

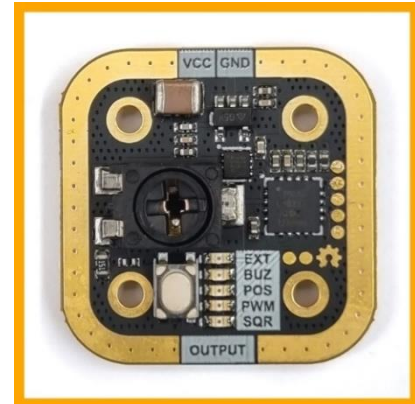
flexar

FLEXAR DRIVER

1. Introduction

The Flexar-Driver makes it easier to control and learn about PCB actuators. It features a six-mode differential driver that can supply up to 1.8 Amps and control the position, speed, or sound of one or more actuators. The board's dimensions are just 2.48 cm x 2.48 cm making it small, compact, and even stackable with the [12-layer PCB Coil](#). This driver can also be used to drive other off-the-shelf dc motors and solenoids.

The open-source files for this driver are available [here](#).

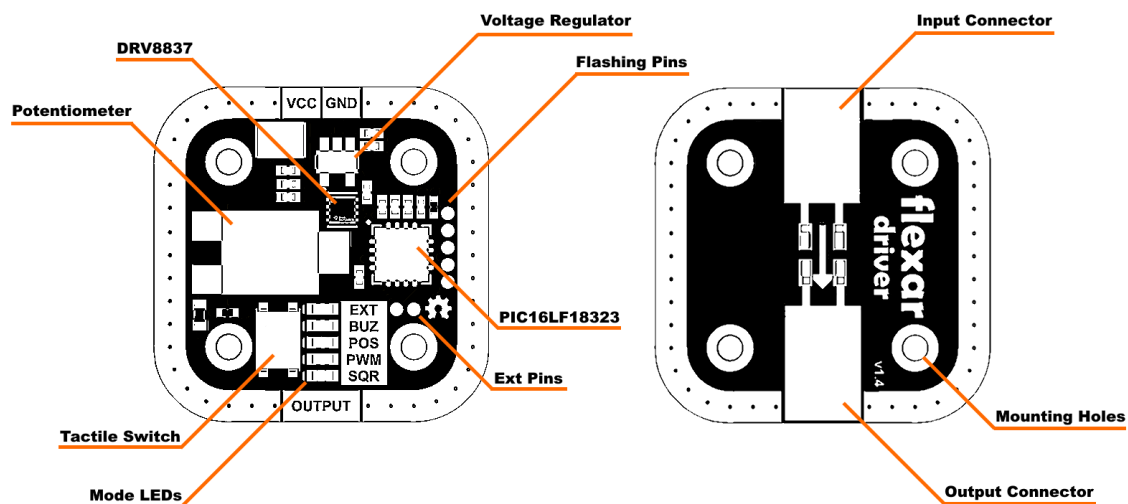


2. Electrical Specifications

The driver's input and output connectors are on the backside and have a standard 2.54mm pitch female connector.

Electrical Specifications	
Minimum Input Voltage	3.5 V
Maximum Input Voltage	11 V
Maximum Output Current	1.8 A
Maximum Drain-Source Resistance	330 mΩ
Logic Voltage	3.3 V

The top silkscreen indicates the input voltage polarity which is marked with 'VCC' and 'GND'. This has an allowable input voltage range of 3.5V to 11V. However, make sure to power each PCB actuator within its datasheet recommended voltage level to avoid over-heating. The board has an on-board 3.3V voltage-regulator with over-current protection, thermal protection, and reverse-current protection.



The four M2 mounting holes and exposed copper, are connected to ground. These holes can be used to stack the [12-layer PCB Coil](#). Non-conductive screws are preferred, as grounding the 12-layer PCB Coil's copper plane could diminish its magnetic field strength by around 1mT.

The board also has a DRV8837 h-bridge driver that is controlled by PIC16LF18323 microcontroller. Using the tactile switch, one can change between six-modes (SQR, PWM, POS1, POS2, BUZ, EXT) and vary the frequency or duty cycle using the on-board potentiometer.

3. Firmware

When the driver is turned on, it will initially:

- Initialize its peripherals and light up the LEDs sequentially
- Output a 1.9kHz PWM signal to making a buzzing sound. This will only be audible if a flexar actuator is connected (PCB coil + magnet)
- Reads the potentiometer value and set up the output according to the initial mode. On the first power-up the mode will be set to 'SQR' mode. However, if the user uses another mode more frequently (longer than 5minutes) the driver will automatically save this new function as the initial start-up mode. This saving procedure is indicated by briefly increasing the brightness of the corresponding mode-LED.

The whole initialization sequence will be performed in under 0.6 second. Once this is performed, the software will continuously monitor both the tactile switch and the potentiometer. The potentiometer is used to control the actuator's parameters, which can be adjusted using a phillips-screwdriver. Whenever the tactile switch is pressed, the driver's mode will change the output's functionality and light up the designate LED. Each function is explained below:

3.1. SQR (Square Wave Mode)

In this mode the output will drive a square wave between +Vcc and -Vcc. Turning the potentiometer will adjust the frequency between 0.5Hz to 30Hz in steps of 0.5Hz, which changes the actuation speed of the coil or magnet. The signal accuracy is described below:

- Maximum Error of $\pm 0.03\text{Hz}$ for frequencies between 0.5Hz to 5Hz
- Maximum Error of $\pm 0.1\text{Hz}$ for frequencies between 5Hz to 20Hz
- Maximum Error of $\pm 0.25\text{Hz}$ for frequencies between 20Hz to 30Hz

Note that, the maximum speed of the PCB-actuator does not only depend on the driving frequency, but also on the actuation distance, total weight, magnet's strength, and other mechanical parameters. In most applications the maximum speed will be lower than 15Hz, to give the coil or magnet enough time to react to the changing magnetic field. Higher frequencies can be used for other vibration applications.

3.2. PWM (Pulse-Width-Modulation Mode)

Using this function, the actuator will be driven more 'gently' than the SQR-mode. The output will still be driven differentially, but instead of applying a square-wave it uses a series of 20.2kHz PWM pulses with varying duty-cycles, to create a triangular waveform.

This function is more intended for lower frequency applications. Turning the potentiometer will adjust the frequency of the wave between 0.5Hz to 30Hz in steps of 0.5Hz, which changes the actuation speed of the coil or magnet.

3.3. POS (Position Mode 1)

In this mode the output is powered with a 20.2kHz square wave. The potentiometer can be used to adjust the output's duty-cycle between 0% to 100%, in 2% steps to control the position of the magnet or coil. The 2% steps have a $\pm 0.3\%$ error that depends on the supply voltage and loading current.

Note that, the maximum actuation distance of the PCB-actuator will also depend on the total weight, magnet's strength, and other mechanical parameters.

3.4. POS (Position Mode 2)

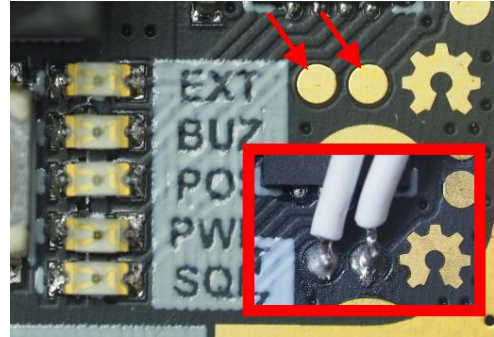
This function is identical to *Position Mode 1* but the position will be adjusted in the opposite magnetic polarity. Both *Position Mode 1* and *Position Mode 2* will light up the same POS-LED.

3.5. BUZ (Buzzer Mode)

This mode allows you to use PCB actuators as buzzers. The output is driven differentially with a fixed 50% duty-cycle and turning the potentiometer will adjust the frequency between 1.78kHz-16.8kHz divided into 64 unique values.

3.6. EXT (External Mode)

This function allows you to control the driver with two external signals and directly control the DRV8837 driver. This can be done by soldering two wires on the pads as shown in the image. These signals can be provided by any other 3.3V logic level microcontroller.



Please note that:

- The maximum rated voltage on these pins is 3.3V. Any higher voltage might damage the controller.
- During power on, the board will play a buzzing sound used by these pins. To avoid damage, make sure that the externally supplied signals are enabled after the driver's initialization routine (0.6seconds).

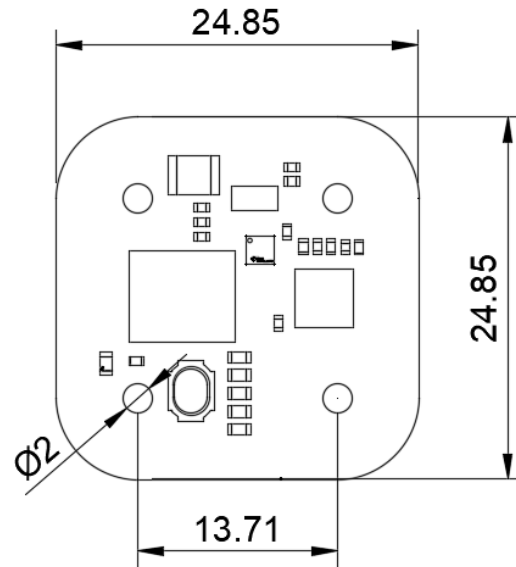
One can also write custom firmware and reflash the PIC16LF18323 microcontroller using the pins shown in the image.



The open-source files for firmware are available [here](#).

5. Mechanical Drawing

PCB Specifications	
Dimensions	24.85mm x 24.85mm
Connector Pitch	2.54mm
PCB Thickness	0.8mm
Total thickness	4.8mm
Weight	2.4 grams
Tg Rating	150°C
Layers	4
Soldermask	Black
Silkscreen	White
Copper Thickness	1oz

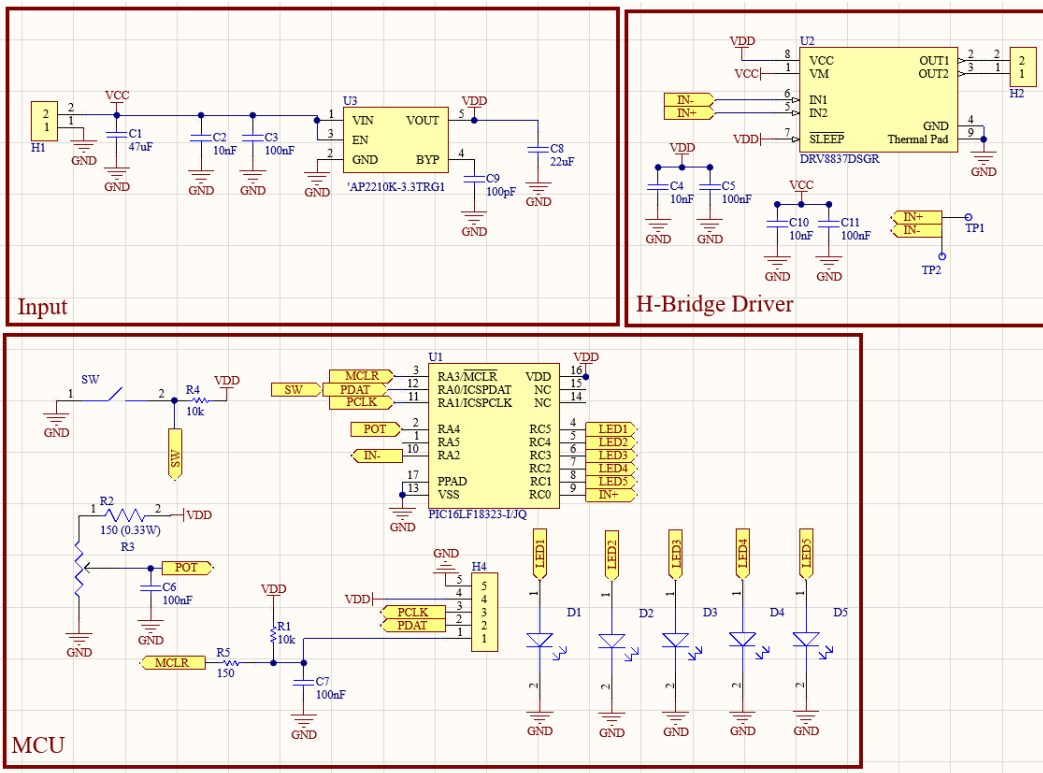


The open-source files for 3D Printed Cases are available [here](#).

Other information:

- PCB is ROHS Compliance
- PCB meets IPC-A-600 II standard requirements

4. Schematics



5. Bill of Materials

Part Number	Designator
CL32A476KOJNNE	C1
04025C103MAT2A	C2, C4, C10
CL05B104KA5NNNC	C3, C5, C6, C7, C11
CM05X5R226M06AH080	C8
CC0402KRX7R9BB101	C9
LTST-C190KFKT	D1, D2, D3, D4, D5
BG300-02-A-L-A	H1, H2
RC0402JR-0710KL	R1, R4
CRCW0603150RJNEAHP	R2
N6L50T0S-503A3030R-E	R3
RC0402FR-07150RL	R5
PTS815 SJK 250 SMTR LFS	SW
PIC16F18323-I/JQ	U1
DRV8837DSGR	U2
AP2210K-3.3TRG1	U3

The open-source files for PCB are available [here](#).