Critical Safety Elements in Smart Battery Pack Design

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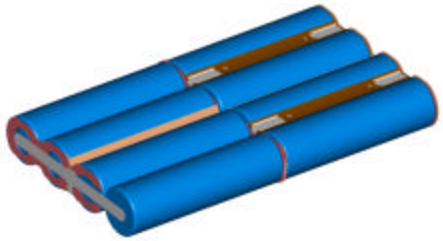
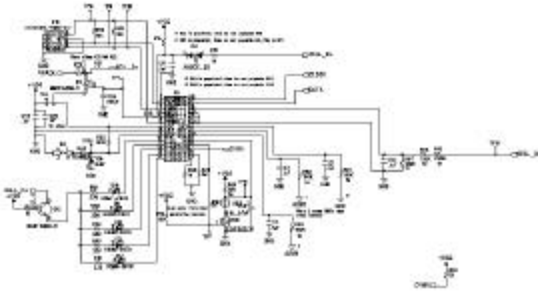
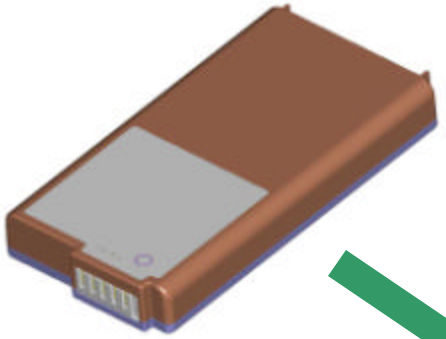


Cell Characterization

System Knowledge and Usage Environment

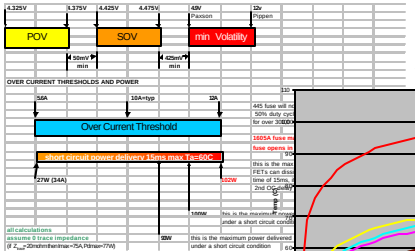
Safety Circuit Design

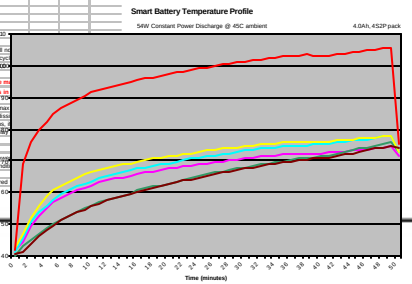


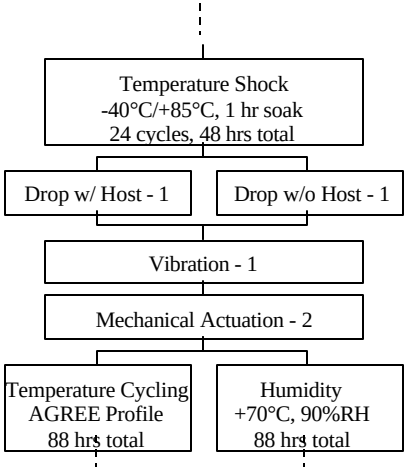


SMBus Safety Features

Analysis and Test







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Safety Test Requirements for Li Ion Cells

Cell Characterization

- **Cell safety performance data should be thorough**
- **Optimum safety circuit design strongly depends on good cell characterization data**
- **Testing is crucial**

Test	Failure Code	Description	Purpose	Referenc	Requirements				
					Leak	Vent	Fire	Explosion	Other
Specific safety abuse tests.									
1	A	Thermal abuse, oven test at 150 C for 60 minutes	Ability to withstand thermal abuse and test relative cell stability. Minimum survivability is 10 minutes (UL spec).	modified UL			X	X	*Cell surface T < 200 C*
1a	A	Thermal abuse, oven test at 130 C for 60 minutes	Ability to withstand thermal abuse. Test performed only if cell fails #3 before 60 minutes.	IEC			X	X	*Cell surface T < 200 C*
2	A	Crush, flat plates as per UL 2054	Ability to withstand mechanical abuse	UL and IEC			X	X	
3	A	Impact, round bar and weight as per UL 2054	Ability to withstand mechanical abuse from sudden impact	UL and IEC			X	X	
4	B	Short circuit, < 0.5 ohm load, 60 C	Ability to withstand short circuit	UL and IEC			X	X	Cell surface T < 150 C
5	B	Short circuit, < 0.5 ohm load, room temp.	Ability to withstand short circuit	UL and IEC			X	X	Cell surface T < 150 C
6	*B*	*Overcharge at $I_{0,}$ V= 5 V*	*Survive minimal level of overcharge*	*modified UL/IEC*			*X*	*X*	
7	*B*	*Overcharge at $3I_{0,}$ V= 4.5 V*	*Survive faulty charger condition*	*modified UL/IEC*			X	X	
8	*B*	*Overcharge mapping: 3 cells at 5 different test currents; V= 10 V*	*Determine maximum safe level of overcharge for safe design*						
9	B	Forced disc							

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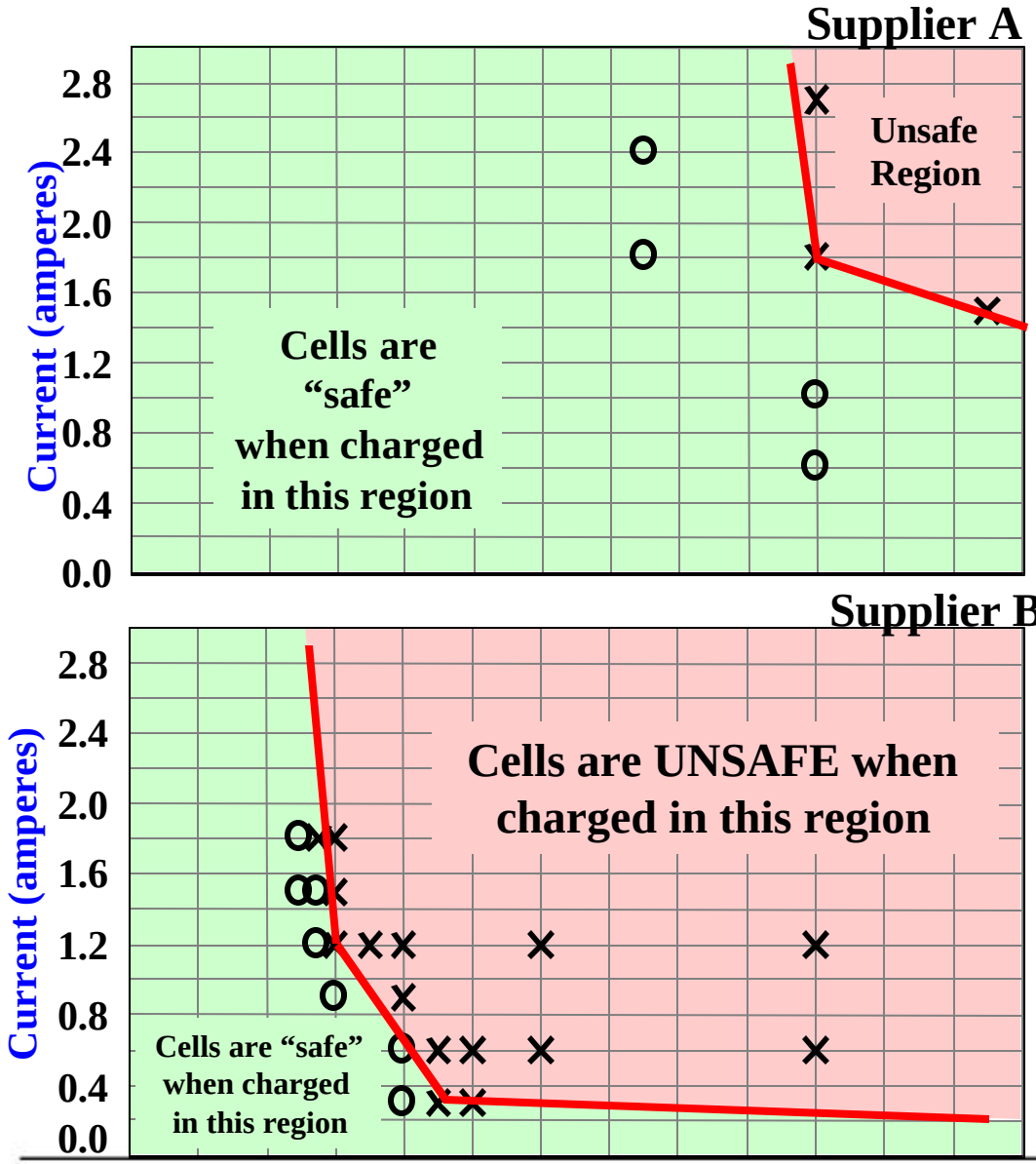

Lithium Ion Cell Failure (overcharged, insulated cells)

- All cells are not created equally
- Failure to take into consideration the differences between cells could lead to a safety circuit that is either under-designed or over-designed

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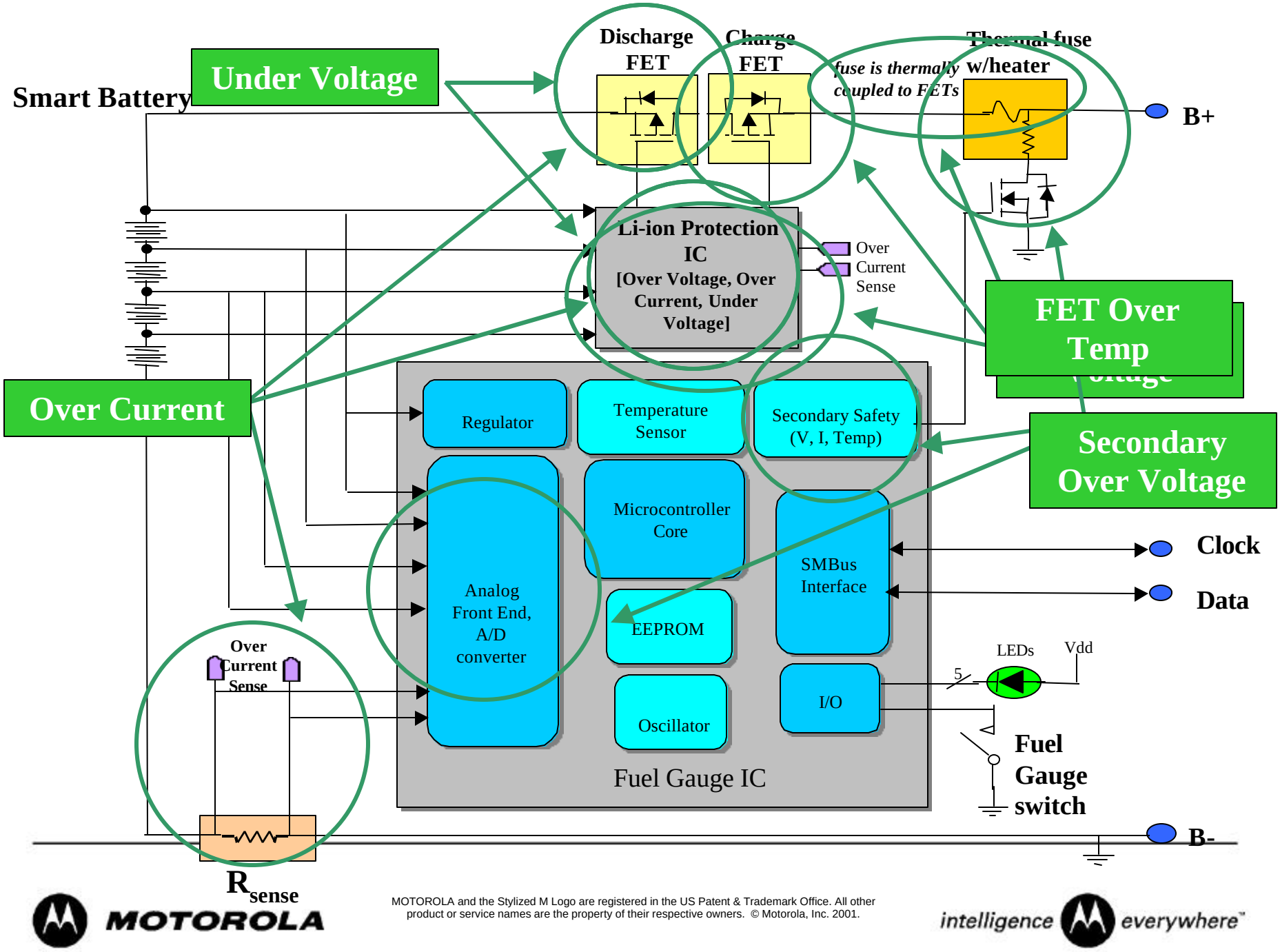

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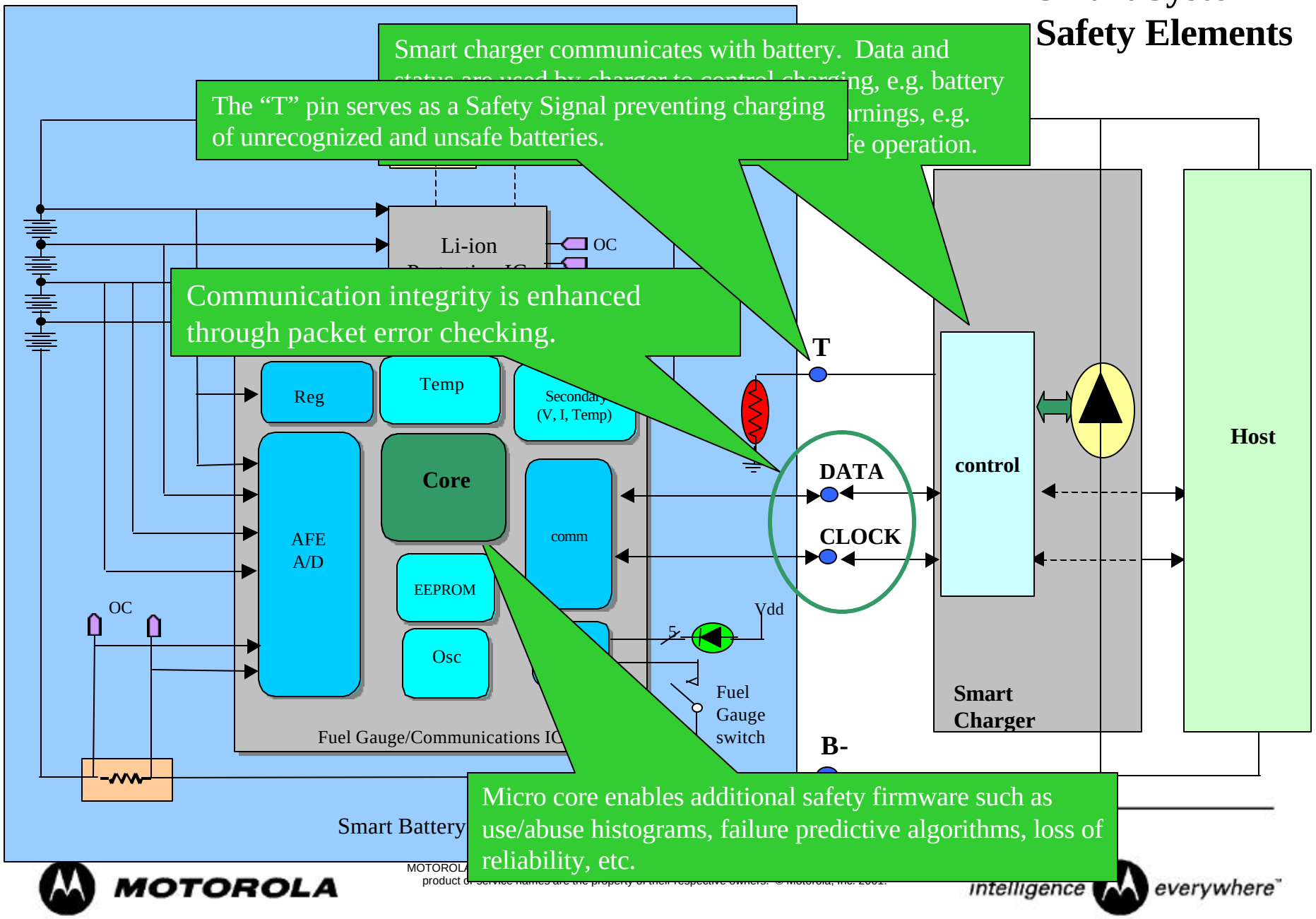
Smart System Safety Elements



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