Solar Solutions

Total Charge Technology

HELIOS Mk-I

SIMON FRASER UNIVERSITY
SCHOOL OF ENGINEERING SCIENCE
ENSC 440/305 – CAPSTONE PROJECT
APRIL 16, 2014

RICHARD HARGROVE
SULKI HONG
SAM CHOW
FILIP ZIVKOVIC
SAMAN HOSHYAR

Contents

Solar Solutions
Total Charge Technology

Contents

Solar Solutions
Total Charge Technology

Team Members

Solar Solutions
Total Charge Technology

- Richard Hargrove, Team Leader
  - Lead hardware designer
  - PCB Design and layout
  - Firmware
  - Technical Writing
  - Developed MPPT algorithm
  - Testing
  - Full assembly of PCB
  - Mechanical and Thermal
- Sulki Hong
  - Main technical writer
  - Helping both subgroups
  - Developed MPPT algorithm
  - Bill of Material
  - Testing
  - Partial assembly of PCB

Team Members

Solar Solutions
Total Charge Technology

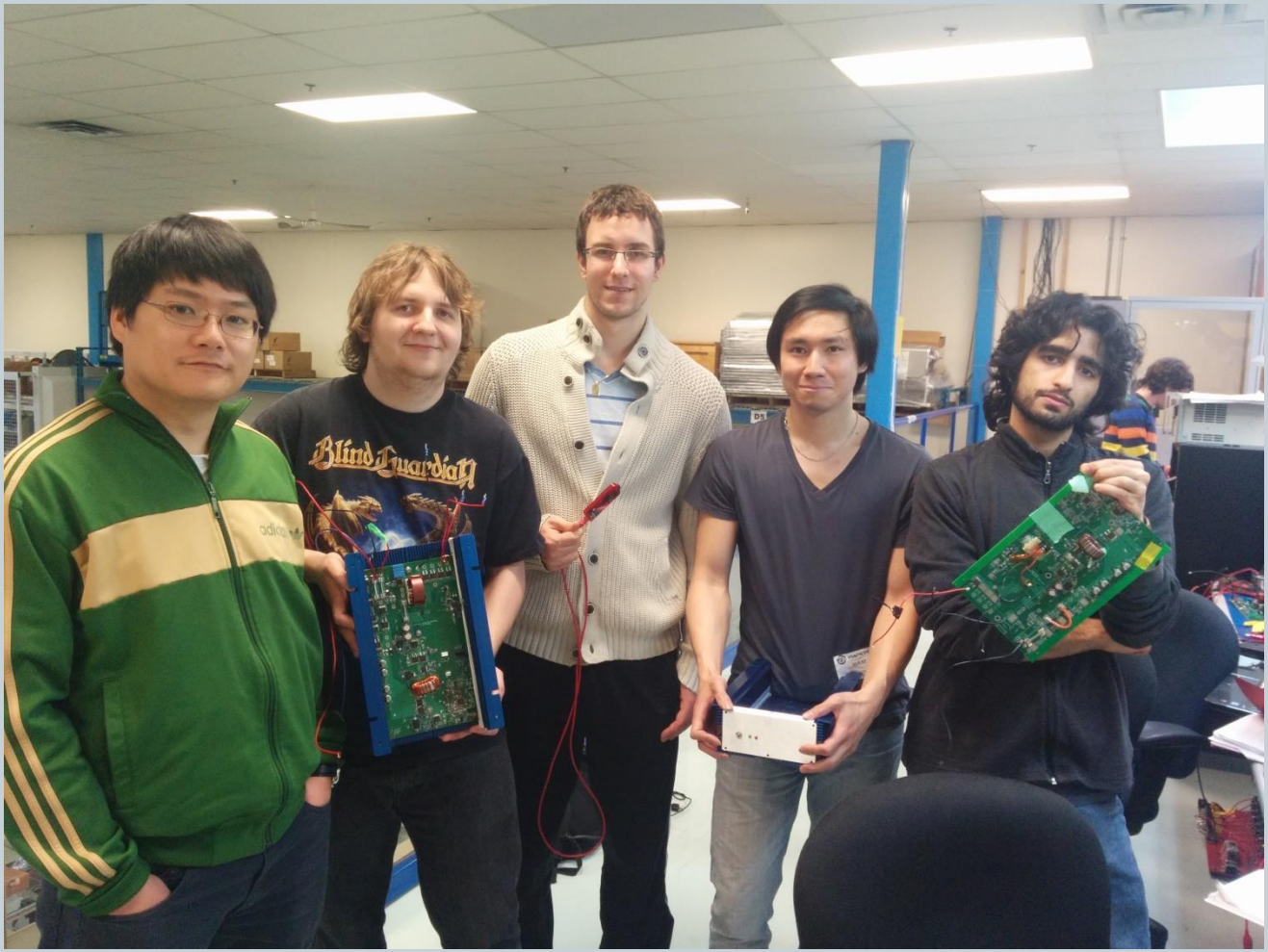
- Sam Chow
  - Mechanical and Thermal Lead
  - Full assembly of PCB
  - Shop Technician
  - 3D Design for PCB, Chassis, and Parts
  - Assisted with Firmware
  - Hardware Designer
  - Technical Writing
  - Developed MPPT algorithm
  - Testing
- Saman Hoshyar
  - Hardware designer
  - Assisted with Firmware
  - Developed MPPT algorithm
  - Scheduled and scribed the meetings
  - Testing and partial Assembly of PCB
  - Technical Writing

Team Members

Solar Solutions
Total Charge Technology

- Filip Zivkovic
  - Developed firmware
  - Developed and implemented MPPT algorithm
  - Main Technical Writing
  - Partial Assembly of PCB

Team Members



Contents

Solar Solutions
Total Charge Technology

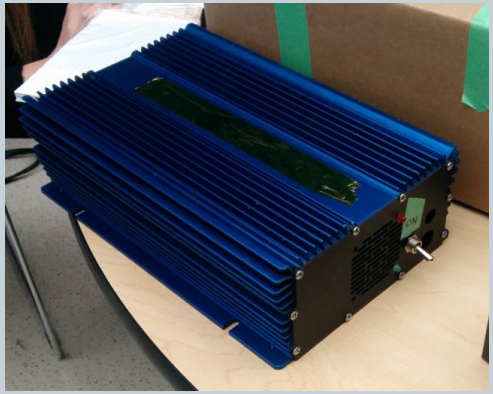
Introduction to Helios Mk-I

Solar Solutions
Total Charge Technology

- Helios Mk-I is a solar panel battery charger that implements maximum power point tracking algorithm to optimize power transfer from solar panel to load
- Funded by and property of Analytic Systems
- Ultimate goal:

To provide energy for the future that is renewable, innovative and sustainable.

Helios Mk-I System



Helios Mk-I

Solar Panel, Battery and Load

- The Load, Solar Panel and Battery are arbitrary
- Panel Size will dictate maximum charge rate
- Battery Charge Profiles would be implemented in Firmware
- RS-232 intended to be used to:

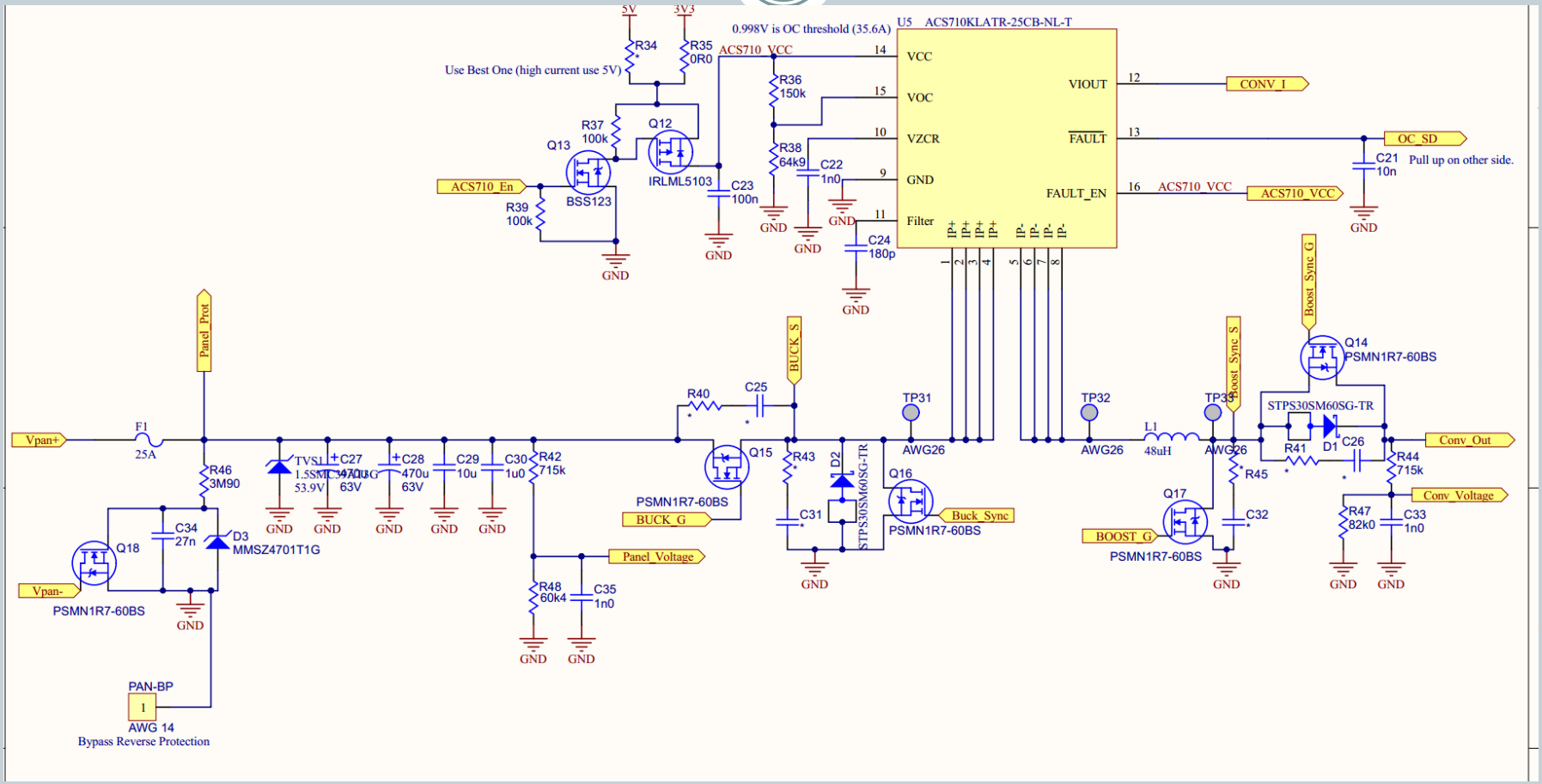
I. Set up charging profile
II. Set current limits
III. Obtain Energy Usage and Harvest data

Contents

Solar Solutions
Total Charge Technology

Buck/Boost Theory of Operation

Solar Solutions
Total Charge Technology



Contents

Solar Solutions
Total Charge Technology

Note

Hardware took priority over firmware.

Hardware Challenges

Solar Solutions
Total Charge Technology

Challenges:

- High Side MOSFET Drive
- Peak Current Sensing
- Low ESR
- Thermal Dissipation
- Load Disconnects/Ideal OR-ing Diodes
- Auxiliary Supply
- PCB

Hardware Changes for MK2

Solar Solutions
Total Charge Technology

- Change PCB dimensions
- Add a 5mm edge to PCB
- Utilize the open space
- Minor changes were made to Schematic (resistor changes, op-amp amplifier type, an op-amp was rewired, the microcontroller had some pin changes)
- Modified panel design

Contents

Solar Solutions
Total Charge Technology

dsPIC33F Microcontroller

Solar Solutions
Total Charge Technology

Advantages

- Low cost, low power, high performance.
- Free C complier, free development environment, free reference designs.

Disadvantages

- Prolonged software development.
- Occasional malfunctions within the silicon.

Errata for dsPIC33F

Solar Solutions
Total Charge Technology

24. Module: Core

Device debugging is not functional when using the PGEC3/PGED3 clock/data pins.

Work around

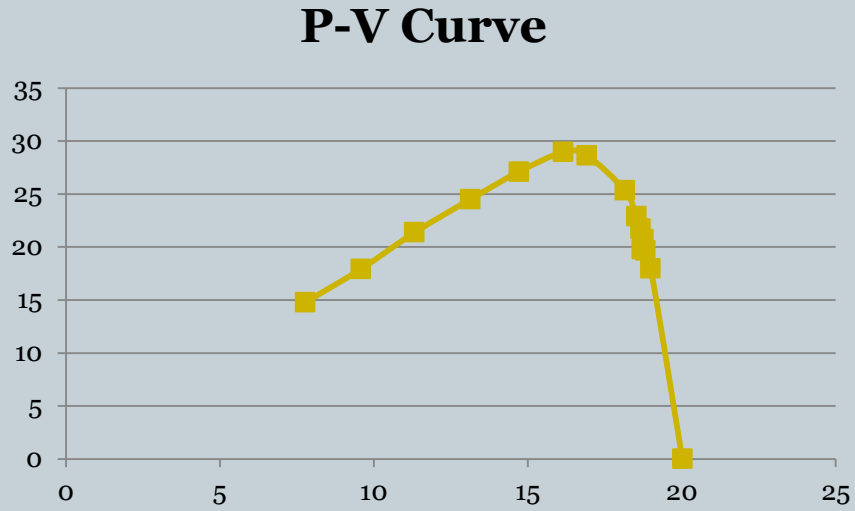
Use PGEC1/PGED1 or PGEC2/PGED2 clock/ data pins for debugging functionality.

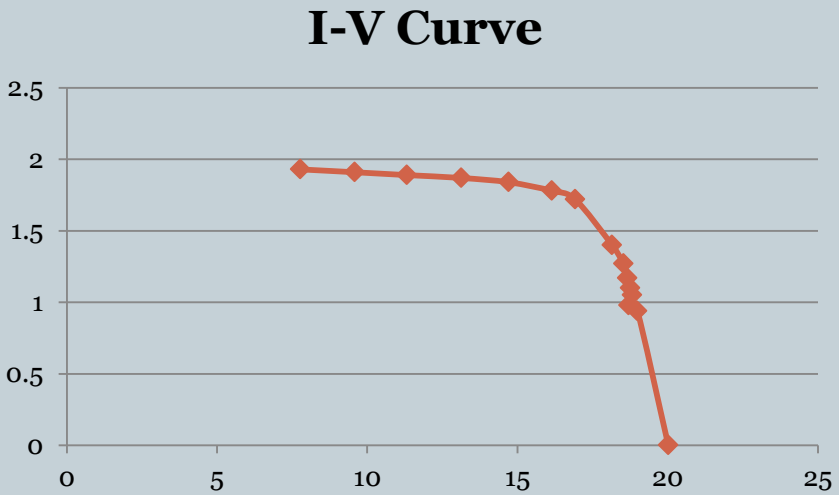
Affected Silicon Revisions

A0	A1						
X	X						

Maximum Power Point Tracking

Solar Solutions
Total Charge Technology





Characteristics	
Open circuit voltage (Voc)	21.8V
Optimum operating voltage (Vmp) - minimum	17.2V
Short circuit current (Isc)	3.93A
Optimum operating current (Imp) - minimum	3.78A
Power at STC (Pm) - minimum	65Wp

Table 1: Electrical Characteristics of SP65-M Solar Panel.

Difficulties of MPPT Battery Charging

Solar Solutions
Total Charge Technology

- Quote:

"it is difficult to guarantee the designed behavior for all the operating range, and also it is not possible to provide a general controller for any application[1]."

Indeed.

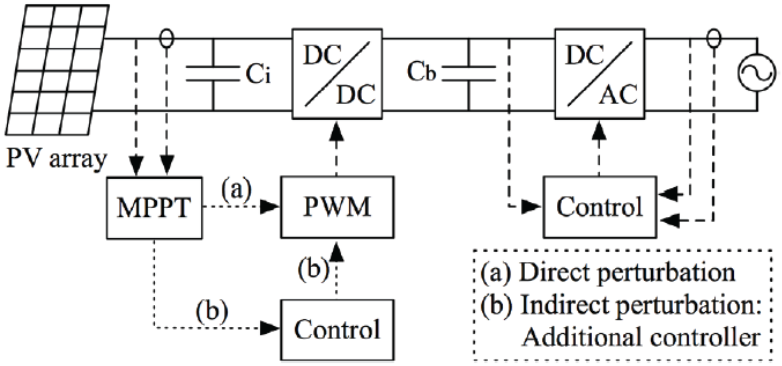


Figure 1 Double stage PV grid-connected system

The mode (a) is simpler from the implementation point of view because the MPPT is able to track the MPP for any uniform irradiance condition, but it is sensible to disturbances at the dc/dc converter output. Instead, mode (b) is able to reject load perturbations, but classically its design depends on the system parameters [3], so it is difficult to guarantee the designed behavior for all the operating range, and also it is not possible to provide a general controller for any application. Therefore, PV systems based on mode (a) are

Our Favourite Quote

Solar Solutions
Total Charge Technology

"Forget MPPT. You guys won't get to it until NEXT April."

-Adam Cerenzia,
Analytic Systems, March 2014

MPPT by Changing Duty Cycle

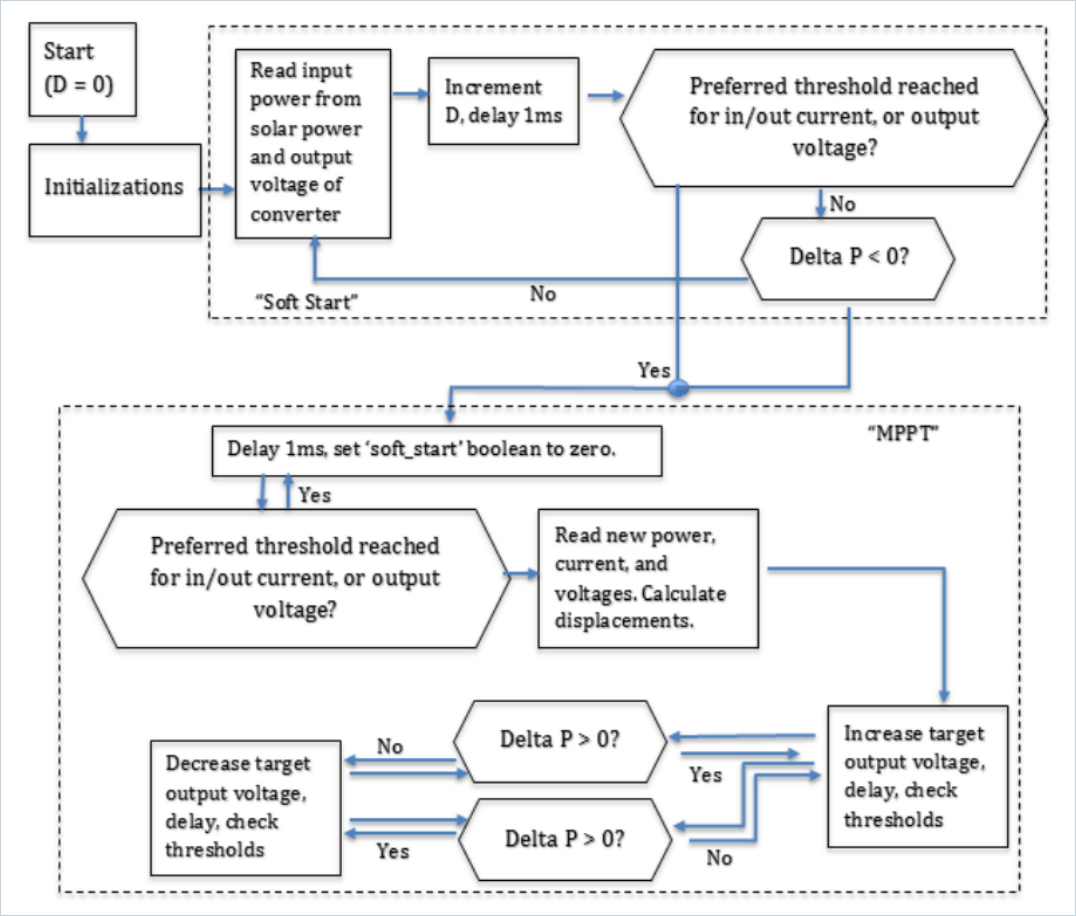
Solar Solutions
Total Charge Technology

- Saman's Video.

Attempted MPPT Algorithm

- Partly completed.
- Difficulty meeting feedback timing.

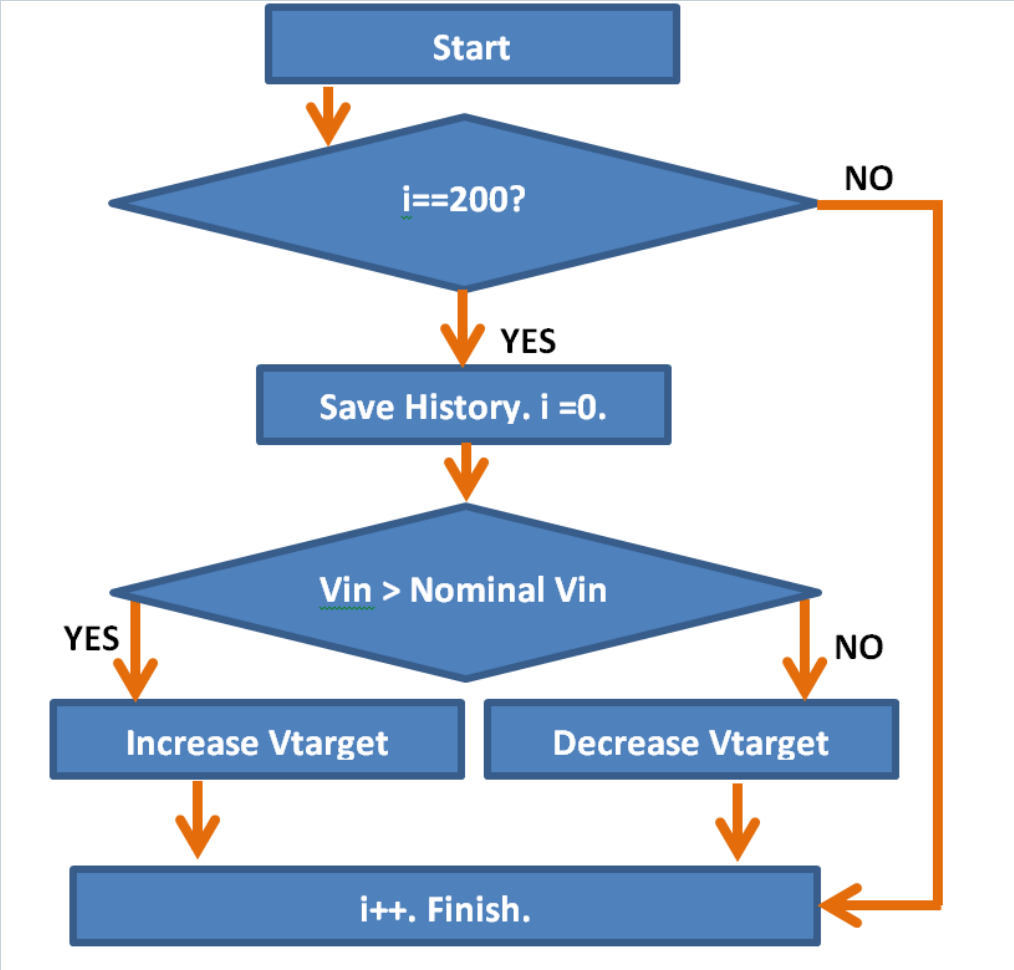
Instead, simplified!



Solar Solutions
Total Charge Technology

Simplified MPPT Algorithm

Solar Solutions
Total Charge Technology

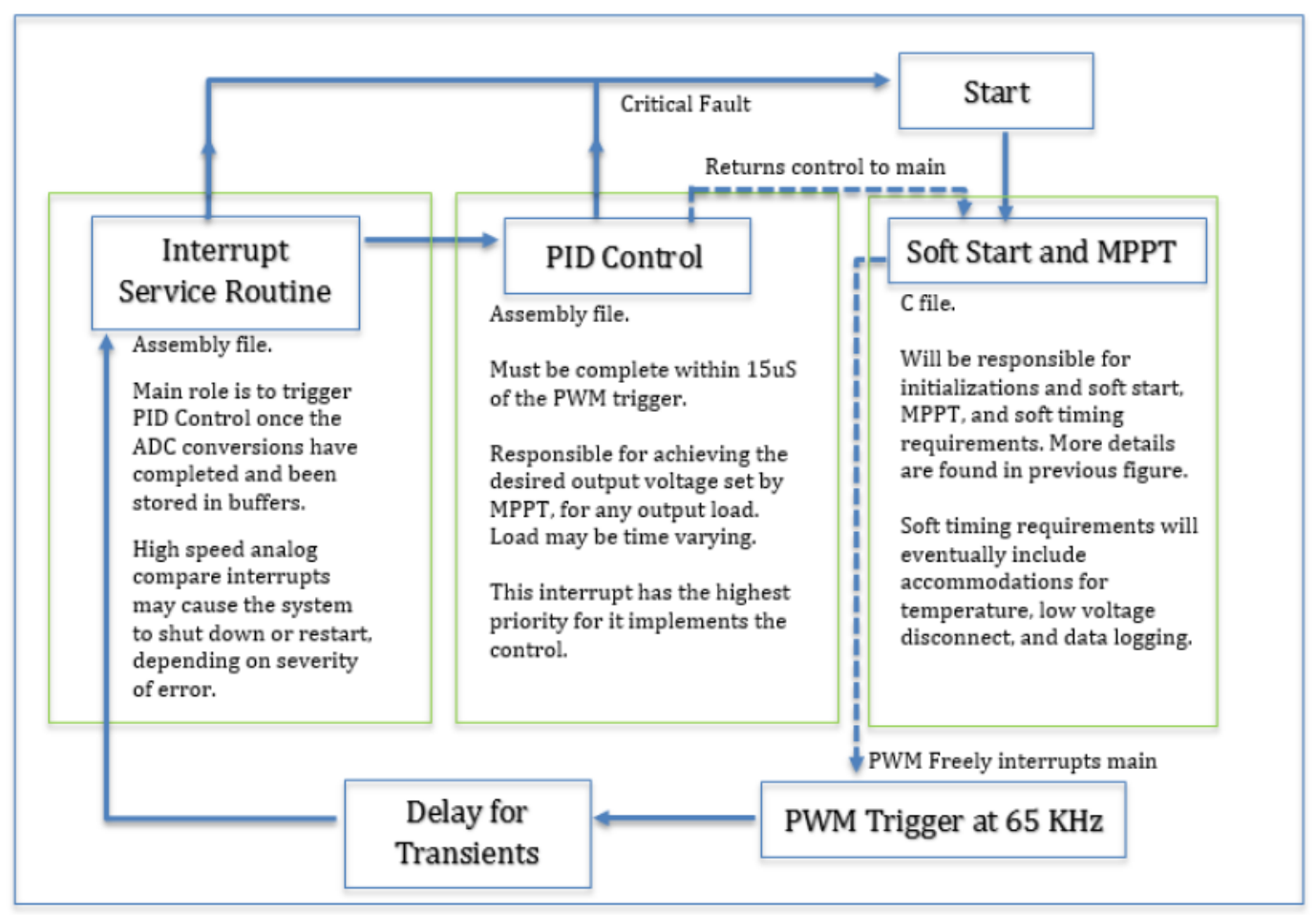


Only one changing variable.

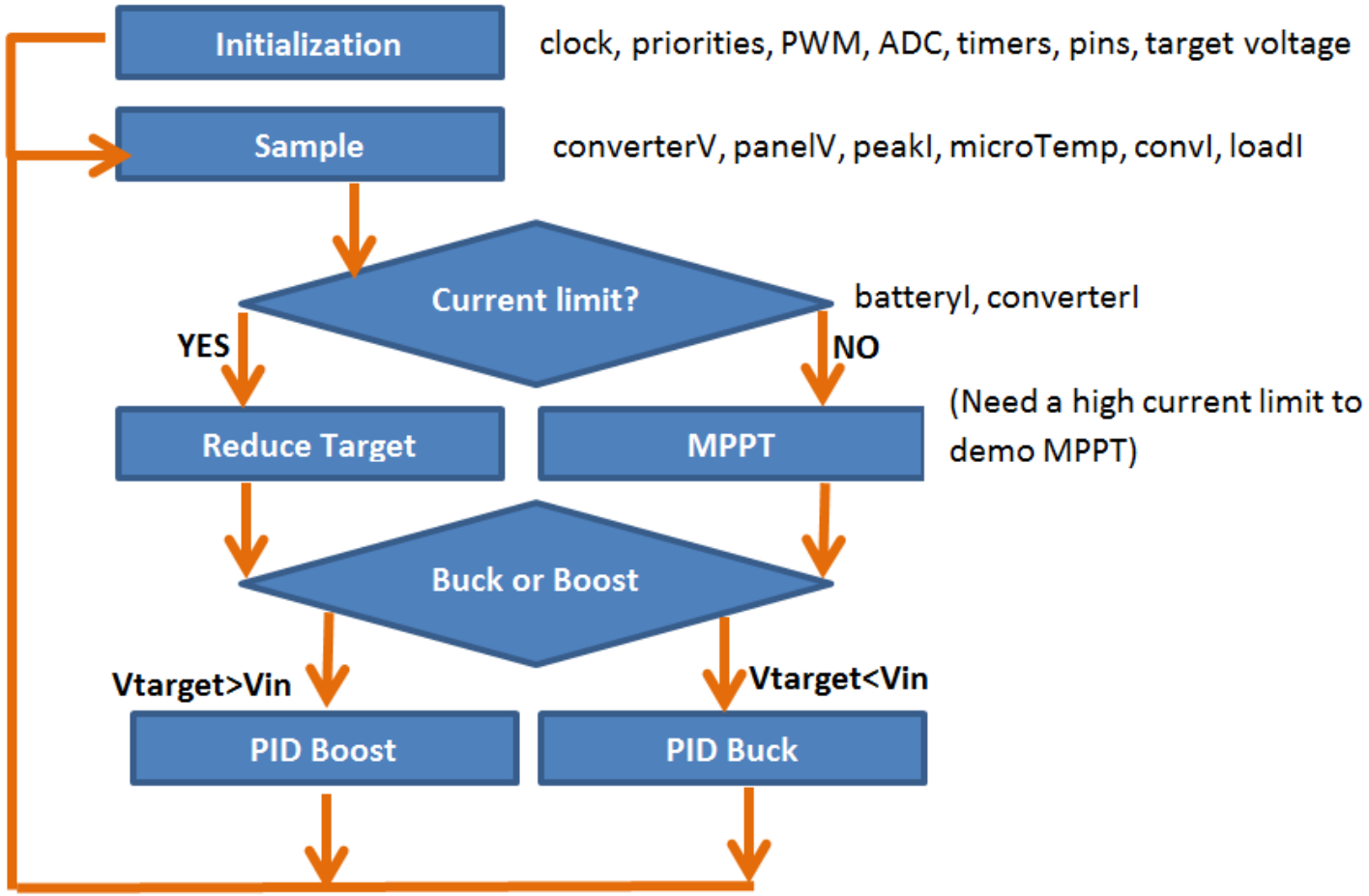
(Show video)

Planned Firmware System

Solar Solutions
Total Charge Technology



Simplified Firmware System



Contents

Solar Solutions
Total Charge Technology

Timeline: Expected

Solar Solutions
Total Charge Technology

Item #	Tentative Deadline
First Revision Ordered	February 1, 2014
Functional Specification	February 17, 2014
Design Specification	March 10, 2014
RS-232 Code Working	February 10, 2014
RS-232 Code Working	February 10, 2014
First Revision Tracking MPP	February 15, 2014
First Revision Converting Power	February 25, 2014
Second Revision Ordered	March 25, 2014
Cross Firmware over to Second Revision	April 10, 2014

Timeline: Actual

Solar Solutions
Total Charge Technology

Item #	Tentative Deadline
PCB layout complete and order placed	March 25th, 2014
PCB received	March 28th, 2014
Soldering of all 300 components per board, for all five boards, with ongoing functional verification	March 31st, 2014
Preliminary firmware demonstration	April 2nd, 2014
Maximum Power Point Tracking demonstration	April 5th, 2014
All five PCB's fully soldered and functioning	April 5th, 2014
Preliminary Firmware outputting 300W as Buck and Boost	April 6th, 2014
Final demo preparation and post-mortem complete	April 16th, 2014

Budget

Solar Solutions
Total Charge Technology

- Solar Solution Contracted by Analytic Systems
- Funding of approximately $2500
- Actual cost of the project: $2800

The difference was due to cost of PCB and the components

Budget

Solar Solutions
Total Charge Technology

Item #	Estimated Cost	Actual Cost
Components for Prototype #1	$500	$1400
PCB Prototype #1	$500	$1400 (rapid prototyping)
Chassis	Recovered from Scrap	Cost Unknown
Components for Prototype #2	$500	N/A
PCB Prototype #2	$500	N/A
Total	$2000	$2800

Team Dynamics

Solar Solutions
Total Charge Technology

- Overall project has been divided into subgroups:

1) Firmware

2) Hardware

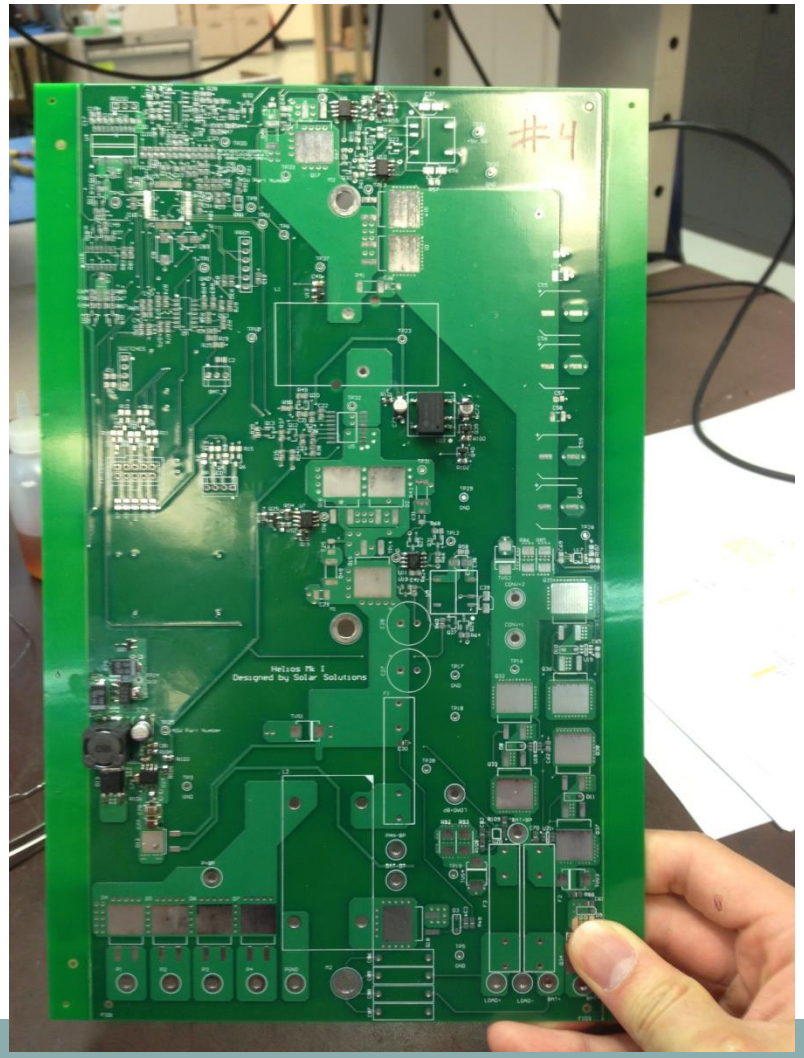
3) Mechanical

- Communicated using *the* social network
- Team members were helpful and encouraging

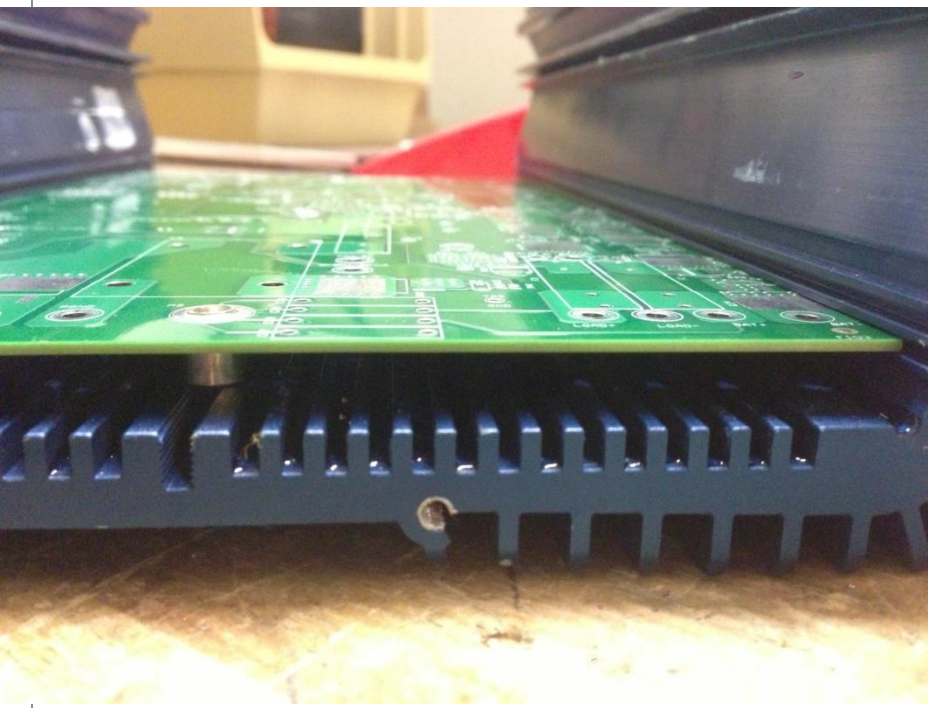
Contents

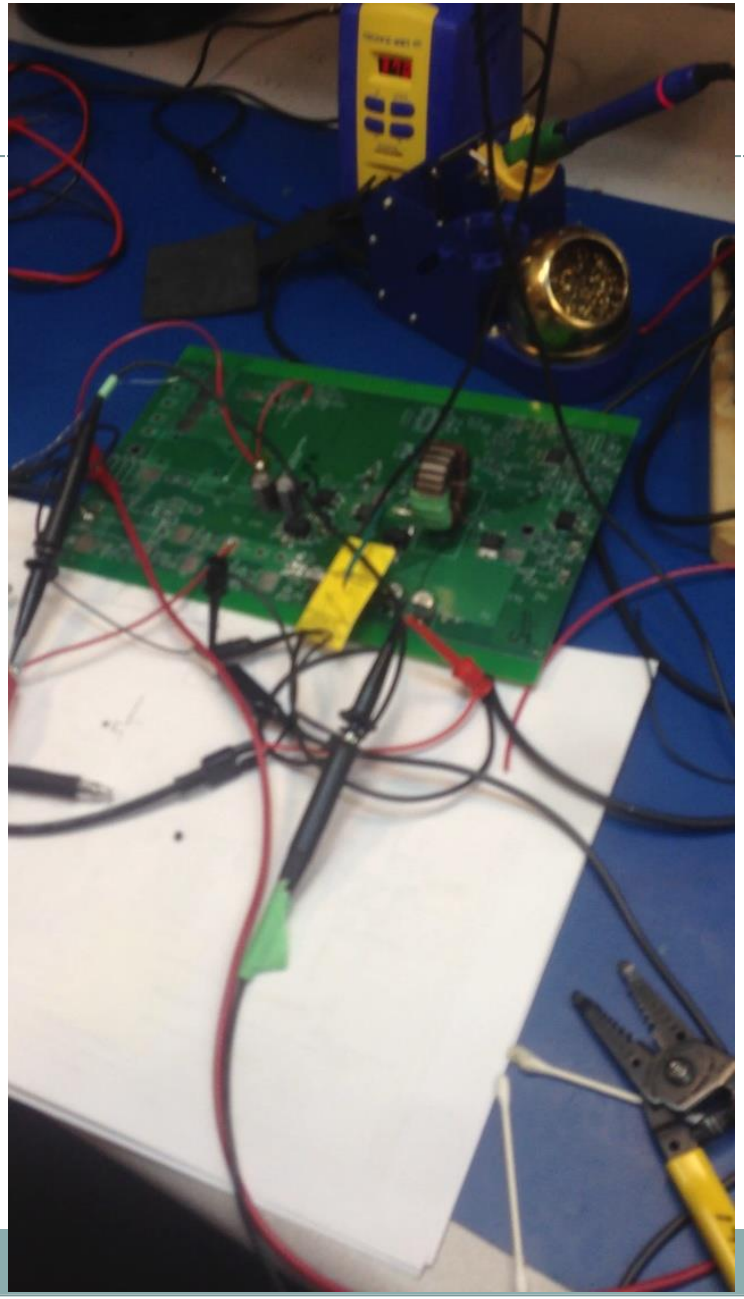
Solar Solutions
Total Charge Technology

Stages of Board

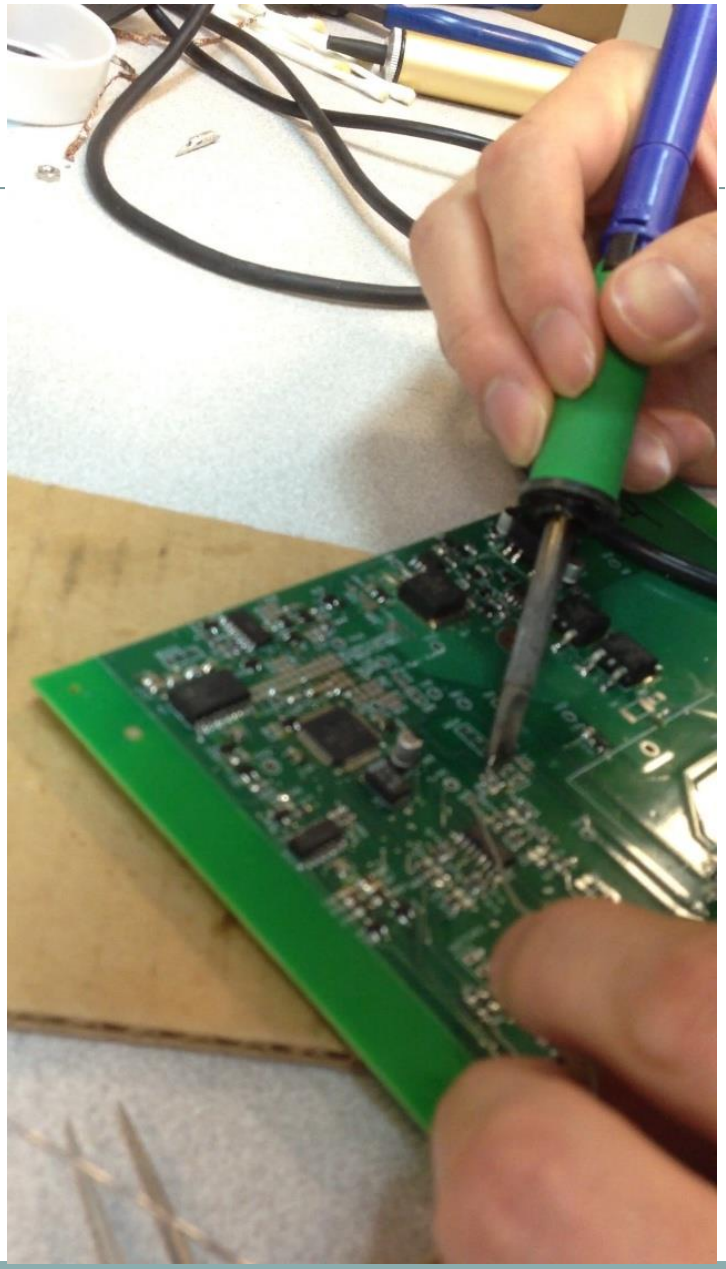


Stages of Board

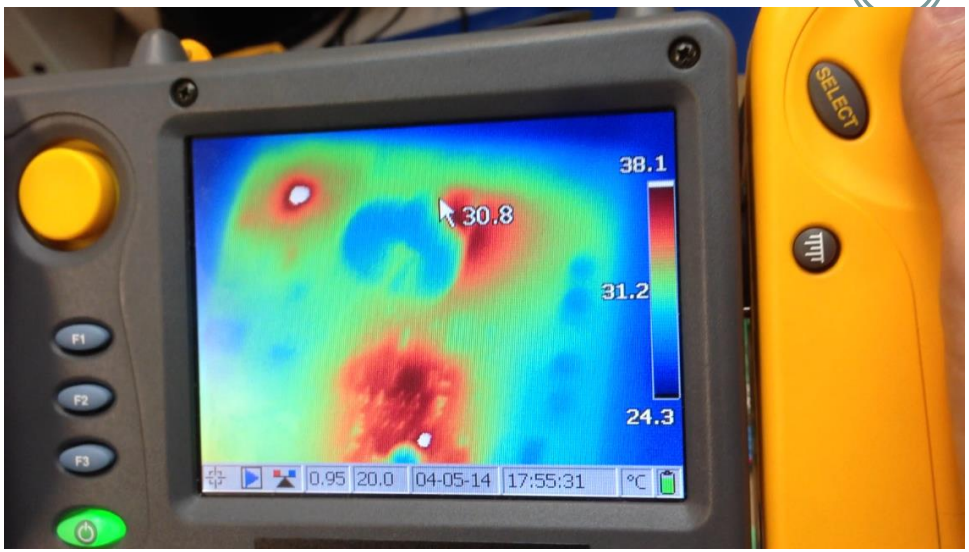


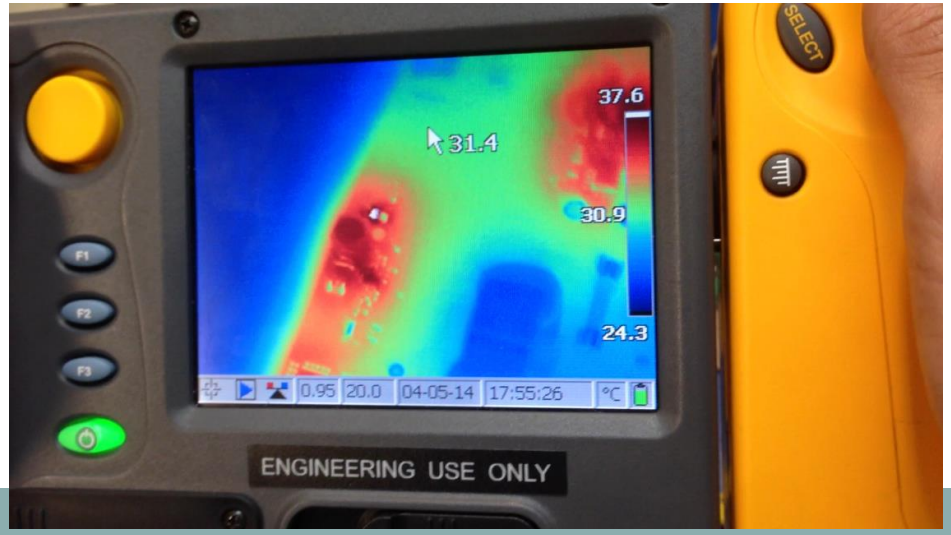


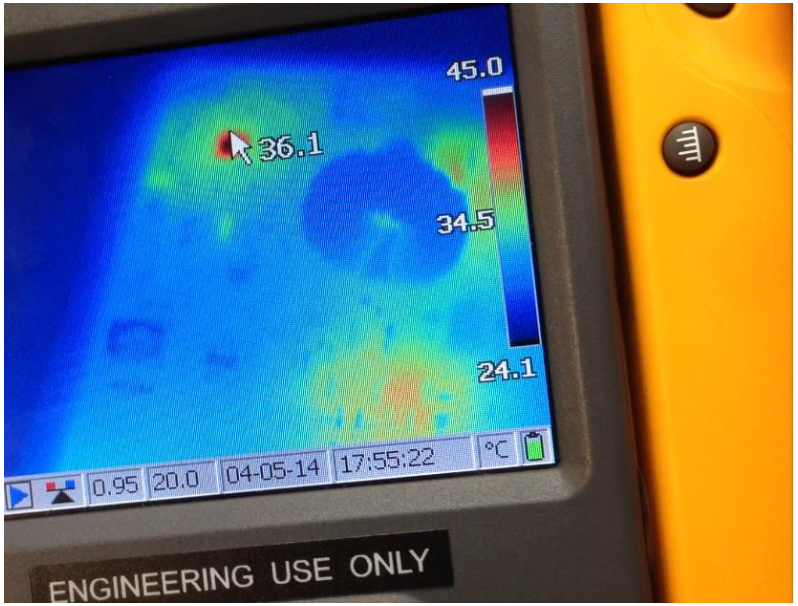
Surface Mount Soldering



Thermal Camera







Contents

Solar Solutions
Total Charge Technology

Conclusion & Summary

Solar Solutions
Total Charge Technology

- Hardware design of power electronics
- Surface mount soldering (300+ components / PCB).
- Iterative design process
- Firmware for dsPIC Microchip Family
- Documentation

Acknowledgments

- Thanks to:

- Analytic Systems for funding the project and providing us the space for testing and assembly
- Blair “is it done yet?” McLachlaan
- Adam “DON’T DO THAT” Cerennzia
- Bob “that’s not funny” Bulllock
- Eugen “bring back my equipment” Tranndafir
- ENSC 440/305 Instructors and TAs

Fun Fact

- As we discovered McDonald's stops serving dinner (and ice cream) at 4am

Questions