DesignTek Enterprises

Xtreme Chariot RDX-4398 PRO Limited Edition

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Abstract

The Xtreme Chariot RDX4398-Pro Limited Edition project consolidates a variety of data valuable to a cyclist within arm's reach. The product attaches two light units on the bicycle fork and handlebars. A sensor on the wheel provides measurement of speed and acceleration, while the head unit tracks trip and total distance as well as GPS position information. The system not only provides immediate information to the user, but also provides wireless Bluetooth capabilities which can be transferred to a personal computer. It is easy to setup and allows the rider to focus on riding. At a basic level, speed and acceleration are measured by monitoring a spoke mounted magnet over time. A small microprocessor reads this signal and sends the rotational speed of the wheel wirelessly over Bluetooth to the handle bar mounted head unit. The solar powered head unit monitors the data being sent from the wheel to track distance and acceleration. The head unit also contains a GPS receiver to track position. The information calculated by the unit is both displayed on an LCD and transferred wirelessly via Bluetooth for later retrieval on a PC. The goal of this project is to produce a device which demonstrates valuable functionality to a cyclist. The product incorporates a number of features, any one of which, alone, would be a saleable product. Although the initial manifestation of this project is conceptual, its components form a basis for practical devices.

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Project Features/Objectives

Magnet Sensor
A magnet is placed on the spokes of the front bike wheel which turns on a Reed switch with every rotation and provides the measurement for the speed and acceleration. A microprocessor reads the signal and sends the rotational speed wirelessly via Bluetooth to the head unit, which is attached to the handlebars.

Head Unit
The head unit will be composed of seven major components: GPS, LCD, Heart Rate Receiver, Solar Battery Charger, Bluetooth Module and MSP430 microprocessor. The unit will be mounted on the bike handlebars. The device will track the total distance which will be immediately displayed on the LCD via Bluetooth. The data stored within the buffers can be transferred via Bluetooth to your PC at home for results viewing!

GPS
The GPS receiver will be within the head unit. This will allow the Xtreme Chariot RDX4398-Pro Limited Edition to track one's position on a bike ride. The signal to the GPS will be received from satellites. The time, date, longitude, latitude, altitude, number of satellites and position are all displayed on the LCD for the cyclist to view.

LCD
The LCD will be part of the head unit on the handlebars. It will display the time, the date, your speed, longitude, latitude, your heart rate, altitude, number of satellites you are using and if your position is fixed on the GPS. The display will be on once the power switch is in the ON position.

Bluetooth
There will be two Bluetooth devices used, one on the magnet sensor board and one in the head unit. The sensor board's Bluetooth device will communicate to the head unit so that the processor can store the distance and speed information into buffers which will then be displayed onto the LCD. The head unit Bluetooth device will also be able to communicate with your PC's Bluetooth adapter so you can view your results at home!

Solar Battery Charger
We will have two 4.5V 80mA solar panels attached to the handlebars of the bicycle. When biking in the sun, it will charge the lithium-ion battery within the head unit.

Heart Rate Monitor
Also included in the head unit with be a heart rate receiver device. When wearing the Polar transmitter chest strap, your heart rate will be monitored continuously and updated every few seconds onto the LCD screen.

Analysis of Competitive Products

There are numerous bike computers on the market today for cyclists to buy that include a few features we have included in our product. The following describes 3 of those bike computers.

Garmin Edge 305:

- Rugged, lightweight Edge attaches easily to the stem or handlebars of your bike with the included bike mount.
- Edge 305 automatically measures your speed, distance, time, calories burned, altitude, climb and descent, and records this data for your review.
- High-sensitivity GPS receiver tracks your position even in tree cover and canyons, making it extremely reliable for distance and speed information.
- Virtual Partner® lets you race a virtual competitor over a specified distance and speed.
- Courses let you race against a previously recorded workout, so you can compare your current and past performances over the same ride.
- Auto Pause pauses the timer when you slow down or stop and resumes when you speed up again, so you can focus on your ride.
- Auto Lap automatically starts a new lap each time you pass a specified location or travel a preset distance.

The bad, while pairing with the heart rate and cadence sensors, it consumes a lot of battery. The maximum battery life is 5 hours, so you can't use the Edge 305 for long rides. Also, the software is nowhere near as good as the Polar software for recording training activities. The bike computer does not allow for easy additional route setup, you can only ride routes on the bike computer that you've rode before. The Edge 305 is also pricey, starting at $350.

Vetta Solar Flare:

The buttons have been eliminated from the face bike computer and you press the face down on the upper portion of the display to activate the rear mounted button and cycle through the functions. It has the following features: Speed, Speed Comparator, Trip Distance, Cumulative Odometer, Ride Time, 12/24 Hour Clock, Solar Powered, Dual Bike Memory, EZ Tire Setup and Service Timer. The Solar Flare is cheap and you get what you pay $20 for. The bad: This bike computer has the basic features. For an advanced cyclist, one might want to monitor their heart rate and use the GPS for mapping trails.

Bryton Rider 50 GPS Bike Computer w/ Heart Rate/Cadence:

This bike computer has 33 options for display information and includes the following features:

- Training Options: 6 modes (Fitness / Simple / Advanced / Zone Based / Interval / Lap)
- 2.2" Color Transflective TFT Display
- Preloaded Detailed Maps, POIs and Bike Routes
- Waterproof: IPX7 (Against water immersion for 30 minutes at a depth of 1m)
- GPS: High-Sensitivity Chipset
- Accepted Data Card: micro SD Card

Xtreme Chariot RDX-4398 PRO Limited Edition

- Mini USB Connection Interface
- Wireless Interface: 2.4 GHz ANT+
- Rechargeable Lithium Battery (Max 15 hours usage)
- Barometer & Digital Compass
- All displays are in English (17 optional languages)

The bad, there are issues transferring data to and from the bike computer because of file formats. Everything needs to be created with the Byron software available online and cannot be used with other Training software. The Bryton Rider 50 also costs anywhere from $360 to over $400 dollars depending on where you purchase it from.

Concept/Technology Selection

The Xtreme Chariot RDX4398-Pro Limited Edition is based on a popular paradigm for cycling data collection. A sensor unit attaches to the frame or fork and communicates information to a head unit placed on the handlebars. The product uses a common method for measuring the angular rotation of the wheel by passing a magnet over a Reed switch which drives an input to a microprocessor. This microprocessor calculates the rotational velocity and communicates the information over Bluetooth to the head unit. The hardware chosen for the task is the Bluetooth SMD Module Rayson BTM-182, which is well documented by Sparkfun. Bluetooth was chosen because it presents a common and well tested interface for wireless data transmission.

The head unit contains the GPS unit, LCD, Heart rate receiver, Bluetooth and the main MSP430f5436 processor. The head unit processor will receive, via Bluetooth, the current rate of revolution from the sensor and use the information to generate ride statistics such as speed and distance traveled. The Bluetooth within the head unit will transfer information from the microprocessor buffers to a Bluetooth enabled PC when within range. The GPS capability is included as it demonstrates a useful product to cyclists that want to track their rides. The LCD display is designed to provide as minimal and simple an interface as possible in order to avoid distracting the rider. The Heart rate receiver provides the cyclist with clear readings of their heart rate on the display for fitness purposes and tracking their development as a rider. The Polar transmitter was chosen for its slim, lightweight and elastic chest strap. It is worn snugly and comfortably below your chest muscles which allows for accurate transmission of heart rate data to the receiver.

Project Architecture

Solar Battery Charger

When the solar panels are placed in direct sunlight, they will begin charging the battery. The solar cells within the panel are also known as photovoltaic, which convert sunlight directly into electricity. The photovoltaic cells are made of semiconductors, most likely silicon. When sunlight strikes the solar cell, a portion of it is absorbed within the material. The energy absorbed loosens electrons and allows them to flow around creating a current. Metal placed on top of the cells draws the current out, combining with the cell's voltage, it provides power to the lithium ion battery attached.

Battery and Power Circuit

The3.7V lithium ion battery goes to a power switch, which powers the entire bike computer via the power circuit. Since each device within the bike computer head unit required different voltages, the power circuit had to be created. The power circuit is composed of: 5V Breakout board, 5V to 3.3V Low Drop-out Regulator, 6V Step-up circuit and the solar panel charger. The 5V Breakout board can receive an input voltage anywhere between 1-4V and outputs 5V. The 5V powers the GPS module, the Heart rate receiver, the 6V Step-up circuit and the LDO Regulator which produces 3.3V. The 3.3V powers the MSP430f5436 and the comparator circuit. The 6V Step-up circuit receives the 5V and outputs the 6V to power the LCD. The comparator circuit compares the battery voltage to a stable voltage to determine if the battery is low and needs to be charged. The stable voltage comes from the 5V but connected to a voltage divider to produce 2.5V. When the battery voltage is dropped below 2.5V, an LED will illuminate, alerting the cyclist that the solar battery charger must be turned on shortly. Refer to Figure 3.

Magnet Sensor

A sensor unit is attached to the frame or fork. The unit uses a common method for measuring the angular rotation of the wheel by passing a magnet over a Reed switch which drives an input to the MSP430f5436. The microprocessor calculates the rotational velocity and communicates the information over Bluetooth to the head unit processor attached to the handlebars. The LCD displays your speed and distance based on the information received and calculated by the processor. Refer to Figure 2.

Head Unit

*Refer to Figure 4 for Hardware information and Figure 5 for software information.

GPS

When the bike computer is placed outside, the GPS receiver module picks up satellite signals. The module is preprogrammed to output NMEA commands. Out of the six types of commands, we chose GGA and RMC. The RMC, or Recommended Minimum Specific, and GGA, or Global Positioning System Fixed Data, commands each output strings which include twelve and fifteen fields, respectively. Each field is separated by a comma until the end of message termination. We chose nine of those fields to be displayed on the LCD: UTC time, Latitude, N/S Indicator, Longitude, E/W Indicator, Number of Satellites, Altitude, Position Fixed and date. The GGA and RMC output messages were parsed so that each field could be displayed in its designed section of the display.

LCD

The LCD is designed to read and display data from the MSP430f5436 within the head unit. The data is sent from the buffers, which stores the heart rate value, the speed and distance information and GPS GGA and RMC output message. The LCD we purchased for our project came with a built on microprocessor, which we program with our software in the format created by the manufacturer.

Heart Rate

The Polar Chest strap uses a magnetic field to transmit your heart rate data to the receiver. The magnetic field is generated and detected using coils in the transmitter and receiver. The receiver coil is place in parallel with the magnetic flow generated by the transmitter for maximum energy transfer. The maximum distance between the transmitter and receiver should not exceed 2.6 feet.

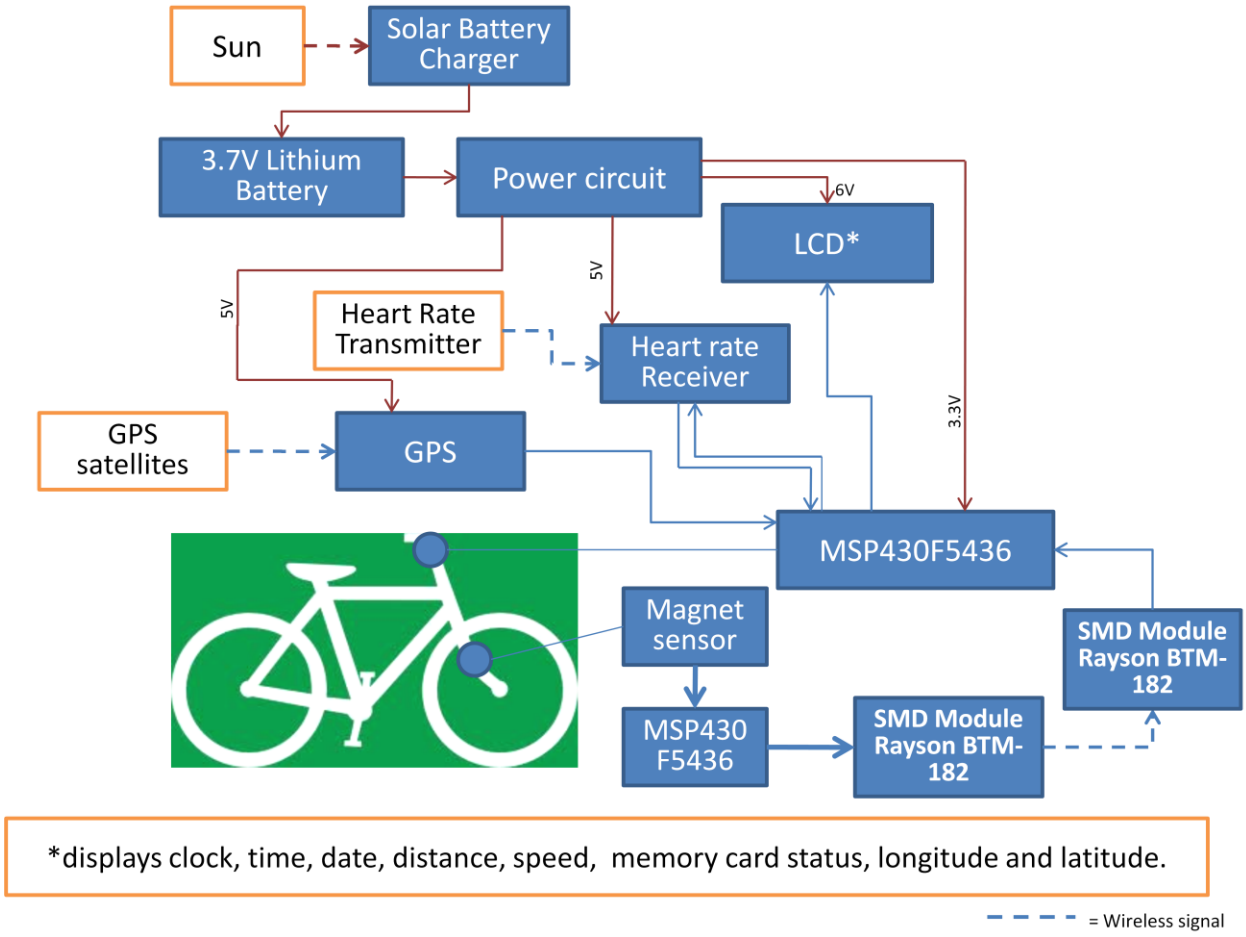


Figure 1: Block Diagram of Overall System

Flowcharts and Diagrams

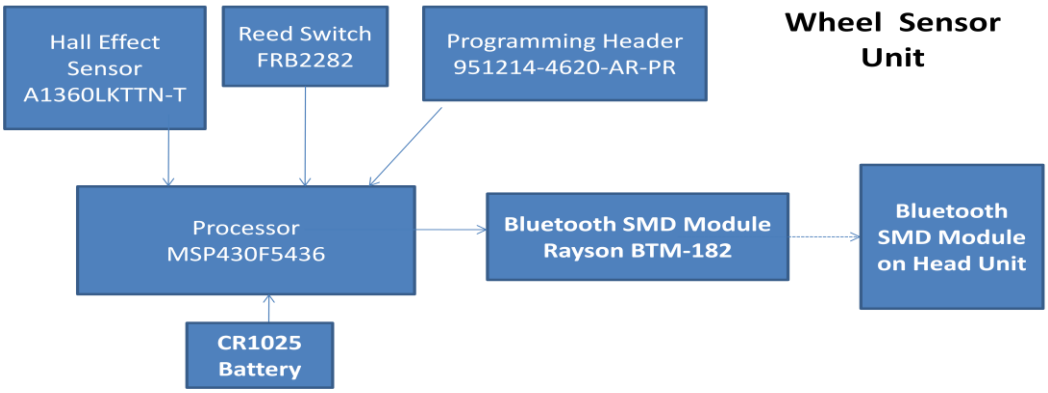


Figure 2: Wheel Sensor Board Diagram

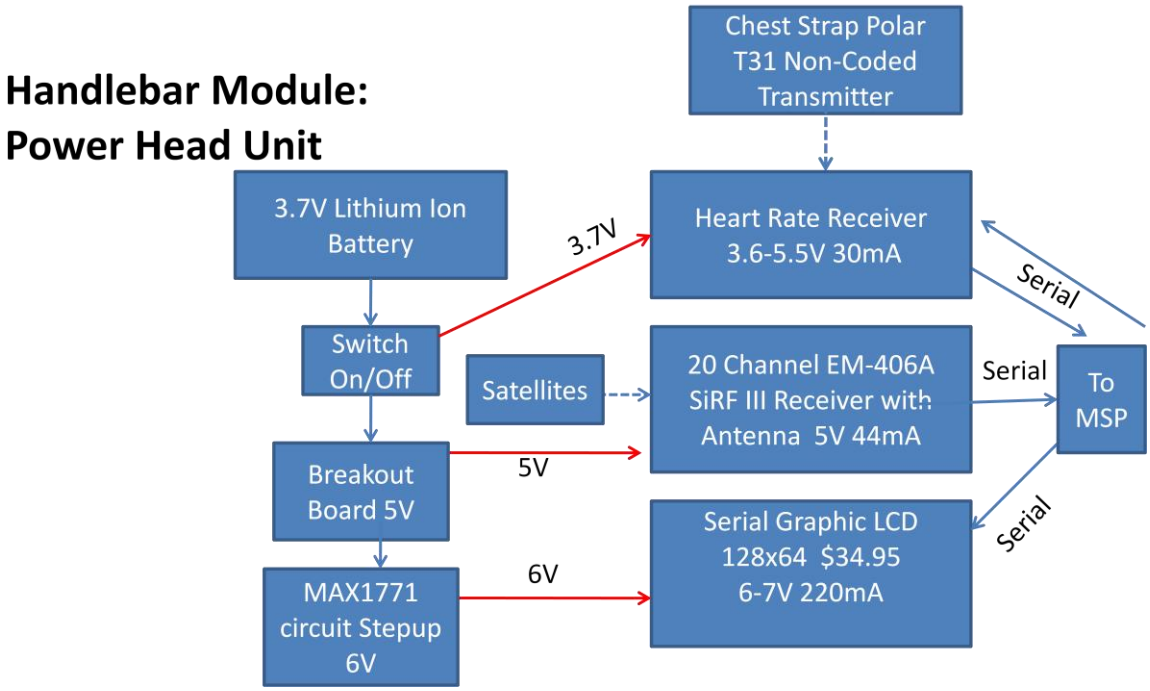


Figure 3: Power Board Diagram

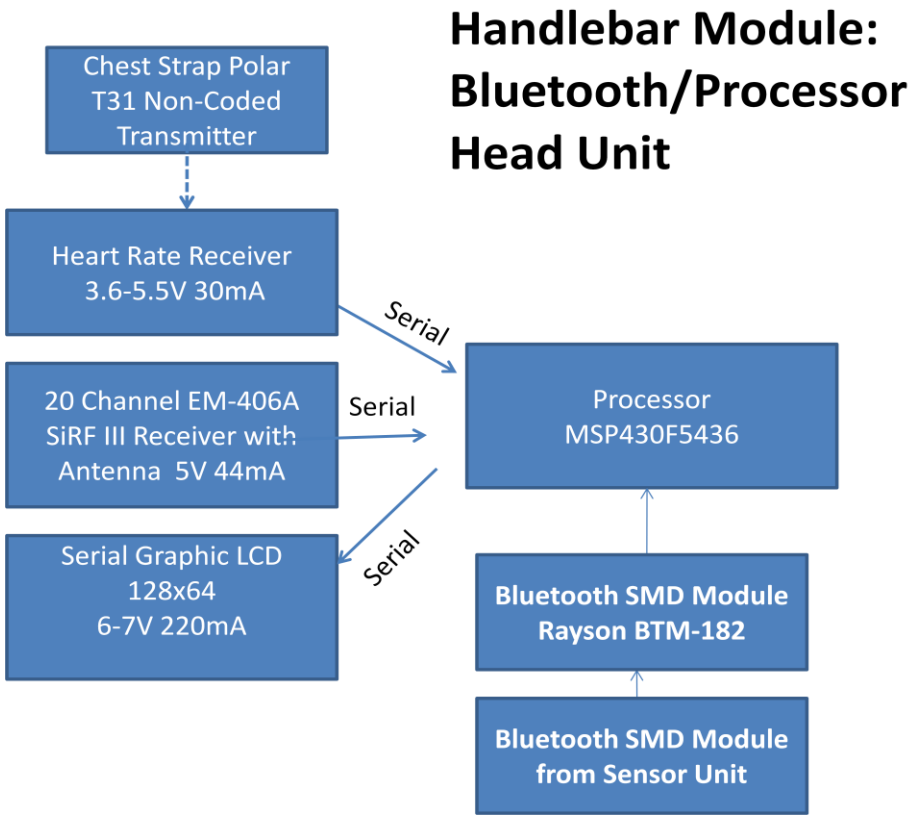


Figure 4: Head Unit Processor Diagram

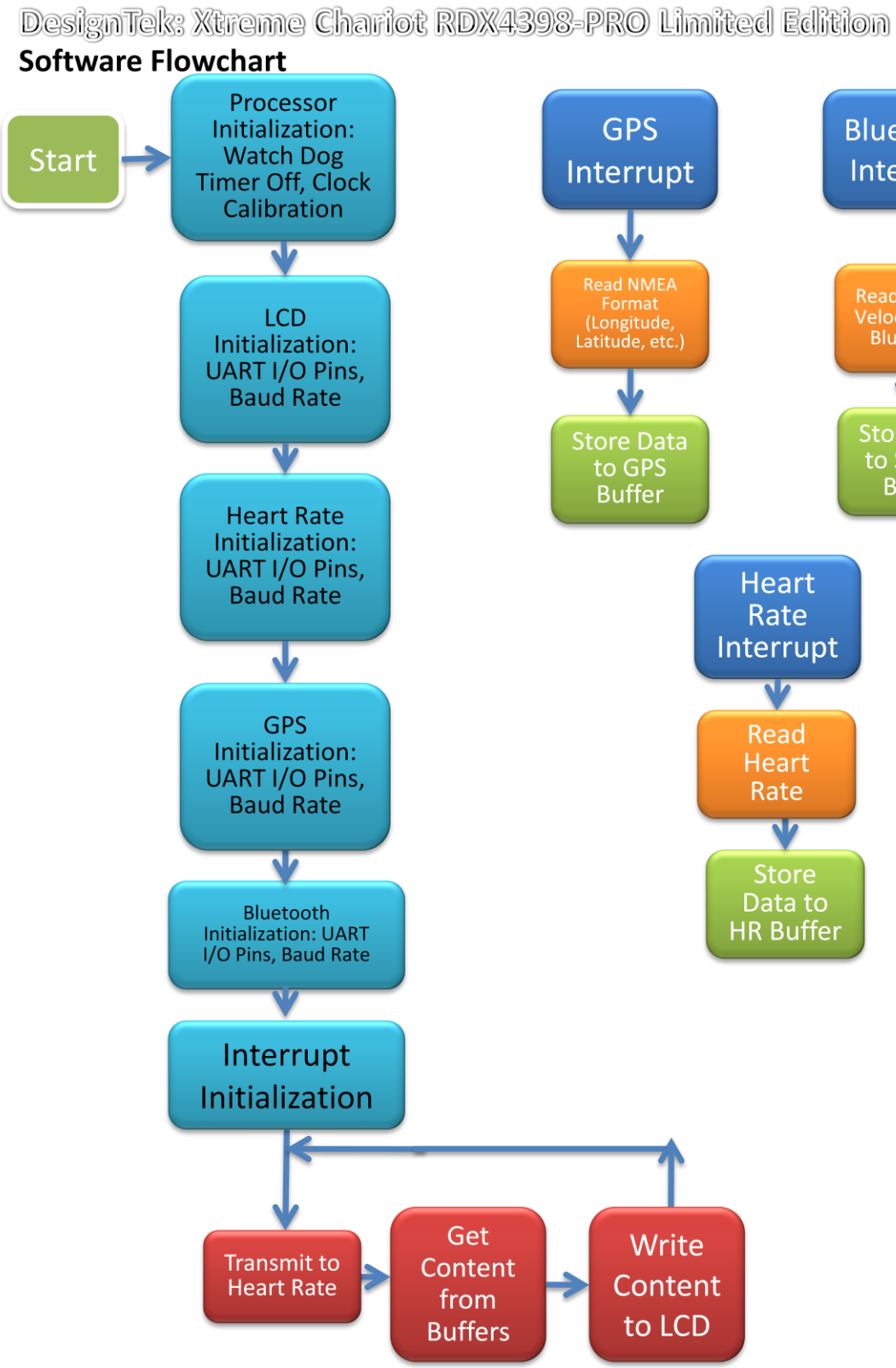


Figure 5: Software Flowchart

Separation of Work

Table 1: Specific Roles for the Project

Kristina	Megan	Adam
Research	Research	Research
Testing/Debugging Components on Breadboard	Order All Components	Testing/Debugging Components on Breadboard
Designed Power Board Schematic/PCB	Testing/Debugging Components on Breadboard	Designed Sensor Board Schematic/PCB
Soldered/Assembled Power Board	Designed Power Board Schematic/PCB	Designed Head Unit Schematic/PCB
LCD Initialization Software	Design Comparator Circuit	Additional LCD Software
GPS Initialization Software	Assembled Power Board	Additional GPS Software
Soldering PCB boards	LCD Initialization Software	Interrupt Software
Testing/Debugging Components on Power and Head Unit PCB	Design Solar Panel Battery Charger	Soldering/Testing/Debugging Components on Head Unit PCB
Heart Rate Software	Testing/Debugging Components on Power & Head Unit PCB	Soldering/Testing/Debugging Components on Sensor PCB
Bluetooth Software	Heart Rate Software	Bluetooth Software
Oral Presentation & Final Presentation	Bluetooth Software	Oral Presentation
Bike Computer Assembly	Oral Presentation & Final Report & Final Presentation	Bike Computer Assembly
Final Hardware Testing/Debugging	Bike Computer Assembly	Final Hardware Testing/Debugging
Final Software Testing/Debugging	Final Hardware Testing/Debugging	Final Software Testing/Debugging

STEP 1

Mount your bike computer onto your handlebars.

STEP 2

Turn on the power switch on the front of the bike computer labeled POWER. Allow at least 2-3 minutes for GPS and Heart Rate startup. Once the values on the LCD update, you are ready to ride!

STEP 3

When the Red LED turns on, this indicates that your battery is low and must be charged. Simply turn on the power button located on the front labeled CHARGE. The Red LED will turn off when the battery is charged.

*Please note: Your battery is rechargeable and is recharged using Solar Energy. Charging will occur best in direct sunlight. It's recommended to charge before you ride.

Problems?

If at any point you have a question about Operating your bike computer or something has Stopped working, please call us at:

1-800-DESIGNT

Thank you for purchasing the...

Xtreme Chariot RDX-4398 PRO Limited Edition

Bill of Materials

Table 2: BOM: Cost of Entire Project

Parts	Quantity	Price
Serial Graphic LCD 128x64	1	$34.95
20 Channel EM-406A SiRF III Receiver with Antenna	1	$59.95
Polar T31 Non-Coded Transmitter and Belt Set	1	$38.95
Battery Lithium 3V Coin 3V 10MM	1	$1.08
Transistor NPN GP 100MA 45V SOT23	1	$0.31
LED Green525NM WTR Clear SMD	3	$2.10
LED Blue 470NM WTR Clear SMD	1	$0.39
Conn Header 14POS 2MM R/A SMD	3	$8.79
Battery Holder	1	$0.96
Switch Reed SPST 0.5A SMD	1	$1.19
IC Hall Effect Sensor LN 4-SIP	1	$3.99
IC Bus TRANSCVR 4-Bit Dual 16QFN	2	$0.00
IC REG LDO 1.8V 0.25A 6SON	2	$0.00
Antenna Chip 2.4GHZ	2	$1.36
IC MCU 16-Bit 256KB Flash 113BGA	2	$13.12
Bluetooth Module HCI NO ANT PAN1315	2	$28.82
Polymer Lithium Ion Battery - 2000mAh	1	$16.95
NCP1400-5V Step-Up Breakout	1	$5.95
Polar Heart Rate Monitor Interface	1	$59.95
IC DC/DC CTRLR STEP-UP ADJ 8DIP	1	$5.04
Step Up/Down Inverting Switching Regulator	1	$1.95
RES 18K OHM CARBON FILM 1/4W 5%	1	$0.09
KG RAD ALUM ELEC CAP 68UF 6.3V	1	$0.30
CAP 3300UF 6.3V ELECT NHG RADIA	1	$0.74
CAP 100PF 250VAC CERAMIC Y2/X1	1	$0.52
DIODE SCHOTTKY 1A 20V DO41	1	$0.42
IC MCU 16-Bit 192KB Flash 100 LQFP	4	$17.20
Central Semi Diodes	2	$0.12
KOA Speer RF Inductors 150nH	2	$1.06
Kemet Multilayer Ceramic Capacitors 30pF	4	$1.08
TDK Power Inductor 22uH	2	$3.60
Thick Film Resistors - SMD 47K 1%	4	$0.20
Thick Film Resistors - SMD 1/8watt 1Kohms .5%	3	$0.33
Carbon Film Resistors - Through Hole .1 OHM	2	$0.46
Multilayer Ceramic Capacitors (MLCC) - 2.2pF	1	$0.21
Multilayer Ceramic Capacitors (MLCC) - 1uF	2	$0.44
Multilayer Ceramic Capacitors (MLCC) - 0.1uF	3	$0.60

Multilayer Ceramic Capacitors (MLCC) - 0.01uF	4	$0.72
Rocker Switch	3	$2.85
LiPo Charger Basic - Micro-USB	1	$9.95
4.5 Volt 80 ma CIS Solar Cell		$8.00
Bluetooth SMD Module - Rayson BTM-182	2	$29.90
Miscellaneous		$31.39
Sales Tax		
Estimated Shipping Costs		$77.09
	28	**$473.07**

Gantt Chart

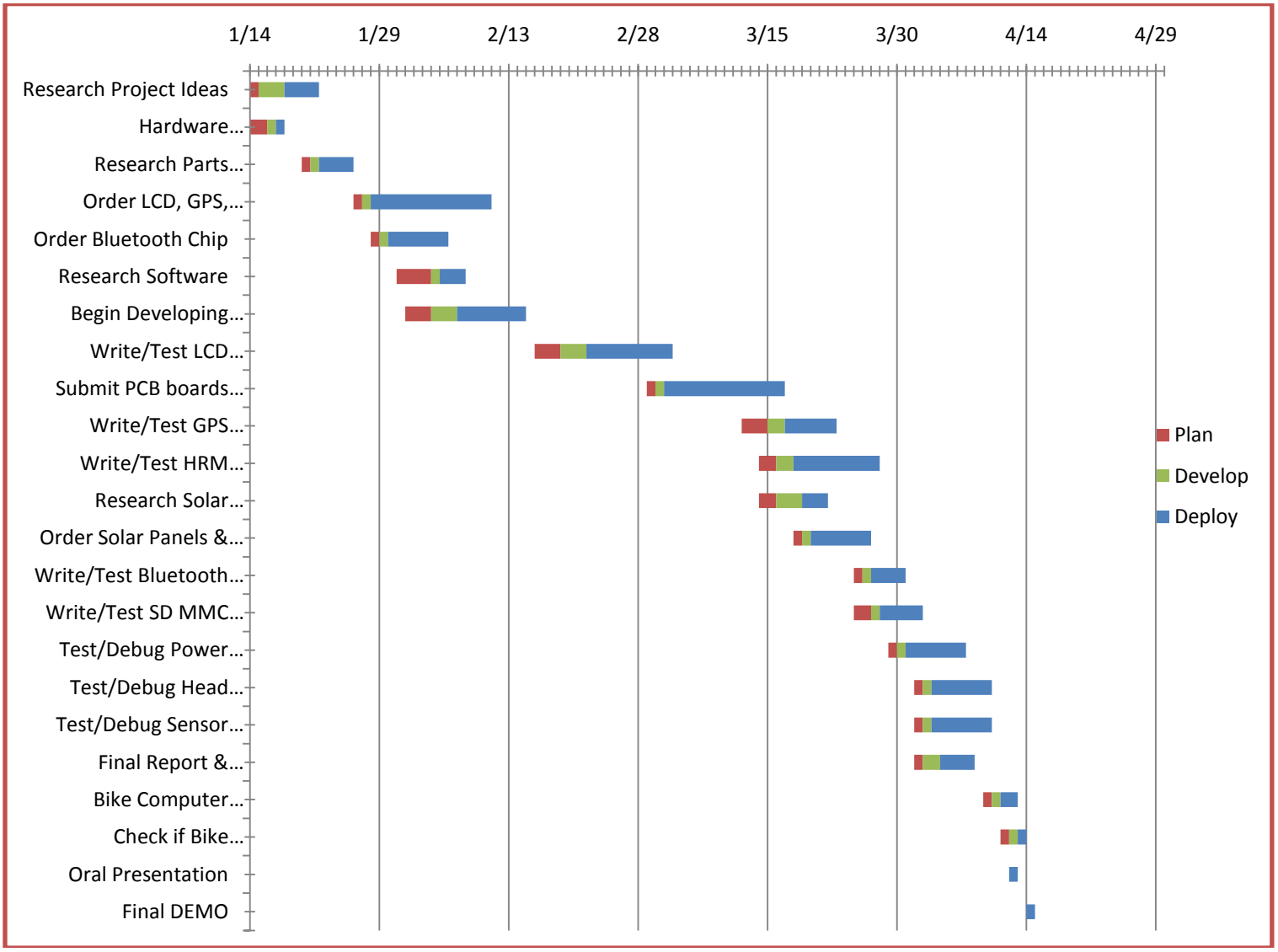
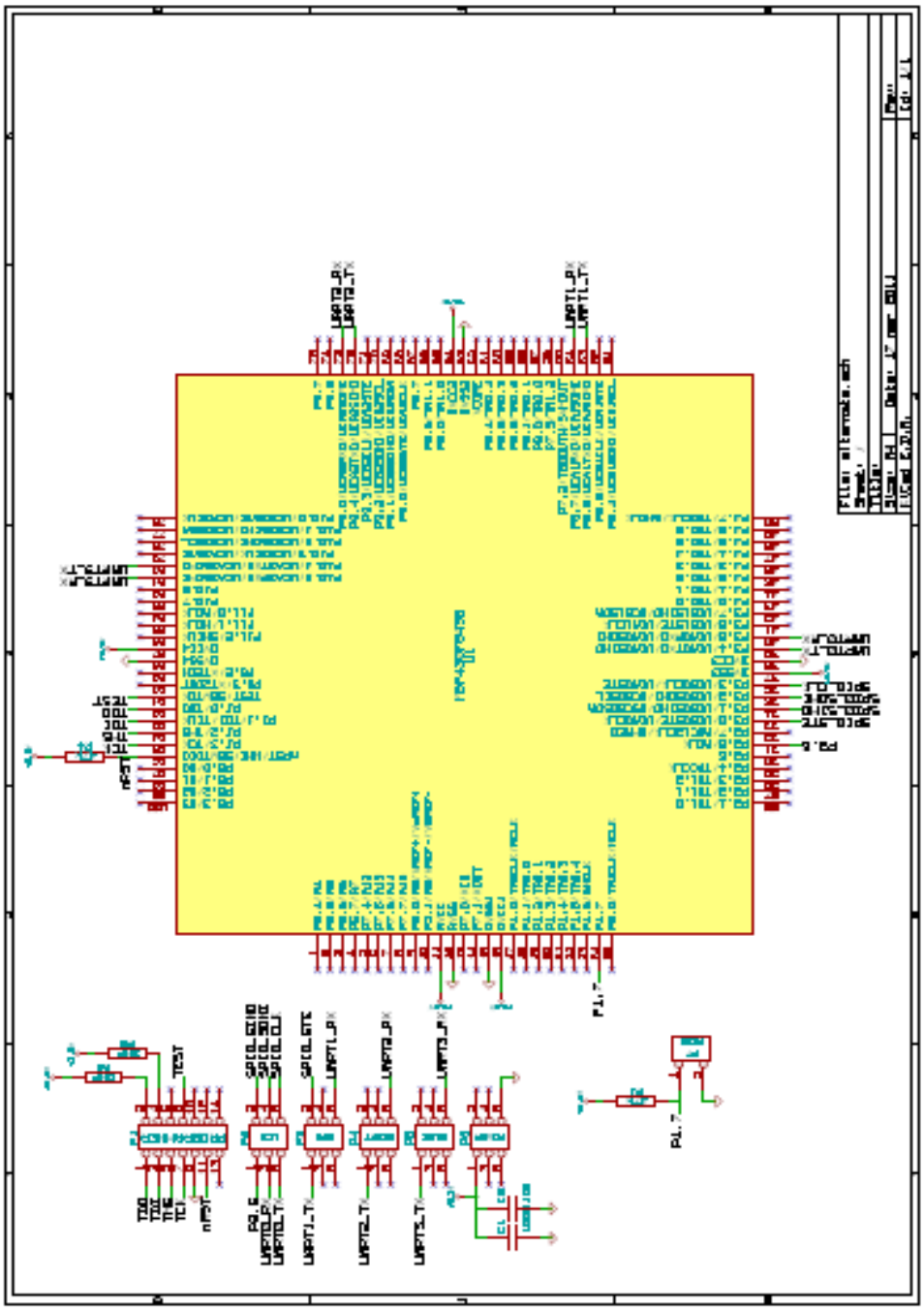


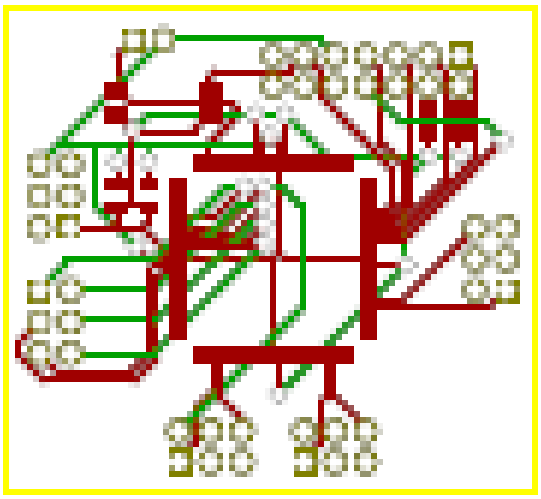
Figure 7: Gantt Chart Reflecting Timeline of Overall Project

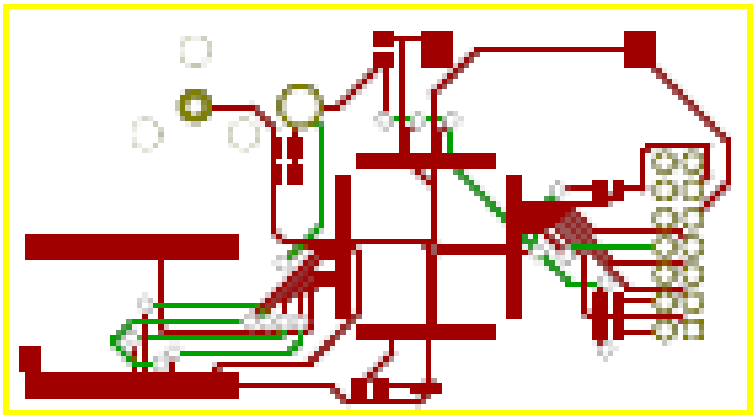
Appendices

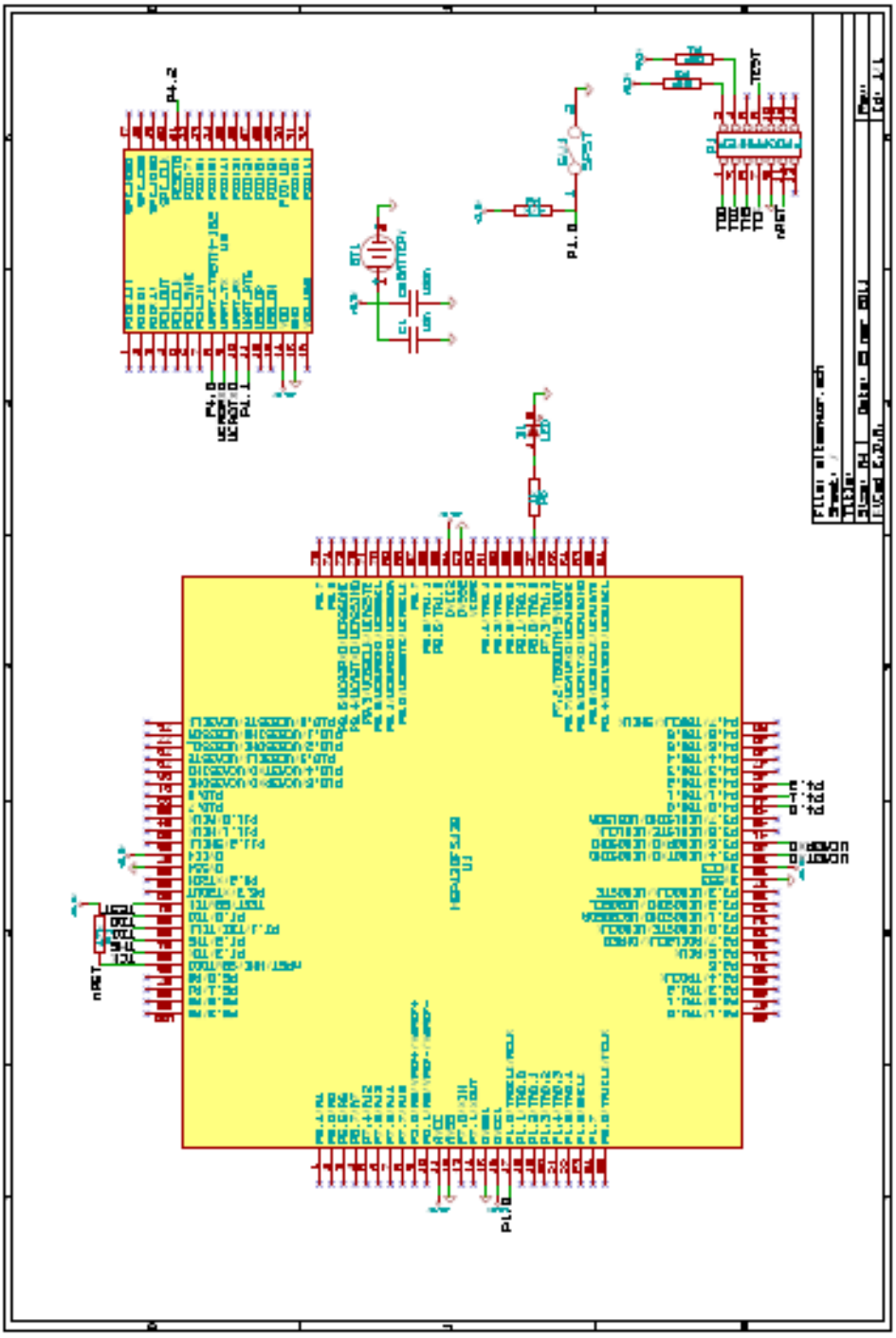
Big Thanks to the following:

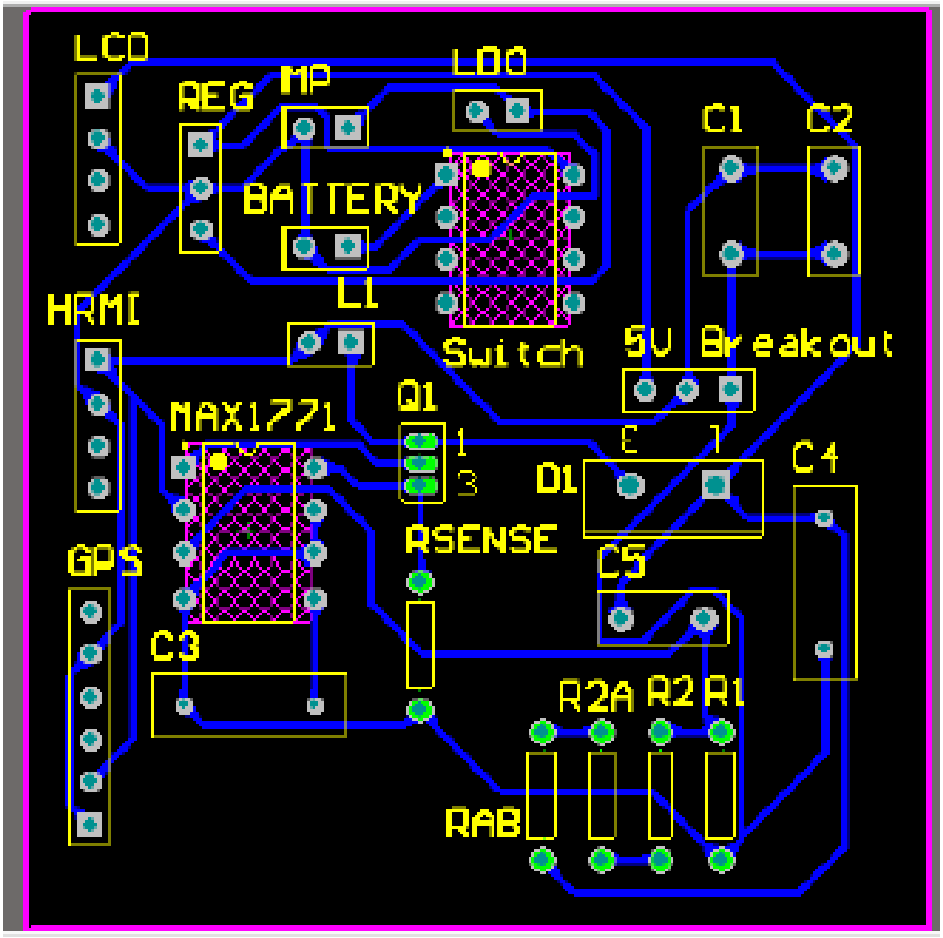
For Sponsoring our Senior Design Project! We appreciate it greatly!







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REG
MP
LDO
BATTERY
C1
C2
HRMI
L1
Switch
5V Breakout
MAX1771
Q1
D1
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R2A
R2
R1
RAB