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Intelligent Battery Balancing Charger

Prof. Dr.-Ing. Christoph Weber
Fabian Franke
Institute of Mechatronics
University of Applied Sciences
Kiel, Germany

Dr. José Francisco Sanz Osorio
Escuela Universitaria Ingeniería Técnica Industrial
Zaragoza
University of Zaragoza
Zaragoza, Spain



Institute of Mechatronics



FACHHOCHSCHULE KIEL
University of Applied Sciences

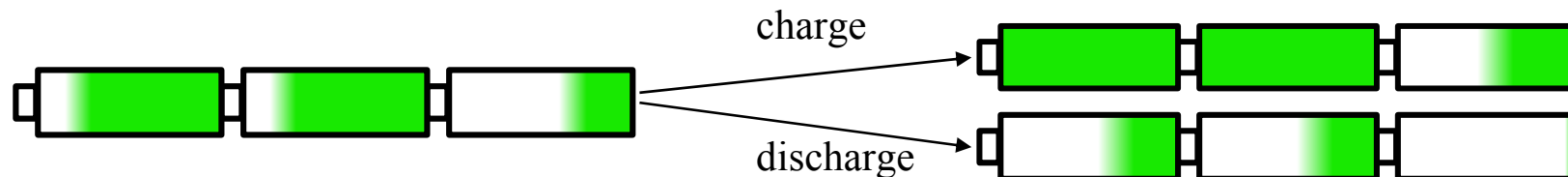
Agenda

- Overview: Balancing methods
- Test system: Energy Storage System
- Battery Balancing Charger (BBC)
- Summary & Outlook



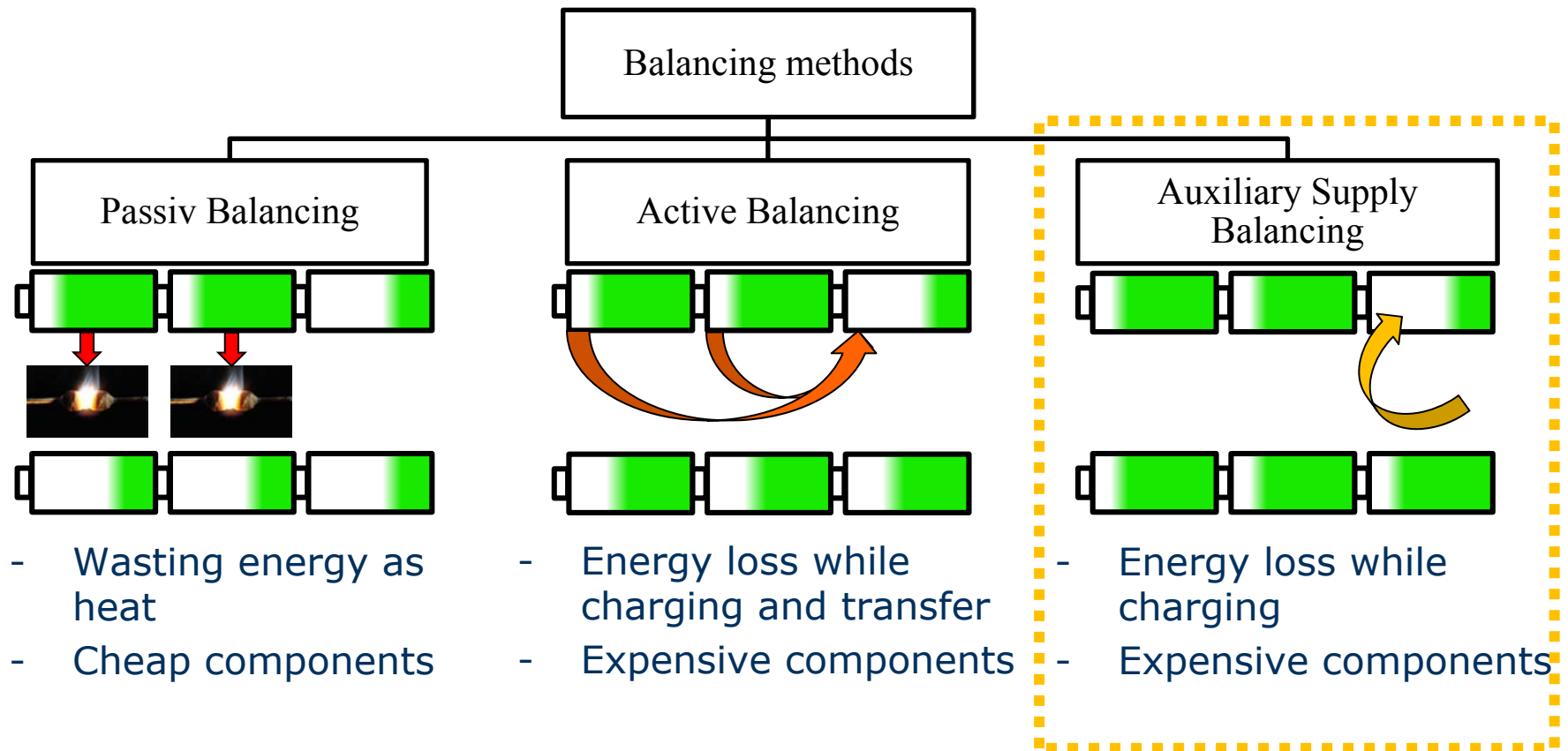
Why is balancing / battery equalization necessary?

- ❑ Production tolerance of battery cells even after sorting
(capacity, internal resistance, ...)
- ❑ Temperature differences between cells
→ results in differences in the state of charge (SoC) of
single battery cells of a battery



➤ **Maximization of battery capacity**

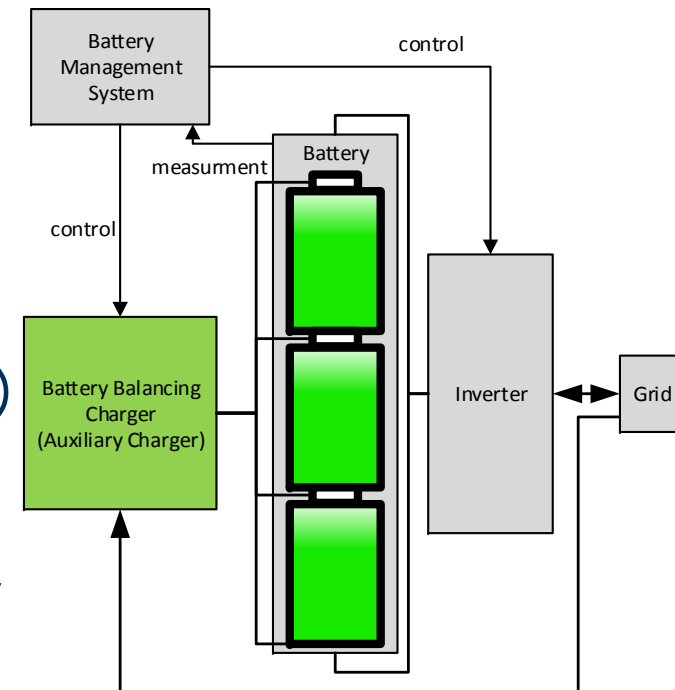
Balancing methods



Test System overview

□ Energy Storage System:

- Battery with single cells in series (LiFePO₄-Graphite with 40Ah)
- Battery Management System (BMS) (Limit monitoring, SoC, ...)
- Inverter for charging and discharging of the complete battery
- Auxiliary/Balancing Charger (BBS) for single cells charging



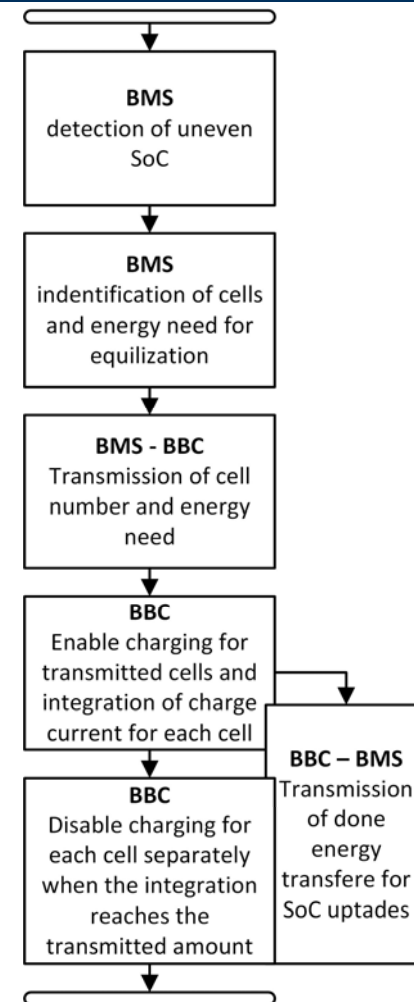
Interaction with the Test System

□ BMS:

- Identification of cells for balancing via SoC comparison
- Transfer information to the BBC
(Cell + energy deficit)

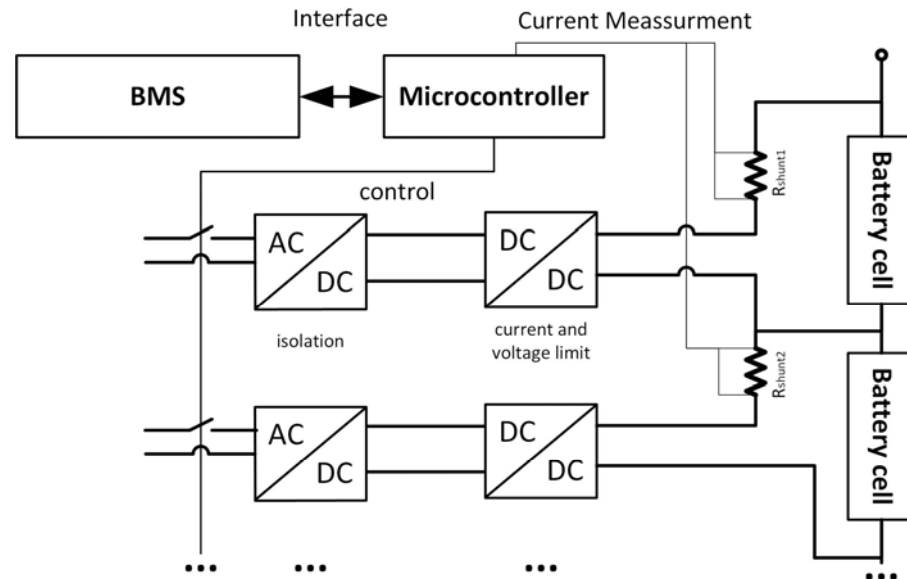
□ BBC:

- Charge the needed amount of energy for each cell
- Transmission of information about done charging for SoC updates in the BMS



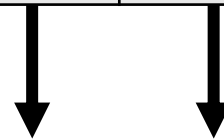
Battery balancing charger

- Isolated AC-DC converter and DC-DC step down converter for each cell
- Microcontroller for communication, control and current measurement (coulomb counting)
- BMS for balancing initiation and control



Battery balancing charger Example

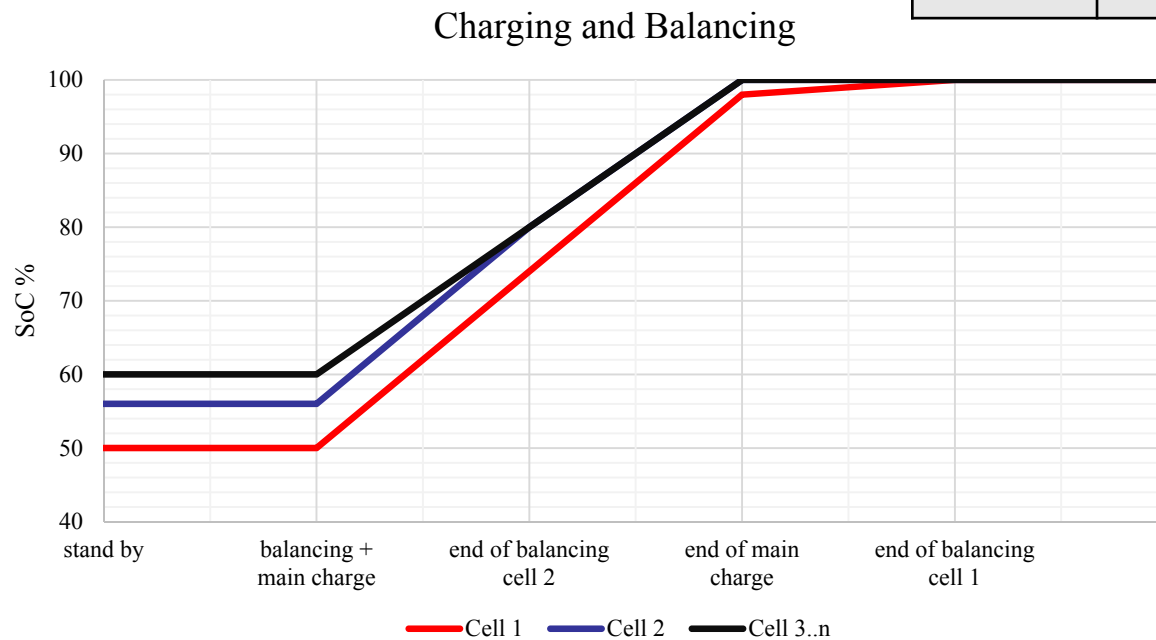
Cell	1	2	3..n
SoC %	50	56	60



selection of cells for balancing by BMS
(cells with lower SoC related to max SoC)

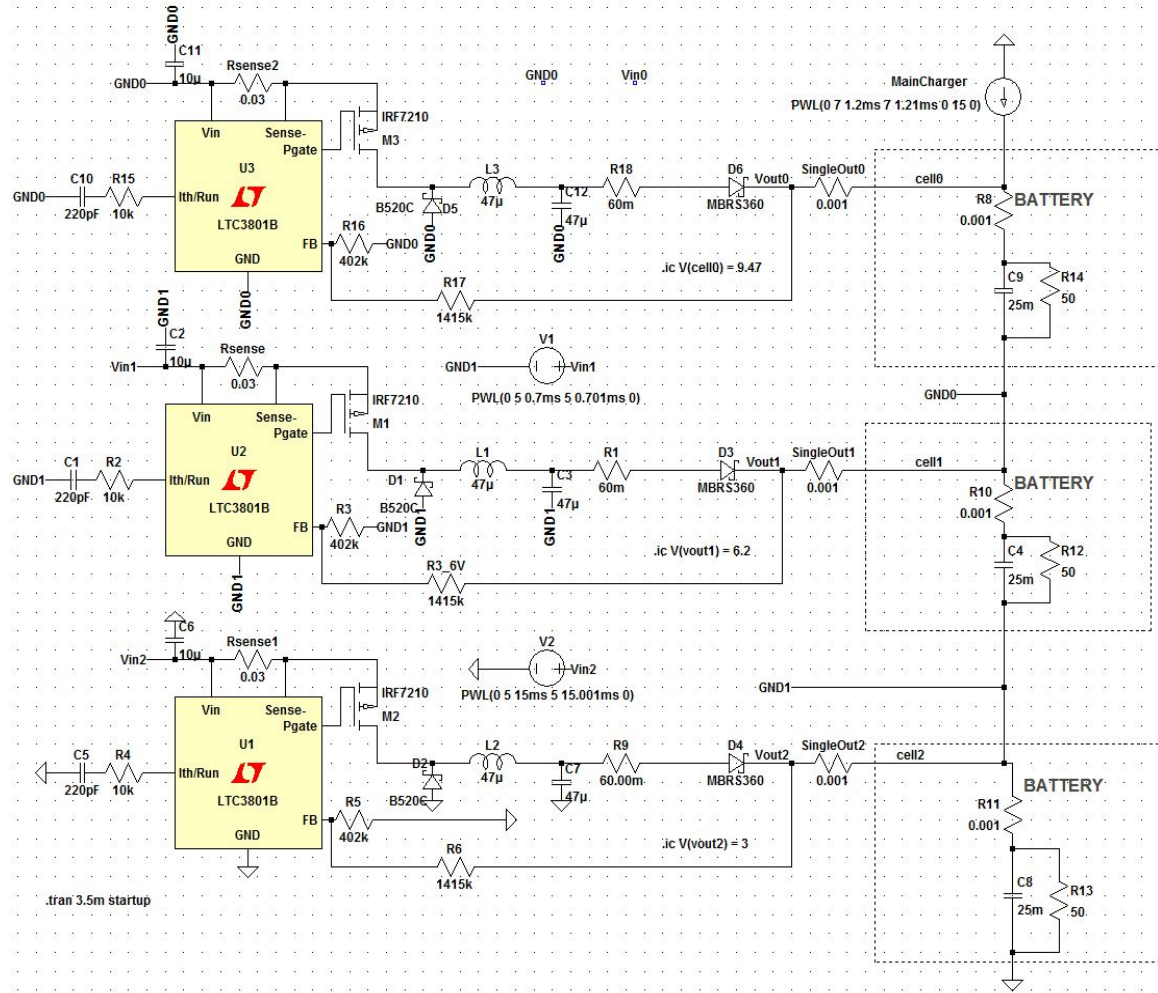
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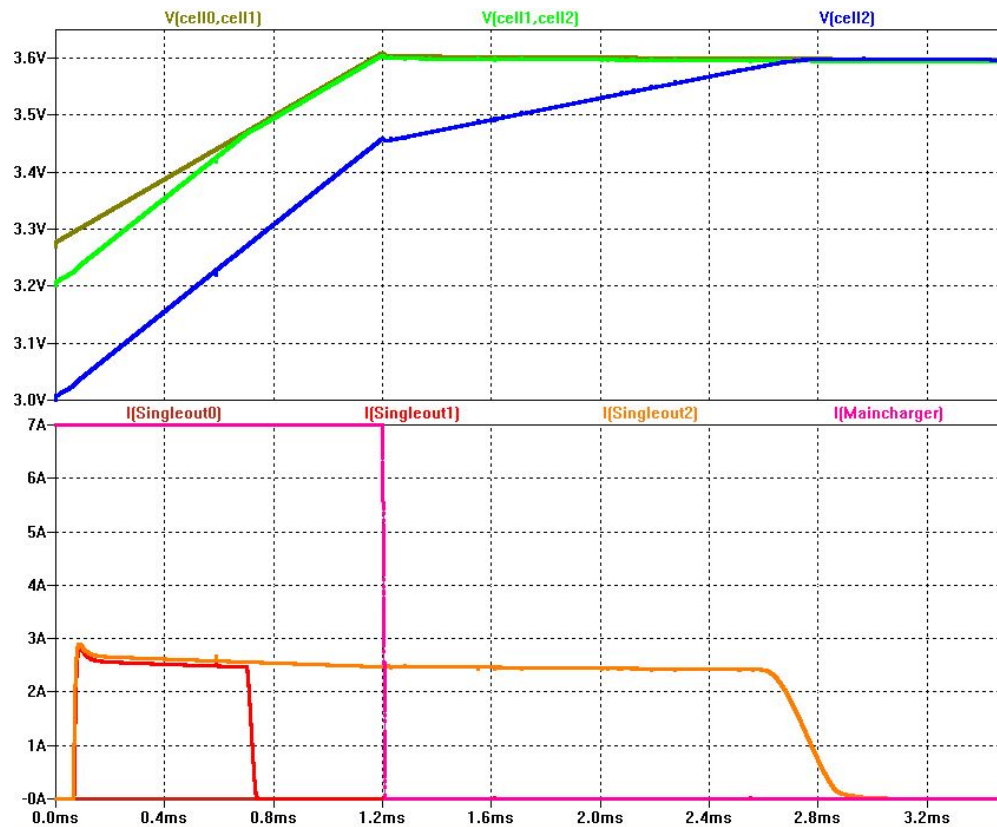


Simulation

- 3 battery cells
 $V_{init} = 3V, 3.2V, 3.27V$
 $R_i = 1m\Omega$
- Current Source as main charger
 $I_{main} = 7A$
- DC-DC charger (BBC) for each cell
 $I_{limit} \approx 2.7A$
 $V_{limit} = 3.6V$



Simulation results

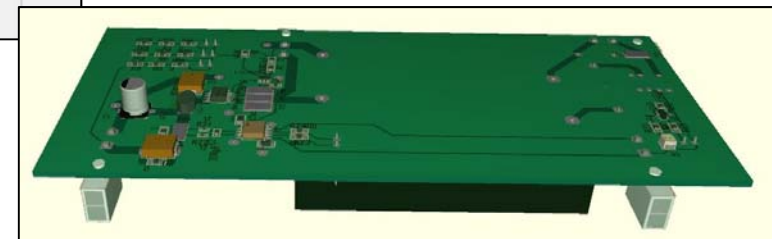
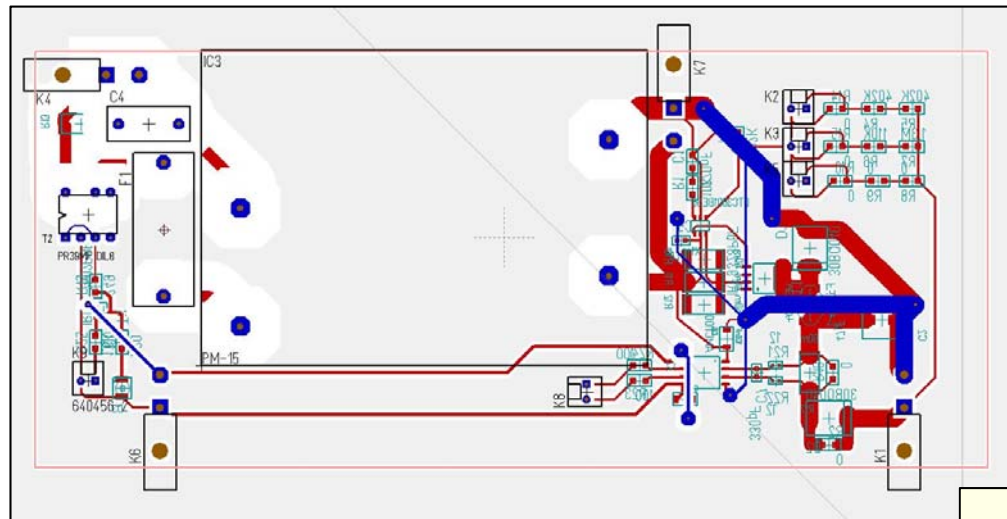


□ Main charge of all 3 cells

□ Balancing charge of 2 cells

→ Cells equalized and fully charged

PCB-Test-Design



Summary

- ❑ High component complexity → expensive

- ❑ Reduced energy consumption and battery cycle use for balancing

- Application:
 - Energy Storage Systems
(long-term use → 2nd life batteries)
 - charging poles (multiuse)
 - charging station for battery change systems (multiuse)

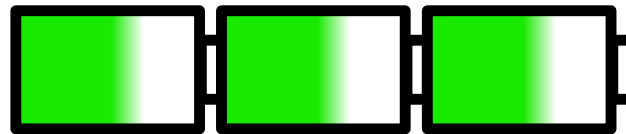


Outlook

- ❑ Building a physical battery balancing charger
- ❑ Testing of the battery balancing charger in a real energy storage system with a simulated environment (source and sink)
- ❑ Analysis and evaluation the energy and cycle use of the balancing method



Thank you very much for your
attention!



References

- ❑ Imtiaz, A. M. and Khan, F. H., “Time Shared Flyback Converter” Based Regenerative Cell Balancing Technique for Series Connected Li-Ion Battery Strings,” *Power Electronics, IEEE Transactions on*, vol. 28, no. 12, pp. 5960–5975, 2013.
- ❑ V. Bart. Burnedresistor [Online]. Available: <http://www.bvsystems.be/burnedresistor.jpg>. Access: 2015.09.20

