UniverSOL Charge Station

Group 17

Jonathan German
Amy Parkinson
John Curristan
Brock Stoops

Sponsored

leidos

DUKE ENERGY

Motivations

Environmental

- Renewable Energy
- Carbon Emissions

Power Demand

- Power Dependency
- Availability

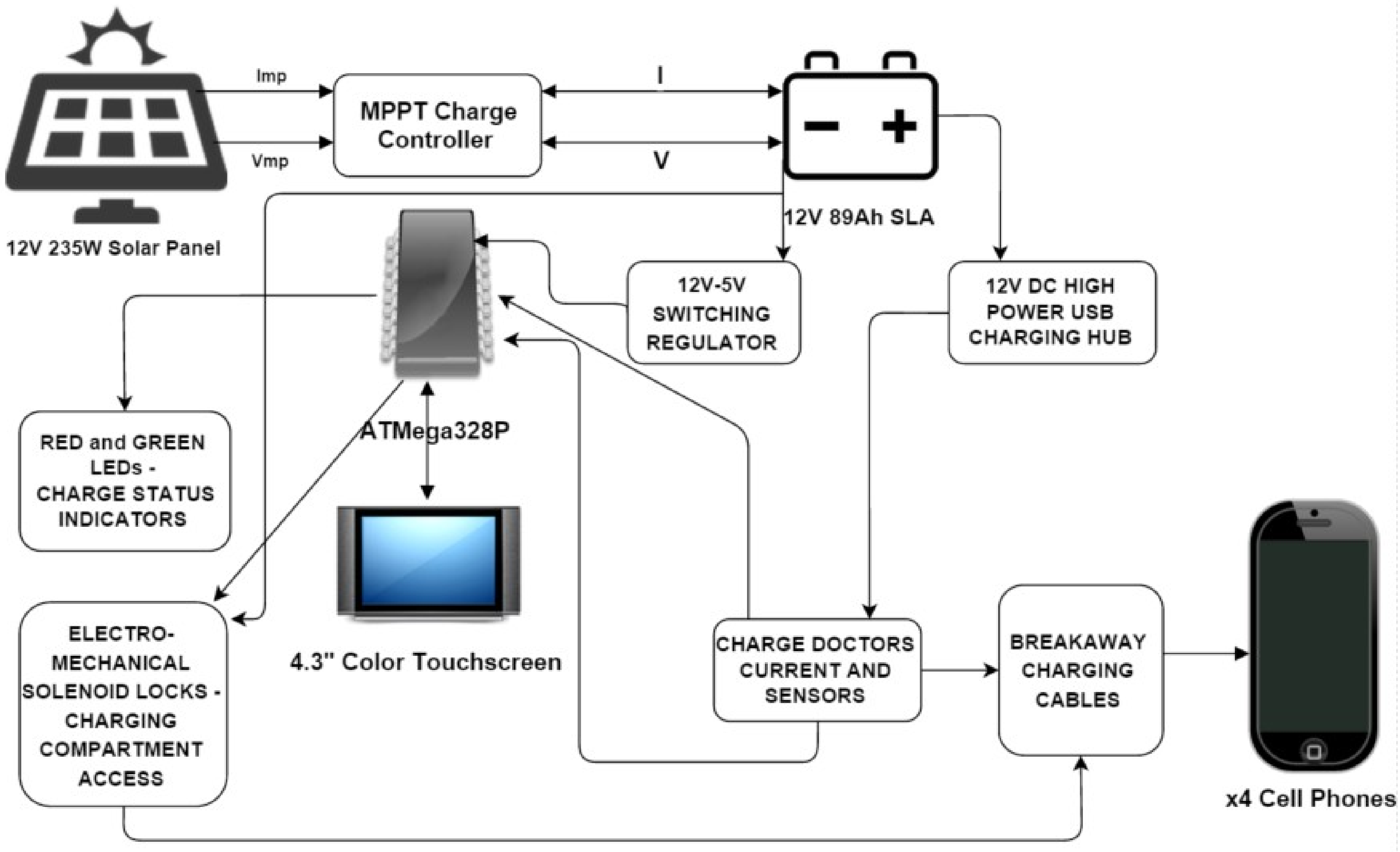
UniverSOL Charge Station

- A Solar Powered Cell Phone Charging Station
- Self Sustainable
- Color Touchscreen User Interface
- Personalized PIN Number Security Access Code
- Monitors Charging Activity
- 24 Hour Autonomy

Specifications

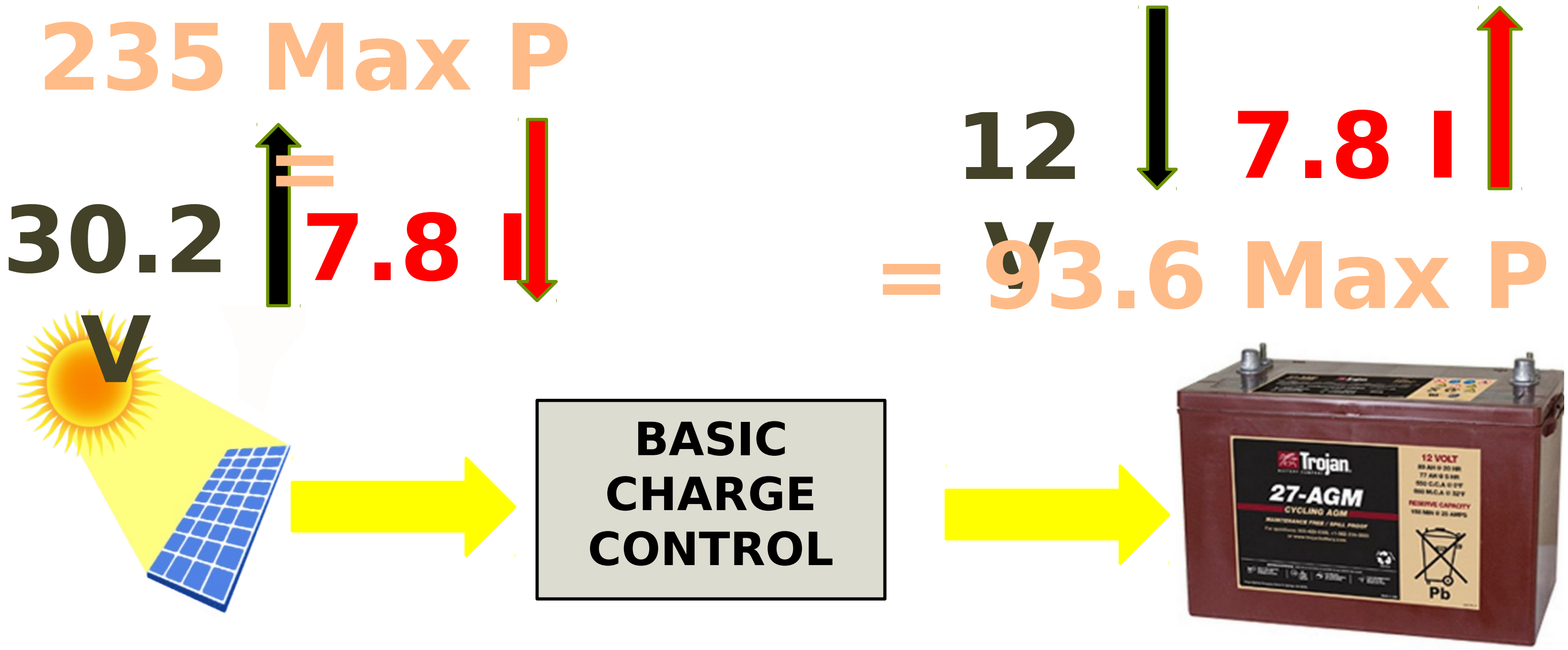
Item	Qty	Description
12V 235W Solar Panel	1	PV System Power Input
30A MPPT Charge Controller	1	Optimize the Efficiency of PV System
12V 89Ah SLA Battery	1	Rechargeable Battery
12V-5V Switching Regulator	1	DC to DC Converter
12V DC USB Charging HUB	1	Cell Phone Charging Hub
Breakout Charging Cables	4	4th and 5th Generation Android and Iphone Devices
ATMega328P	1	Microcontroller
16 Mhz Clock	1	Standalone Atmega328P on the PCB
Green LEDs	12	Charge Status Indicators
Red LEDs	12	Charge Status Indicators
Current Sensors	4	Cell Phone State of Charge (SOC) Sensors
Current and Voltage Meters with Display	4	LED Segment Display of Current and Voltage
4.3” Color Touchscreen	1	User Interface
12V Electro-Mechanical Solenoid Locks	4	Cell Phone Charging Compartment Locks
Metal Enclosure with see through doors	1	Metal Locker with See-Through Doors
PCB board	1	Manufactured by Osh Park

Overall Block Diagram



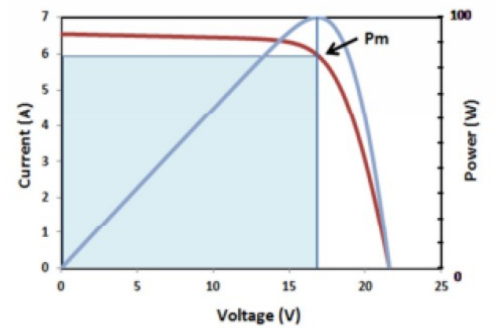
Photovoltaic (PV) Power System

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



Maximum Power Point Tracking (MPPT)

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



Ideal Conditions/ Ideal Goal

235 W Max P =

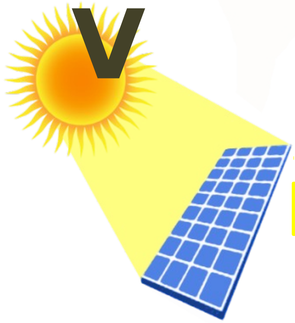
30.2 V

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

Establish Total Electrical Load Consumption

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

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
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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

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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%

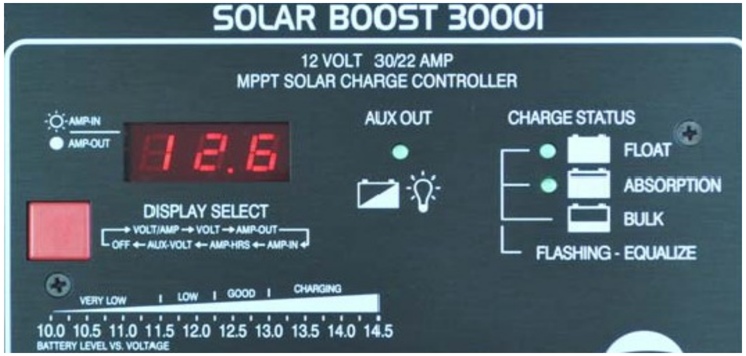
Select the solar charge controller that fits your needs

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.

Charge Control/MPPT

30A/15V BLUE SKY Solar Boost 3000i



- 95% power efficient
- Built-in **Charging Algorithm/MPPT** and **Heat Sink**
- **Digital Display**
  - Solar Amp In
  - Controller Voltage Out
  - Controller Amp Out

Monitoring MPPT Efficiency/Battery SOC

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 AGM	Lithium Ion
Average battery life	Replace every 10 years	Replace every 10 years
Deep cycle DOD efficiency	60%	80%
Weight	64 lbs.	4 lbs.
Space requirements	12.05 x 6.84 x 9.32 inches	7.17 x 6.61 x 3.03 inches
Cost	$250.00	$560.00
Charge Efficiency	75%	97%
Environmental hazards	97% recyclable	60% recyclable

- Maintenance Free
- Cost Efficient
- Eco-conscious
- Weight and Space Accommodations met by Enclosure

SOC	VOC
100	12.84
75	12.54
50	12.24
25	11.94
0	11.64

Power System Compatibility

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

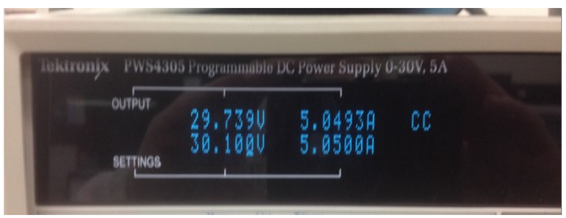
- Solar Panel Max Power at STC (Pmax): 235 W 60 Cell Module
- Battery Voltage: 12V DC
- Solar Panel Open-Circuit Voltage (Voc): 37.0 V
- Under most conditions: Controller Amp Capacity: 19.6 A

235 W Solar Panel
Highest Irradiation days

- Lose 2.5 A
- Controller Amp Capacity: 24.5 A due to 1.25 NEC buffered power factor

Afford Small Loss – Rare Conditions – More than Ample Power Supply

UniverSOL PV
System Performance



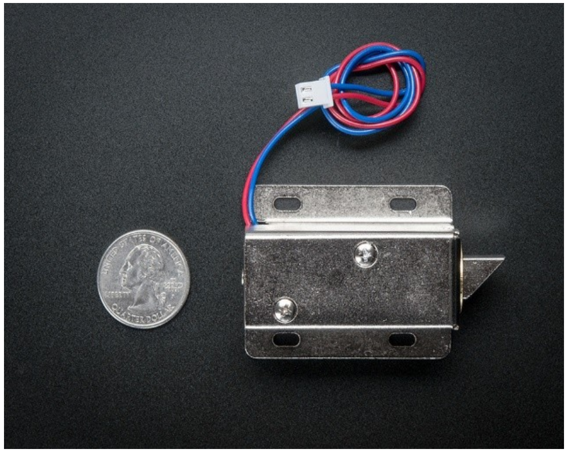
SETTING	Pin W	Vout	Iout	PV Pout W	PWM Pout W	SYSTEM GAINS
Lab	150	13.3	10.3	137	67	47%
Low	46	12.9	3.4	43.8	43.8	0%
High	228	13.6	14.4	195.8	105.9	54%

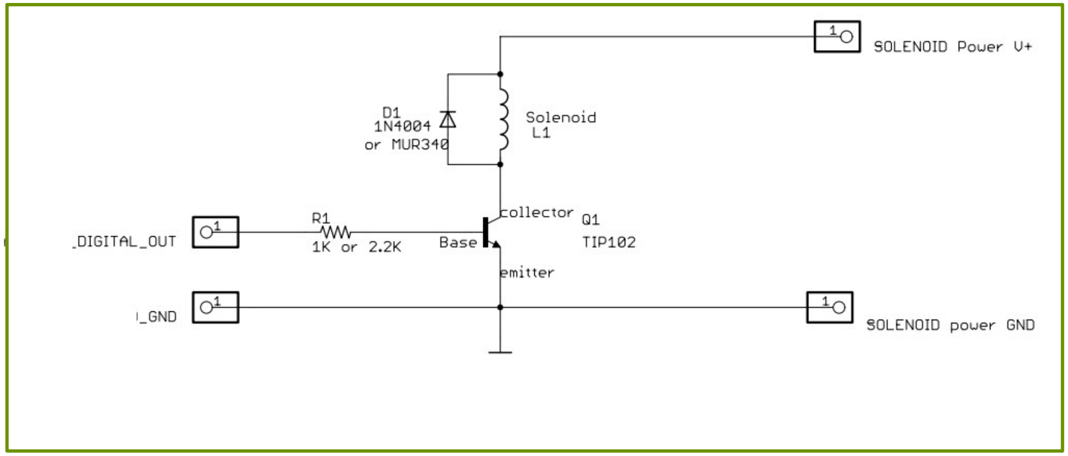
DC to DC Converter

- 12V to 5V Switching Voltage Regulator
  - Higher Efficiency then Linear Voltage Regulators
  - Buck Switching Voltage Regulator, 1.5A Output
  - Small Footprint, 3 terminal SIP package
  - Heat D

Input Voltage Range (V)	7 to 36
Design Origin	Murata Power Solutions
Dimensions (inch)	0.41 x 0.65 x 0.30
Dimensions (mm)	10.4 x 16.5 x 7.62
Efficiency (%)	90.5

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

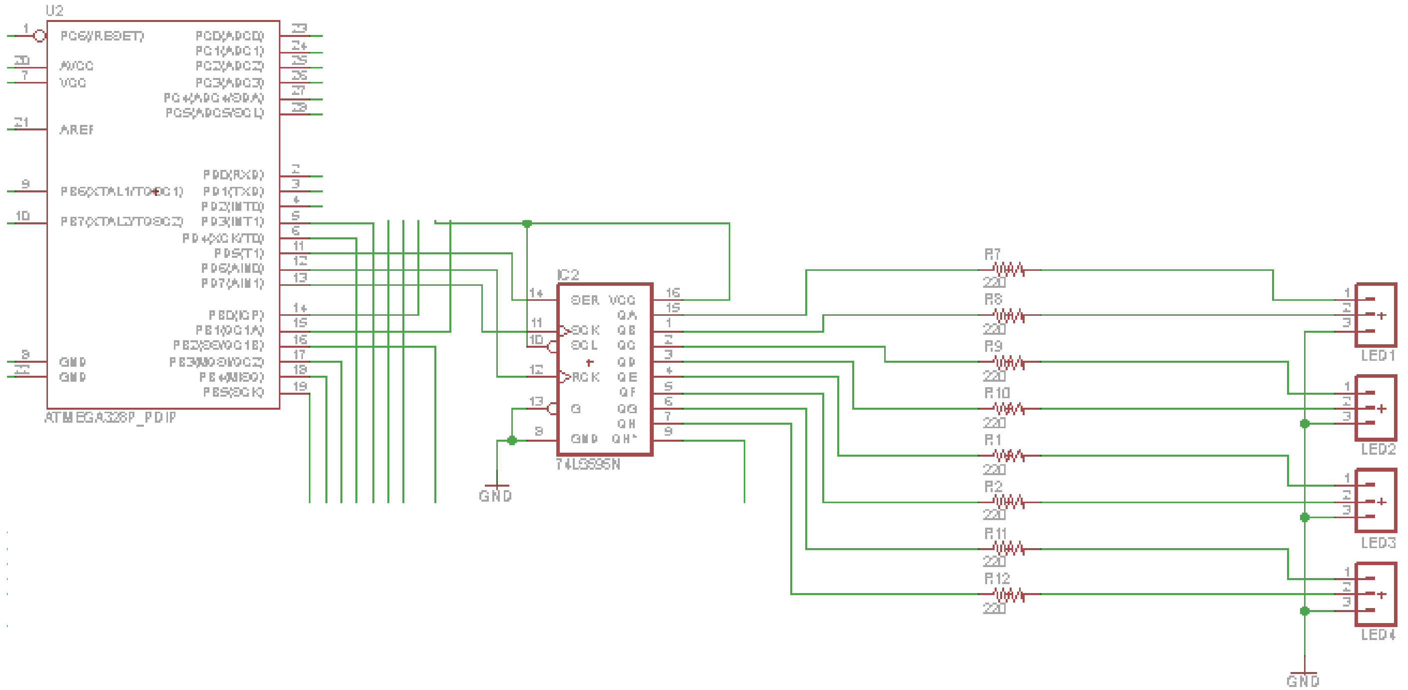
Current Sensors

- 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
- Magnetic field is sensed by the integrated Hall IC and converted into a proportional voltage
- The ATMEGA328 processor reads th voltage to determine the charge status of the phone being charged

I/O Expansion

74HC_HCT9595

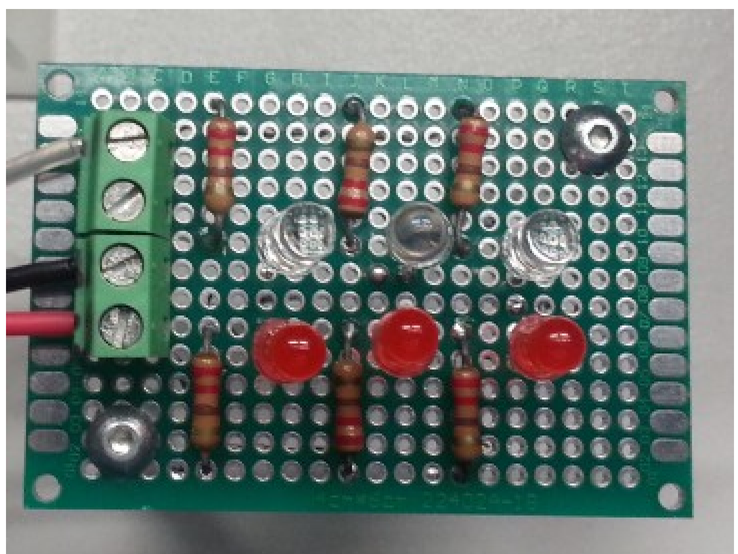
Shift Register - Uses Only 3 Pins from the Atmega328



Charge Indicator Board

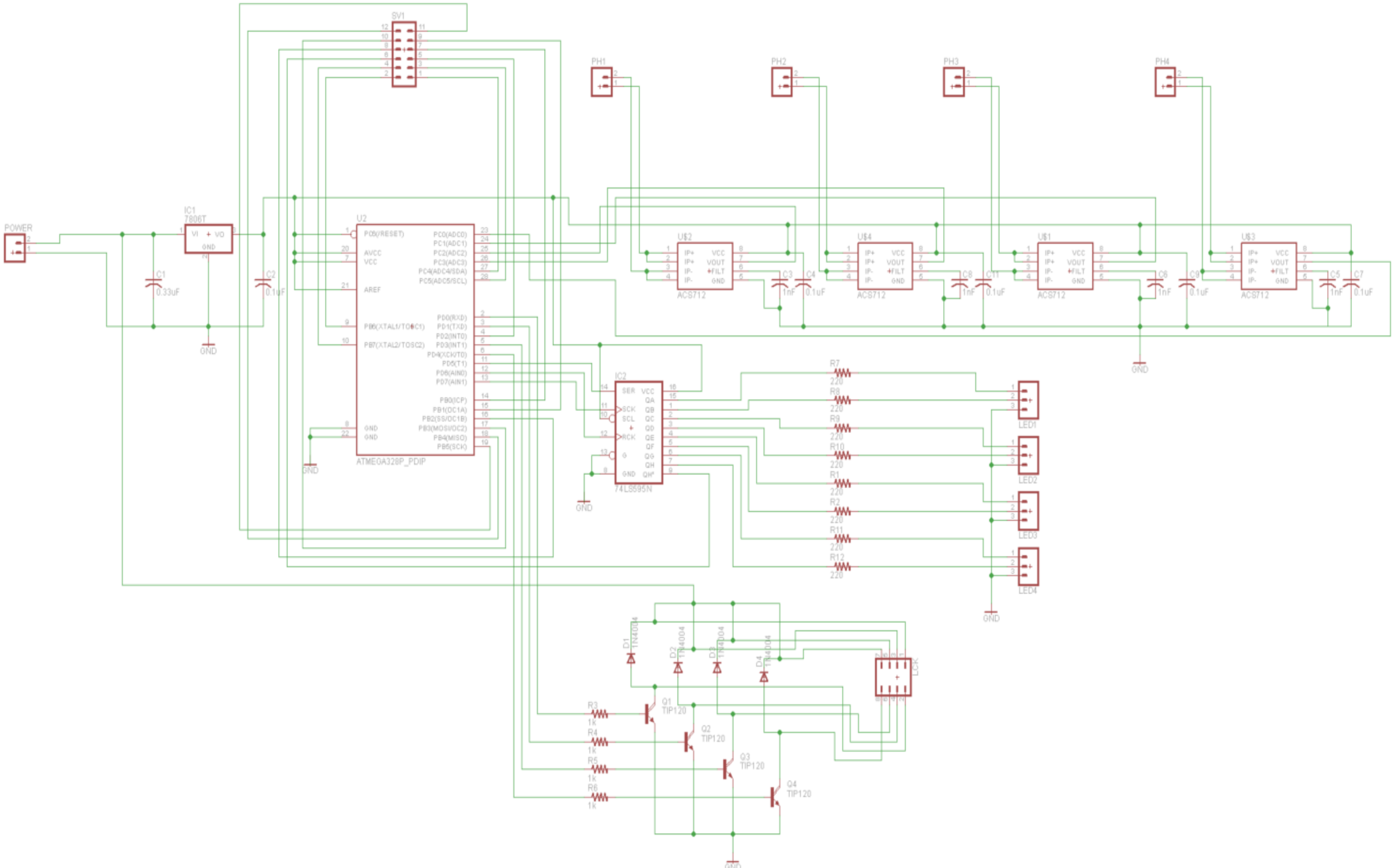
- Status of charge level on phones
- Three green and three red LEDs mounted inside each locker
- Visible from outside of locker to indicate status of phone
- Each LED circuit contains a 220 ohm current limiting resistor

Red indicates phone is charging.



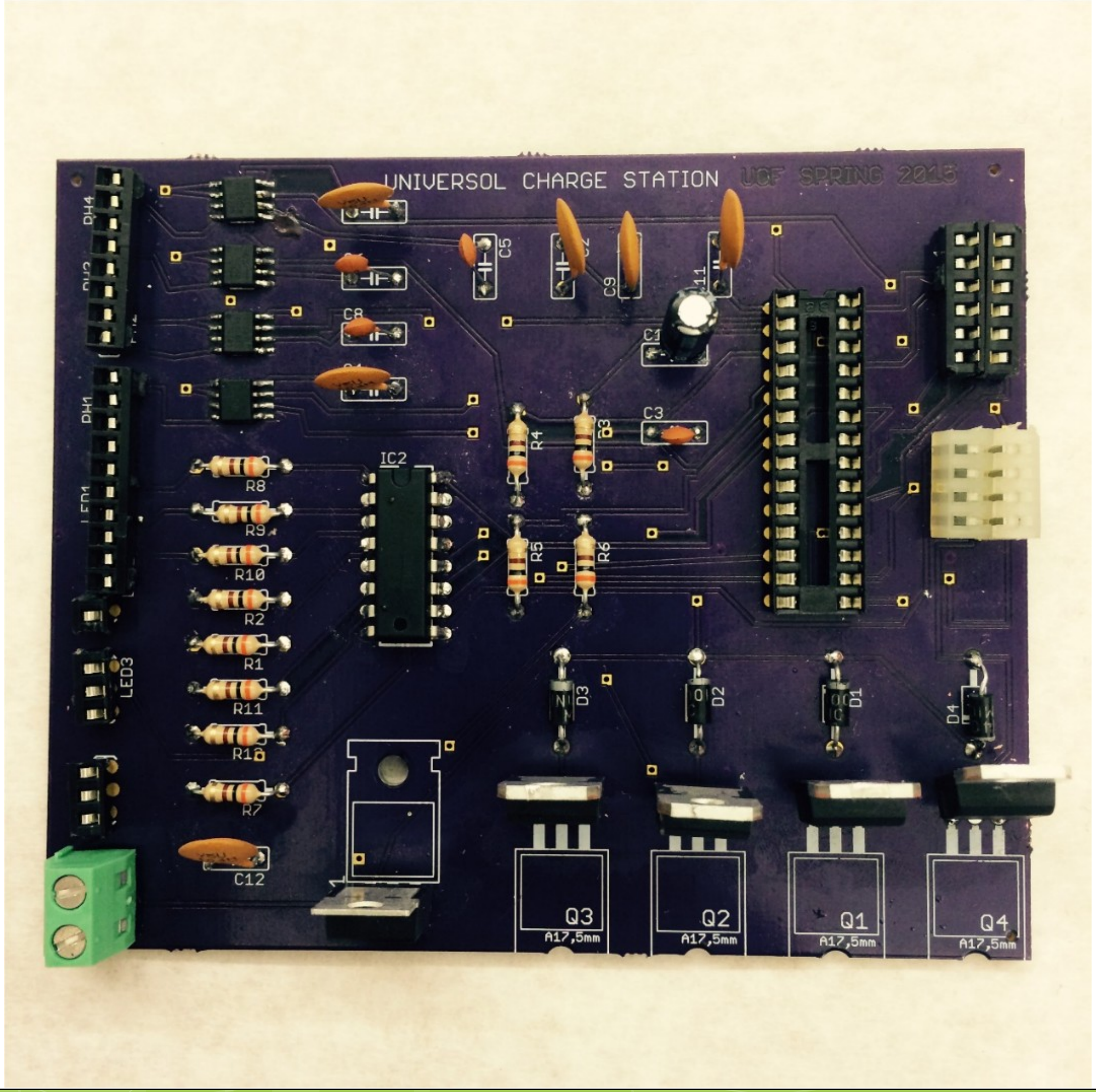
Green indicates phone charging complete.

PCB Design Schematic



PCB Design

Assembled PCB Board



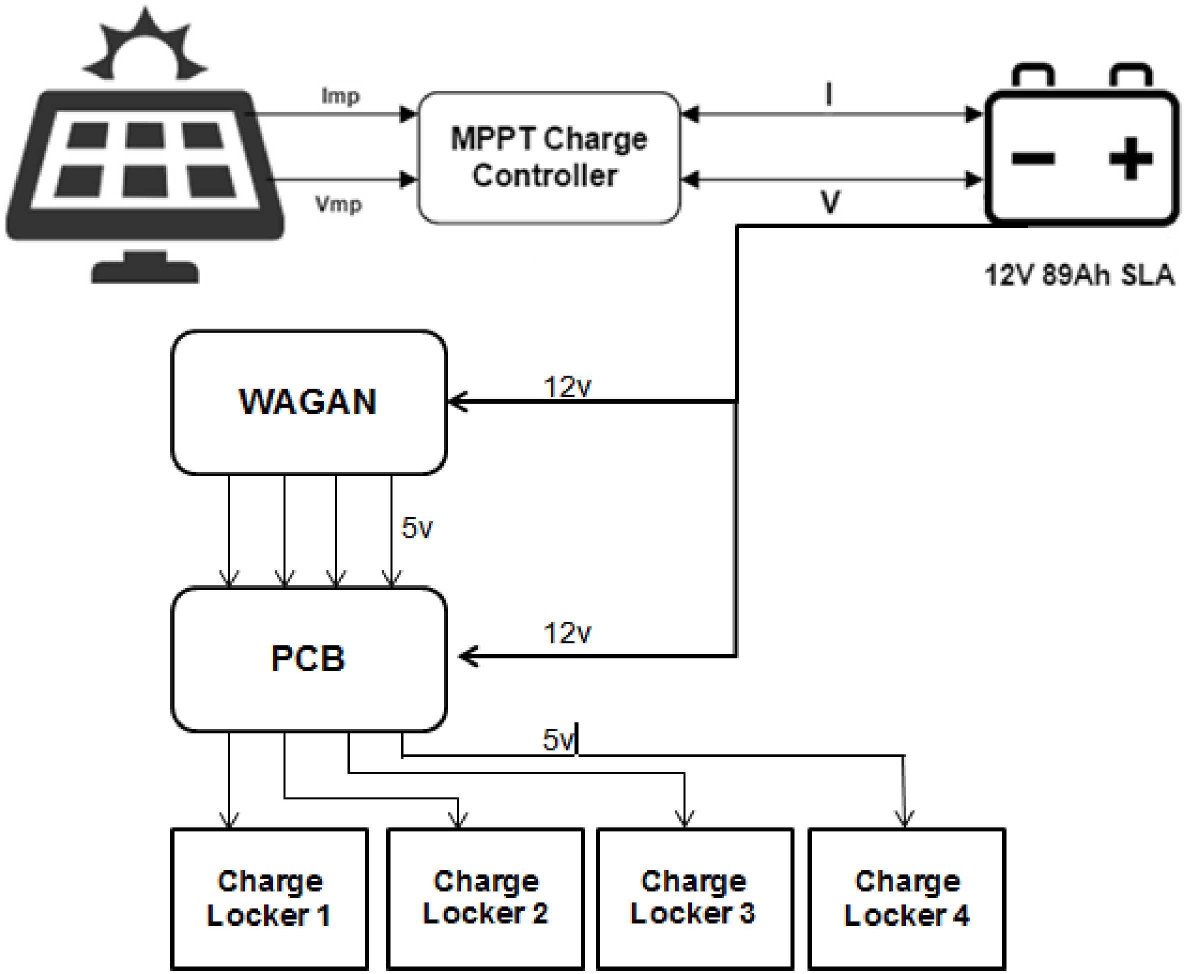
The Charger Doctor Current and Voltage Meter

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

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
- Lockers 1, 3, 4, and 5 to be used for cell phone charging
- Locker 2 will house touch screen display
- Locker 6 used for storing battery and MPPT charge controller

Power Distribution



4-in-1 Breakout Cables

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

Cabinet Back

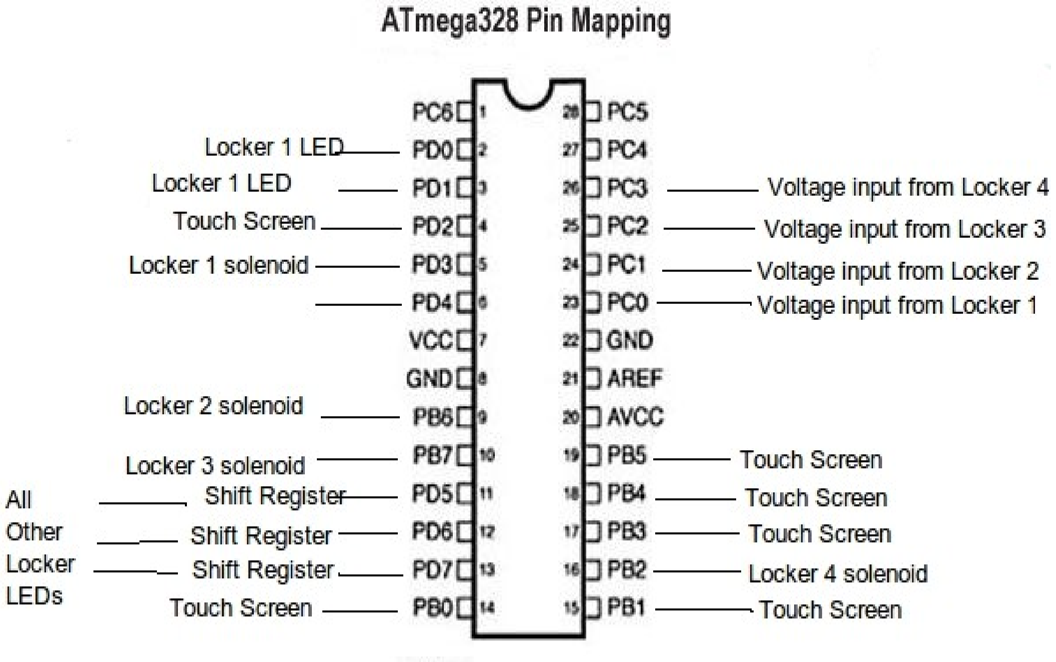
Easily accessible rear control panel, containing:

- WAGAN 12v input to four 5v USB output ports
- Printed Circuit Board
- Charge Doctor in-line current sensors for constant current and voltage monitoring

Embedded System
Microcontroller Unit I/O

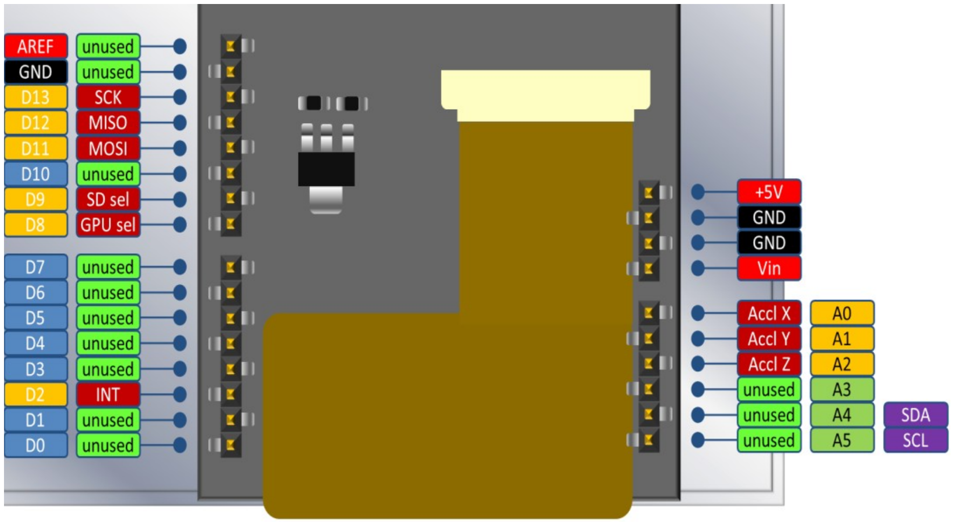
- Atmel ATmega328P
- 8-bit microcontroller
- 32 KB Program Memory
- Operating Voltage 1.8 to 5.5 Volts
- 6 analog input/output pins
- 14 digital input/output pins

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

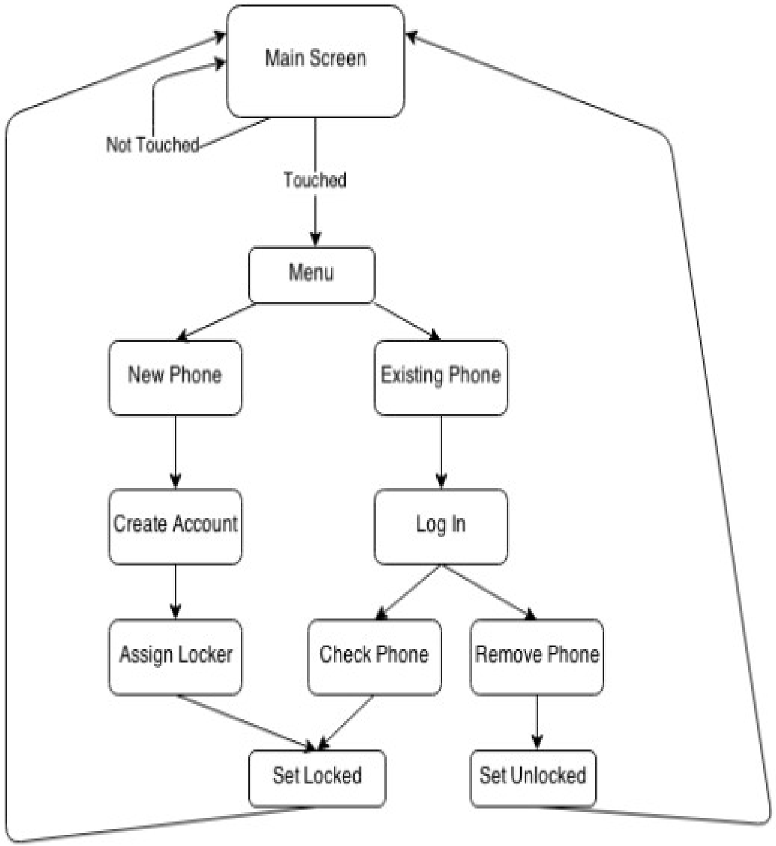
Touch Screen



- Main Component of our user interface
- 4.3 inch LCD Display
- Anti-glare
- Connected to the microcontroller by diagram shown to the right

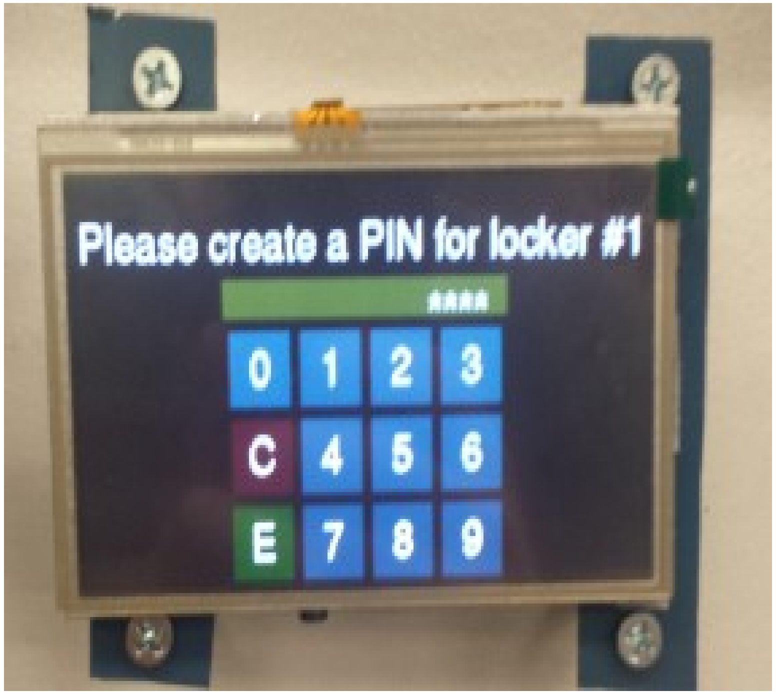
Touch Screen

User Interface Flowchart



- Something always displayed on the touch screen
- Each screen represents a different state
- Code runs a continuous loop

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

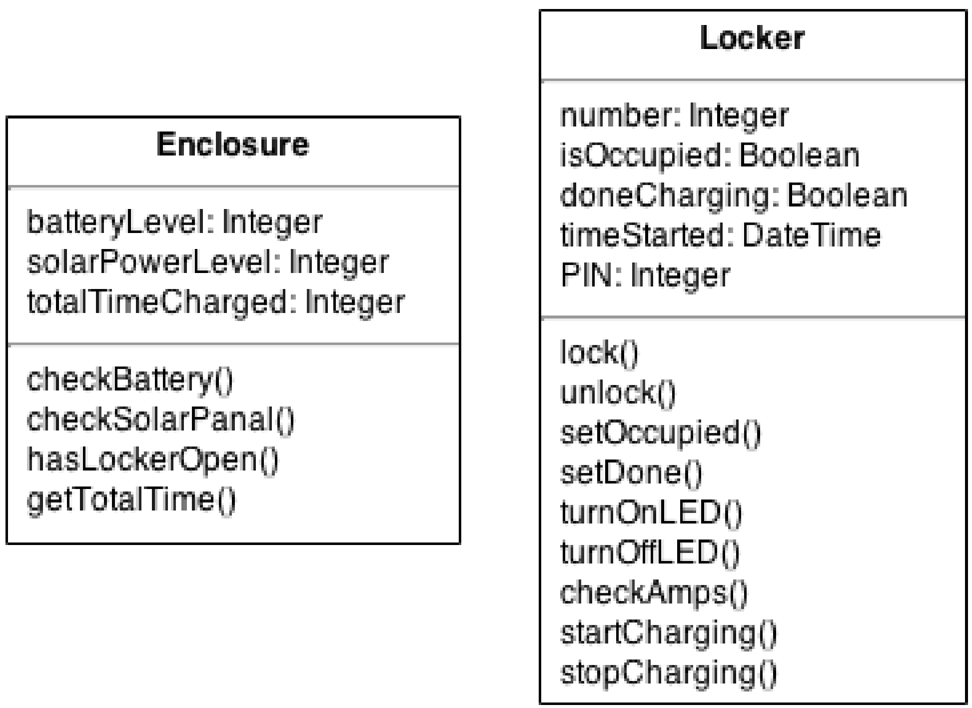
Lock Box/LEDs

- 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

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**

Project Fully Funded

Balance

Balance

$\$2071.00 - \$1,182.76 = \$745.18$

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
Atmega328P	$40.00		$0.00
Current Meters	$8.54		$8.54
LEDs	$20.00		$20.00
4.3” Touchscreen	$79.19		$79.19
5V Switching Voltage Regulator	$12.99		$12.99
High Powered USB Hub	$25.49		$25.49
12V 89Ah SLA Rechargeable Battery	$259.00		$259.00
Wire/Cable	$40.00		$40.00
PCB	$85.00		$79.25
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		$25.00
Total	$1,621.43		$1,182.76

THANK YOU
FOR YOUR ATTENTION
AND
ANY QUESTIONS?