The background features a collage of various battery-related icons and circuit diagrams. At the top center is a large battery symbol with a plus sign. Below it are several smaller battery icons, some with plus signs. On the left and right sides, there are vertical columns of battery symbols, each with a plus sign and a minus sign. In the center, there are several circuit diagrams, including a battery symbol with a plus sign and a minus sign, and a battery symbol with a plus sign and a minus sign. At the bottom, there is a detailed circuit diagram of a battery charger, showing a battery symbol with a plus sign and a minus sign, and a battery symbol with a plus sign and a minus sign. The text is centered over this collage.

Switching Lithium Polymer Battery Charger By Trip C

Introduction

The University of Idaho Marching Band has been incorporating multimedia displays into their performances, including synchronized light emitting diodes powered by Lithium-Polymer battery packs. There is a need for a charging system capable of charging approximately 200 packs safely and efficiently within a one week time frame.

Specifications

Marketing specifications:

- 200 batteries need to be charged per week.
- Should be user friendly and require minimum amount of interfacing during or after charging.
- The device should be scalable so that the prototype could be multiplied or added to charge more batteries in future iterations i.e. a modular system.
- The charging status should be indicated to the user.

Engineering Specifications:

- Since 200 batteries needs to be charged per business week, a battery matrix system (charging multiple batteries or charging in sequence through a single board) needs to be formulated. Charging circuit for parallel (simultaneously) or series (charging 1 battery then switching to the next in series) needs to be devised.
- For minimum interfacing, a control system needs to be integrated within the design that controls the voltage and current flow to the batteries. Possible microcontroller programming required.
- The rows and column number of the battery matrix will decide the number of batteries to be charged, parallel or serial charging and the amount of interfacing required. The number of batteries being charged per 2 hrs. (Approx. charging rate for a single battery) or over a course of a day or a week needs to be analyzed to allow the client minimum interfacing but good results.

Design Specifications:

- A battery matrix of 10 X 1 was decided. The design will charge one battery at a time and switch to the next one in the column as soon as the microcontroller senses a voltage change. Hence the design will charge 10 batteries in roughly 20 hours and 40 batteries in the same time if 4 modules of the design are used and connected in parallel to a power supply. Thus, it will charge 200 batteries/business week. This matrix was selected since it will require minimum interfacing from the user as 40 batteries have to be connected once and removed by the end of the day rather than charging 10 batteries in parallel, that will require plugging the batteries in and out after every 2 hours. The single evaluation board circuit (single IC) will be used to charge and will switch to the next battery in the column through a switching circuit consisting of a Solid State Relay (TLP3100) and controlled by a microcontroller.
- Arduino Uno was selected because of it's small size and a list of important functions (required for the project) that it could implement.
- For charging 200 batteries per week, four of the PCB boards (10 X 1 matrix per board) connected in parallel to a power supply can be used. The whole modular system will charge 40 batteries per day hence 200 batteries per week. A single PCB board will be designed and made while the modular system is left for future senior design teams to finish.

Constraints

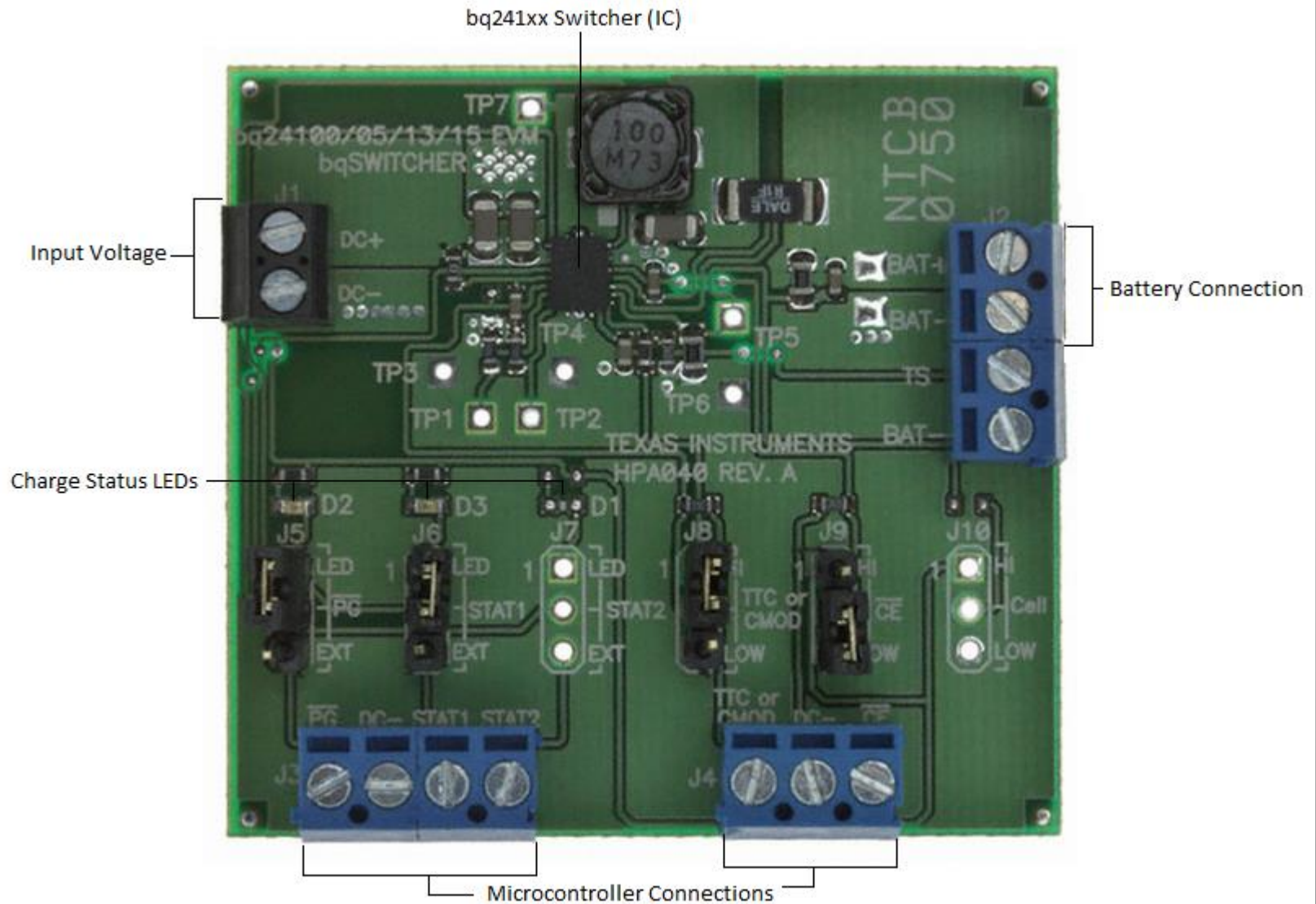
- Circuit for charging batteries-Some kind of Evaluation Module
- How to switch between batteries-Switching Circuit Requirements?
- Battery Matrix-Serial or Parallel?
- Cell Balancing?

Evaluation Module Options

- MAX1641
- MAX1701
- BQ24115/105

Bq24115 was selected from the above list since it met with all battery requirements and because of it's availability. The EVM was changed to BQ24105 because the previous selection had sleep mode problems from the manufacturer's side.


BQ24105EVM

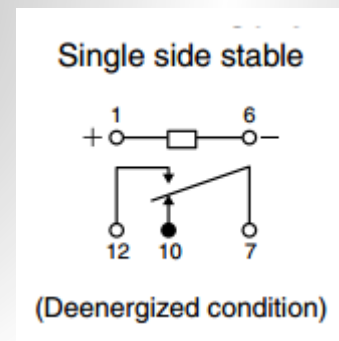


Switching Circuit

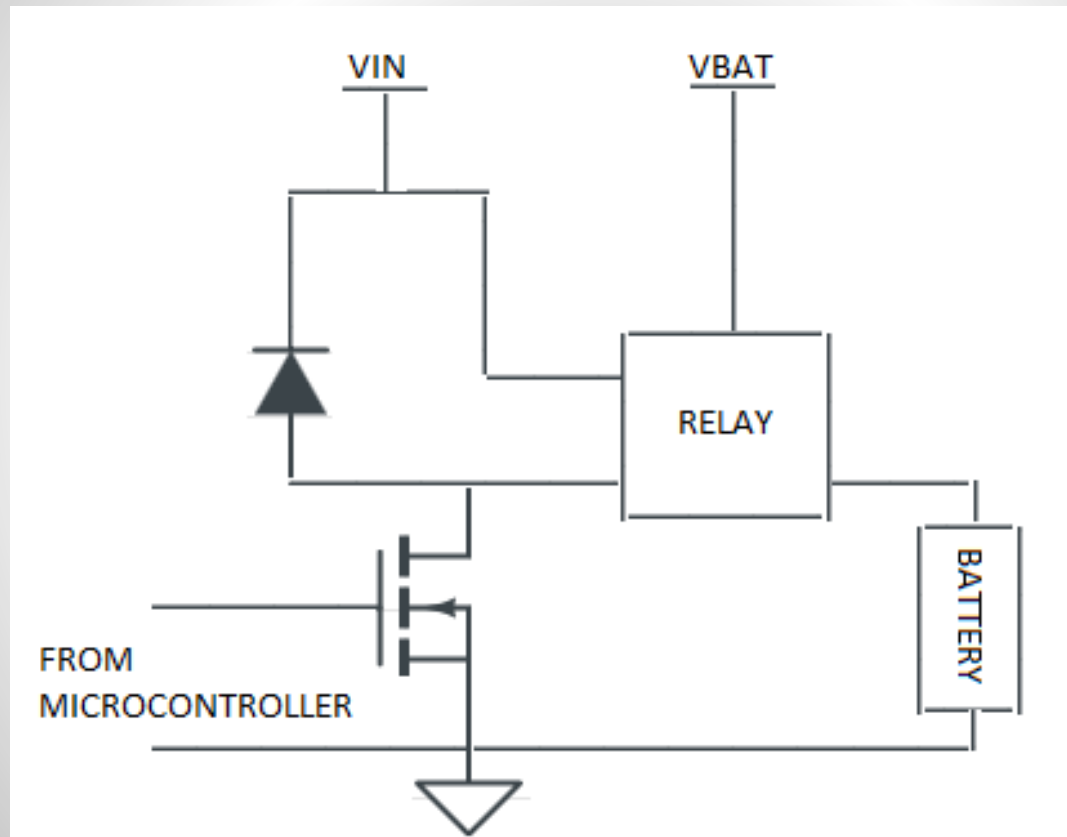
- MOSFETs or relays can be used as switches between the charging circuit and battery to make or break the connection.
- Since MOSFETs are not technically ever off, they leak a bleeding voltage which might be sensed by the IC (bq241xx switcher) as an invalid battery and the charge process will fail.
- Solid state relays were selected at first but had the same problem of leakage voltage.
- Finally electromechanical relays were used since they provide complete electrical isolation when turned off.

Panasonic DS1E-M-DC12V

Manufacturer:	Panasonic
Product Category:	Low Signal Relays - PCB
RoHS:	
Brand:	Panasonic Industrial Devices
Product:	Low Profile Relays
Type:	Miniature
Contact Form:	SPDT (1 Form C)
Contact Current Rating:	3 A
Coil Voltage:	12 V
Maximum Switching Current:	3 A
Coil Current:	33.3 mA
Coil Type:	Non-Latching
Power Consumption:	400 mW
Termination Style:	Solder Pin
Contact Rating:	2 A at 30 VDC
Mounting Style:	Through Hole
Packaging:	Tube



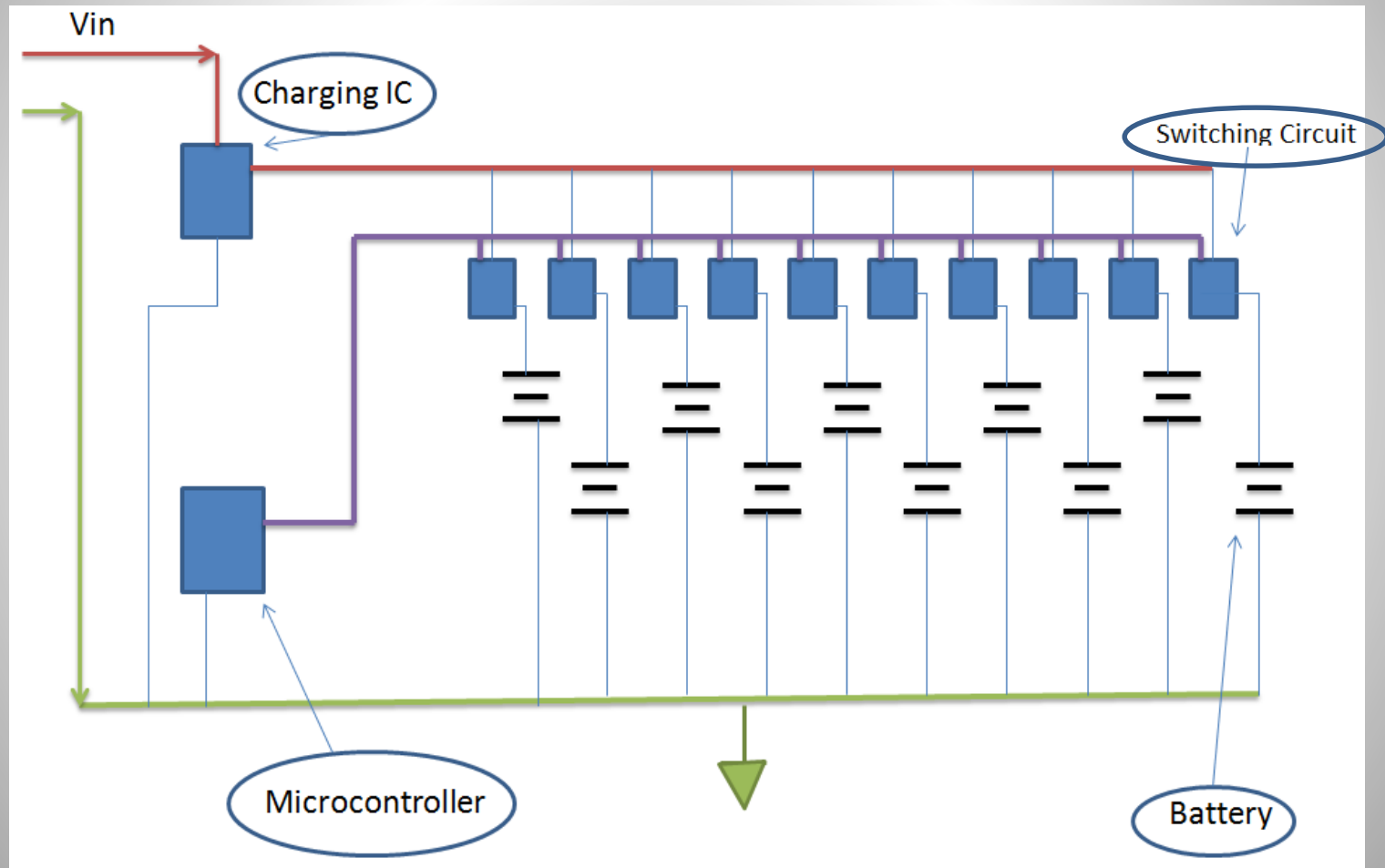
Switching Circuit



Battery Matrix

- A serial battery matrix was chosen since the client wanted only around 10 batteries to be charged per day with least amount of user interface.
- The serial battery matrix will charge one battery at a time in a series of 10 connected batteries.
- A modular system can be developed in future renditions of the project which will include 4 of the prototypes connected in parallel

Block Diagram for Serial Matrix Configuration

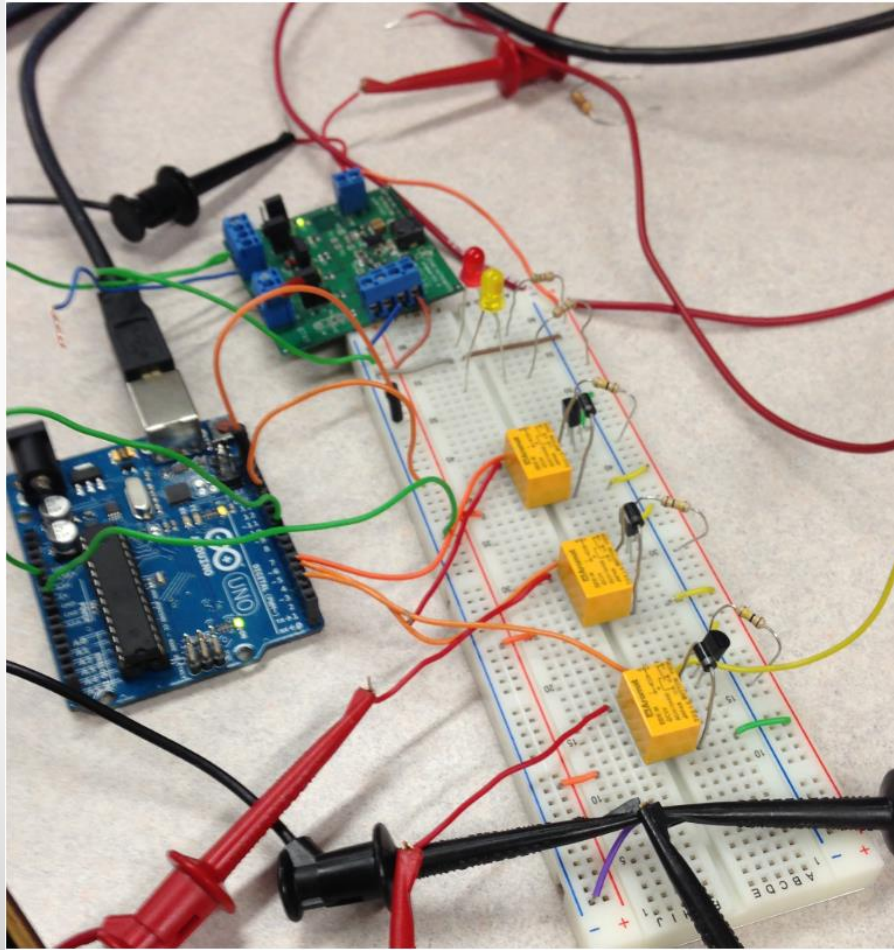


Cell Balancing

Cell balancing is generally used to improve the life of a battery by maintaining the required cell voltages. Typical means used to perform cell balancing include by-passing the cells during charge and sometimes during discharge by connecting external loads parallel to the cells through controlling corresponding FETs.

However, the underlying reasons for voltage differences on the level of battery chemistry and discharge kinetics are not widely understood and usually attempted balancing can often lead to more harm than good. A lot of common cell balancing means result in a pack more unbalanced than the initial unbalance state.

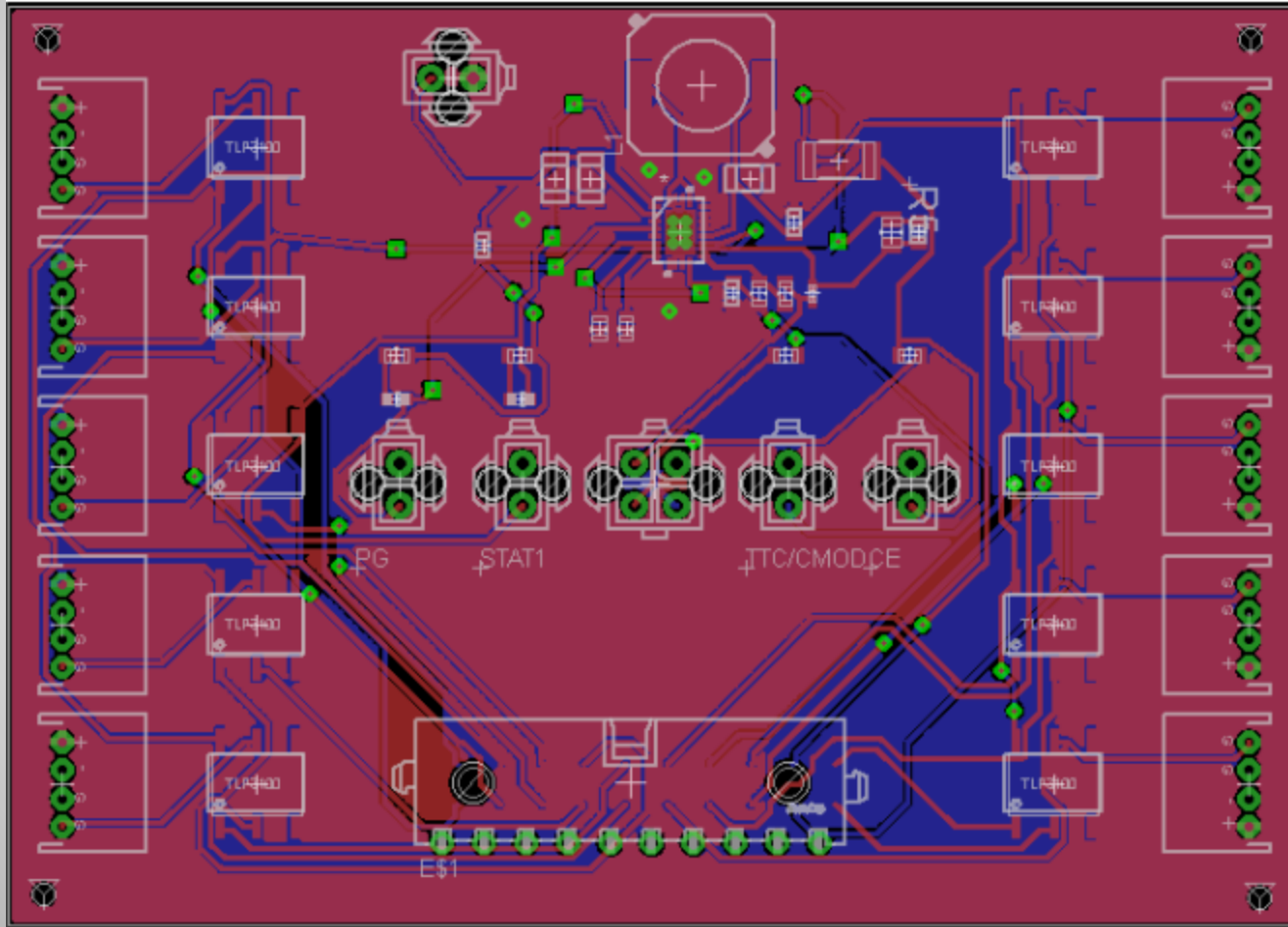
Breadboard Prototype



Breadboard Prototype

- The above circuit shows the design implementation. All the selected components are connected together and make the required charging and switching circuit.
- The yellow blocks are the electromechanical relays that electrically isolate or connect the EVM charging circuit to the batteries.
- The diode and N-channel MOSFETs are part of the switching circuit.
- The arduino uno polls the STAT1 and STAT2 pins continuously and starts charging as soon as it detects any batteries connected.
- As soon as a battery is charged the STAT2 pin goes on and the microcontroller senses the change and switches to the next battery in the sequence.

PCB Layout



Current Status

The microcontroller connection to STAT1 and STAT2 requires minor fixes to rectify status sensing issues.

Trip C

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