



**GigaDevice**



**WHITE PAPER**

# Enable Reliable and Efficient EV Charging with Highly Integrated GigaDevice MCUs

# Introduction

As the world transitions to clean energy to reduce carbon emissions, using battery powered electric vehicles (EVs) has become the inevitable future for the automotive industry. In 2022 EVs constituted 10% of the total vehicle sales globally. EV sales in the US have also seen explosive growth in 2022, reached around 6% of total vehicle sales in the third quarter of 2022. Many market research reports project EV sales to grow at over 20% CAGR during 2023 to 2030.

While more EVs are on the road, building the infrastructure of EV charging network is certainly the priority around the world. Many European countries have been pushing incentive programs for the installation of both commercial and private charging stations. The U.S. Departments of Transportation and Energy in 2022 announced a nearly \$5 Billion budget plan that would be made available to build out a national electric vehicle charging network. This was an important step towards making EV charging more accessible to consumers.

To address the booming demand of EV charging facilities, GigaDevice offers a rich portfolio of Microcontrollers (MCUs) to serve various functional control needs inside charging station such as power control, communications, and other subsystems control needs.

# EV Charging Station Landscape and Architecture

The electrical charging station is defined by National Electronics Manufacturers Association as Electric Vehicle Supply Equipment (EVSE) which provides electricity to an EV and recharges the batteries. EVSE systems include hardware, software and communication protocols to deliver power safely and efficiently to an electric vehicle. In North America EVSE is classified as Level 1 (120V AC), Level 2 (240V AC) and Level 3 DC charger. DC fast charging is the most powerful option that can reduce the charging time to less than 30 minutes to restore the full battery capacity on an EV.

Most of the low-power AC charging stations are installed in residential and office areas, while the high-power AC and DC charging stations are mainly installed for commercial charging infrastructure.

The below picture shows the difference between AC and DC charging mechanisms for EVs:

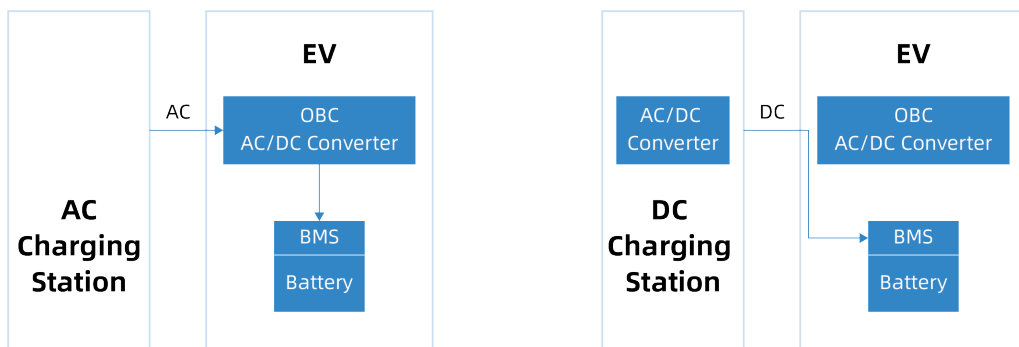


Figure 1 Difference between AC and DC charging for EVs

There are two types of AC charging stations: single-phase or 3-phase system. The EV on-board charger (OBC) will be involved to convert AC to DC and recharge the battery.

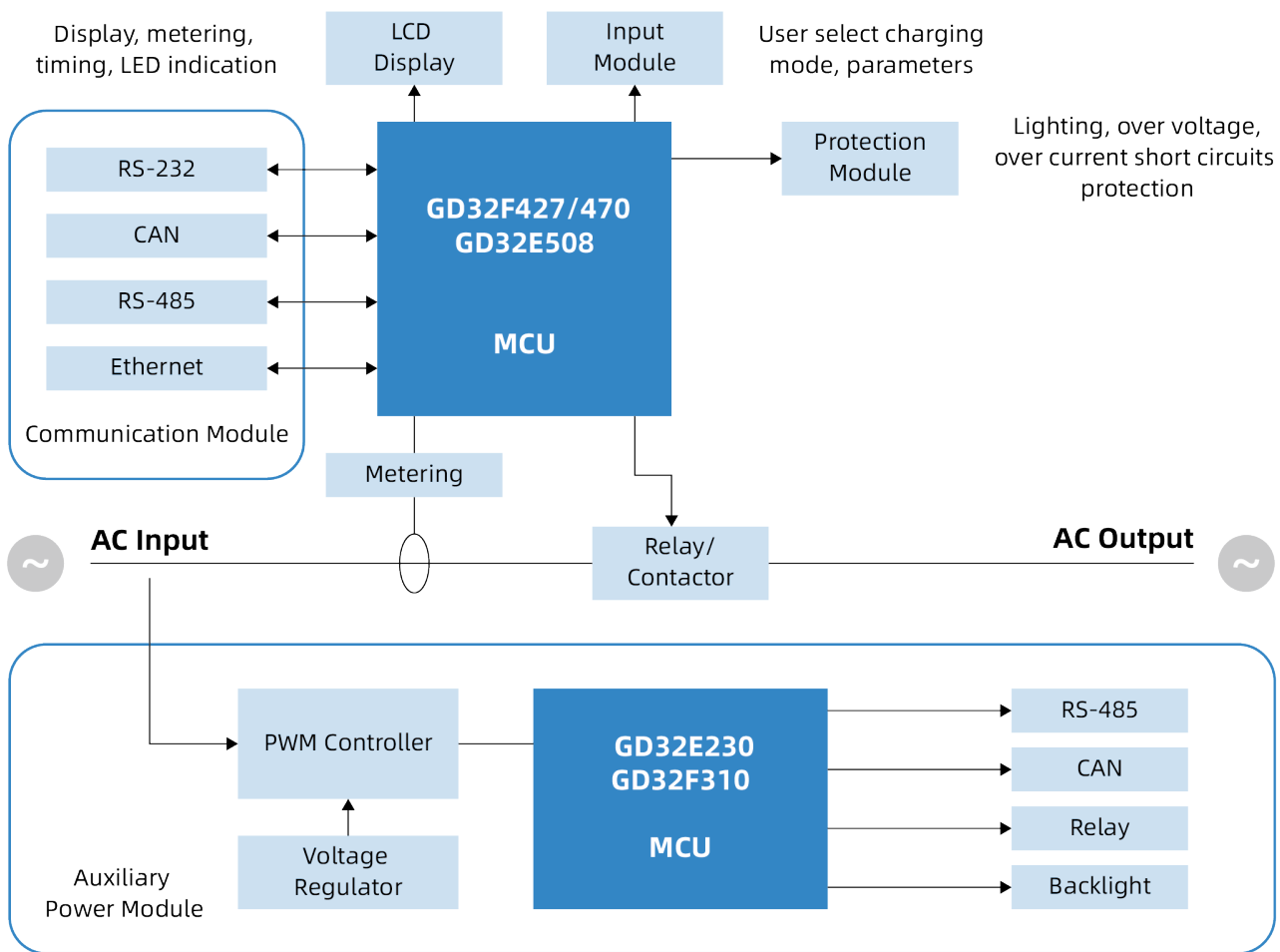


Figure 2. AC charging stations with GigaDevice MCUs

DC charging, also called DC fast charging station converts AC to DC within the EVSE, therefore the EV's on-board AC/DC converter is not required. This makes high-power charging to the EV possible, and it can significantly reduce the charging time.

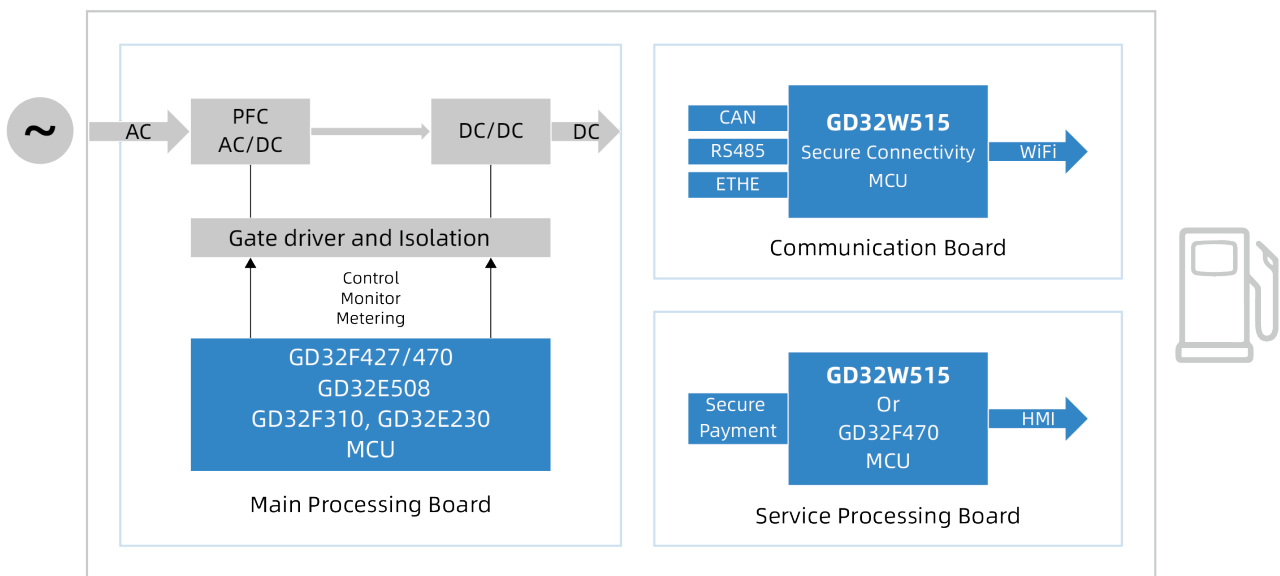


Figure 3. DC fast charging station with GigaDevice MCUs

At a system level, an EV charging station needs to provide power conversion and power management module to supply safe and stable power to an EV, as well as securely monitor and measure the delivery and storage of the power. Furthermore, EV charging station provides functions for communication with intelligent devices. In commercial charging station, it also provides human machine interface (HMI) and payment functions for user or customer interaction.

## GigaDevice MCUs Enable Reliable and Efficient EV Charging Stations

MCU is one of the key components of the EV charging station design. GigaDevice has a scalable 32-bit MCU product family that fits the design consideration of many different charging station types and form factors.

One or more MCUs can be used inside an EVSE to accomplish the below functionalities:

- Control and monitoring of power stages: An MCU controls and monitors the current and voltage for protection and metering functions, it also manages AC to DC conversion, power factor correction, DC to DC conversion, gate driver and switch control to deliver desired power level charging to the vehicles.
- Communication and connectivity: An MCU provides the needed peripherals for communication such as WiFi and Ethernet for network connectivity; CAN bus, SPI and RS485 for on board power electronics control and communications; USB for diagnostics and user interface, etc.
- Security and safety functions: An MCU provides system-level security and safety with hardware security acceleration and SW security algorithm for an EVSE to comply with V2G (Vehicle-to-Grid) communication protocols, as well as functional safety standards, such as ISO15118, OCPP2.x, IEC61508, etc.
- Human machine interface (HMI): An MCU enhances human interaction by various HMI interfaces (e.g. LCD display, touch interface, etc.).

GigaDevice MCU product family has integrated many of these functions into one device and offers a large variety of microcontrollers with CPU frequencies ranging from 48MHz to 240MHz, suitable for many EVSE subsystem needs.

The below picture shows GigaDevice’s rich MCU portfolio:


| Type            | Arm® Cortex®-M 32-bit MCUs (CPU MHz, Flash KB/RAM KB) |                                    |  |  |   | RISC-V MCUs   |  |  |
|-----------------|---|------------------------------------|--|--|---|---|--|--|
| Core            | Cortex®-M23   | Cortex®-M3                         |  | Cortex®-M4   |   | Cortex®-M33   | RISC-V   |  |
| GD32 MCU Family | High-Performance                                      |                                    | <b>GD32F207</b><br>120MHz, 3M/256K<br><b>GD32F205</b><br>120MHz, 3M/256K | <b>GD32F450</b><br>200MHz, 3M/512K<br><b>GD32F407</b><br>168MHz, 3M/192K<br><b>GD32F405</b><br>168MHz, 3M/192K<br><b>GD32F403</b><br>168MHz, 3M/128K | <b>GD32F470</b><br>240MHz, 3M/768K<br><b>GD32F427</b><br>200MHz, 3M/256Kv<br><b>GD32F425</b><br>200MHz, 3M/256K | <b>GD32W515</b><br>180MHz, 2048K/448K<br><b>GD32E507</b><br>180MHz, 512K/128K<br><b>GD32E503</b><br>180MHz, 512K/128K<br><b>GD32E508</b><br>180MHz, 512K/128K<br><b>GD32E505</b><br>180MHz, 512K/128K |  |  |
|                 | Main-Stream   | <b>GD32L233</b><br>64MHz, 256K/32K | <b>GD32F107</b><br>108MHz, 1M/96K<br><b>GD32F103</b><br>108MHz, 3M/96K   | <b>GD32F105</b><br>108MHz, 1M/96K<br><b>GD32F101</b><br>56MHz, 3M/80K  | <b>GD32F307</b><br>120MHz, 1M/96K<br><b>GD32F303</b><br>120MHz, 3M/96K  | <b>GD32F305</b><br>120MHz, 1M/96K<br><b>GD32C/E103</b><br>120MHz, 128K/32K  | <b>GD32VF103</b><br>120MHz, 128K/32K   |  |
|                 | Best Value  | <b>GD32E230</b><br>72MHz, 64K/8K   | <b>GD32F150</b><br>72MHz, 64K/8K   | <b>GD32F130</b><br>48MHz, 64K/8K   | <b>GD32F350</b><br>108MHz, 128K/16K<br><b>GD32F310</b><br>72MHz, 64K/8K   | <b>GD32F330</b><br>84MHz, 128K/16K  |  <b>38 Product Series</b><br><b>450+ Part Numbers</b> |  |
|                 | Specific  | <b>GD32E232</b><br>72MHz, 64K/8K   |  |  | <b>GD32FFPR</b><br>168MHz, 1M/128K  |   | <b>GD32E501</b><br>100MHz, 512K/32K<br><b>GD32EPRT</b><br>168MHz, 384K/96K+4M  |  |

Figure 4. GigaDevice MCU portfolio

GD32F470 is a high performance and highly integrated MCU series, which supports CPU frequency of 240MHz, with up to 3MB Flash and up to 512KB of SRAM. It also integrates external memory controller interface for external SDRAM, SRAM, NOR or NAND flash memory connection. The GD32F470 product family was awarded “Best-in-Show” in 2022 Electronica show in Munich and won the 2022 Asian Gold Award in Taiwan.

GD32W515 is another highly integrated MCU with robust security functionality and optional WiFi connectivity. It offers ARM® Cortex® - M33 CPU up to 180MHz with TrustZone® features. GD32W515 includes up to 2MB Flash and large SRAM of 448KB. GD32W515 supports 2.4GHz Wi-Fi with integrated RF module.

GD32E230 and GD32F3x0 are cost effective MCUs with scalable pin package and memory selections, ideal for monitoring and housekeeping functions of the charging station designs.

# GigaDevice MCU's unique features and differentiations

There are some key challenges in the development of EVSE. GigaDevice MCUs provide unique features to address those challenges to enable robust EV charging solutions.

## 1. Advanced and Super High-Resolution Timers (SHRTIMER):

In EV charging, AC needs to be converted to DC to charge the battery. The conversion takes place either inside the EV with on-board charger or inside the charging station itself. In either case, the AC needs to be rectified using a Power Factor Correction (PFC) to achieve the best efficiency to maximize the energy output. The efficiency of conversion varies based on PWM used to control high and low-side power switches and ensure both power switching are not simultaneously turned on, this is achieved by so-called “dead time” .

GigaDevice MCU with integrated advanced TIMER unit generates PWMs supporting short but safe “dead time” to optimize conversion efficiency.

In high-end application with more precise PWM requirement, GD32E5 series offer SHRTIMER with 90ps resolution for fine granularity control.

## 2. Accurate and safe power monitoring and measurement:

MCU is the key component to deliver and manage power accurately and safely. GigaDevice MCU includes 12-bit high resolution ADC with high sampling rate for current, voltage and temperature data sensing. It can trigger interrupt handling if any abnormal event happens.

To measure delivered power with high accuracy, higher resolution sigma-delta ADC is required in the metering and measurement system of EVSE. GD32W515 includes a HPDF (High Performance Digital Filter) module for external sigma-delta modulator. External sigma-delta modulator can be connected with MCU by the serial interface (e.g. SPI) and data output by sigma-delta modulator can be filtered. HPDF offers the flexibility of choosing a specific analog device according to the EVSE needs.

## 3. Integrated Connectivity Interfaces:

In the evolution of IoT, EV charging station can upgrade the functionality through Over the Air (OTA) firmware updates via network connectivity. It can also provide charging information monitoring over the mobile device through wireless interface. For commercial EV charging station, the charger needs to be connected to the cloud to access and collect the data. GigaDevice MCU provides integrated wired and wireless connectivity interfaces to reduce the design effort and cost.

GD32F3, GD32F4 and GD32E5 series have Ethernet option to support 10/100Mbps speed compliant to IEEE802.3-2002 and IEEE1588-2008 standards.

GD32W515 has wireless option to support Wi-Fi 2.4G with built-in RF module. Its Wi-Fi function complies to WPA3 and protected management frames. It is certified by WFA, RF FCC/CE and ARM PSA.

## 4. Robust Security with TrustZone® and Hardware Security Accelerators:

Security is one of important elements in EV charging stations. GD32W515 integrates high secure Cortex® - M33 core with TrustZone®. It reduces attack of key hardware and software elements and delivers services in a secured environment.

In addition to TrustZone®, GD32W515 also includes security hardware accelerators:

- **TRNG** (True Random Number Generator) to generate 32-bit random value by continuous analog noise.
- **CAU** (Cryptographic Acceleration Unit) to accelerate Data Encryption Standards (DES), Triple DES (TDES), Advanced Encryption Standard AES128/192/256 calculation.
- **HAU** (Hash Acceleration Unit) to implement Hash SHA-1/-224/-256, MD5, HMAC for various applications for validating data integrity.
- **PKCAU** (Public Key Cryptographic Acceleration Unit) to support asymmetric encryption and accelerate RSA, key exchange, Elliptical curve cryptography (ECC), GF(p) operations.
- **EFUSE** with 256\*8bit non-volatile macro to securely store system parameters.

The below picture shows complete security functions offered in GD32W515 MCU:

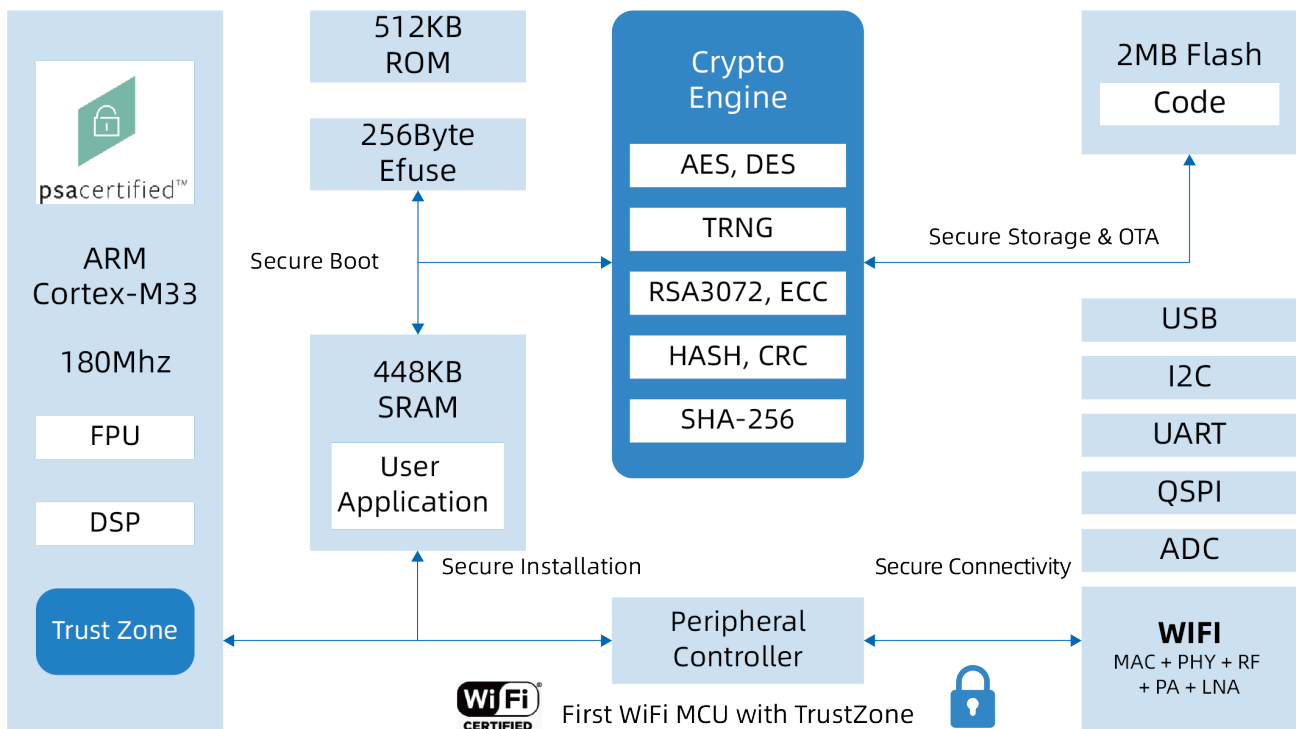


Figure 5. GD32W515 Security functions

## 5. On-board HMI Interface:

In many public EV charging stations, additional services (e.g. customer interaction, payment, value-add customer services, etc.) are offered. Integrated HMI is certainly a key feature to be considered in the commercial EV charging station development. GigaDevice MCUs provide various HMI interface for designer to optimize development:

- **TSI (Touch Sensing Interface)** in GD32W515 and GD32F350 provides a convenient option for touch keys, sliders and capacitive proximity sensing applications.
- **TLI (TFT-LCD Interface)** module in GD32F4 handles the synchronous LCD interface and provides pixel data, clock and timing signals for passive LCD display up to 2048 x 2048 resolution.
- **SLCD (Segment LCD)** controller in GD32L233 can directly drive the monochrome passive LCD displays by creating the AC segment and common voltage signals automatically. It can support up to 32 segments and 8 commons of display for the cost-sensitive EV charging solutions.
- **DCI (Digital Camera Interface)** module in GD32F4 and GD32W515 can capture video or picture from camera. It supports various colour space such as YUV/RGB as well as compression format (e.g. JPEG).

## Conclusion

EV charging station around the globe is only to grow to power the rapidly increasing electric vehicles on the road. GigaDevice as one of the global top 10 MCU suppliers is well positioned to support the EV charging network build out with its highly efficient and quality devices. With scalable portfolio and highly integrated rich feature set, GigaDevice offers one stop shop for all EV charging station MCU needs, enable reliable solutions for green energy transformation.

## Reference:

1. [EVs Hit 10 Percent Of Global New Car Sales, BYD And Tesla Lead \(insideevs.com\)](https://www.insideevs.com/news/evs-hit-10-percent-of-global-new-car-sales-byd-and-tesla-lead)
2. [Fully Electric Vehicles Reached ~6% Of Auto Sales In USA In 3rd Quarter - CleanTechnica](https://www.cleantechnica.com/2022/09/08/fully-electric-vehicles-reached-6-percent-of-auto-sales-in-usa-in-3rd-quarter/)
3. [Global Electric Vehicle Market \(2022 to 2030\) - Rising Demand for Electric Vehicles in Automotive and Transportation Sectors Presents Opportunities - Research And Markets.com | Business Wire](https://www.researchandmarkets.com/research/10000000/global-electric-vehicle-market-2022-to-2030/)



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