

# Application Brief

## EV Charging Reference Designs Selection Guide



### Introduction

Modern electric vehicle (EV) charging infrastructure, often referred to as Electric Vehicle Supply Equipment (EVSE), brings together several sub-systems that must operate as one coordinated system. Communication, user interaction, protection, power conversion, metering, and backend connectivity all contribute to a safe, efficient, and reliable charging experience.

Deploying an EVSE solution successfully requires a comprehensive understanding of the fundamental systems involved. For developers, the challenge is not only to select the right components, but also to understand how communication, safety, power conversion, metering, and software interact during a charging session.

Texas Instruments has developed a complete portfolio of reference designs that address each of these critical functional areas, supporting developers with their product development and therefore accelerating time-to-market.

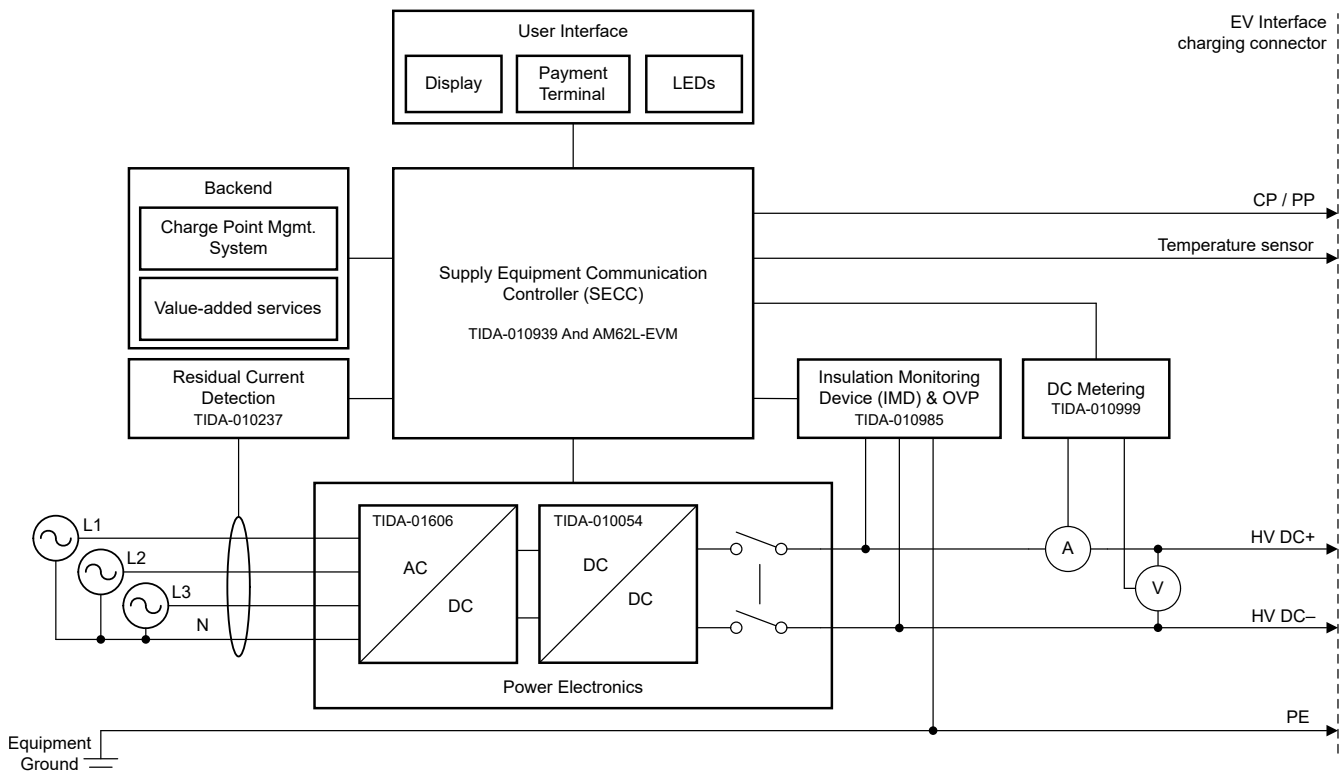
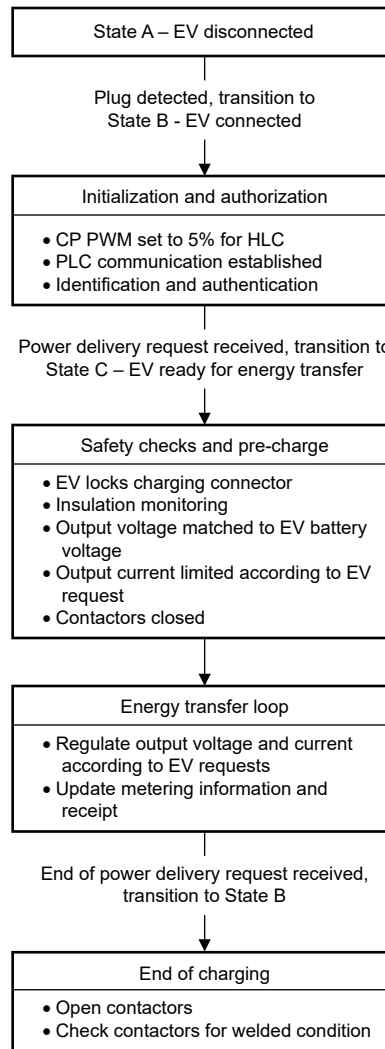


Figure 1. EVSE Block Diagram

## Charging Process

The charging process starts with a simple physical action: the driver plugs the vehicle into the charging station. From that moment on, the EVSE coordinates a defined sequence of communication, safety checks, power delivery, metering, and transaction handling before energy is delivered to the battery.



**Figure 2. DC charging process**

First, the EVSE detects that a vehicle is connected and establishes low-level signaling with the EV. This analog signaling confirms the connection state and indicates either the available current capability of the charging station or the need for high-level communication.

For simple AC charging, this low-level communication can be sufficient. For DC fast charging, Plug & Charge, and vehicle-to-grid (V2G) operation, high-level communication is required so the EV and the EVSE can exchange information such as charging limits, battery voltage requirements, authentication data, and session control messages.

Once communication is established, the user can interact with the charger through the Human-Machine Interface (HMI). Depending on the charger class, the HMI can range from status LEDs and buttons to a display with touch control. In commercial or connected charging stations, backend communication also enables user authentication, pricing updates, payment processing, and charge-point management.

Before power is enabled, the EVSE must verify that the system is safe. DC fast chargers must monitor the insulation resistance between the high-voltage DC system and Protective Earth (PE). AC-connected systems must detect residual currents and disconnect the grid connection if a ground fault occurs.

After the safety checks have passed, the EVSE enables the appropriate power path. In AC charging, the station safely switches AC power to the vehicle, while the vehicle's onboard charger performs the AC/DC conversion. In DC fast charging, the station performs the power conversion itself, rectifying grid AC to a DC link and then adapting the DC output to the voltage and current requested by the EV.

To calculate charging fees, the amount of electricity used during a charging session must be measured accurately by energy meters. Since charging fees often depend on real-time energy prices, a reliable connection to backend systems is required. This connection, typically established through Ethernet or wireless networks, provides not only up-to-date pricing, but also user authentication, and secure payment processing.

## Texas Instruments EV Charging Reference Designs and EVMs

To enable faster time-to-market, Texas Instruments offers a complete portfolio of reference designs and evaluation modules (EVMs) addressing all critical EVSE functions. The following overview connects each design to its role in the charging process.

**Table 1. Reference Designs according to functions**

Reference Design	Description	Function
<a href="#">TIDA-010939</a>	Universal EVSE front-end and charging controller platform	Communications / HMI
<a href="#">TIDA-010239</a>	AC level 2 charger platform	Power - AC Charging
<a href="#">TIDA-010985</a>	Resistive-bridge insulation monitoring device for 800V DC systems with large Y capacitors	Protection - DC
<a href="#">TIDA-010237</a>	AC and DC Residual Current Fault Detection	Protection
<a href="#">TIDA-01606</a>	11-kW bidirectional three-phase, three-level (T-type) inverter and PFC	Power - DC Charging
<a href="#">TIDA-010054</a>	Bi-directional, dual active bridge for Level 3 electric vehicle charging stations	Power - DC Charging
<a href="#">TIDA-010999</a>	Direct Current (DC) Electricity Meter	Metering - DC
<a href="#">TIDA-010243</a>	Three-phase current transformer e-meter	Metering - AC

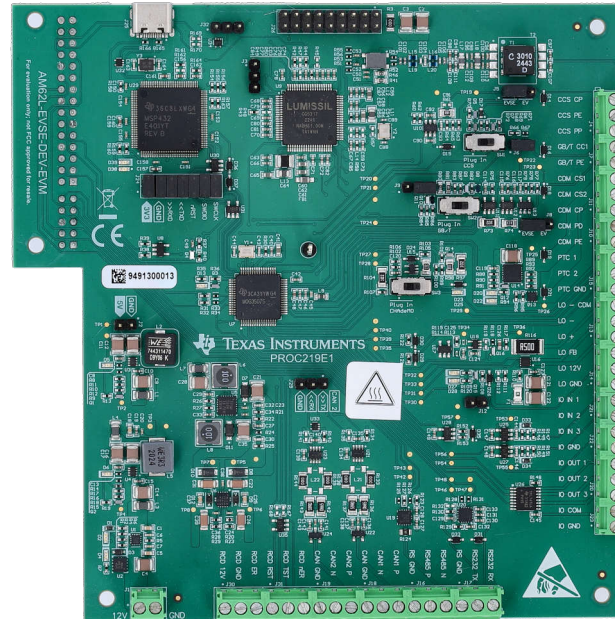
## Communications and HMI

The charging session begins when the EV is connected to the EVSE. Low-level signaling verifies the connection and communicates basic charging capability. If the charging use case requires it, the EVSE then establishes high-level communication with the vehicle.

High-level communication is especially important for DC fast charging, Plug & Charge, and V2G, where the charging station and the EV must continuously exchange battery limits, target voltage, current limits, and session information. This communication enables the EVSE to coordinate power delivery instead of simply switching energy on or off.

The user interface is part of the same system-level experience. A simple charger may only need LEDs and buttons, while a public charging station often uses a display with touch control to guide the user, show charging status, and create a consistent experience across locations. Backend connectivity extends this flow with authentication, pricing, payment, and charge-point management.

The [TIDA-010939](#) EVSE front-end controller design supports this communication and control layer. The complete platform combines the [AM62L EVM \(TMDS62LEVM\)](#), the EVSE front-end controller, and the optional [TIDA-010239](#) AC charging platform. The AM62L processor supports the high-level software stack, HMI, Ethernet, and wireless connectivity, while the EVSE front end manages low-level EV signaling, hosts the HomePlug Green PHY, plug locking, and temperature monitoring at the charging connector.



**Figure 3. TIDA-010939 / AM62L-EVSE-DEV-EVM**

The platform is intended to work with the [AM62L-EVSE-SDK](#). This software includes EVerest, an open-source EV charging stack that supports ISO 15118 and IEC 61851 based charging implementations. Together with the software examples provided, the SDK enables developers to evaluate communication, control, and charging workflows on the EVSE hardware platform without first building a complete test software stack from scratch. [TIDA-010939](#) can be ordered by using part number [AM62L-EVSE-DEV-EVM](#).

While the [TIDA-010939](#) acts as a universal communication controller, the [TIDA-010239](#) expands the design and highlights additional parts that are required for AC charging. It includes an isolated auxiliary AC/DC power stage with supercapacitor backup, efficient relay and contactor drive circuitry, and isolated line-voltage sensing across the relay and contactor to monitor the state of the relay. Together with the EVSE controller, it demonstrates the basic blocks to enable AC charging according to ISO 15118, J1772, and IEC 61851.

### Protection Devices

Once communication and compatibility are established, the EVSE must verify electrical safety before charging can begin. Protection requirements differ between AC and DC charging, but the goal is the same: prevent hazardous touch currents and disconnect power quickly if a fault occurs.

### Insulation Monitoring for DC Charging

In high-voltage DC charging systems, the DC output is isolated from Protective Earth. The insulation resistance must remain high enough to limit leakage current and reduce the risk of electrical shock. An Insulation Monitoring Device (IMD) observes this resistance and reports a fault to the main controller when the insulation becomes insufficient.

The [TIDA-010985](#) reference design implements a resistive-bridge IMD for 800-V DC systems with large Y capacitors. It detects symmetrical and asymmetrical insulation faults and can also measure system capacitance. This makes the design suitable for DC fast-charging systems where large EMI filter capacitances can affect insulation monitoring behavior.

## Residual-Current Detection for AC and DC Faults

In AC-connected EVSE systems, the grid connection is not isolated in the same way as the high-voltage DC output. If a ground fault occurs, the EVSE must detect the residual current and trip a relay or contactor to disconnect power from the grid.

The [TIDA-010237](#) reference design detects AC and DC residual currents by monitoring the phase and neutral conductors. In normal operation, the current sum is zero. During a ground fault, the sum is no longer zero, indicating residual current. The design targets fault thresholds such as 6 mA DC and 30 mA RMS AC according to IEC 62752 and IEC 62955.

## Power Conversion

The power-conversion architecture depends on whether the charger delivers AC or DC energy to the vehicle. In AC charging, the EVSE controls and protects the AC output, while the vehicle's onboard charger converts AC to DC. In DC fast charging, the EVSE performs the conversion outside the vehicle and directly supplies regulated DC power to the battery.

### AC/DC Stage

The first power stage in a DC fast charger is the AC/DC stage. It rectifies the three-phase grid input and creates a stable high-voltage DC link. This stage also provides power factor correction (PFC) and can support bidirectional power flow for V2G applications.

The [TIDA-01606](#) reference design shows how to implement a bidirectional three-phase, three-level T-type active front end and PFC stage. The design uses SiC devices, switching frequencies up to 90 kHz, and an LCL output filter to reduce magnetic component size. The design achieves a peak efficiency of 98.6% and demonstrates three-phase AFE control in the DQ domain. This bidirectional converter enables both DC fast charging and vehicle-to-grid (V2G) applications.

### DC/DC Stage

The second power stage in a DC fast charger is the DC/DC converter. It receives the DC-link voltage and adjusts the output to match the EV battery voltage. During the charging session, the EV continuously communicates voltage and current limits, and the power stage must follow these limits dynamically.

The [TIDA-010054](#) reference design implements a single-phase dual active bridge (DAB) DC/DC converter. The DAB topology supports galvanic isolation, high efficiency, soft-switching operation, high-voltage conversion ratios, and bidirectional power flow. These characteristics make it suitable for modular DC fast chargers and energy-storage applications.

## Energy Metering

At the end of the charging chain, the EVSE must measure how much energy was delivered. Accurate metering is required for billing, diagnostics, and grid-facing energy management. To account for power losses, the measurement should take place close to the point of load so that conversion losses are handled correctly. For DC fast charging, this requires a meter that can measure high DC voltages and currents accurately.

The [TIDA-010999](#) reference design addresses DC energy metering by measuring high DC voltages and currents in a compact form factor. It targets revenue-grade metering applications and supports evaluation across emerging DC power infrastructures, including DC fast chargers.

For AC charging, standard AC electricity metering can be used either inside the EVSE or as a separate module. Depending on the number of phases, current sensor type, and required security features, TI offers several AC metering reference designs, including three-phase current-transformer based designs such as [TIDA-010243](#).



**Figure 4. TIDA-010243**

More information on AC meters can be found in [Electricity Metering Reference Designs Selection Guide](#).

### Summary

An EV charging station can be understood as a sequence of coordinated functions. The EVSE first detects and communicates with the vehicle, authenticates the user, verifies electrical safety, enables the appropriate AC or DC power path, measures the delivered energy, and reports the charging session to backend systems.

Texas Instruments reference designs support these steps with hardware building blocks for communication, HMI, protection, power conversion, energy metering, and connectivity. In addition, TI provides software examples and development platforms that help connect these functions into a working EVSE system, including support for the open-source Everest software stack on the AM62L EVSE development platform.

By combining reference hardware, processor SDK software, and system-level examples, developers can evaluate key EVSE functions earlier, select the designs that match their charging architecture, and shorten the path from concept to implementation.

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