# 永續推動電源新發展
# 迎接未來新需求

MICROCHIP

A Leading Provider of Smart, Connected and Secure Embedded Solutions

FAR EAST

09:35-10:15

**Microchip Power Team**

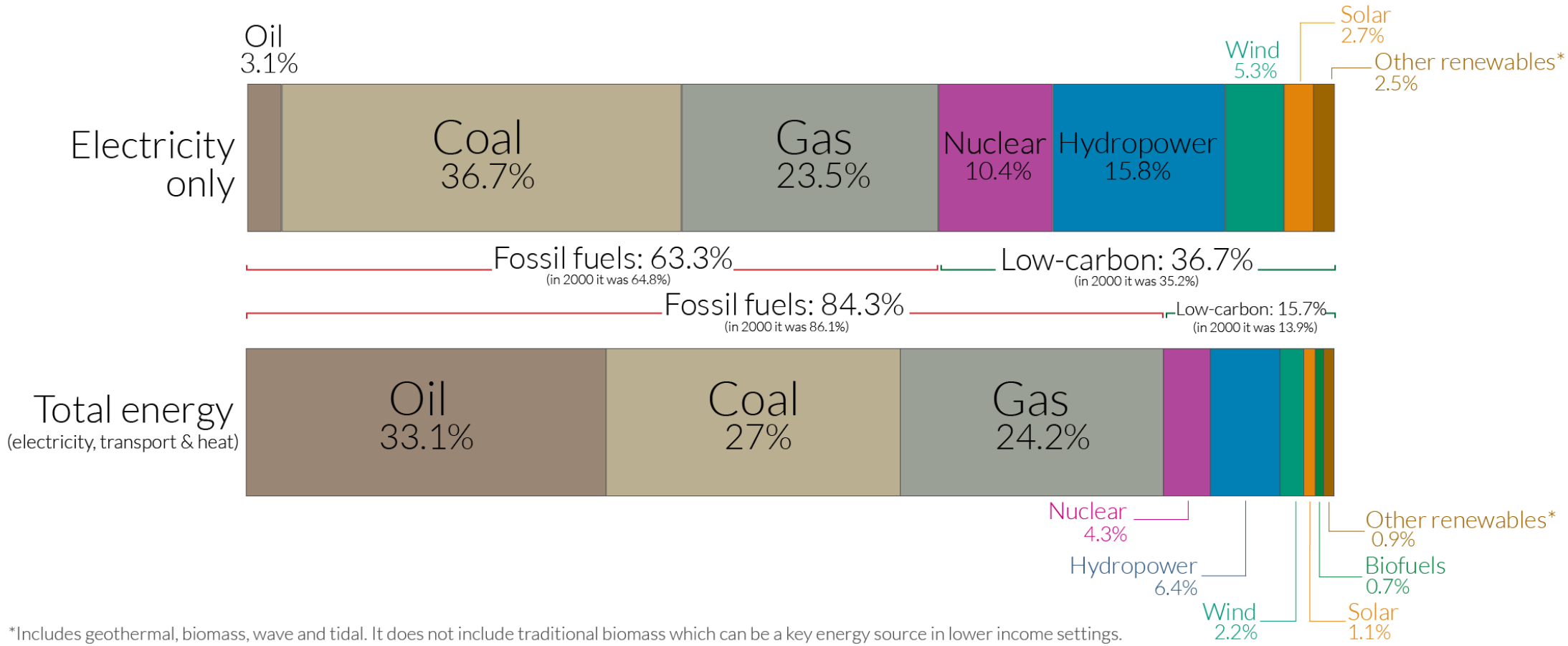
Nov, 2023

SMART | CONNECTED | SECURE

# Energy Creation

## More than one-third of global electricity comes from low-carbon sources; but a lot less of total energy does

Our World in Data




*Includes geothermal, biomass, wave and tidal. It does not include traditional biomass which can be a key energy source in lower income settings.

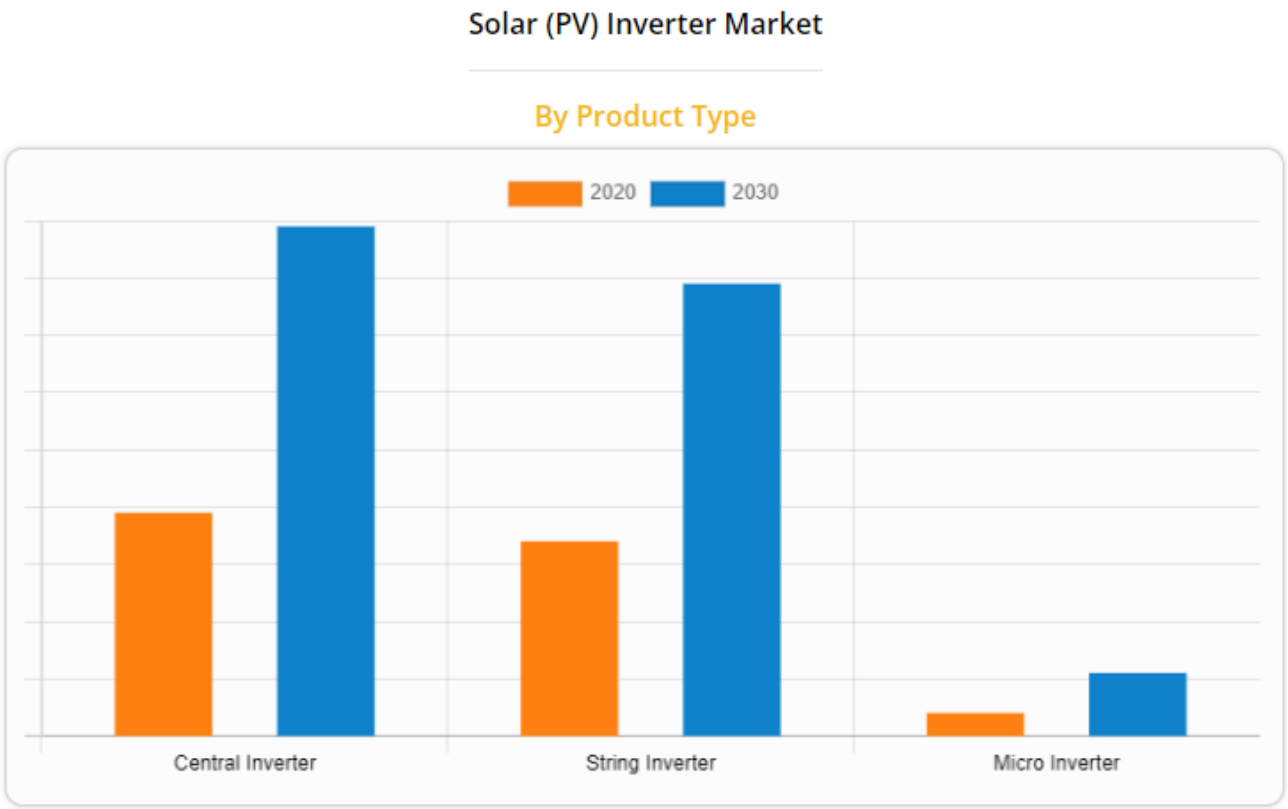
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Source: Our World in Data based on BP Statistical Review of World Energy (2020). Based on the primary energy and electricity mix in 2019.

# Growing Market for Solar

- Global solar (PV) inverter market size
  - Valued at $7.7 billion in 2020
  - Expected to reach $17.9 billion by 2030,
  - CAGR of 8.8% from 2021 to 2030

- Growth fueled by multiple factors:
  - Rapid development in the renewable energy sector
  - Easy installation of solar inverters
  - Increase in government initiatives
  - Investments in the electrification of rural and remote areas
  - Growth expected across residential, commercial and utilities segments




Source: https://www.alliedmarketresearch.com/pv-inverters-market-A10500

# Solar Commercial Deployments

## Where Mobility and Sustainability Megatrends meet

- **Typical use case**


**ESS purpose:**

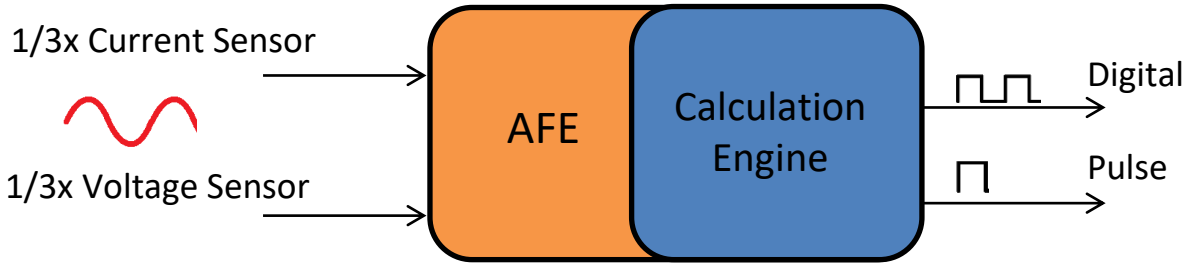
- Energy peak shaving
- Backup

- **EV charging** part of installation scenario
- **HVAC** is more and more solar powered

# Smart Energy and Sustainability

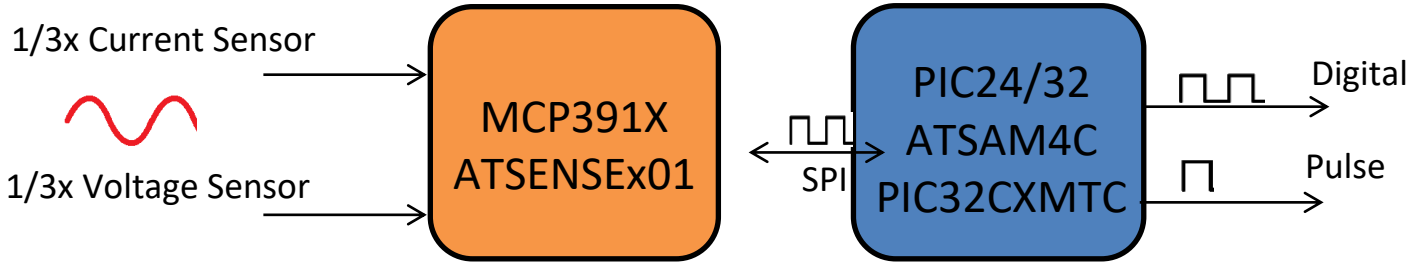
- **Smart electric meter solutions**
  - Product options for variety of meter designs (metering ADCs, AFEs, SoCs and single/dual core MCUs)
- **Any other metrology solutions**
  - EV charger
  - PDU (Power Distribution Unit)
  - Circuit breaker
  - Energy management/power monitor
- **Communication**
  - Certified PRIME and G3-PLC
  - Certified PLC/RF Hybrid
  - Wi-SUN, 802.15.4g RF transceiver
- **Edge Computing**
  - Powerful MPU
  - Machine leaning including non-intrusive load identification

# AFE: Single/Poly Phase Energy Meter




| Part Number | ATM90E26 | ATM90E32AS | ATM90E36 |
|---|---|---|---|
| Phase | Single | Poly | Poly |
| Number of ∑Δ ADC Channel | 3 | 6 | 7 |
| Accuracy | 0.1% Active, 0.2% Reactive | 0.1% Active, 0.2% Reactive | 0.1% Active, 0.2% Reactive |
| Dynamic Range | 5000:1 | 6000:1 | 6000:1 |
| Calculations | Power & Energy<br>PF, f, Zero-Cross | Power & Energy<br>PF, f, Zero-Cross | Power & Energy<br>PF, f, Zero-Cross |
| Output Pulse | Yes | Yes | Yes |
| Event Detection | Yes | Yes | Yes |
| Harmonic Measurement | No | Yes | DFT & THD Analysis |
| Neutral Monitoring | Yes | No | Yes |
| Comm. I/F | UART, SPI | SPI | SPI |
| Temperature Sensor | No | Yes | Yes |

# ADC: 1 to 8 Channels Metering ADC

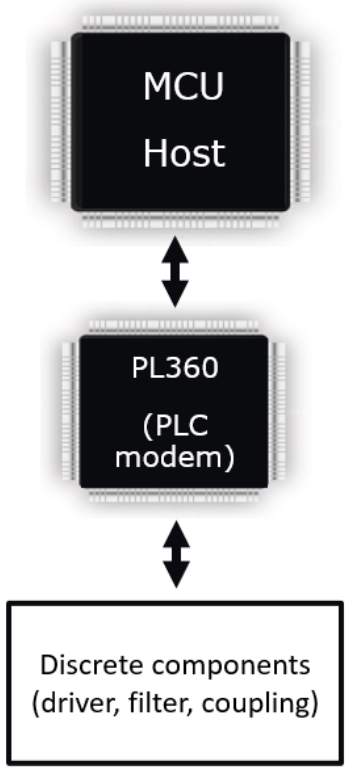



| Part Number | MCP3910/12/13/14/18 | ATSENSE101/201/301 |
|---|---|---|
| # of ADCs | 2/4/6/8/1 | 3/4/7 |
| Dynamic Range | 0.1%, 10,000:1 | 0.1%, 3,000:1 |
| SINAD | 93.5-94.5 dB | 84 dB |
| Voltage Reference | 9 ppm/°C | 10 (H-Version) or 50 ppm/°C |
| PGA | Up to 32x, All Channels | Up to 8x, Current Channels |
| Digital Temp. Compensation of Vref | No | Yes |
| Phase Delay Comp. | Yes | No |
| CRC | Yes, 16-bit | No |
| 2-Wire Mode | Yes (Poly-Phase Shunt) | No |
| Temperature Range | - 40°C, +125°C | - 40°C, +85°C |
| Package | SSOP20, QFN20 | SOIC20, TQFP32 |

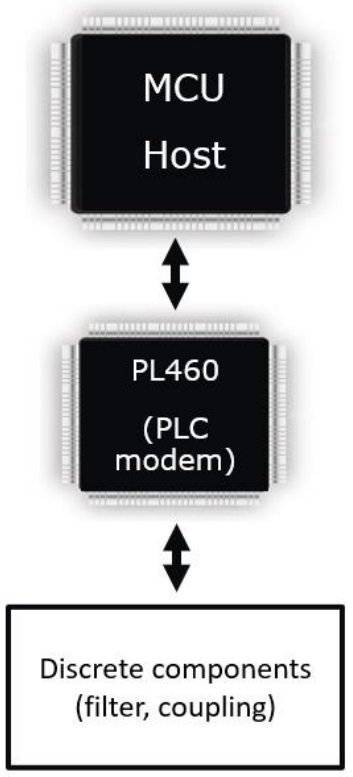
# Power Line Communication

## PLC Transceiver: PL360 & PL460

| | PL360 | PL460 |
|---|---|---|
| **Description** | PLC Modem (PHY only) | PLC Modem (PHY only) |
| **Standard** | PRIME 1.3.6/1.4, G3 | PRIME1.3.6/1.4, G3 |
| **Band** | < 500 kHz | < 500 kHz |
| **PLC signal amplification** | External discrete components | **Embedded in device** |
| **PLC injection efficiency** | 43% in CEN-A - Class D amplifier - | 43% in CEN-A - Class D amplifier - |
| **Package** | QFN 48 / TQFP 48 | BGA 81 |
| **Availability** | **Mass Production** | **Mass production** |
| ***Comments*** | *Controlled by host MCU* | *Controlled by host MCU* |




*Typical PL360 application*




*PL460 embeds the PLC driver*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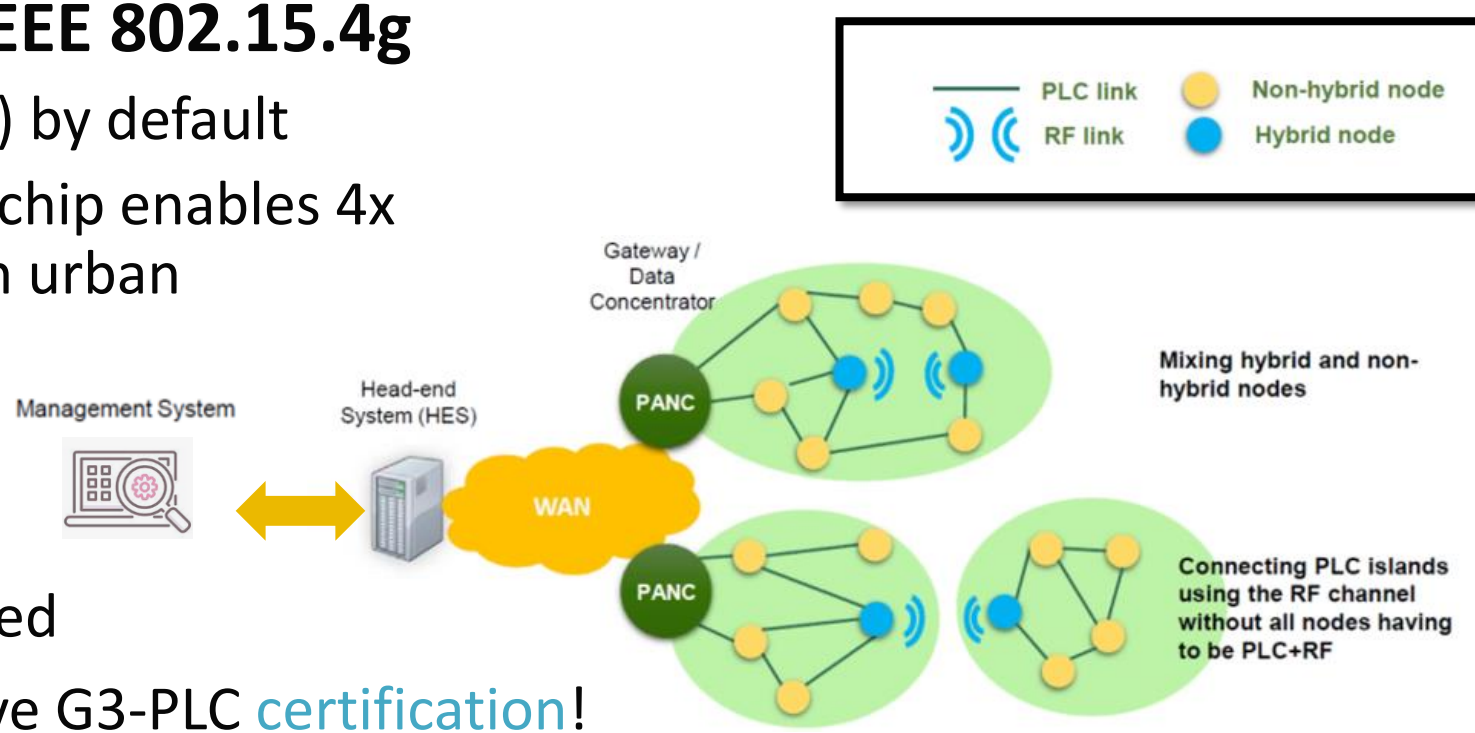
# Hybrid PLC & RF

- **Combination of Radio and PLC for Smart Grid and IoT applications**
- **Provides one single network over wired and wireless media**

- **Radio interface – based on IEEE 802.15.4g**
  - Wi-SUN FSK PHY (863-870 MHz) by default
  - OFDM PHY supported by Microchip enables 4x more robust communications in urban environments!

- **PLC interface**
  - G3-PLC and PRIME PLC supported
  - Microchip hybrid: first to achieve G3-PLC certification!





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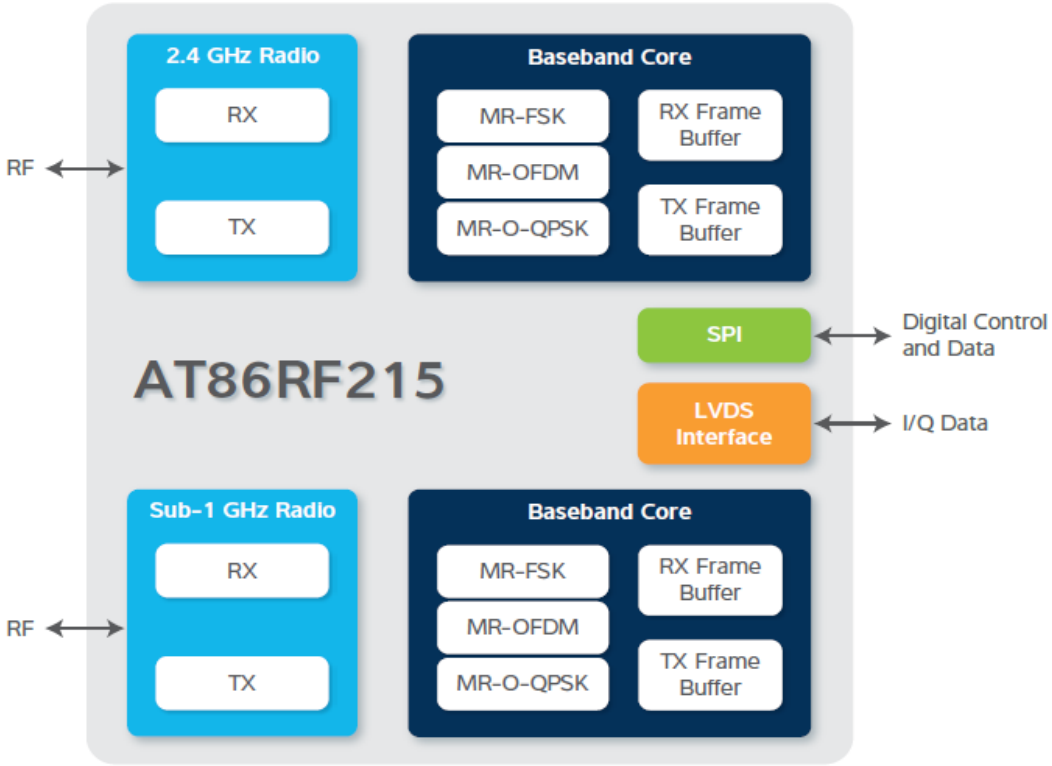
# RF Transceiver




AT86RF215 Block Diagram


REB215-XPRO Evaluation Board

## Device Family Overview

| Device | Description |
|---|---|
| AT86RF215 | Sub-1 GHz/2.4 GHz transceiver compliant to IEEE 802.15.4g-2012, IEEE 802.15.4-2011, and ETSI TS 102 887-1 |
| AT86RF215M | Sub-1 GHz transceiver compliant to IEEE 802.15.4g-2012, IEEE 802.15.4-2011, and ETSI TS 102 887-1 |
| AT86RF215IQ | Sub-1 GHz/2.4 GHz I/Q radio |

***Sole sub-GHz + 2.4GHz transceiver supporting OFDM!***

***Best-in-class OFDM sub-GHz transceiver!***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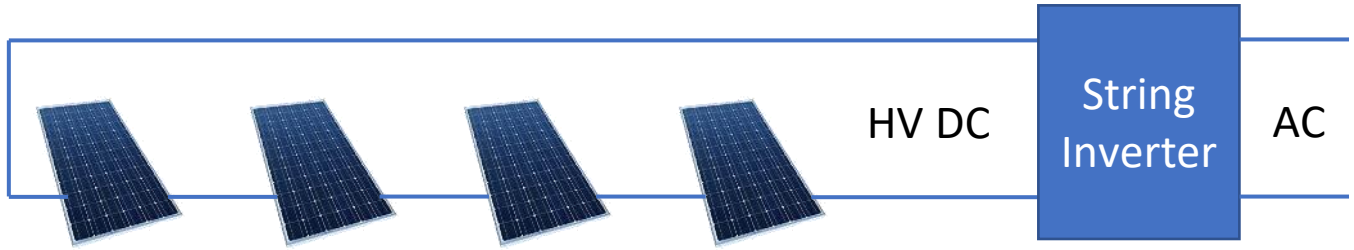
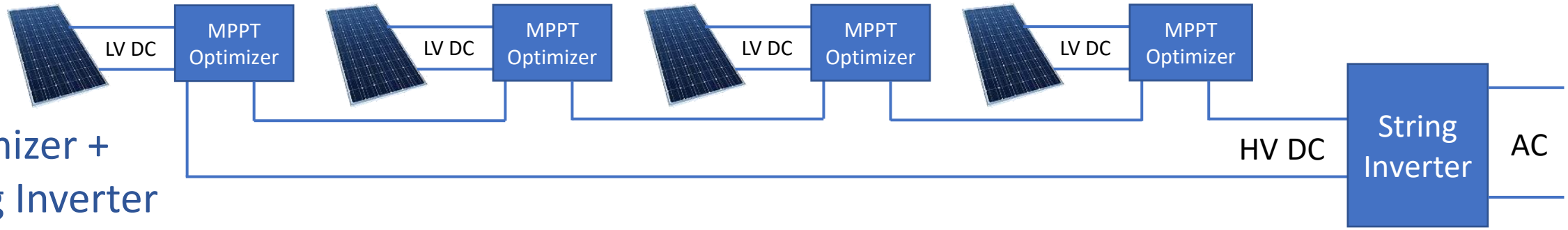
# Solar Power Topologies

String Inverter




Micro Inverter

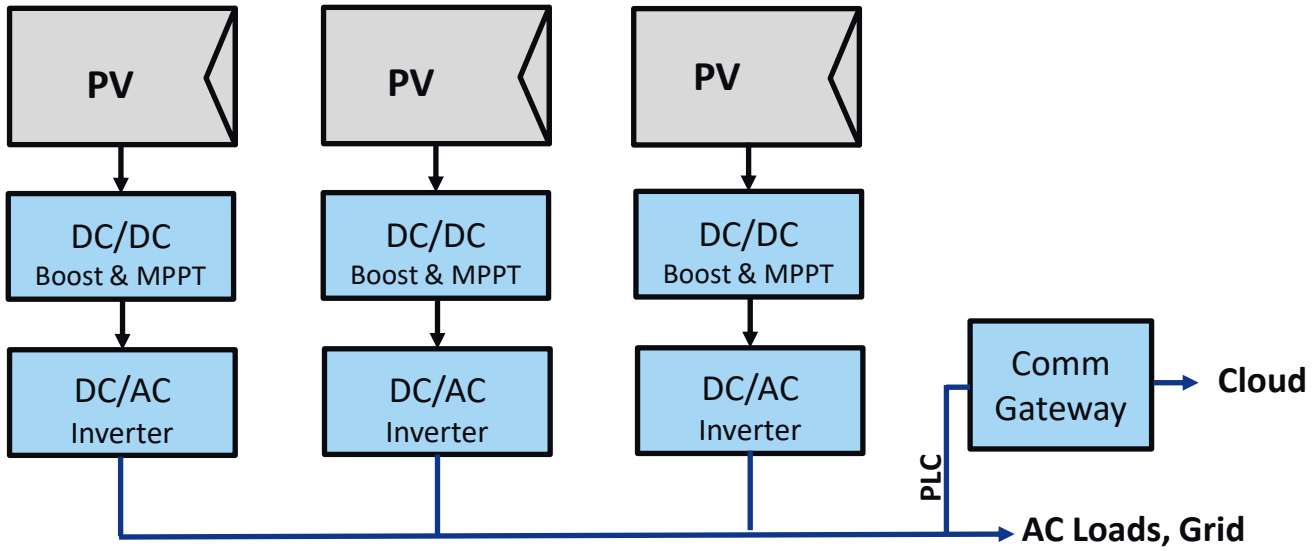

Optimizer + String Inverter



# Micro Inverters

## Building Blocks for Residential and Commercial

- **Control 1 per panel or per few (up to 4) panels**
- **2 stages power conversion**
  - DC/DC, including Boost and MPPT
  - Inverter DC/AC
  - dsPIC33-based control
- **Communication Gateway**
  - PIC32 + Security
- **Micro-inverters proprietary to each vendor; lack interoperability**



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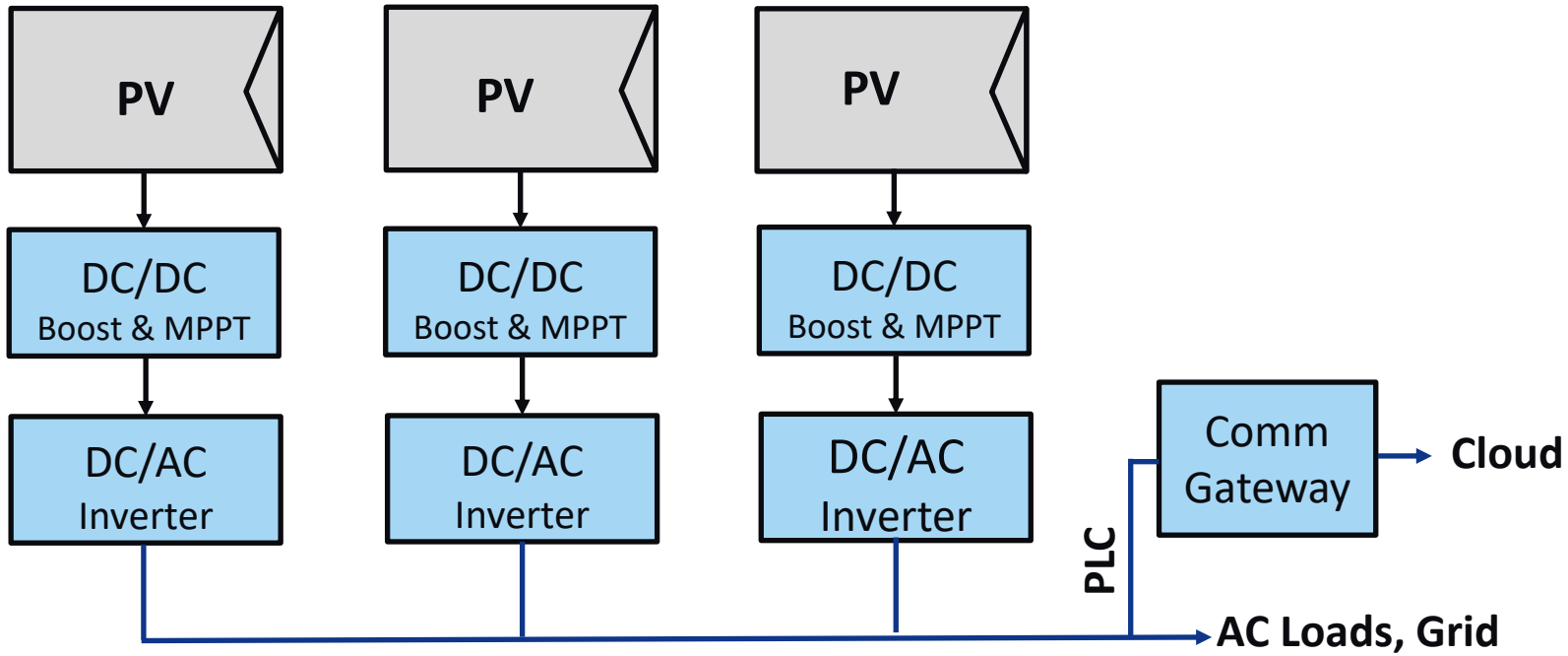
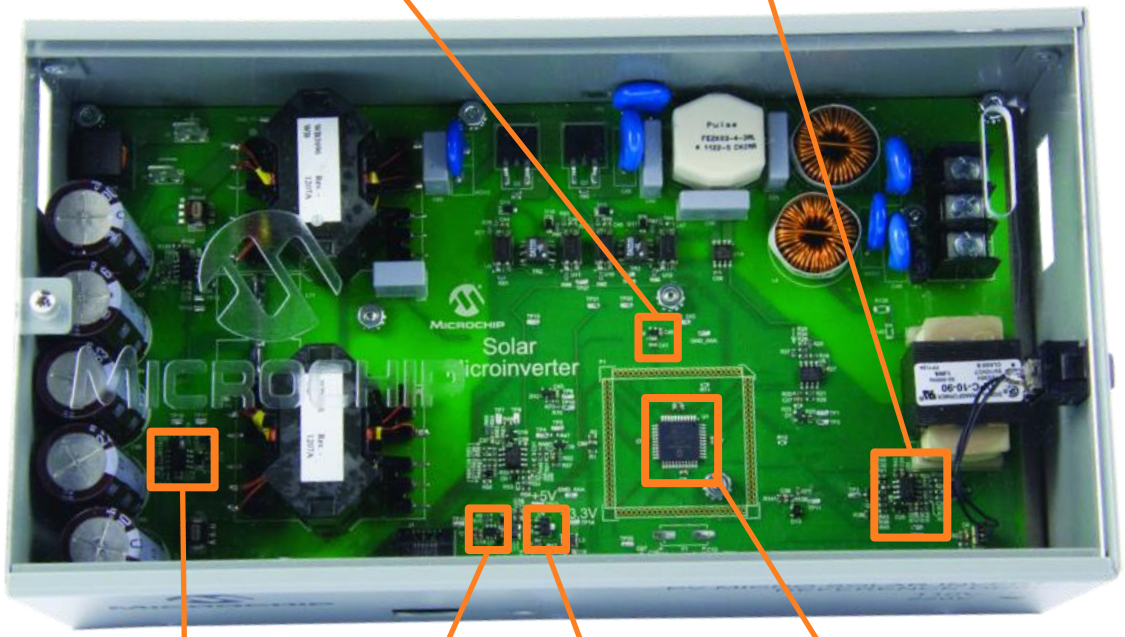


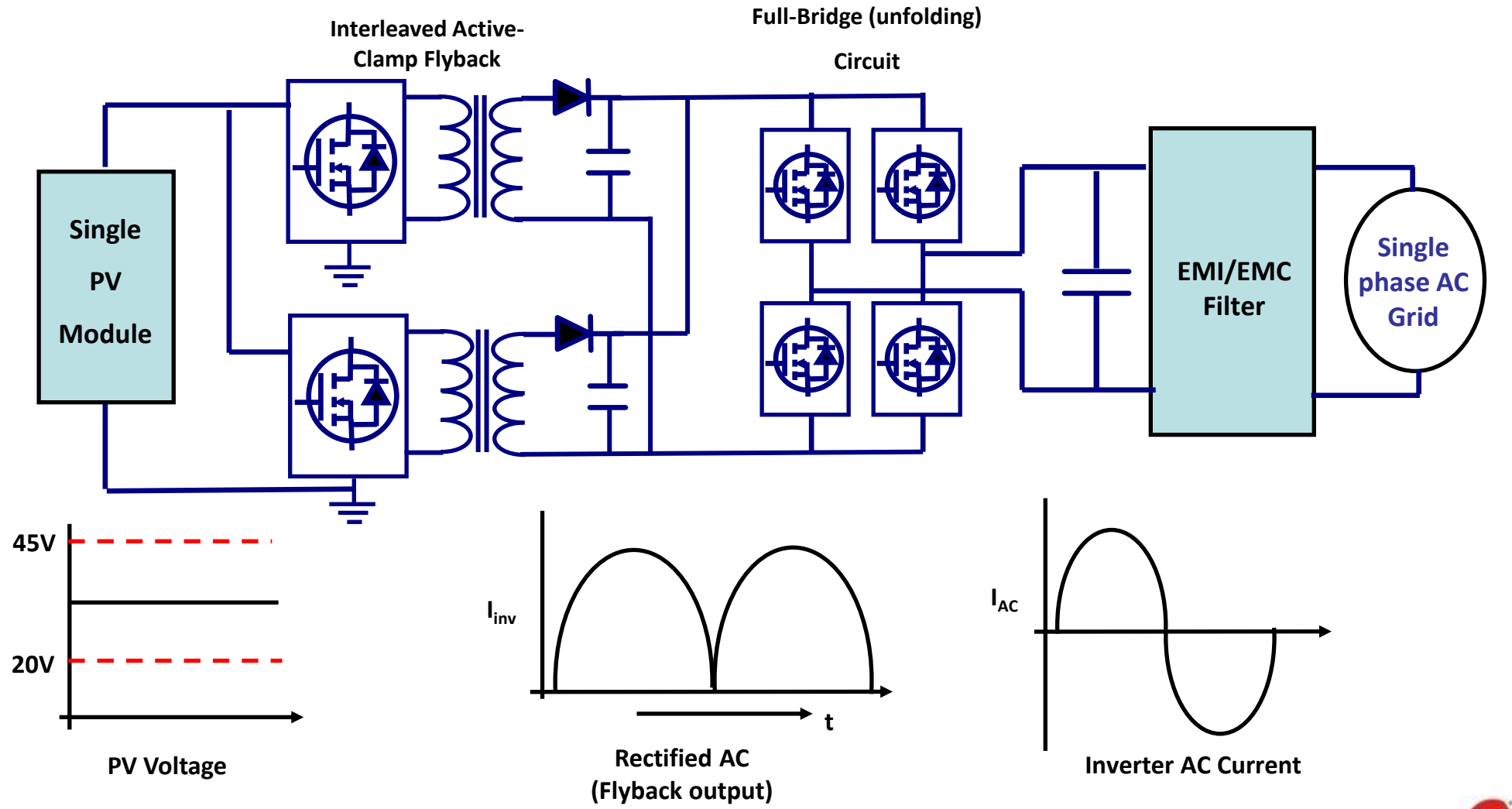
# Grid-Connected Solar Microinverter Ref. Design

- **PV Input Power: 250W (max)**
- **Maximum Output Power: 215W**
- **Open Circuit PV Voltage: 53Vdc (max)**
- **Maximum Power Point Tracking: 99.5%**
- **MPPT Voltage: 20Vdc – 45Vdc**
  - Power de-rating: Vdc < 25Vdc
- **AC Output Voltage range (50/60 Hz)**
  - 210Vac – 264Vac
  - 90Vac – 140Vac
- **Total Demand Distortion: < 5%**
- **Output Power Factor: > 0.95**
- **Peak Efficiency: 94.5% (nominal conditions)**



# Grid-Connected Solar Microinverter Ref. Design

## Solar Microinverter Schematic

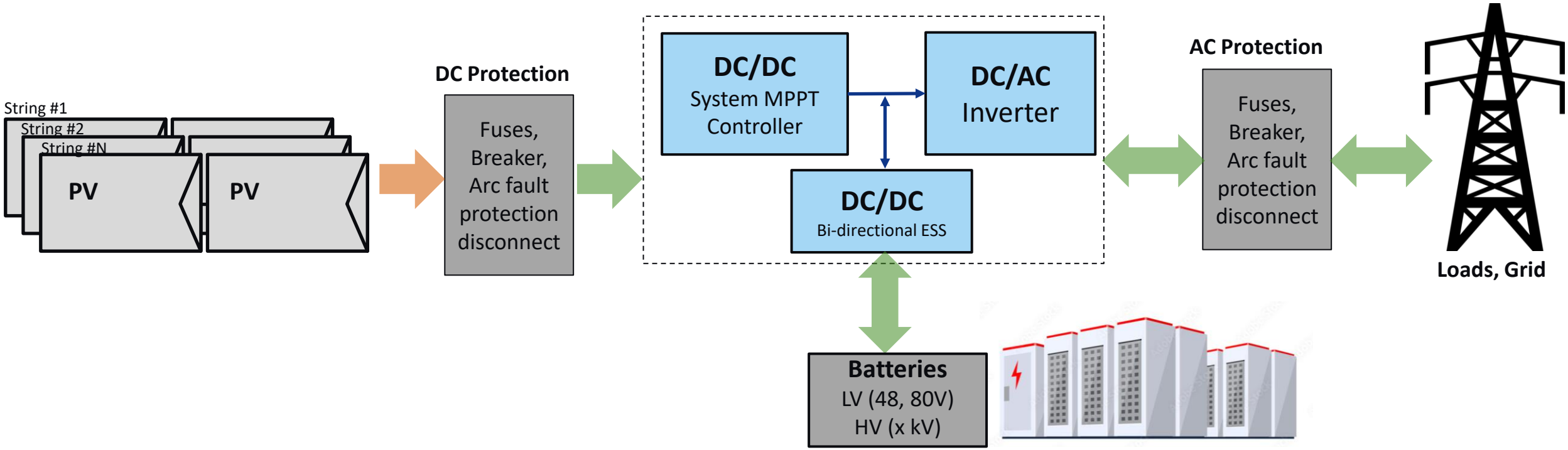


# String Inverter or Hybrid Inverter

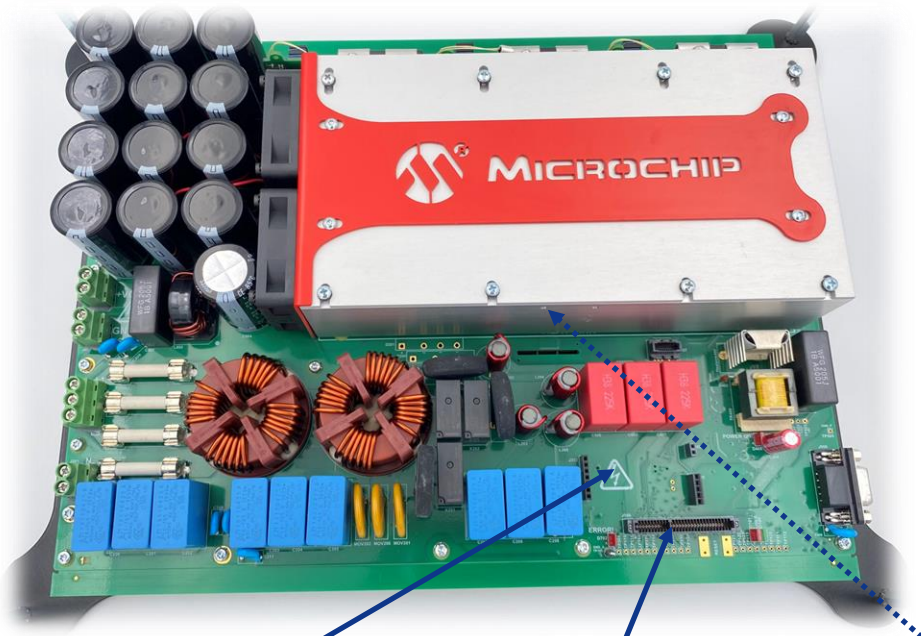
## Building Blocks for Residential and Commercial

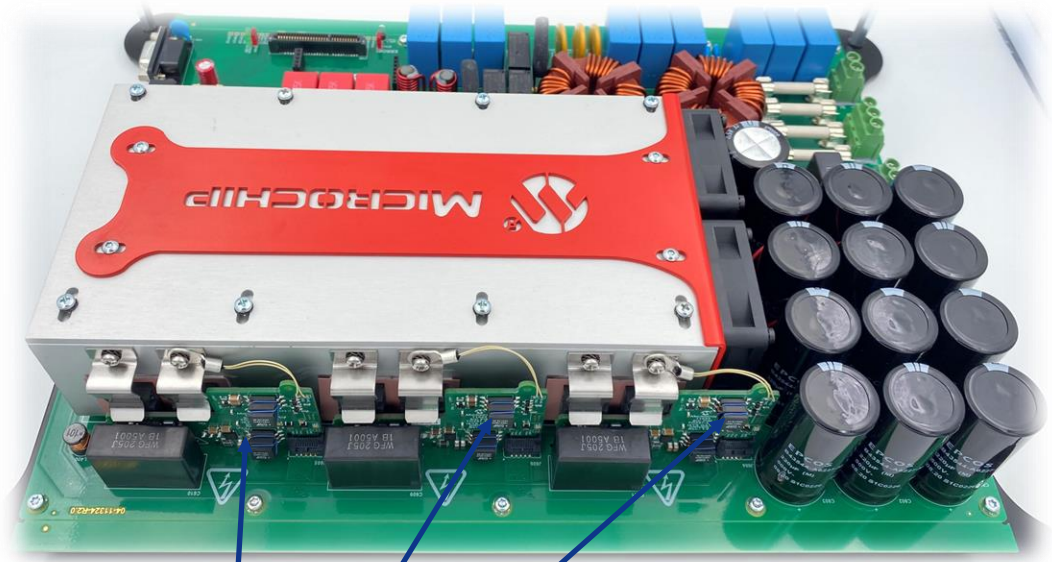
### String Inverter or Hybrid Inverter

- Single or 3-phase
- Optional ESS (Energy Storage System)
- Possible use of PV optimizers (on solar panels strings)



# 11 kW Bi-directional Totem Pole PFC Demo

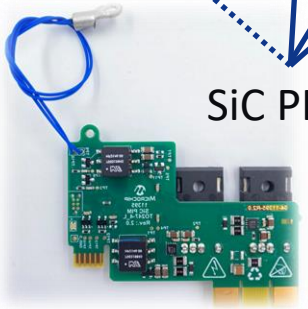



Isolated Voltage Acquisition Board

dsPIC33CH DP PIM

SiC PIMs



**Solution**

- dsPIC33CK/CH – dsPIC® DSC Single and Dual Core
- PIC16F – 8-Bit MCU
- MSC025SMA120 – 1200 V SiC MOSFET
- HV9123 – Flyback Switch Mode Controller
- MCP16331 – DC/DC Converter
- MCP1755 – LDO
- ATA6563 – CAN Transceiver
- MIC4120 – MOSFET Driver

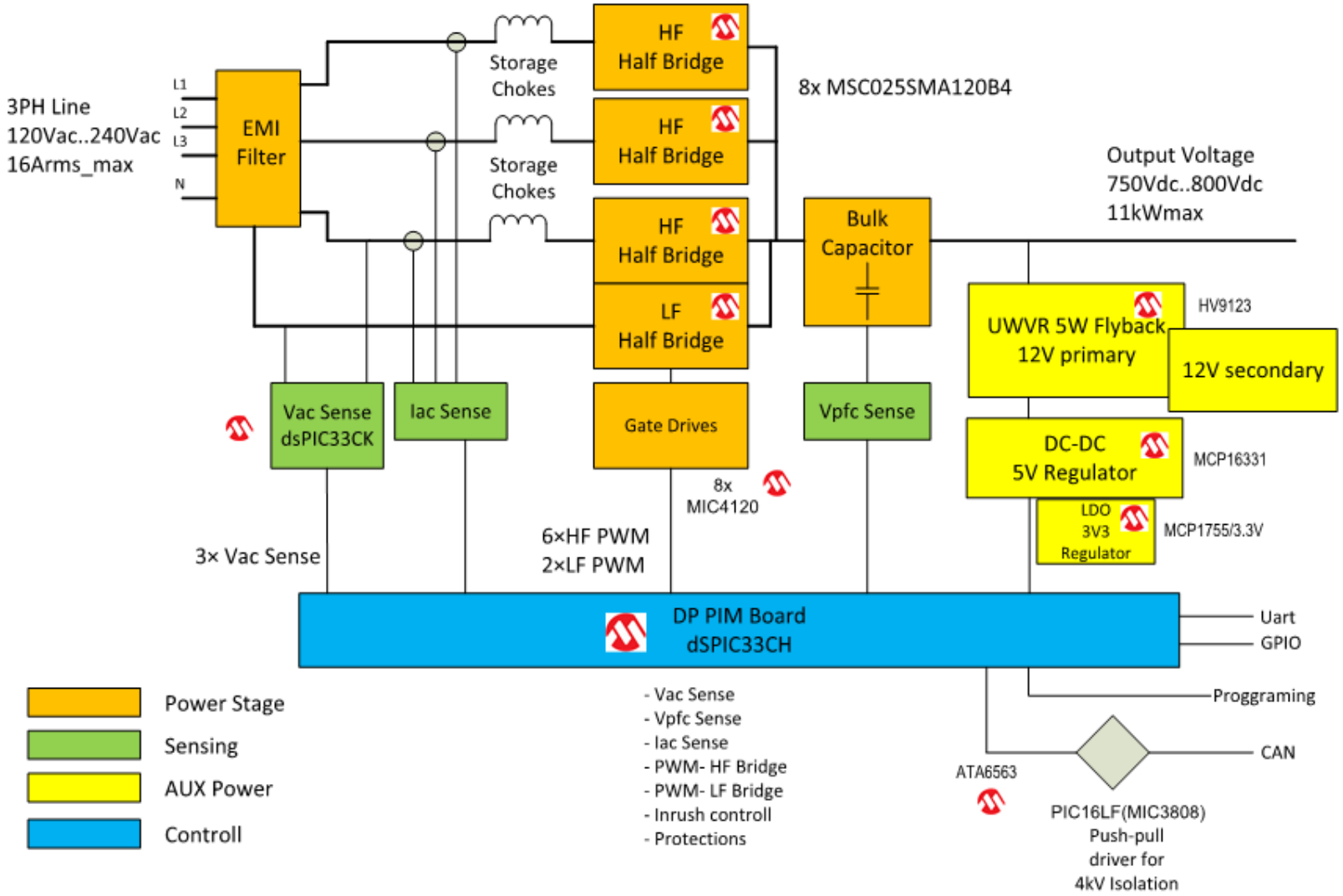
**Useful Links**

- Reference Design Link

# 11 kW Totem-pole PFC Development System

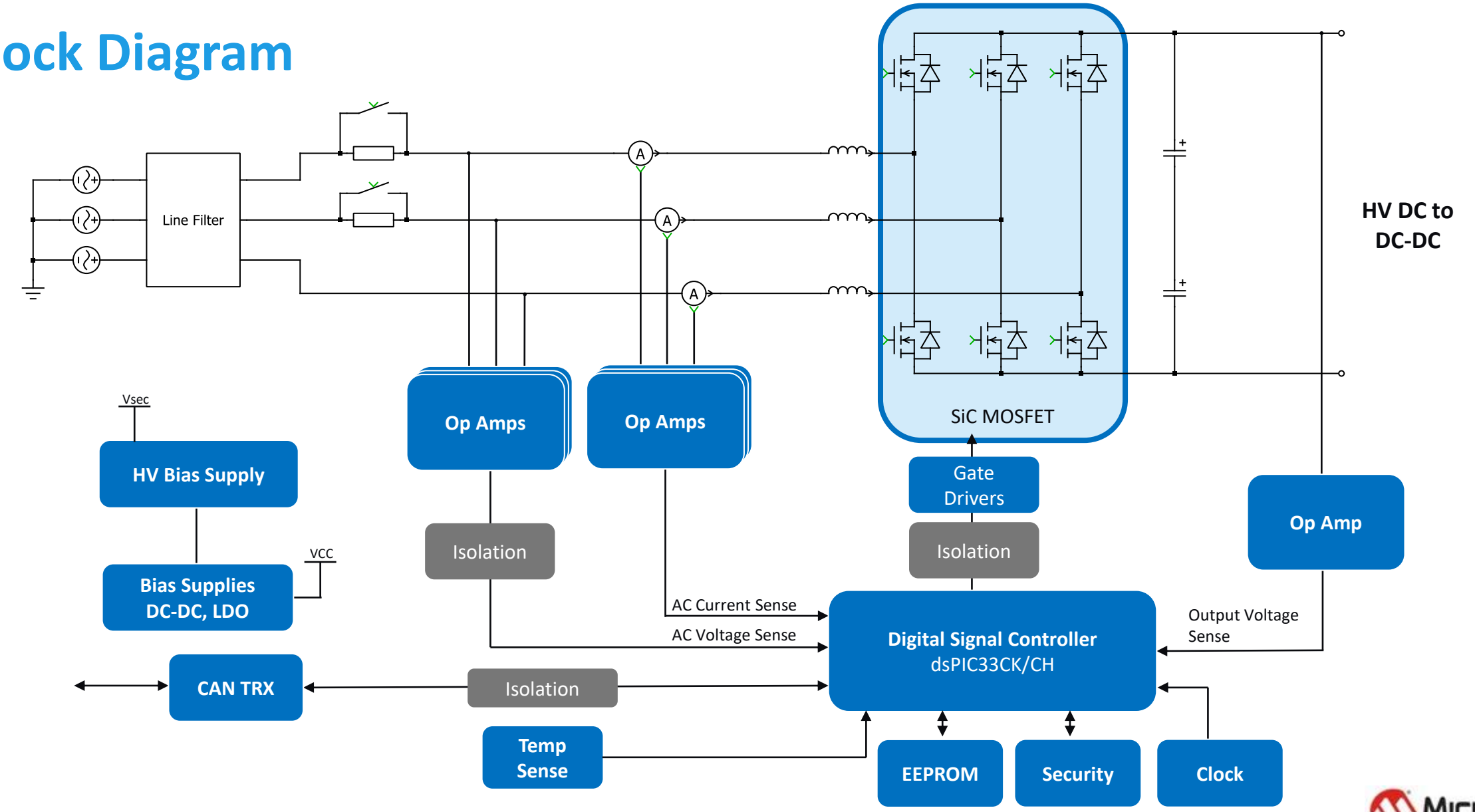
## 11 kW Totem-pole PFC Features:

- Single- or 3-phase AC source
  - Level 2: 11 kW from 3-phase source
  - Up to 3.6 kW from single-phase
  - Bidirectional operation
- Uses dsPIC33 DP PIMs and new FET PIMs for SiC power MOSFETs
- AEC-Q100 qual'ed components
- Forced-air cooled
- **Development Board available for evaluation**



# 11 kW Bi-directional Totem Pole PFC Demo

## Block Diagram



# VAR Correction - STATCOM

# STATCOM – Static Synchronous Compensator

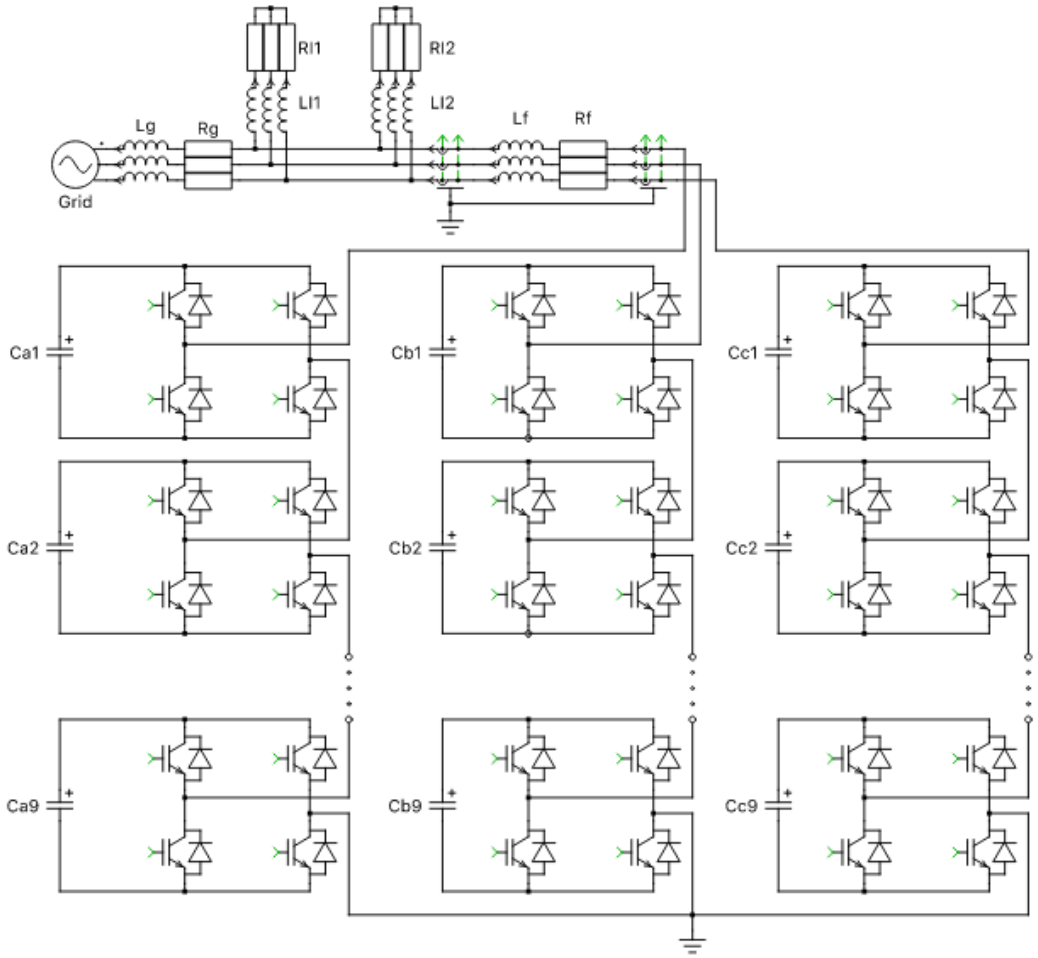
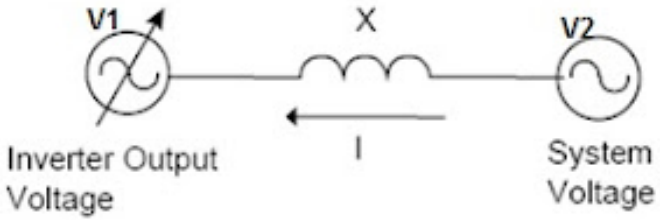
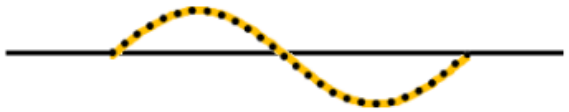
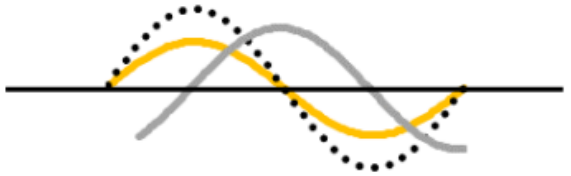
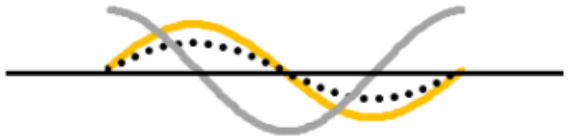



Figure 1: Cascaded H-Bridge circuit schematic




V1 – Inverter Output (black dot)
V2 – Grid (Yellow)
Gray – Reactive Power

| Work Mode | V-I waves | Description |
|---|---|---|
| No Load |  | If both voltages are equal, there is no current Flow. |
| VAR generation |  | If the STATCOM voltage is higher, it will deliver VARs to the grid |
| VAR absorption |  | If the STATCOM voltage is lower, it will absorb VARs from the grid |

https://uploads-ssl.webflow.com/6165afb04b166a2c717cf5c3/63bed83bc5831a7c930d891a_DIRAM_FACTS_BROCHURE_ENG.pdf

# STATCOM – Static Synchronous Compensator

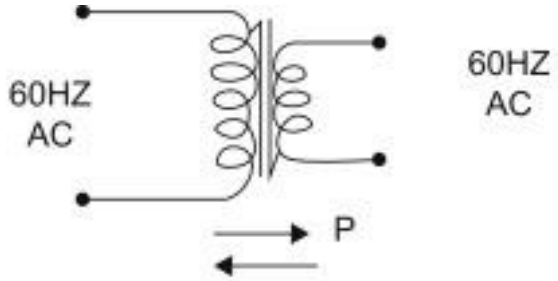
- Provide or Absorb reactive current to/from grid
- Regulates voltage at point of connection to grid
- Class of Flexible AC Transmission System Devices (FACTS)
- Based on semiconductor based Voltage Source Converter (VSC) often in a modular multi-level configuration
- Many STATCOMs are IGBT based but SiC based STATCOMs are available

https://uploads-ssl.webflow.com/6165afb04b166a2c717cf5c3/63bed83bc5831a7c930d891a_DIRAM_FACTS_BROCHURE_ENG.pdf

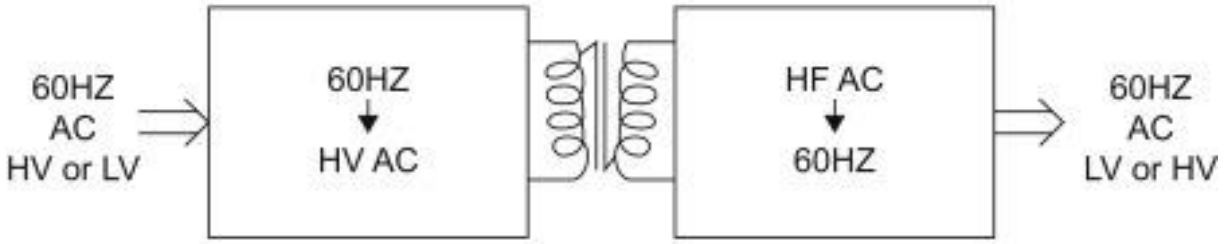
# Solid State Transformers

# Grid Infrastructures (Solid State Transformers)

- SSTs or power electronics transformers are modern network devices that combine multiple power electronics converter stages with a medium frequency (~2–10 kHz) or high frequency (>20 kHz) transformer.
- Extending the typical functionalities of a regular transformer, advantages of SSTs include enhanced power flow control, decoupling between the high-voltage and low voltage networks, enhanced voltage regulation, **harmonic isolation**, and power quality regulation.




(A)

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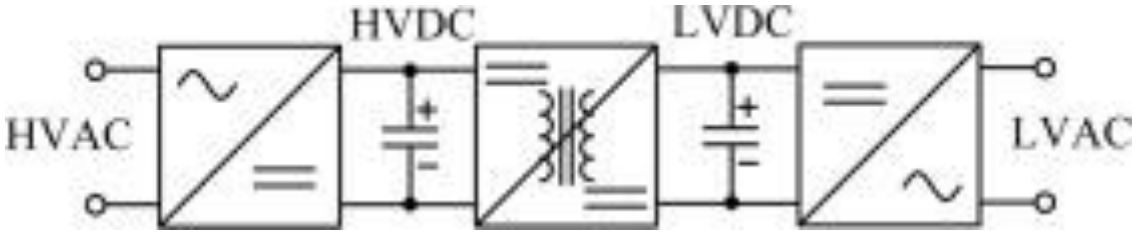
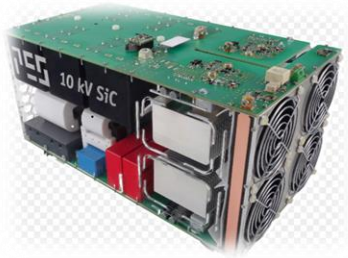


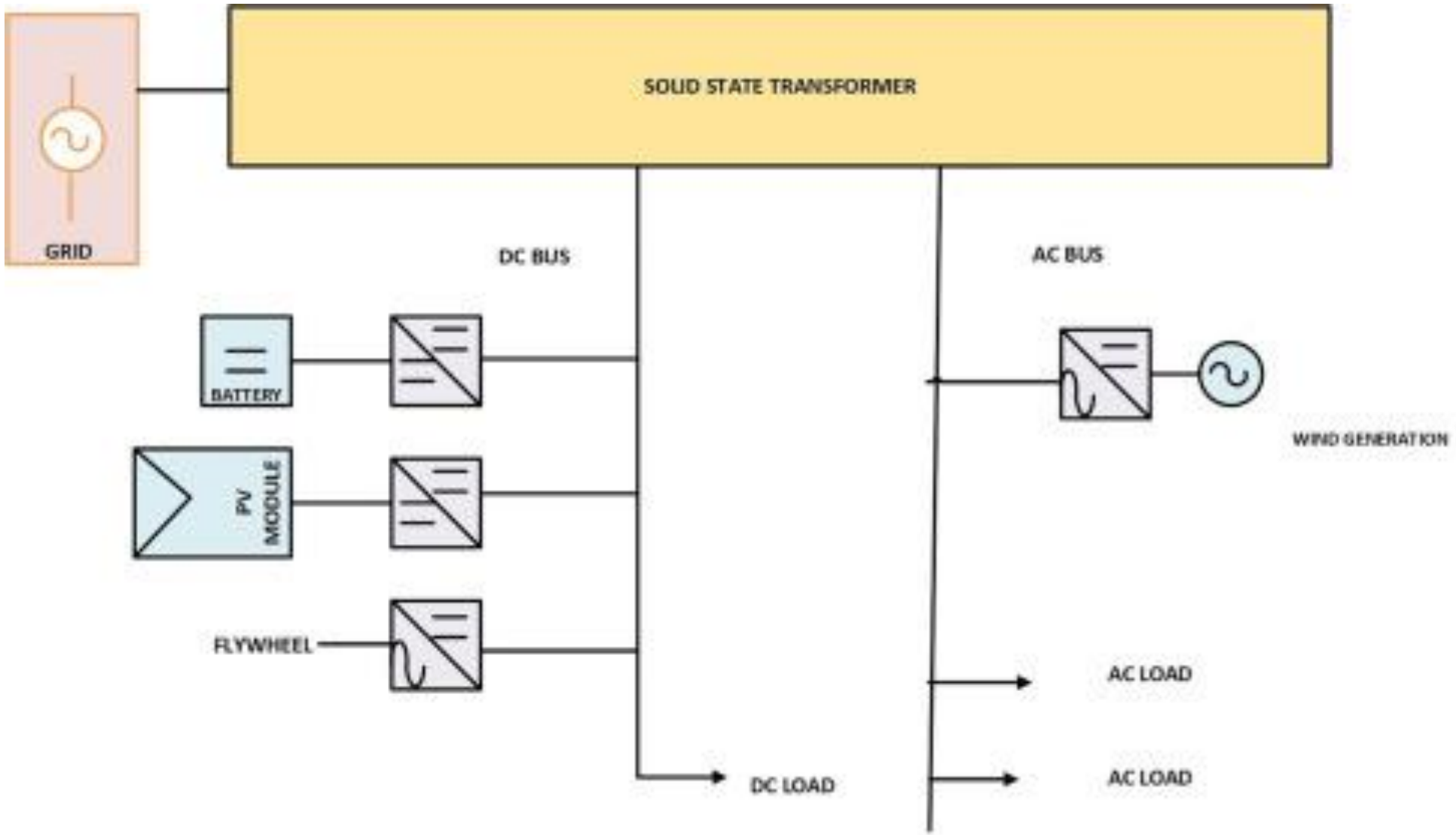

LF Transformer



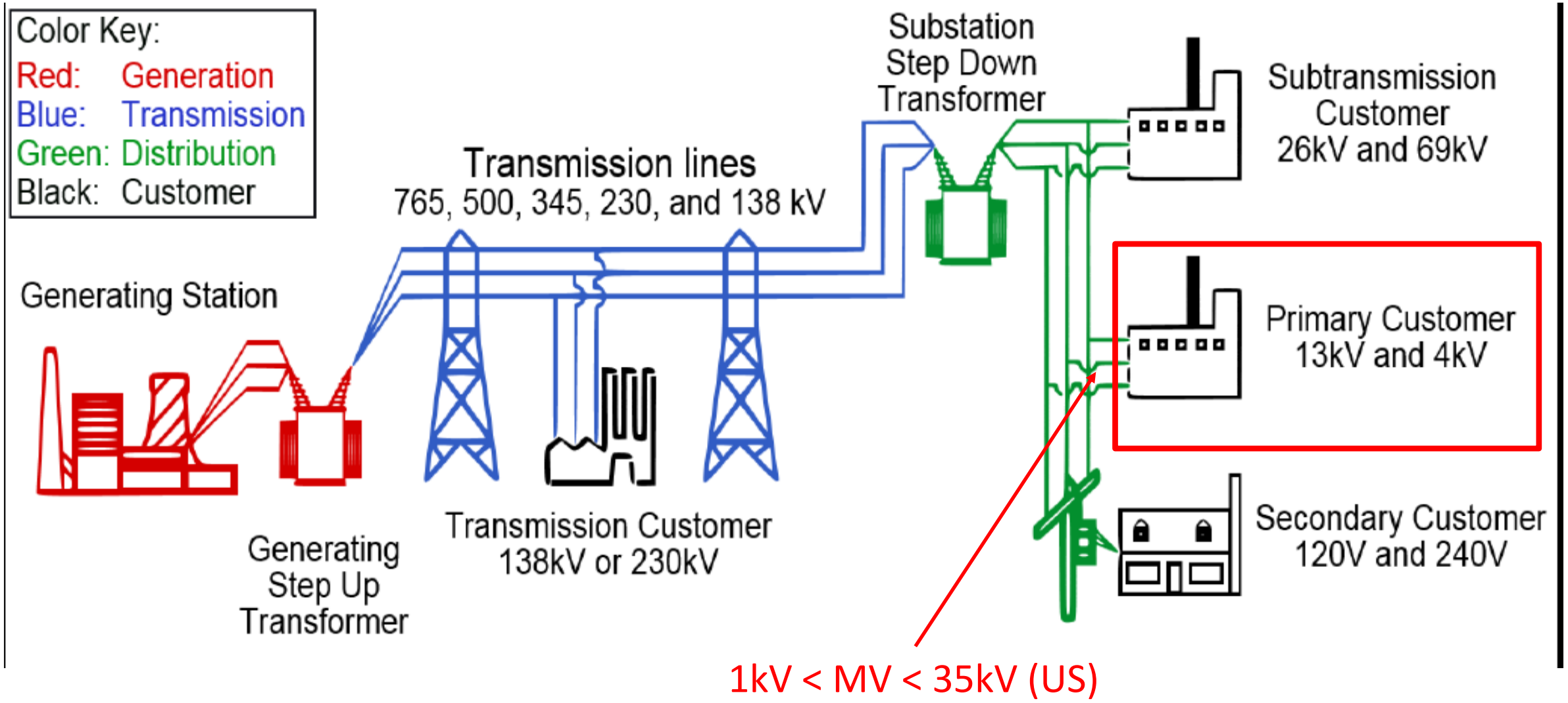

SST

# Grid Infrastructures (Solid State transformers)

**Medium Voltage (MV) Grid**

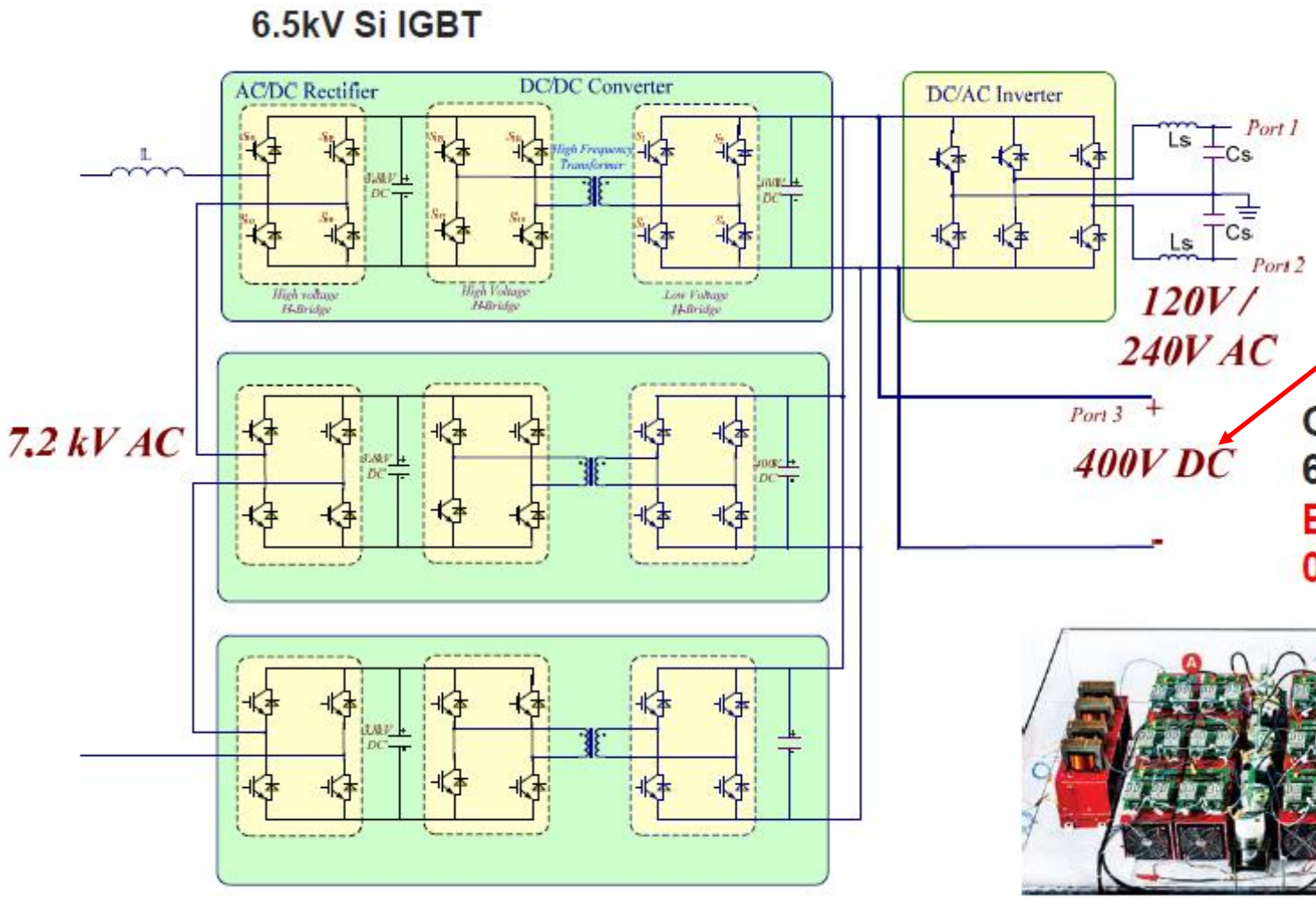


# What is Medium Voltage?



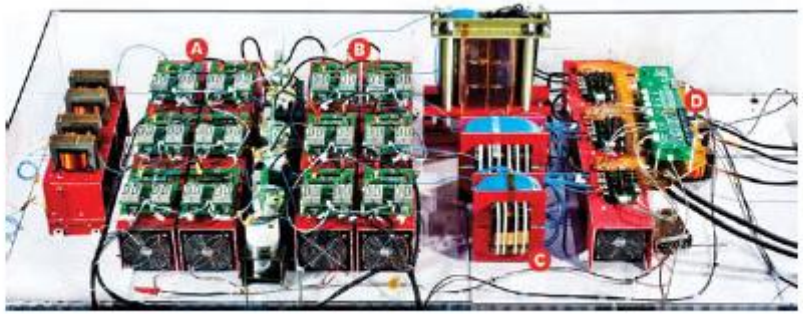
# Cascaded H Bridge SST Topology

- Modular Cascaded H Bridge is a popular topology
- SiC improves SST efficiency and supports increased switching frequency which leads to decreased size

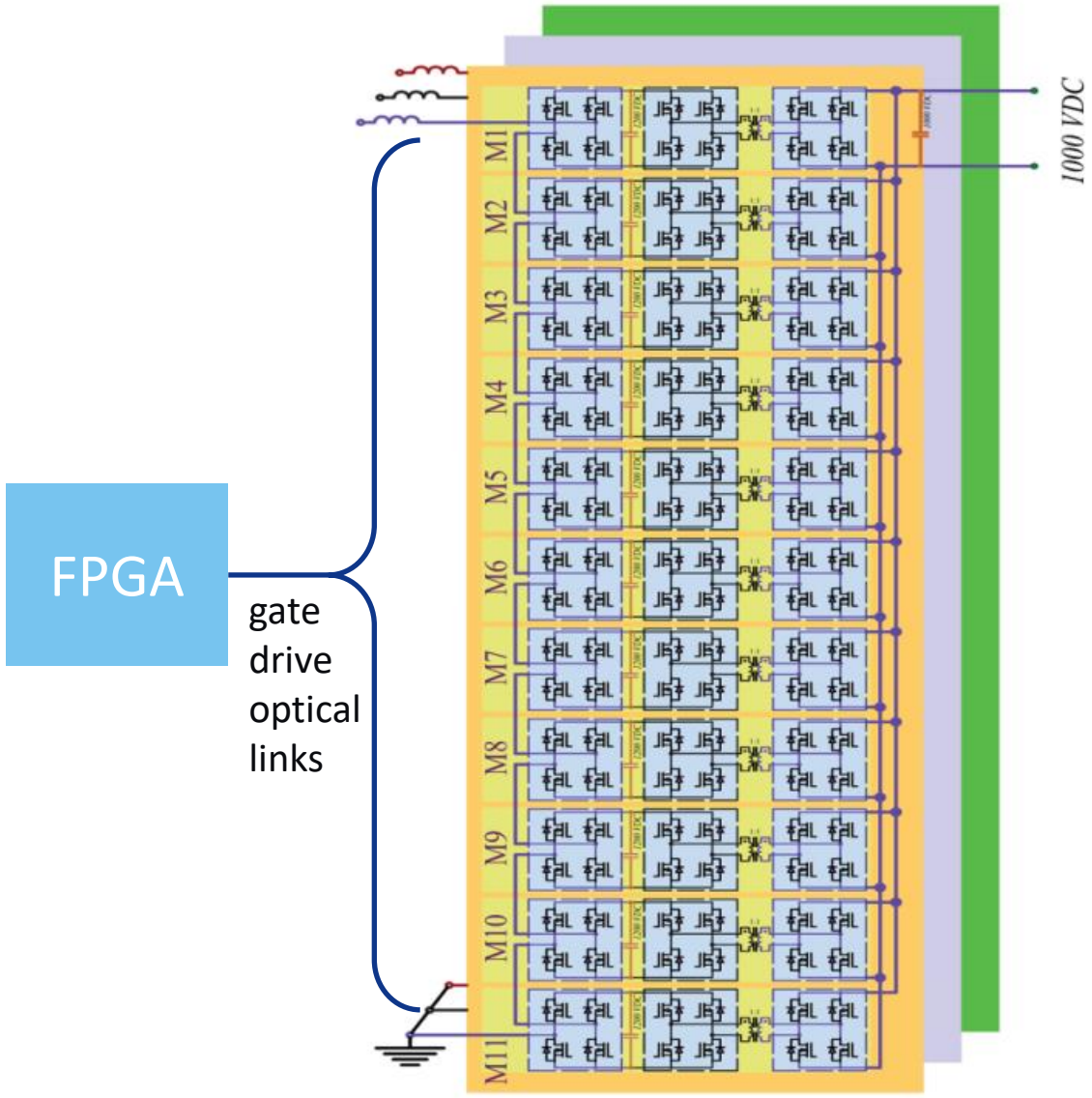



DC Output ideal for EV fast chargers

Gen- 1 SST:
6.5 kV IGBT @ 3 kHz
Efficiency:
0.96x0.95x0.97 = 88%



# Cascaded H Bridge SST Topology – DC Output




- Multi-Level SST uses a lot of HV SiC!
- The higher the SiC FET $BV_{D-S}$ rating the lower the number of required modules
- 3.3kV SiC FETs require half the modules of 1.7kV
- Each level requires isolated gate drive
- MV voltage applications usually requires optical isolation between gate driver and module
- Control is complex and provides TSS opportunity for MCU, FPGA, gate drivers, analog, metering, PMICs

# SST Based EV Fast Charger

# Typical Fast Charging Station – What you see

olsun.com/wp-content/uploads/2020/11/olsun-electric-vehicle-charging-stations-project-application.pdf

Charger Dispenser – User Interface, cable management

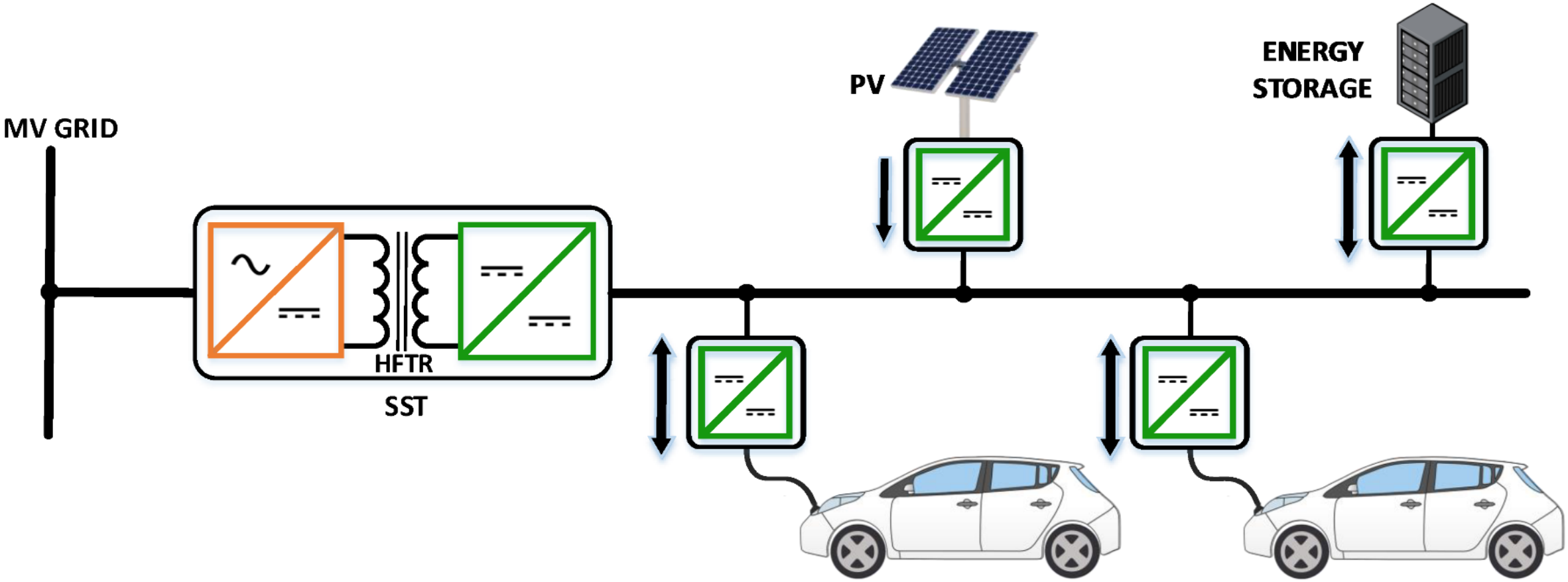
# Typical Fast Charging Station - What you don't see

EV charger power electronics cabinets

olsun.com/wp-content/uploads/2020/11/olsun-electric-vehicle-charging-stations-project-application.pdf

- 1.4MW MV to LV distribution transformer
- Large, heavy and expensive
- Labor intensive installation
- EV Charger with SST can eliminate this!

# SST Enhances Sustainable Charging Solutions



# Customer Application Example – MW Charger for Heavy Trucks

- Multi-bay charging depot
- Existing fast charger requires > 1hr to charge trucks
- > 1MW MV charger will reduce charge time to under 20 minutes
- Charger locations include solar and battery energy storage

# That is the way, Sustainability!!!

## Thank You!