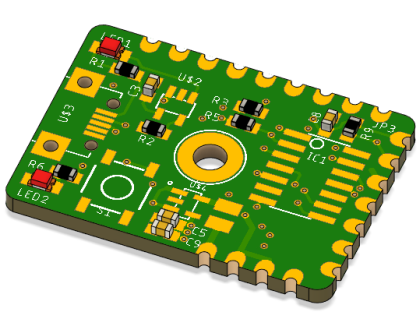
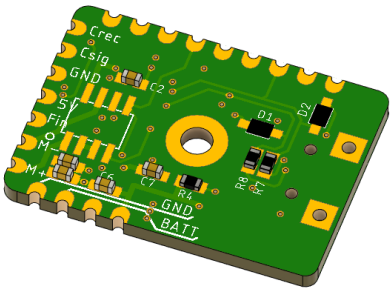
Perfect-Capo

Electrical Overview

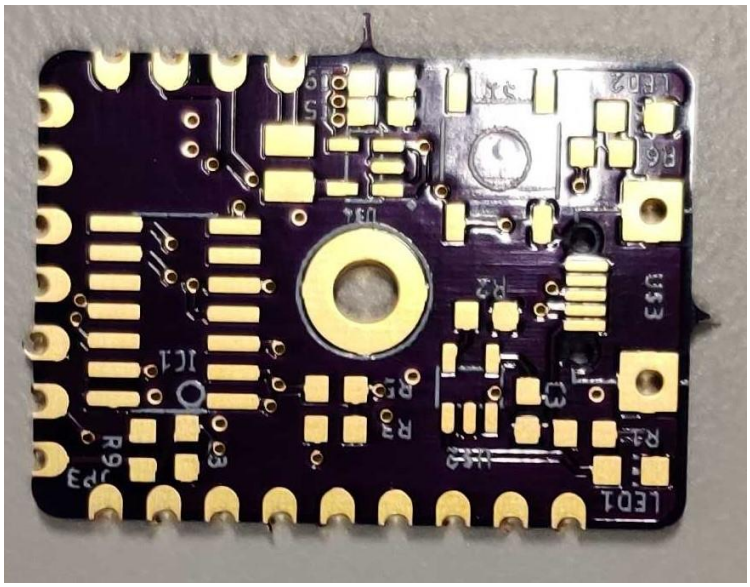
Generate Fall 2019

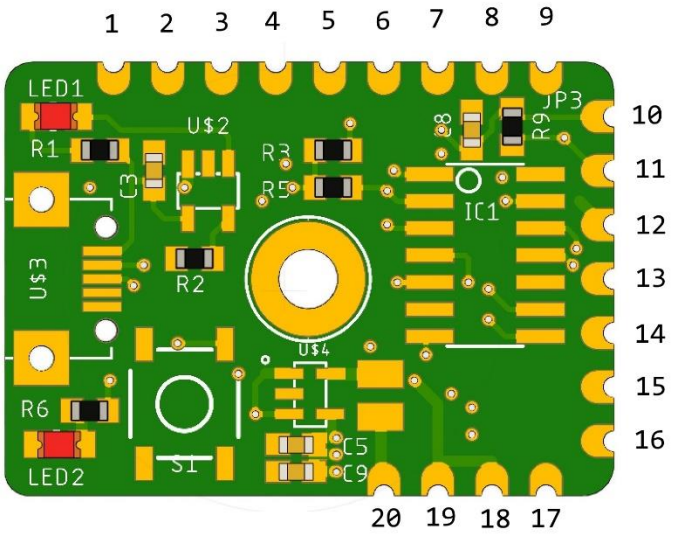
Overview:



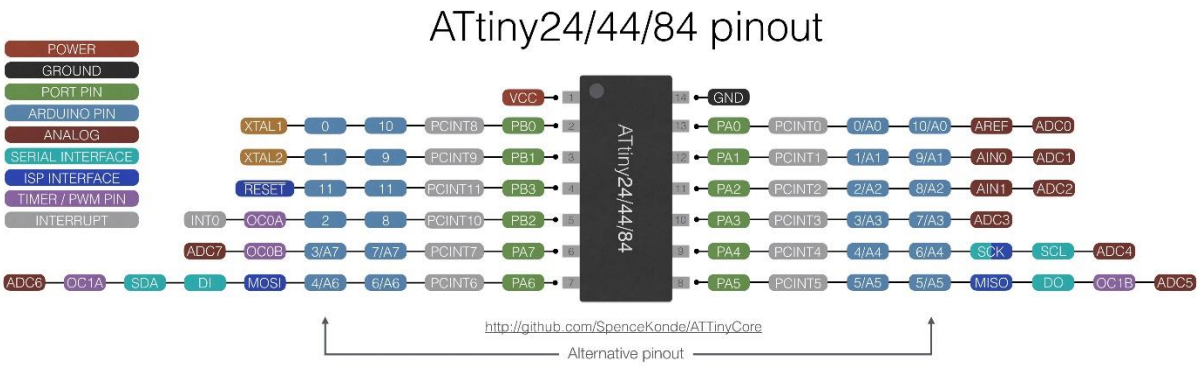


The electrical system of perfect-capo is capable of unclenching the clamp mechanism via capacitive touch. The board uses an ATtiny84 MCU for basic logic and control. It is capable of driving the speed and direction of a DC Motor via an H-bridge. The pins along the edge of the PCB are for external connections to be soldered on (such as Motor, Capacitive touch, Battery, Switch). The entire system is powered by a 3.7v LiPo Battery which is buck-boosted to 5v for better motor performance. A Micro-USB connector is present for programming and battery charging. The MCU uses a bootloader to simulate USB for simple hardware implementation. It is also able to charge the LiPo via the MCP73831 IC. Many additional pinouts are available for easy hackability and ease of use.





Pin	Function	Pin_Ref
1	Miso	5
2	Reset	Reset(11)
3	D-	10
4	D+	9
5	GND	GND
6	Rin	6
7	Fin	8
8	SCK	4
9	5V	5V
10	Cap_Rec	2
11	Cap_Sig	1
12	GND	GND
13	5V	5v
14	Fin	8
15	M-	N/A
16	M+	N/A
17	Bat_GND	N/A
18	V_Bat	N/A
19	$Switch_1$	N/A
20	$Switch_2$	N/A

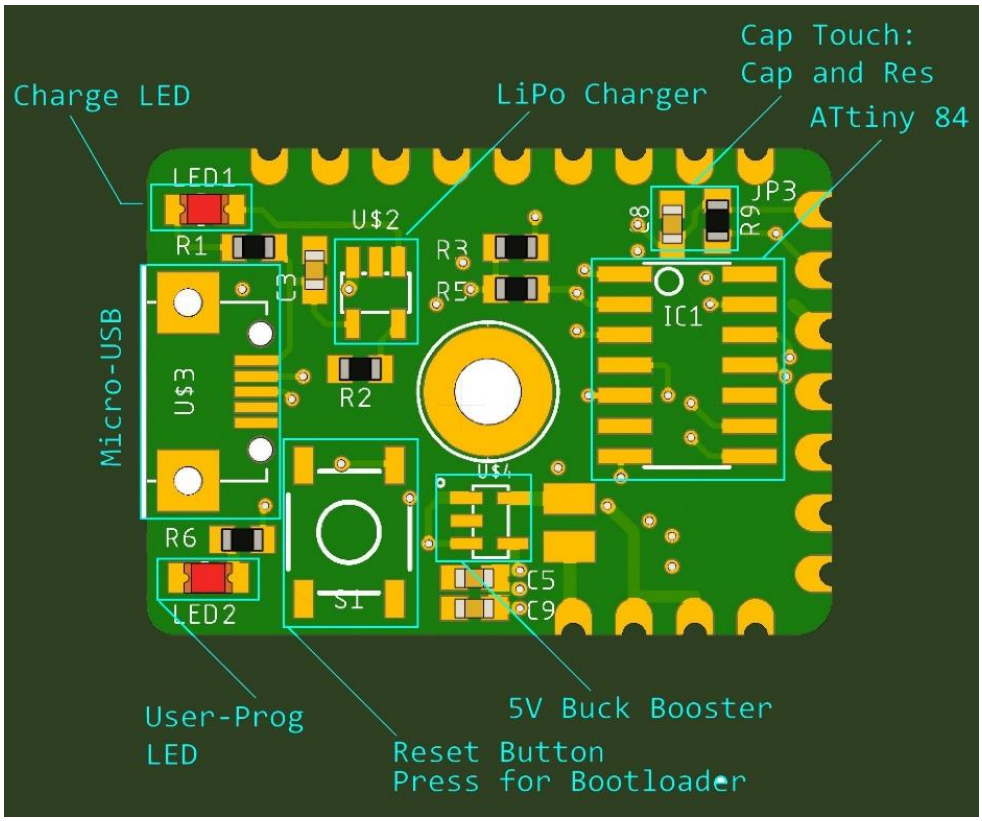


Hardware:

The hardware overview will focus on each crucial portion of the schematic. Explaining how it works, its limits, why its there, and additional information.

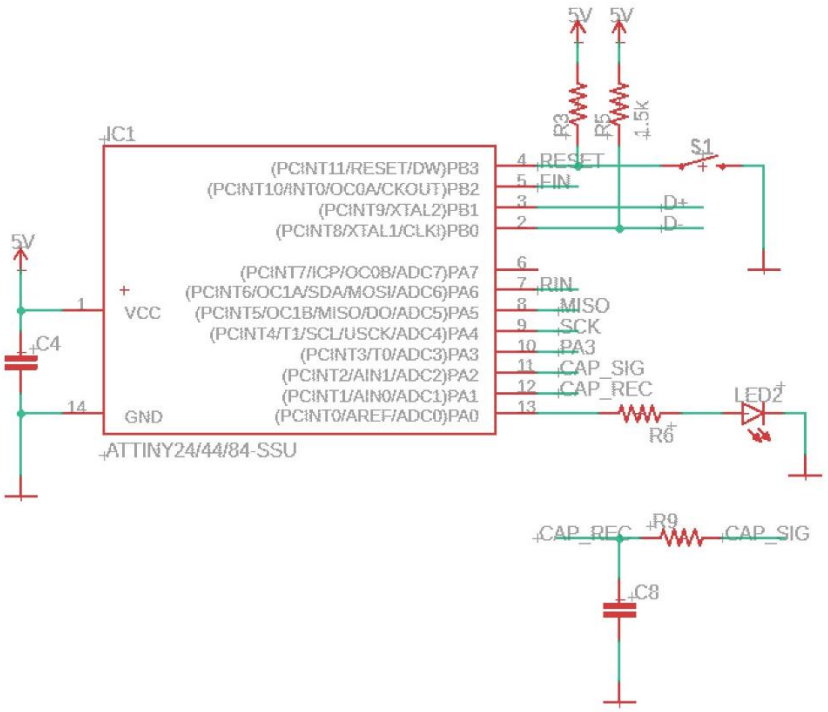
Sections:

- ATtiny 84
- 5V Booster
- H-Bridge
- LiPo Charger



Physical Board Layout

ATtiny 84:

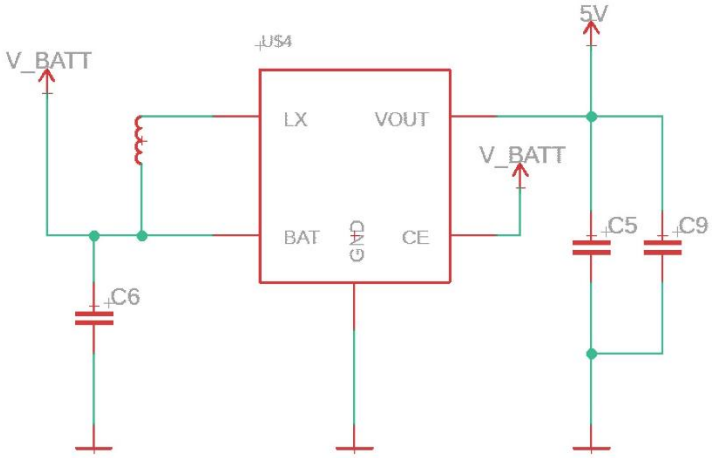


The ATtiny84 holds the core functionality and logic for the device. It engages the motor as it detects the capacitive touch. There is a debug LED used for testing purposes or additional indication. The Reset button is required to force the ATtiny84 into it's bootloader. Once in the bootloader the device will wait for 10 seconds before running the user defined program. During those 10 seconds the user defined program can be rewritten with IDE and Micro-USB. C8 and R9 are used for setting the RC constant for capacitive touch (more info in software section). As usual there is a 100nF capacitor near the 5V and GND pin to reduce noise.

Additional Resources:

- Bootloader How-To:
  - https://learn.sparkfun.com/tutorials/how-to-install-an-attiny-bootloader-with-virtual-usb/all
- Capacitive Touch:
  - https://playground.arduino.cc/Main/CapacitiveSensor/
- ATtiny 84:
  - https://www.digikey.com/product-detail/en/microchip-technology/ATTINY84A-SSUR/ATTINY84A-SSURCT-ND/2774136

5V Buck-Booster:

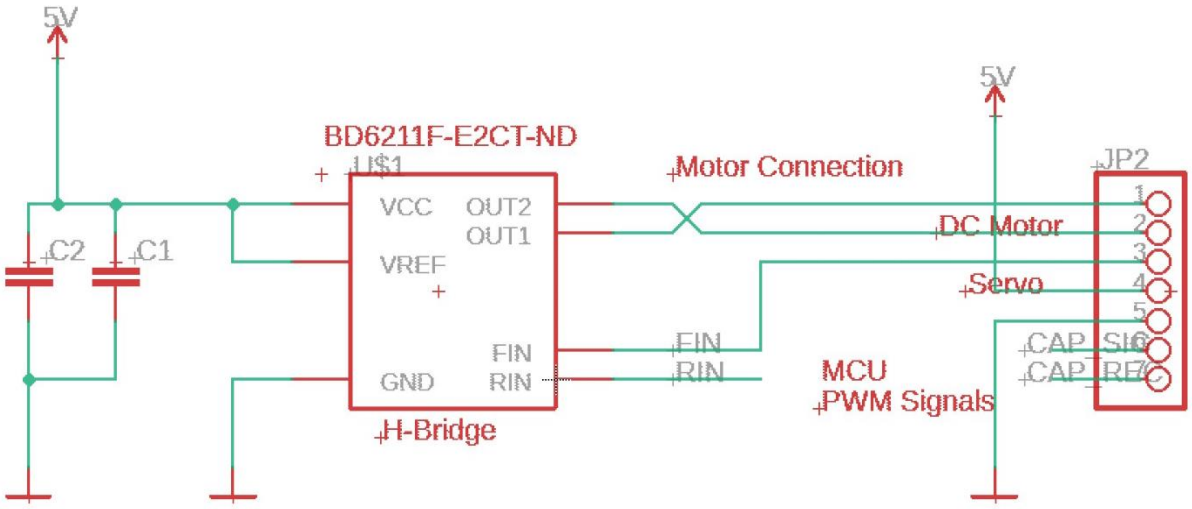


The XC9141B50 IC is capable of boosting the LiPo battery and providing 5V and 800mA to the entire system. It uses a 4.7uH inductor with a switching frequency of 1Mhz. It provides just enough to power the DC motor. Ideally it should be able to supply more current since the max torque current draw of the DC Motor is exactly 800mA. Also, more capacitance is needed. Additional capacitors were soldered on after fabrication. The capacitors used here were rated: 0603 10V 10uF.

Additional Resources:

- **Buck Booster IC:**
  - https://www.digikey.com/product-detail/en/torex-semiconductor-ltd/XC9141B50CMR-G/893-1369-1-ND/6148753
- **Inductor:**
  - https://www.digikey.com/product-detail/en/w-rth-elektronik/74405024047/732-10778-1-ND/6598212

H-Bridge:



The BD6211F is the perfect H-Bridge for driving a mid-tier DC Motor. The H-Bridge can handle 5.5V with a max current draw of 1A. The H-bridge is controlled through its FIN and RIN pins which are connected to GPIO on the ATtiny84. The MCU then can supply a PWM signal to control the speed and direction of the DC Motor. Additional Capacitance is needed on VCC.

Table 4 Logic table

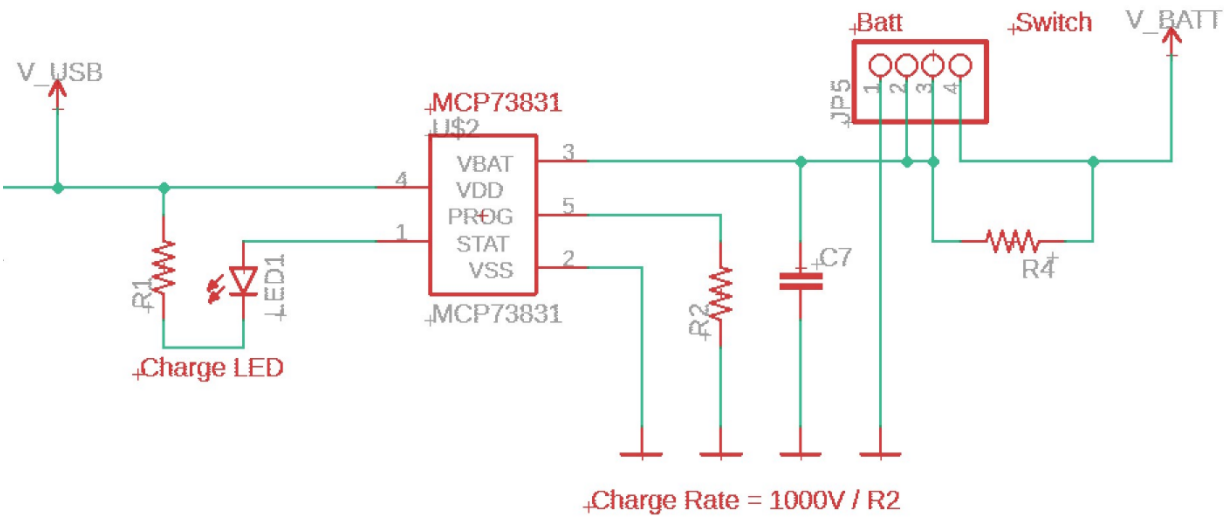
Mode	FIN	RIN	VREF	OUT1	OUT2	Operation
a	L	L	X	Hi-Z(Note)	Hi-Z (Note)	Stand-by (idling)
b	H	L	VCC	H	L	Forward (OUT1 > OUT2)
c	L	H	VCC	L	H	Reverse (OUT1 < OUT2)
d	H	H	X	L	L	Brake (stop)
e	PWM	L	VCC	H	$\overline{PWM}$	Forward (PWM control mode A)
f	L	PWM	VCC	$\overline{PWM}$	H	Reverse (PWM control mode A)
g	H	PWM	VCC	$\overline{PWM}$	L	Forward (PWM control mode B)
h	PWM	H	VCC	L	$\overline{PWM}$	Reverse (PWM control mode B)
i	H	L	Option	H	$\overline{PWM}$	Forward (VREF control)
j	L	H	Option	$\overline{PWM}$	H	Reverse (VREF control)

Logic table for valid FIN and RIN control signals. Datasheet Page 10.

Additional Resources:

- **H-Bridge:**
  - https://www.digikey.com/product-detail/en/rohm-semiconductor/BD6211F-E2/BD6211F-E2TR-ND/1739142

Lipo-Charger:



The MCP73831 is an amazingly convenient single cell 4.2v LiPo charger. It's easy to implement and operate. A single resistor sets the charge rate (which should not be greater than the capacity of the LiPo). The LED indicates the charge status. The STAT pin will be grounded while charging and high when done charging. The direction of the LED will indicate either state.

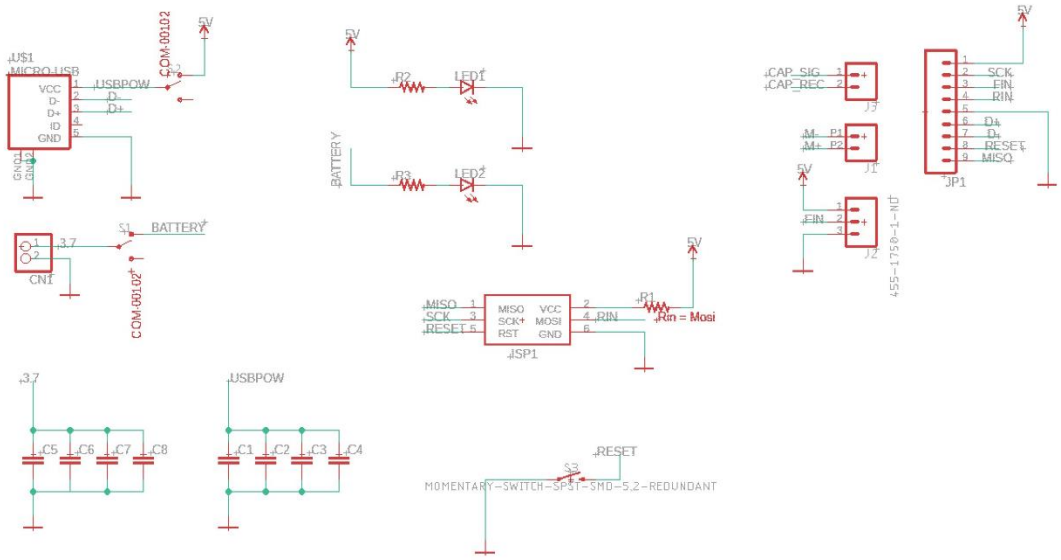
It should be noted that the photo above also includes pinouts (JP5:3 JP5:4) for a switch (which is also R4). This could be used as a power switch for the perfect-capo unit.

Additional Resources:

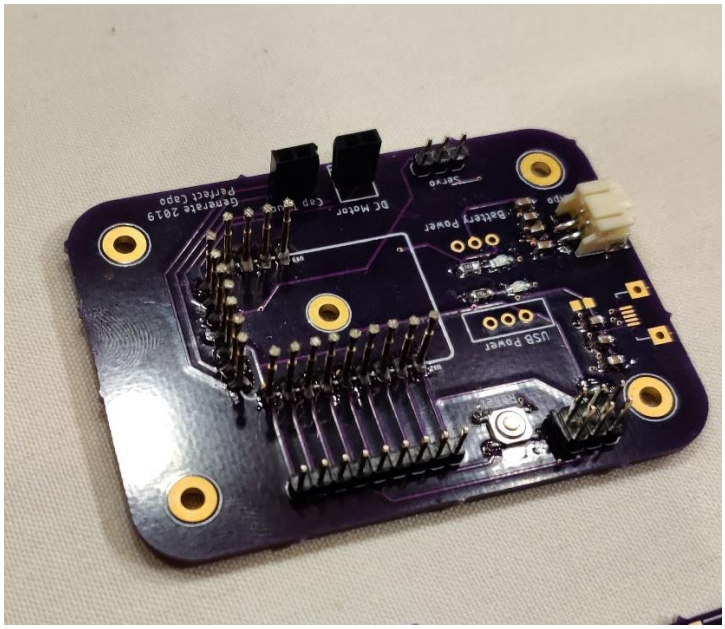
- **LiPo Charger IC:**
  - https://www.digikey.com/product-detail/en/MCP73831T-2ACI%2fOT/MCP73831T-2ACI%2fOTCT-ND/1979802

Development Board:

Since the Perfect-Capo PCB is rather small, a development board was created to help with initial prototyping and ease of interfacing. Another use for the development board could be for mass production testing. The board has pogo-pins which allow for quick and easy temporary connection. The dev board can perform initial programming and testing before continuing through production.



The Development Board provides a connector for every feature of the perfect-capo PCB. The PCB has power switches for Battery and USB which allows for power selection. Pin headers are primarily used for external connections. There is also ISP Programming pins for initial bootloader flashing. Silkscreen also provides information, labelling each connector.



What’s in The Box?

The box handed off to the client will contain the entire electrical prototype as well as spare electrical components crucial to development.

Contents:

- Capo electrical prototype
- 1x PCBA Dev board and capo controller
- Spare Battery
- Micro-Usb cable
- Spare Hardware
- Spare Battery connectors and pogo pins
- 2x PCB Dev board and capo controller

BOM

Part Number	Description	Price	Quantity
CDS0D323-T08L	USB TVS Diode	$0.73	2
TL3342F160QG	Reset Button!	$0.70	1
ATTINY84A-SSUR	MCU	$0.84	1
MCP73831T-2ACI/OT	USB Charger	$0.58	1
10118194-0001LF	Micro USB	$0.43	1
1528-1858-ND	Battery 350mAh	$6.95	1
587-3258-1-ND	0603 10uF 10V Cap	$0.19	35
XC9141B50CMR-G	IC REG BOOST 5V 800MA SOT25	$1.27	1
732-10778-1-ND	FIXED IND 4.7UH 1A 270 MOHM MAX	$0.63	1
Various Resistors not shown			

Additional Photos: