ANALOG DEVICES

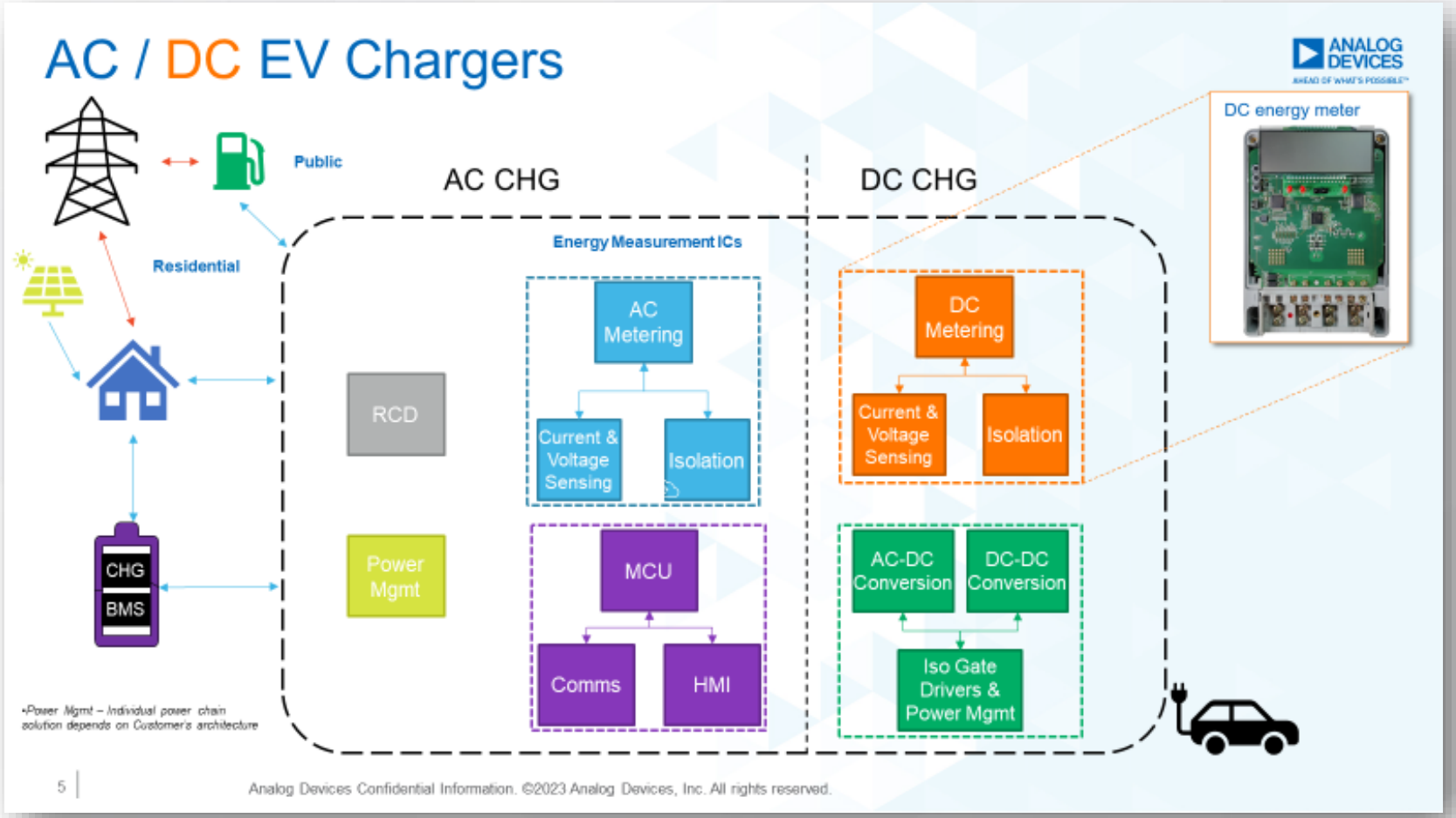
AHEAD OF WHAT'S POSSIBLE™

Emerging Solutions for EV Charging from ADI

Electric Vehicle Charging Infrastructure

	AC Level One	AC Level Two	DC Fast Charge	DC High Power
Power required	1.9kW	2.5 to 19.2kW	50kW	350kW
Charge time	~16 hours	~2-12 hours	~20-40 minutes	~6-8 minutes
Grid connection	Residential	Residential	Public	Direct to grid

Note: Charge time based on a 40kWh battery size. DC High Power — Charge time is applicable when EVs are capable of this charging speed
Source: L.E.K. and Tritium analysis



AC Metering

- Assure accuracy of the billing function
- Extend meter lifetime in the field

EVSE Charging Equipment

AC Charger
<5kW
Home and Portable

ADEXXX Energy metering
Isolation Tech
Power

AC Wallbox

AC Charger
22 kW
Car park and
Communal blocks

ADEXXX Energy metering
Isolation Tech
Power
Comms
MCU – Secure Payment

DC Charger
25 kW
Car park and
Communal blocks

Precision ADC
ADEXXX energy metering
Isolation Tech
Power Mgmt
MCU – Secure Payment
Comms

Fast DC Charger
>100 kW +
Installed in gas Station
of the future

Precision ADC
ADEXXX energy metering
Isolation Tech
Power Mgmt
MCU – Secure Payment
Comms

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EV Charging

Key Technologies

Metrology

AC Metering
- Current Sensor Agnostic
- MID Certifiable
- Load Management
- Demand Response
- Power Quality
- Shunt
- Rogowski
- CT

DC Metering
- Current & voltage Sensing
- Accuracy Class B, -40°C to 85°C
- VDE-AR-E-2418-3-100, IEC 62053-41, ANSI C12.32-2021

HMI

GMSL – Multi Display
Audio/Video
LED Drivers
Cyber Security & Tampering

Precision

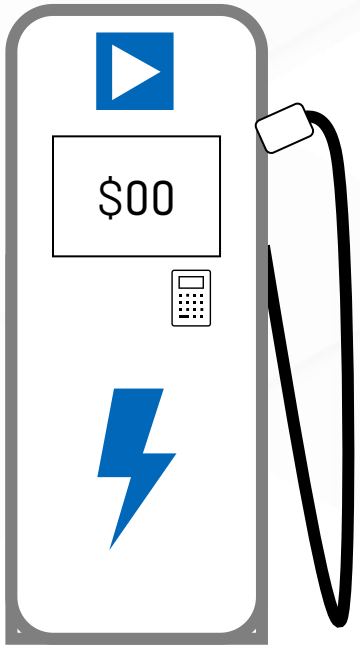
ADC's
Amplifiers
Temp Sensors
Impedance Measurements

Communications

Industrial Ethernet
RS-485
RS-232
5G

MCU's

AI
Ultra-Secure
Low-Power
Wireless

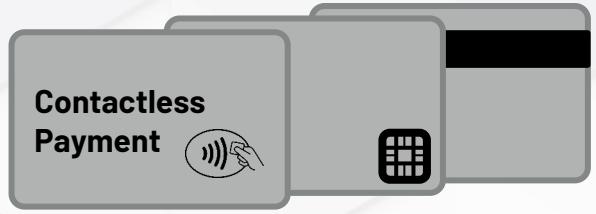


Isolation

Power Conversion & Gate Drivers
Digital Isolators

Secure Payments

MAX32561
- Enables Payment by Mag Stripe, Chip Cards & Contactless Payment
- ISO 7816
- ISO 14443



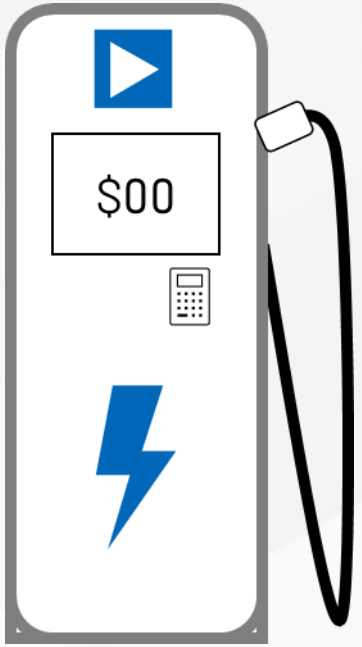
Power Mgmt

Signal Conditioning
Regulators
SuperCaps

EV Infrastructure - Metering

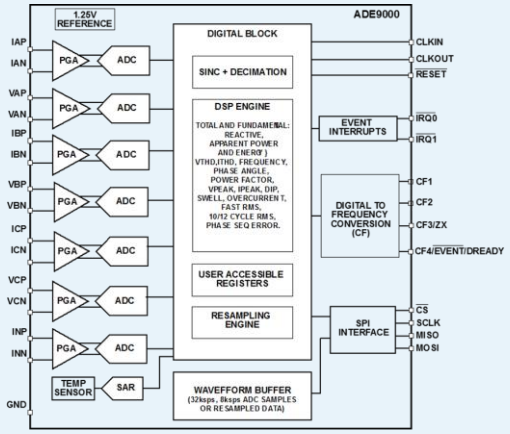
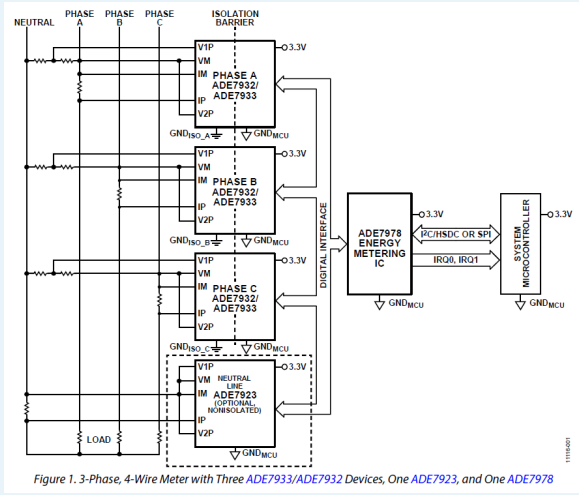
- **Low Power AC Chargers**
  - Single-phase, 120 V outlet, Americas
    - 1 – 2 kW
    - In-home, energy measurement typically not required, usually only informational
  - Single-phase, >200 V, Global
    - 2.5 – 10 kW
    - Public charger, typically 7.2 kW and will require energy measurement
  - IC's: **ADE9153A, ADE7953**

- **High Power AC Chargers**
  - Polyphase, >200 V, Global
    - 10 – 25 kW
    - Public fast charger, typically 11 kW or 22 kW
  - **ADE9322 + ADE7979**
  - **ADE7932 + ADE7978** (shunts are cheaper and easier to work with)
  - **ADE9078** (if preference is in CT's)



- **DC Fast Charger**
  - 50 kW +
  - See a system solution DC metering design here: DC Energy Metering Applications | Analog Devices

3-phase EVSE Electricity Metering Solutions by sensor technology

	Current Transformer / Rogowski (di/dt)	Shunt
Isolation Type	Isolated with sensor	Isolation in IC
Block Diagram		 Figure 1. 3-Phase, 4-Wire Meter with Three ADE7933/ADE7932 Devices, One ADE7923, and One ADE7978
ADI solution	W/ Power Quality: ADE9000 W/o Power Quality: ADE9078	W/ Metrology: ADE7932/3 + ADE7978 W/o Metrology: ADE7912/3

Isolated Meter Chipset Enables 3Phase Shunt-Based Meters

- Immune to magnetic fields
  - Proven *i*Coupler® & *iso*Power® contain no ferromagnetic materials
- Reduces system cost and size
  - Shunts are smaller and cheaper than CT's
  - Integrated isoPower® isolated dc-to-dc converter
- Improved harmonic accuracy
  - High accuracy enables class 0.5 meters and higher.
  - No phase shift
- Target applications
  - Meters and sub-meters
  - Datacenters (UPS, PDU)
  - EV chargers
  - Inverters
  - …

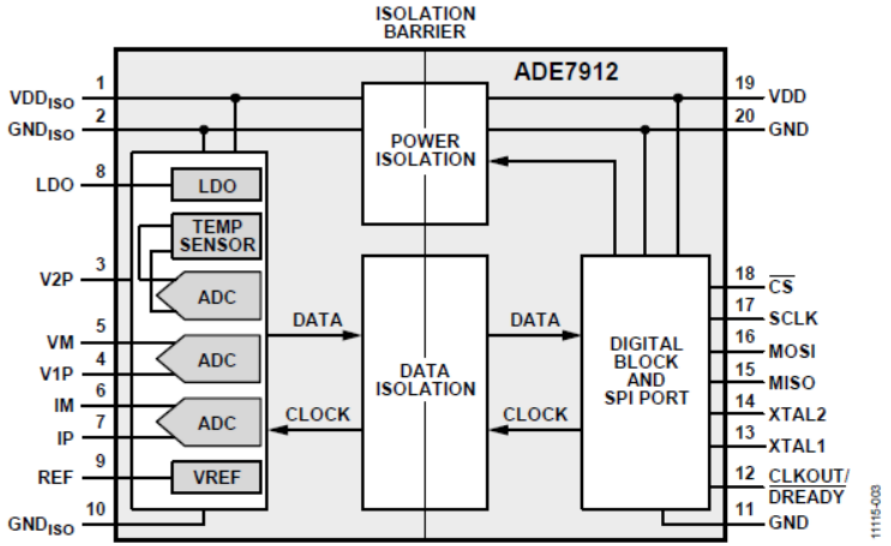


Figure 2. ADE7912 Functional Block Diagram

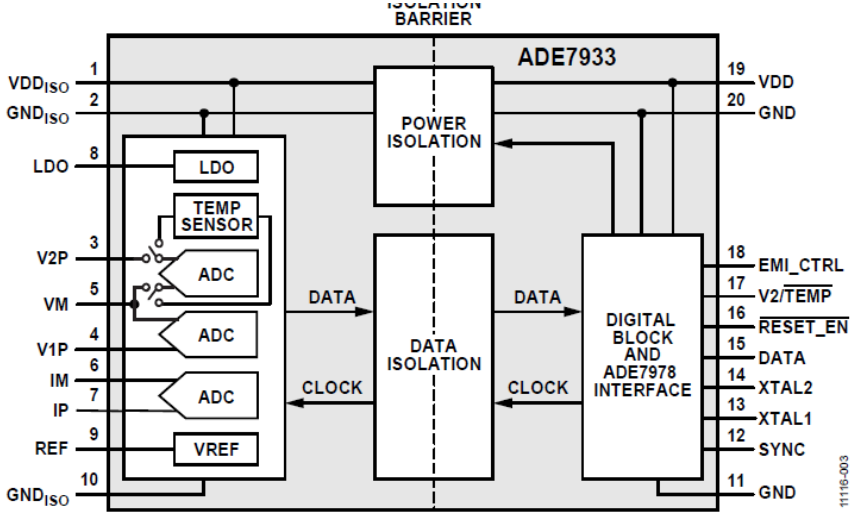


Figure 3. ADE7933 Functional Block Diagram

Isolated Metering IC's Enable Shunt-Based Metering Solutions

Features and Specifications

Product Features	ADE7978+ADE7932/33
Sensor Options	Shunt resistor on all three phases
Measurement Parameters	Active, Reactive and Apparent power, Voltage and Current RMS, THD, Temperature
Energy Accuracy	0.2% error at 2000:1
SNR (dB) PGA = 1	Current Channel: 67dB Voltage Channel:75dB
Interface	SPI, I2C and HSDC
Waveform Data	High Speed HSDC interface to capture waveform samples
Insulation Rating	5000 Vrms for 1min per UL1577 IEC61010-1: 300Vrms max working voltage

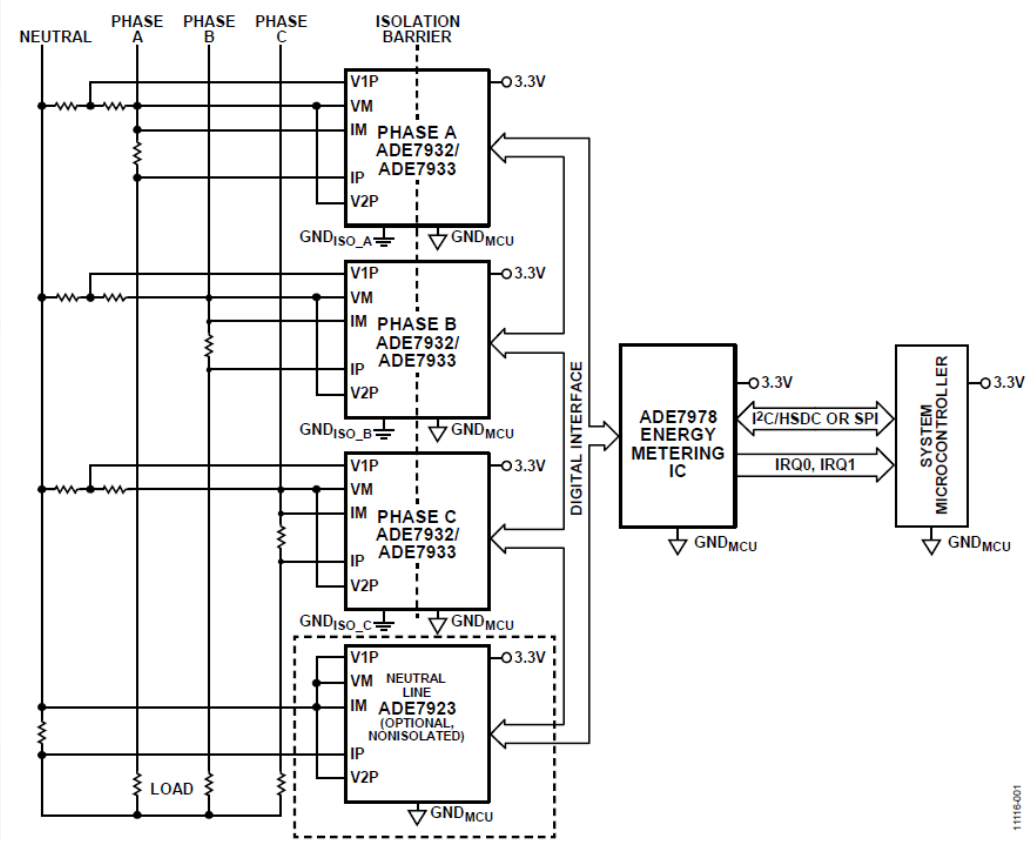


Figure 1. 3-Phase, 4-Wire Meter with Three ADE7933/ADE7932 Devices, One ADE7923, and One ADE7978

Key Benefits:

- Enables implementation of three-phase meter platforms with shunt resistors (Class 1, Class 0.5 energy meters)

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DC Energy Metering

ADI Solutions

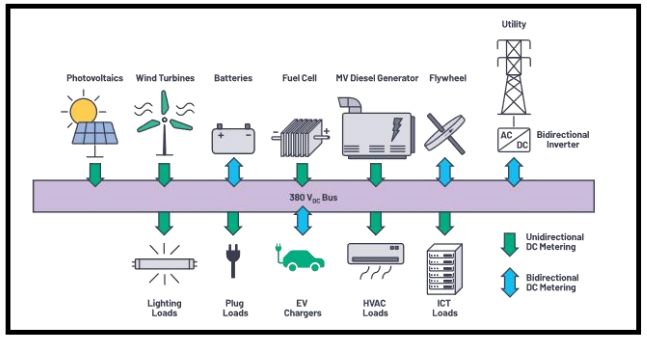
DC energy meter – applications:

- Sustainability drives both consumer demand & government “green” policies and funding
  - Ramp in Electric Vehicles drives the demand for Fast Charging
  - Growth in AI drives demand for Data Centers and DC power
  - Distributed Energy Resources drive the growth of microgrids

Accurate DC Energy Metering

EV DC Chargers

DC Data Centers



DC Microgrids

- So far, customer interest in DC metering is dominated by EV DC fast chargers.
- Other sub-metering applications may rump-up later.

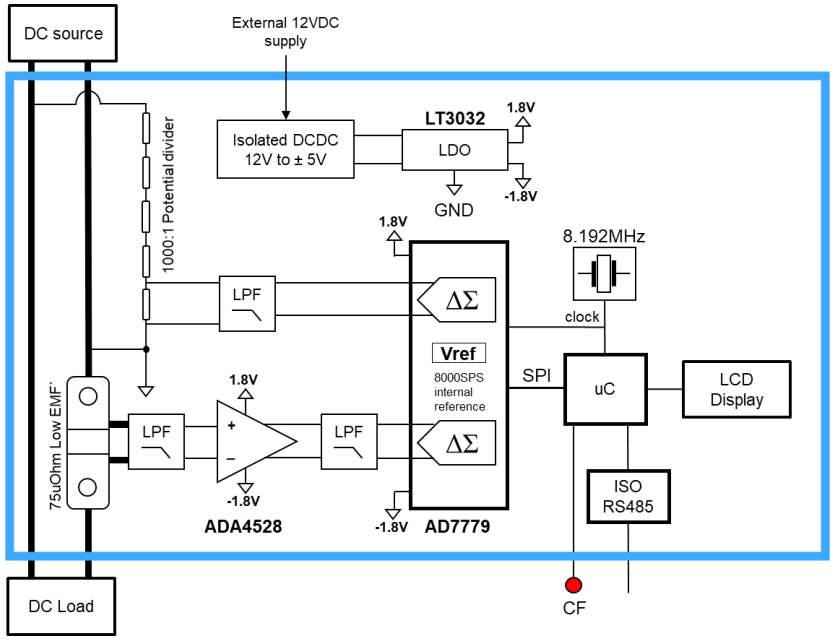
Gen 1 Reference Design

Parameter	Nominal	Dynamic Range	Measurement (Max. range)
Voltage	±400VDC	100:1	±600VDC
Current	±80A	100:1	±240A
Meter Constant	1000imp/kWh		
V and I Bandwidth	2.5kHz		
Shunt value	75uOhm	0.5W @ nominal Current	
Operative temp	-25C to 55C		
Energy Accuracy			
Range 1-5% Inom	1%		
Range 5-120% Inom	0.5%		

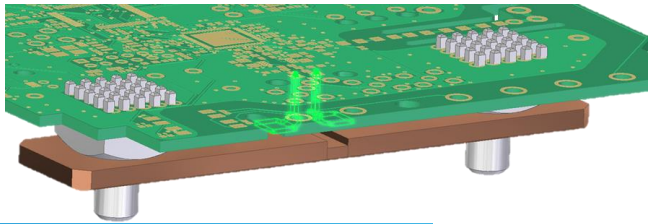
Value Proposition

- **Meets IEC 62053-41 DC Energy meter accuracy classes 0.5 and 1.**
- **Form factor realistic**

[DC Energy Metering Applications | Analog Devices]



ADA4528 + AD7779



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Digital Security for EV Charging Stations (EVSE)

EVSE Cybersecurity Threats And Challenges

Malware

- Uncontrolled behavior
  - Free charging…
- Denial of Service

Connection to cloud

- Authenticity, Integrity, Confidentiality
  - User data protection
- Denial of Service

S.A.F.E. Software Alliance for E-mobility

Billing

- Authentication to various players
  - PKI, multiple certificates

User Authentication

Payment

Analog Devices EVSE Security Solutions

Malware

DS28S60, MAXQ1065

- Root of Trust
- Secure boot
- Secure updates

Connection to cloud

DS28S60, MAXQ1065

- Authentication
- User data signature
  - Includes S.A.F.E standard

MAXQ1065

- Full TLS protocol support

Billing

MAXQ1065

- On board PKI
- Multiple certificates tree management

User Authentication

MAX66301

- NFC reader

MAX66250

- NFC tag

Payment

MAX32570

- Contactless payment
- Banking standards

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Industrial Ethernet

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INDUSTRIAL CONNECTIVITY

Trusted Industrial Connectivity Solutions for Factories of the Future

BLE

- Ultralow power solutions
- Leading-edge security
- Darwin family of microcontrollers

60 GHz

- Latency free wireless data link
- True wireline-like performance
- Protocol agnostic

5G

- Best-in-class 5G radio technology
- Full signal-chain capabilities
- Ultrareliable low latency and low power

IO-LINK & DIGITAL I/O

- Simplified installation
- Automated parameter setting
- Enhanced diagnostics

WIRELESS SMART MESH

- Highly robust and reliable
- Ultralow power
- Scalable solutions

INDUSTRIAL ETHERNET

- Lowest latency, lowest power Ethernet
- Complete communication platforms
- Scalable solutions

ISOLATED RS-485

- 25 Mbps throughput
- Reinforced isolation
- Fully integrated with power

MULTIPOINT-LVDS

- Low power and ultrasmall footprint
- High temperature range
- Enhanced ESD protection

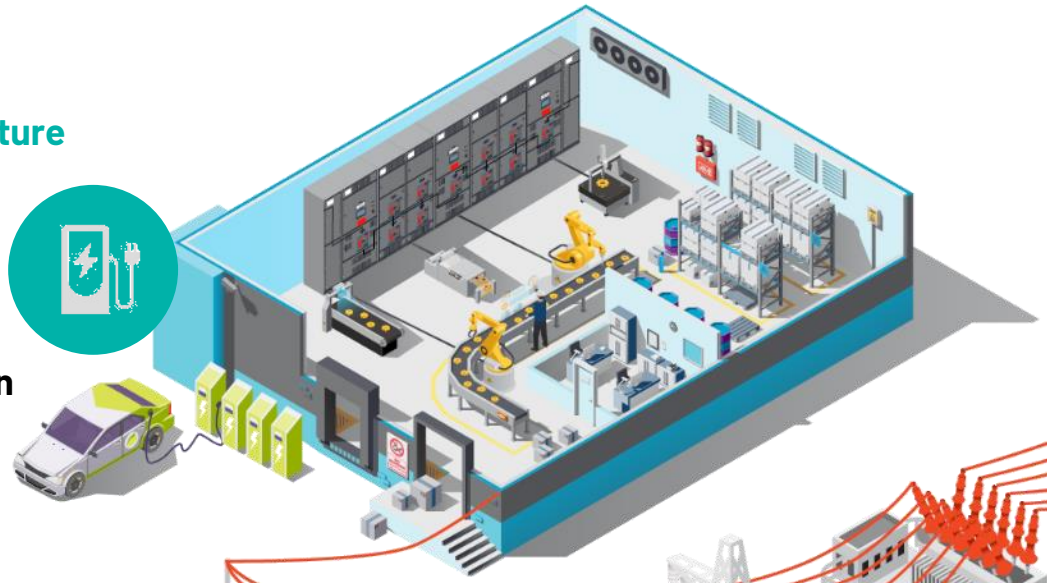
ISOLATED USB

- Enhanced robustness
- Compact ease of use USB port isolators
- Auto speed detection features

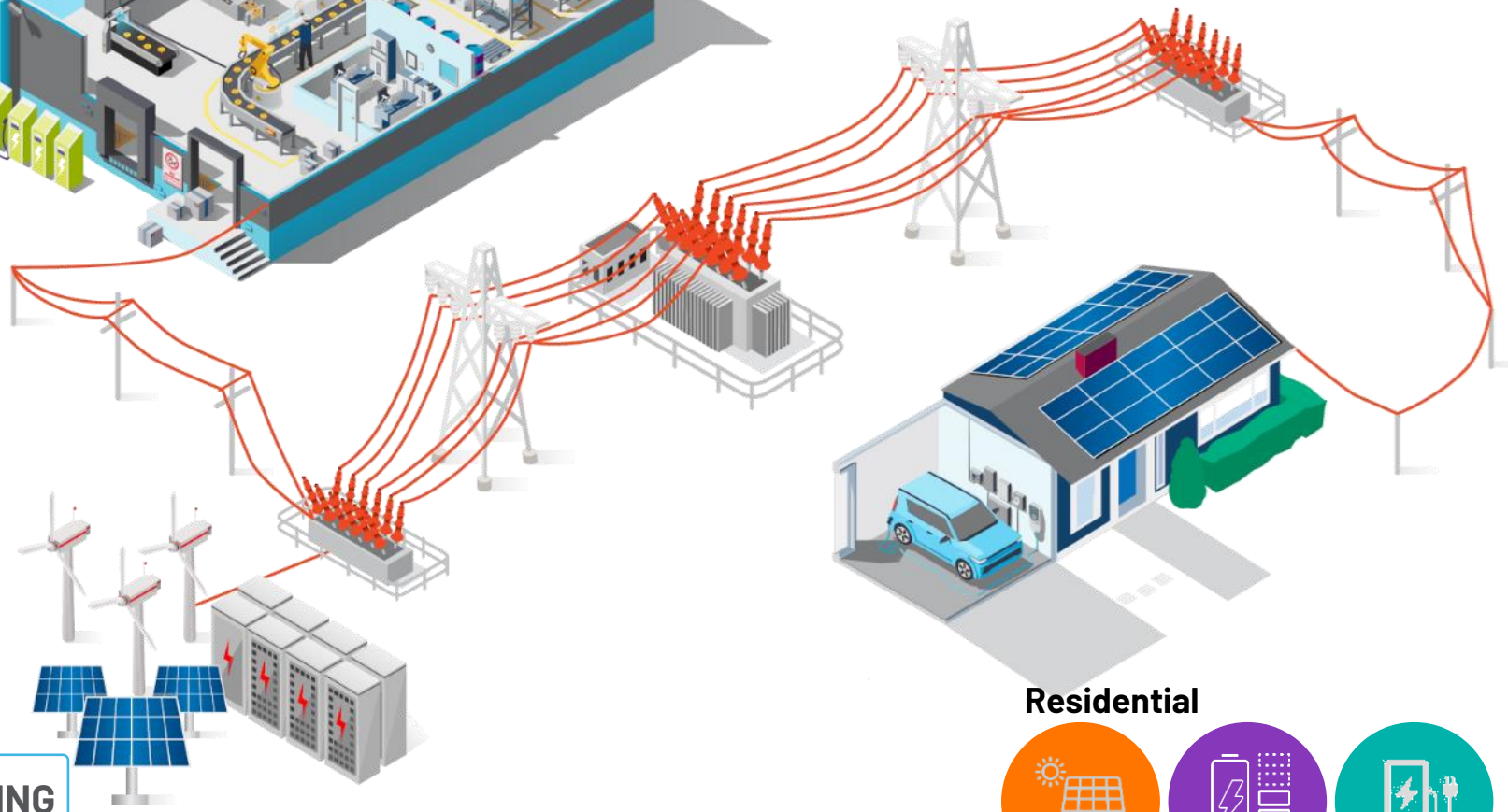
Sustainable Energy Applications – Connectivity

EV Charging Infrastructure

Grid Stability
Boost the Charge
V2G
Load Balancing
Energy Bill Optimization



FIELD INSTRUMENTS 2.0 with ETHERNET-APL
10BASE-T1L PHY and MAC-PHY



CONNECTIVITY
Increased connectivity to access new insights
- Industrial Ethernet, TSN, IO-Link, digital I/O, isolated RS-485
- 5G, wireless SmartMesh™, 60 GHz latency free wireless data link

Residential

EDGE SENSING AND INTELLIGENT PROCESSING
Precision measurement and sensing technology

ADI Microcontrollers

An over Twenty-Year Overnight Sensation!

1995-2002
Intel 8051

2004-Present
MAXQ

2012-Present
ARM – 90nm

2017-Present
ARM – 40nm

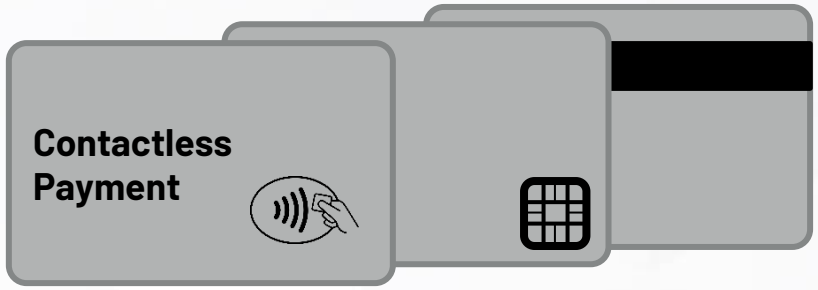
2019-Present
ARM – Wireless

- MAX32666
  - First Dual Core ARM M4F MCU with integrated BLE

- High Performance
- Small Form Factor
- Wireless Connectivity
- Ultra Low Power
- Strong Security & Reliability

Public EV Charger stations

- Enabling secure payments with ADI microcontrollers
- **MAX32561**
  - **Enables Payment by Mag Stripe, Chip Cards & Contactless Payment**
    - Triple-Track Magnetic Stripe Head Interface
    - ISO 7816 Smart Card Interface w/ Integrated Transceiver & Smart Card Interface
    - ISO 14443 type A/B EMV Compliant Contactless Reader w/ Internal Transceiver



  - **Proven Use in PCI/EMV Applications!**
  - **Perfect Fit for Payment Industry Security**
    - Arm Cortex M3 Processor Core
    - 108MHz Core Operating Frequency
    - 1MB Flash / 384KB SRAM / 8KB AES Self Encrypted NV SRAM
    - Physical Tampering Sensors
    - Secure Boot Loader
    - AES, DES and SHA accelerators
    - Crypto Accelerators supporting RSA, DSA & ECDSA

MCU Portfolio

AI MCUs

MAX78000
128 kB RAM/512 kB FLASH
Convolutional Neural Network (CNN)
100 MHz Cortex®-M4F

Ultra Secure MCUs

MAX32558
96 kB RAM/512 kB FLASH
60 MHz Cortex-M3

MAX32550
256 kB RAM/1 MB FLASH
108 MHz Cortex-M3

MAX32560
384 kB RAM/1 MB FLASH
108 MHz Cortex-M3

MAX32570
760 kB RAM/1 MB FLASH
150 MHz Cortex-M4F

MAX32520
170 kB RAM/2 MB FLASH
120 MHz Cortex-M4F

Low-Power MCUs

MAX32660
96 kB RAM/256 kB FLASH
96 MHz Cortex-M4F

MAX32670
160 kB RAM/384 kB FLASH
100 MHz Cortex-M4F

MAX32672
160 kB RAM/1 MB FLASH
100 MHz Cortex-M4F

MAX32630/31
512 kB RAM/2048 kB FLASH
96 MHz Cortex-M4F

MAX32650/51
1024 kB RAM/3072 kB FLASH
120 MHz Cortex-M4F

MAX32675
160 kB RAM/384 kB FLASH
100 MHz Cortex-M4F
(Precision Analog + HART)

Wireless MCUs

MAX32680 ●
160 kB RAM/512 kB FLASH
100 MHz Cortex-M4F
(Precision Analog + HART)

MAX32655 ●
160 kB RAM/512 kB FLASH
100 MHz Cortex-M4F

MAX32666
560 kB RAM/1024 kB FLASH
2 × 96 MHz Cortex-M4F

● RISC-V Radio Coprocessor

● Most products require NDA.

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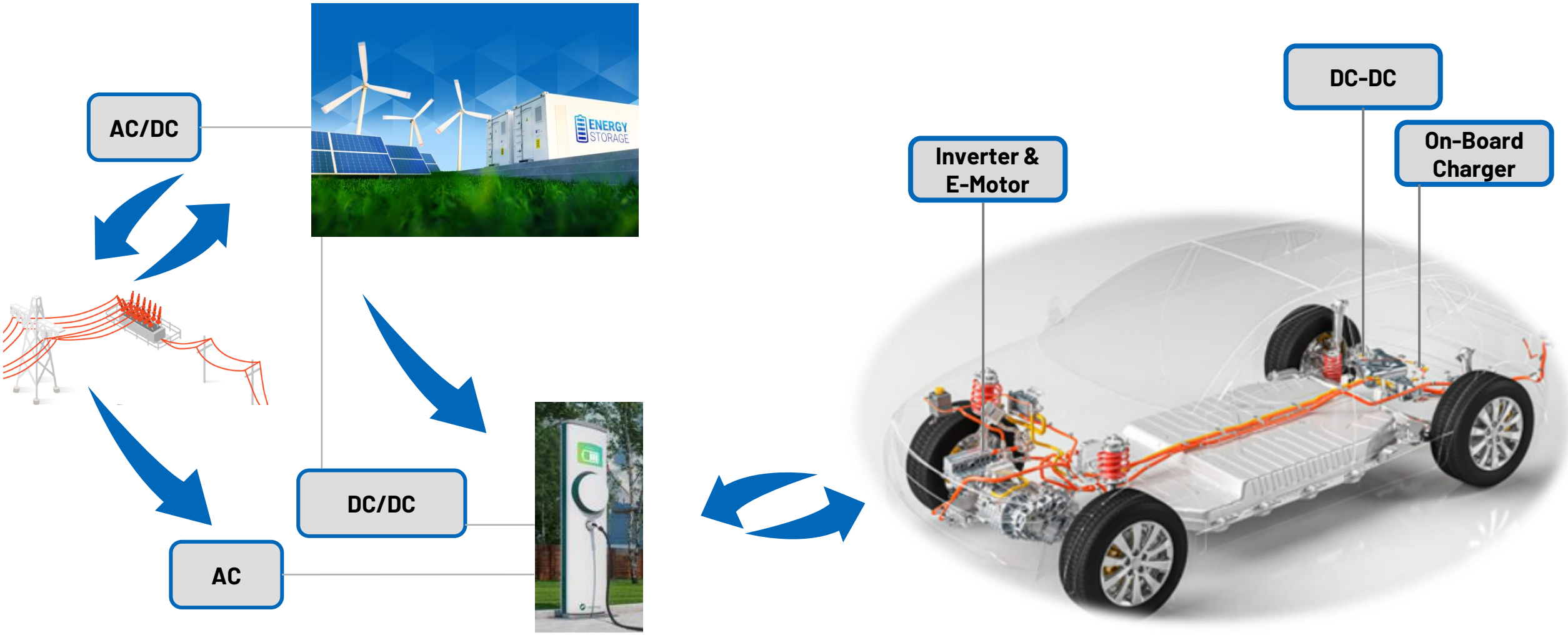
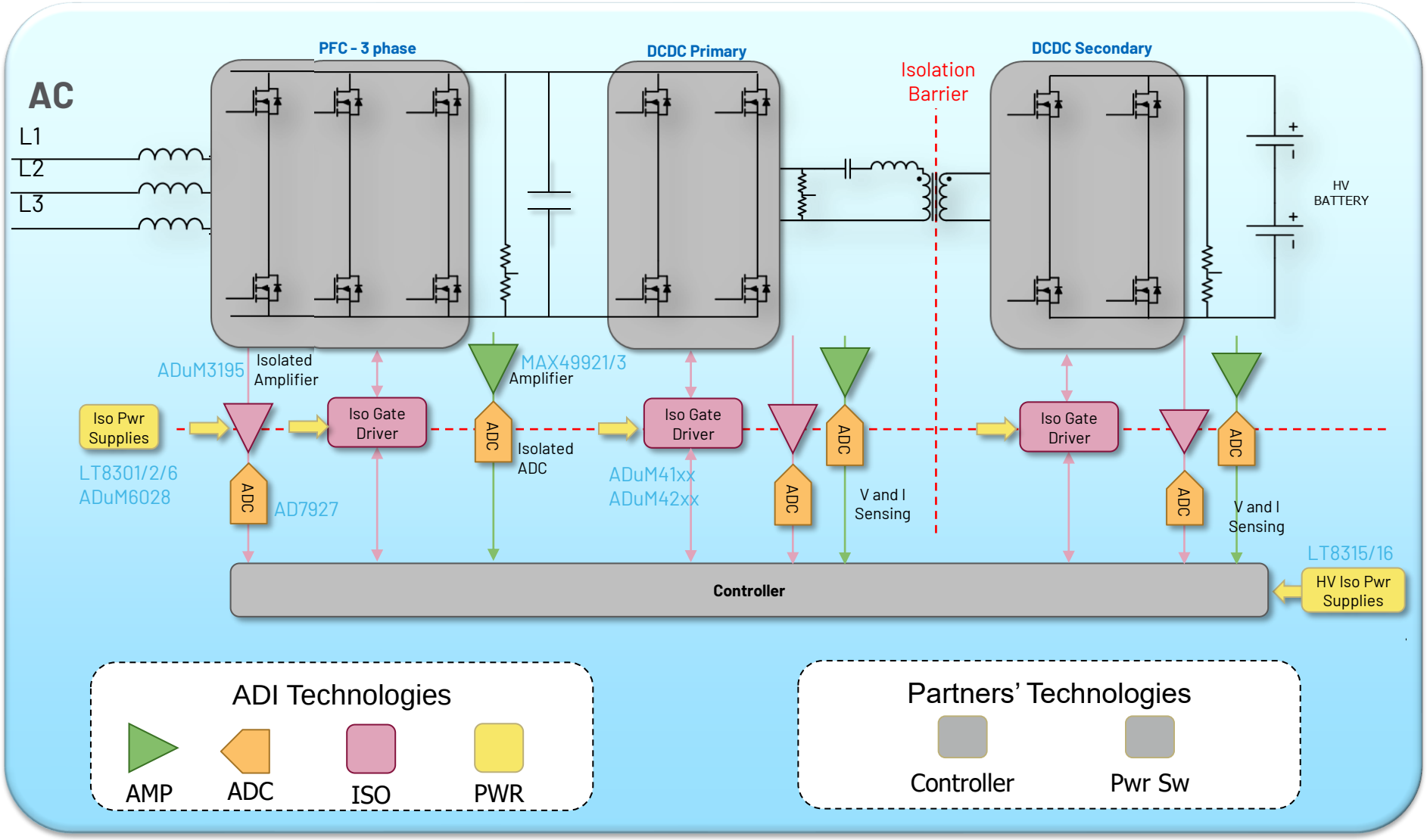
DC Power Conversion

Energy Conversion Solutions – key applications

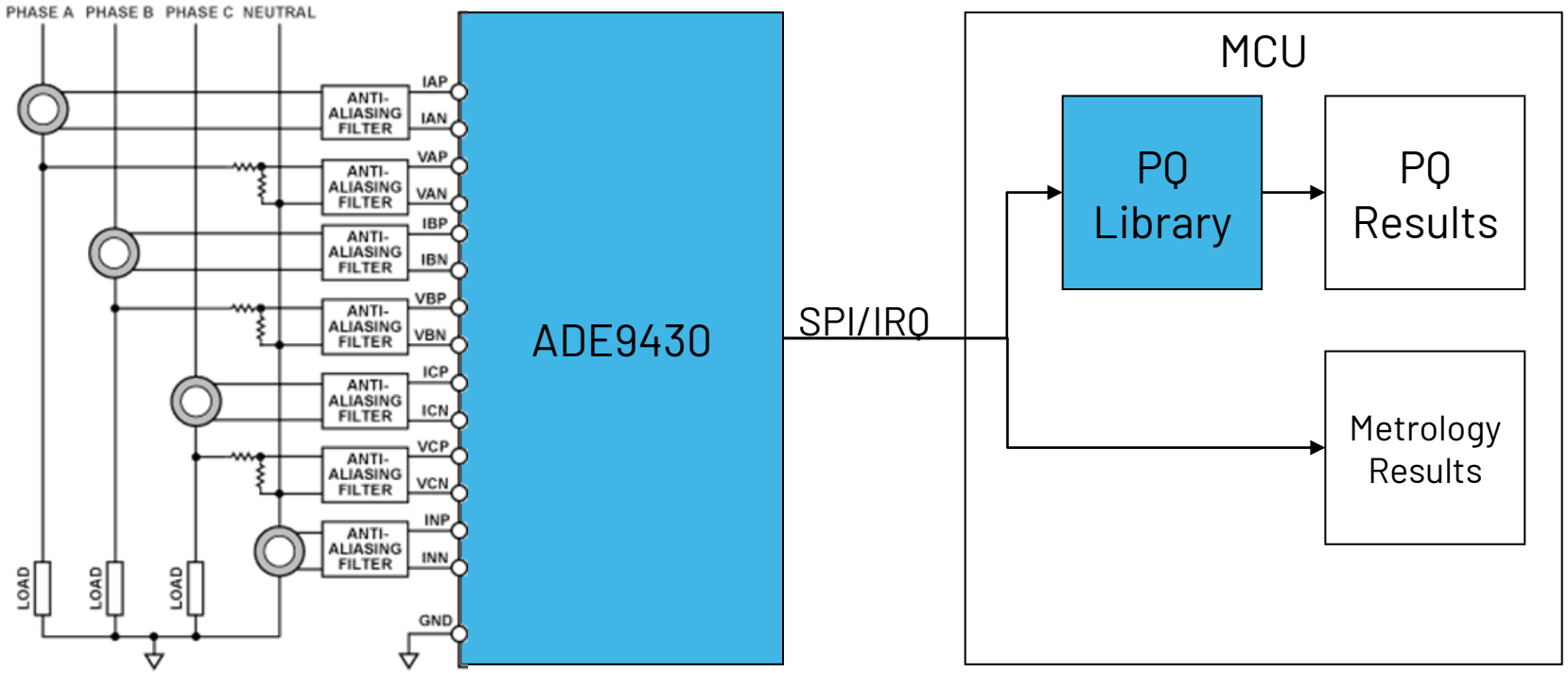


Grid ESS and DC Fast Charge



ADE9430 HW + SW Power Quality Solution

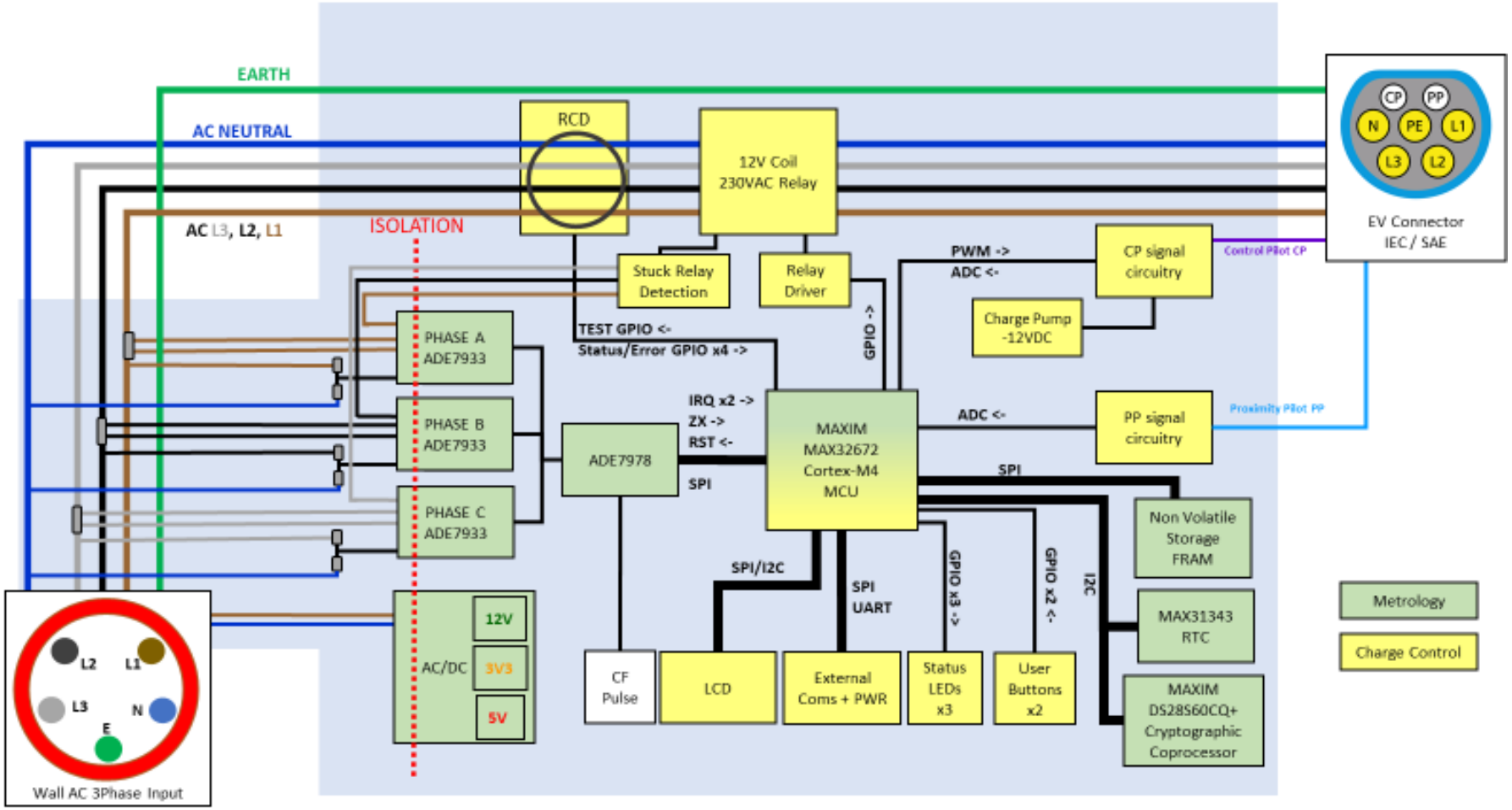
- ADI AFE + SW Library
  - Generates standards compliant PQ results
  - IEC 61000-4-30 Class S
  - Includes metrology
  - Software library
    - Runs on customer uC
    - HW agnostic
    - Included with AFE
- Certified EVK
- Reduces development time and cost



Generic	Power Quality Level	Features
ADE9000	Partial Class-S	Power Factor RMS THD
ADE9430	Class-S	Adds: • Flicker • V/I Harmonics
AD7606	Class-A	GPS Synchronised

EVSE Use Case

3-phase Metrology and Charge Control reference design



EV Charging Infrastructure

ESS

BMS – Best Accuracy BMS delivers longest Lifetime

Wireless BMS – Delivers Secure Flexibility & Scalability

Battery Analytics & Insights – Drive Data Value and Enable new business models

METERING

Metrology – ease of use highly integrated solutions

System expertise – decades designing for regulated utility smart meters

PRECISION

Current sense – precision control of power stages

Isolation - safety certified signal & power ensures robust signal integrity

Communications – isolated transceivers provide superior noise immunity over long distances

POWER

Power – AC/DC & DC/DC conversion

ISO gate drivers – superior timing performance enables high switch speed

DrSiC – smart power switch delivers high power density and efficient charging

Summary

- ADI's metrology Technology
  - AC Metering
  - DC Metering
- Digital Security and its role in EVSE
- System-level solutions
  - MCU’s & Secure payment,
  - Communications including industrial ethernet
  - Power Conversion
- How ADI can help you get started, and what is available now

Questions

Scalable Ethernet Solutions for Deterministic Applications

10/100Mb Industrial Ethernet Technology

Superior Industrial Ethernet Solutions

ADIN2299

- **Platform Solution**
  - ✓ Multiprotocol hardware and software solution
  - ✓ Pre-certified industrial protocols

- **Embedded Switch**
  - ✓ 2-Port switch for determinism and line / ring topologies

- **100BASE-TX PHY**
  - ✓ Lowest latency
  - ✓ Lowest power

TSN Technology

Industry Leading Ethernet Switch and PHY Solutions

- **Ethernet TSN Switches**
  - ✓ Scalable 6- and 3-Port switches
  - ✓ Fully compliant TSN on each port
  - ✓ Any speed on any port

- **1000BASE-T PHY**
  - ✓ Lowest latency & power
  - ✓ Smallest package and proven robustness

Single Pair Ethernet Technology

Industry's Lowest Power 10BASE-T1L Solutions

- **10BASE-T1L MAC PHY**
  - ✓ Robust / Intrinsic Safe operation
  - ✓ Pairs with any micro to simplify fieldbus migration

- **10BASE-T1L PHY**
  - ✓ Robust / Intrinsic Safe operation
  - ✓ Standard xMII Interface connects to any processor