Driving the Data Center on Wheels

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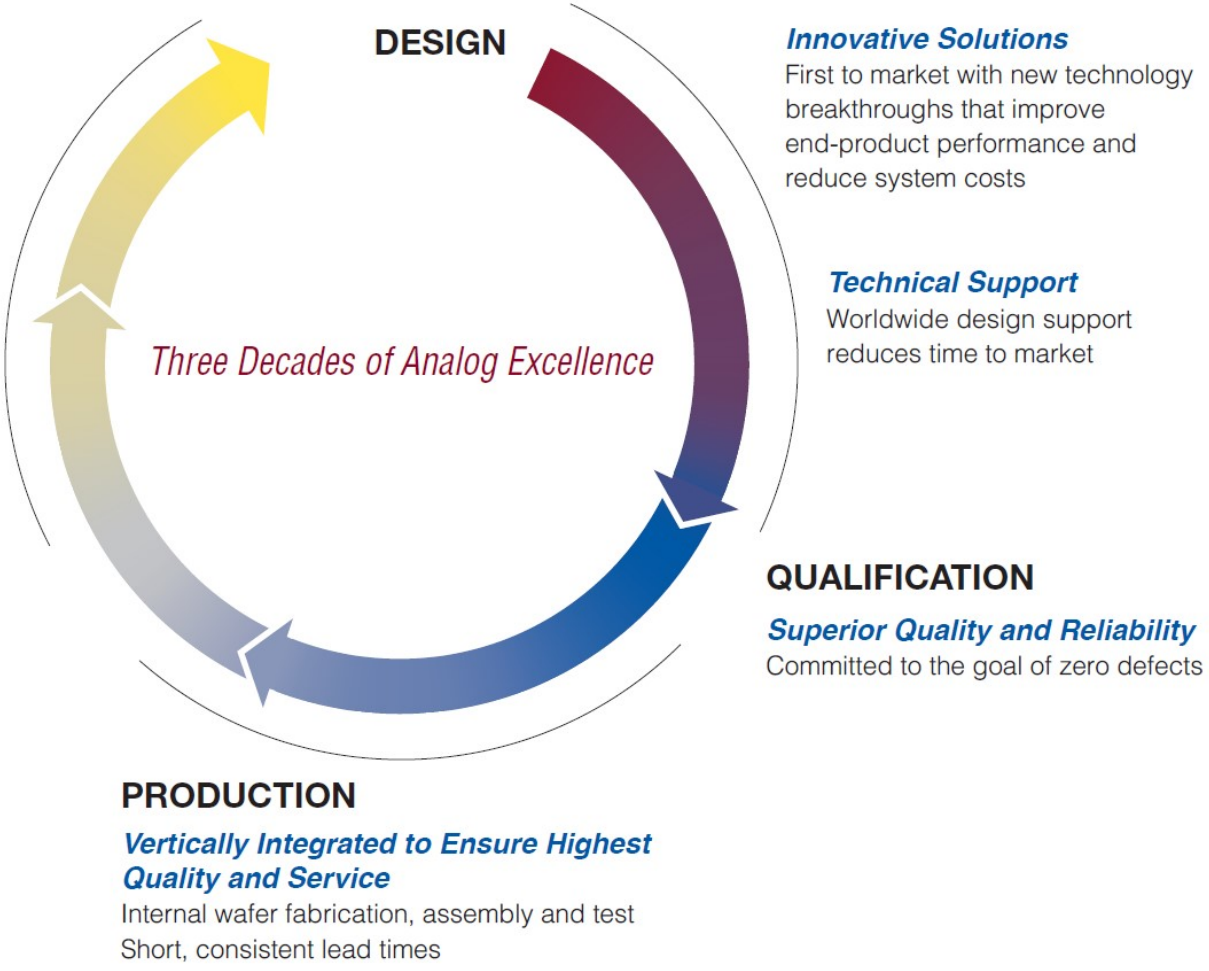
Linear Technology Office of the CTO

LINEAR TECHNOLOGY

LTC – What We Do



Automotive & Transportation Electronics Solutions

High Performance Analog ICs



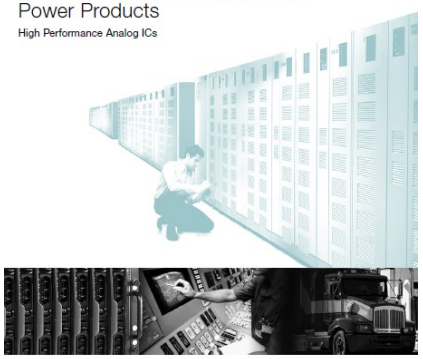

Battery Charging and Management Solutions

High Performance Analog ICs




Telecom, Datacom and Industrial Power Products

High Performance Analog ICs



Power Management for LEDs

High Performance Analog ICs

Linear Low Dropout (LDO) Regulator Solutions

High Performance Analog ICs




Wireless & RF Solutions

High Performance Analog ICs

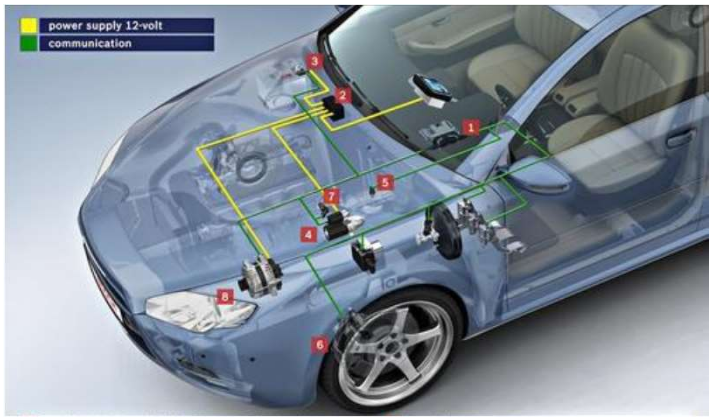



High Performance DC/DC Controllers




Data Center on Wheels

- Lessons learned in the data center world:
  - 48V power distribution
  - Power System Management
- Unique vehicle requirements:
  - Reliability
  - Safety and ISO26262



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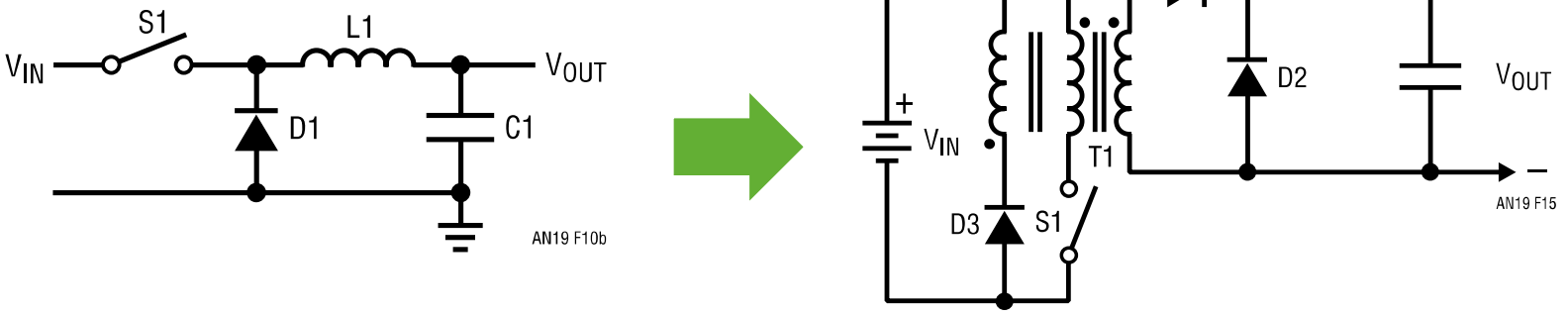
Ohms are the Enemy

- Power loss in wiring = I^2R
- Reducing R requires more copper
  - More weight and cost
  - Improvement comes linearly
- Reducing I requires raising voltage
  - No wiring changes
  - Improvement comes as a squared term
- Change from 12V to 48V:
  - Current/4
  - Power/16

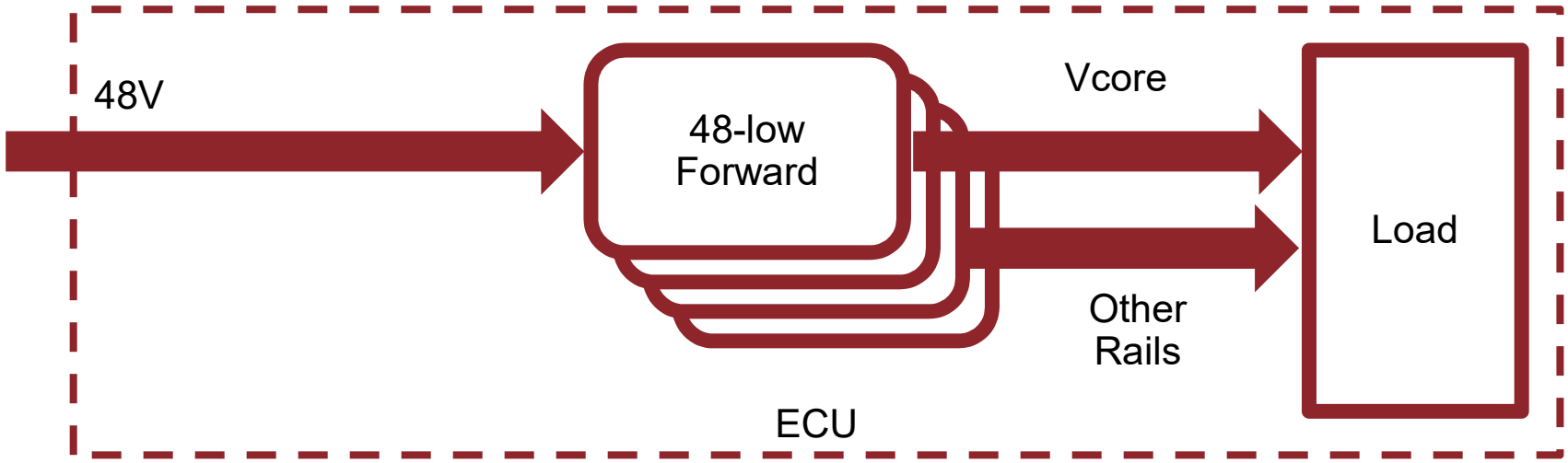
48V Doesn't Come for Free

- Logic supplies are <5V
- Typical core logic runs at ~1V@100A
  - Large stepdown ratios required
- Synchronous buck designs are handicapped by very narrow duty cycles
- Transformer-based solutions aren't as fully optimized



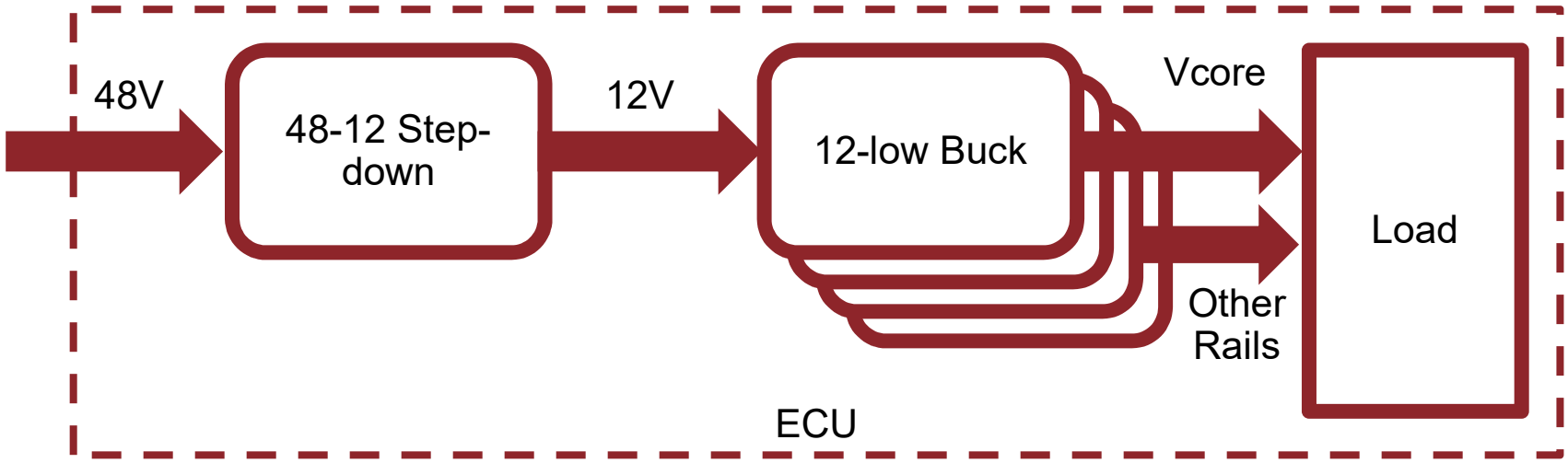
48-low

- Single (more complicated) regulator per rail
- Forward or Flyback regulator technology



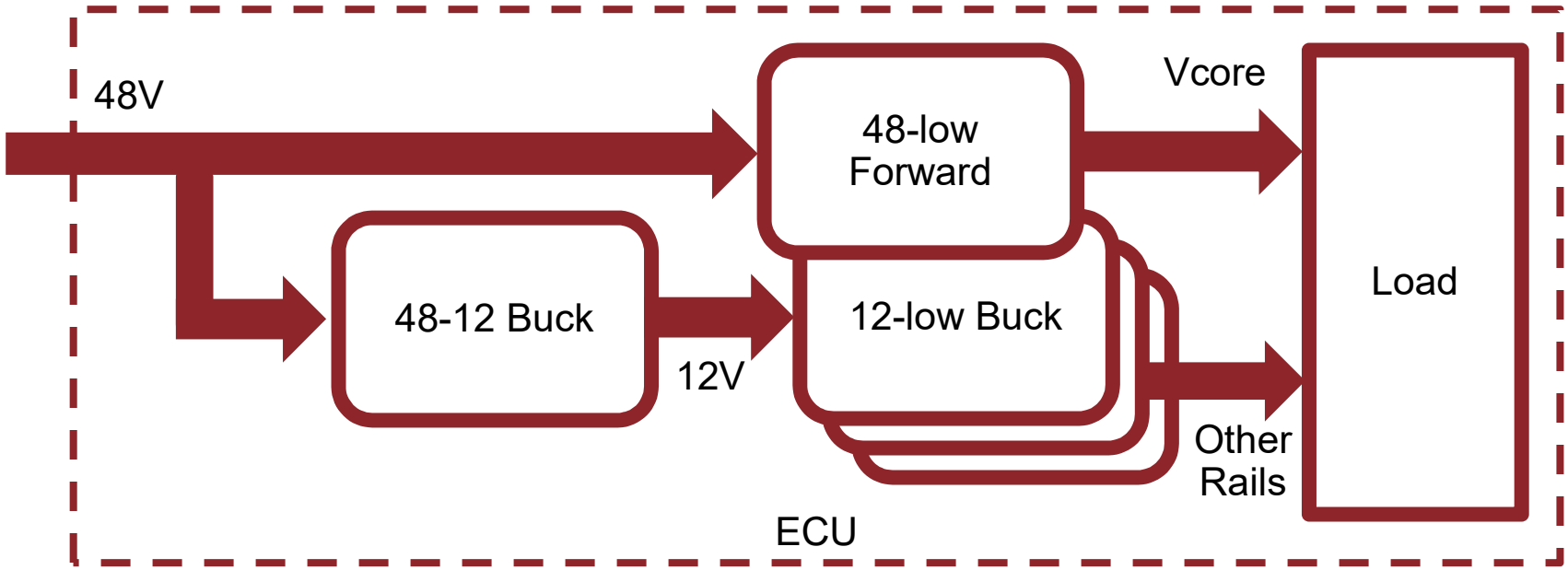
48-12-low

- Two regulators in series to keep stepdown ratios under control
- Standard regulator technology
- Efficiencies are multiplied



Hybrid Approach

- Largest rails direct from 48V
- Smaller rails use standard regulator technology
- System efficiency dominated by core supply

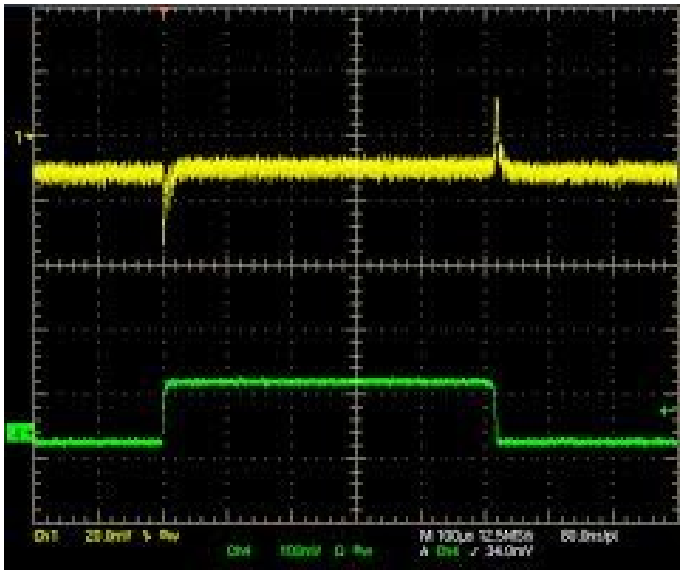


Power System Management

- Another idea borrowed from Telecom: Digital Management of Analog Supplies

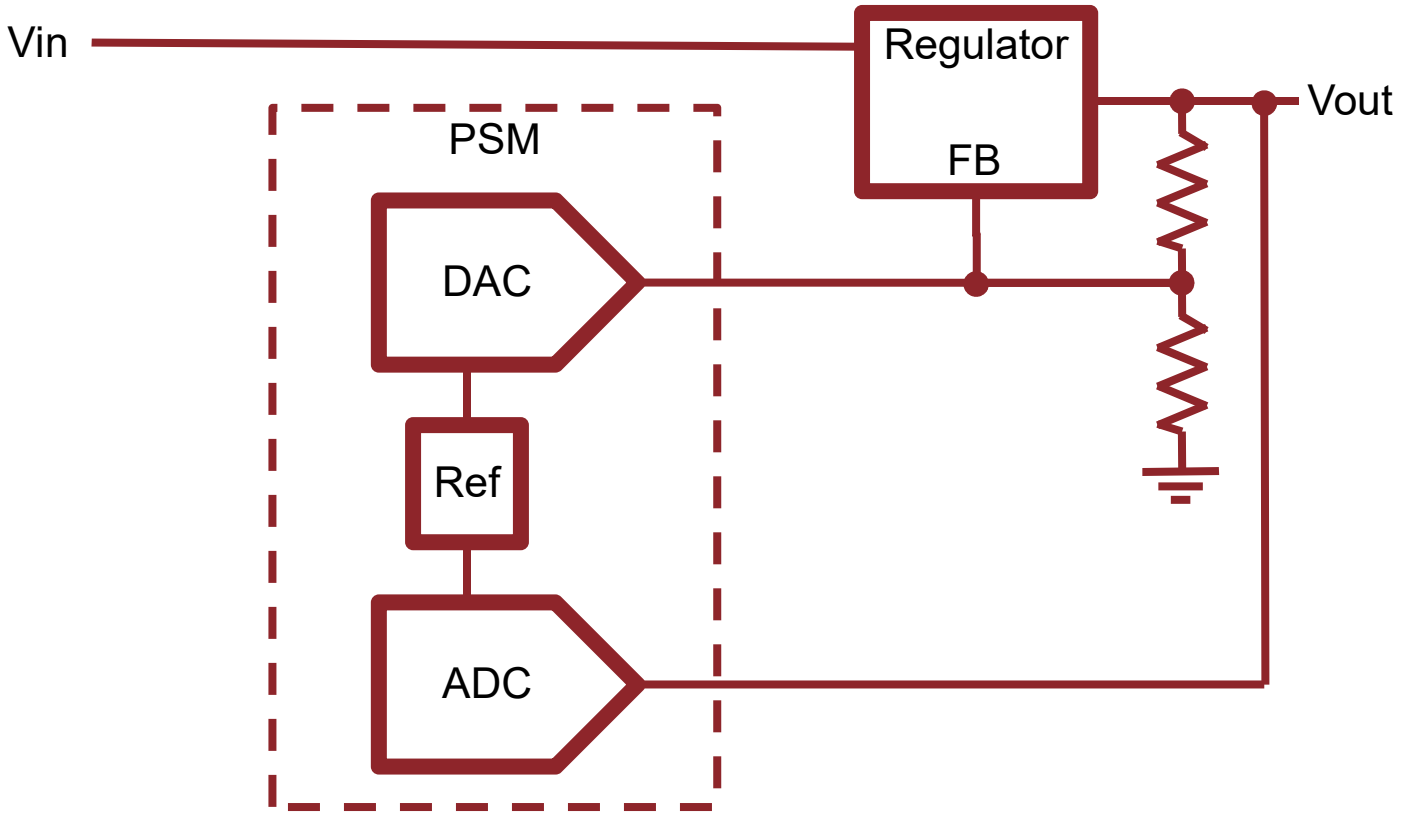
- Analog Power Supply
  - Fast transient response
  - High Accuracy

- Digital Power Management
  - Programmability
  - Telemetry



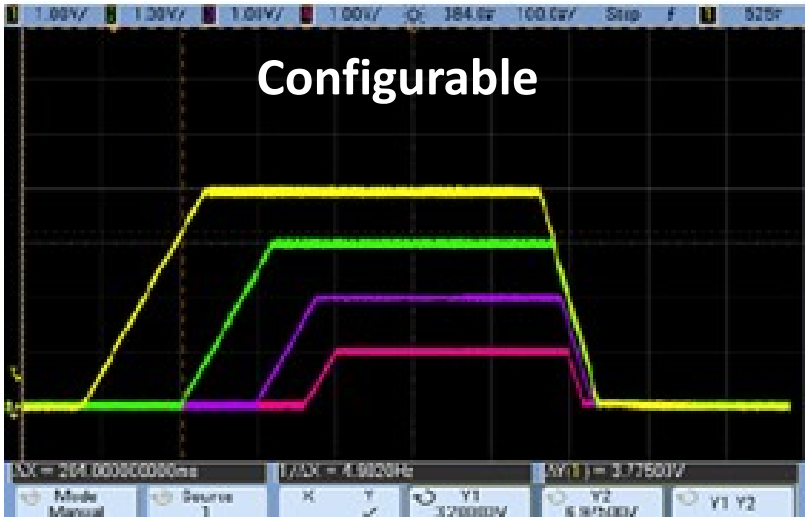
PSM in a Nutshell

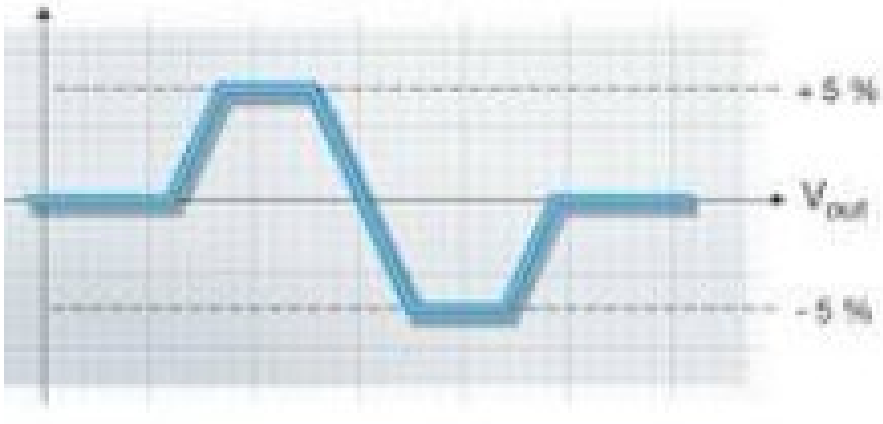
- Basic idea: Monitor and Control a power supply
- But it can do much more…



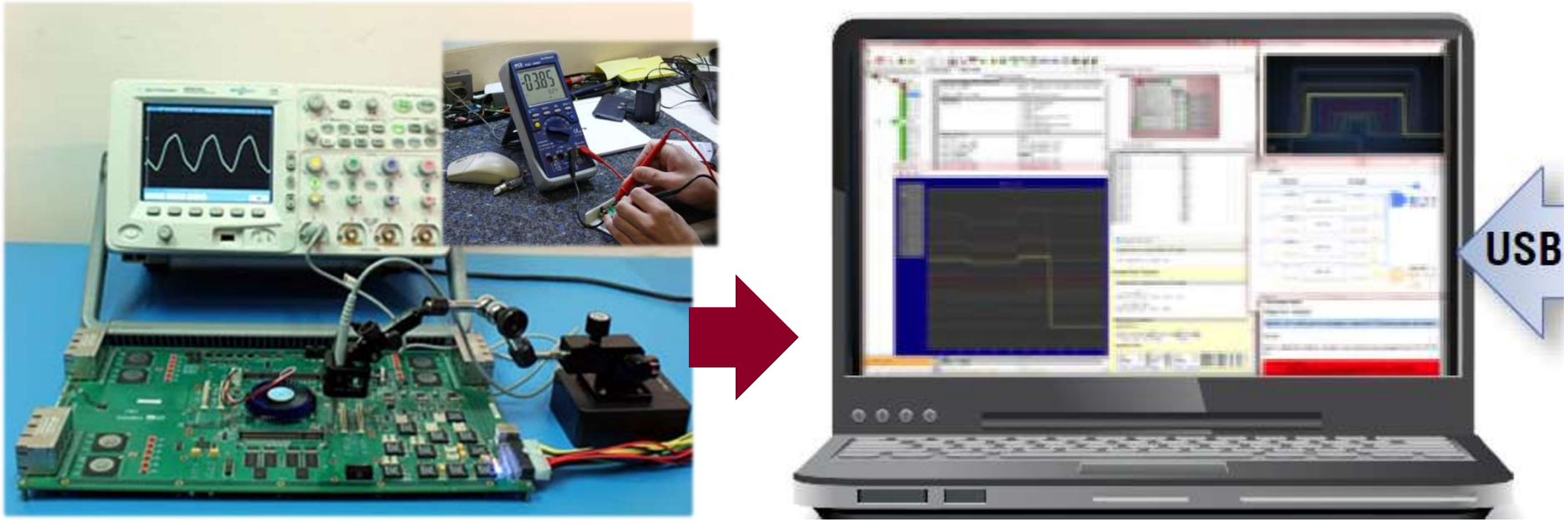
Programmable Sequencing and Margining

- Built-in Sequencing Control
- Autonomous Power-up
- Margin Test at ICT
  - Improve quality
- Cascade with other PSM devices
- Easily configurable





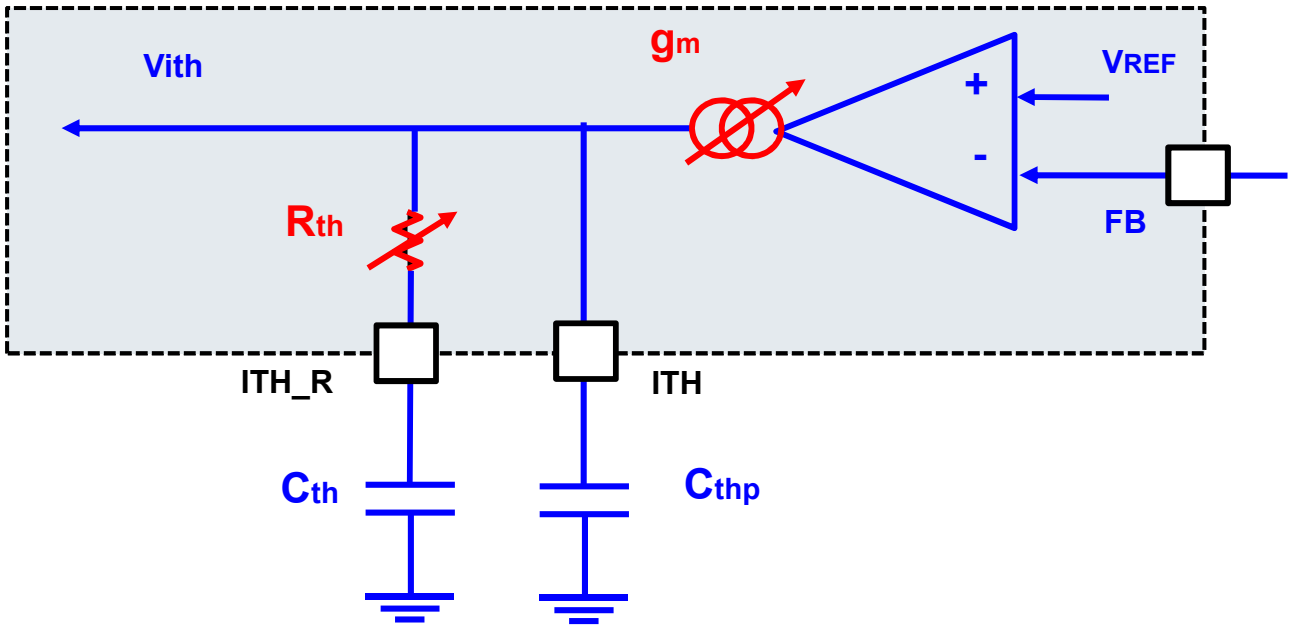
Power System Characterization



- Use built-in telemetry and GUI to measure voltage, current and temperature
- Characterize power during prototyping
- Test power during ICT
- Allows for remote debug or in-field updates

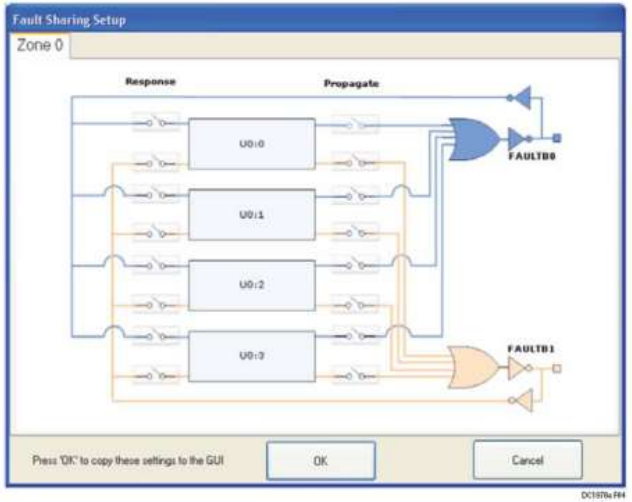
Programmable Compensation

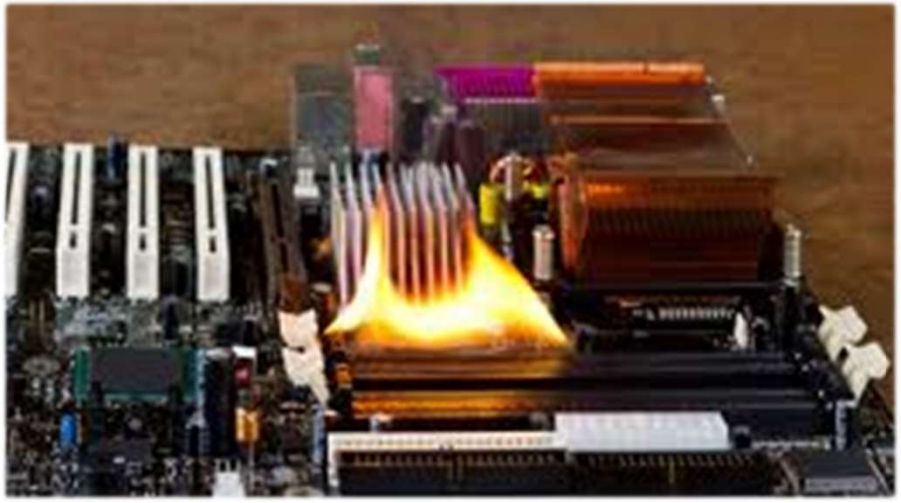
- Adjust loop compensation over PMBus
- Tune transient response on the fly



Programmable Fault Response

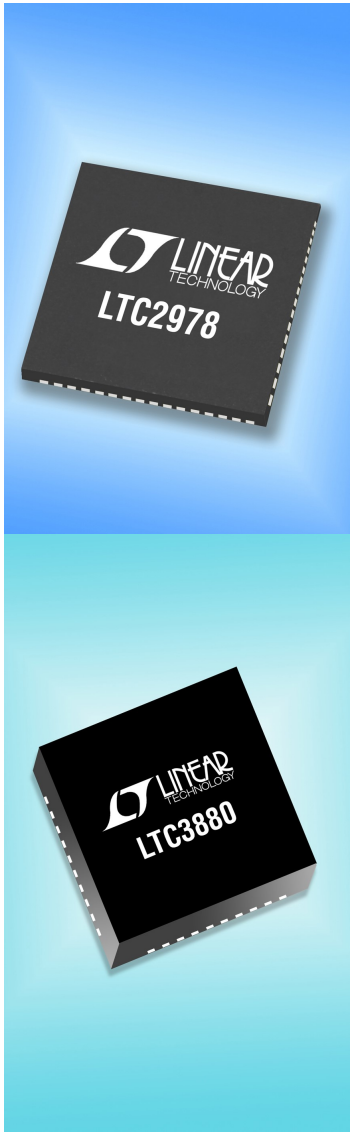
- Programmed OV/UV/OC/OT fault levels
- Protects expensive CPU/ASIC/FPGA devices
- Records faults into NVM





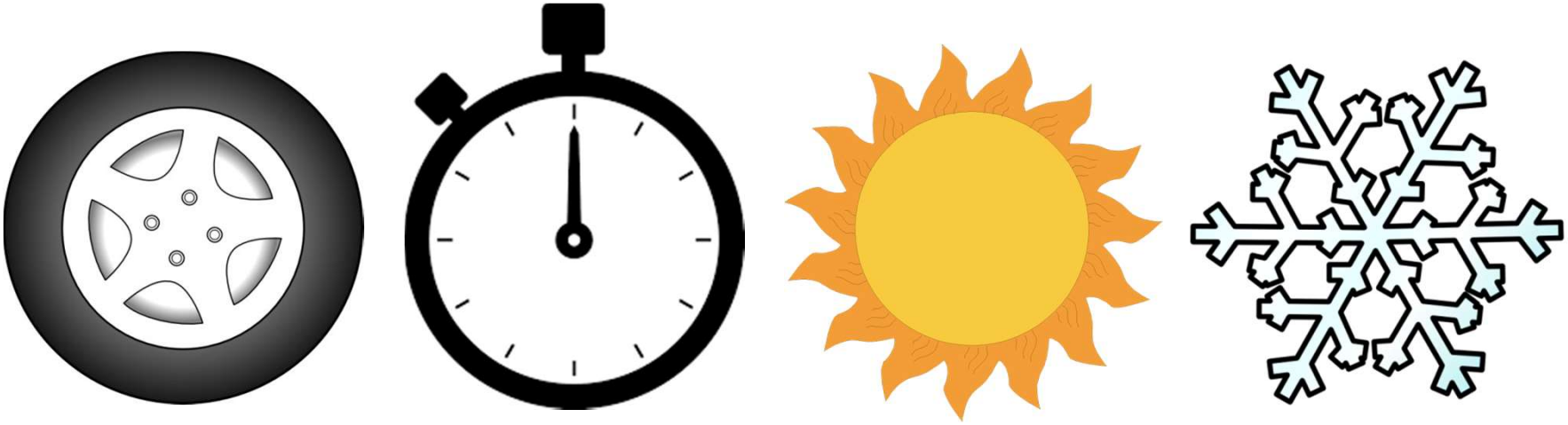
LTC PSM Highlights

- Best-in-Class Accuracy
- Interoperable Products
  - Power System Managers
  - DC/DC Controllers with PSM
  - Fully Integrated µModule Regulators
- LTPowerPlay: Engineering-Level Development GUI
- Autonomous Operation—No Software Coding Required
- EEPROM for Configuration and Black Box Fault Logging
- Coordinate Sequencing and Fault Management Across PSM Devices



Automotive Specific Requirements

- Traditional data centers don’t move
  - Safety and reliability matter in vehicles, especially for ADAS systems
- Traditional data centers don’t have to boot up in milliseconds
- Traditional data centers don’t park in Las Vegas in the summer or Alaska in the winter



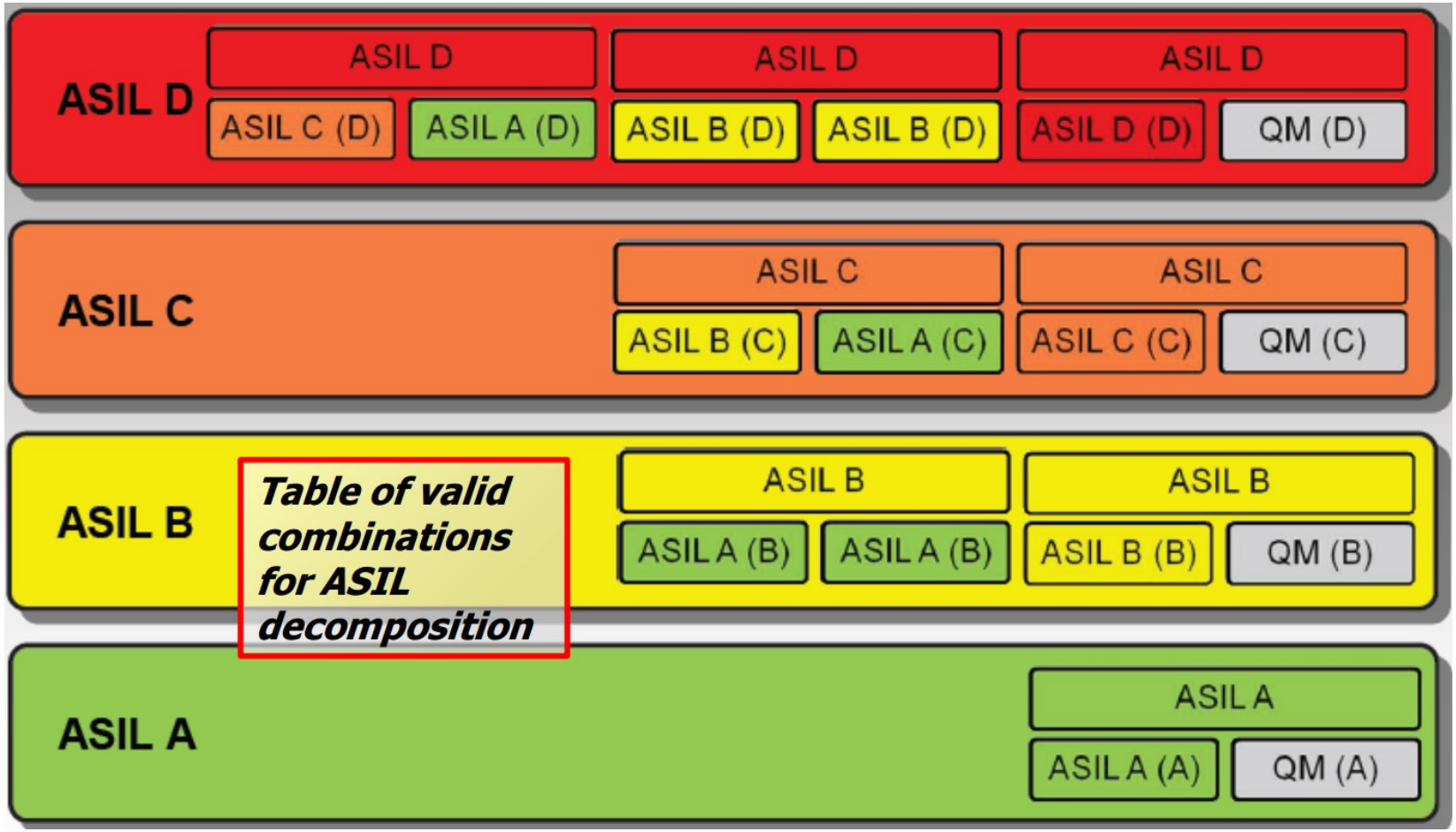
ISO26262

- Level 4/5 ADAS = ASIL D
- Strategies exist to meet ASIL D – but they don't work without power
- **The power system needs to meet the same requirements as the load**

ASIL	Random hardware failure (PMHF) target values	Single-point fault metric	Latent-point fault metric
D	<10 FIT (required)	≥99%	≥90%
C	<100 FIT (required)	≥97%	≥80%
B	<100 FIT (recommended)	≥90%	≥60%
A	No requirement	None	None
QM	None	None	None

1 FIT =8.7ppm/year

ASIL Requirement Decompositions

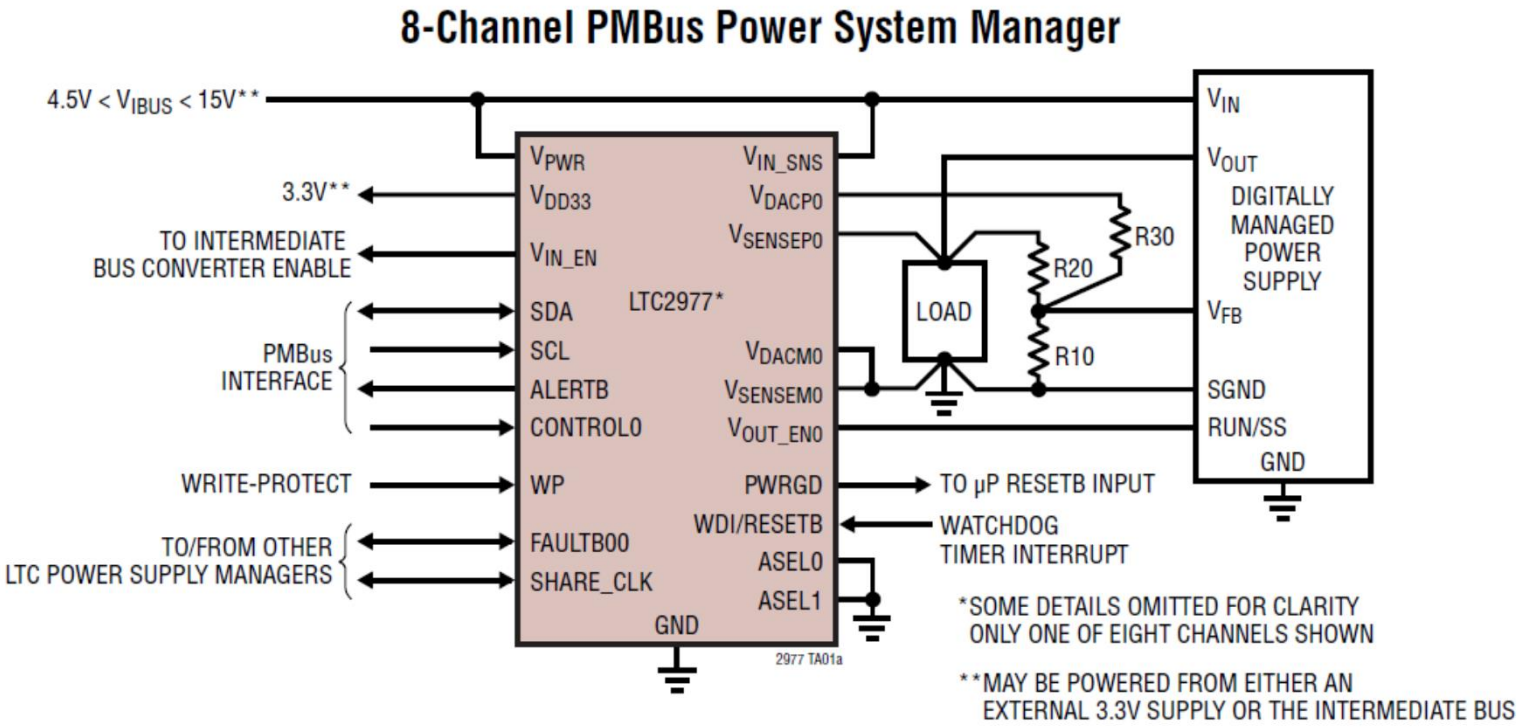


SEooC

- Power supplies are almost always “Safety Elements out of Context”
  - Only the complete system carries an ASIL level
- Automotive-specific power supplies are increasingly designed to be used in ASIL-rated systems
- Included documentation helps support particular ASIL levels

PSM and ISO26262

- PSM can be used as a Safety Mechanism
- Stand-alone PSM also provides redundancy



Safety Strategies

- Redundancy and fail-over
- Failure Monitoring (as a Safety Mechanism)
- Failure Prediction

LTC Power and Automotive Safety

- Initial Products: 48-12V converters
  - LT8228
  - LTC3871
- Designs with Safety Case documentation:
  - 48V-low regulators
  - 12V-low regulators
  - General purpose LDOs