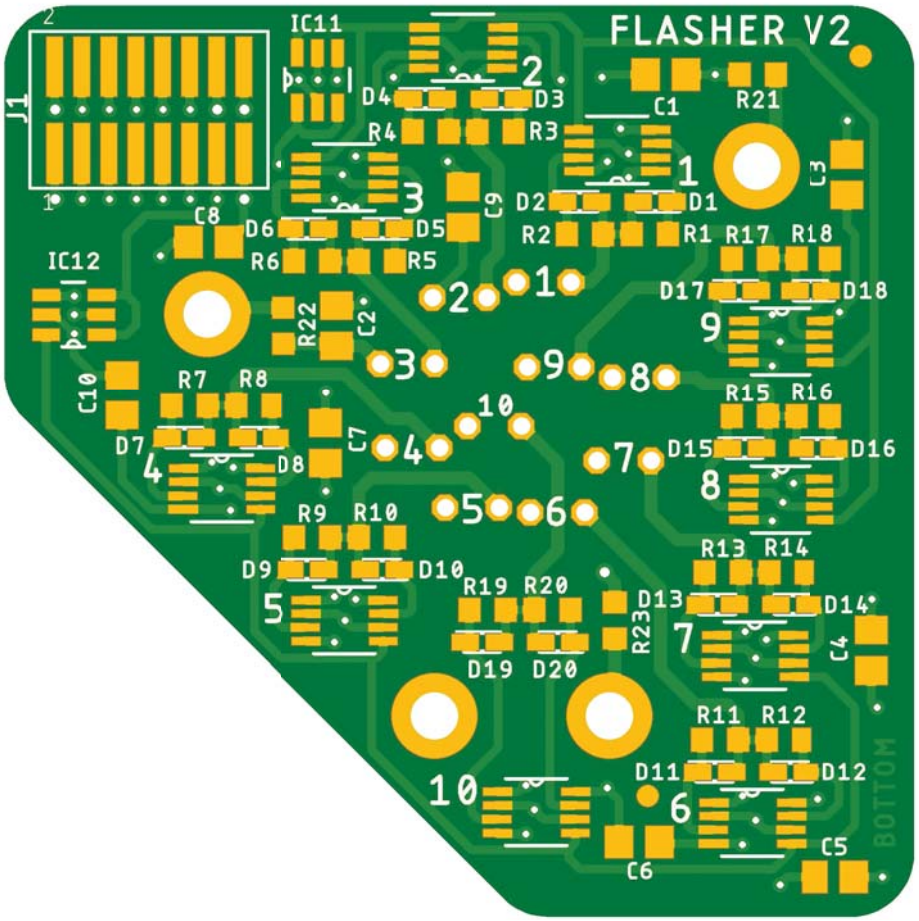
Calibration Flasher LED Board V2

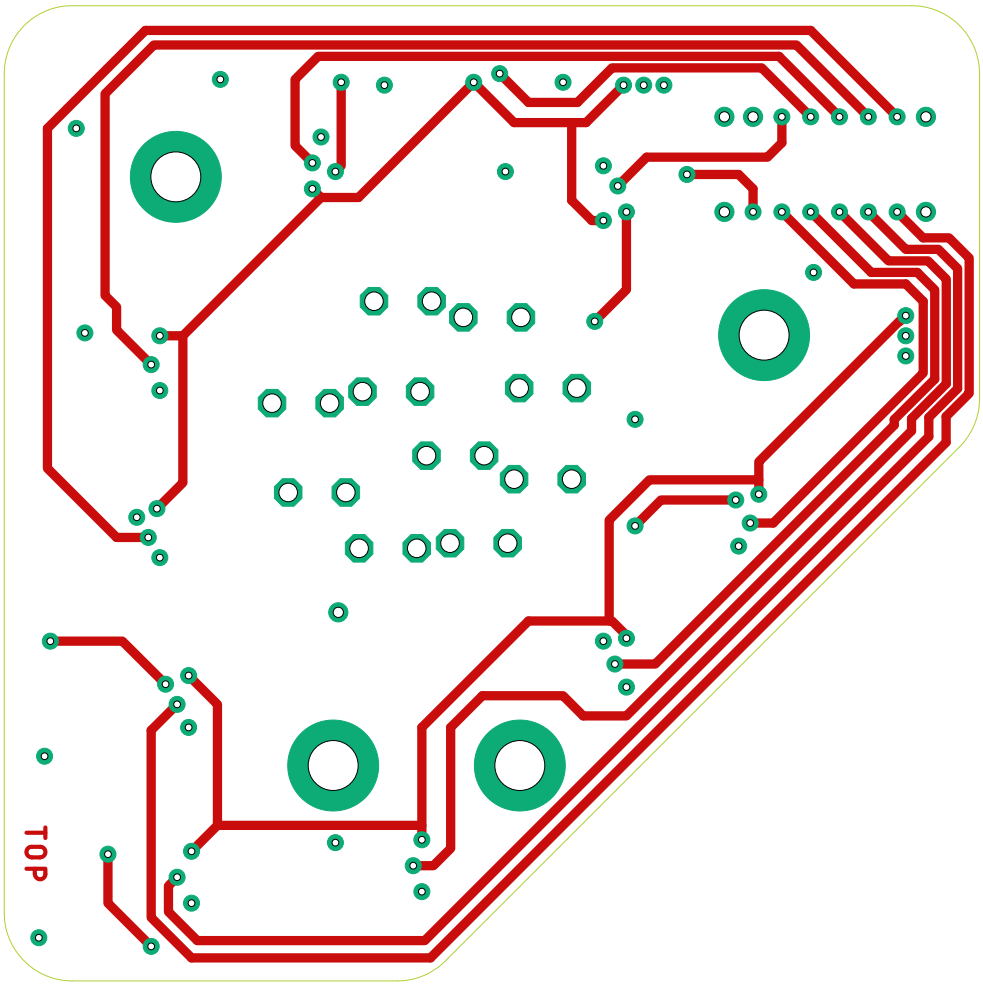
Fiducials

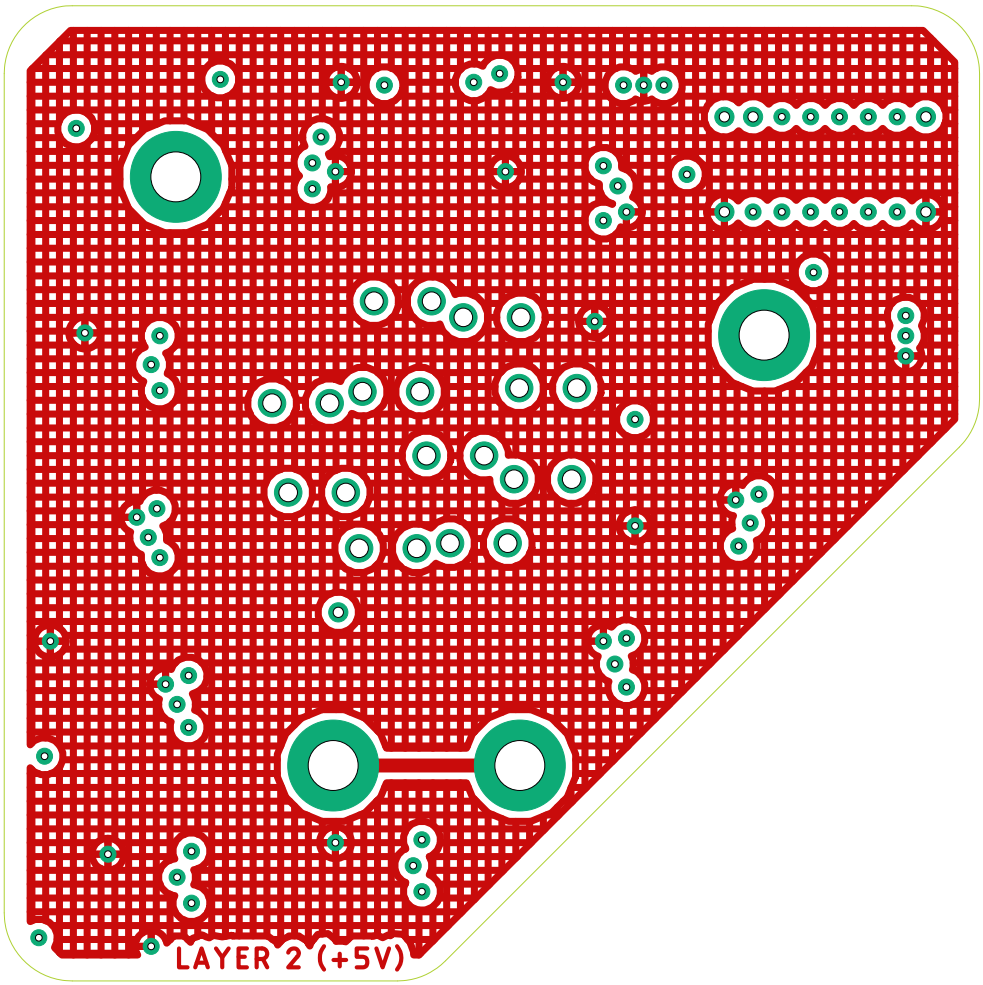
	Flasher_LED_Board
	05/12/2018 15:23
	Sheet: 1/1

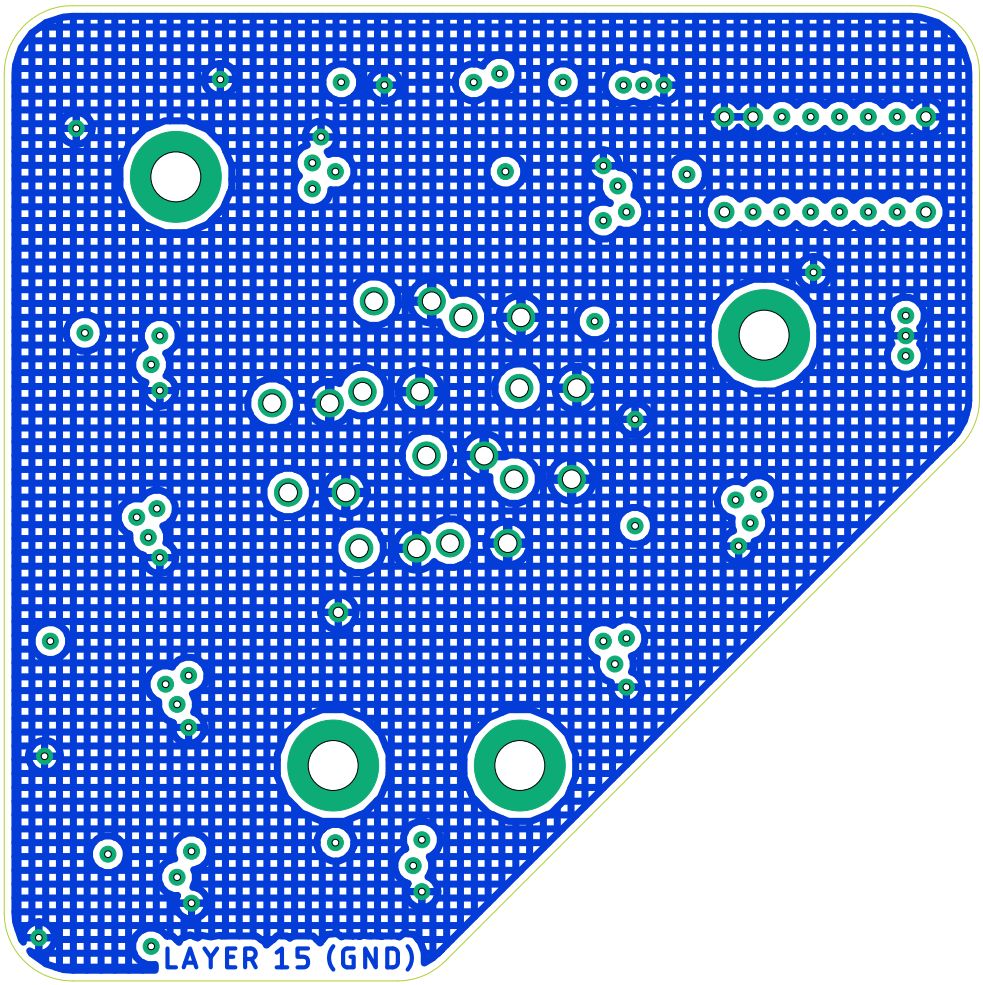

43.00
43.00

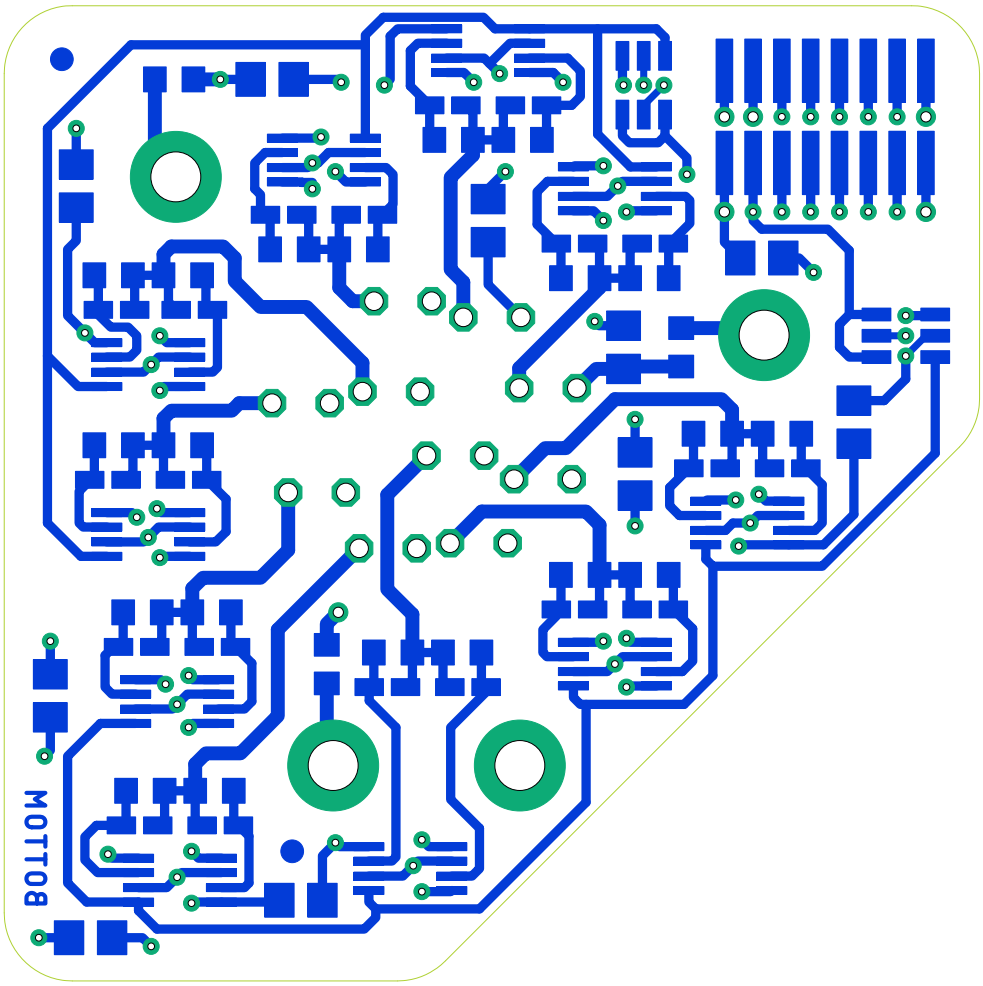

1
2
3
4
5
6
7
8
9
10
CALIBRATION.
FLASHER
.LED BOARD V2


FLASHER V2
J1
IC11
IC12
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
D13
D14
D15
D16
D17
D18
D19
D20
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
BOTTOM

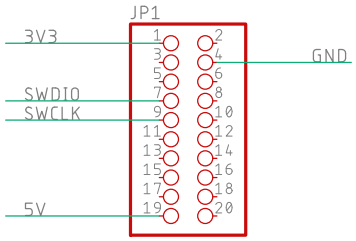

TOP

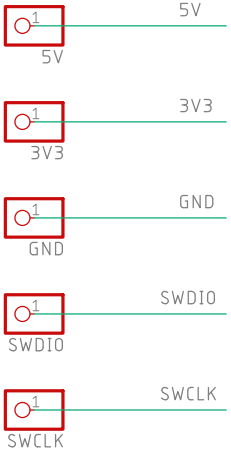

LAYER 2 (+5V)


LAYER 15 (GND)

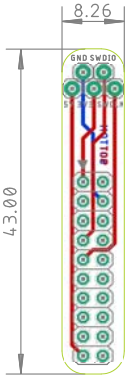

MOTTOB

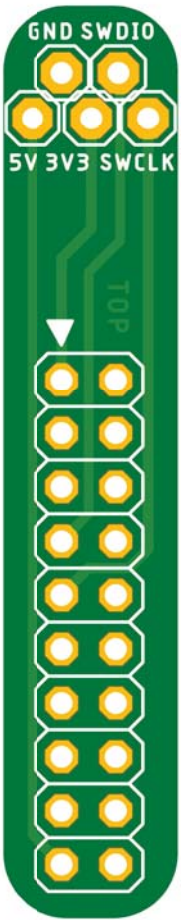
Part	X	X (Mirrored)	Y	Angle	Angle (Mirrored)	Package	Value	Manufacturer	Manufacturer Part No	Farnell Part No	RS Part No	Description
Dimensions	**43.00**		**43.00**									
Fiducials - for solder paste mask alignment:												
FD1	2.54	40.46	40.64	0								Fiducial 1mm
FD2	12.70	30.30	5.71	0								Fiducial 1mm
Surface Mount Components:												
C1	11.81	31.19	39.75	0	0	0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C2	27.30	15.70	27.94	270	90	0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C3	3.18	39.82	35.05	90	270	0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C4	2.03	40.97	12.57	270	90	0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C5	3.81	39.19	1.91	0	0	0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C6	13.08	29.92	3.56	0	0	0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C7	27.81	15.19	22.35	90	270	0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C8	33.40	9.60	31.88	180	180	0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
C9	21.34	21.66	33.53	270	90	0805	10nF	Walsin	0805B103K500CT	2496939		MultiLayer Ceramic Capacitor; 10nF; 50V; 0805; X7R
C10	37.47	5.53	24.64	270	90	0805	10uF	Walsin	0805F106Z100CT	2496998		MultiLayer Ceramic Capacitor; 10uF; 10V; 0805
D1	12.32	30.68	33.78	180	180	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D2	15.88	27.12	33.78	0	0	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D3	19.56	23.44	38.61	180	180	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D4	23.11	19.89	38.61	0	0	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D5	25.15	17.85	32.51	180	180	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D6	28.70	14.30	32.51	0	0	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D7	34.54	8.46	22.61	0	0	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D8	30.99	12.01	22.61	180	180	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D9	28.70	14.30	16.38	0	0	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D10	25.15	17.85	16.38	180	180	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D11	9.53	33.47	6.86	0	0	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D12	5.97	37.03	6.86	180	180	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D13	9.40	33.60	14.73	0	0	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D14	5.84	37.16	14.73	180	180	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D15	8.13	34.87	22.10	0	0	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D16	4.57	38.43	22.10	180	180	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D17	8.38	34.62	29.59	0	0	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D18	4.95	38.05	29.59	180	180	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D19	20.45	22.55	12.95	0	0	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
D20	16.89	26.11	12.95	180	180	0603	CD0603-B00340	Bourns	CD0603-B00340	1456534		Small Signal Schottky Diode, 40 V, 370 mV, 500 mA
IC1	14.10	28.90	36.20	180	180	SOP65P400X130-8N	SN74LVC2G02DCTR	Texas Inst	SN74LVC2G02DCTR	1236358		NOR Gate, 2 Input, 32 mA, 1.65 V to 5.5 V, SSOP-8
IC2	21.34	21.66	41.02	180	180	SOP65P400X130-8N	SN74LVC2G02DCTR	Texas Inst	SN74LVC2G02DCTR	1236358		NOR Gate, 2 Input, 32 mA, 1.65 V to 5.5 V, SSOP-8
IC3	26.92	16.08	34.93	180	180	SOP65P400X130-8N	SN74LVC2G02DCTR	Texas Inst	SN74LVC2G02DCTR	1236358		NOR Gate, 2 Input, 32 mA, 1.65 V to 5.5 V, SSOP-8
IC4	32.77	10.23	20.19	0	0	SOP65P400X130-8N	SN74LVC2G02DCTR	Texas Inst	SN74LVC2G02DCTR	1236358		NOR Gate, 2 Input, 32 mA, 1.65 V to 5.5 V, SSOP-8
IC5	26.92	16.08	13.97	0	0	SOP65P400X130-8N	SN74LVC2G02DCTR	Texas Inst	SN74LVC2G02DCTR	1236358		NOR Gate, 2 Input, 32 mA, 1.65 V to 5.5 V, SSOP-8
IC6	7.75	35.25	4.45	0	0	SOP65P400X130-8N	SN74LVC2G02DCTR	Texas Inst	SN74LVC2G02DCTR	1236358		NOR Gate, 2 Input, 32 mA, 1.65 V to 5.5 V, SSOP-8
IC7	7.62	35.38	12.32	0	0	SOP65P400X130-8N	SN74LVC2G02DCTR	Texas Inst	SN74LVC2G02DCTR	1236358		NOR Gate, 2 Input, 32 mA, 1.65 V to 5.5 V, SSOP-8
IC8	6.35	36.65	19.69	0	0	SOP65P400X130-8N	SN74LVC2G02DCTR	Texas Inst	SN74LVC2G02DCTR	1236358		NOR Gate, 2 Input, 32 mA, 1.65 V to 5.5 V, SSOP-8
IC9	6.35	36.65	27.18	0	0	SOP65P400X130-8N	SN74LVC2G02DCTR	Texas Inst	SN74LVC2G02DCTR	1236358		NOR Gate, 2 Input, 32 mA, 1.65 V to 5.5 V, SSOP-8
IC10	17.91	25.09	4.95	0	0	SOP65P400X130-8N	SN74LVC2G02DCTR	Texas Inst	SN74LVC2G02DCTR	1236358		NOR Gate, 2 Input, 32 mA, 1.65 V to 5.5 V, SSOP-8
IC11	28.19	14.81	39.50	90	270	SOT95P280X145-6N	SN74LVC2G14DBVT	Texas Inst	SN74LVC2G14DBVT	1740048		Dual Inverter, 32 mA, 1.65 V to 5.5 V, SOT-23-6
IC12	39.75	3.25	28.45	180	180	SOT95P280X145-6N	SN74LVC2G14DBVT	Texas Inst	SN74LVC2G14DBVT	1740048		Dual Inverter, 32 mA, 1.65 V to 5.5 V, SOT-23-6
J1	36.20	6.80	38.10	0	0		FTSH-108-02-L-DV	Samtec	FTSH-108-02-L-DV-P			Samtec FTSH Connector, 1.27mm, 16 pins, 2 rows, pick & place
R1	12.57	30.43	32.26	0	0	0603	130R	Multicomp	MCWR06X1300FTL	2447248		SMD Chip Resistor, 130 ohm, 50 V, 0603, 100 mW
R2	15.62	27.38	32.26	180	180	0603	130R	Multicomp	MCWR06X1300FTL	2447248		SMD Chip Resistor, 130 ohm, 50 V, 0603, 100 mW
R3	19.81	23.19	37.08	0	0	0603	110R	Multicomp	MCWR06X1100FTL	2447235		SMD Chip Resistor, 110 ohm, 50 V, 0603, 100 mW
R4	22.86	20.14	37.08	180	180	0603	110R	Multicomp	MCWR06X1100FTL	2447235		SMD Chip Resistor, 110 ohm, 50 V, 0603, 100 mW
R5	25.40	17.60	30.99	0	0	0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R6	28.45	14.55	30.99	180	180	0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R7	34.29	8.71	24.13	180	180	0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R8	31.24	11.76	24.13	0	0	0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R9	28.45	14.55	17.91	180	180	0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R10	25.40	17.60	17.91	0	0	0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R11	9.27	33.73	8.38	180	180	0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R12	6.22	36.78	8.38	0	0	0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R13	9.14	33.86	16.26	180	180	0603	100R	Yageo	RC0603FR-07100RL	9238360		SMD Chip Resistor, 100 ohm, 75 V, 0603, 100 mW
R14	6.10	36.90	16.26	0	0	0603	100R	Yageo	RC0603FR-07100RL	9238360		SMD Chip Resistor, 100 ohm, 75 V, 0603, 100 mW
R15	7.87	35.13	23.62	180	180	0603	120R	Multicomp	MCWR06X1200FTL	2447240		SMD Chip Resistor, 120 ohm, 50 V, 0603, 100 mW
R16	4.83	38.17	23.62	0	0	0603	120R	Multicomp	MCWR06X1200FTL	2447240		SMD Chip Resistor, 120 ohm, 50 V, 0603, 100 mW
R17	7.87	35.13	31.12	180	180	0603	140R	Multicomp	MCWR06X1400FTL	2447251		SMD Chip Resistor, 140 ohm, 50 V, 0603, 100 mW
R18	4.83	38.17	31.12	0	0	0603	140R	Multicomp	MCWR06X1400FTL	2447251		SMD Chip Resistor, 140 ohm, 50 V, 0603, 100 mW
R19	20.19	22.81	14.48	180	180	0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R20	17.14	25.86	14.48	0	0	0603	80R6	Multicomp	MCWR06X80R6FTL	2694949		SMD Chip Resistor, 80.6 ohm, 75 V, 0603, 100 mW
R21	7.49	35.51	39.75	180	180	0603	0R	Multicomp	MCMR06X000PTL	2073345		SMD Chip Resistor, 0 ohm, 75 V, 0603, 100 mW
R22	29.85	13.15	27.94	270	90	0603	0R	Multicomp	MCMR06X000PTL	2073345		SMD Chip Resistor, 0 ohm, 75 V, 0603, 100 mW
R23	14.22	28.78	13.97	90	270	0603	0R	Multicomp	MCMR06X000PTL	2073345		SMD Chip Resistor, 0 ohm, 75 V, 0603, 100 mW
Non-surface mount components:												
LED1-10								Bivar	UV3TZ-400-15		713-5021P	Ultraviolet LED, 3mm, 10mW, 400nm, 15 deg, 3.3V, 20mA Max

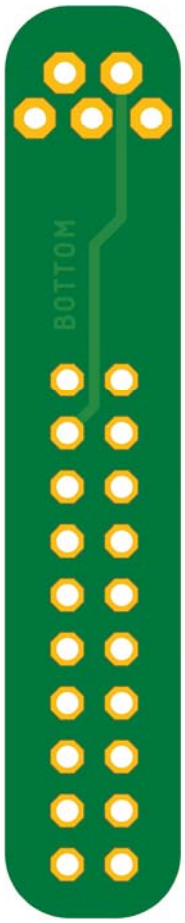




Programming_Adaptor	
04/03/2019 11:40	
Sheet: 1/1	


8.26
43.00
GND SWDIO
INCTOP


GND SWDIO
5V 3V3 SWCLK
TOP


BOTTOM