

Recycling Lime Rental Scooters for Personal Use

A Story of the Lime Gen 2
2018-2020

Backstory – the first rental scooters

- Bird's Xiaomi Mi M365
- consumer-grade
- minor modifications
- custom controller
- replacement “bird brains”
available on AliExpress
- whole scooter for ~\$400





LCQPTW

24 HOUR SHIPPING

**Dashboard for Xiaomi M365 Pro 1S
Bluetooth BT Circuit Board Parts**

★★★★★ 4.6 221 Reviews 1,0

Welcome deal

\$1.04 🔥 New shoppers save
~~\$18.98~~

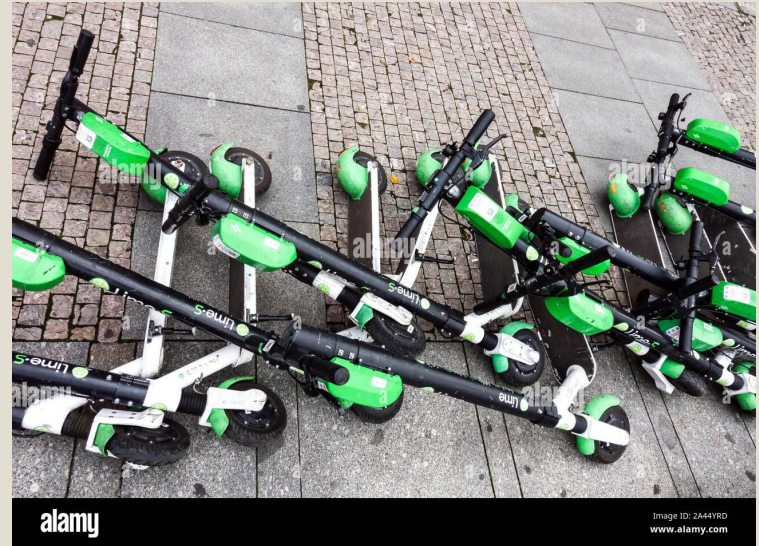
Import charges included ; Extra 1% off with code

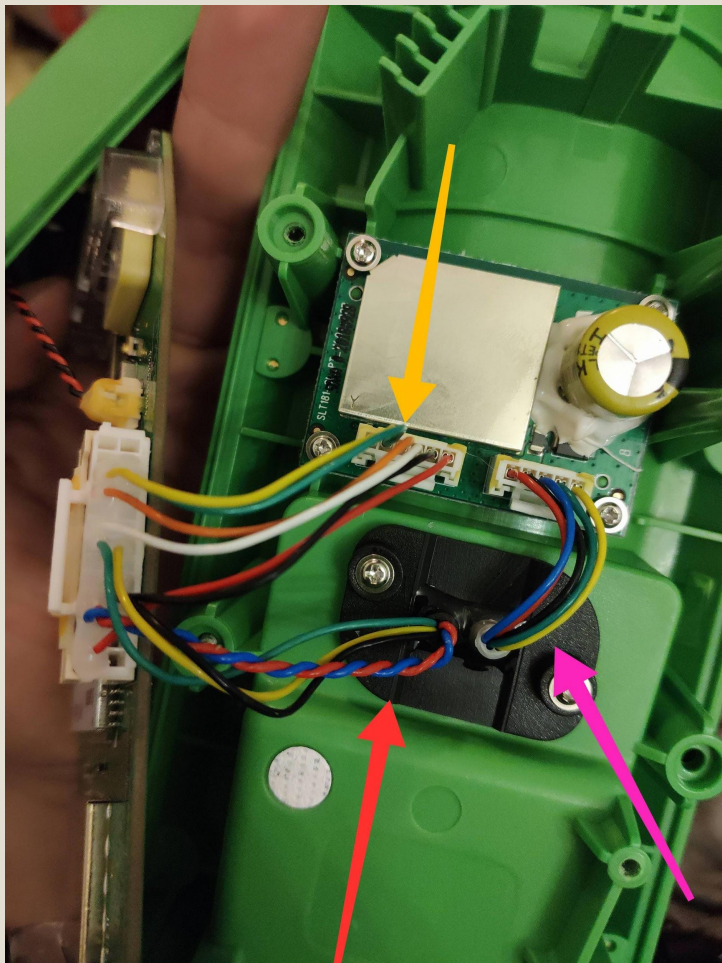
Color: green



Lime Gen 2 (early 2018)

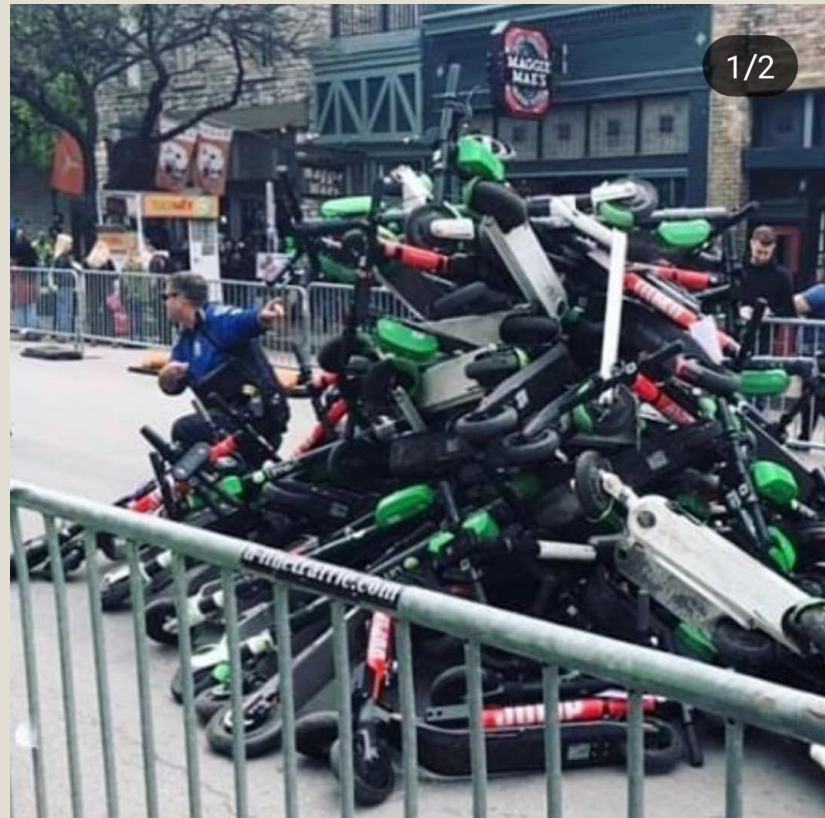
- Highly customized specifically rental
- More durable and tamper resistant





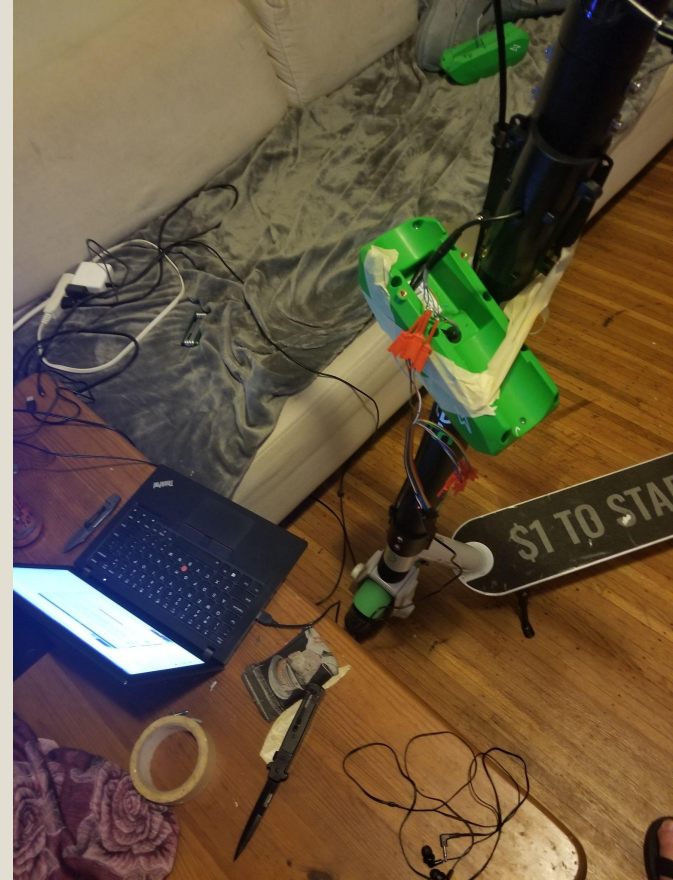
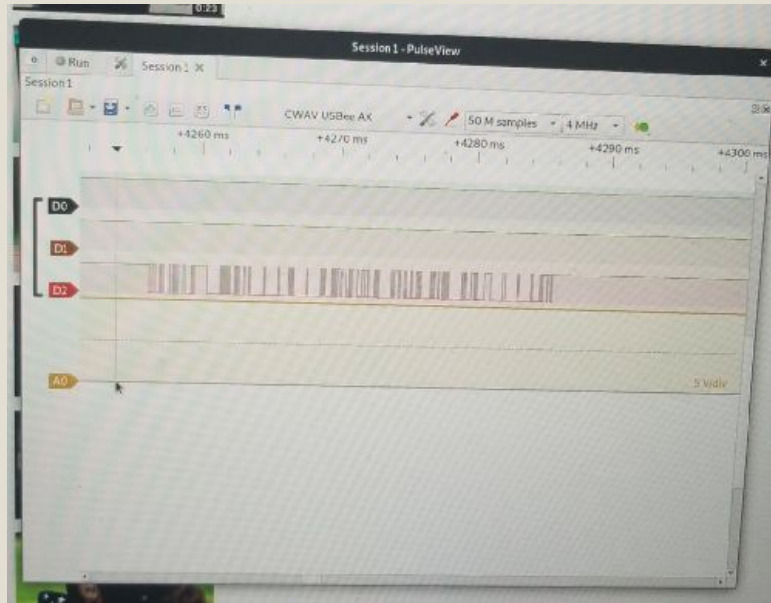
The plan: replace the lime brain

1. Figure out what the brain does
 - a. Get a scooter (easy)
 - b. Capture brain to scooter communication (medium?)
 - c. Interpret the data (hard??)
2. Replay data to impersonate the brain (???)
3. Make a board to replace a brain (?????)



What the Brain Does

- Get “signal analyzer ” to analyze signals
- Connect analyzer wires to scooter wires
- Pay for scooter on app – record data



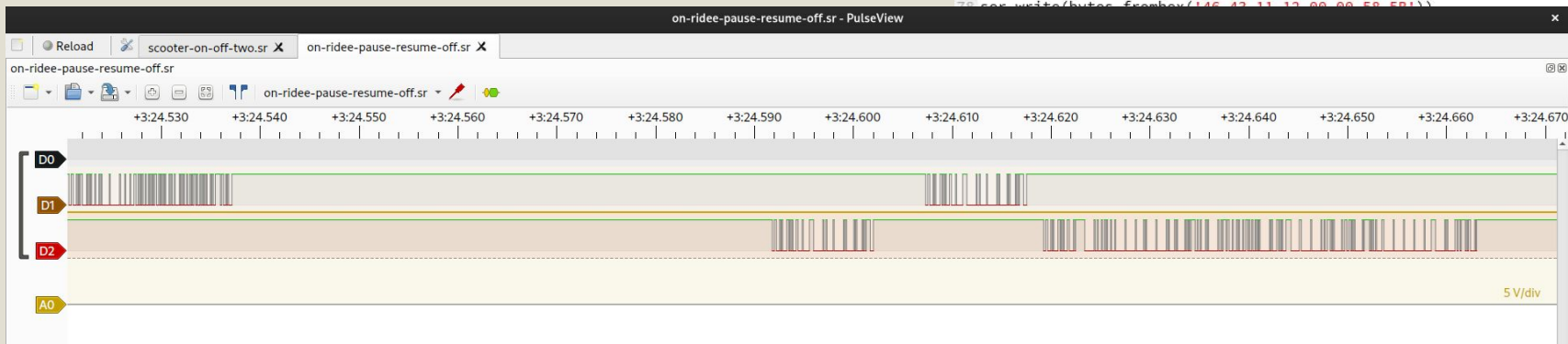
Data

- Data is UART
- Dumped it to text.
- Send over serial with Python
- Connect scooter and laptop with FTDI
- “lime_bike”

```
6431299 fdc: 46 43 16 21 00 09 06 4E 4F 57 53 41 4E 30 31 90 60
6450704 fdc: 46 43 16 21 00 09 06 4E 4F 57 53 41 4E 30 31 90 60
6470106 fdc: 46 43 16 21 00 09 06 4E 4F 57 53 41 4E 30 31 90 60
8151748 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 95 42 00 75 44 3F 52 00 61 F0 80 00 0
8190338 tx: 46 43 16 11 00 02 01 0F E6 A5
8201506 fdc: 46 43 16 11 00 02 01 0F E6 A5
8217076 tx: 46 43 16 90 00 04 01 0F 21 00 B4 91
8230194 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 9F 42 00 77 44 40 52 00 61 F0 80 00 0
8257975 tx: 46 43 16 90 00 04 01 0F 21 00 B4 91
8281408 fdc: 46 43 16 90 00 04 01 40 21 00 85 0D
8398779 tx: 46 43 16 61 00 01 F1 F2 8F
8408978 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B A2 42 00 77 44 40 52 00 61 F1 80 00 0
8446330 tx: 46 43 16 61 00 01 F1 F2 8F
8458542 fdc: 46 43 16 61 00 01 F1 F2 8F
8568759 tx: 46 43 16 12 00 01 F1 2B 26
8578794 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B A9 42 00 77 44 40 52 00 61 F1 80 00 0
8616031 tx: 46 43 16 12 00 01 F1 2B 26
8626150 fdc: 46 43 16 12 00 01 F1 2B 26
9176892 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 7B 42 00 77 44 40 52 00 61 F1 80 00 0
9257172 tx: 46 43 11 71 00 00 9A 60
9266075 fdc: 46 43 11 71 00 00 00 00 00 00 01 DF C2 0F
9388945 fdc: 46 43 11 12 00 00 58 5B
9398024 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 02 42 00 77 44 40 52 00 61 F1 80 00 0
9445230 tx: 46 43 11 12 00 00 58 5B
9454348 fdc: 46 43 11 12 00 01 F1 4C F2
10005304 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 8F 42 00 75 44 3F 52 00 61 F1 80 00
10556682 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 88 42 00 77 44 40 52 00 61 F1 80 00
11108583 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 8F 42 00 77 44 40 52 00 61 F1 80 00
11660037 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 8F 42 00 77 44 40 52 00 61 F1 80 00
12211289 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 8F 42 00 77 44 40 52 00 61 F1 80 00
12726232 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 8F 42 00 77 44 40 52 00 61 F1 80 00
13313977 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 8F 42 00 77 44 40 52 00 61 F1 80 00
13855433 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 8F 42 00 77 44 40 52 00 61 F1 80 00
14416767 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 8F 42 00 77 44 40 52 00 61 F1 80 00
14968607 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 95 42 00 77 44 40 52 00 61 F1 80 00
15519826 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 95 42 00 77 44 40 52 00 61 F1 80 00
16071078 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 95 42 00 77 44 40 52 00 61 F1 80 00
16522417 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 95 42 00 77 44 40 52 00 61 F1 80 00
17174184 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 95 42 00 77 44 40 52 00 61 F1 80 00
17725525 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 95 42 00 77 44 40 52 00 61 F1 80 00
18276774 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 95 42 00 77 44 40 52 00 61 F1 80 00
18828041 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 95 42 00 77 44 40 52 00 61 F1 80 00
19379400 fdc: 46 58 0C FF 00 15 11 00 00 40 00 01 3B 95 42 00 77 44 40 52 00 61 F1 80 00
```

Ln 1, Col 1

```
47 sleep(1.15)
48 # should be three '46 43 ...' type packets
49
50 print('set blue wire low for 0.5 sec')
51 ser.dtr = not ser.dtr
52 print('sleep for 0.5 sec')
53 sleep(0.51)
54 print('set blue wire high')
55 ser.dtr = not ser.dtr
56
57 sleep(0.10)
58 print('send datas')
59 packet = ser.read(8).hex()
60 ser.write(bytes.fromhex('46 43 16 11 00 02 01 0F E6 A5'))
61 sleep(0.017)
62 ser.write(bytes.fromhex('46 43 16 90 00 04 01 0F 21 00 B4 91'))
63 sleep(0.038)
64 ser.write(bytes.fromhex('46 43 16 90 00 04 01 0F 21 00 B4 91'))
65 sleep(0.118)
66 ser.write(bytes.fromhex('46 43 16 61 00 01 F1 F2 8F'))
67 sleep(0.037)
68 ser.write(bytes.fromhex('46 43 16 61 00 01 F1 F2 8F'))
69 sleep(0.112)
70 ser.write(bytes.fromhex('46 43 16 12 00 01 F1 2B 26'))
71 sleep(0.037)
72 ser.write(bytes.fromhex('46 43 16 12 00 01 F1 2B 26'))
73 sleep(0.632)
74 ser.write(bytes.fromhex('46 43 11 71 00 00 9A 60'))
75 sleep(0.123)
76 ser.write(bytes.fromhex('46 43 11 12 00 00 58 5B'))
77 sleep(0.047)
78 ser.write(bytes.fromhex('46 43 11 12 00 00 58 5B'))
```



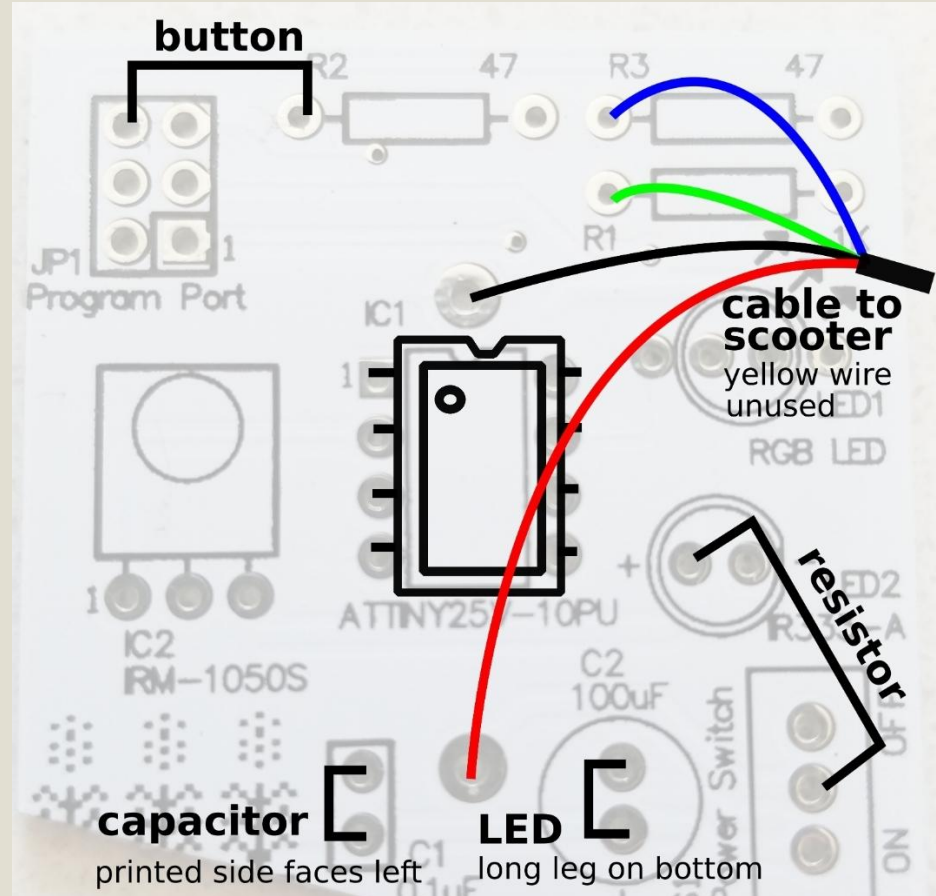
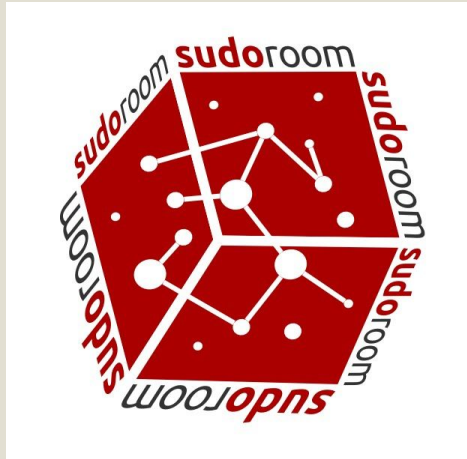
Make a board?

- I can turn on the scooter with my laptop.
- I can not ride scooter with my laptop.
- arduino and ~300 LOC worked
- Original prototype was in tupperware container, a cable, and a buck converter
- Downsides
 - Not very reproducible
 - buck converters kept exploding
 - bulky



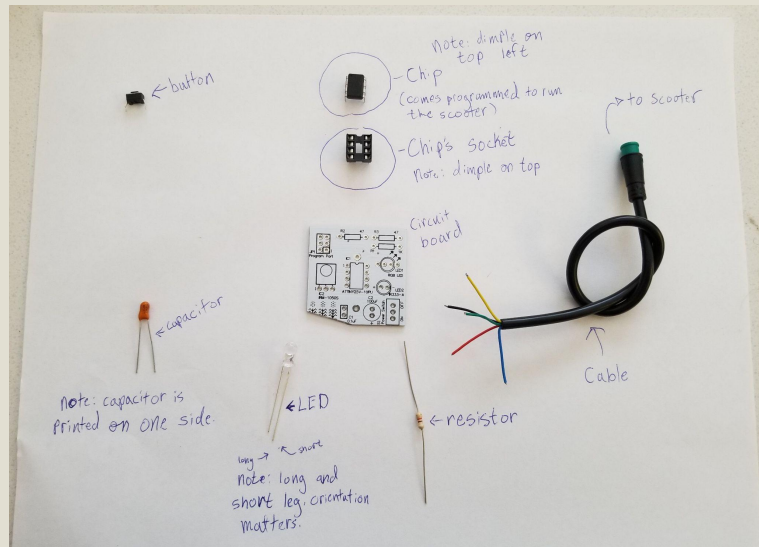
Bringing my Product to Market

- My (then) local hackerspace had a bunch of these boards for free
- ATtiny85 programmable with Arduino
- some cheap components
- creative thinking



The cable

- A very specific “ebike ” cable
- Important to make re-use easy
- Only available from China. Difficult to buy.
- Some fell off the back of a truck



使用环境及主要技术特征

产品型号: JL-F39-Z208JT, Z308JT, Z408JT, Z508JT, Z608JT

温度范围: $-40^{\circ}\text{C} \sim -85^{\circ}\text{C}$

额定电压: 200V AC

额定电流: 3A (根据具体情况所配电缆来确定)

接触电阻: $\leq 10\text{m}\Omega$

绝缘电阻: 在常态条件和潮湿条件下应 $\geq 10\text{M}\Omega$

耐电压: AC 200V 50Hz 1分钟无击穿或闪络现象

接触件: 铜合金镀锡/镀金

防护等级: IP66

机械寿命: 200次

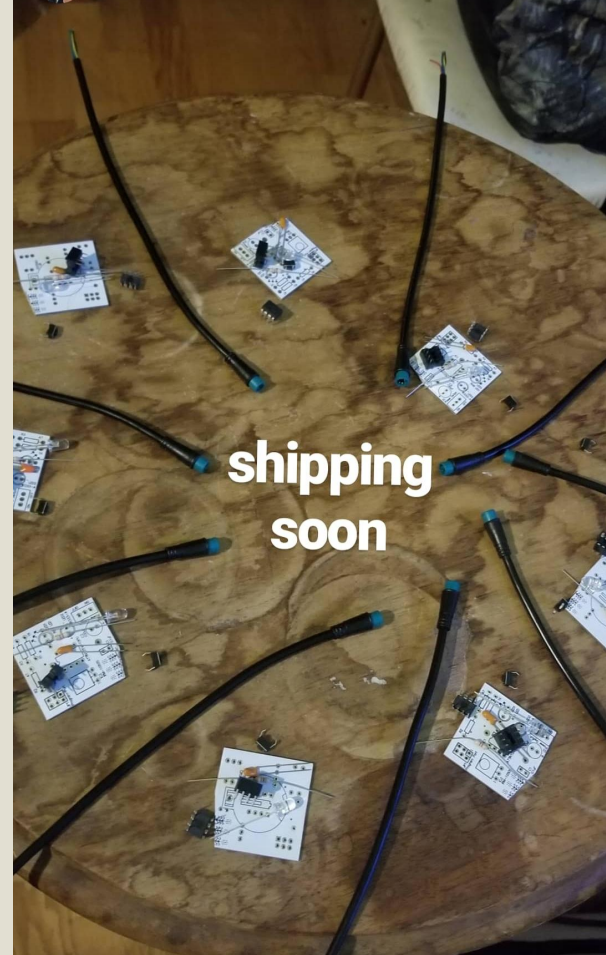
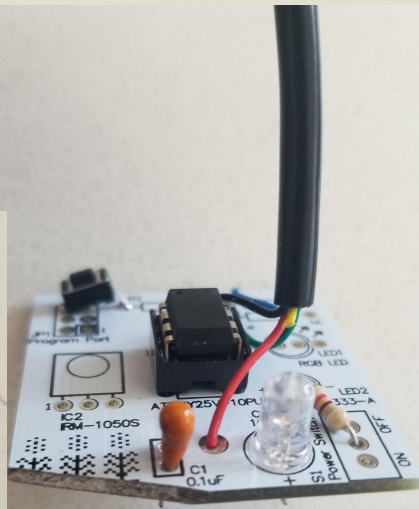
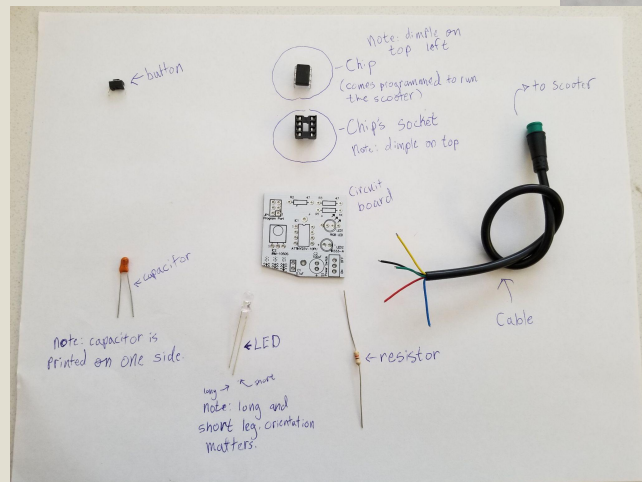
最大外径: 8.8mm

配合总长: 39mm

使用导线规格: $0.1\text{mm}^2 - 0.2\text{mm}^2$

应用范围: 应用于电子电器设备的电源连接及信号传输

- I bundled everything into a kit
- sold 50+ through word of mouth for ~\$20 (cost + shipping)
- Programming chips is annoying
- Many scooters were recycled
- Also free chargers!!!



addendum

- Hardware hacking is fun. Shoutout Jake & Sudoroom in Oakland
- Lime stopped using these in 2020
- Newer scooters are much harder to tamper with
- The motors and batteries scooters are also nice to recycle
- These things are really dangerous
- Bird is bankrupt

