Universol Charge Station

Group 17

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Sponsored

leidos

DUKE ENERGY

Motivations

Environmental

- Renewable Energy
- Carbon Emissions

Power Demand

- Power Dependency
- Availability

Solution

Universol Charge Station

- A Solar Powered Cell Phone Charging Station
- Photovoltaic Battery Charging System
- Zero Carbon Emissions
- Color Touchscreen User Interface
- Personalized PIN Number Security Access Code
- Charge Up To 4 Cell Phones Simultaneously
- Monitor Charging Activity
- Company Advertisement Slots
- 24 Hour Autonomy

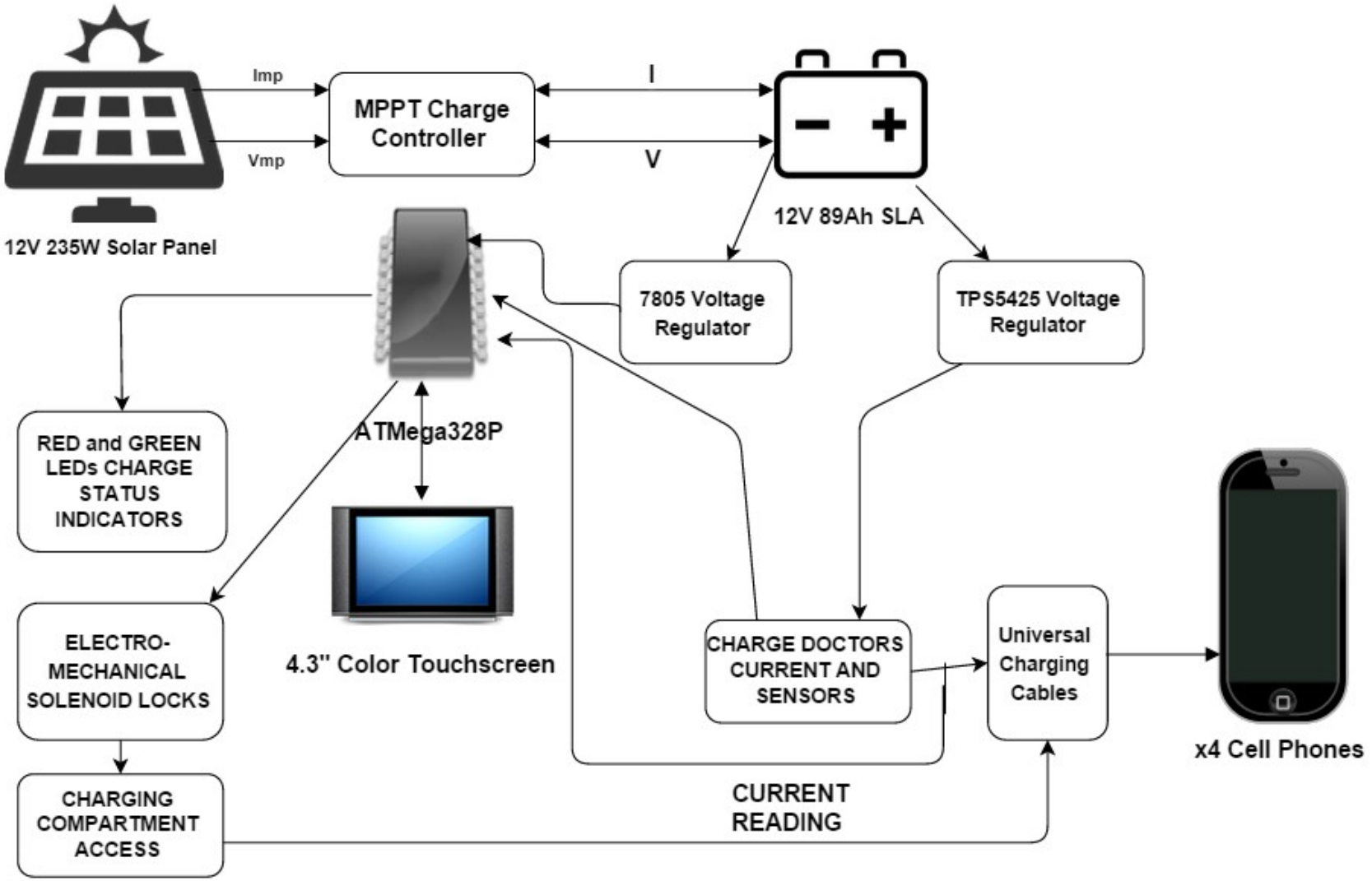
Specifications

Item	Qty	Description
12V 235W Solar Panel	1	Power Input
30A MPPT Charge Controller	1	Controls Power from Solar Panel to Battery
12V 89Ah SLA Battery	1	Rechargeable Battery
12V DC 5V 1A USB HUB	1	Voltage Regulating Charging Hub
Universal Charging Cables	4	4th and 5th Gen. Android and Iphone
ATMega328P	1	Microcontroller
Green LEDs	4	Charge Status Indicators
Red LEDs	4	Charge Status Indicators
Current Shunt Resistors	4	Charge Status Sensor
4.3" Color Touchscreen	1	User Interface, Advertisemnts
5V Voltage Regulators	2	12V – 5V Voltage Regulators
Electro-Mechanical Solenoid Locks	4	Programmable Compartment Locks
Metal Enclosure with see through doors	1	Metal with Clear Doors Weight: 60 LBS Dimensions: (12 x 78 x 18)in
Solar Panel Mount	1	Adjustable
PCB board	1	Special Order

Requirements

- Optimized Power System Efficiency through MPPT
- The MCU must continuously monitor the current delivered to the charging phones
- LED charge status indicators
- High-Level Security Access
- Durability – High volume of users
- The System must be able to operate with24 hours

Overall Block Diagram



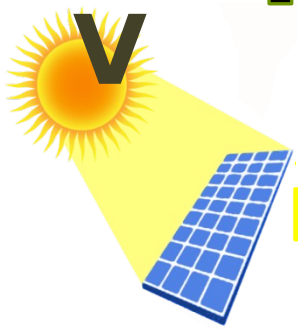
Photovoltaic (PV) Power System

- Small Off-Grid PV System
- Solar Panel Voltage Rated Higher than Battery
- Charge Control inhibits overcharge of battery
- Solar Panel Output Current Limited

235 Max P

30.2 V = 7.8 I

12 V 7.8 I = 93.6 Max P



BASIC CHARGE CONTROL

Maximum Power Point Tracking (MPPT)

- **Solution MPPT**
- Uses an algorithm to track max. power curve
- Enhances Power Gain by Increasing Current

Ideal Conditions/ Ideal Goal

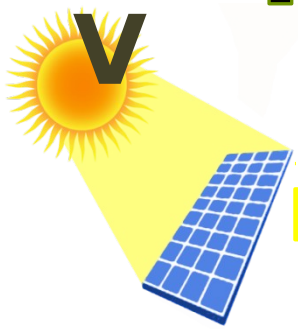
235 W Max

P =

30.2 V | 7.8 I

12 V | 19.5 I

= 235 W Max P



MPPT CHARGE CONTROL

Design Considerations

Common Industry Recommendations:

- 12 V Deep Cycle Battery
- Depth of Discharge (DOD) - 60% capacity

Location:

- 5.76 Average annual Sun Hours in Central Florida

Days of Autonomy:

- Selected 24 hours of system operation without Solar Power

Sizing the PV System

Electrical Loads	Quantity	Watts	Hours/Day	Watt-Hours/day
Cell Phones	4	5	24	480
4.3" Color Touch Screen	1	0.25	24	6
ATmega 328 P	1	0.2	24	4.8
				490.8

- Establi

- $Total\ Electrical\ \frac{Load}{day} = \sum \frac{Watt * hours}{day}$

Size Battery Bank Capacity

Size Battery Bank Capacity

- Battery Bank Size (Amp Hours) $= \frac{Watt\ hours * Days\ of\ Autonomy}{.85 * Max.DOD * Nominal\ Battery\ Voltage}$

Establish minimum Current output by Solar Panel

Establish minimum Current output by Solar Panel

Establish maximum Current output Charge Controller should handle

- $Solar\ Panel\ Amperage = \frac{\frac{Wh}{day}}{batttery\ nominal\ voltage} * \frac{1}{5.76\left(\frac{h}{day}\right)}$

Establish maximum Current output Charge Controller should handle

- $Charge\ Control\ Amp\ Cap. = \frac{Solar\ Panel\ (Watts)}{Nominal\ Battery\ Voltage} + (.25 * \frac{Solar\ Panel\ (Watts)}{Nominal\ Battery\ Voltage})$

1.25 NEC power factor buffer

PV System Analysis/Design

Minimum Requirements Design

Electrical Loads	Quantity	Watts	Hours/Day	Watt-Hours/day
Cell Phones	4	5	24	480
4.3" Touch Screen	1	0.25	24	6
ATmega 328 P	1	0.2	24	4.8
				490.8

Design Parameters	Nominal Values	Units
Autonomy	1	Days
Nominal Battery Voltage	12	Volts
DOD	0.6	Percent
Average Sun Hours Central Florida	5.76	Hours/Day

Design Results	Nominal Values	Units	Cost	
Battery Bank Size	80.20	Amp-hours	$250.00	
Solar Panel Amperage	7.10	Amps	$230.00	
Charge Controller Amperage Capacity	15.63	Amps	$265.00	
			$745.00	Total Main System Cost

Final Design

Saved $230.00

Electrical Loads	Quantity	Watts	Hours/Day	Watt-Hours/day
Cell Phones	4	5	24	480
4.3" Touch Screen	1	0.25	24	6
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Nominal Battery Voltage	12	Volts
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Average Sun Hours Central Florida	5.76	Hours/Day

Design Results	Nominal Values	Units	Cost	
Battery Bank Size	80.20	Amp-hours	$250.00	
Solar Panel Amperage	7.10	Amps	$0.00	
Charge Controller Amperage Capacity	24.48	Amps	$265.00	
			$515.00	Total Main System Cost

Design Verification

Trojan Battery off-grid calculator

Trojan BATTERY COMPANY
Clean energy for life.

RE Renewable Energy Off-Grid Battery Sizing Calculator

Welcome to the Trojan Battery Renewable Energy Sizing Calculator. This calculator is a tool to help you determine the model and quantity of Trojan batteries needed for your renewable energy or backup power system. The calculator recommends batteries based on your inputs and the results are ranked according to cycle life performance.

RE STEP 1

Please Select Your System Design Parameters

Choose system design battery voltage (12V, 24V, or 48V)
12 V

Choose desired battery depth-of-discharge (DOD)
50%

Type of Battery
VRLA – Maintenance Free

Days of Autonomy
1

System Loads and Battery Capacity Requirements

Values below will change as you enter system parameters and load estimates.

Battery watt-hours per day for AC loads (including 15% AC inverter loss)	0.00	Wh/day
Battery watt-hours per day for DC loads	490.80	Wh/day
Total battery watt-hours per day (assuming 97% wiring and distribution efficiency)	505.98	Wh/day
Avg daily battery amp-hours needed (with 12V battery system)	42.16	Amp-hours (@12V)
Required system capacity* (based on desired 50% DOD) to achieve 1 days of Autonomy.	84.33	Amp-Hours (@12V)

Battery w/in 5% (84.33 Ah)

RE STEP 2

Please Enter Your Average Daily Load Estimates

Click here to see average wattage for a typical appliance.

Load Description	DC Load? (uses AC load unless checked)	Watts	Quantity	Hours Per Day	Days Per Week	Total Watts	Total Average Watt Hours Per Day*	Remove Item
cell phone charging	☑	5	4	24	7	20W	480Wh	REMOVE
touch screen	☑	.25	1	24	7	0W	6Wh	REMOVE
Microcontroller	☑	.2	1	24	7	0W	5Wh	REMOVE

AltE off-grid calculator

STEP 3:

Determine How Many Solar Panels You Need In Your Array

How many solar panels do you need? That depends on the panel you choose.

Select the wattage of the panel your interested in, and see the results below:

235 watts per panel

You will need 1 panels for a total of 235 watts.

Select the solar panel that fits your needs.

Sizing your Solar Charge Controller

You will need a charge controller that can handle 20 amps

CC w/in 2.5%

Select the solar charge controller that fits your needs

Sizing a charge controller can be complex, the above answer is a conservative estimate. Please feel free to call us to find a more accurate fit for your needs.

Now that you have sized up the system that fits your needs, call our Knowledgeable Sales Folks at 800-320-9514 and let them help you find the exact products for your system.

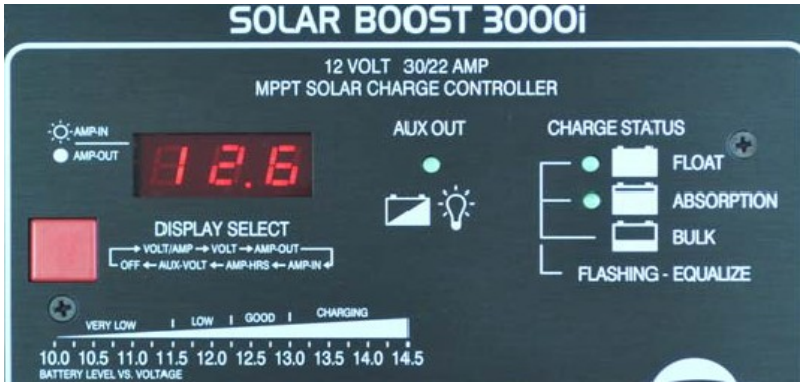
MPPT Charge Controller

BLUE SKY Solar Boost 3000i

Characteristics	Blue Sky SB3000i MPPT Controller System	Linear Technology LT8490 I.C. System
Efficiency	95%	97%
Power Loss	5%	2-3%
Cost	$265.00	$195.00
Digital Display	Yes	No
Complexity of Design	Simple	Complex
Temperature Compensation	Optional	No
Communications Control	Remote Access	No
Adjustable Voltage Set Points	Yes	Yes

- **30A/15 V** Amperage Voltage Output Capacity
- Built-in **Charging Algorithm/MPPT**
- Built-in **Heat Sink**
- 95% power efficient

Monitoring MPPT Efficiency/ Battery DOD



- Digital Display
  - **Solar Amp In**
  - **Controller Voltage Out**
  - **Controller Amp Out**

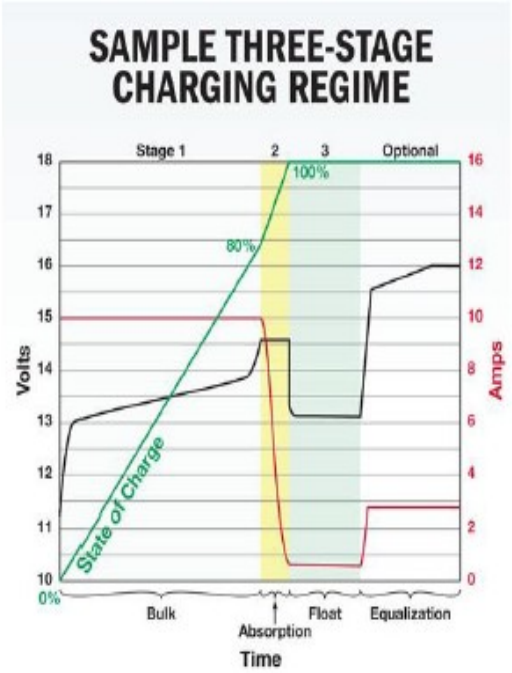


Figure 3.4-3 Sample Three-Stage Charging Regime

CHARGE STATUS LED's	CHARGE MODE	APPROX. BATTERY CHARGE LEVEL	CURRENT OUTPUT
ABSORPTION & FLOAT OFF	CHARGE OFF	0%/DISCONNECTED	NONE
ABSORPTION & FLOAT ON	BULK	<70% FULL	HIGH
ABSORPTION ON – FLOAT OFF	ABSORPTION	70% - 95% FULL	TAPERS OFF
ABSORPTION OFF – FLOAT ON	FLOAT	FULLY CHARGED	TRICKLE/MAINTENANCE CHARGE

Solar Panel Comparison

Minimum Current Output of 7.1A

	Monocrystalline Solar Panel	Polycrystalline Solar Panel
Efficiency	**About 17%**	**11% - 14%**
Power generated per (ft^2)	**More**	**Less**
Aesthetics	**Consistent Deep Black Design**	**Inconsistent Blue Cell Design**
Temperature Tolerance	**Higher**	**Lower**
Cost	**Higher**	**Lower**

Solar Panel Selection

Suntech 235W Polycrystalline Solar Panel

Electrical Characteristics	
STC	STP235-20/Wd
Maximum Power at STC (Pmax)	235 W
Optimum Operating Voltage (Vmp)	30.2 V
Optimum Operating Current (Imp)	7.79 A
Open Circuit Voltage (Voc)	37.0 V
Short Circuit Current (Isc)	8.35 A
Module Efficiency	14.4%

Dimensions	1640 × 992 × 35mm (64.6 × 39.1 × 1.4 inches)
Weight	18.2 kgs (40.1 lbs.)

Battery

TROJAN 12 V 89 Ah (Absorbent Glass Mat) AGM

Parameters	Lead Acid Gel Sealed	Lead Acid AGM	Lithium Ion
Average battery life	Replace every 3-5 years	Replace every 10 years	Replace every 10 years
Deep cycle DOD efficiency	50%	60%	80%
Weight	66 lbs.	64 lbs.	4 lbs.
Space requirements	8.1 x 8.1 x 5.9 inches	12.05 x 6.84 x 9.32 inches	7.17 x 6.61 x 3.03 inches
Cost	$200.00	$250.00	$560.00
Charge Efficiency	75%	75%	97%
Energy Efficiency	Moderate	Moderate	High
Environmental hazards	80% recyclable	97% recyclable	60% recyclable

- Most common practice in PV Systems
- Maintenance Free
- Cost Efficient
- Eco-conscious
- Weight and Space Accommodations met by Enclosure

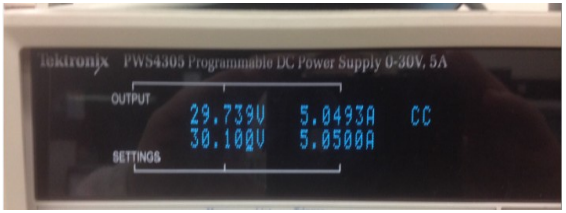
Power System Compatibility (Lose it?)

SPECIFICATIONS	Solar Boost 3000i
Nominal Battery Voltage	12 VDC
Automatic Output Current Limit	30.0A with 36 cell PV input • 22.0A with 60 cell PV input
Maximum PV I_{SC} / Power	24.0A / 400W with 36 cell PV input • 11.8A / 290W with 60 cell PV input
Maximum Battery & PV Voltage	50.0VDC absolute maximum① (Recommend maximum PV V_{OC} at STC ≤ 40.0VDC)
Standby Power Consumption	30mA typical
Charge Algorithm	3-stage Bulk/Absorption/Float • Plus Auto/Manual Equalization
Power Conversion Efficiency	97% typical, 36 cell modules delivering 24A

295 W Solar Panel

- Solar Panel Max Power at STC (Pmax): 295 W 60 Cell Module
- Battery Voltage: 12 V DC
- Solar Panel Open Circuit Voltage (Voc): 32.0 V
- Amperage Capacity Output Charge Current: 24.0 A plus a 1.25 NEC buffered power factor
- Max. Current: 23.5 A
- Under ideal conditions: 19.6 A

UniverSOL PV System Prototyping



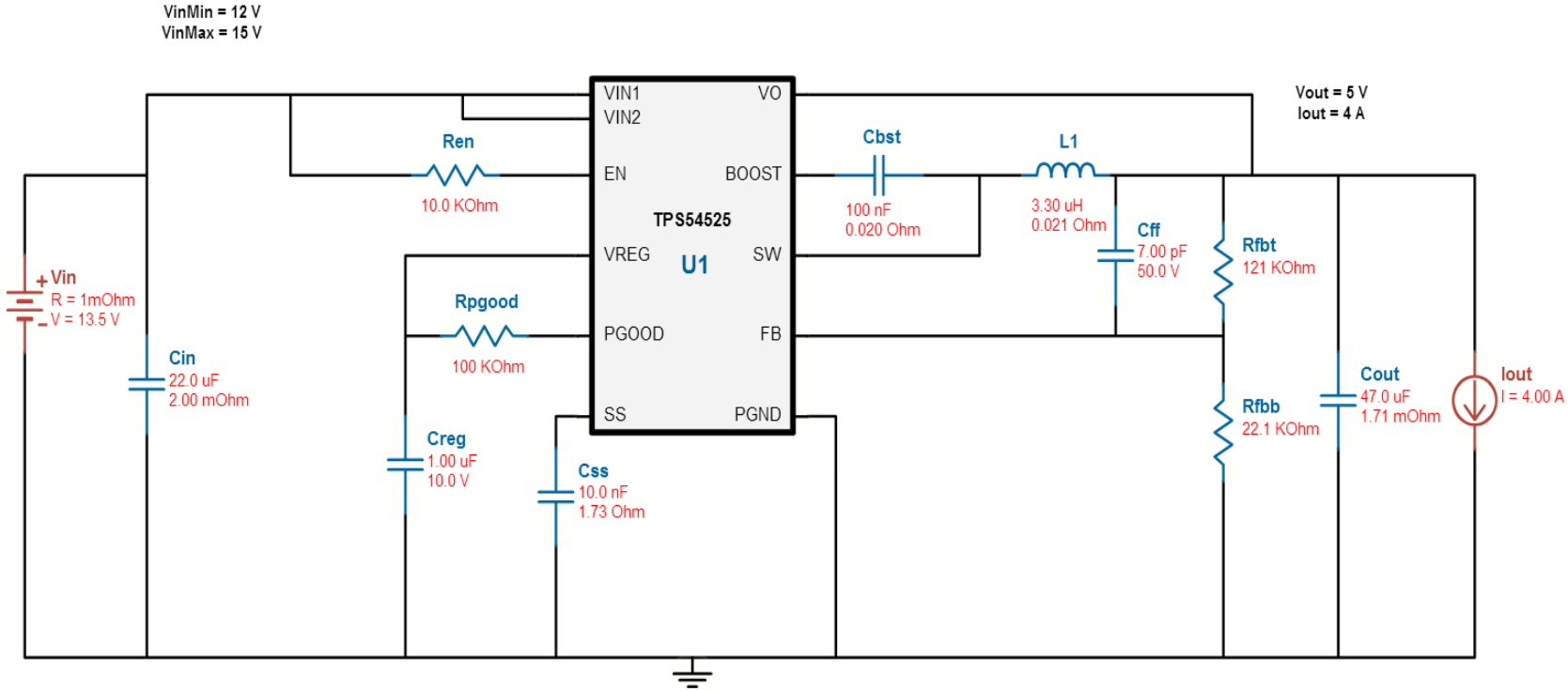
INPUT
150 W

OUTPUT
137 W

91 % OF TOTAL POWER

Voltage Regulators

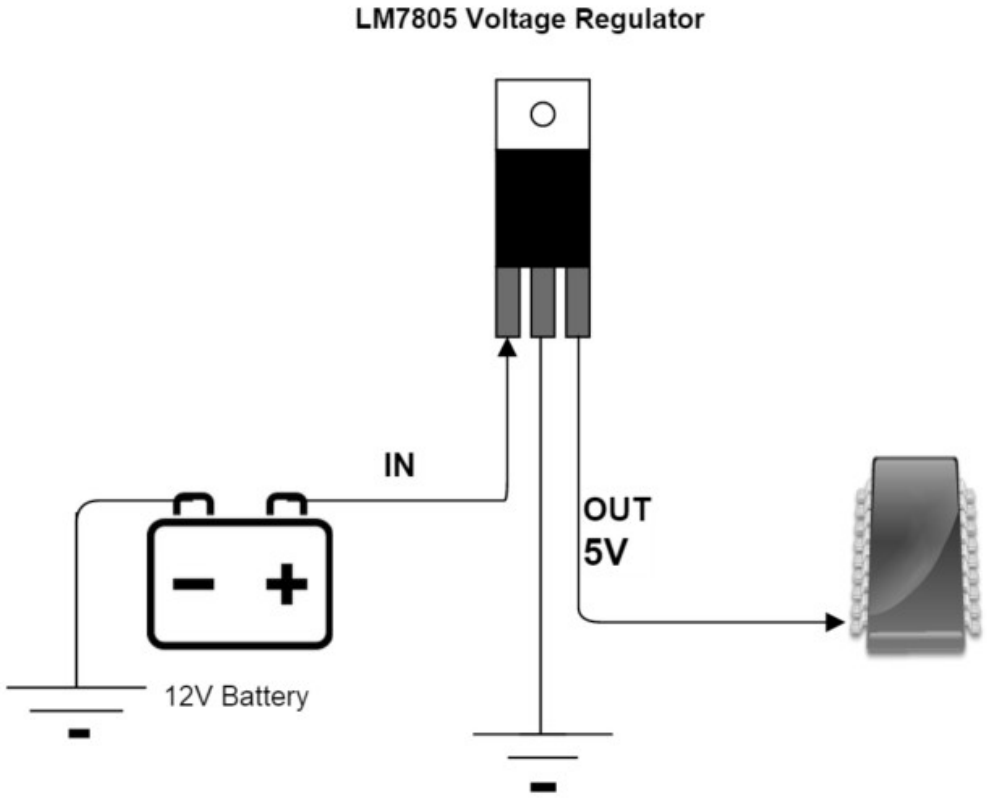
- Pharmas



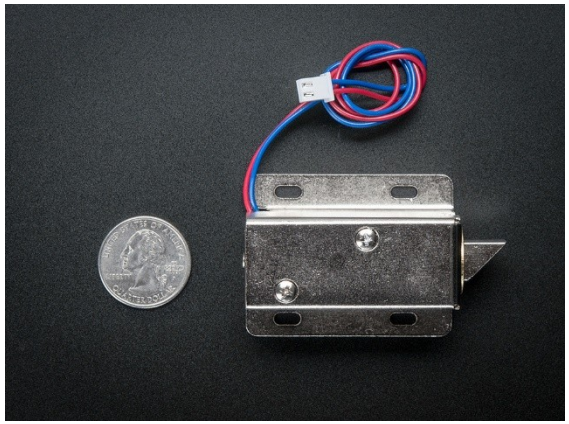
Voltage Regulators

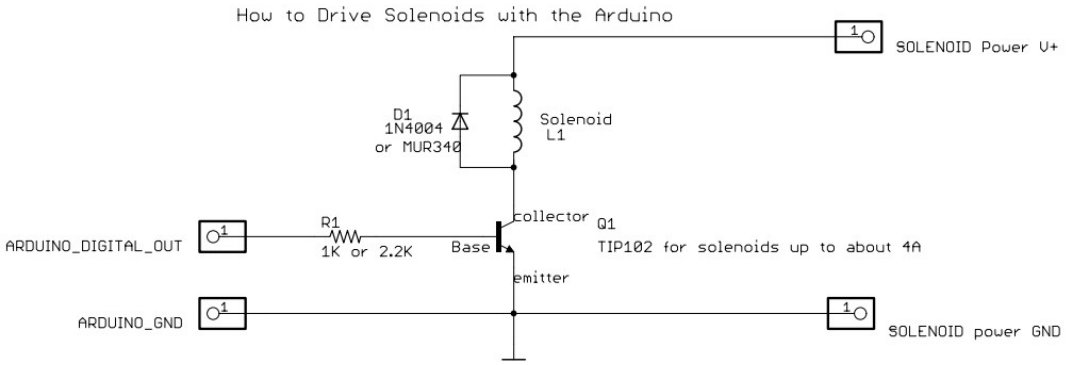
- Mic
  - 12
  - LM

nt



Cabinet Locks





TECHNICAL DETAILS

- 12VDC (you can use 9-12 DC volts, but lower voltage results in weaker/slower operation)
- Draws 650mA at 12V, 500 mA at 9V when activated
- Designed for 1-10 seconds long activation time
- Max Dimensions: 41.85mm / 1.64" x 53.57mm / 2.1" x 27.59mm / 11.08"
- Dimensions: 23.57mm / 0.92" x 67.47mm / 2.65" x 27.59mm / 11.08"
- Wire length: 222.25mm / 8.75"
- Weight: 147.71g

Current Sensors

- The PCB will have four mounted ACS712 Hall-Effect-Based Linear Current Sensor ICs with 2.1 kVRMS Voltage Isolation and a Low-Resistance Current Conductor
- Current flowing through a copper conduction path generates a magnetic field which is then sensed by the integrated Hall IC and converted into a proportional voltage
- The ATMEGA328 processor reads t voltage to determine the charge status of the phone being charged

LED Status Indicators(JC)

- Status of charge level on phones
- Green and Red LED mounted inside each locker
- Visible from outside of locker to indicate status of locker or phone

Red indicates phone is charging.

Green indicates phone charging complete.

The Charger Doctor Current and Voltage Meter

- Current and voltage test tool
- Digital LED 7-segment readout
- Alternates between voltage and current readings every 5 seconds

Current Sensing to Indicate Charge Status

- **No cell phone connected to charger plug**
- **All Indicator lights off due to no current**

- **Cell phone connected to charger plug**
- **Indicator light illuminated red due to cell phone battery receiving charge**

- **Connected cell phone completely charged**
- **Indicator light illuminated green due to cell phone battery drawing limited amount of current**

Charging Cabinet Modifications

- Decrease the height from 78” to 72” by removing legs, so Universol’s available charging lockers are at a more user-friendly height
- New dimensions: 72”Hx12”Wx15”D
- Locker 1 used for storing battery and MPPT charge controller
- Locker 2 will house touch screen display
- Lockers 3 through 6 to be used for cell phone charging

4-in-1 Breakout Cables (JC)

- Apple i3 and i4 dock connector
- Apple Lightning iPhone 5, 5S, 6, 6+
- Micro USB
- Mini USB
- Total Length is 12.80”

Cabinet Modification Detail: User-Charging Locker

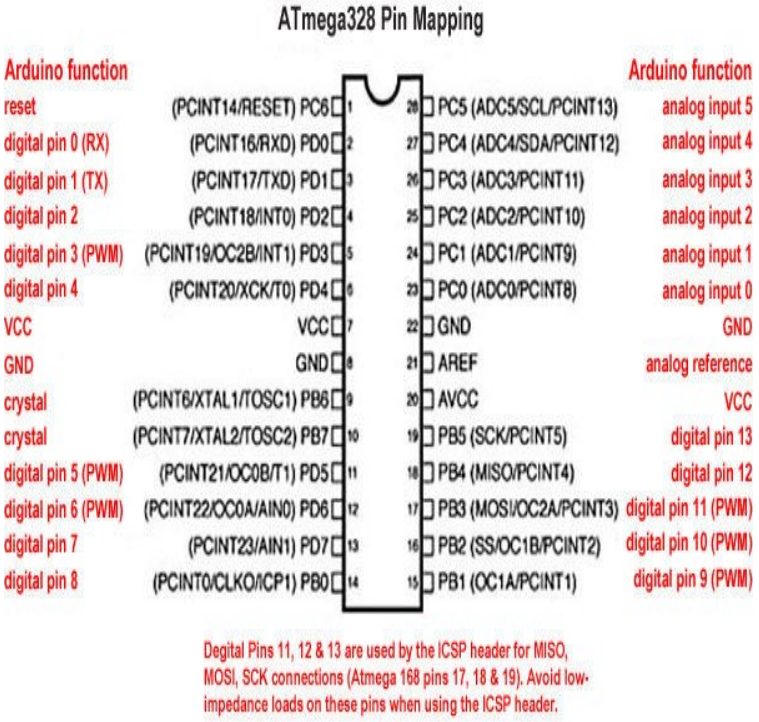
Each locker:

- Has a solenoid lock controlled by a user PIN entered through the touch-screen
- Will be equipped with red and green LED indicators
- Will have the 4-in-1 charging break-out cables for various cell phones

Cabinet Back

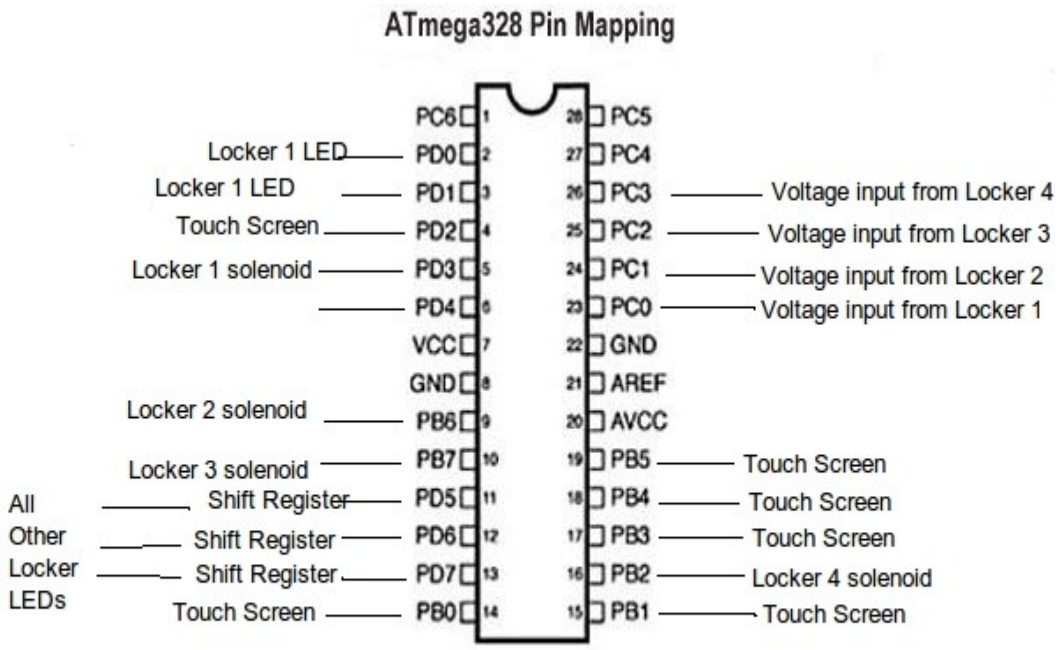
- Easily accessible rear control panel
- Terminal strip for common tie-in points
- Power and signal separation to eliminate noise issues
- Charge Doctor in-line current sensors for constant monitoring of current to the phones
- Locker 1 to be ventilated due to heat released during battery operation

Embedded System
Microcontroller Unit I/O



- Atmel ATmega328P
- 8-bit microcontroller
- 32 KB Program Memory
- Operating Voltage 1.8 to 5.5 Volts
- 6 analog input/output pins
- 14 digital input/output pins

Microcontroller I/O



Input voltage from phone in each locker

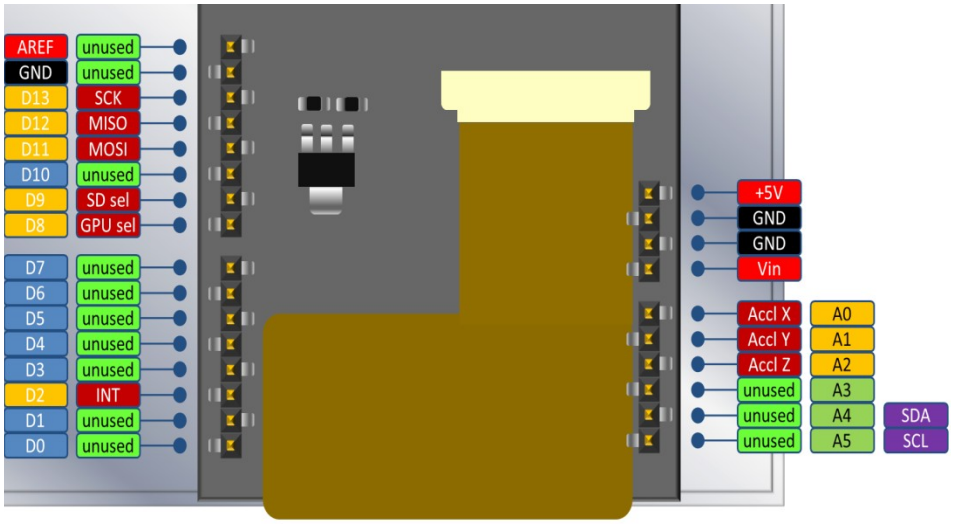
One output to each locker for the solenoid locking mechanism

Output signal to the LED inside each locker

Input and output for the user display and interface via touchscreen

Shift register to add more digital pins

Touch Screen



Main Component of our user interface

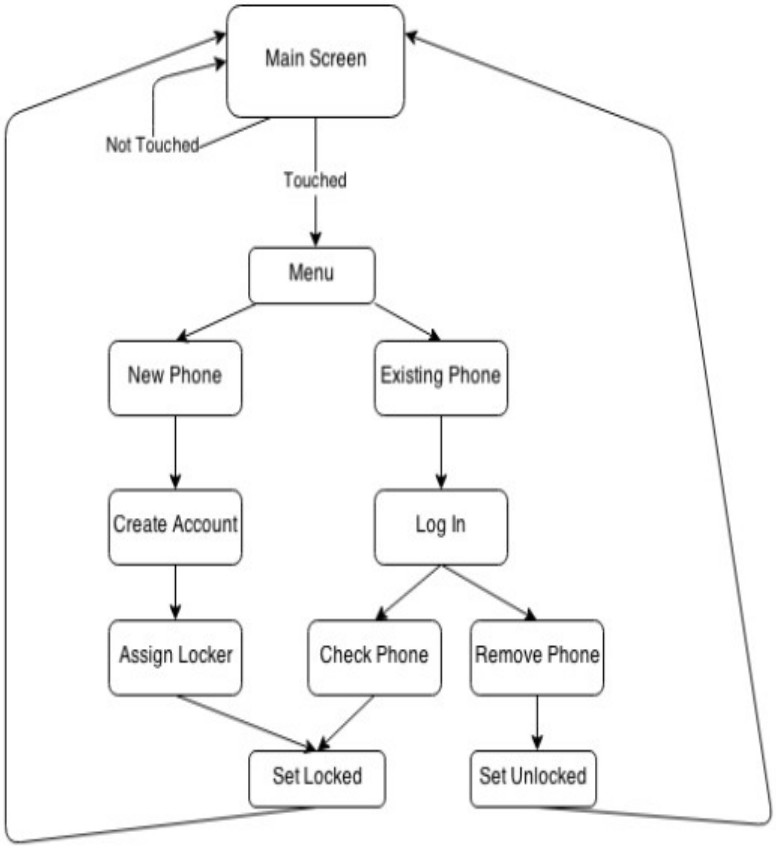
4.3 inch LCD Display

Anti-glare

Connected to the microcontroller by diagram shown to the right

Touch Screen

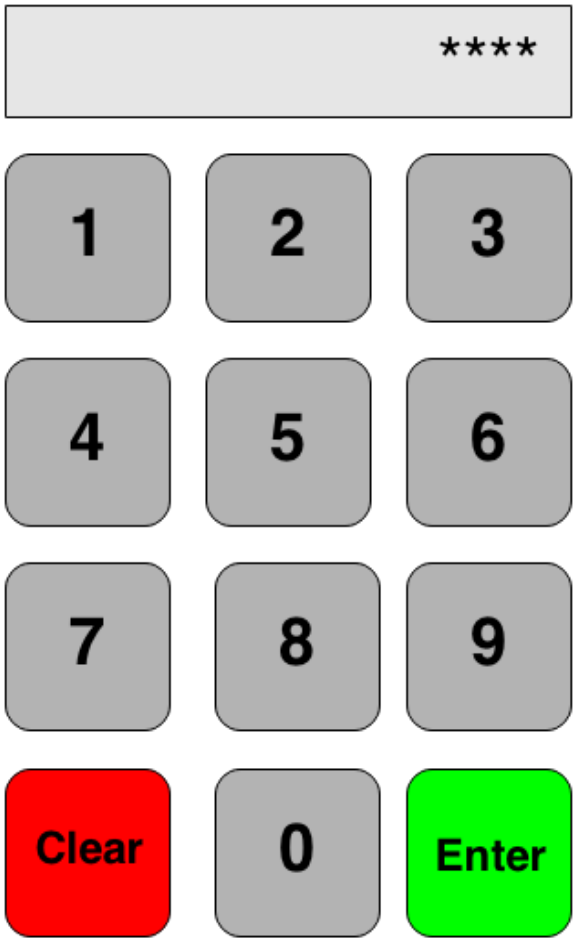
User Interface Flowchart



Something always displayed on the touch screen

After 20 seconds Main Screen will go into power saving advertisement mode

Security System User Interface



- Each locker saves a 4 digit PIN
- Simple Easy to use with big buttons.
- Requires typing a PIN twice to ensure correct numbers
- All old PIN #s get deleted when the locker is done being used

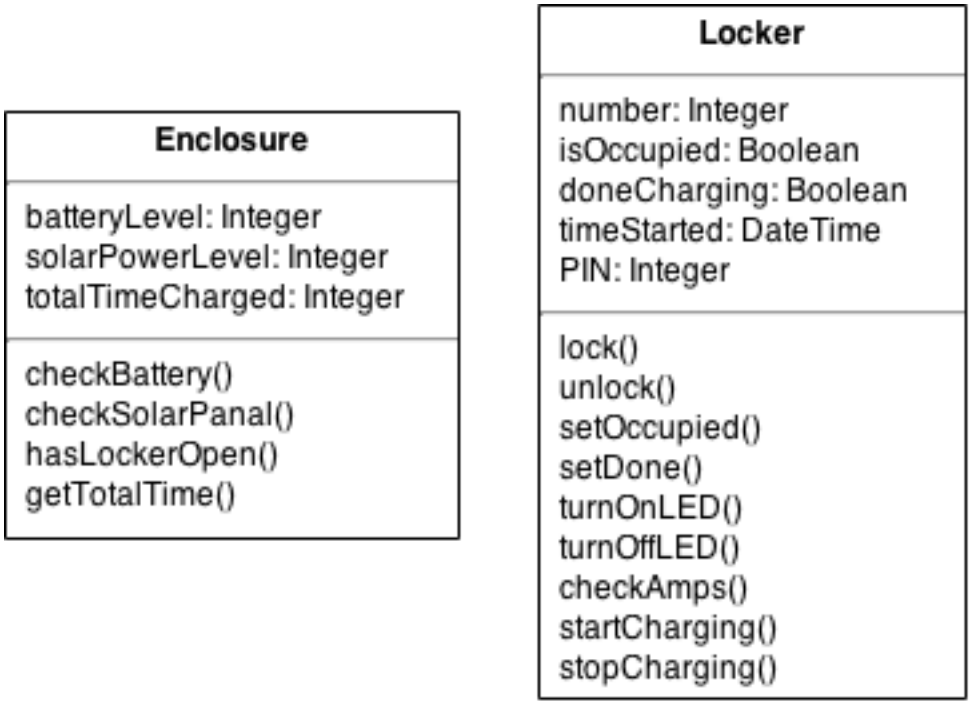
Lock Box/LEDs

Magnetic Solenoid lock receives signal from Atmega328

Red = Charging
Green = Done Charging
No LED on = Vacant

Current sensor uses hall effect to get the current values from the phones

Class Diagram

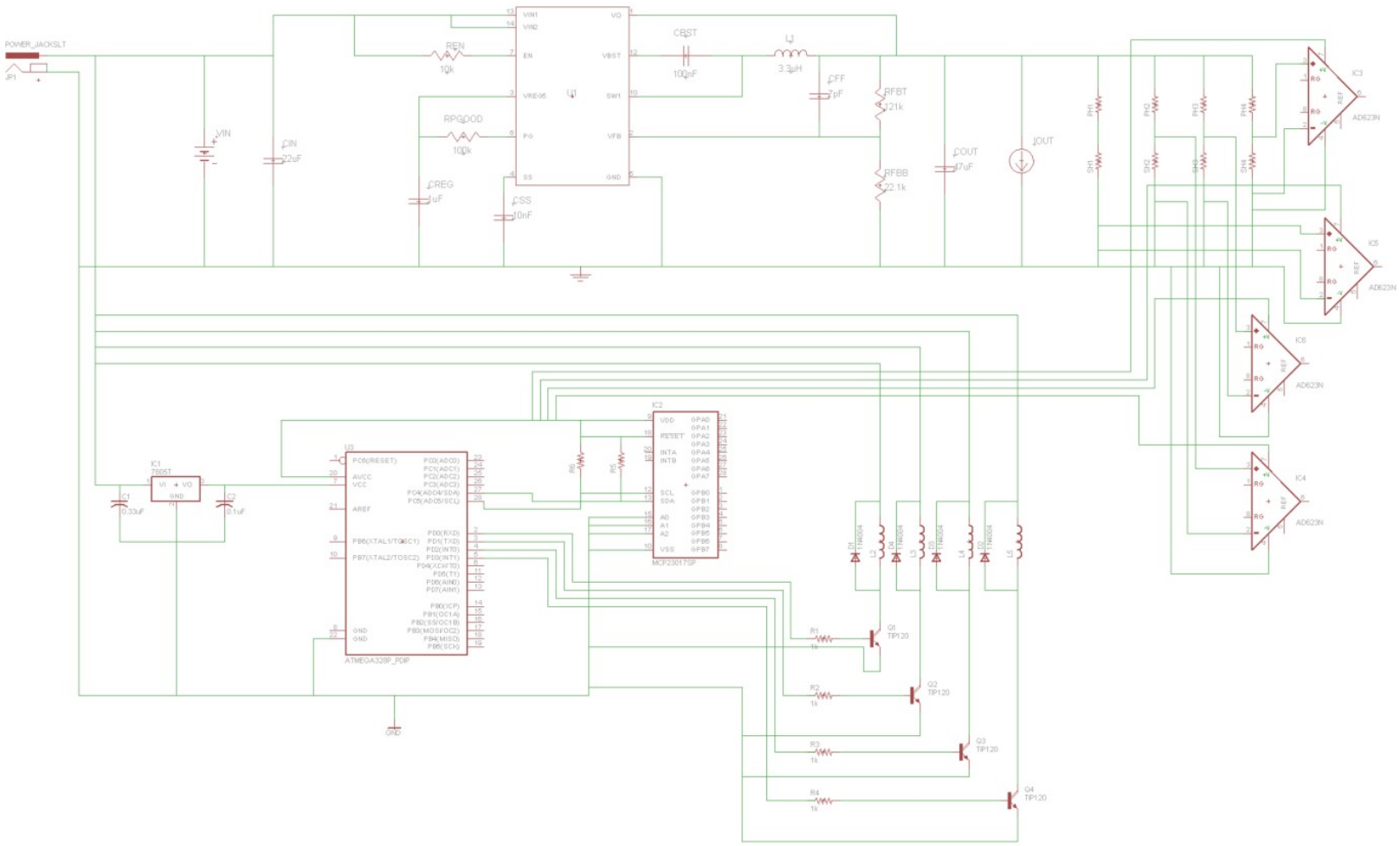


4 instances of Locker class

1 instance of Enclosure

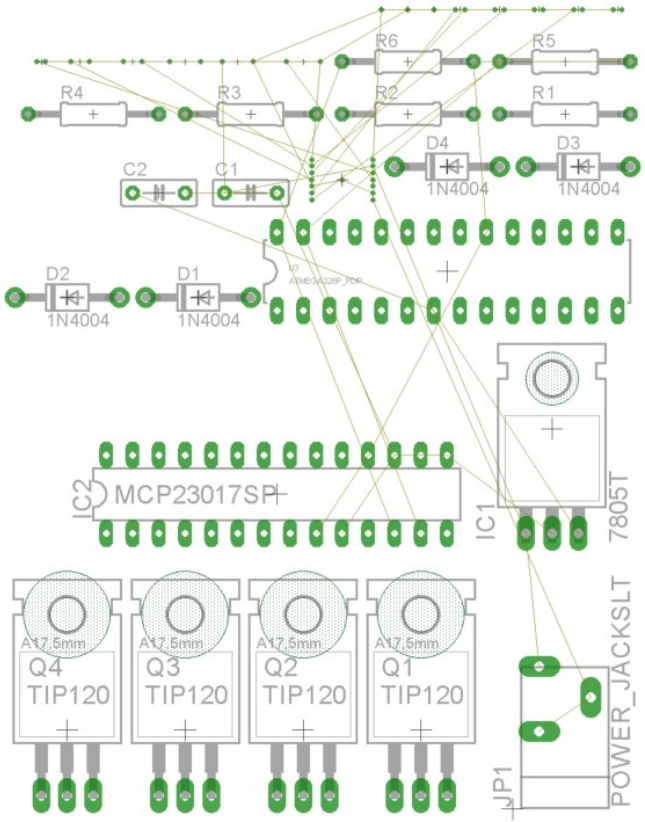
Enclosure handles all overall system information

PCB Design


POWER_JACKSLT
JP1
VIN
CIN
22uF
REN
10k
RPGOOD
100k
CREG
1uF
CSS
10nF
CBST
100nF
LJ
3.3µH
CFF
7pF
RFBT
121k
RFBB
22.1k
COUT
47uF
IOUT
IC1
7805T
C1
0.33uF
C2
0.1uF
U3
ATMEGA328P_PDIP
IC2
MCP23017SP
R5
R6
D1
D2
L1
L2
L3
L4
L5
R1
R2
R3
R4
Q1
TP120
Q2
TP120
Q3
TP120
Q4
TP120
IC3
IC4
IC5
IC6
AD623N
GND

PCB Design

Board



Division of Work

Amy	Jonathan	Brock	John

• Power System
  • Battery
  • MPPT
• Microcontroller
• Hardware
• Testing
	• DC to DC Converters
	• PCB Design
	• Hardware
	• Testing
	• Fabrication
		• Software
		• Microcontroller
		• Touchscreen
		• Testing
		• Security System
			• Hardware
			• Sensors
			• Safety
			• Programming
			• Testing
			• Fabrication

Budget and Finance

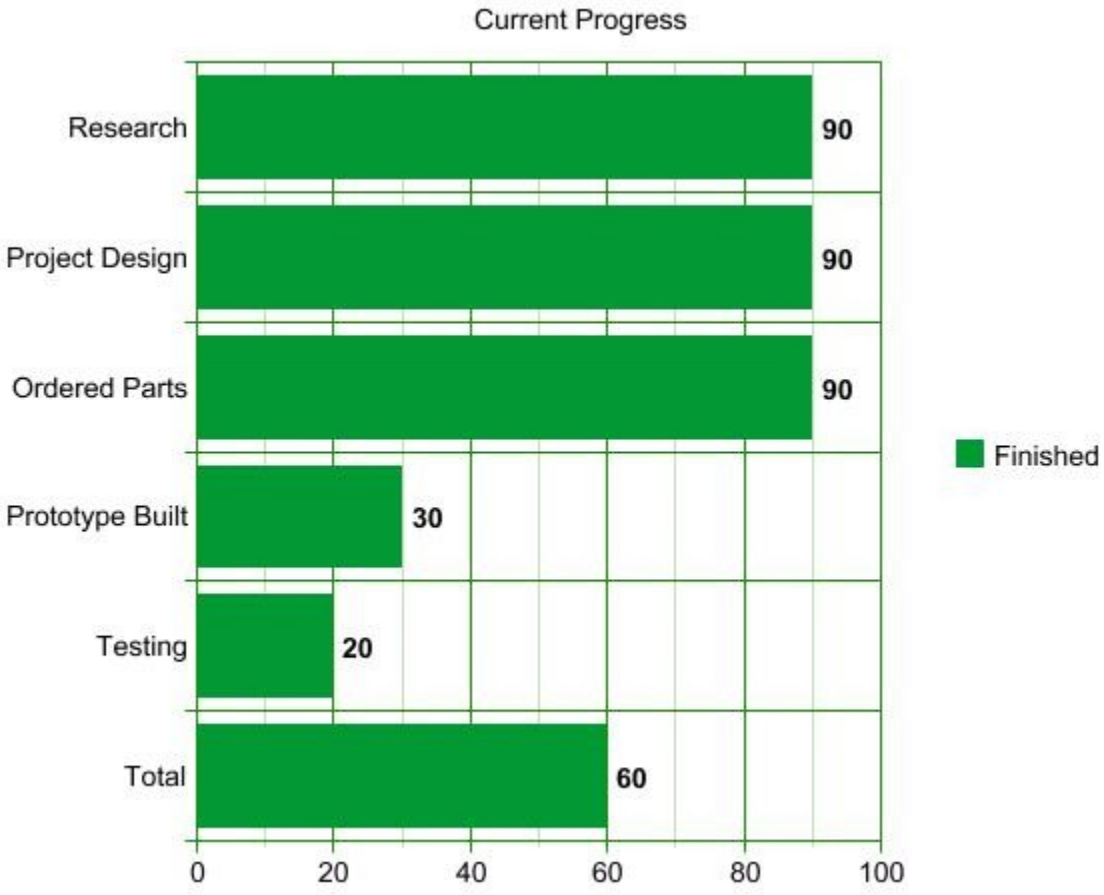
- Project Fully Funded
  - Duke
  - Leidos

Balance

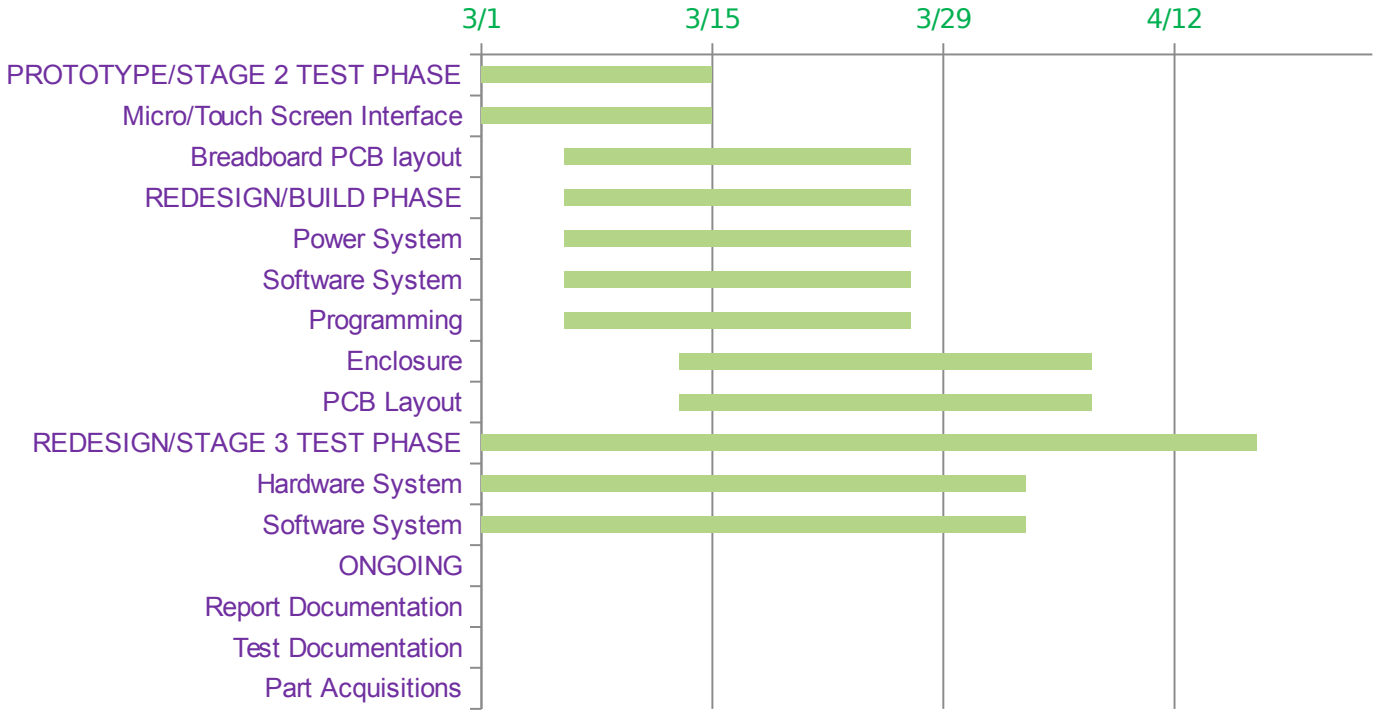
$$\$2071.00 - \$1,211.06 = 859.94$$

Item	Price		Cost
235W Solar Panel	$275.00		$0.00
30A MPPT Charge Controller	$279.24		$279.24
USB Charging Cables	$14.48		$14.48
Universal Cell Phone Charging Cables	$9.00		$9.00
Atmega323	$40.00		$0.00
Current Meters	$8.54		$8.54
LEDs	$5.00		$0.00
9” Touchscreen	$79.19		$79.19
18F PIC MCU	$13.06		$13.06
PIC Dev Board	$175.00		$175.00
5V Voltage Regulator	$2.00		$0.00
High Powered USB Hub	$25.49		$25.49
12V 89Ah SLA Rechargeable Battery	$259.00		$259.00
Wire/Cable	$15.00		
PCB	$85.00		
Solenoid Locks	$75.00		$23.87
Printing	$36.00		$36.00
Enclosure	$300.00		$233.21
Protoype Socket	$37.50		$37.50
Misc.Circuit Components	$25.00		$17.48
Total	$1,758.50		$1,211.06

Current Progress Report



Projected Design Stages

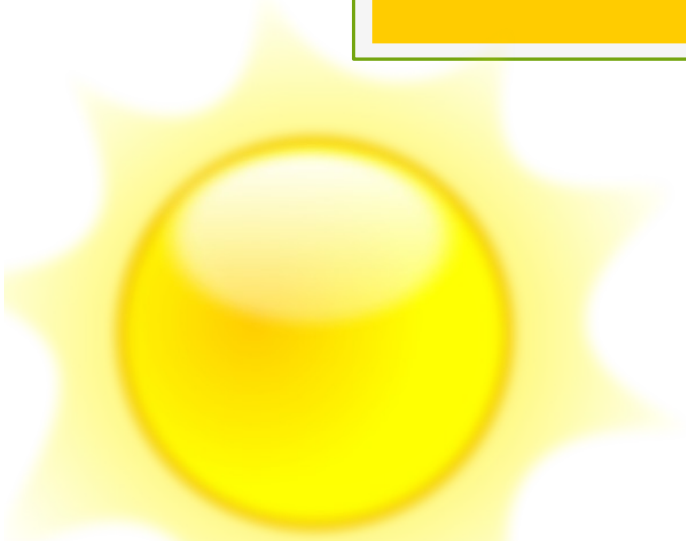


Issues

- Touch Screen?

- Wiring through doors
- Solenoids Locks or Combination Lock

- Green Energy Chart
- System loses all power (hurricane)



THANK YOU
FOR YOUR ATTENTION
AND
ANY QUESTIONS?