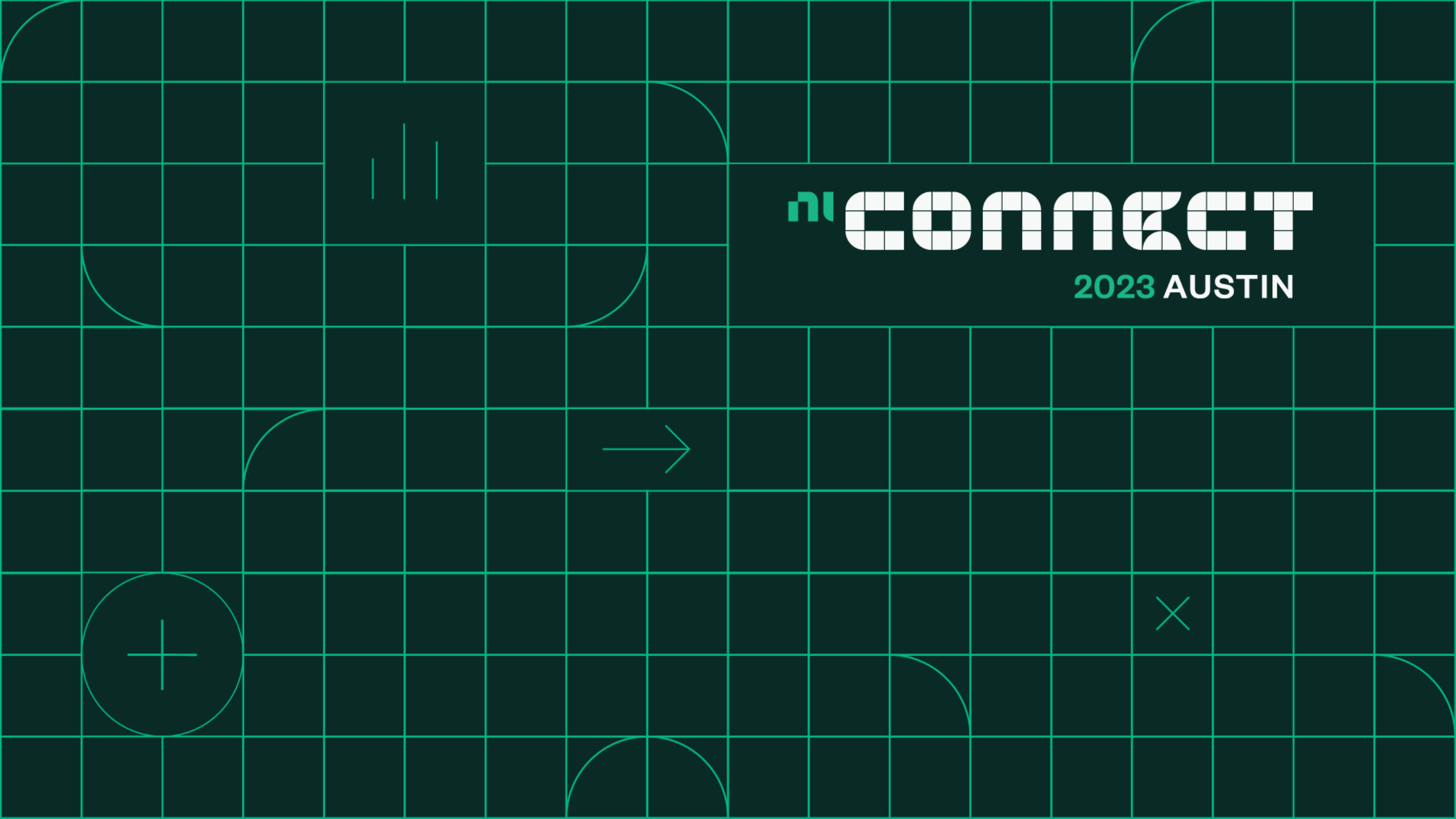

CONNECT
2023 AUSTIN

Empowering PMIC Validation in an Evolving Market

Nick Jamshidi

Agenda

- Introduction & market trends (10 mins)
- ***NEW*** 300W PXI Power Instruments Deep-Dive (15 mins)
- Demo (10 mins)
- Q&A (remaining time)

PMIC Market | Trends

PMICs in **mobile, automotive, and industrial applications** driving needs for power density and efficiency

Top design considerations for today's PMIC landscape	
1. Increasing power density and efficiency	➢ Designers are required to squeeze more with less space, while increasing efficiency and thermal performance
2. Lowering cost – Electromagnetic Interference (EMI)	➢ Low EMI design can reduce filter size, cost, and complexity, especially in automotive and industrial applications
3. Lowering quiescent current – extend battery and shelf life	➢ Battery-operated systems are often in standby/sleep mode for long periods
4. Lowering Noise – Enhancing precision	➢ Excessive noise can harm sensitive applications and peripheral circuits (such as ADCs, AFEs, and clock sources)
5. Increasing Safety and Quality - Isolation between high and low voltage domains	➢ Good isolation management enhances system reliability, simplifies EMI compliance, and reduces form factors

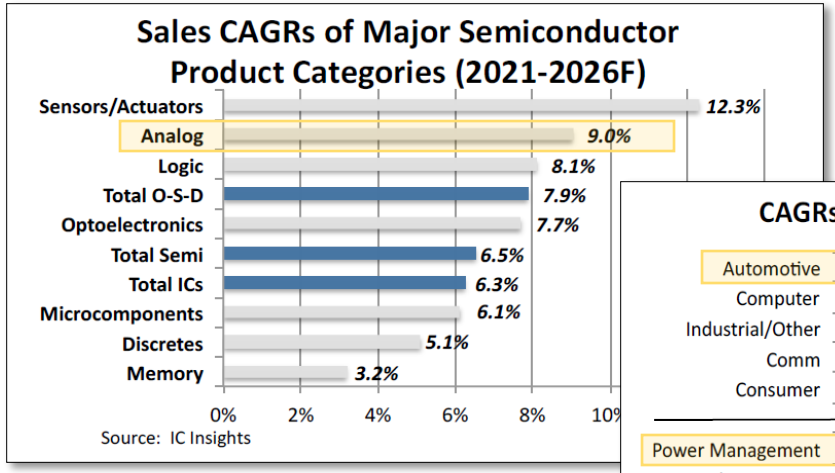
PMIC and Automotive | Semiconductor Growth Leaders

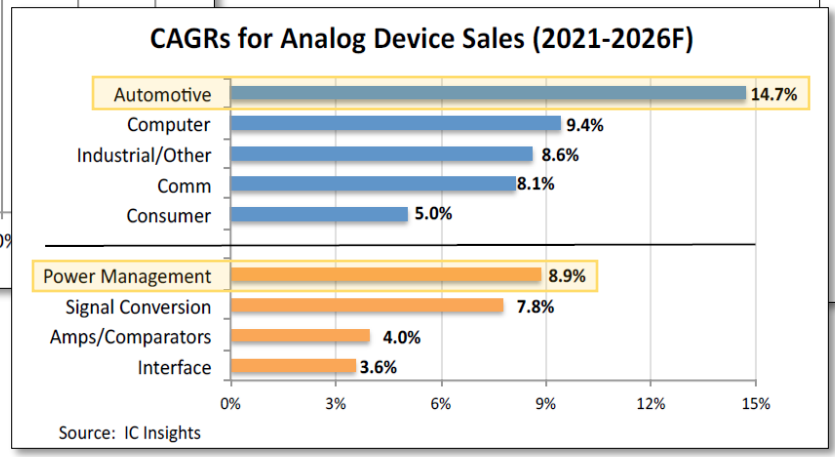
Analog ICs:

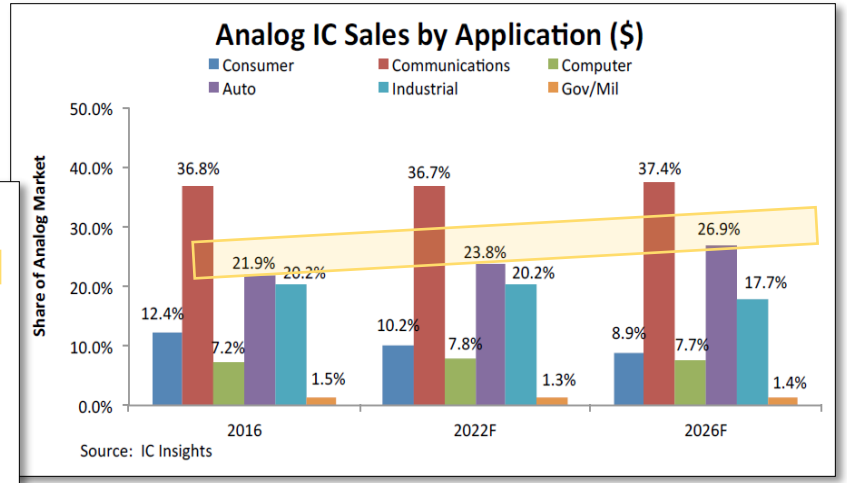
- Second highest growth product category in Semiconductor market
- PMIC highest growth sub-type of analog ICs

By Application:

- Communications to maintain largest market share position ~37%
- Automotive poised for significant growth
  - CAGR 14.7%
  - Expected to make up for >25% of Analog IC market by 2026







Mobile PMICs | Trends

Fast Charging

*Extensive validation and testing needed for charger IC devices to ensure **performance**, **interoperability**, and **safety** meet industry standards*

Higher Power Delivery (Speed)

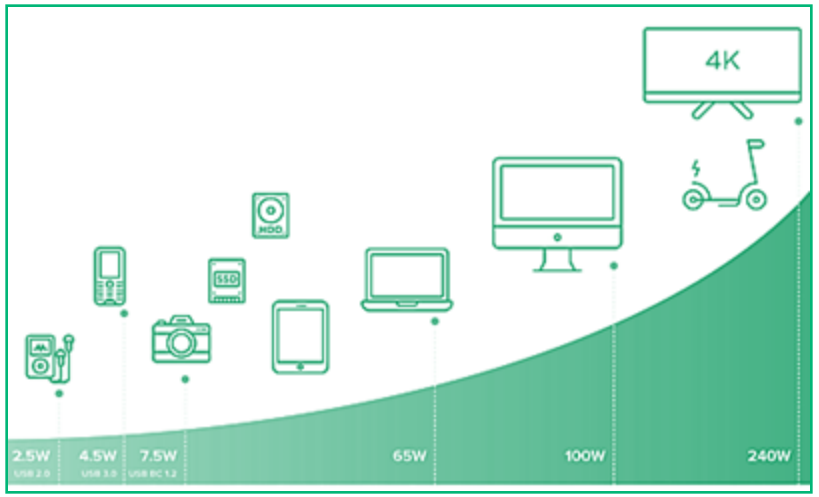
Trends:	Test impact:
1. Support for ~100W+ charging becoming commonplace 2. USB-PD 3.1 capable of 240W+	1. Capable HW up to 300W+ 2. Increased importance of temperature and safety testing

Broad Ecosystem Support

Trend:	Test impact:
1. Growing need for charging ICs that support multiple protocols	1. Greater need for interoperability testing across devices 2. More protocols need to be tested

Intelligent Charging

Trend:	Test impact:
1. Intelligent charging that optimizes charging times and improve battery health 2. Smaller form factors	1. Increased importance of temperature and safety testing



USB-PD 3.1 pushing past 100W

Wide variety of charging standards in market

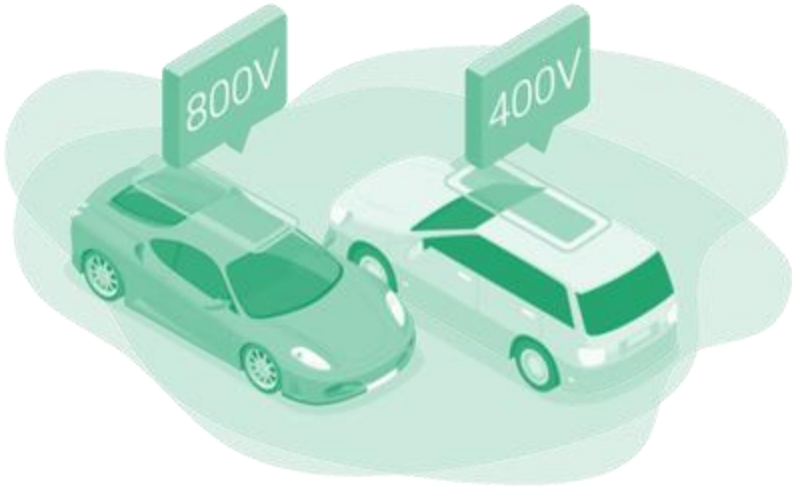
Automotive PMICs | Trends

Vehicle Electrification

*Vehicle electrification necessitates **increased validation** and testing of automotive electronics, driving new PMIC capabilities for **reliable electric vehicles***

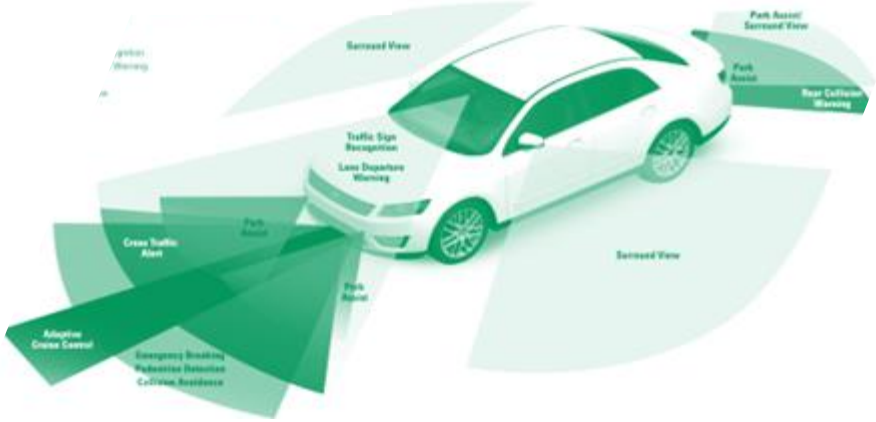
Batteries: Range & Efficiency

Trend:	Test impact:
1. Higher power PMICs needed for regulation of **increased battery capacity** 2. Efficient PMICs critical for **optimized system efficiency** during charging 3. **Vehicle-to-Grid (V2G)** technology requires PMICs supporting safe and efficient bi-directional power flow for charge / discharge modes	Capable HW to validate and test higher power PMICs and support bi-directional power flow



Safety, ADAS, Infotainment: Complexity

Trend:	Test impact:
1. Demand for highly-integrated PMICs for Infotainment, ADAS, and Safety applications 2. Complex safety requirements necessitate extensive PMIC validation and testing → ISO26262, IEC60730, IEC61508	Scalable test & measurement platform with diverse instrumentation and robust software & data tools



Aligning Investments with Trends

Increasing Power Density and Efficiency

1. **Mobile – Fast Charging**
   1. Proliferation of 65W-100W charging
   2. USB-PD 3.1 capable of 240W+
2. **Automotive - Vehicle Electrification**
   1. EV battery architectures demanding higher power front-end (battery) PMICs
   2. Advancements in power density through SiC and GaN devices

NEW NI PXI 300W Instrumentation

NEW Power Semiconductor Reliability Solutions

SET is now NI

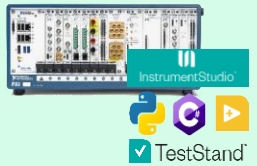
H3TRB/DRB
HTGB/DGS
Power Cycling & IOL
Custom Solutions

Increasing Complexity from Design to Test

1. Broadened functionality of devices & systems
2. Stringent safety & reliability requirements
3. New technologies like wireless charging and V2G

NI Platform

Naturally suited for efficient and thorough PMIC Validation



1. Hardware
   1. Simple and precise timing & synchronization
   2. Cost-effective, scalable, flexible platform
   3. Broad instrument portfolio *(Digitizers, FGENs, Digital, DMMs, Power Supplies, E-Loads, SMUs, Switches)*
2. Software
   1. Interactive and Automated Measurements *(InstrumentStudio, TestStand, APIs)*
   2. Data Ingestion, Management, and Spec Compliance Tools *(DataStudio)*
   3. System and Asset Utilization *(SystemLink)*

Q3 2023

High-Performance 300 W PXI Power Instruments

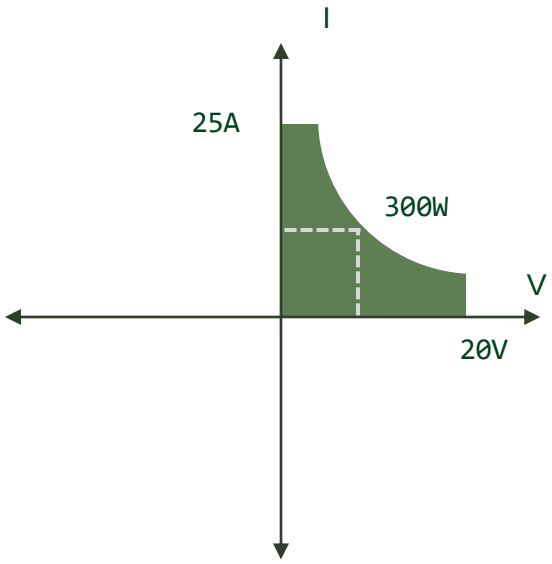
PXIe-4151 300 W Power Supply	PXIe-4051 300 W E-load
• 1 channel, 2 PXI slots • Up to 20 V / 25 A / 300W • 60V variant (2024)	• 1 channel, 3 PXI slots • Up to 60 V and 40 A
Ranges • Current: Full scale, 1 A, & 100 mA ranges (up to 10 nA resolution) • Voltage: Full scale and 6 V ranges (up to 1 mV resolution)	**Ranges** • Current: Full scale and 4 A ranges (up to 4 µA resolution) • Voltage: Full scale and 6 V ranges (up to 30 µV resolution)

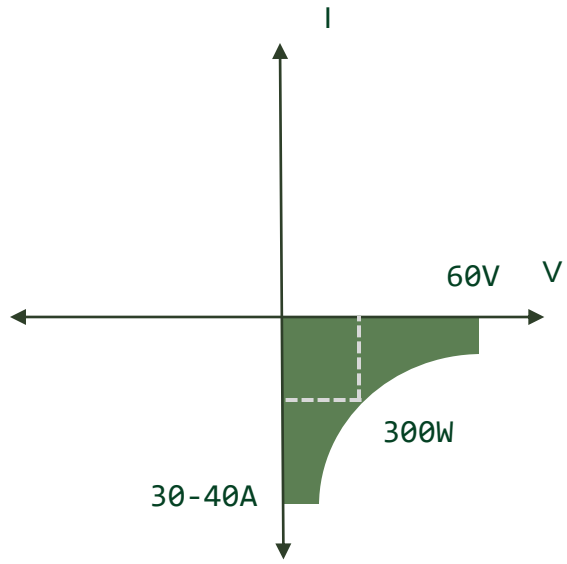
Common Features:

- Max sink/source power: 300 W
- Simultaneous I & V measurements
- DMM-like measurement accuracy
- 1.8 MS/s sample rate & 100 kS/s update rate
- Transient response tuning (SourceAdapt)
- Advanced sequencing (per-step properties)

PXIe-4151

PXIe-4051





Comparing Types of Programmable Power Instruments

"Basic" Power Supplies & E-loads

- More affordable (more Watts per $)
- Minimal or no measurement capabilities
- Accuracy of ~1% for setpoint
- Burdensome timing & synchronization options
- Basic programming API & minimal documentation
- Lacking application software for interactive tasks

E.g. NI RMX-41xx Power Supplies & E-loads

High-Performance Power Supplies & E-loads

- Premium power instruments
- Simultaneous DMM-class I & V measurements
- Accuracy of ~0.0x% (setpoint & measurements)
- Integrated PXI-class timing & synchronization
- Robust API, example programs, & documentation
- InstrumentStudio support for interactive actions

E.g. NI PXIe-415x Power Supplies & PXIe-405x E-loads

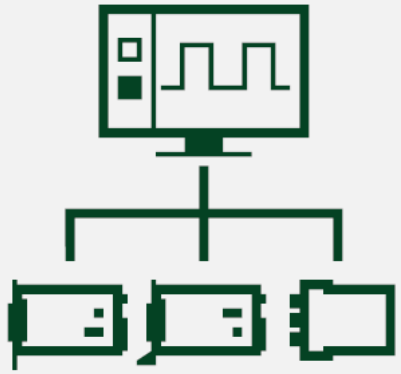
Benefits of NI's 300 W PXI Instruments

Accuracy

NI's 300 W PXI-based instruments offer high accuracy for output values and simultaneous, voltage and current measurements

Speed

NI's PXI-based instruments are designed for fast operation and fast measurements to help you reduce test time and improve throughput

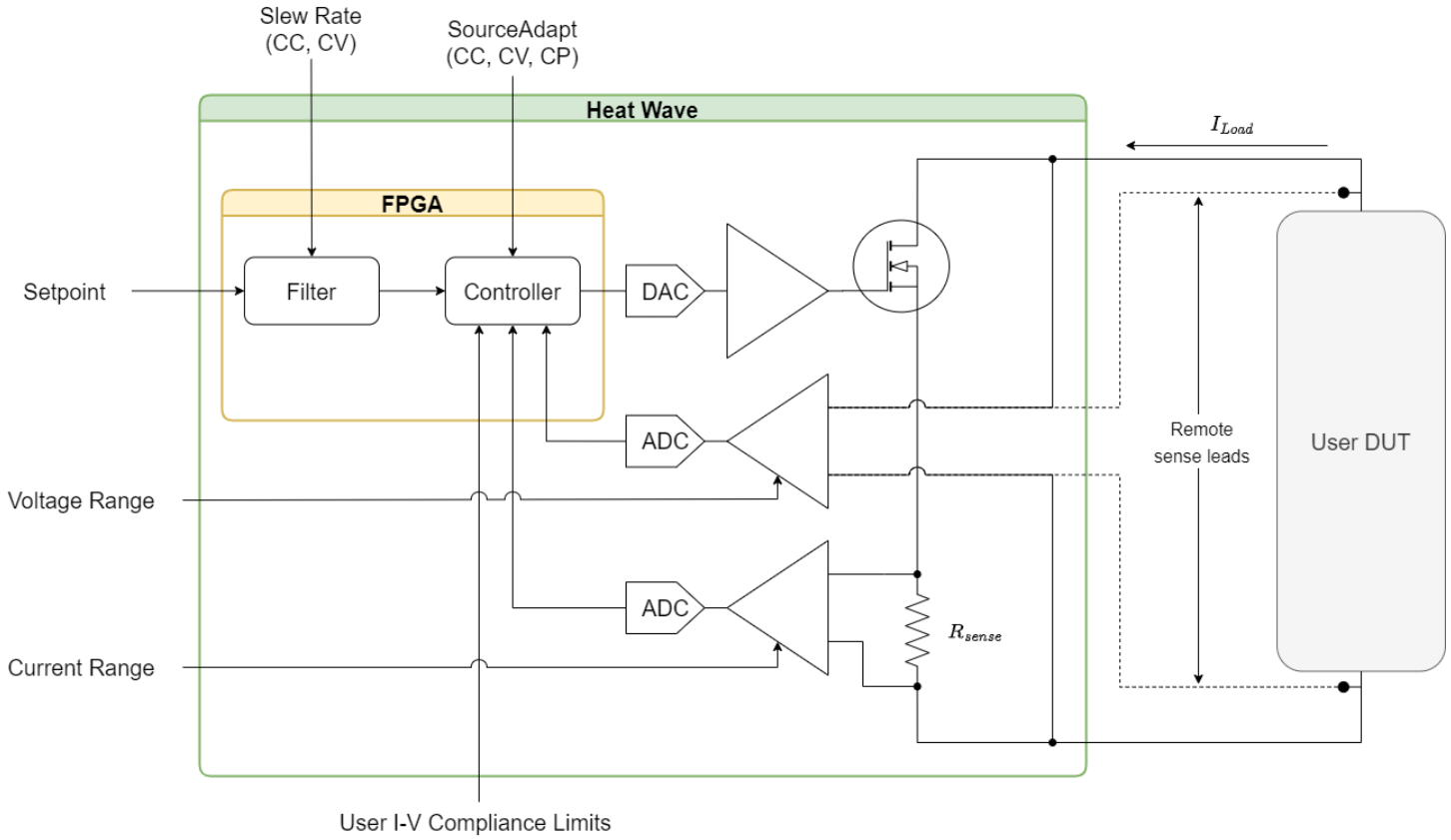


Timing & Synchronization

PXI-based instrument can be easily triggered and synchronized with other instrumentation, and can reuse existing code from NI SMUs

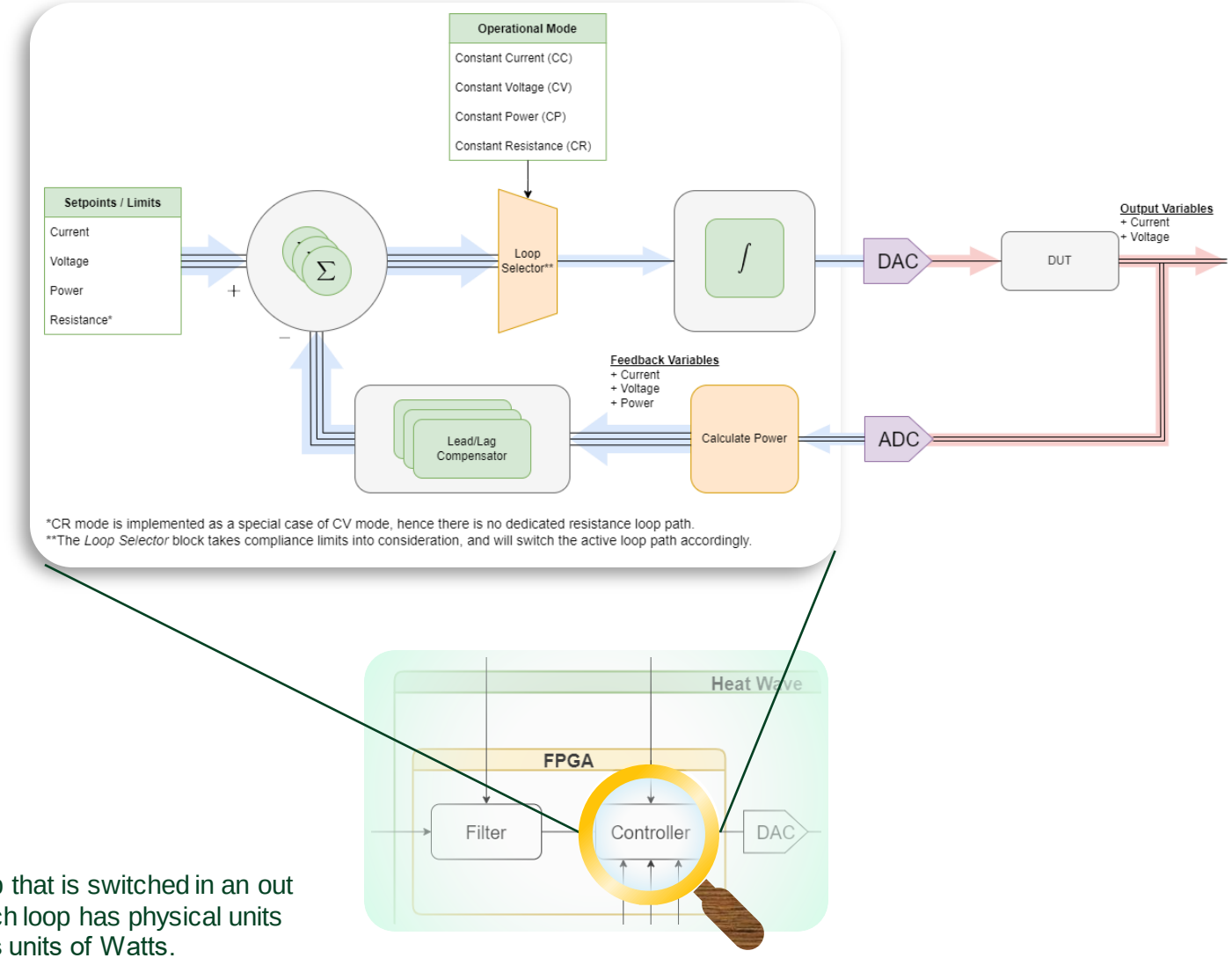
PXIe-4051 | Functional Block Diagram

- User-programmable setpoints (all modes) and slew rates (CC, CV only)
- *SourceAdapt* allows user to control FlexLoop parameters:
  - Gain-bandwidth
  - Compensation frequency
  - Pole-Zero ratio
- Slew rate control implemented by filter block
- Current sensed by measuring differential voltage across R_{sense}
- Controller acts on the gate of the load FET, behaving as a voltage-controlled resistance
- Other user-programmable parameters:
  - Voltage and current measurement range
  - Current and voltage limits



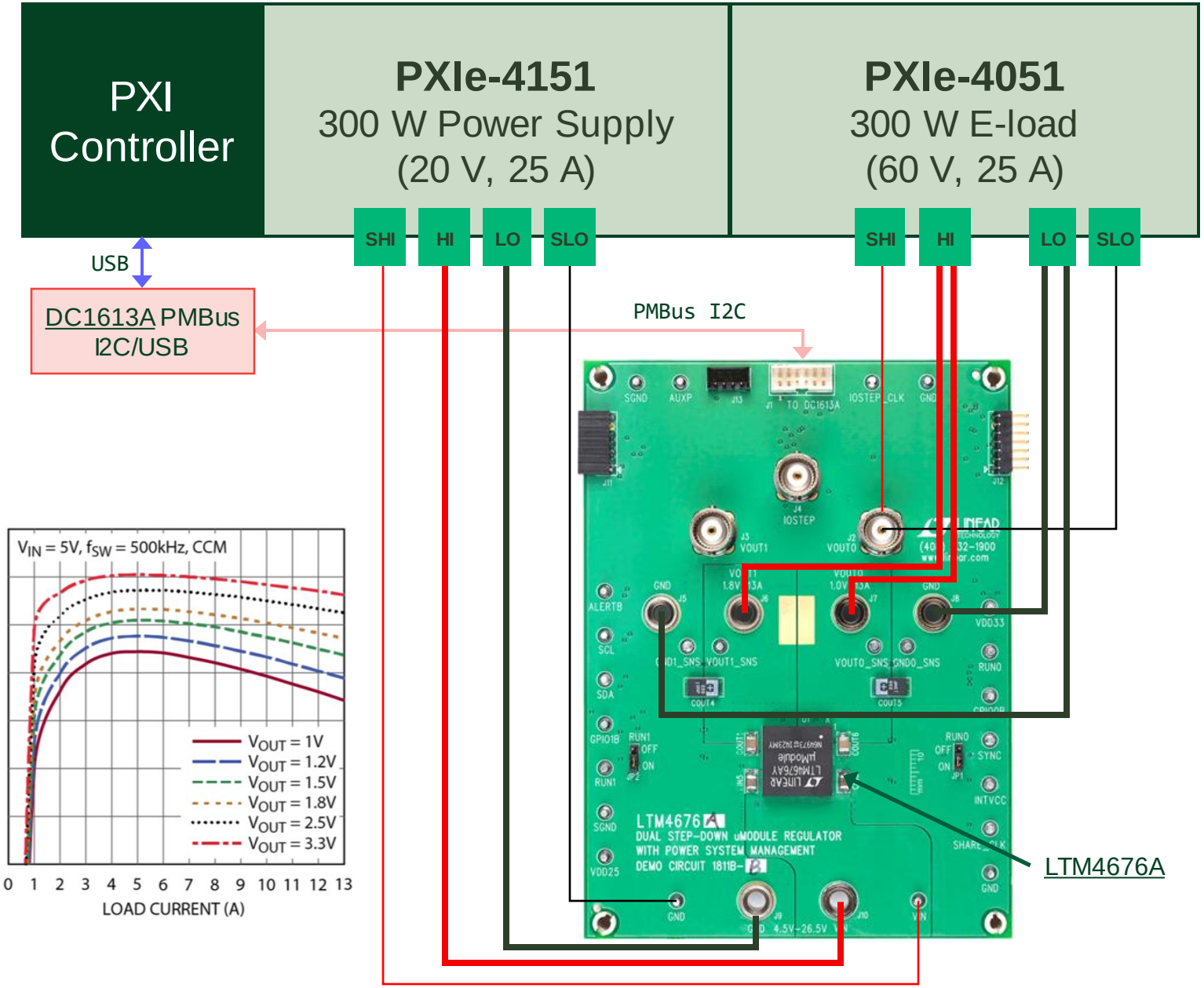
PXIe-4051 | *SourceAdapt* Control Loop

- Control is split into digital and analog domains
- Digital implementation allows custom-tuned system response
- *SourceAdapt* user-programmable parameters[1]:
  - Integrator gain (GBW)
  - Compensation frequency
  - Pole-zero ratio
- *SourceAdapt* optimizes system response by:
  - Minimizing rise times
  - Reducing overshoot
  - Minimizing oscillations



[1]CC, CV, and CP modes are each governed by a dedicated control loop that is switched in an out of the main loop path depending on the chosen operational mode. Each loop has physical units that correspond to the control variable e.g. the 'power' control loop has units of Watts.

Demo Overview



Hardware Components:

- PXIe-4151 20V, 25A PPS
- PXIe-4051 60V, 40A e-load
- APS-4158/9 auxiliary power
- LTM4676A buck converter on DC1811B-B EVM
- DC1613A PMBus I2C/USB interface

Software Components:

- LabVIEW + NI-DCPower Driver API
- *LTPowerPlay* for digital control

Example Measurements:

- Efficiency
- Line/Load Regulation
- Load Transient

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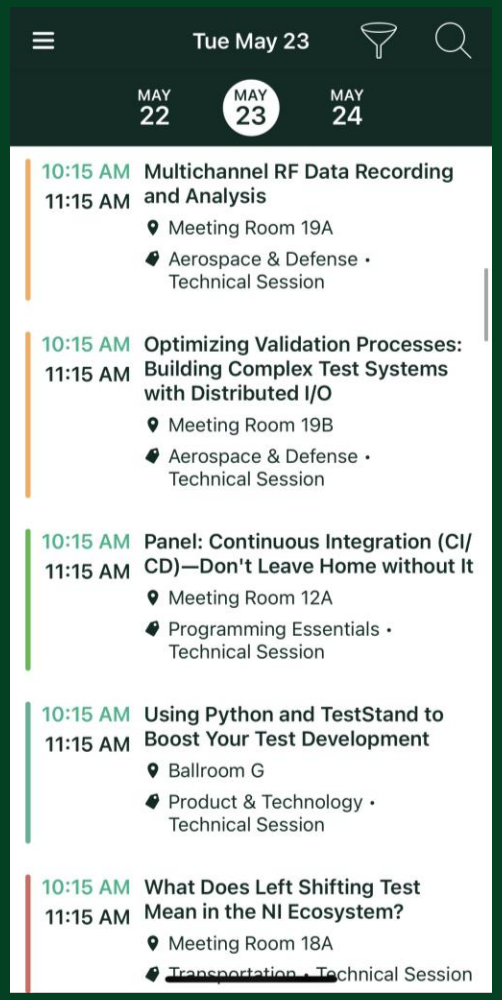

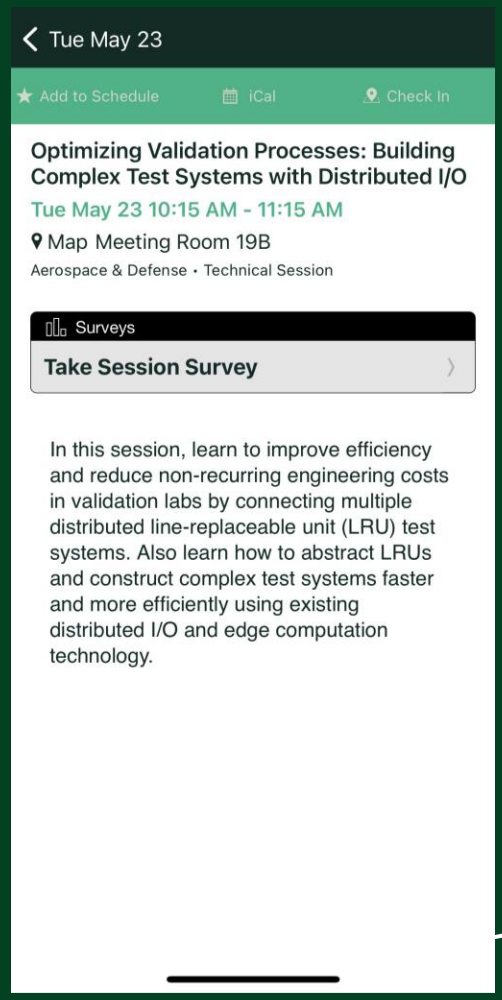

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