UCF

FLORIDA SOLAR BEACH BUGGY CHALLENGE

Group 3

Cecilie Barreto, Drew Curry, and Grace Yoo

MOTIVATION

- Superimpose solar power and autonomous technologies
- Potentially provide a useful tool for future coastal research
- Reduce impact of beach vehicles on surrounding environment
- Promote interest and awareness of solar energy

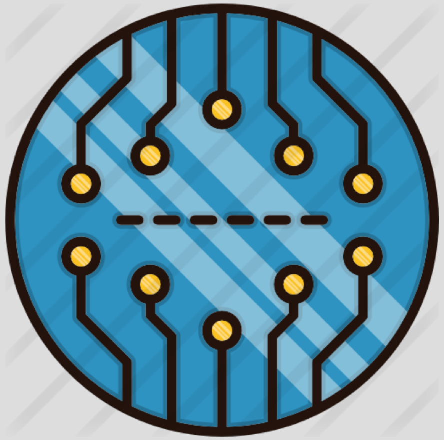
OBJECTIVES & REQUIREMENTS

- Autonomously traverse a 10 mile stretch of beach from Daytona to Ponce Inlet (and return) within 8-hour time span.
- Capable of transporting one passenger (Max payload: 120 lbs.)
- Top allowable speed → 3 mph
- Run completely on solar energy
- Do no harm to environment and beachgoers
- Detect and avoid both stationary and moving obstacles (e.g., rocks, docks, people, birds, turtles, etc.)

WORK DISTRIBUTION

Mechanical Engineering

Computer Science



Electrical & Computer Engineering

MECHANICAL TEAM

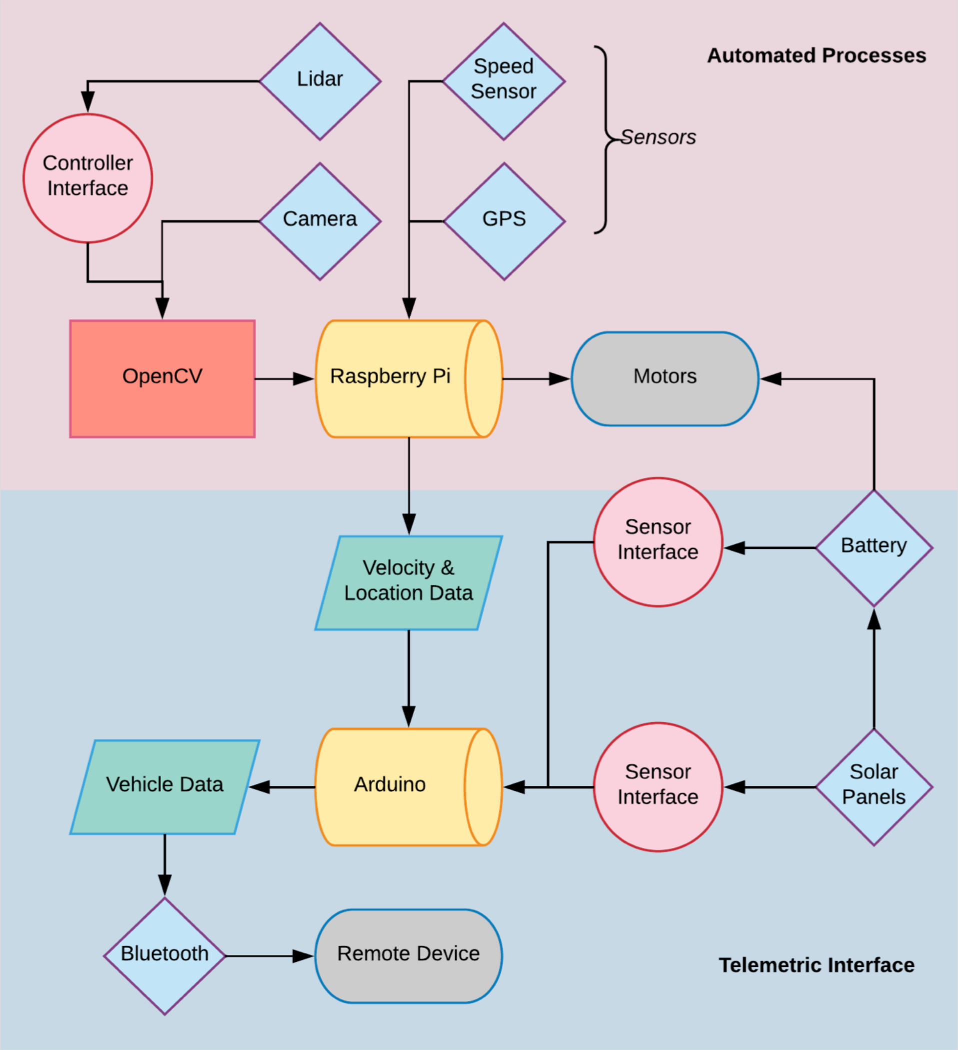
Responsibilities

- Aluminum apparatus
- Motor selection
- Wheel type/size
- Wattage calculations, maximum load required

COMPUTER SCIENCE TEAM

Responsibilities

- Navigational programming
- Decision processing
- GPS integration
- Stereo camera/image processing



WORK DISTRIBUTION

Cecilie Barreto
Computer Engineering

- Interpretation of raw sensor data
- Power management research
- Indoor/outdoor affects on sensors
- Communication between microcontrollers
- Overall autonomous system design
- PCB Design and parts selection
- Collaborate with CS team

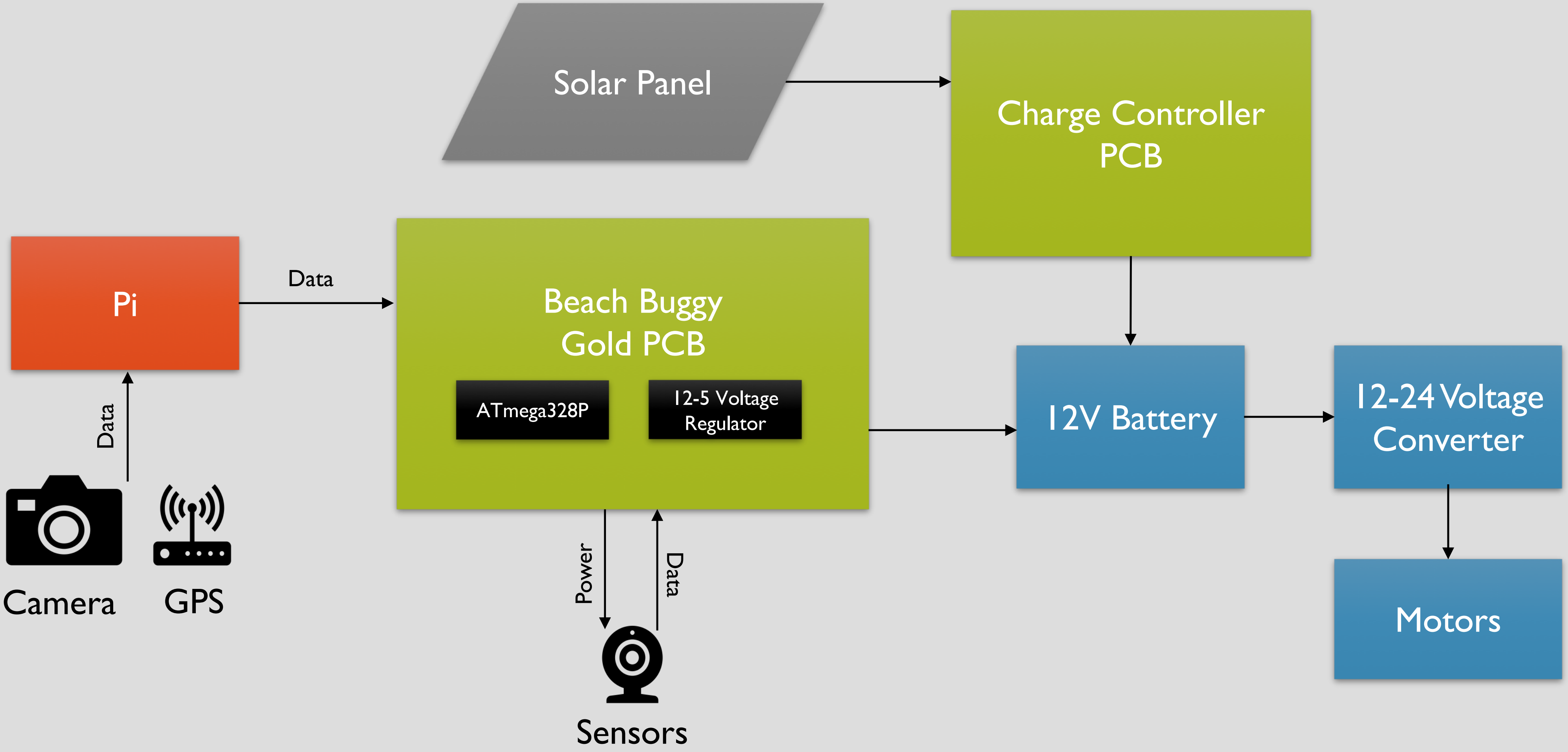
Drew Curry
Electrical Engineering

- Sensor research and selection
- Printed circuit board design
- Voltage regulator design
- Battery research and selection
- Charge controller research and selection
- Overall power distribution design
- Collaborate with ME team

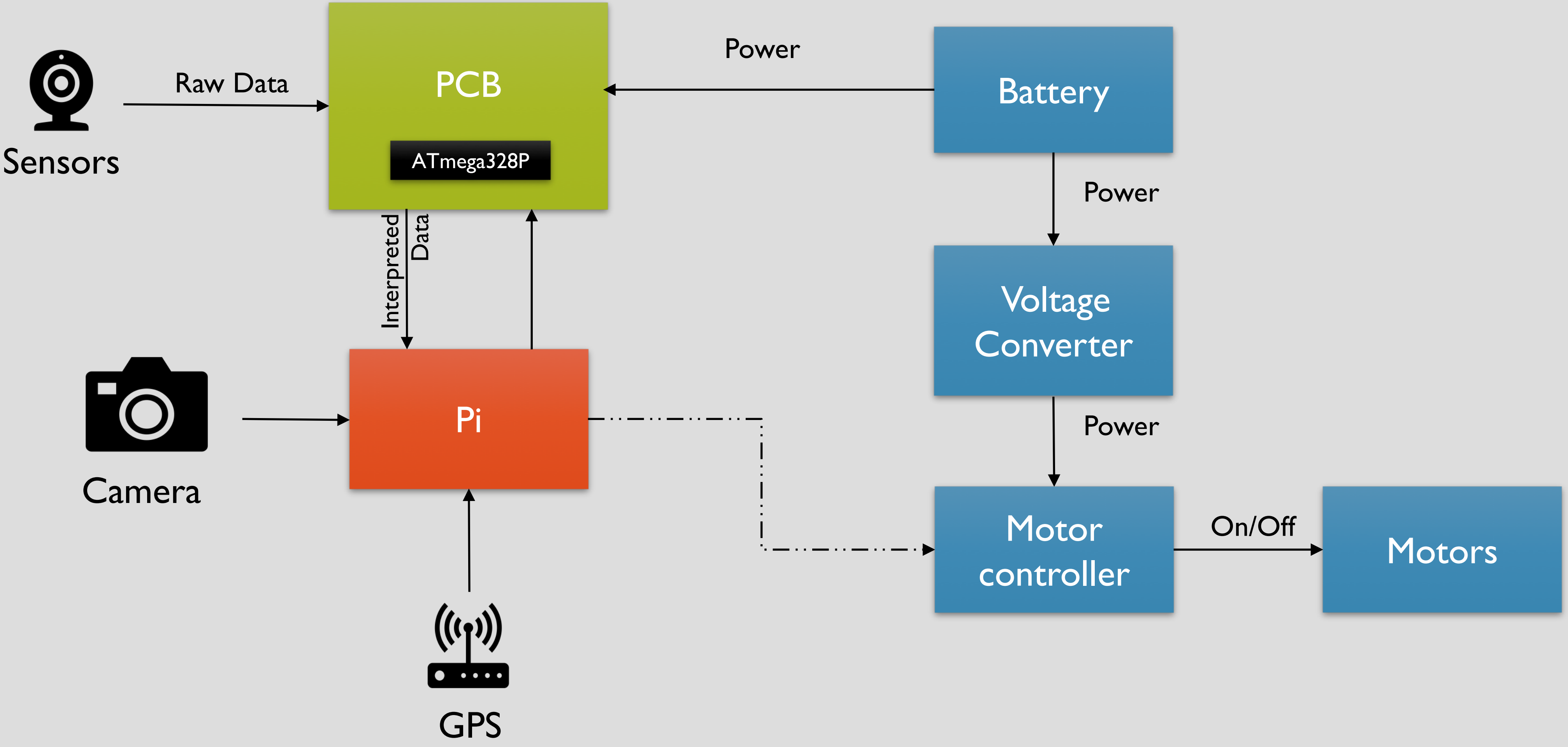
Grace Yoo
Computer Engineering

- Interpretation of raw sensor data
- Microcontroller/microchip research
- Communication between sensors and ATmega328P
- Communication between microcontrollers
- Overall autonomous system design
- Collaborate with CS team
- Soldering

OVERALL SYSTEM DIAGRAM



AUTONOMOUS SYSTEM DIAGRAM



SOFTWARE

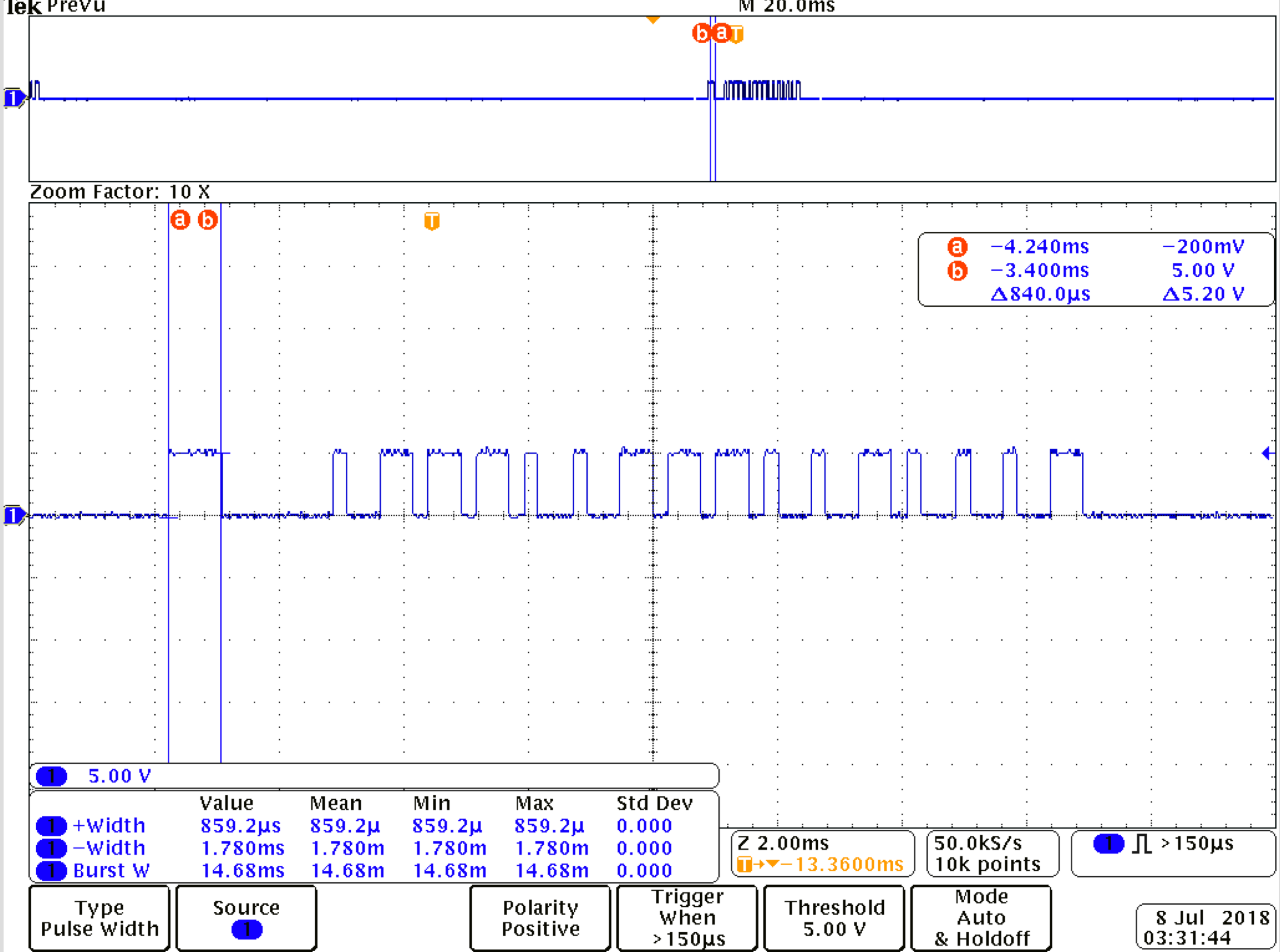
- Python
  - Raw data manipulation
    - PySerial
  - Microcontroller communication
- Arduino IDE
  - ATmega328P
- Robot Operating System (ROS)
  - Leading robotics software in industry
  - Supporting role

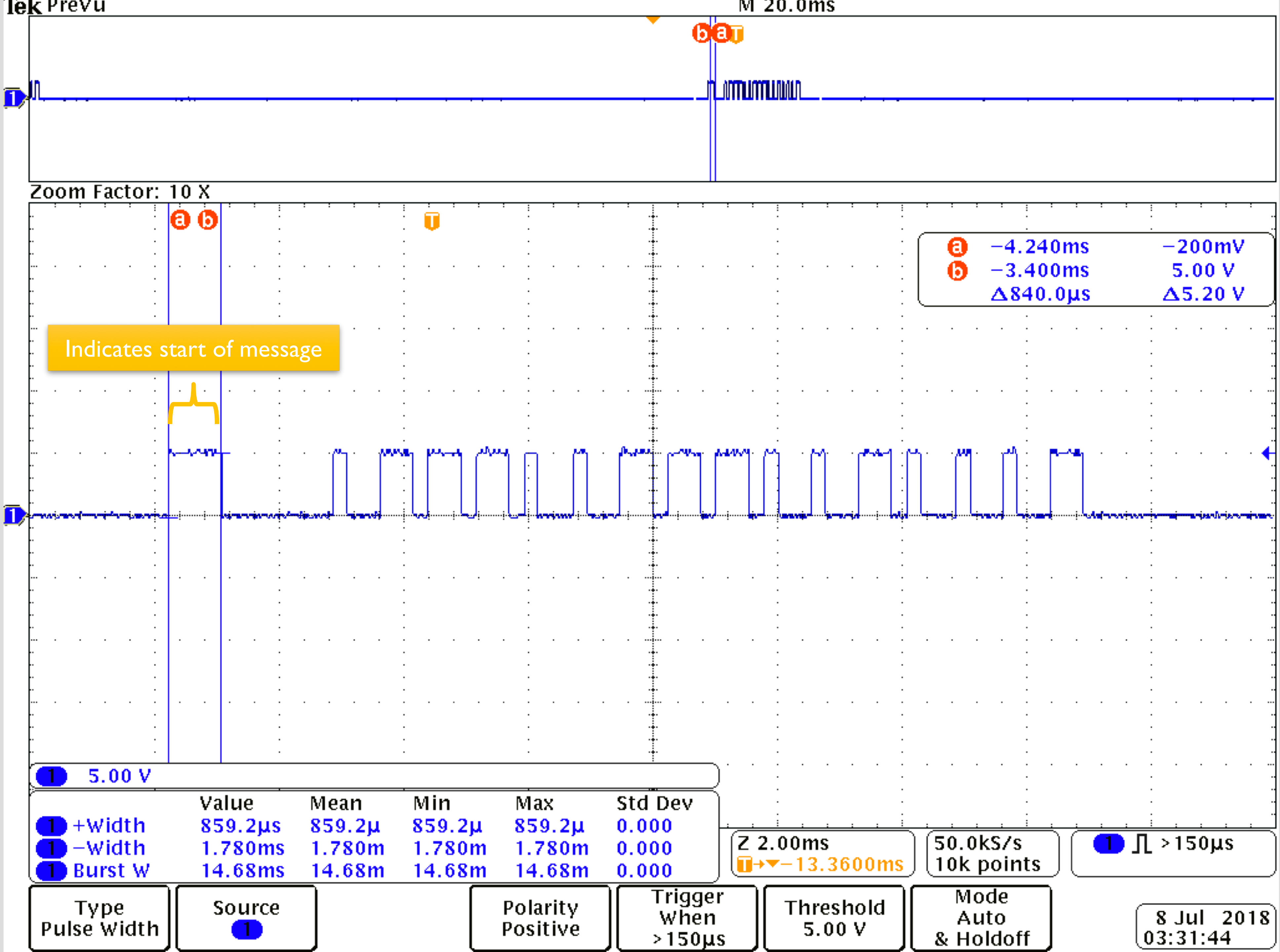
```python
##########################################################################
# Main()
##########################################################################
import serial
import time
import signal

# Port addresses to decipher which sensor is reporting data
portJOne   = "1010"
portJTwo   = "1110"
portJThree = "0110"
portJFour  = "0010"

# Set default signal flags
signalGo        = True
startUp         = True

# Set object detection flags
leftFrontSensor  = False
leftSensor       = False
rightFrontSensor = False
rightSensor      = False

# Serial port for sensors and motors
serialSensors = serial.Serial('/dev/ttyACM0', 9600)
serialMotors  = serial.Serial('/dev/ttyS0'  , 9600, timeout = 10)
```

DS18 PRKD14

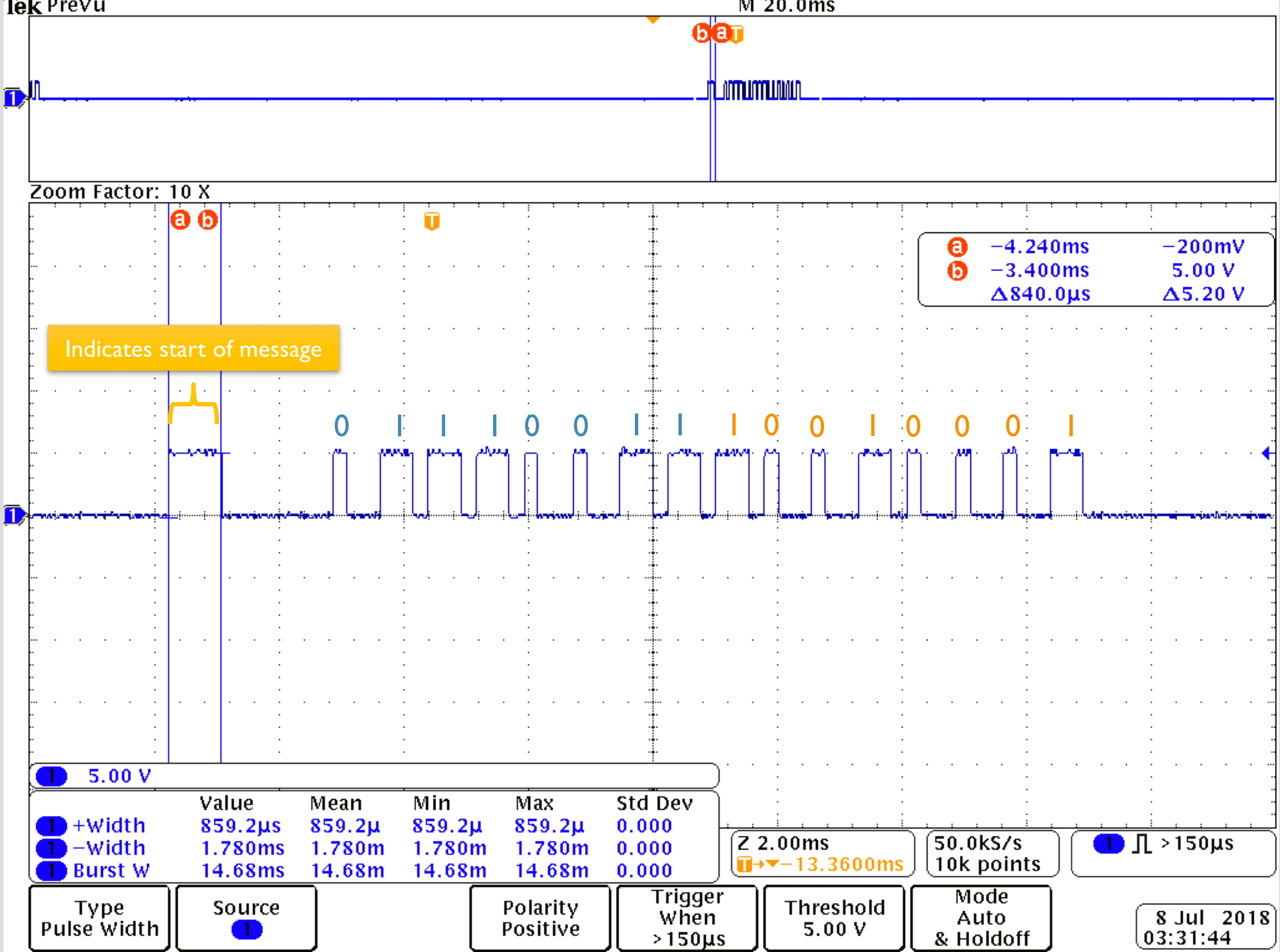
- Cost-effective
- Rated for outdoor use
- Voltage: 12V DC-16V
- DC rated current: 10mA - 250mA
- Detection Distance: 0.3 - 2.5m
- Working Temperature: -30 - 80 degrees Celsius
- Ultrasonic Frequency: 40KHz

DECODING SENSOR DATA

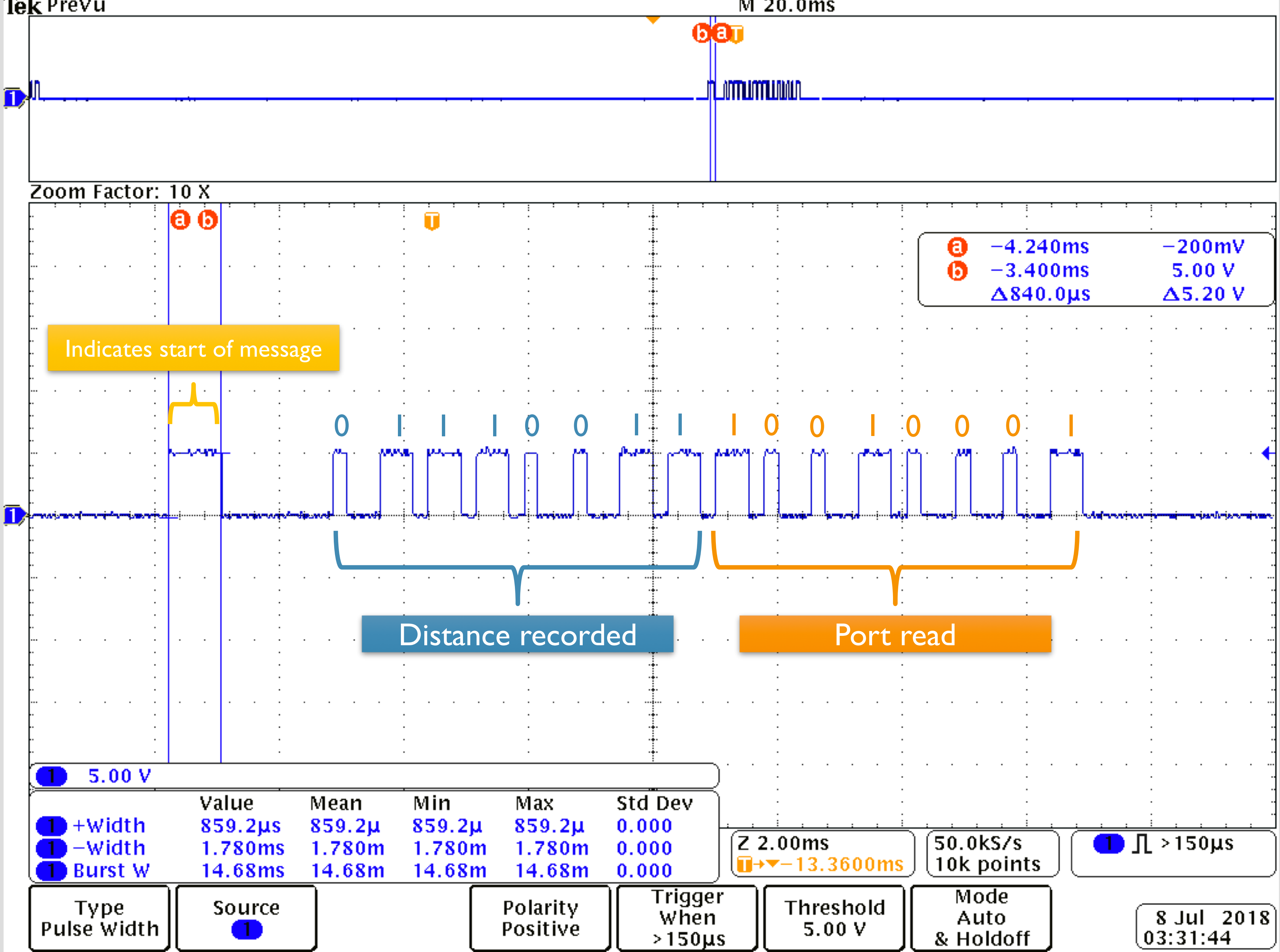

Tek PreVu
M 20.0ms
Zoom Factor: 10 X
a −4.240ms −200mV
b −3.400ms 5.00 V
Δ840.0µs Δ5.20 V
1 5.00 V
Value Mean Min Max Std Dev
1 +Width 859.2µs 859.2µ 859.2µ 859.2µ 0.000
1 −Width 1.780ms 1.780m 1.780m 1.780m 0.000
1 Burst W 14.68ms 14.68m 14.68m 14.68m 0.000
Z 2.00ms
T→▼−13.3600ms
50.0kS/s
10k points
1 ⎍ >150µs
Type Pulse Width
Source 1
Polarity Positive
Trigger When >150µs
Threshold 5.00 V
Mode Auto & Holdoff
8 Jul 2018
03:31:44



Tek PreVu
M 20.0ms
Zoom Factor: 10 X
Indicates start of message
a −4.240ms −200mV
b −3.400ms 5.00 V
Δ840.0µs Δ5.20 V
1 5.00 V
Value Mean Min Max Std Dev
1 +Width 859.2µs 859.2µ 859.2µ 859.2µ 0.000
1 −Width 1.780ms 1.780m 1.780m 1.780m 0.000
1 Burst W 14.68ms 14.68m 14.68m 14.68m 0.000
Z 2.00ms
T→▼−13.3600ms
50.0kS/s
10k points
1 >150µs
Type
Pulse Width
Source
1
Polarity
Positive
Trigger
When
>150µs
Threshold
5.00 V
Mode
Auto
& Holdoff
8 Jul 2018
03:31:44



Tek PreVu
M 20.0ms
Zoom Factor: 10 X
Indicates start of message
0 1 1 1 0 0 1 1 1 0 0 1 0 0 0 1
a −4.240ms −200mV
b −3.400ms 5.00 V
Δ840.0µs Δ5.20 V
1 5.00 V
Value Mean Min Max Std Dev
1 +Width 859.2µs 859.2µ 859.2µ 859.2µ 0.000
1 −Width 1.780ms 1.780m 1.780m 1.780m 0.000
1 Burst W 14.68ms 14.68m 14.68m 14.68m 0.000
Z 2.00ms
T→▼−13.3600ms
50.0kS/s
10k points
1 >150µs
Type Pulse Width
Source 1
Polarity Positive
Trigger When >150µs
Threshold 5.00 V
Mode Auto & Holdoff
8 Jul 2018
03:31:44


Tek PreVu
M 20.0ms
Zoom Factor: 10 X
a −4.240ms −200mV
b −3.400ms 5.00 V
Δ840.0µs Δ5.20 V
Indicates start of message
0 1 1 1 0 0 1 1
1 0 0 1 0 0 0 1
Distance recorded
Port read
1 5.00 V
Value Mean Min Max Std Dev
1 +Width 859.2µs 859.2µ 859.2µ 859.2µ 0.000
1 −Width 1.780ms 1.780m 1.780m 1.780m 0.000
1 Burst W 14.68ms 14.68m 14.68m 14.68m 0.000
Z 2.00ms
T→▼−13.3600ms
50.0kS/s
10k points
1 >150µs
Type Pulse Width
Source 1
Polarity Positive
Trigger When >150µs
Threshold 5.00 V
Mode Auto & Holdoff
8 Jul 2018
03:31:44


0 1 1 1 0 0 1 1
1 0 0 1 0 0 0 1
Distance recorded
Port read

0 1 1 1 0 0 1 1

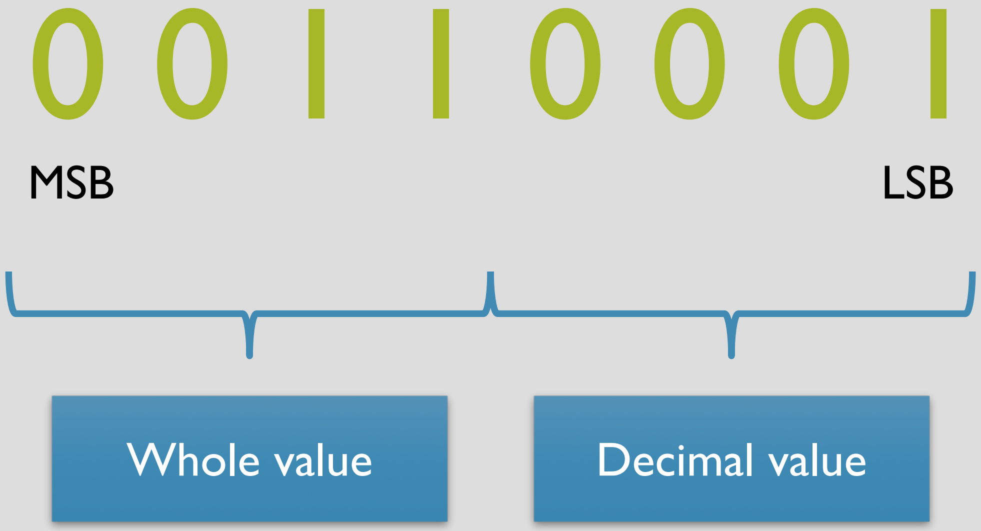
LSB MSB

Distance recorded

1 1 0 0 1 1 1 0

MSB **LSB**

Distance recorded (dm)

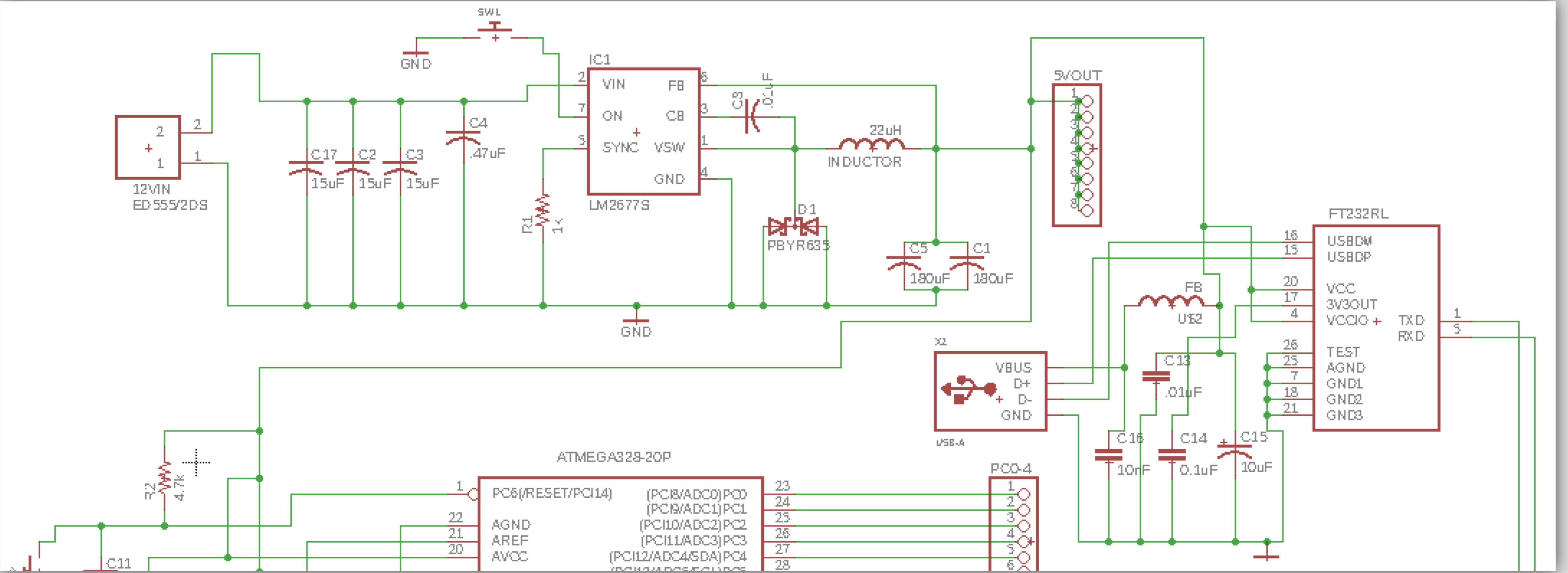

0 0 1 1 0 0 0 1
MSB
LSB
Whole value
Decimal value

3 1

Whole value

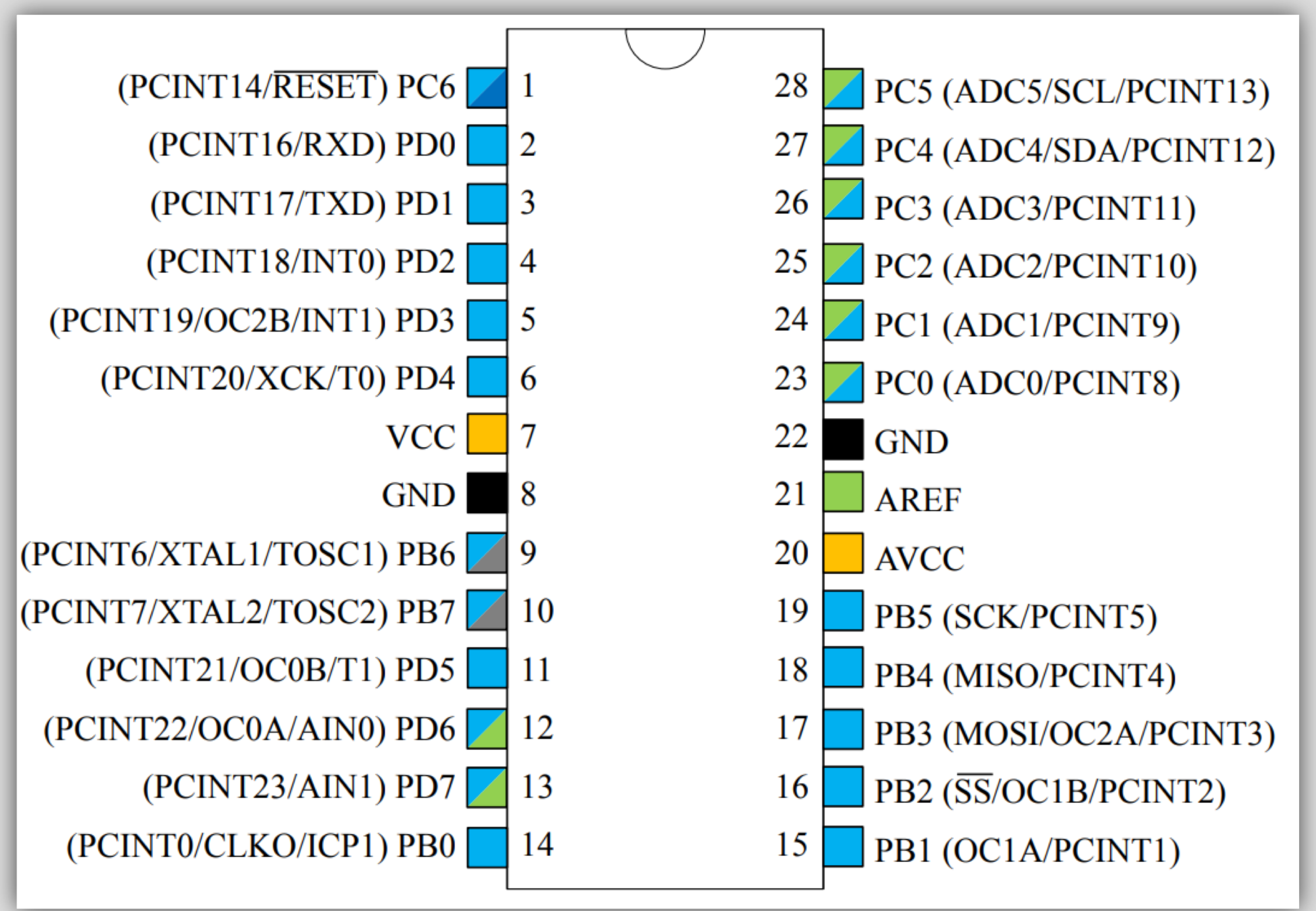
Decimal value

3.1 meters


SWL
GND
IC1
VIN
FB
ON
CB
SYNC
VSW
GND
LM2677S
C8
.01uF
22uH
INDUCTOR
D1
PBYR635
C5
180uF
C1
180uF
5VOUT
12VIN
ED555/2DS
C17
15uF
C2
15uF
C3
15uF
C4
.47uF
R1
1k
GND
FT232RL
USBDM
USBDP
VCC
3V3OUT
VCCIO
TXD
RXD
TEST
AGND
GND1
GND2
GND3
FB
U$2
X1
VBUS
D+
D-
GND
USB-A
C13
.01uF
C16
10nF
C14
0.1uF
C15
10uF
ATMEGA328-20P
PC6(/RESET/PCI14)
AGND
AREF
AVCC
(PCI8/ADC0)PC0
(PCI9/ADC1)PC1
(PCI10/ADC2)PC2
(PCI11/ADC3)PC3
(PCI12/ADC4/SDA)PC4
PC0-4
R2
4.7k
C11

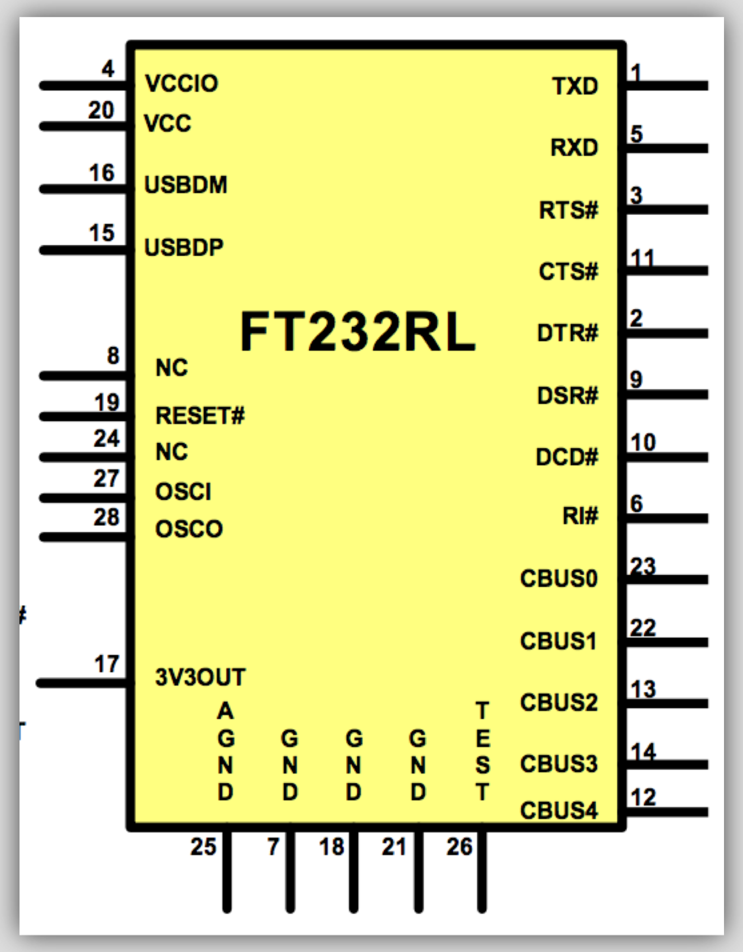
ATMEGA328P MICROCONTROLLER

- 16 MHz external oscillator crystal used as clock frequency generator
- Programmable using Arduino Uno IDE
- Manually bootloaded
- Can be used for more in future

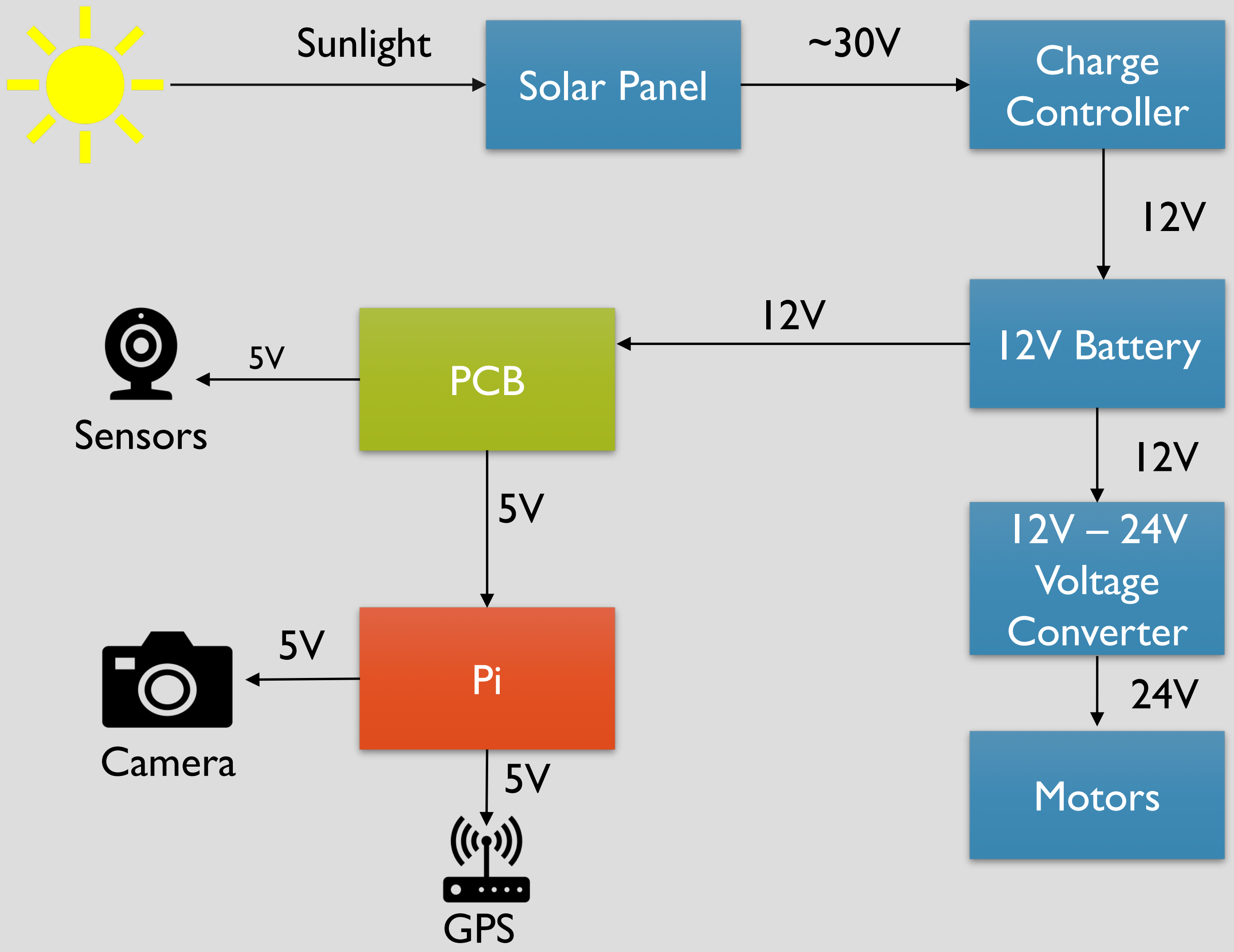


FT232RL

- USB to serial UART interface
- Used to allow serial communication between ATMega328p and Raspberry Pi
- No external crystal required



POWER SYSTEM DIAGRAM



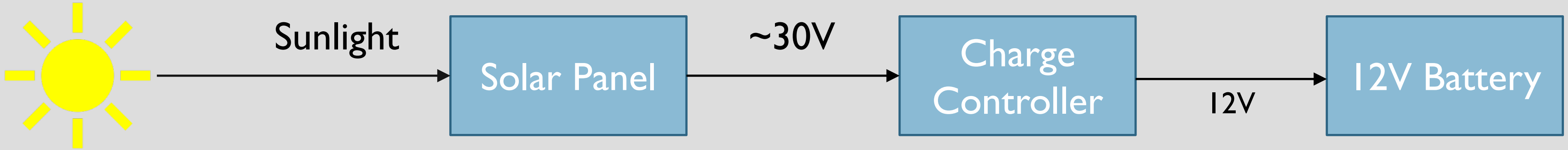
SOLAR PANEL

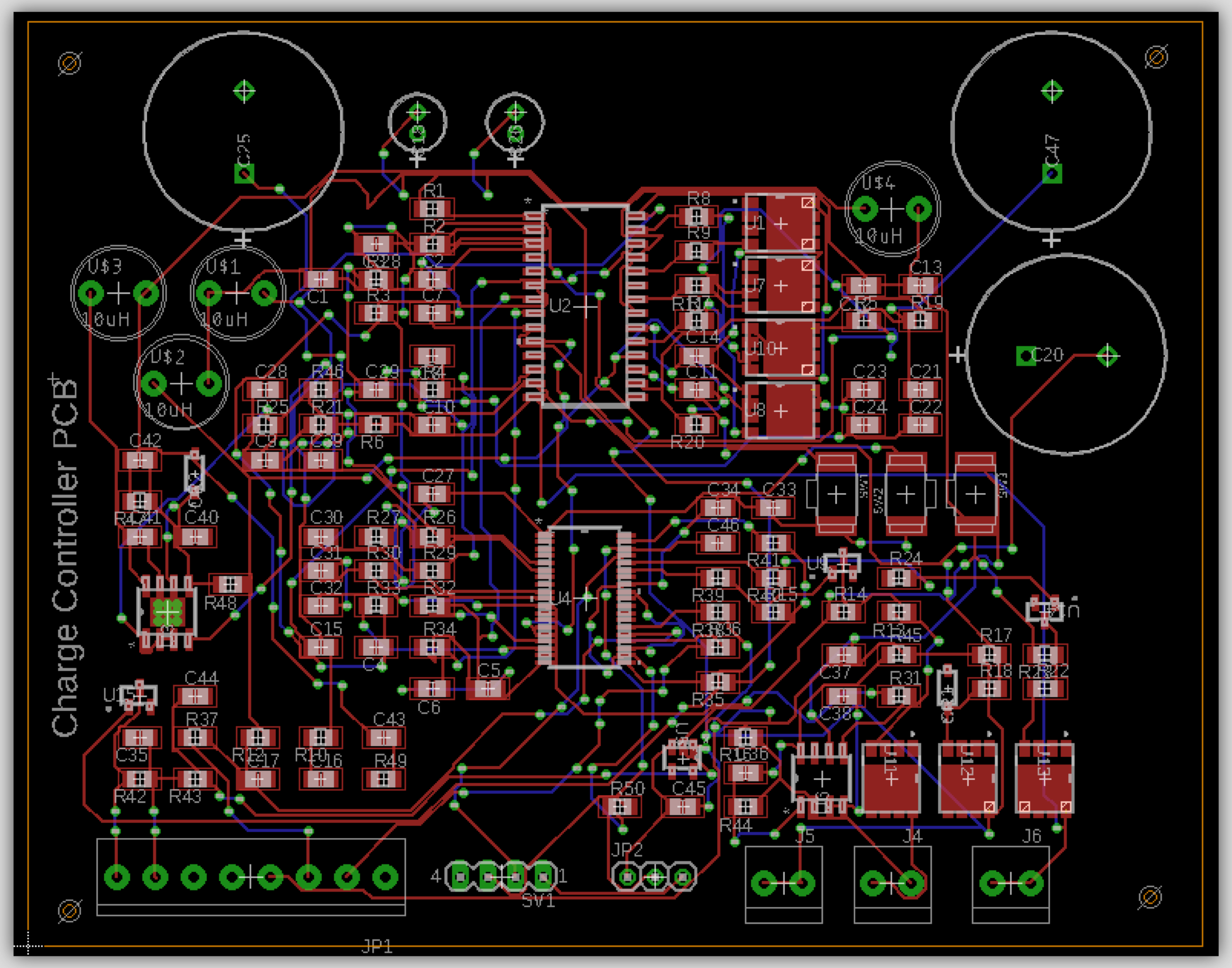
Suntech© Solar Panel

- Maximum Usage: 235W
- Maximum Current Output: 7.79 Amps
- Voltage Output: 30.16 V
- System will consume wattage from panel and battery simultaneously

CHARGE CONTROLLER

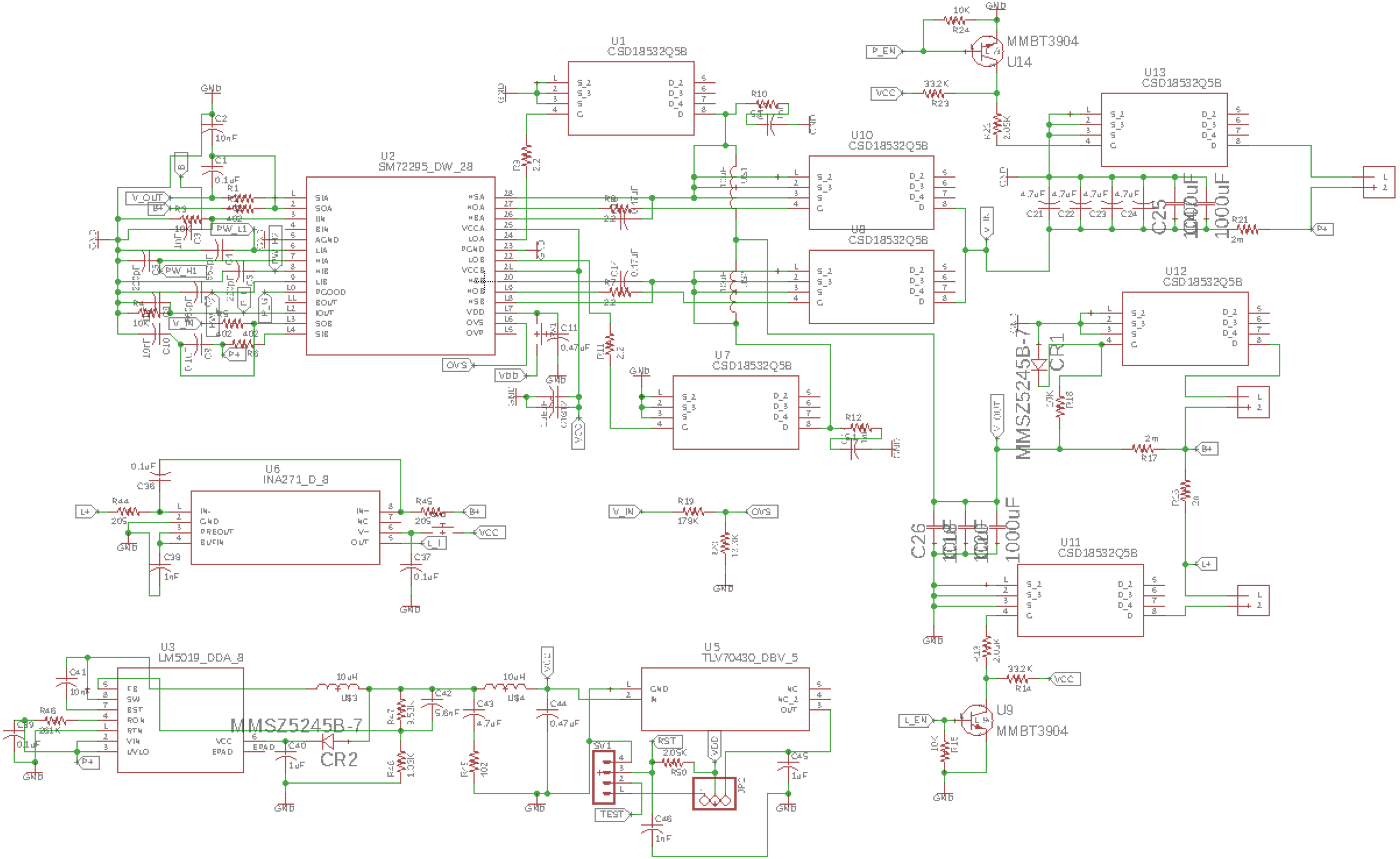
- 20A Maximum Power Point Tracking (MPPT) solar charge controller
  - Finds the maximum power point on the I/V curve and tracks that point as sunlight conditions vary
- Based on Texas Instruments TIDA-00120
- More than 96% efficiency at full load in 12V and 24V systems





Charge Controller PCB
U$1
U$2
U$3
U$4
10uH
U1
U2
U4
U7
U8
U10
C1
C13
C20
C21
C22
C23
C24
C27
C28
C30
C33
C34
C35
C37
C38
C40
C42
C43
C44
C45
C46
R1
R2
R3
R6
R8
R9
R14
R17
R18
R20
R24
R25
R26
R27
R29
R31
R34
R37
R39
R41
R42
R43
R44
R48
R49
R50
J4
J5
J6
JP1
JP2
SV1

- *MSP430F5132 Mixed Signal Microcontroller*
  - Preferred MCU for charge controller
  - Ultra-low power consumption
  - Easily programmable


U1
CSD18532Q5B
U2
SM72295_DW_28
U3
LM5019_DDA_8
U5
TLV70430_DBV_5
U6
INA271_D_8
U7
CSD18532Q5B
U8
CSD18532Q5B
U9
MMBT3904
U10
CSD18532Q5B
U11
CSD18532Q5B
U12
CSD18532Q5B
U13
CSD18532Q5B
U14
MMBT3904
MMSZ5245B-7
CR1
CR2
C25
C26
P_EN
L_EN
VCC
V_OUT
V_IN
OVS
VDD
RST
TEST
GND
SV1
JP2
1000uF
10uH
U$3
U$4

TLV704

- Low dropout voltage linear regulator
- Ideal power-management attachment to low-power microcontrollers
- Used to regulate power to MSP430

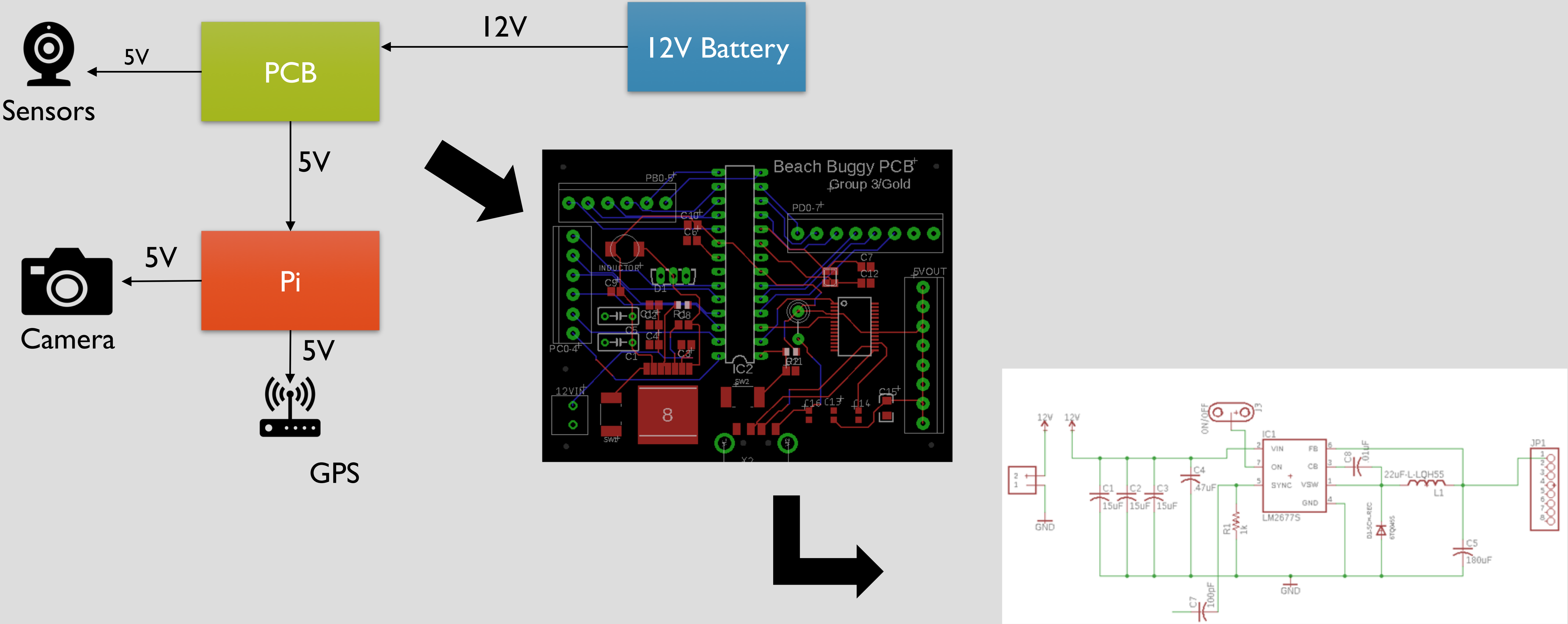
LM5019

- Constant On-Time Synchronous Buck Regulator
- Minimizes output load variation

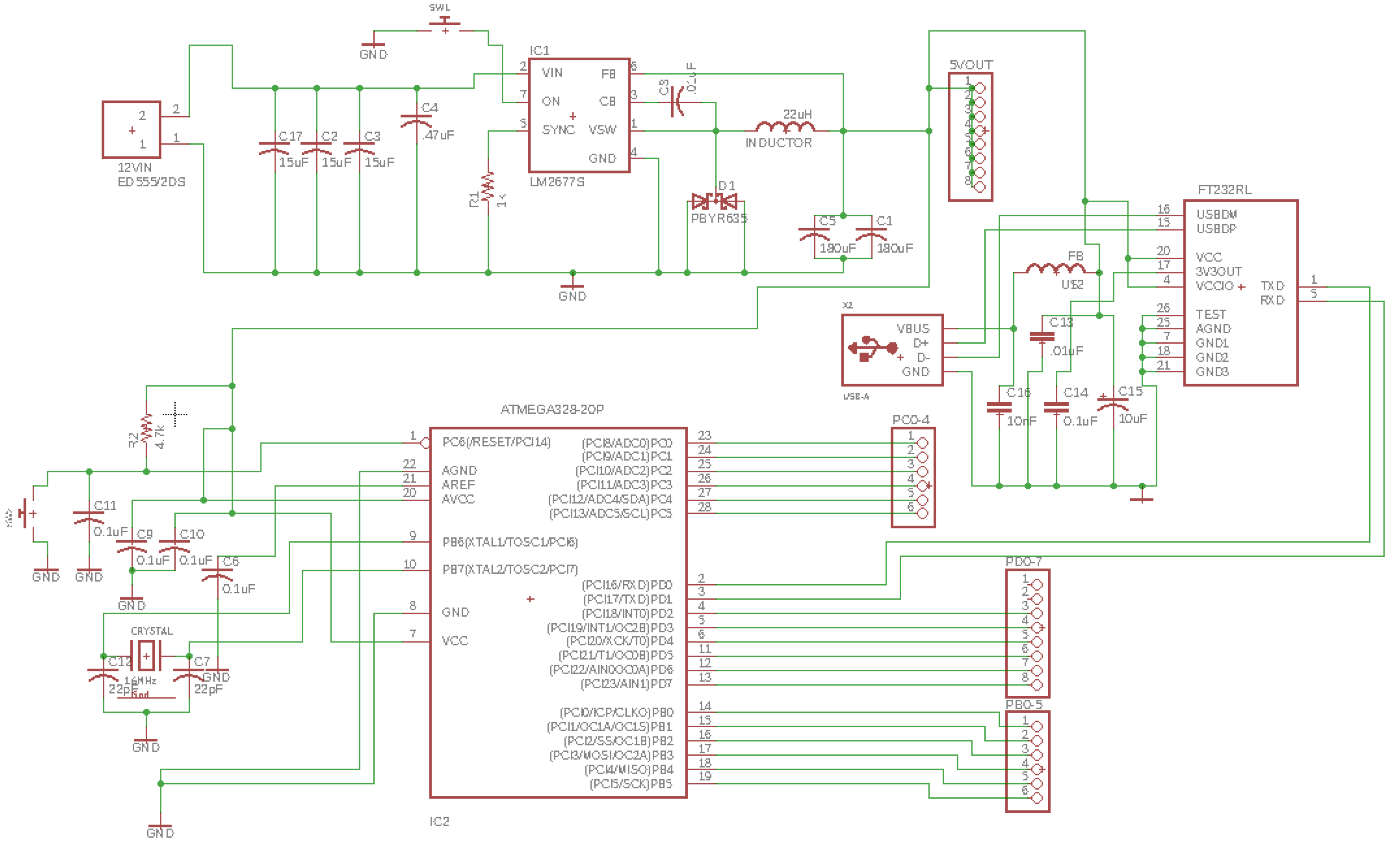
SM72295

- Photovoltaic Full Bridge Driver
- Current sensing is provided by 2 amplifiers with externally programmable gain and filtering to
  - remove ripple current
  - provide average current DC information to the control circuit

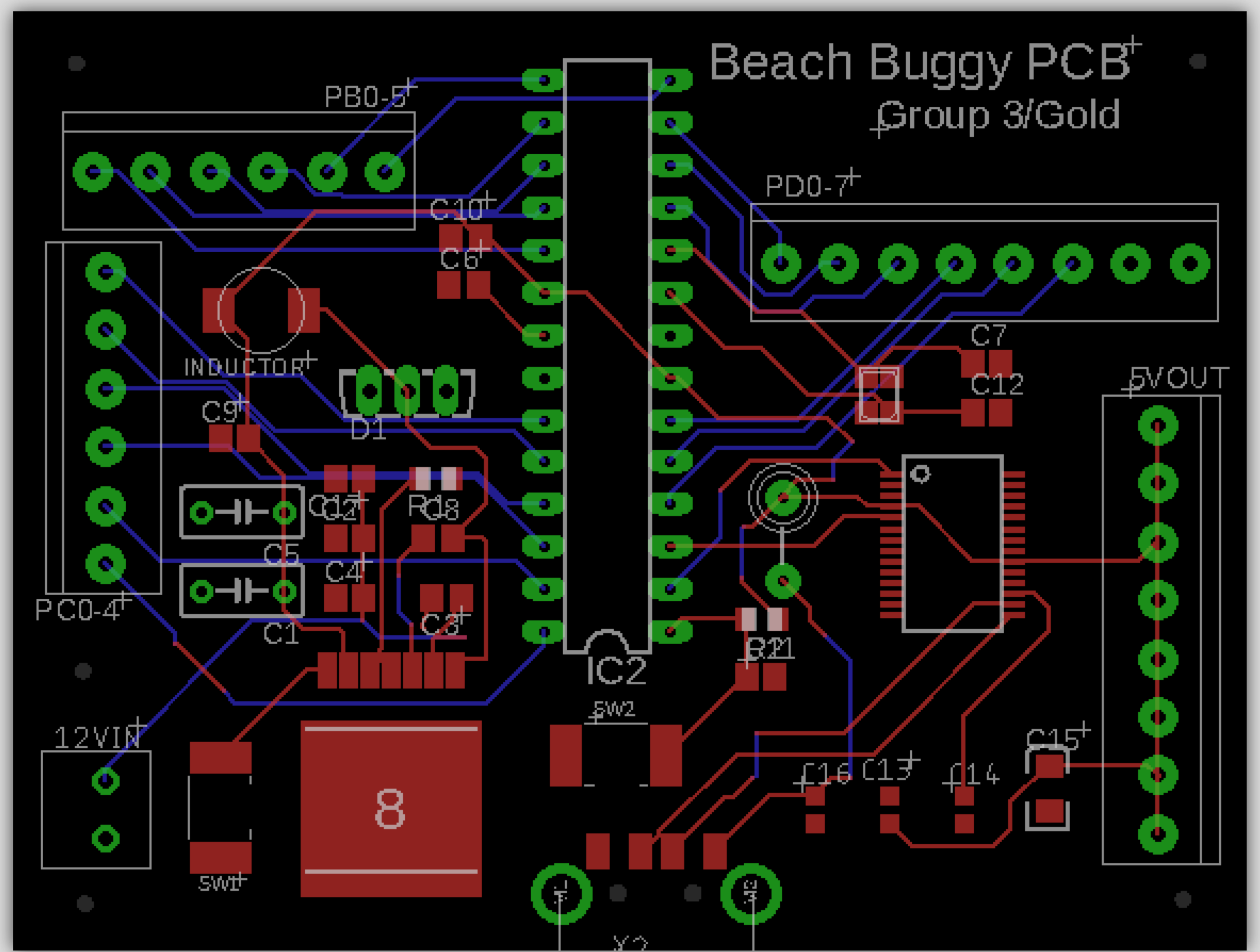
12-5 VOLTAGE REGULATOR



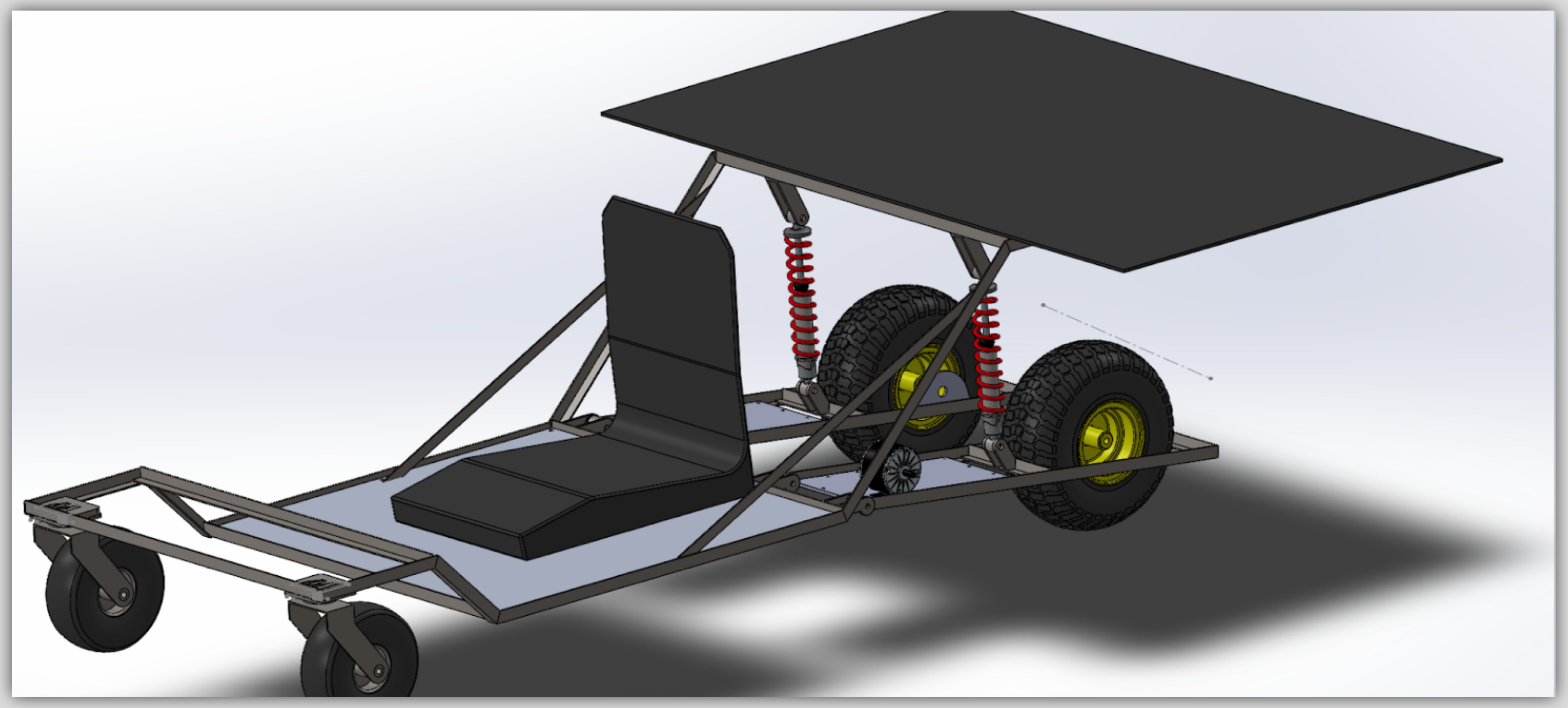
12v step down to 5v, 5A Buck Switching Regulator



SW1
GND
IC1
VIN
FB
ON
CB
SYNC
VSW
GND
LM2677S
12VIN
ED555/2DS
C17
C2
C3
C4
15uF
15uF
15uF
.47uF
R1
1k
C3
.01uF
22uH
INDUCTOR
D1
PBYR635
C5
C1
180uF
180uF
GND
5VOUT
FT232RL
USBDM
USBDP
VCC
3V3OUT
VCCIO
TXD
RXD
TEST
AGND
GND1
GND2
GND3
FB
U$2
X1
VBUS
D+
D-
GND
USB-A
C13
.01uF
C16
10nF
C14
0.1uF
C15
10uF
ATMEGA328-20P
PC6(/RESET/PCI14)
AGND
AREF
AVCC
PB6(XTAL1/TOSC1/PCI6)
PB7(XTAL2/TOSC2/PCI7)
GND
VCC
(PCI8/ADC0)PC0
(PCI9/ADC1)PC1
(PCI10/ADC2)PC2
(PCI11/ADC3)PC3
(PCI12/ADC4/SDA)PC4
(PCI13/ADC5/SCL)PC5
(PCI16/RXD)PD0
(PCI17/TXD)PD1
(PCI18/INT0)PD2
(PCI19/INT1/OC2B)PD3
(PCI20/XCK/T0)PD4
(PCI21/T1/OC0B)PD5
(PCI22/AIN0/OC0A)PD6
(PCI23/AIN1)PD7
(PCI0/ICP/CLKO)PB0
(PCI1/OC1A/OC1S)PB1
(PCI2/SS/OC1B)PB2
(PCI3/MOSI/OC2A)PB3
(PCI4/MISO)PB4
(PCI5/SCK)PB5
IC2
PC0-4
PD0-7
PB0-5
R2
4.7k
C11
0.1uF
C9
0.1uF
C10
0.1uF
C6
0.1uF
CRYSTAL
16MHz
C12
22pF
C7
22pF
GND


Beach Buggy PCB
Group 3/Gold
PB0-5
PD0-7
PC0-4
INDUCTOR
C10
C6
C9
D1
C7
C12
5VOUT
C5
C4
C1
C3
IC2
SW2
12VIN
SW1
8
C16
C13
C14
C15

PROTOTYPE




THUNDER POWER RC
Lithium Polymer
5000mAh
G8 Performance Pro
45C
TP5000-2SPR45
Powerizer®
LiFePO4 Battery Pack

BUDGET

	Budget Build		Intermediate Build		Optimal Build	
Frame	Steel, 90-degree plates	$500	Steel, rectangular tubing	$700	Aluminum, round tubing, 3rd party welding	$1,200
Suspension	Struts, coils	$200	Struts, coils	$200	Struts, coils	$200
Tires	Basic Tires	$60	Basic Beach Tires	$120	Premium Beach Tires	$350
Motors	2750 RPM Electric Motor	$300	2750 RPM Electric Motor	$300	2750 RPM Electric Motor	$300
Sensors	Stereo camera, 7 sensors, GPS	$300	2D LIDAR, Camera, 4 ultrasonic, GPS	$1,400	3D LIDAR, HD Camera, 4 ultrasonic, GPS	$3,000
Solar Panels	ECE Panels (Bulky)	Donated	Commercial Panels	$700	Flexible Panels	$1,000
Battery	50 Ahr Lead Acid	$100	100 Ahr Lead Acid	$250	100 Ahr Lithium Ion	$1,000
Controllers	Raspberry Pi 3, ATMega 328PCB Circuit Board	$250	Raspberry Pi 3, 2 ATMega 328PCB Circuit Board	$300	NVIDIA Jetson TX2, 2 ATMega 328PCB Circuit Board	$1,000
Total Cost		***$1,710***		***$3,970***		***$8,050***

CONSTRAINTS

- Financial constraints:
  - Fair distribution across mechanical/CS/ECE scopes
- Sensor Constraints
  - PIR reliability
  - Ultrasonic reliability
- Processing power constraints
  - ATmega328P vs Raspberry pi
- Environmental Constraints
  - Weather conditions/Sunlight intensity
  - Terrain of beach
  - Safety concerns

QUESTIONS?