Design Guide: TIDA-010939

Electric Vehicle Supply Equipment Front-End Controller Reference Design

Description

This reference design is an Electric Vehicle Supply Equipment (EVSE) front-end controller which acts as the central communication module for the EV charging process. The design supports AC and a wide range of global DC charging standards, including Combined Charging System (CCS), Guobiao/Tuijian (GB/T), and Charge de Move (CHAdeMO).

Resources

TIDA-010939	Design Folder
TMDS62LEVM, MSPM0-SDK	Tool Folder
AM62L-PROCESSOR-SDK	Tool Folder
MSPM0G3507, AM62L, TLV1805	Product Folder
TS12A4515, TPS281C100, DRV8220	Product Folder
THVD2429, TRSF3221E	Product Folder
TCAN1044A-Q1, TPL7407LA, TLV9151	Product Folder
TLV7011, SN74LVC1G17	Product Folder

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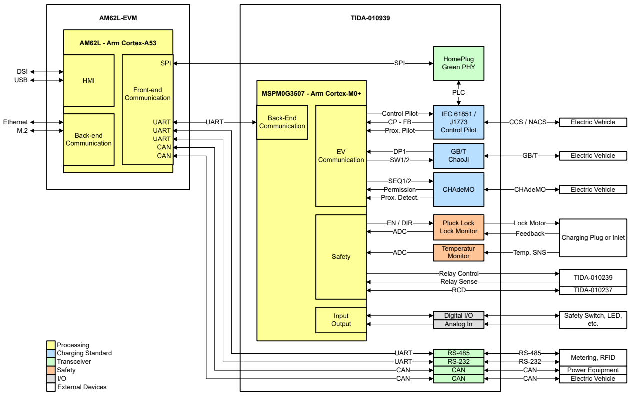
Features

- J1772 and International Electrotechnical Commission (IEC) 61851 compliant Control Pilot – Full support for AC charging control signaling
- Power Line Communication (PLC) – High-level communication according to ISO 15118
- Relay control and safety features – Including integrated temperature monitoring
- Multiple communication interfaces – Controller Area Network (CAN), RS-485, RS-232, and Ethernet for control of power conversion units, external metering devices, peripherals, and networking
- Display human-machine interface (HMI) support – Display Serial Interface (DSI) connector on the AM62L-EVM for HMI integration

Applications

- EV charging station HMI module
- AC charging (pile) station



1 System Description

EV charging stations are complex systems that require multiple components to work together seamlessly to safely charge an electric vehicle (EV). The process begins when the vehicle is plugged into the charging station, also known as Electric Vehicle Supply Equipment (EVSE). At this point, a communication handshake takes place, to make sure the vehicle and station are compatible and ready to charge.

In the case of DC fast charging, the vehicle continuously communicates the required voltage level and current limits to the station. This must be followed and dynamically adjusted by the power modules, which are responsible for converting alternating current (AC) from the grid into the direct current (DC) needed to charge the EV battery.

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, such as charge-point management systems, is required. This connection, typically established through Ethernet or wireless networks, provide not only up-to-date pricing, but also user authentication, and secure payment processing.

Many modern charging stations feature integrated display with touch control to provide not only a clean and responsive user interface, but also to create a consistent look and experience across different locations – making it easier for users to recognize and trust the charging infrastructure.

Connecting all subsystems required for EV charging and coordinating the interaction is the responsibility of the central control unit – the EVSE Front-End Controller which is demonstrated with this design.

1.1 Key System Specifications

Table 1-1. Key System Specifications

FEATURE	TIDA-010939 | AM62L EVM
Main CPU	AM62L(1)
Front-End Controller	MSPM0
Power Supply	10.8V–13.2V, maximum 5A
Charging Interface	IEC 61851 | SAE J1772 | ISO 15118 | GB/T 18487(2) | GB/T 20234^{2} (2) | CHAdeMO(2)
Communication	2 × CAN | 2 × 1000Base-T(1)
	1 × RS-232 | 1 × RS-485
Inputs and Outputs	2 × Digital Input (24V tolerant), 1 × 0V–12V Analog Input
	3 × Digital Output (Low-Side Switch)
Temperature Inputs	2 × Temperature Sensor Input
Display Support	1 × Display with MIPI DSI(1)
Optional Connectivity	Wi-Fi®, *Bluetooth*® through M.2(1)

(1) On the AM62L-EVM.
(2) Only hardware support at this time.

2 System Overview

The TIDA-010939 reference design is part of the TI-EVSE development platform for AM62L and represents a universal charging controller for AC and DC charging stations with open-source software stack. The complete platform consists of three separate parts, the AM62L-EVM, TIDA-010939, and the TIDA-010239.

The AM62L-EVM, serving as the main CPU, running the EVerest Open Source Software charging stack on Linux® is handling the digital communication with the EV. In addition to that, the EVM supports Ethernet and Wireless Connectivity for communications with the backend or a charge point management system, respectively. If required, the EVM can be used to support a display for HMI as well.

The TIDA-010939 acts as the front-end controller based on the MSPM0 microcontroller. The design controls the analog handshakes with the EV as well as safety functions like locking the charging plug and monitoring the temperature of the high-voltage contacts inside. The MSP communicates through Universal Asynchronous Receiver Transmitter (UART), a serial communication protocol with the AM62L.

Add the TIDA-010239 to include an AC charger. This reference design completes the platform with an isolated AC to DC power supply with backup power in case of a grid outage. The TIDA-010239 contains the high-voltage contractor and a driver to connect the electric vehicle to the grid. Additionally, the TIDA-010239 detects if the relay is welded.

The primary function of the charging controller is to connect all the systems required for charging together, and handling the communication between these systems and the electric vehicle. The communication with an EV is always done with an analog handshake. The exact requirements vary between the different charging standards. The TIDA-010939 offers circuitry to support the following standards Combined Charging System 1 and 2 (CCS1 CCS2), North American Charging Standard (NACS), Guobiao/Tuijian (GB/T), and Charge de Move (CHAdeMO).

In addition to the analog handshake, a second, high-level communication is required for DC-charging. In this case, not the onboard charger (OBC) of the EV, but the EVSE serves as the charger and needs to detect which voltage level and current limit is required to safely charge the EV battery. The standard ISO15118, which is used for CCS1, CCS2, and NACS, specifies Powerline Communication through a HomePlug Green PHY (HPGP) as physical layer, while GB/T and CHAdeMO use the CAN for this kind of communication. Therefore, the TIDA-010939 includes an HPGP and a dedicated CAN transceiver. Both elements are connected to the AM62L, as the processor handles the digital communication.

Additional safety functions which are required by the charging standards are either included on the TIDA-010939, or can be added by external TIDA reference designs. The onboard safety functions include temperature monitoring of the contacts in the charging cable and circuitry to control a motorized locking mechanism, designed to prevent removal of the cable during the charging cycle. The TIDA-010939 also includes connections for an external residual current detection (RCD) device, given by the TIDA-010237. To be able to connect further devices for testing, like a safety switch, or to control status LEDs, the TIDA-010939 supports two digital inputs (24V tolerant), one analog input (0V–12V) and three digital outputs (low-side switch).

To enable communication with peripherals like energy meters and power modules, the TIDA-010939 supports transceivers for RS-485, RS-232, and CAN.

2.1 Block Diagram

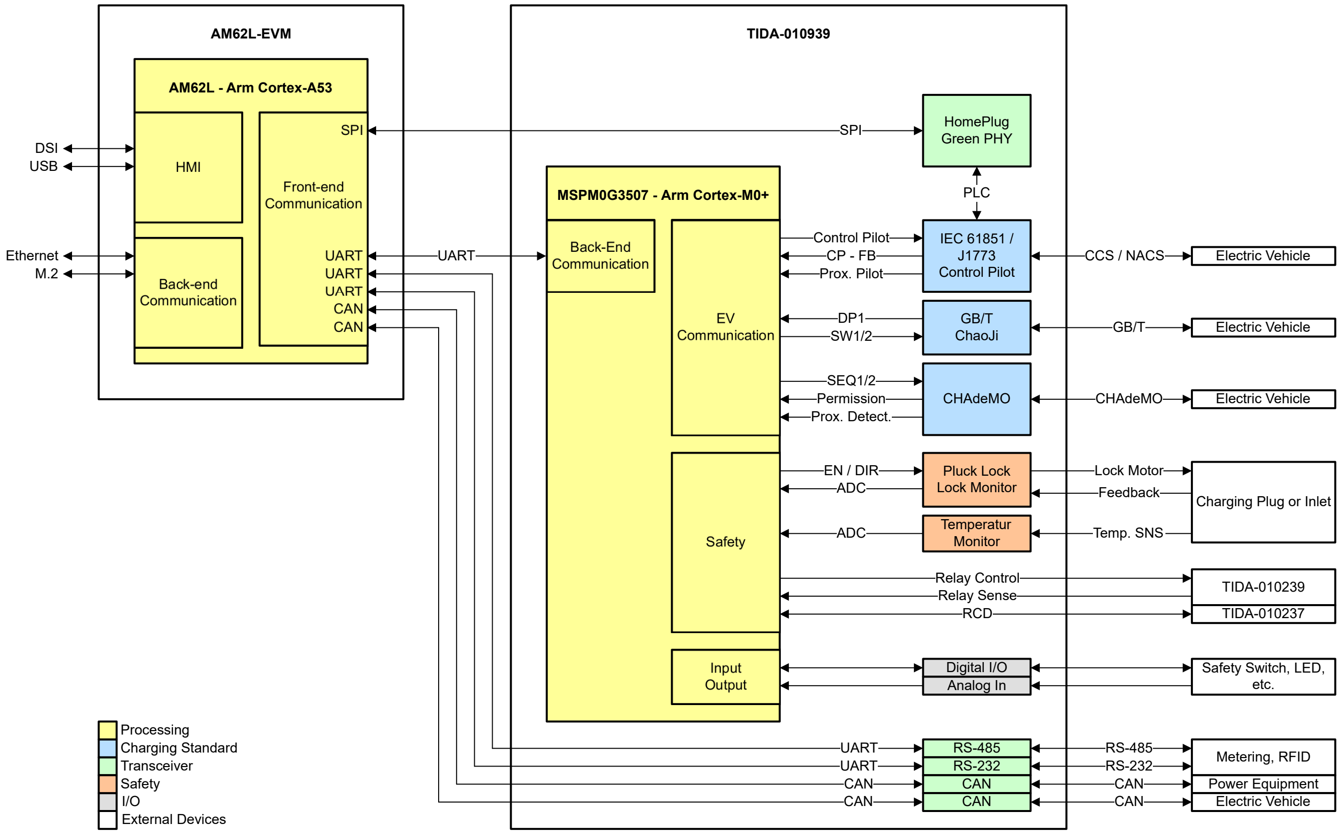


Figure 2-1. TIDA-010939 Block Diagram

2.2 Design Considerations

2.2.1 Control Pilot

The Control Pilot (CP) enables the basic communication between the electric vehicle and the charging station. Therefore, the charging station generates a ±12V, 1kHz pulse-width modulated (PWM) signal. The duty cycle of this signal is used to transmit the current capability of the EVSE to the electric vehicle, or to indicate that the high-level communication protocol through the HPGP is required.

The EV on the other side, loads the CP signal with different load resistances, causing a voltage drop on the CP line. Based on the voltage level, different states like *ready to charge* are indicated by the EV and can be detected by the EVSE.

This control pilot signal is used by the standards IEC 61851, SAE J1772, and GB/T 18487.

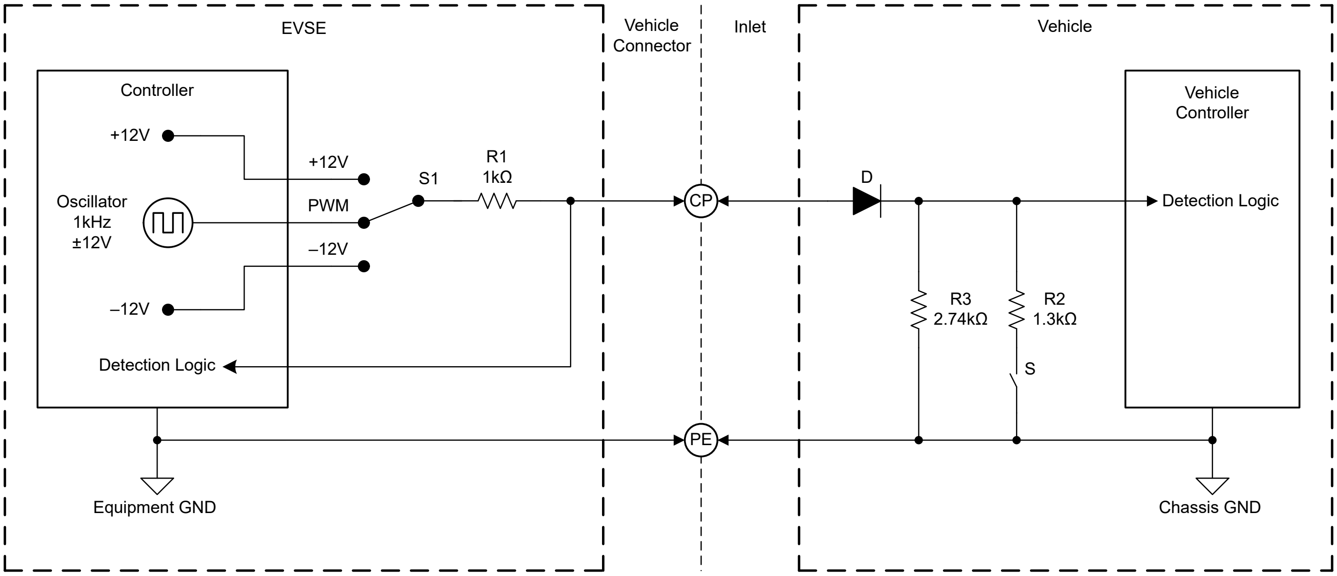


Figure 2-2. Typical Control Pilot Circuit

2.2.1.1 Signals

Table 2-1. Control Pilot Signals

NAME	MSP PIN	FUNCTION	DESCRIPTION
MSP_PWM_CP	PB10 (62)	PWM	Control pilot, DC, 1kHz PWM signal
MSP_ADC_CP	PA27(31)	ADC	Feedback signal, reads out the CP voltage level
MSP_ADC_PP	PA25(26)	ADC	Proximity detection

2.2.1.2 Duty Cycle

The duty cycle of the pilot signals communicates the limit of current the EVSE is capable of supplying to the vehicle in AC charging; the vehicle can then use up to that amount of current for the charging circuitry. This current rating is primarily determined by the electromechanical components in the EVSE, such as conductors, relays, contactors, and the service connection.

The relationship between duty cycle and current is defined by two different equations depending on the current range specified; for a 6A to 51A service (10% ≤ duty cycle ≤ 85%), see Equation 1.

$$\text{Duty cycle} = \frac{\text{Amps}}{0.6} \tag{1}$$

Equation 2 is for a higher service in the 51A to 80A range (85% < duty cycle ≤ 96%).

$$\text{Duty cycle} = \frac{\text{Amps}}{2.5} + 64 \tag{2}$$

If digital communication is required, the duty cycle must be set to 5% (only in IEC 61851 and SAE J1772).

Table 2-2. Vehicle Control Pilot Duty Cycle Interpretation

AVAILABLE LINE CURRENT (A)	NOMINAL DUTY CYCLE PROVIDED BY EVSE
Digital communication is used to control an offboard DC charger or communicate available line current for an onboard charger.	5 %
5	8.3%
15	25%
30	50%
40	66.6%
65	90%

Table 2-2. Vehicle Control Pilot Duty Cycle Interpretation (continued)

AVAILABLE LINE CURRENT (A)	NOMINAL DUTY CYCLE PROVIDED BY EVSE
80	96%

In this design, the PWM is generated by a timer module on the MSPM0 microcontroller. For AC chargers, the current rating can typically be set as a permanent value in the firmware because the current rating is so tightly coupled to the external hardware.

2.2.1.3 Signal State

The EVSE connection and negotiation occurs through various states of the PWM signal and load resistances of the vehicle. Table 2-3 highlights these states.

Table 2-3. Pilot Signal State Parameters

STATE	PILOT HIGH VOLTAGE	PILOT LOW VOLTAGE	FREQUENCY	RESISTANCE	DESCRIPTION
State A	12V	N/A	DC	N/A	EV not connected
State B1	9V	N/A	DC	2.74kΩ	EV connected, EVSE not ready to supply energy
State B2	9V	–12V	1kHz	2.74kΩ	EV connected, EVSE ready to supply energy
State C	6V	–12V	1kHz	882Ω	EV charging
State D	3V	–12V	1kHz	246Ω	EV charging, ventilation required
State E	0V	0V	N/A	–	Error
State F	N/A	–12V	N/A	–	Unknown error

States A, B, and C are the core functionality and define the normal operation. An EVSE typically performs several self-tests upon initially powering on and then enters State A. When ready, the normal connection process follows several steps:

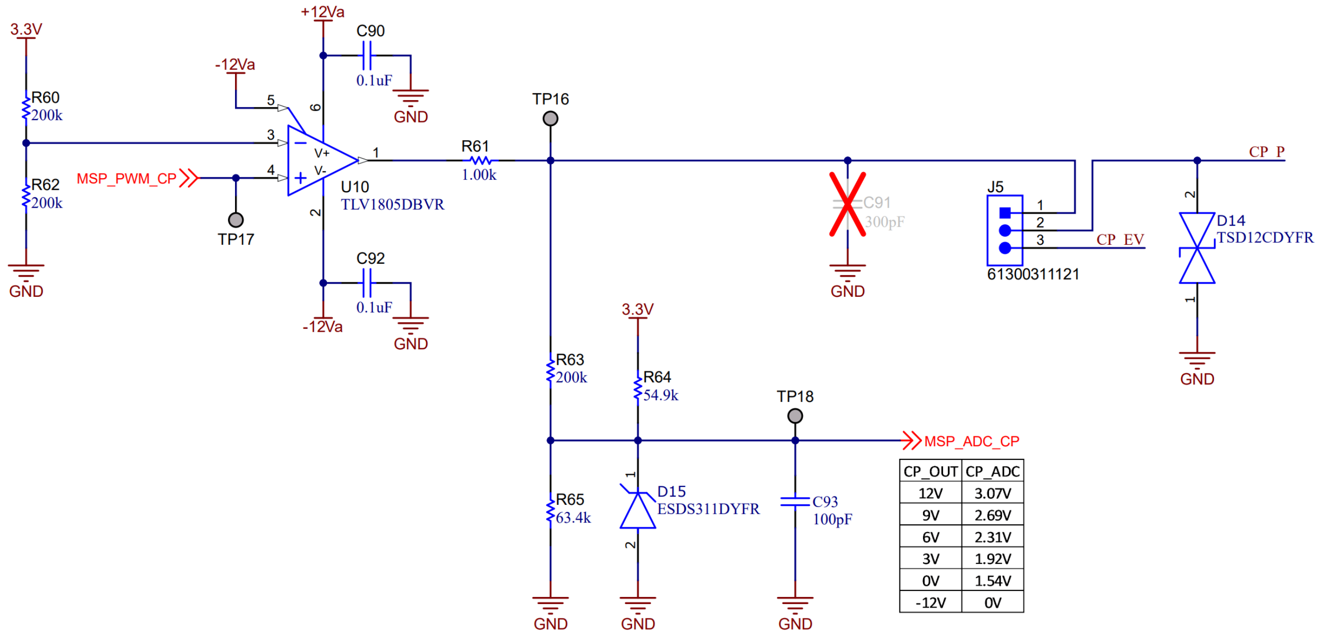
1. State A: The EVSE puts 12V on the pilot wire. This transmission signals the vehicle when the plug is connected.
2. State B1: When the plug is connected, the vehicle places a 2.74kΩ load on the pilot line, which drops the voltage to 9V.
3. State B2: The EVSE moves to State B2, where the EVSE enables the PWM, which signals the vehicle how much current the vehicle can draw. The EVSE also closes the relays, providing power to the vehicle.
4. State C: The vehicle starts to draw power and switches to the 882Ω load, which drops the voltage to 6V, signaling the EVSE that charging has started.

Most vehicles continue to pull low amounts of power in state C, even when fully charged, so the charging process is ended by unplugging the cable, which returns the voltage to 12V. The EVSE measures this process and closes the relays and returns to State A.

Additional error handling such as missing diodes in the vehicle or an improper connection can be detected and handled by the EVSE by cutting the power, as well.

2.2.1.4 Control Pilot Signal Circuit

Figure 2-3 shows the full schematic of the control pilot subsystem.



CP_OUT	CP_ADC
12V	3.07V
9V	2.69V
6V	2.31V
3V	1.92V
0V	1.54V
-12V	0V

Figure 2-3. Control Pilot Signal Generator Circuit

The bipolar ±12V control pilot signal is required to travel down several meters of cable and through a load resistance. Therefore, an amplifier must have a minimum of ±12mA sinking and sourcing current with a rise time and fall time < 2µs, per SAE J1772 specifications.

To accommodate these parameters, an amplifier with a wide input range and reasonable power output is selected. The TLV1805 device has a voltage rating of ±18V and a current rating of 475mA, making the device a good match for the application. In addition, while most EVSEs do not require an automotive qualification, a Q1-rated variant of the TLV1805-Q1 device exists, if this feature is desired. The amplification circuit is a simple rail-to-rail output configuration of the TLV1805 device, with the MCU I/O driving the positive input.

The output of the pilot amplifier is also fed into a simple voltage divider so that the MCU can measure the voltage during operation and detect the load resistance of the vehicle. To take variances such as resistor tolerances, cable resistance, ground shift, chassis resistance, active accessory devices (air conditioning, rear defog, and so forth), or other factors that can shift these values into account, the SAE J1772 standard recommends following boundary voltages as Table 2-4 shows.

Table 2-4. Control Pilot Boundary Voltages

STATE	MINIMUM VOLTAGE	NOMINAL VOLTAGE	MAXIMUM VOLTAGE
State B	8V	9V	10V
State C	5V	6V	7V
State D	2V	3V	4V

2.2.1.5 EV Simulation Circuit

The TIDA-010939 design includes circuitry to simulate the behavior of an electric vehicle. Configuration is selected through jumper J5: shorting pins 1–2 set the board to EVSE mode, which connects the control pilot signal generator to the CP output at screw terminal J4. Shorting pins 2–3 sets the circuit to EV mode, which connects the EV simulation circuitry to the CP output.

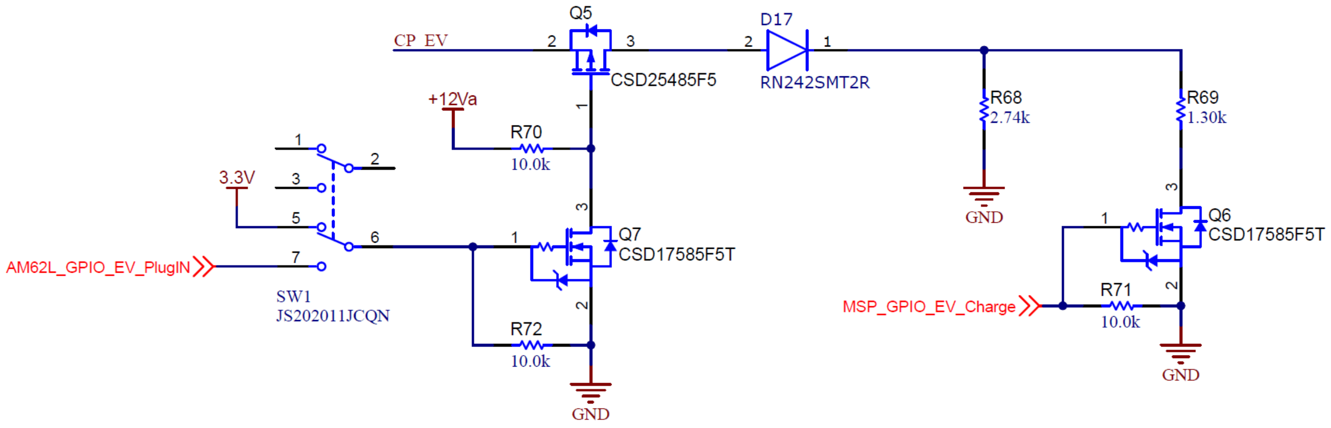


Figure 2-4. CCS EV Simulation Circuit

In EV mode, SW1 simulates connecting the vehicle by loading the CP line with a 2.74kΩ resistor, corresponding to State B – EV connected. To transition to State C – EV charging, the microcontroller output MSP_GPIO_EV_Charge must be set high, which connects resistor R69 (1.3kΩ) in parallel to the CP line.

Diode D17 makes sure that only the positive half of the PWM signal is passed through, indicating to the EVSE that a valid load is present.

2.2.2 HomePlug Green PHY - Powerline Communication

While the basic signaling is handled by the control pilot, the DIN 70121, ISO 15118 standard (*Road vehicles - Vehicle-to-grid communication interface)* is developed to allow more advanced communication between electric vehicles and charging stations. This standard introduces secure communication and high-level data exchange, including encryption and authentication mechanisms.

ISO 15118 standardizes the communication of the charging parameters, such as voltage levels, current limits, and charging states which are constantly updated during a charging session. In addition to that, the standard enables advanced features like plug and charge, enabling payment without user interaction or Vehicle-to-Grid (V2G) for bidirectional power transfer.

Part 3 of ISO 15118 defines the HPGP standard as physical layer for this kind of communication. The HPGP standard is a powerline communication (PLC) architecture, operating in the 2MHz to 30MHz frequency band and supports data rates up to 10Mbps. The TIDA-010939 supports the Lumissil® IS32CG5317 HPGP device. The PHY is connected to the AM62L through a serial-peripheral interface (SPI).

For the latest information and support, contact Lumissil:

- https://www.lumissil.com
- https://cbu-support.lumissil.com/

2.2.2.1 HomePlug Green PHY Circuit

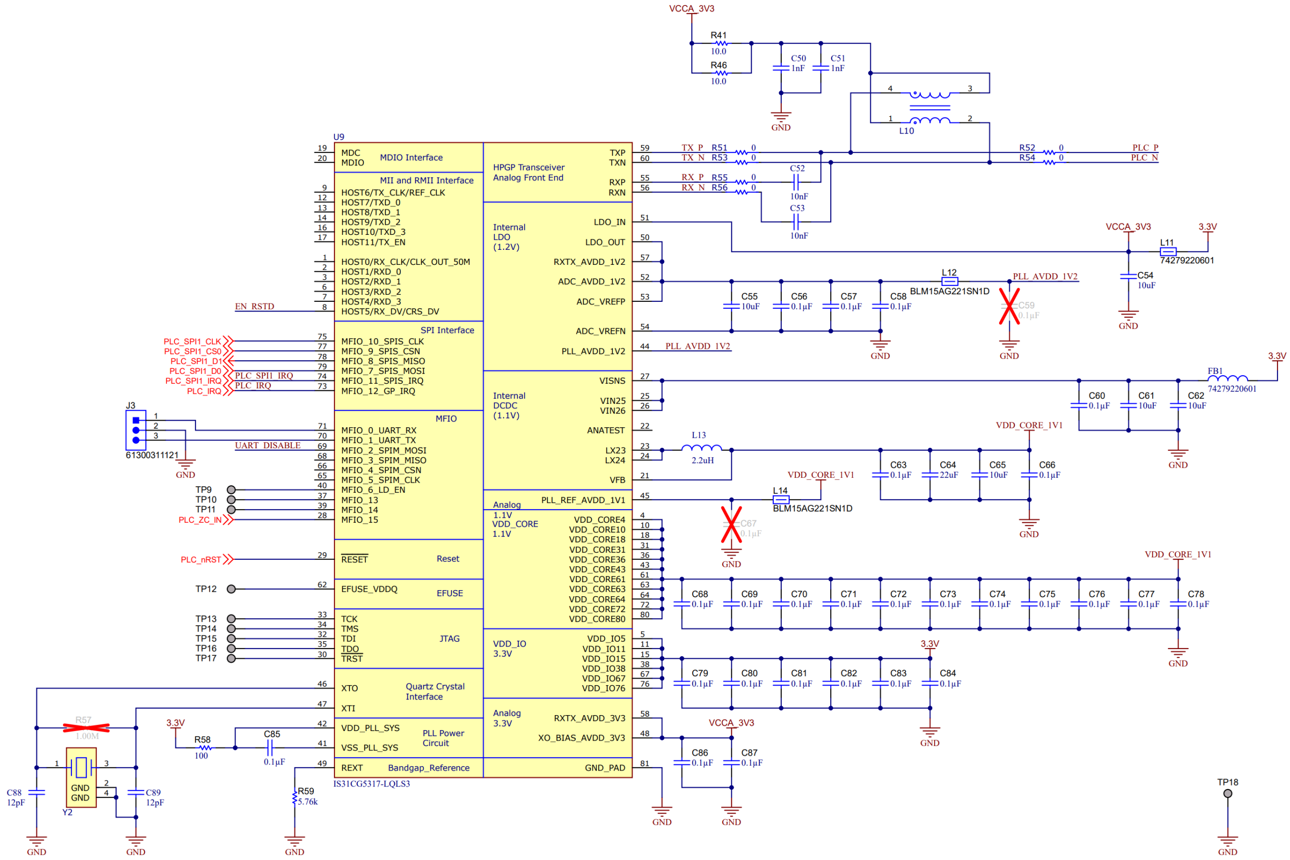


Figure 2-5. HomePlug Green PHY Circuit

2.2.3 Proximity Pilot

In comparison to internal combustion engine vehicles, electric vehicles are often charged while parked for extended periods. This increases the likelihood that drivers can forget the vehicle is still connected to the charging station. To address this, the Proximity Pilot (PP) is used to prevent the EV from being driven away, while still physically connected to the charger. This is achieved by implementing a circuit using a resistor connected to the protective earth (PE) pin, allowing the vehicle to detect the presence of the charging cable.

The implementation of the PP signal differs between Type 1 or NACS and Type 2 connectors. Type 1 charging cables are typically permanently attached to the charging station, while Type 2 cables often feature plugs on both ends, making them detachable. In case of the exchangeable Type 2 cable, the PP also serves a second function. The PP indicates the current capacity of the cable by using different resistor values. This prevents the system from exceeding the rated capacity of the cable, thereby avoiding overheating and potential safety hazards.

2.2.3.1 Type 1 and NACS

The Type 1 plug has a button with a mechanical lever that hooks into the inlet of the EV. To disconnect the plug, the button must be pressed activating a switch inside the plug. This leads the PP resistor inside the plug to change from 150Ω to 480Ω, signaling the EV and the EVSE to stop the charging session and disconnect the contacts from the high voltage.

Monitoring of the Proximity Detection Circuit by the EVSE is optional for AC charging but mandatory for DC charging. In this case, charging is only allowed after the EVSE verifies the PP and the operation of switch (S3).

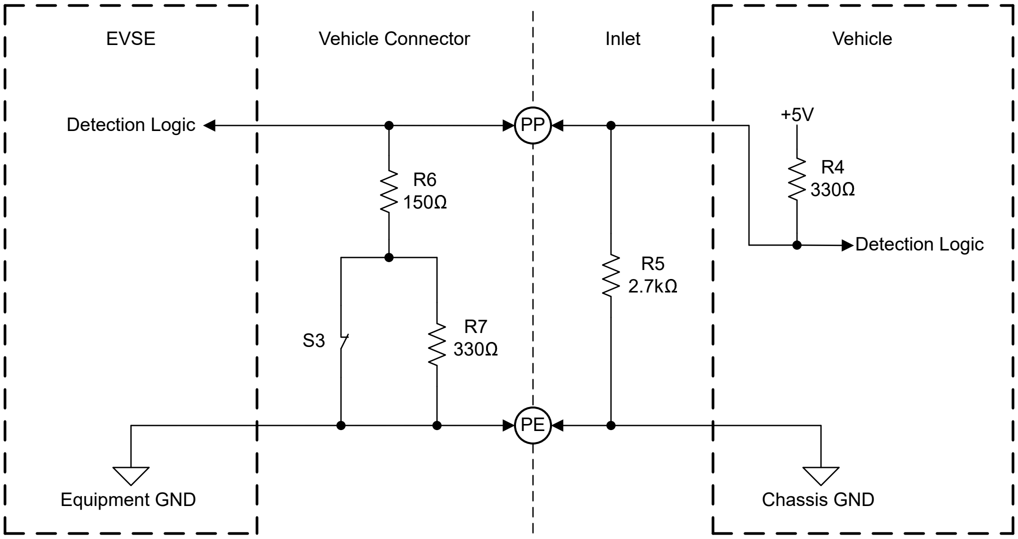


Figure 2-6. Proximity Pilot Type 1

Table 2-5. Proximity Pilot Type 1 States

STATE	CONNECTOR RESISTOR VALUE	VOLTAGE
EV not connected	–	0V
EV connected – latch (S3) is depressed	480Ω	2.76V
EV connected – latch (S3) is released	150Ω	1.51V

2.2.3.2 Type 2

If a detachable cable assembly is used, the proximity contact serves two tasks simultaneously. First, for proximity detection and second, for coding of the current capability of the cable assembly. Defined by the value of resistor (R_C) inside the plug, the EV and the EVSE can read out the current capability and interrupt the current supply if the current capability of the cable is exceeded. For fixed cable assemblies, only the EV monitors the PP as the current capability of the cable is known by the EVSE.

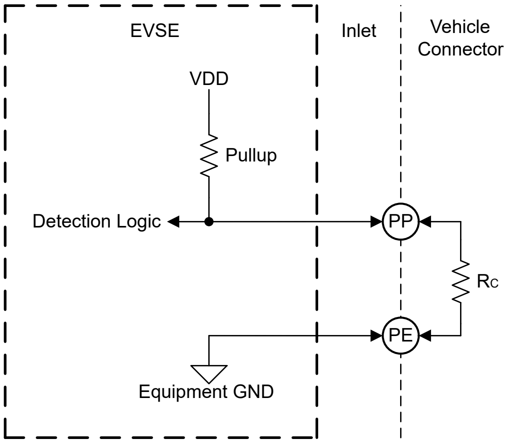


Figure 2-7. Proximity Pilot Type 2

Table 2-6. Type 2 - Resistor Coding for Vehicle Connectors and Plugs

CURRENT CAPABILITY	R_C RESISTOR VALUE	MSP ADC VOLTAGE (PULLUP = 1kΩ)
13A	1.5kΩ	1.98V
20A	680Ω	1.34V
32A	220Ω	0.595V
63A	100Ω	0.3V

2.2.3.3 Proximity Detection Circuit

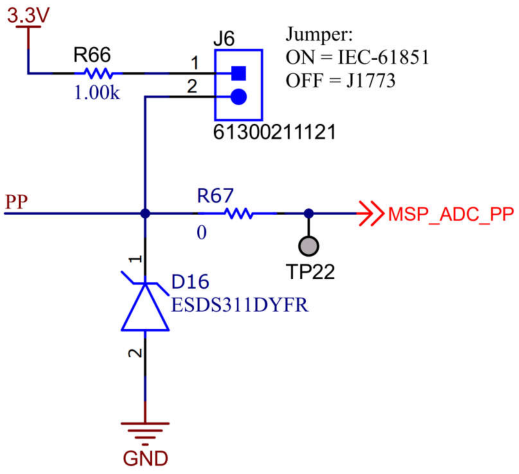


Figure 2-8. Proximity Detection Circuit

The PP signal is routed directly to the ADC input of the MSPM0. To protect the microcontroller, an ESD protection diode is placed at the PP connector input. Jumper J6 can be used to connect a pullup resistor to the signal for operation with Type 2 plugs. When a Type 1 plug is used, the PP signal is instead pulled up by the EV.

2.2.4 GB/T – ChaoJi

The Chinese national charging standard GB/T is a set of standards covering both AC and DC fast charging. While CCS uses a single plug for both AC and DC charging – extending the AC connector with two additional pins to carry the DC power – GB/T uses two separate connectors for AC and DC charging. AC charging is done similar to the Control Pilot and Connection confirmation circuit described in Section 2.2.1 and Section 2.2.3.

For DC charging, GB/T uses two types of signaling. Charge Confirmation 1 (CC1) and Charge Confirmation 2 (CC2) indicate the vehicle is connected and ready to charge, with analog communication between the EVSE and the EV carried on the CC1 line. S+ and S− form a differential pair for high-level CAN communication, exchanging parameters such as required voltage, current, and status messages.

The EVSE monitors the CC1 line at Detection Point 1 (DP1), where specific voltage levels relate to different charging states. The exact voltage levels differ between GB/T and the ChaoJi standard (also referenced as CHAdeMO 3.0).

2.2.4.1 Signals

Table 2-7. GB/T - ChaoJi Signals

NAME	MSP PIN	FUNCTION	DESCRIPTION
MSP_GPIO_GBT_S0	PB25 (27)	GPIO	S0 enable signal
MSP_GPIO_GBT_S1	PB24 (23)	GPIO	S1 enable signal
MSP_ADC_GBT_DP1	PA26 (30)	ADC	CC1 feedback at detection point 1 (DP1)

2.2.4.2 GB/T

Before the charging process begins, the EVSE determines whether the vehicle plug is fully inserted into the vehicle socket by measuring the voltage at Detection Point 1 (DP1). If the plug is fully connected, the voltage at DP1 is approximately 4V. In this state, the locking mechanism must be engaged, and digital communication can be initiated to proceed with the charging process.

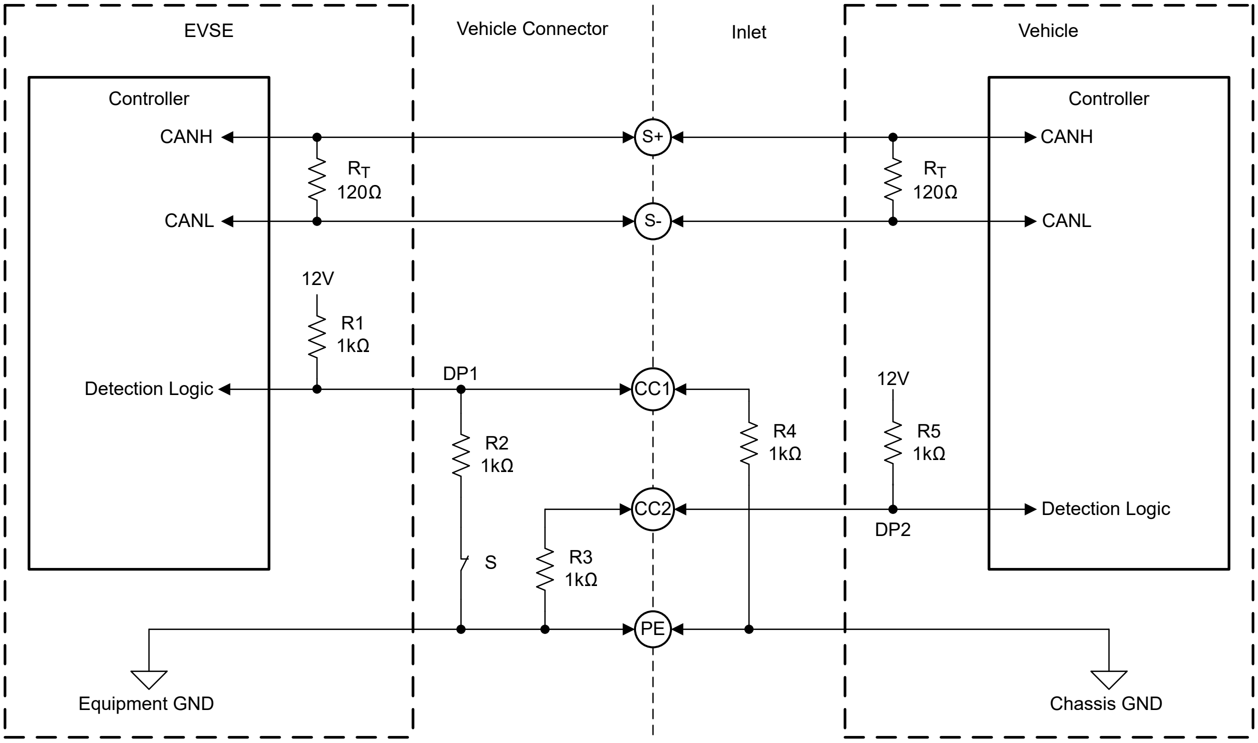


Figure 2-9. GB/T Circuit

During charging, the EVSE continuously monitors the DP1 voltage. If the connection changes from fully connected to unreliable, or if the normally closed switch S inside the charging plug opens – the DP1 voltage rises to approximately 6V. In this case, the EVSE must immediately stop the charging process.

Table 2-8. GB/T Signal State Parameters

STATE	VOLTAGE
EV disconnected	6V (5.2V–6.8V)
Latch depressed – no connection with EV	12V (11.4–12.6)
EV connected	4V (3.2V–4.8V)

2.2.4.3 ChaoJi

ChaoJi extends the GB/T signaling circuit while remaining backwards compatible. On the EVSE side, ChaoJi adds resistor R1' and the switches S0 and S1 to the CC1 line.

S0 is optional and is closed only after charging authorization (for example, after RFID card swipe) to enable the CC1 signal. The purpose of the S0 switch is to reduce the risk of a short circuit between the 12V CC1 supply and protective earth (PE) when the connector is not in use. S1 is controlled by the charger to connect R1' when the charging readiness signal is sent.

Inside the vehicle connector, switch S3 and resistor R2 are optional components used to verify the integrity of the PE and CC1 lines at the EVSE before the coupler is mated.

Once charging conditions are met, the EVSE closes S1, connecting R1' to indicate readiness. Both EVSE and EV continuously monitor the voltage at Detection Points 1 and 2 to determine whether charging is permitted or if an abnormal state occurs. In the event of an emergency during charging, S1, S2, or both switches must be opened to stop the process immediately.

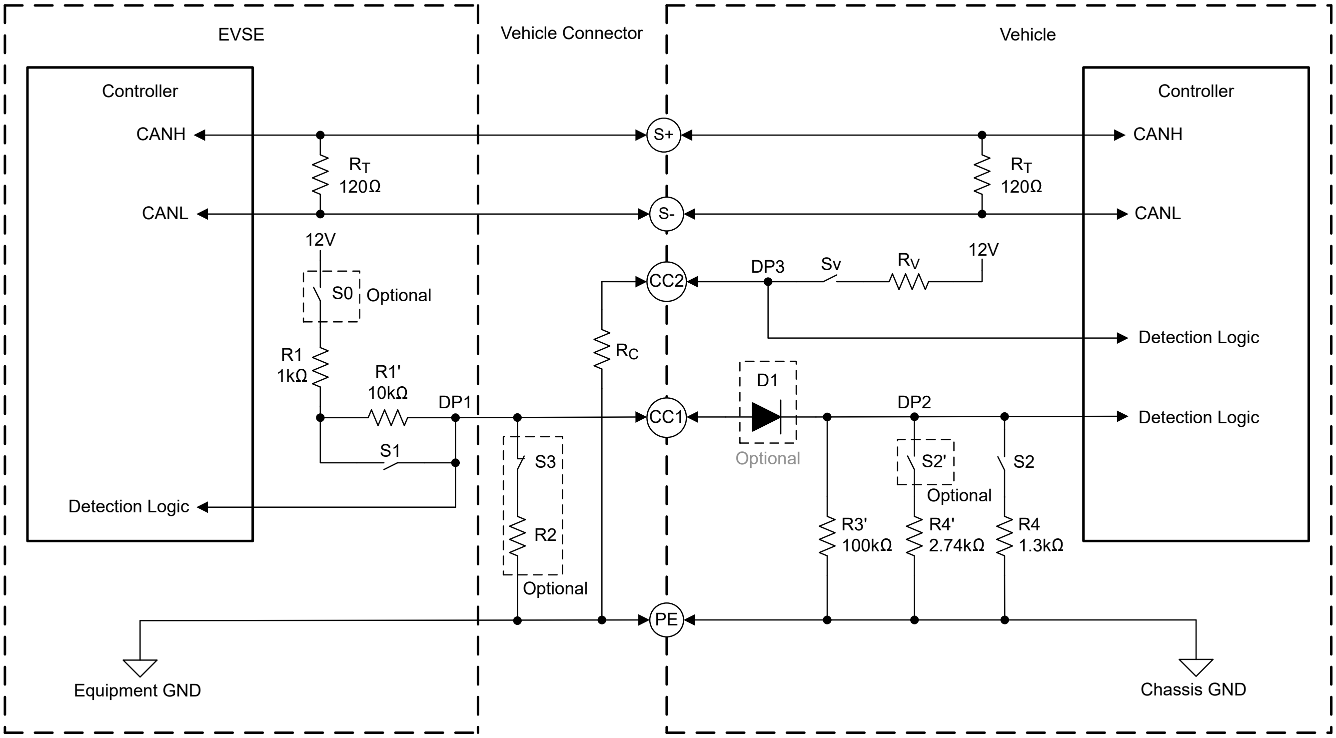


Figure 2-10. ChaoJi Circuit

Table 2-9. ChaoJi Signal State Parameters

STATE	S0	S1	S2	S2'	CC1 VOLTAGE
State A(1) – EV not connected	1	0	N/A	N/A	12V
State A' – EV connected	1	0	0	0	10.8V
State B(2) – EV Wake Up	1	0	0	1	2.34V
State C(3) – Charger readiness	1	1	0	1	8.73V
State D(4) – Vehicle readiness	1	1	1	1	5.6V
State E(5) – Emergency stop	1	0	1	1	0.88V
	1	1	0	1	6.78V

(1) State A: When the operator authorizes the charger for operation, switch S0 is closed. This enables the 12V supply on the CC1 line.
(2) State B: After authorization, the charger verifies that the vehicle plug is fully inserted into the socket by measuring the voltage at Detection Point 1. A DP1 voltage of approximately 2.34V indicates a complete and secure connection.
(3) State C: Once the charger is ready, S1 is closed, and high-level communication through CAN is established. Before any power transmission occurs, the vehicle must lock the plug using the electronic locking mechanism
(4) State D: When the vehicle is ready to accept power, the vehicle charging controller closes S2. If both charger and vehicle are ready, and during the charging process, the voltage at DP1 is approximately 5.6V.
(5) State E: During the power transmission phase, an emergency shutdown can be triggered by either party. The charger opens S1 to signal the vehicle to stop charging immediately, while the vehicle opens S2 to initiate the emergency shutdown. A regular shutdown is performed by sending a charging abort message through CAN before opening S1 or S2, respectively.

2.2.4.4 Schematics

The CC1 line carries a 12V signal with a maximum current of 12mA limited by the 1kΩ resistor R73. For ChaoJi, two additional switches (S0 and S1) are required. To accomplish this action, the TS12A4515 device is used. The TS12A4515 is a single-pole, single-throw (SPST), low-voltage, single-supply CMOS analog switch, with very low switch on-state resistance. The device can handle rail-to-rail analog signals and can continuously supply ±20mA of current which exceeds the required maximum of 12mA in this application. The TS12A4515 is a normally closed (NC) type, so no control signal is needed if the circuit is to follow the GB/T 18487 standard. The digital inputs have 0.8V to 2.4V logic thresholds, providing compatibility with the MSPM0 microcontroller, when control is needed. If a normally open (NO) switch is preferred, the TS12A4514 can be used instead.

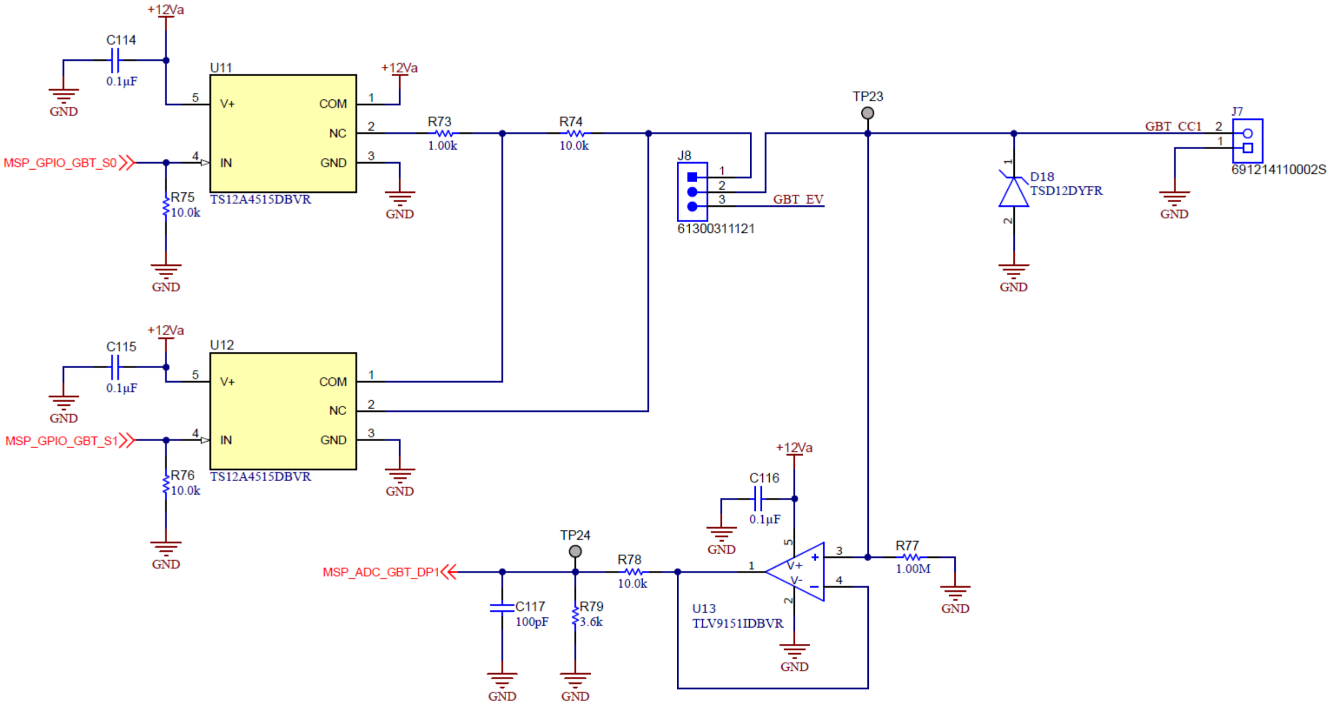


Figure 2-11. GB/T - ChaoJi Circuit

To monitor Detection Point 1, the CC1 signal is connected to a non-inverting amplifier. Since ChaoJi uses high-value resistors (100kΩ) on the CC1 line, the sensing circuit must present a high-impedance input to avoid loading the signal and causing inaccurate voltage readings. This is implemented with the TLV9151 amplifier. The TLV9151 is part of the TLV915x family (TLV9151, TLV9152, and TLV9154) of 16V, general purpose operational amplifiers. These devices offer exceptional DC precision and AC performance, including rail-to-rail output, low offset (±125µV, typical), low offset drift (±0.3µV/°C, typical), and 4.5MHz bandwidth. With an input voltage range which exceeds the supply rails and rail-to-rail output, it makes an excellent choice to enable the correct measurement of the 12V CC1 signal, while using a 12V supply.

To scale the amplifier output to the ADCs valid input range (0V–3.3V), a voltage divider consisting of R78 and R79 is used. In case S0 is open and no EV is connected, R77 provides a high-impedance path to ground, preventing the CC1 signal from floating.

2.2.4.5 EV Simulation

The TIDA-010939 design includes circuitry to simulate the behavior of an electric vehicle. Configuration is selected through jumper J8: shorting pins 1–2 sets the board to EVSE mode, which connects the CC1 signal to the output at screw terminal J7. Shorting pins 2–3 sets the board to EV mode, which connects the EV simulation circuitry to the CC1 output terminal.

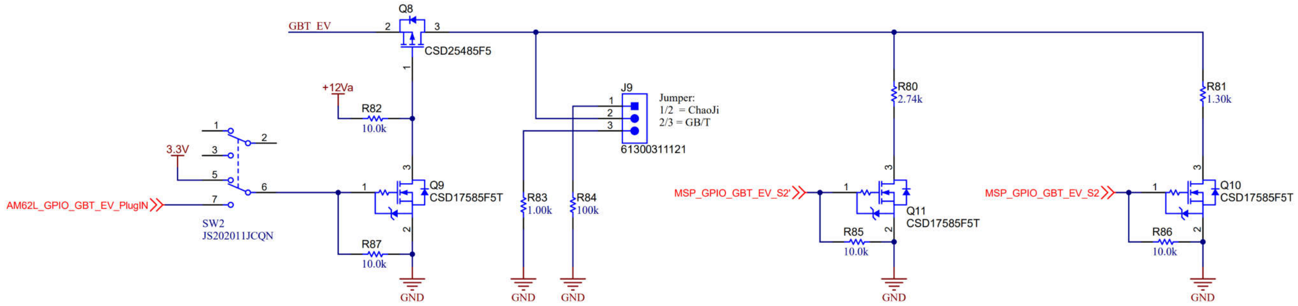


Figure 2-12. GB/T - ChaoJi EV Simulation Circuit

Switch SW2 simulates connecting the EV by loading the CC1 signal. The load resistance is set through jumper J9: Shorting pins 1–2 configures the test circuit for GB/T 18487 operation, applying a 1kΩ resistor. Shorting pins 2–3 connects a 100kΩ resistor, as required for ChaoJi operation. For ChaoJi, the EV controls two additional switches (S2 and S2′). These can be simulated by the MSPM0 microcontroller, if needed, allowing testing of different charging states.

2.2.5 CHAdeMO

The CHAdeMO standard, developed in 2010 by the CHAdeMO Association, is primarily used in Japan and supports DC fast charging of electric vehicles. The CHAdeMO connector provides nine electrical contacts: two for high-voltage DC power transfer (DC+ and DC–), and the remaining contacts for control signals.

The communication between the charging station and the vehicle relies on analog and digital signals. Analog control signals include Charge Sequence 1 and 2 (CS1, CS2), Vehicle Charge Permission (VCP), and the Proximity Pilot (PP). CS1 and CS2 are used by the EVSE to indicate charging states such as *ready to charge*. VCP allows the vehicle to instruct the charging station to initiate or terminate the charging process. The Proximity Pilot detects the presence of the vehicle.

For high-level communication, such as the maximum battery voltage, requested current, or the output capability of the charger, the system relies on a CAN interface.

2.2.5.1 Signals

Table 2-10. CHAdeMO Signals

NAME	MSP PIN	FUNCTION	DESCRIPTION
MSP_GPIO_CdM_d1	PB20 (19)	GPIO	D1 enable signal
MSP_GPIO_CdM_d2	PA22 (18)	GPIO	D2 enable signal
MSP_GPIO_CdM_j	PB18 (15)	GPIO	Vehicle Charge Permission
MSP_GPIO_CdM_PD	PB17 (14)	GPIO	Proximity Detection

2.2.5.2 Standard

The charging process begins when the user connects the CHAdeMO plug to the EV. Upon successful connection, the Proximity Pilot (PP) signal indicates the presence of the vehicle to the EVSE.

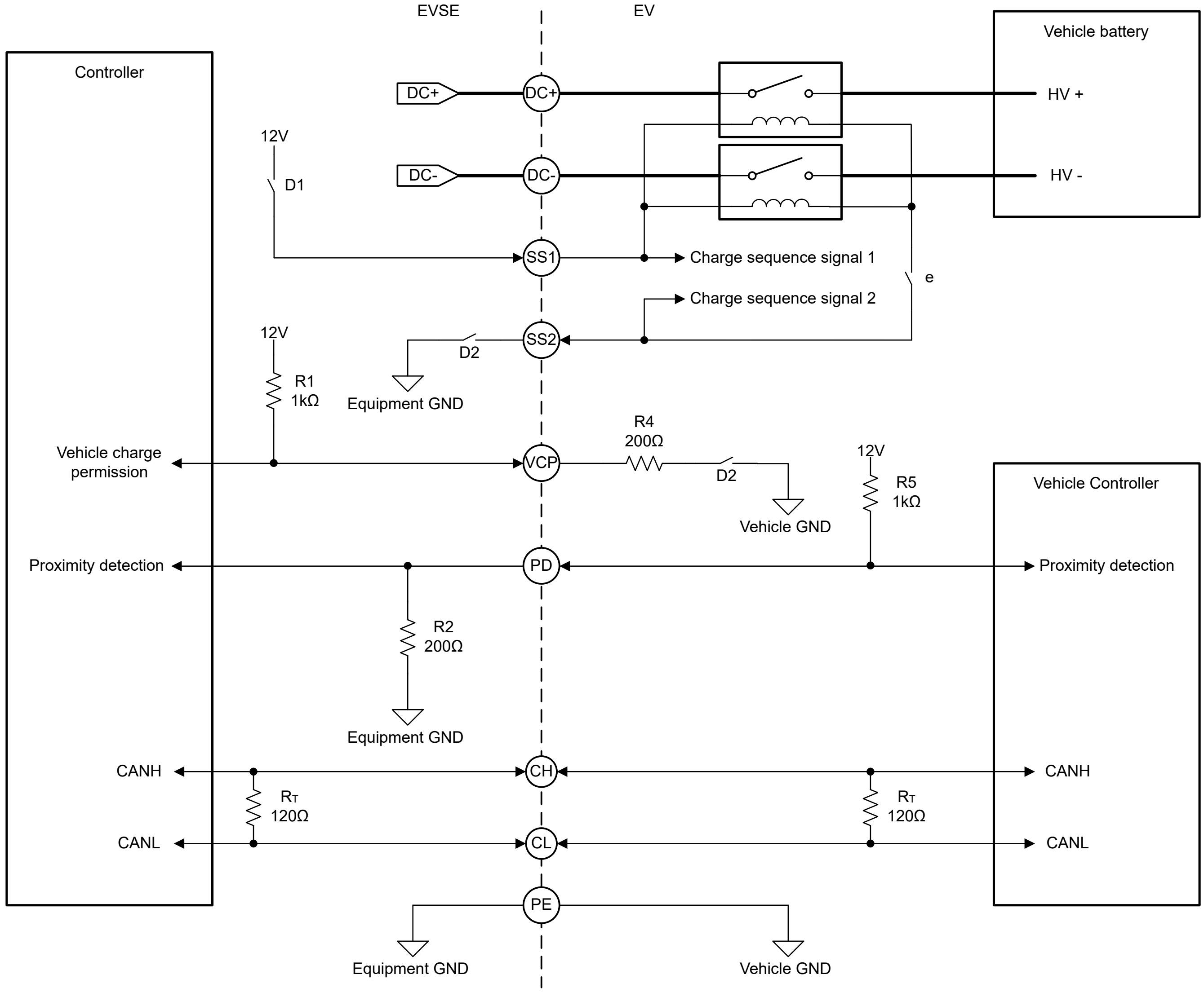


Figure 2-13. CHAdeMO Circuit

In the CHAdeMO protocol, the EVSE not only supplies high-voltage power but also provides the auxiliary 12V required to power the internal high-voltage contactors of the EV. This is achieved through two control signals: Charge Sequence 1 (CS1) and Charge Sequence 2 (CS2). CS1 acts as a high-side switch, supplying 12V to the relay coils of the EV. CS2 functions as the low-side switch, closing the circuit by connecting the circuit to ground. The EV can only close the high-voltage relays once both signals are active.

In response to the detected PP signal, the EVSE activates CS1 by enabling the high-side switch (D1), applying 12V to the CS1 line. The EV detects this voltage and recognizes that the EVSE is ready.

At this point, the EV initiates digital communication through the CAN interface. The EV transmits parameters such as current battery voltage, maximum voltage, and other charging requirements. If the EVSE supports these parameters, the EVSE responds with a listing of capabilities, such as maximum voltage and current. After verifying compatibility, the EV indicates readiness by pulling the Vehicle Charge Permission (VCP) signal low.

Before the high-voltage power transfer can be enabled, the EVSE must lock the connector to prevent disconnection under load. After that, the EVSE activates CS2 by closing the low-side switch (D2), enabling the EV to close the internal high-voltage contactors.

The EV then closes the contactors, and power transfer begins. Throughout the charging session, the EV continuously monitors battery parameters such as voltage, temperature, and state of charge. The required charging current and voltage is transmitted to the EVSE every 100ms through CAN.

Once the battery reaches the target voltage, or charging is otherwise complete, the EV sends a stop command over CAN. The EV opens the high-voltage contactors, the EVSE deactivates CS1 and CS2, and the VCP signal is released, safely ending the charging session.

2.2.5.3 Schematics

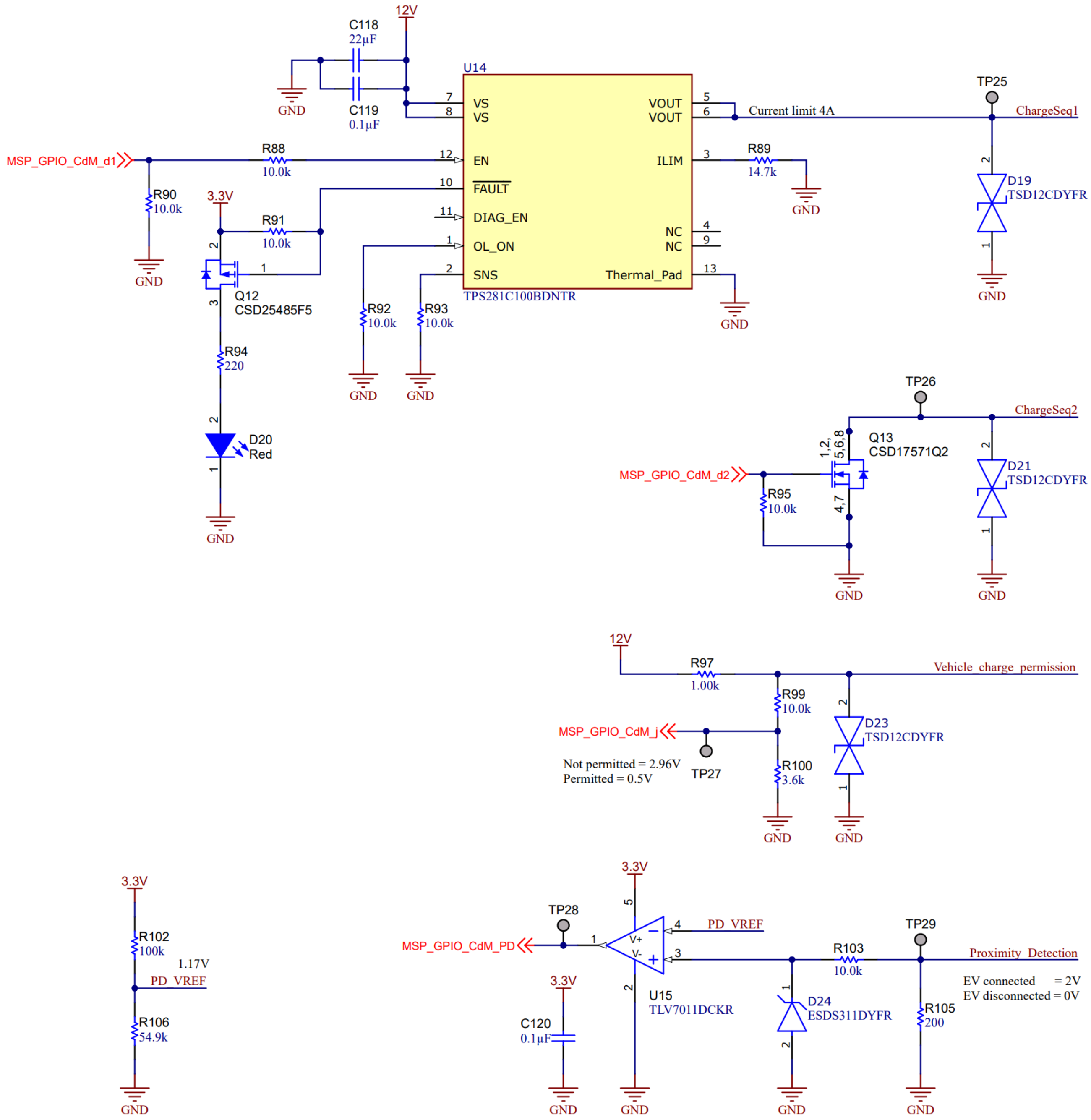


Figure 2-14. CHAdeMO Circuit

2.2.5.3.1 High-Side Switch (CS1)

The vehicle can use the 12V auxiliary power supplied by the EVSE to operate the internal high-voltage contactors. Therefore, the CHAdeMO standard defines a maximum load current up to 2A through the CS1 and CS2 lines.

The TPS281C100 is used to securely control the CS1 signal. This single-channel smart high-side switch has an operating voltage range of 6V to 60V and an adjustable current limit between 1A and 5A. Additionally the device integrates further protection features such as thermal shut down and output clamp to improve the system robustness during fault events such as short circuit. To protect the power supply, PCB traces, connectors, and the EV from overcurrent conditions, the current limit is set to 4A maximum (3.48A typical, 2.6A minimum) using a 14.7kΩ resistor connected to the ILIM pin of the TPS281C100. An LED (D20) indicates a fault condition such as thermal shutdown or overcurrent, providing visual feedback for system diagnostics.

2.2.5.3.2 Low-Side Switch (CS2)

The low-side switch for CS2 is implemented using the CSD17571Q2, an N-channel NexFET™ Power MOSFET. This device is rated with a Drain-to-Source voltage of up to 30V and a Gate-to-Source voltage of ±20V. With a very low on-resistance of 20mΩ (V_{GS} = 10V), the device is designed to minimize losses in power conversion and load management applications, while offering excellent thermal performance for the size of the package. The MOSFET supports a continuous drain current of 7.6A, which exceeds the 4A current limit of the CS1 high-side switch.

2.2.5.3.3 Proximity Detection

The Proximity Pilot (PP) signal allows the EVSE to detect when the CHAdeMO plug is connected to a vehicle. On the EVSE side, the signal is pulled down to ground through a 200Ω resistor. On the EV side, the PP signal connected to 12V through a 1kΩ resistor. When the plug is inserted into the vehicle inlet, these two resistors form a voltage divider and the signal on the EVSE side rises to approximately 2V. Since the positive-going input threshold voltage of the MSPM0 microcontroller is 2.3V (0.7 × V_{DD}), this voltage is not sufficient to register a valid high signal. To resolve this, the PP signal is fed to a TLV7011 comparator. This low-power, single-channel comparator features rail-to-rail inputs, internal hysteresis, and robust behavior under noisy or slow-changing input conditions. The switching threshold is set to 1.17V using a resistor divider, providing reliable detection of the *plug connected* state.

2.2.5.3.4 Vehicle Charge Permission

The VCP signal is used by the EV to indicate charging readiness. According to the CHAdeMO specification, this is a 12V signal sourced by the EVSE, current-limited through a 1kΩ resistor. When charging is permitted, the EV pulls the signal low by connecting the VCP signal to ground through a 200Ω resistor, resulting in a voltage drop to approximately 2V. When charging is not permitted, the signal remains at 12V. To make the signal compatible with the voltage input thresholds of the MSPM0 microcontroller, the VCP line is connected to the MSP through a voltage divider. This scales the signal voltage down by a factor of 4:

- Charging not permitted: 12V is reduced to approximately 3V
- Charging permitted: 2V is reduced to approximately 0.5V

These resulting levels are well within the valid digital input range of the MSPM0 (V_{DD} = 3.3V), where a logic high is defined as ≥ 2V and a logic low as ≤ 0.8V.

2.2.5.4 EV Simulation

The TIDA-010939 design includes circuitry to simulate the behavior of an EV according to the CHAdeMO charging standard.

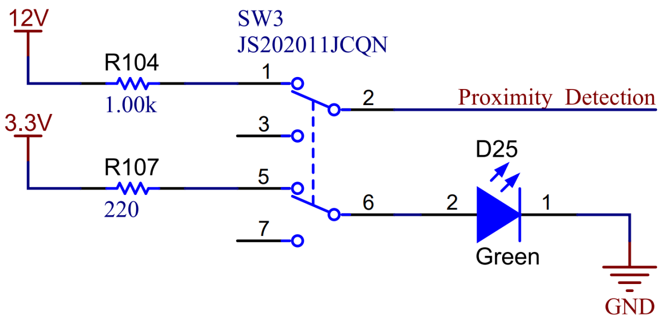


Figure 2-15. CHAdeMO EV Simulation Proximity Detection

Switching SW3 enables proximity detection by connecting 12V through a 1kΩ resistor to the proximity detection signal. LED D25 indicates the EV connected state.

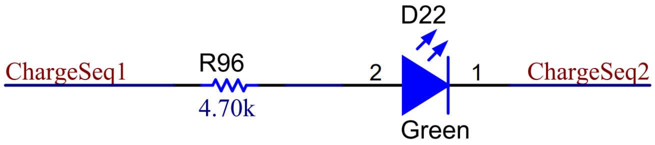


Figure 2-16. CHAdeMO EV Simulation CS1, CS2

To show whether CS1 and CS2 are active, LED D22 is connected between the two lines.

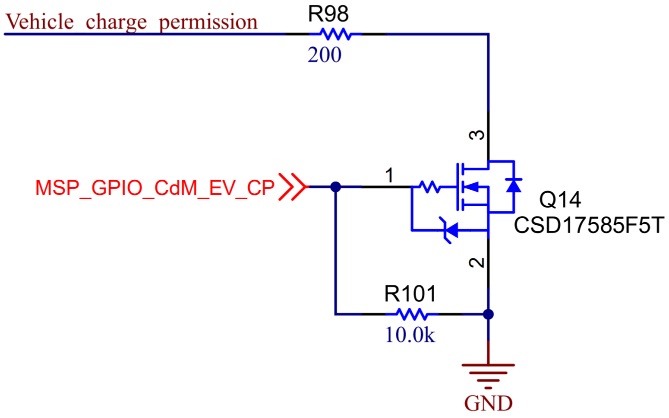


Figure 2-17. CHAdeMO EV Simulation Vehicle Charge Permission

The Vehicle Charge Permission signal can be controlled by the MSPM0 to indicate that charging is allowed. Setting the CdM_EV_CP control signal to logic high connects a 200Ω load resistor to the vehicle charge permission line.

2.2.6 Pluck Lock

Charging inlets or plugs contain a motorized locking mechanism, designed to prevent removal of the cable during the charging cycle when hazardous voltages can be present and to prevent cable theft. There are two different kinds of the plug lock mechanism.

For CCS and GB/T, the locking mechanism is a simple DC motor, driving a locking pin. For proper operation, 12V is applied in different polarities to the DC motor to push a pin into the inlet, or to extract the pin. To indicate the status of the locking actuator, a feedback circuitry is provided by the locking mechanism.

The locking mechanism for CHAdeMO consists of a solenoid, instead of a DC motor. This solenoid can only be activated if the pluck is completely mated with the electric vehicle. To monitor the status of the locking mechanism, the current consumption of the solenoid is measured. Only if the feedback signal indicates that the plug is locked can the charging sequence be initiated. If the feedback signal gets interrupted during a charge sequence, charging must be aborted.

For CCS1, CCS2, and NACS the lock mechanism is located in the charging inlet. Therefore, the control circuity is only required on the EV side, or if a detachable cable assembly is used. For the charging standard GB/T and CHAdeMO, the locking mechanism is located in the plug, requiring a control circuity on the EVSE even if the cable assembly is permanently connected to the EVSE.

2.2.6.1 Signals

Table 2-11. Pluck Lock Signals

NAME	MSP PIN	FUNCTION	DESCRIPTION
MSP_GPIO_PL_nSLEEP	PB26 (28)	GPIO	Enable
MSP_GPIO_PL_DIR	PB27 (29)	GPIO	Direction of Motor DRV

Table 2-11. Pluck Lock Signals (continued)

NAME	MSP PIN	FUNCTION	DESCRIPTION
MSP_PWM_PL_EN	PA28 (35)	PWM	Enable of DRV
MSP_ADC_PL_FB	PA24 (25)	ADC	Feedback of the CCS, GB/T locking mechanism
MSP_GPIO_PL_CdM_FB	PB22 (21)	GPIO	Feedback of the CHAdeMO locking mechanism

2.2.6.2 Schematics

The DRV8220DSG is used to control the locking mechanism. The DRV8220DSG is an integrated H-bridge motor driver with four N-channel power FETs, charge pump regulator, and protection circuitry. The device supports multiple control interface options: PWM (IN1, IN2) interface, phase or enable (PH/EN), or half-bridge interface, and can supply up to 1.76A of output current. With robust internal protection features like supply undervoltage lockout (UVLO), output overcurrent (OCP) and device overtemperature, the device is a good match for the application.

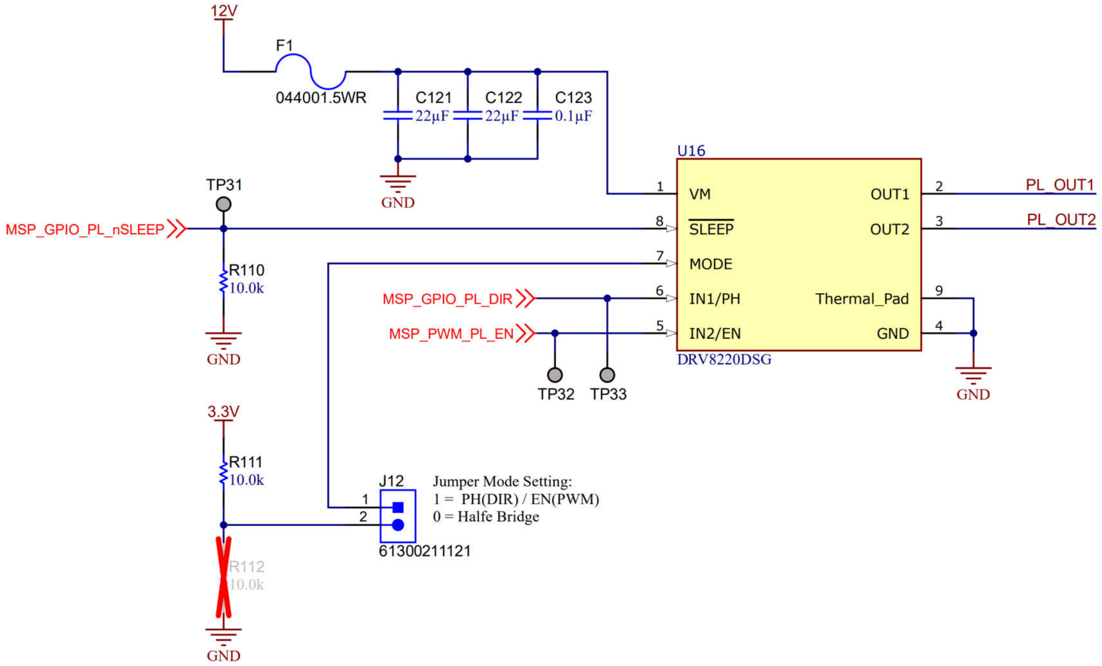


Figure 2-18. Pluck Lock Circuit

In this design the control interface is configured through the J13 jumper. Shorting the jumper enables the *phase-enable* mode, by setting the mode pin to logic high. This allows the controller to use a single PWM generator peripheral on the EN pin while a standard GPIO pin controls directions of the motor using the PH pin.

When no direction control is needed, half-bridge control mode can be selected by letting jumper J13 open during power up. This mode allows for each half-bridge to be directly controlled to support high-side slow decay (or brake), driving two independent loads, or paralleling the outputs for higher current capability for a single load.

In addition to the control signals the DRV8220 must by enabled by setting the nSLEEP pin to logic high, through the MSP_GPIO_PL_nSLEEP pin, to activate the output.

Table 2-12. DRV8220 PH/EN Control Mode

nSLEEP	EN	PH	OUT1	OUT2	DESCRIPTION
0	X	X	Hi-Z	Hi-Z	Low-power sleep mode (H-bridge Hi-Z)
1	0	X	L → Hi-Z	L → Hi-Z	Brake (low-side slow decay) for t_{SLEEP}, then auto-sleep mode (H-bridge Hi-Z)
1	1	0	L	H	Reverse (OUT2 → OUT1)
1	1	1	H	L	Forward (OUT1 → OUT2)

2.2.6.3 Motor Driver

The requirements for driving the locking actuator vary between manufacturers. This design supports motors rated for 12V. Even if the DRV8220 can supply up to 1.76A of output current, the device is protected by a 1.5A input fuse. To control the amount of output current, the duty cycle of the PWM signal can be adjusted.

To monitor the state of the locking actuator, the charging inlet or connector typically provides a feedback mechanism. Normally, this mechanism changes the total resistance depending on the state of the lock. By forming a voltage divider with this circuit, the state can be measured through an ADC of the MSPM0 microcontroller.

In this reference design, resistor R108 (1kΩ) is used to form the voltage divider with the feedback circuitry of the locking mechanism. An ESD protection Diode (D26) is placed at the signal input to protect the MSPM0 microcontroller. A voltage-drop caused by the feedback circuitry also enables the LED D27 to indicate if the charging pluck is locked.

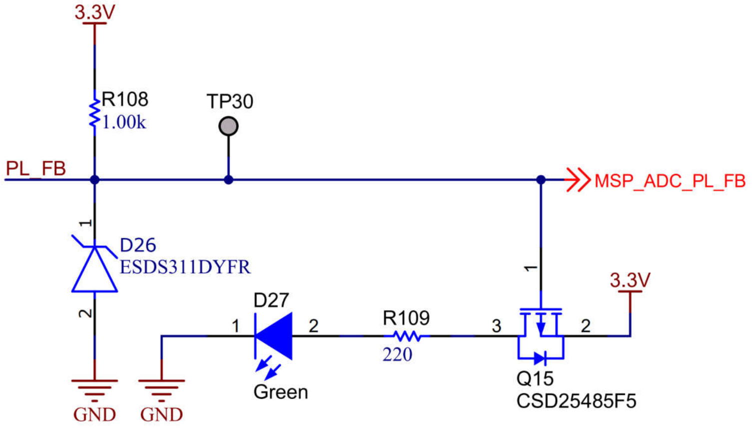


Figure 2-19. CCS, GBT Pluck Lock Feedback Circuit

To create a voltage divider with the feedback circuitry of the locking mechanism, a 1kΩ resistor R108 is used on the reference design. The ESD protection diode D26 is placed at the input of the signal to protect the MSPM0 microcontroller. A voltage-drop caused by the feedback circuitry enables the LED D27.

2.2.6.4 Solenoid Driver

Solenoids are non-latching, if there is no current driving the solenoid the solenoid returns to the default – open – state. Therefore, the solenoid does not require a direction control like the lock mechanism based on a motor.

For this purpose, the DRV8220 can be configured in half-bridge mode by disconnecting jumper J12. The DRV8220 requires no extra external diodes for the use with solenoids, as the other FETs and body diodes in the half-bridge recirculate freewheeling current during the off-time of the PWM duty cycle. The solenoid should be connected to the connector positive terminal J13 pin 1 (LO+) and negative terminal J13 pin 3 (LO – CDM).

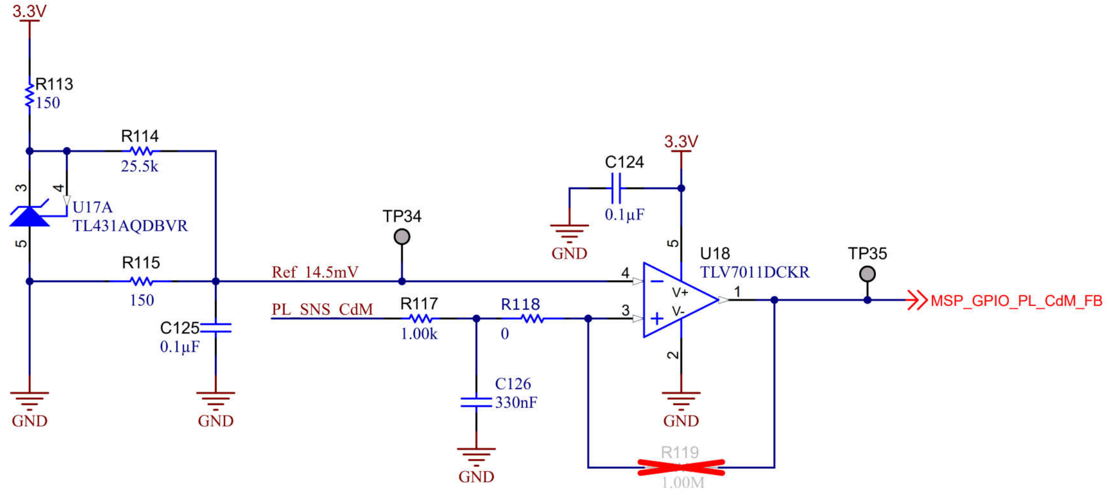


Figure 2-20. CHAdeMO Pluck Lock Feedback Circuit

The CHAdeMO charging plug is equipped with an internal switch, that connects the solenoid to the power supply only if the plug is completely mated with the inlet. This prevents the activation of the solenoid in any other state than mated with the inlet of the EV.

To proof if the plug is locked into the inlet, the current consumption of the solenoid can be monitored. Therefore, a shunt resistor is added to between GND and the LO - CDM connector. As soon as the solenoid is active, current flows through the shunt resistor resulting in a voltage drop above it. The voltage drop enables the output of the comparator U18, setting MSP_GPIO_PL_CdM_FB to logic high and enabling LED D28.

The threshold for the comparator is generated by a precision programmable reference TL431AQ. In this configuration R113 limits the cathode current to 5.5mA. The output of the TL431AQ device is 2495mV, which is further reduced to 14.6mV through a voltage divider formed by R114 and R115.

The shunt resistor has a resistance of 0.5Ω. This leads to a voltage drop equal to the reference voltage at 30mA, which is less than the typical current consumption of a solenoid.

2.2.7 Temperature Sensing

During high-current charging, it is possible to encounter dangerous temperatures if the cable or contactors are damaged. To prevent this hazard, charging plugs and inlets come with integrated temperature sensors. These sensors are typically located at the high-voltage contacts and are most commonly Platinum Resistance Temperature Detectors, especially PT1000 devices. The designation 1000 refers to the ohmic value of the sensor of 1000Ω at 0°C.

By monitoring these sensors, the charging cycle can be shut down in case limits are exceeded. The shutdown temperature during a charging session is specified by the cable assembly manufacturer and is often t > 90°C, equivalent to a PT1000 value of 1347Ω. To stay within the limit, reduce the charging current to the maximum rated current of the cable at an early stage.

To verify functionality of the sensors, the temperature difference between two sensors can be measured during idle state. The diagnostic check for the temperature monitoring function judges a failure when the measured difference between the sensors of the charging connector exceeds a specified threshold.

Table 2-13. PT1000 Sensor Resistance Table

TEMPERATURE	RESISTANCE	TEMPERATURE	RESISTANCE	TEMPERATURE	RESISTANCE
–40°C	842.70Ω	+10°C	1077.90Ω	+60°C	1232.40Ω
–30°C	882.20Ω	+20°C	1097.40Ω	+70°C	1270.70Ω
–20°C	921.60Ω	+30°C	1116.70Ω	+80°C	1308.90Ω
–10°C	1000.00Ω	+40°C	1155.40Ω	+90°C	1347.00Ω
0°C	1039.00Ω	+50°C	1194.00Ω	+100°C	1385.00Ω

2.2.7.1 Signals

Table 2-14. Temperature Sensing Signals

NAME	MSP PIN	FUNCTION	DESCRIPTION
MSP_ADC_TEMP1	PA15 (8)	ADC	Sensor 1
MSP_ADC_TEMP2	PA16 (9)	ADC	Sensor 2

2.2.7.2 Schematics

This temperature sensing circuit uses a resistor in series with a positive–temperature–coefficient (PTC) thermistor to form a voltage–divider, which has the effect of producing an output voltage that is linear over temperature. The series resistor limits the measurement current to prevent self-heating of the PTC sensor. For PT1000 thermistors, a typical measuring current between 0.1mA to 1mA is recommended, depending on the manufacturer.

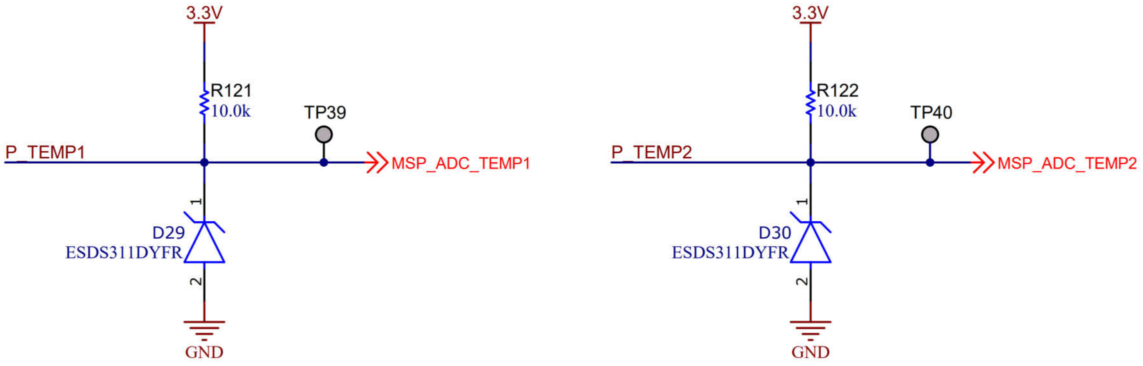


Figure 2-21. Temperature Sensing Circuit

The output of the voltage divider is directly connected to the ADC input of the MSPM0 microcontroller without additional amplification or buffering. To still provide precise measurements despite the higher source impedance, a longer ADC sampling time can be configured in software. The sample-and-hold time determines how long the signal is sampled before digital conversion. During this time, the internal switch of the ADC connects the signal to the sample-and-hold capacitor, allowing the capacitor to be charged. A longer sampling time makes sure that this capacitance reaches the correct voltage level, even when driven by higher-impedance sources.

Since temperature signals change slowly and predictably, fast sampling is not necessary in this application. Additionally, the hardware of the MSPM0 averaging feature can be used to further increase the effective resolution of the ADC, reducing noise and improving accuracy without the need for software and CPU intervention.

2.2.7.3 Calculation

The resistance of a PT1000 sensor is defined in DIN EN 60738-1. In the temperature range of 0°C–850°C, the resistance is set with Equation 3.

$$R_{PT} = R_0 \left(1 + At + Bt^2\right) \text{ with } R_0 = 1000\Omega \tag{3}$$

The temperature coefficients are:

$$A = 3.9083 \times 10^{-3} {}^\circ C^{-1} \qquad B = -5.775 \times 10^{-7} {}^\circ C^{-2}$$

The temperature can be calculated according to:

$$t(R_{PT})^\circ C = \frac{-A + \sqrt{A^2 - 4B\left(1 - \frac{R_{PT}}{R_0}\right)}}{2B} \tag{4}$$

with

$$R_{PT} = \frac{(R_{PullUp} \times V_{ADC\_IN})}{(V_{REF} - V_{ADC\_IN})} \quad \text{or} \quad R_{PT} = \frac{(R_{PullUp} \times ADC_{Value})}{(4095 - V_{ADC\_IN})} \tag{5}$$

where

R_{PullUp} = 10kΩ, R_0 = 1kΩ, V_{REF} = 3.3V

2.2.8 Connectivity

To communicate with additional hardware required for EV charging, the TIDA-010939 supports multiple transceivers connected to the AM62L-EVM.

2.2.8.1 RS-485

The THVD2429 is a 3V-to-5.5V, 20Mbps, half-duplex RS-485 transceiver with integrated surge protection. Surge protection is achieved by integrating transient voltage suppressor (TVS) diodes in the package. This feature increases the reliability by providing better immunity to noise transients coupled to the data cable which eliminates the need for external protection components. The devices in this family feature a wide common-mode voltage range making them an excellent choice for multi-point applications over long cable runs.

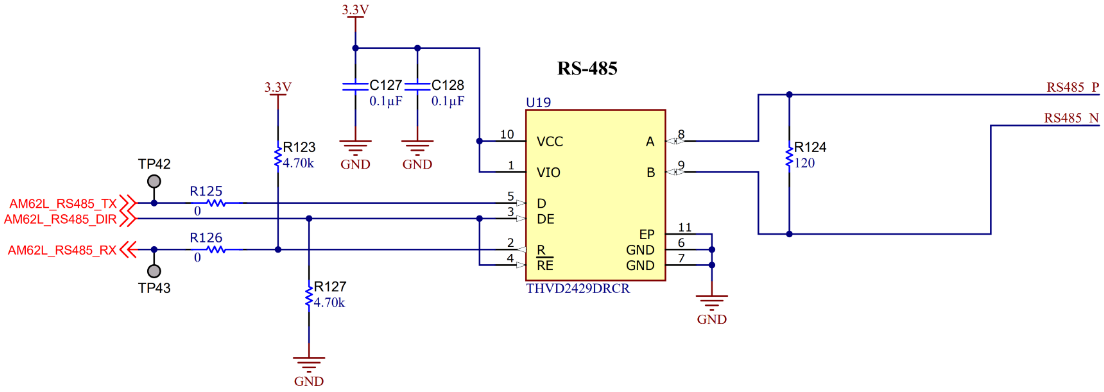


Figure 2-22. RS-485 Circuit

2.2.8.2 RS-232

To properly interface with the RS-232 standard, a voltage translation system is required to convert between the 3.3V domain on the board and from the 12V on the port. To facilitate the translation, the design uses a TRSF3221E device. The TRSF3221E device is capable of driving the higher voltage signals on the RS-232 port from only the 3.3V DVCC through a charge pump system. The TRSF3221E consists of a line driver, a line receiver, and a dual charge-pump circuit with ±15kV IEC ESD protection pin to pin (serial-port connection pins, including GND). The charge pump and four small external capacitors allow operation from a single 3V to 5.5V supply. The TRSF3221E operates at data signaling rates up to 1Mbit/s and a driver output slew rate of 24V/µs to 150V/µs.

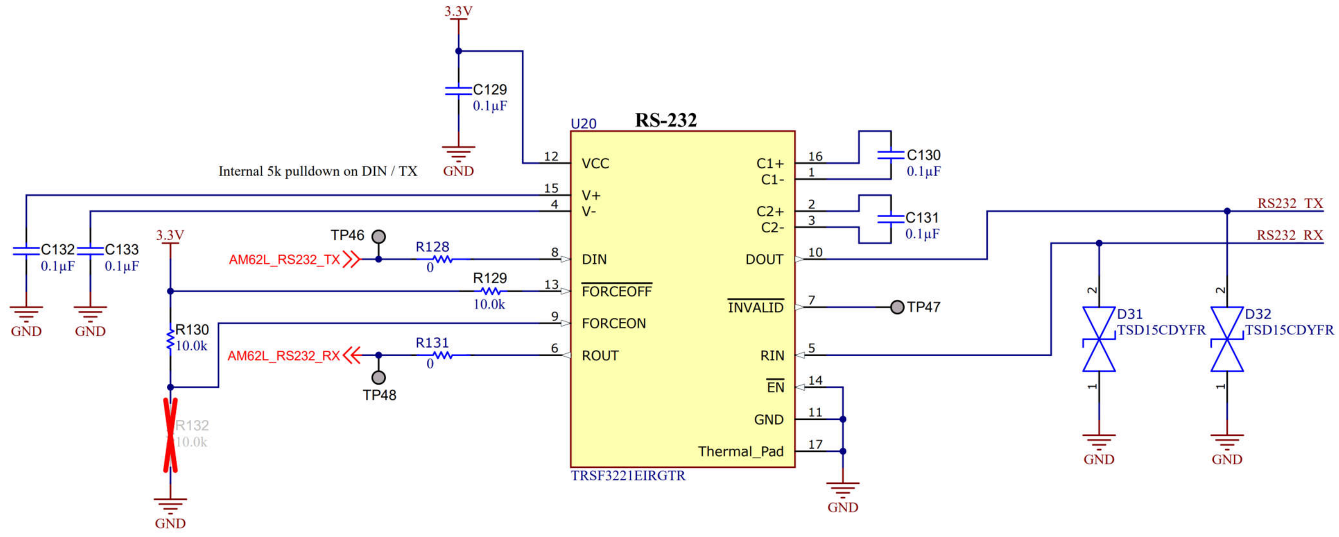


Figure 2-23. RS-232 Circuit

2.2.8.3 CAN

The TIDA-010939 offers two controller area network transceivers, the TCAN1044A-Q1. The device is a high-speed CAN transceiver that meets the physical layer requirements of the ISO 11898-2:2016 high-speed CAN specification. The transceivers have certified electromagnetic compatibility (EMC) operation making the device an excellent choice for classical CAN and CAN FD networks up to five megabits per second (Mbps). The transceivers also include thermal-shutdown (TSD), TXD-dominant time-out (DTO), supply undervoltage detection, and ±58V bus fault protection.

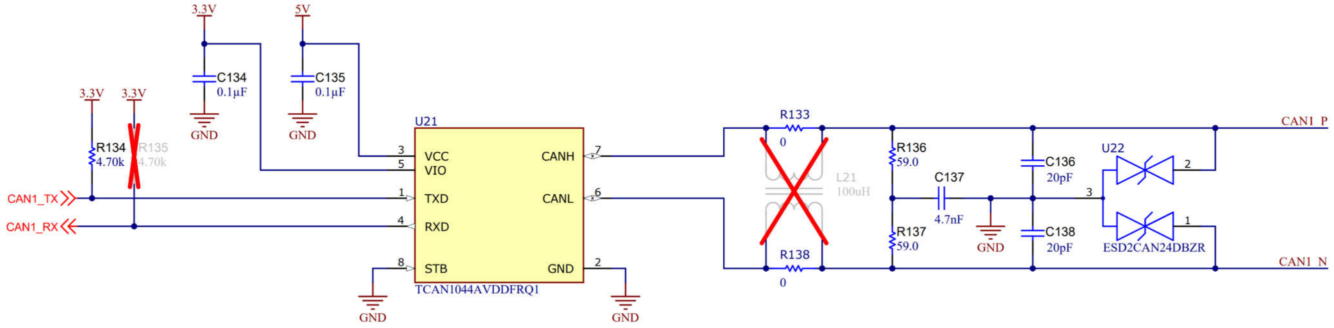


Figure 2-24. CAN Circuit

Both transceivers have a termination of 120Ω in a split configuration, that creates a low-pass resistor-capacitor (RC) filter for the common-mode signal present on the bus. This split termination scheme filters both the common-mode fluctuations caused by transceivers on the bus and the common-mode fluctuations caused by external noise coupling onto the bus.

The charging standard GB/T, as well as CHAdeMO define CAN as the physical layer for digital communication between an off-board conductive charger and the battery management system (BMS) of the electric vehicle (EV). Both protocols utilize a dedicated CAN connection, version 2.0B between the electric vehicle and the charging station and both the charger and the vehicle is equipped with a terminating resistor with a nominal resistance of 120Ω. Based on the recommended national standard GB/T 27930 the communication rate is 250kbps, while CHAdeMO uses a default transition rate of 500kbps.

2.3 Highlighted Products

2.3.1 MSPM0G3507

The MSPM0G3507 microcontroller (MCU) is part of the MSP highly integrated, ultra-low-power 32-bit MCU family based on the enhanced Arm® Cortex®-M0+ 32-bit core platform operating at up to 80MHz frequency. Figure 2-25 shows the MSPM0G350x functional block diagram.

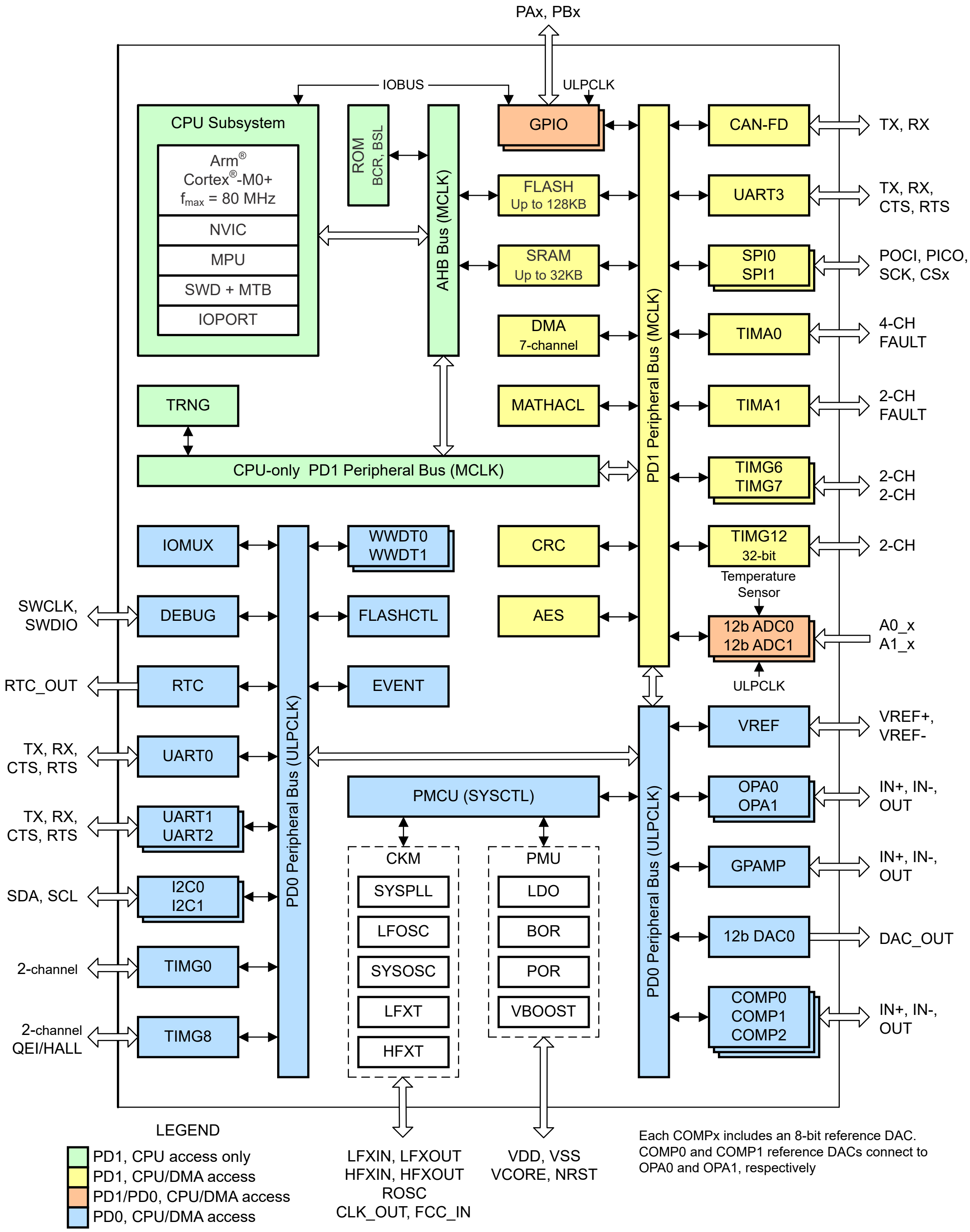


Figure 2-25. MSPM0G3507 Functional Block Diagram

These cost-optimized MCUs integrate high-performance analog peripherals, including two simultaneous sampling 12-bit 4-Msps analog-to-digital converters (ADCs) with up to 17 external channels used for measuring signals such as the control pilot and temperature sensors. With two 16-bit advanced control timers and five general-purpose timers, the MCU can precisely schedule ADC readings to sample both high and low phases of a PWM signal after a given settling time, enabling accurate measurement of the control pilot waveform. The timers are also used to generate PWM outputs for driving relays and controlling the timing of the locking actuator. The integrated CRC module accelerates cyclic redundancy check calculations used to verify the integrity of data packets received from the AM62L MPU through the UART interface.

The main features of MSPM0G3507 are the extended temperature range: –40°C up to 125°C; the wide supply voltage range: 1.62V to 3.6V; and the integrated 128KB of flash memory with built-in error correction code (ECC) and 32KB of ECC protected SRAM with hardware parity.

2.3.2 AM62L

The low-cost and performance optimized AM62L family of application processors are built for Linux® application development. Based on scalable Arm® Cortex®-A53 cores, the devices offer multimedia DSI/DPI support, dual Gigabit Ethernet, advanced lower power management modes, and extensive security options for IP protection with the built-in security features.

The AM62Lx family includes an extensive set of peripherals that make these devices well-designed for industrial and EV-charging applications while offering intelligent features and optimized power architecture as well. In addition, the extensive set of peripherals included in AM62Lx enables system-level connectivity, such as: CAN-FD, USB, MMC/SD, OSPI and an ADC. Figure 2-26 shows the AM62L functional block diagram.

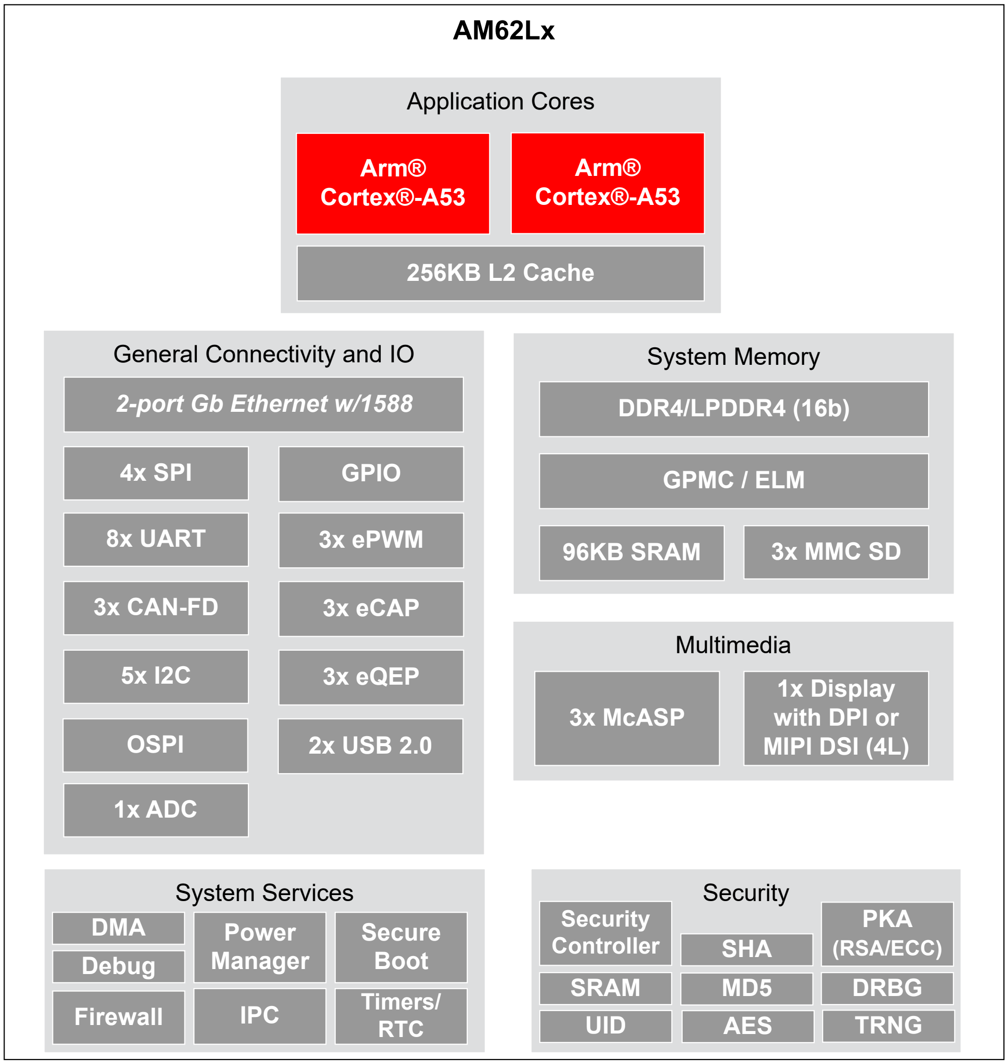


Figure 2-26. AM62L Functional Block Diagram

3 Hardware, Software, Testing Requirements, and Test Results

3.1 Required Hardware and Software

The following items are required to setup the TIDA-010939:

- Auxiliary power supply 12V (10.08V – 13.2V, 5A)
- AM62L-EVM
- USB Type-C® cable
- TIDA-010239 (Optional)
- TIDA-010237 (Optional)

Figure 3-1 is a labeled representation of the top side of the TIDA-010939 board.

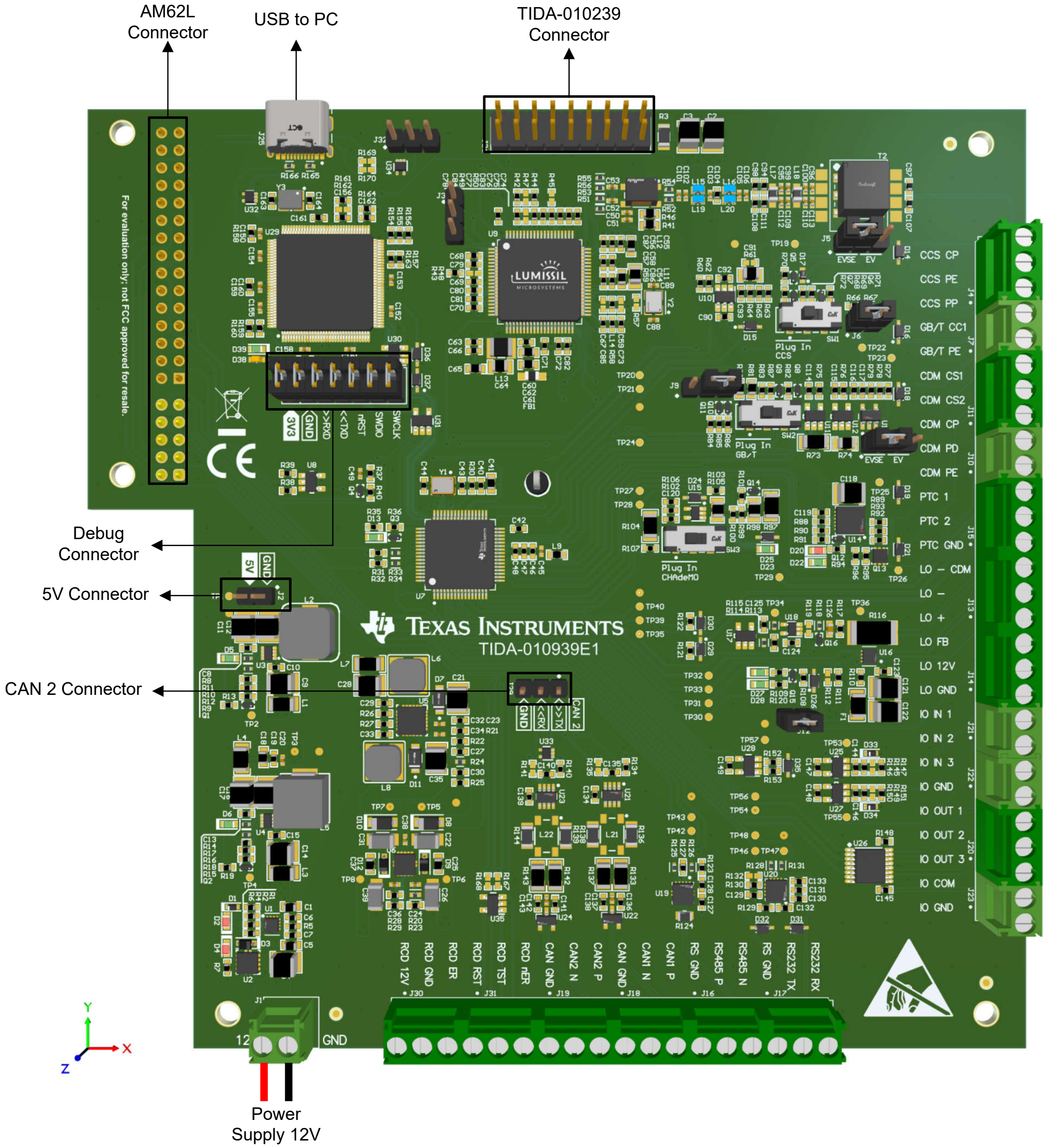


Figure 3-1. TIDA-010939 Top Side

3.2 Test Setup

Before setting up the test board, complete a visual inspection, to make sure the board is in a good condition and free from damage.

3.2.1 Power Supply Options

The TIDA-010939 design can be powered in two ways:

1. External 12V power supply.
    a. The TIDA-010939 can be powered from a single 12V external voltage rail connected at screw terminal J1.
    b. When used together with the TIDA-010239, both boards can be powered from the TIDA-010939 external 12V input. This way the whole system can be supplied without the need of a single- or three-phase high-voltage input.
2. Through the TIDA-010239 board from a single- or three-phase high-voltage input.
    a. In this case, the isolated AC/DC power stage on the TIDA-010239 provides the necessary power to the TIDA-010939.
    b. Do not supply an external 12V input to the TIDA-010939 when it is connected to the TIDA-010239 and powered from grid voltage, as this can cause damage to the system.

3.2.2 XDS110 Debug Probe

To keep development simple, the TIDA-010939 integrates an onboard debug probe, which eliminates the need for additional programmers. The TIDA-010939 has the XDS110 debug probe, which is a simple and low-cost debugger that supports all MSPM0 device derivatives. The XDS110 also provides a *back channel* UART-over-USB connection with the host, which can be very useful during debugging and for easy communication with a PC.

The jumper block at jumper J24 allows the user to connect or disconnect signals between the XDS110 and the MSPM0G3507. This includes XDS110 SWD signals, application UART signals, and 3.3V power.

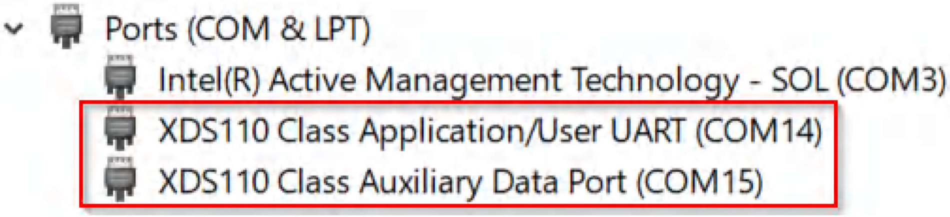
The jumper can be removed to:

- Expose the target MCU pins for other use than onboard debugging and application UART communication
- Expose the programming and UART interface of the XDS110 so that the programming and UART interface can be used for devices other than the onboard MCU
- Power external devices with 3.3V

3.2.2.1 Application (or Back Channel) UART

The back-channel UART allows communication with the USB host that is not part of the main functionality of the target application. This is very useful during development and also provides a communication channel to the PC host side.

The back-channel UART is the UART on UART1 (PA8, PA9) on the MSPM0. On the host side, a virtual COM port for the application back-channel UART is generated when the TIDA-010939 enumerates on the host. Use any PC application that interfaces with COM ports, including terminal applications like Hyperterminal® or Docklight, to open this port and communicate with the target application. Identify the COM port for the back channel. On Microsoft® Windows® PCs, use the *Device Manager* to find the COM ports.



Ports (COM & LPT)
Intel(R) Active Management Technology - SOL (COM3)
XDS110 Class Application/User UART (COM14)
XDS110 Class Auxiliary Data Port (COM15)

Figure 3-2. Application Back-Channel UART in Device Manager

The back-channel UART is the *XDS110 Class Application/User UART* port. In this case, Figure 3-2 shows COM14, but this port can vary from one host PC to the next. After identifying the correct COM port, configure in the host application according to the documentation. The user can then open the port and begin communication from the host.

On the target MSPM0G3507 side, the back channel is connected to the UART1 module. The XDS110 has a configurable baud rate; therefore, it is important that the PC application configuring the baud rate is the same as what is configured on the UART1.

3.2.2.2 Using an External Debug Probe Instead of the Onboard XDS110

Many users have a preferred external debug probe and want to bypass the XDS110 debug probe to program the MSPM0 target MCU. The bypass is enabled by jumpers on the connector J24.

1. Remove jumpers on the JTAG signals on the J24 connector, including NRST, SWDIO, and SWCLK.
2. Plug any ARM debug probe into J24.
3. Plug in 12V extremal power into the TIDA-010939 development kit.
    - Make sure that no 3.3V is connected to the J24 connector when TIDA-010939 is powered through 12V or through TIDA-010239.

3.2.3 Connecting to the AM62L-EVM

To connect the TIDA-010939 to the AM62L-EVM, connect J27 and J28 on the TIDA-010939 to the GPIO expansion headers on the AM62L-EVM.

The GPIO expansion signals on the AM62L-EVM are shared with the High-Definition Multimedia Interface (HDMI) and are routed to HDMI by default. To enable the GPIO expansion header, the AM62L-EVM must be reconfigured. Signal routing can be switched by controlling the SoC_VOUT0_FET_SEL0 and SoC_VOUT0_FET_SEL1 signals through software, and by shorting the J29 jumper on the EVM.

The EVM requires a dedicated USB Type-C *power supply (5V, 3A)*.

See the *expansion headers* section of the *AM62L Evaluation Module* user's guide.

3.2.4 Connector, Pin Header, and Jumper Settings

Table 3-1 lists the header names and jumper settings for the TIDA-010939. Table 3-2 shows the screw terminal pinouts. Table 3-3 shows the TIDA-010239 J27 connector pinout.

Table 3-1. Header Names and Jumper Settings

DESIGNATOR	FUNCTIONALITY	COMMENTS
J2	5V connector	5V output
J3	Lumissil debug header	UART connection for Lumissil IS31CG5317-LQLS3 • Pin 1: UART RX • Pin 2: GND • Pin 3: UART TX
J5	CCS configuration	Configures the CCS hardware ether as EVSE or EV for back-to-back testing • Pin 1 and 2: EVSE • Pin 2 and 3: EV
J6	CCS proximity pilot header	Configures PP between Type 1, NACS, and Type 2 plugs • Populated: Type 2 • Unpopulated: Type 1, NACS
J8	GB/T configuration header	Configures the GB/T hardware ether as EVSE or EV for back-to-back testing • Pin 1 and 2: EVSE • Pin 2 and 3: EV

Table 3-1. Header Names and Jumper Settings (continued)

DESIGNATOR	FUNCTIONALITY	COMMENTS
J9	GB/T – ChaoJi test setup selection header	Configures the GB/T test hardware ether for GB/T or ChaoJi • Pin 1 and 2: ChaoJi • Pin 2 and 3: GB/T
J12	Pluck lock mode setting	Configures the control mode of the DRV8220. Must be set before the device starts-up. • Populated: PH/EN Mode • Unpopulated: Half Bridge Mode
J24	MSP debug header	Header to connect or disconnect the onboard XDS110 debug probe. Remove jumper to connect an external debug probe to the MSPM0. • Pin 1: 3.3V • Pin 2: 3.3V • Pin 3: GND • Pin 4: GND • Pin 5: MSPM0 PA9 (55) – UART1 RX • Pin 6: XDS110 – TXD • Pin 7: MSPM0 PA8 (54) – UART1 TX • Pin 8: XDS110 – RXD • Pin 9: MSPM0 nRST (38) • Pin 10: XDS110 reset out • Pin 11: MSPM0 PA19 (12) – SWDIO • Pin 12: XDS110 TMS SWDIO • Pin 13: MSPM0 PA20 (13) – SWCLK • Pin 14: XDS110 TCK SWDCLK
J29	CAN 2 header	CAN input from the AM62L to the TCAN device • Pin 1: CAN TX • Pin 2: CAN RX • Pin 3: GND
J32	I2C header	Connected to the AM62L for possible I2C communication • Pin 1: I2C SCL • Pin 2: I2C SDA • Pin 3: GND

Table 3-2. Screw Terminal Pinouts

DESIGNATOR	FUNCTIONALITY	COMMENTS
J1	Auxiliary power supply input	External 12V input (10.08V–13.2V, 5A)
J4	CCS, NACS	Connects to charging plug for CCS or NACS • Pin 1: CCS PP - Proximity Pilot • Pin 2: CCS PE - Protective Earth • Pin 3: CCS CP - Control Pilot
J7	GB/T, ChaoJi	Connects to charging plug for GB/T or ChaoJi • Pin 1: GBT PE - Protective earth • Pin 2: GBT CC1 - charging conformation 1
J10	CHAdeMO	Connects to charging plug for CHAdeMO • Pin 1: CDM PE - Protective earth • Pin 2: CDM PD - Proximity detection

Table 3-2. Screw Terminal Pinouts (continued)

DESIGNATOR	FUNCTIONALITY	COMMENTS
J11	CHAdeMO	Connects to charging plug for CHAdeMO • Pin 1: CDM CP - Vehicle Charge Permission • Pin 2: CDM CS2 - Charge Sequence 2 • Pin 3: CDM CS1 - Charge Sequence 1
J13	Pluck lock	Connects to charging Inlet or plug • Pin 1: LO+ Lock Motor Positive Terminal • Pin 2: LO- Lock Motor Negative Terminal • Pin 3: LO- CDM – CHAdeMO Lock Negative Terminal
J14	Pluck lock feedback	Connects to charging Inlet or plug • Pin 1: LO GND – Ground for Feedback • Pin 2: LO 12V – 12V Supply for Feedback • Pin 3: LO FB – Feedback input
J15	Temperature sensing	Connects to charging Inlet or plug • Pin 1: PTC GND – Ground for temperature sensors • Pin 2: PTC 2 – Temperature Sensor 2 input • Pin 3: PTC 1 – Temperature Sensor 1 input
J16	RS-485	RS-485 connector • Pin 1: RS GND – Ground • Pin 2: RS485 P – Bus I/O port, A • Pin 3: RS485 N – Bus I/O port, B
J17	RS-232	RS-232 connector • Pin 1: RS GND • Pin 2: RS232 TX – RS232 line data output • Pin 3: RS232 RX – RS232 line data input
J18	CAN 1	CAN 1 connector • Pin 1: CAN GND • Pin 2: CAN 1 N – Low-level CAN bus I/O • Pin 3: CAN 1 P – High-level CAN bus I/O
J19	CAN 2	CAN 2 connector • Pin 1: CAN GND • Pin 2: CAN 2 N – Low-level CAN bus I/O • Pin 3: CAN 2 P – High-level CAN bus I/O
J20	Digital output	Digital output connector • Pin 1: IO OUT 3 – Digital output 3 • Pin 2: IO OUT 2 – Digital output 2 • Pin 3: IO OUT 1 – Digital output 1
J21	Digital input	Digital input connector: • Pin 1: IO IN 2 – Digital input 2 • Pin 2: IO IN 1 – Digital input 1
J22	Analog input	Analog input connector • Pin 1: IO GND – Ground • Pin 2: IO IN 3 – Analog input

Table 3-2. Screw Terminal Pinouts (continued)

DESIGNATOR	FUNCTIONALITY	COMMENTS
J23	Digital output	Digital output connector • Pin 1: IO GND – Ground • Pin 2: IO COM – Supply input
J30	RCD input	RCD input connector • Pin 1: RCD 12V – 12V output for RCD • Pin 2: RCD GND – Ground • Pin 3: RCD ER – Error input
J31	RCD input	RCD input connector • Pin 1: RCD RST – Reset output • Pin 2: RCD TST – Test output • Pin 3: RCD nER – Negative active Error input

Table 3-3. TIDA-010239 J26 Connector Pinout

PIN	NAME	COMMENTS
1	+12V	+12V ether from the TIDA-010239 flyback output to the TIDA-010939, or from the TIDA-010939 +12V auxiliary power supply to the TIDA-010239
2	+12V	+12V ether from the TIDA-010239 flyback output to the TIDA-010939, or from the TIDA-010939 +12V auxiliary power supply to the TIDA-010239
3	+14V	+14V from TIDA-010239 flyback output
4	-14V	–14V from TIDA-010239 flyback output
5	5V	5V from TIDA-010939 to TIDA-010239
6	3.3V	3.3V from TIDA-010939 to TIDA-010239
7	GND	Ground
8	GND	Ground
9	MSP_PWM_R_ENABLE	Relay control signal
10	Relay_Check	Relay weld detection feedback
11	RCD_nFAULT	RCD negative active fault signal to disable power relay in case of a fault condition
12	R_Mirror_Out	Relay mirror contact feedback
13	GND	Ground
14	GND	Ground
15	PLC_ZC_IN	Zero cross detection for Lumissil IS31CG5317
16	PW_EN_EXT	Enable signal for TPS65130RGER when TIDA-010239 power supply is used
17	GND	Ground
18	Super_Cap_Char	Backup power supply super capacitor charging indicator

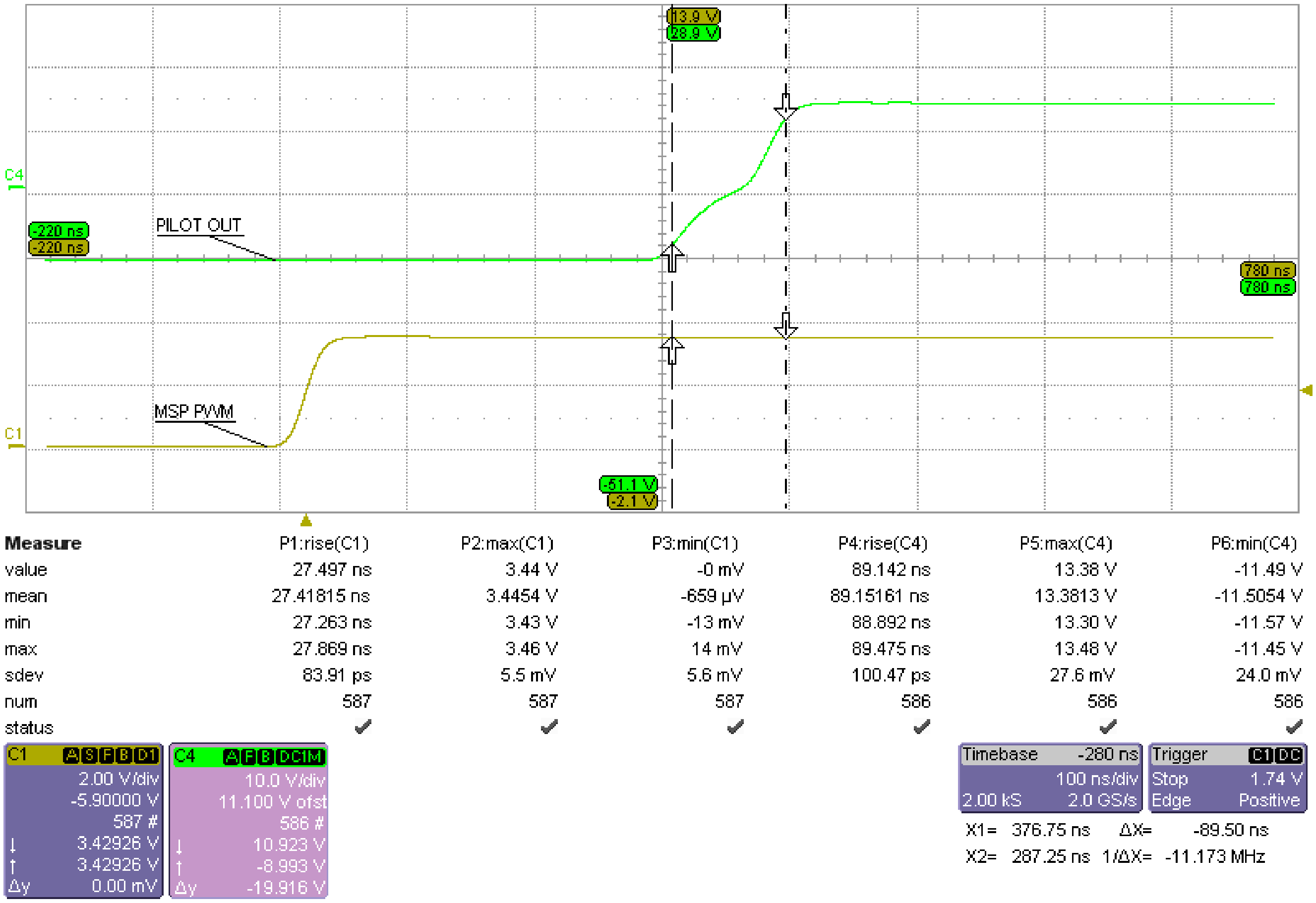
3.3 Test Results

3.3.1 Control Pilot

This section shows test data for control pilot signal logic high and low voltage, pulse width, and frequency.

3.3.1.1 TLV1805 Output Rise and Fall Time

Figure 3-3 and Figure 3-4 show the rise and fall times of the TLV1805 control pilot signal generator.



Measure	P1:rise(C1)	P2:max(C1)	P3:min(C1)	P4:rise(C4)	P5:max(C4)	P6:min(C4)
value	27.497 ns	3.44 V	-0 mV	89.142 ns	13.38 V	-11.49 V
mean	27.41815 ns	3.4454 V	-659 µV	89.15161 ns	13.3813 V	-11.5054 V
min	27.263 ns	3.43 V	-13 mV	88.892 ns	13.30 V	-11.57 V
max	27.869 ns	3.46 V	14 mV	89.475 ns	13.48 V	-11.45 V
sdev	83.91 ps	5.5 mV	5.6 mV	100.47 ps	27.6 mV	24.0 mV
num	587	587	587	586	586	586
status	✓	✓	✓	✓	✓	✓

C1 A S F B D1
2.00 V/div
-5.90000 V
587 #
↓ 3.42926 V
↑ 3.42926 V
Δy 0.00 mV

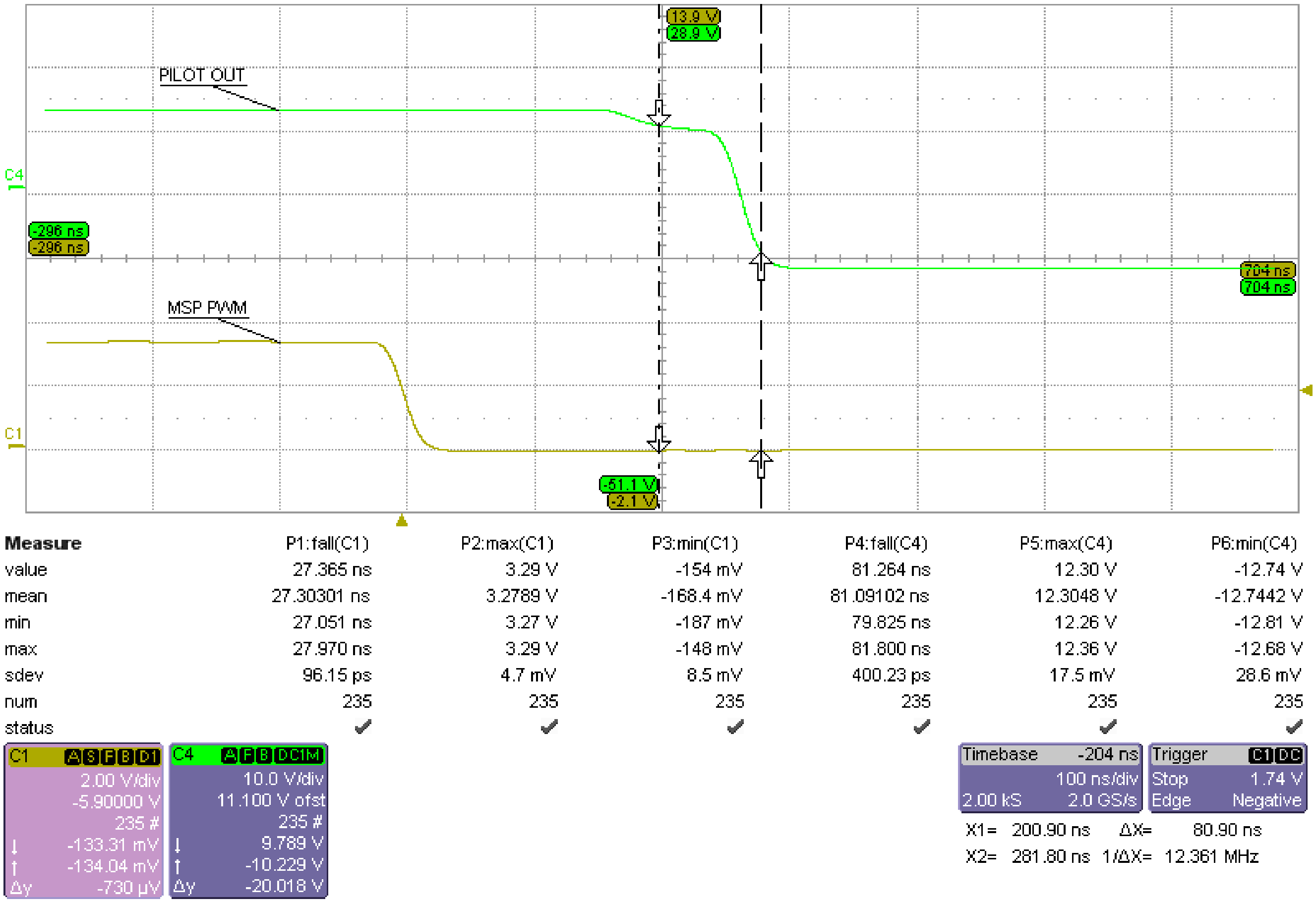
C4 A F B DC1M
10.0 V/div
11.100 V ofst
586 #
↓ 10.923 V
↑ -8.993 V
Δy -19.916 V

Timebase -280 ns
100 ns/div
2.00 kS 2.0 GS/s

Trigger C1 DC
Stop 1.74 V
Edge Positive

X1= 376.75 ns ΔX= -89.50 ns
X2= 287.25 ns 1/ΔX= -11.173 MHz

Figure 3-3. Control Pilot Rise Time



Measure	P1:fall(C1)	P2:max(C1)	P3:min(C1)	P4:fall(C4)	P5:max(C4)	P6:min(C4)
value	27.365 ns	3.29 V	-154 mV	81.264 ns	12.30 V	-12.74 V
mean	27.30301 ns	3.2789 V	-168.4 mV	81.09102 ns	12.3048 V	-12.7442 V
min	27.051 ns	3.27 V	-187 mV	79.825 ns	12.26 V	-12.81 V
max	27.970 ns	3.29 V	-148 mV	81.800 ns	12.36 V	-12.68 V
sdev	96.15 ps	4.7 mV	8.5 mV	400.23 ps	17.5 mV	28.6 mV
num	235	235	235	235	235	235
status	✓	✓	✓	✓	✓	✓

C1 A S F B D1
2.00 V/div
-5.90000 V
235 #
↓ -133.31 mV
↑ -134.04 mV
Δy -730 µV

C4 A F B DC1M
10.0 V/div
11.100 V ofst
235 #
↓ 9.789 V
↑ -10.229 V
Δy -20.018 V

Timebase -204 ns
100 ns/div
2.00 kS 2.0 GS/s

Trigger C1 DC
Stop 1.74 V
Edge Negative

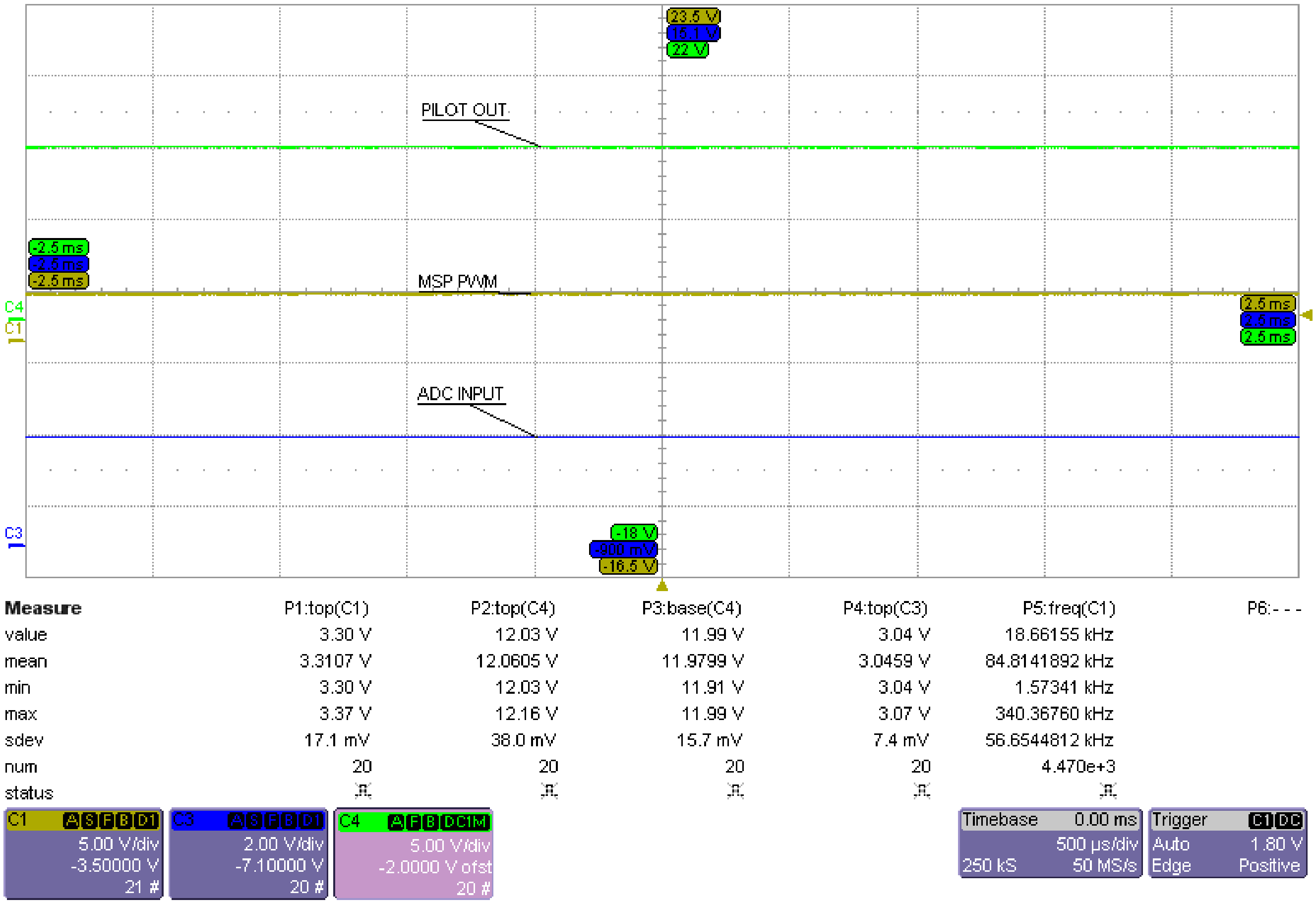
X1= 200.90 ns ΔX= 80.90 ns
X2= 281.80 ns 1/ΔX= 12.361 MHz

Figure 3-4. Control Pilot Fall Time

This circuitry has rise times and fall times faster than 2µs according to J1773, IEC61851. Rise times and fall times slower than this begin to add noticeably to the output rise times and fall times dictated by the 1kΩ resistor and all capacitance on the pilot line. Rise times and fall times are defined by 10% to 90% of complete negative-to-positive transition or 90% to 10% of complete positive-to-negative transition measured between the pulse generator output and R61 (1kΩ). Generator is referring to the TLV1805 (U10) prior to and driving the 1kΩ source resistor with a ±12V square wave.

3.3.1.2 Control Pilot Signal Voltage Accuracy in Different States

Figure 3-5 through Figure 3-7 show the control pilot signal voltage accuracy in different states.



Measure	P1:top(C1)	P2:top(C4)	P3:base(C4)	P4:top(C3)	P5:freq(C1)	P6:- - -
value	3.30 V	12.03 V	11.99 V	3.04 V	18.66155 kHz	
mean	3.3107 V	12.0605 V	11.9799 V	3.0459 V	84.8141892 kHz	
min	3.30 V	12.03 V	11.91 V	3.04 V	1.57341 kHz	
max	3.37 V	12.16 V	11.99 V	3.07 V	340.36760 kHz	
sdev	17.1 mV	38.0 mV	15.7 mV	7.4 mV	56.6544812 kHz	
num	20	20	20	20	4.470e+3	
status	⎍	⎍	⎍	⎍	⎍	

C1 A S F B D1
5.00 V/div
-3.50000 V
21 #

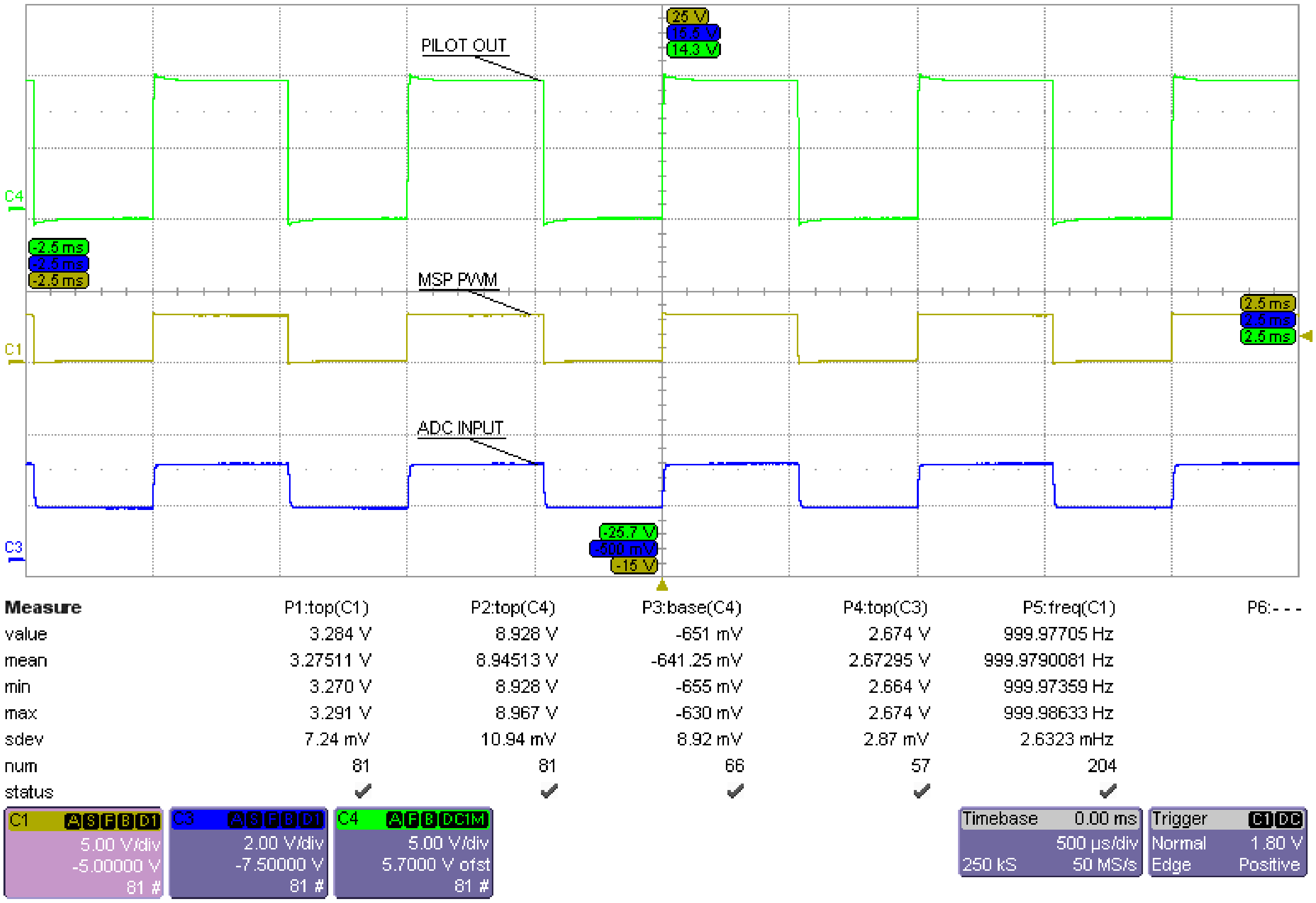
C3 A S F B D1
2.00 V/div
-7.10000 V
20 #

C4 A F B DC1M
5.00 V/div
-2.0000 V ofst
20 #

Timebase 0.00 ms
500 µs/div
250 kS 50 MS/s

Trigger C1 DC
Auto 1.80 V
Edge Positive

Figure 3-5. Control Pilot Signal Voltage Accuracy in State A



Measure	P1:top(C1)	P2:top(C4)	P3:base(C4)	P4:top(C3)	P5:freq(C1)	P6:- - -
value	3.284 V	8.928 V	-651 mV	2.674 V	999.97705 Hz	
mean	3.27511 V	8.94513 V	-641.25 mV	2.67295 V	999.9790081 Hz	
min	3.270 V	8.928 V	-655 mV	2.664 V	999.97359 Hz	
max	3.291 V	8.967 V	-630 mV	2.674 V	999.98633 Hz	
sdev	7.24 mV	10.94 mV	8.92 mV	2.87 mV	2.6323 mHz	
num	81	81	66	57	204	
status	✓	✓	✓	✓	✓	

C1 A S F B D1
5.00 V/div
-5.00000 V
81 #

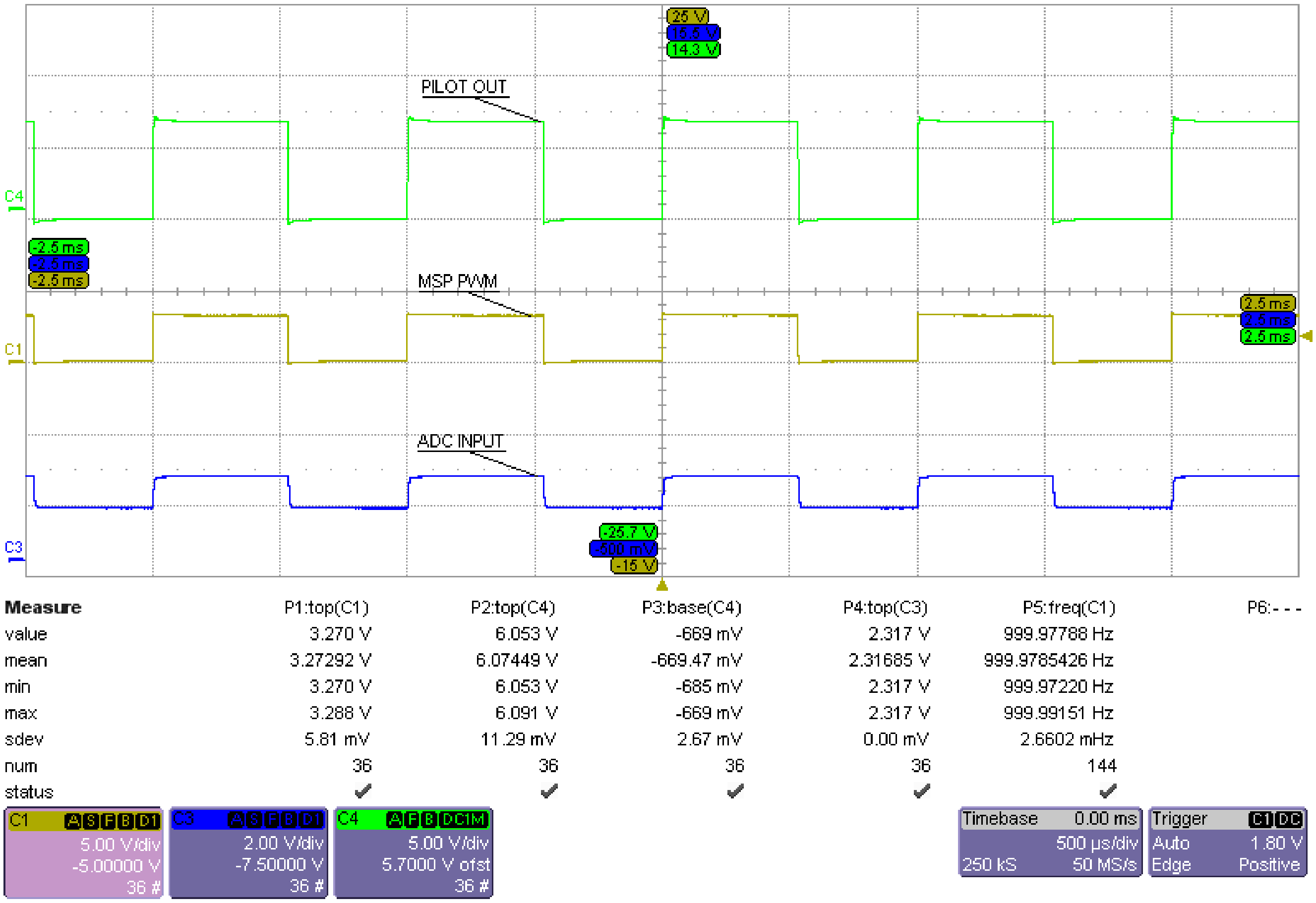
C3 A S F B D1
2.00 V/div
-7.50000 V
81 #

C4 A F B DC1M
5.00 V/div
5.7000 V ofst
81 #

Timebase 0.00 ms
500 µs/div
250 kS 50 MS/s

Trigger C1 DC
Normal 1.80 V
Edge Positive

Figure 3-6. Control Pilot Signal Voltage Accuracy in State B



Measure	P1:top(C1)	P2:top(C4)	P3:base(C4)	P4:top(C3)	P5:freq(C1)	P6:- - -
value	3.270 V	6.053 V	-669 mV	2.317 V	999.97788 Hz	
mean	3.27292 V	6.07449 V	-669.47 mV	2.31685 V	999.9785426 Hz	
min	3.270 V	6.053 V	-685 mV	2.317 V	999.97220 Hz	
max	3.288 V	6.091 V	-669 mV	2.317 V	999.99151 Hz	
sdev	5.81 mV	11.29 mV	2.67 mV	0.00 mV	2.6602 mHz	
num	36	36	36	36	144	
status	✓	✓	✓	✓	✓	

C1 A S F B D1
5.00 V/div
-5.00000 V
36 #

C3 A S F B D1
2.00 V/div
-7.50000 V
36 #

C4 A F B DC1M
5.00 V/div
5.7000 V ofst
36 #

Timebase 0.00 ms
500 µs/div
250 kS 50 MS/s

Trigger C1 DC
Auto 1.80 V
Edge Positive

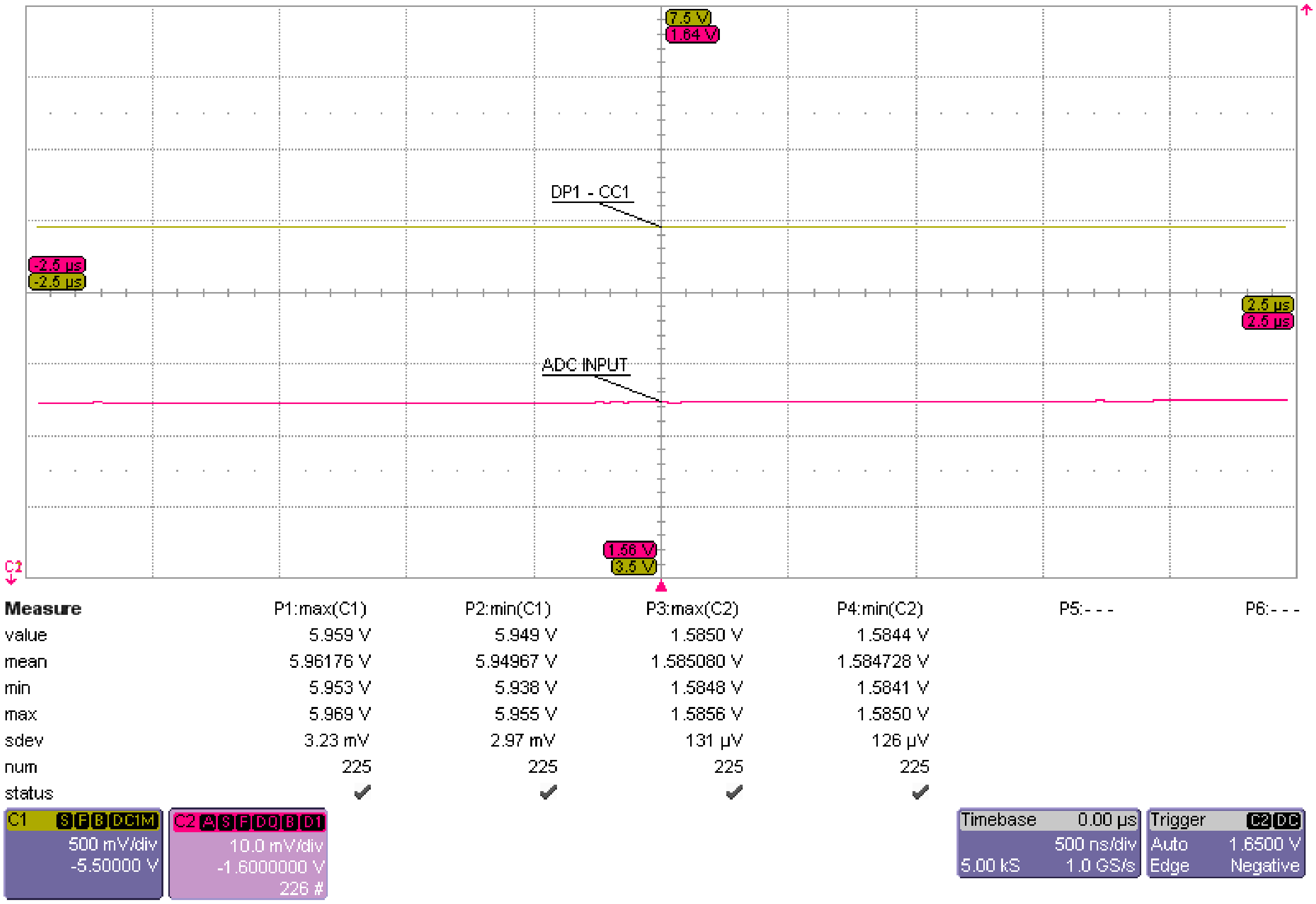
Figure 3-7. Control Pilot Signal Voltage Accuracy in State C

These voltage accuracy results are tested with the EV simulation circuitry on the TIDA-010939.

3.3.2 GB/T ChaoJi

This section shows test data for the GB/T and ChaoJi control signal voltages. The different states are generated with the internal EV simulation circuitry.

3.3.2.1 GB/T Signal Voltage Accuracy

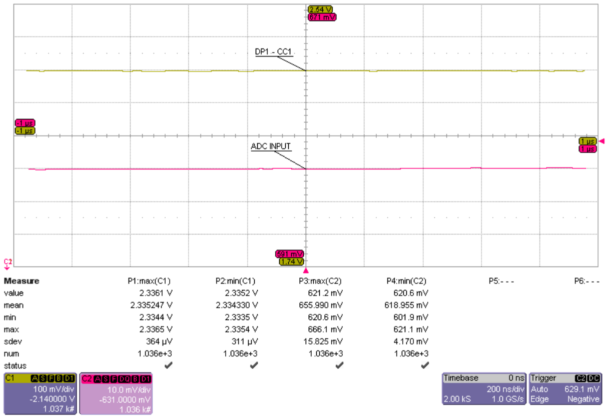


Measure	P1:max(C1)	P2:min(C1)	P3:max(C2)	P4:min(C2)	P5:- - -	P6:- - -
value	5.959 V	5.949 V	1.5850 V	1.5844 V		
mean	5.96176 V	5.94967 V	1.585080 V	1.584728 V		
min	5.953 V	5.938 V	1.5848 V	1.5841 V		
max	5.969 V	5.955 V	1.5856 V	1.5850 V		
sdev	3.23 mV	2.97 mV	131 µV	126 µV		
num	225	225	225	225		
status	✓	✓	✓	✓		

Figure 3-8. CC1 Signal Voltage Accuracy - EV Connected

3.3.2.2 ChaoJi Signal Voltage Accuracy in Different States

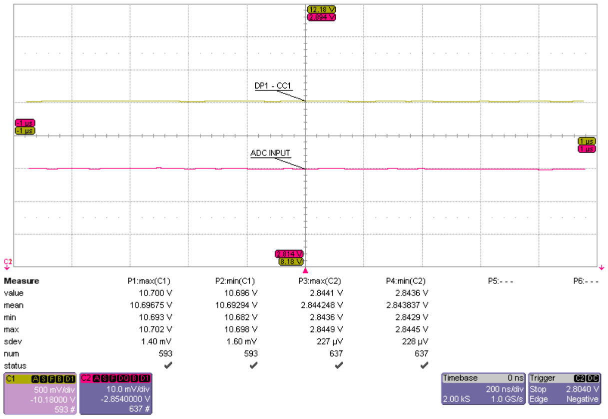
Figure 3-9 through Figure 3-12 show the charge sequence 1 signal voltage accuracy in different states.



Measure	P1:max(C1)	P2:min(C1)	P3:max(C2)	P4:min(C2)	P5:- - -	P6:- - -
value	2.3361 V	2.3352 V	621.2 mV	620.6 mV		
mean	2.335247 V	2.334330 V	655.990 mV	618.955 mV		
min	2.3344 V	2.3335 V	620.6 mV	601.9 mV		
max	2.3365 V	2.3354 V	666.1 mV	621.1 mV		
sdev	364 µV	311 µV	15.825 mV	4.170 mV		
num	1.036e+3	1.036e+3	1.036e+3	1.036e+3		
status	✓	✓	✓	✓		

C1: 100 mV/div, -2.140000 V, 1.037 k#
C2: 10.0 mV/div, -631.0000 mV, 1.036 k#
Timebase 0 ns: 200 ns/div, 2.00 kS, 1.0 GS/s
Trigger C2 DC: Auto, 629.1 mV, Edge, Negative

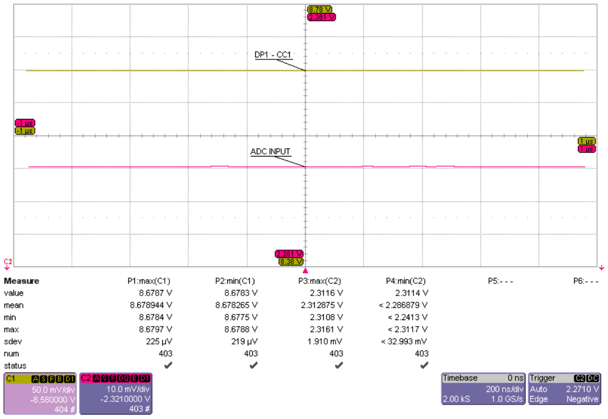
Figure 3-9. CC1 Signal Voltage Accuracy State A



Measure	P1:max(C1)	P2:min(C1)	P3:max(C2)	P4:min(C2)	P5:- - -	P6:- - -
value	10.700 V	10.696 V	2.8441 V	2.8436 V		
mean	10.69675 V	10.69294 V	2.844248 V	2.843837 V		
min	10.693 V	10.682 V	2.8436 V	2.8429 V		
max	10.702 V	10.698 V	2.8449 V	2.8445 V		
sdev	1.40 mV	1.60 mV	227 µV	228 µV		
num	593	593	637	637		
status	✓	✓	✓	✓		

C1: 500 mV/div, -10.18000 V, 593 #
C2: 10.0 mV/div, -2.8540000 V, 637 #
Timebase 0 ns: 200 ns/div, 2.00 kS, 1.0 GS/s
Trigger C2 DC: Stop, 2.8040 V, Edge, Negative

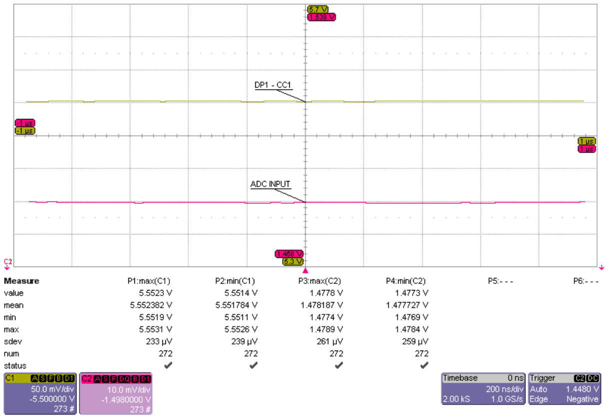
Figure 3-10. CC1 Signal Voltage Accuracy State B



Measure	P1:max(C1)	P2:min(C1)	P3:max(C2)	P4:min(C2)	P5:- - -	P6:- - -
value	8.6787 V	8.6783 V	2.3116 V	2.3114 V		
mean	8.678944 V	8.678265 V	2.312875 V	< 2.286879 V		
min	8.6784 V	8.6775 V	2.3108 V	< 2.2413 V		
max	8.6797 V	8.6788 V	2.3161 V	< 2.3117 V		
sdev	225 µV	219 µV	1.910 mV	< 32.993 mV		
num	403	403	403	403		
status	✓	✓	✓	✓		

C1: 50.0 mV/div, -8.580000 V, 404 #
C2: 10.0 mV/div, -2.3210000 V, 403 #
Timebase 0 ns: 200 ns/div, 2.00 kS, 1.0 GS/s
Trigger C2 DC: Auto, 2.2710 V, Edge, Negative

Figure 3-11. CC1 Signal Voltage Accuracy State C



Measure	P1:max(C1)	P2:min(C1)	P3:max(C2)	P4:min(C2)	P5:- - -	P6:- - -
value	5.5523 V	5.5514 V	1.4778 V	1.4773 V		
mean	5.552382 V	5.551784 V	1.478187 V	1.477727 V		
min	5.5519 V	5.5511 V	1.4774 V	1.4769 V		
max	5.5531 V	5.5526 V	1.4789 V	1.4784 V		
sdev	233 µV	239 µV	261 µV	259 µV		
num	272	272	272	272		
status	✓	✓	✓	✓		

C1: 50.0 mV/div, -5.500000 V, 273 #
C2: 10.0 mV/div, -1.4980000 V, 273 #
Timebase 0 ns: 200 ns/div, 2.00 kS, 1.0 GS/s
Trigger C2 DC: Auto, 1.4480 V, Edge, Negative

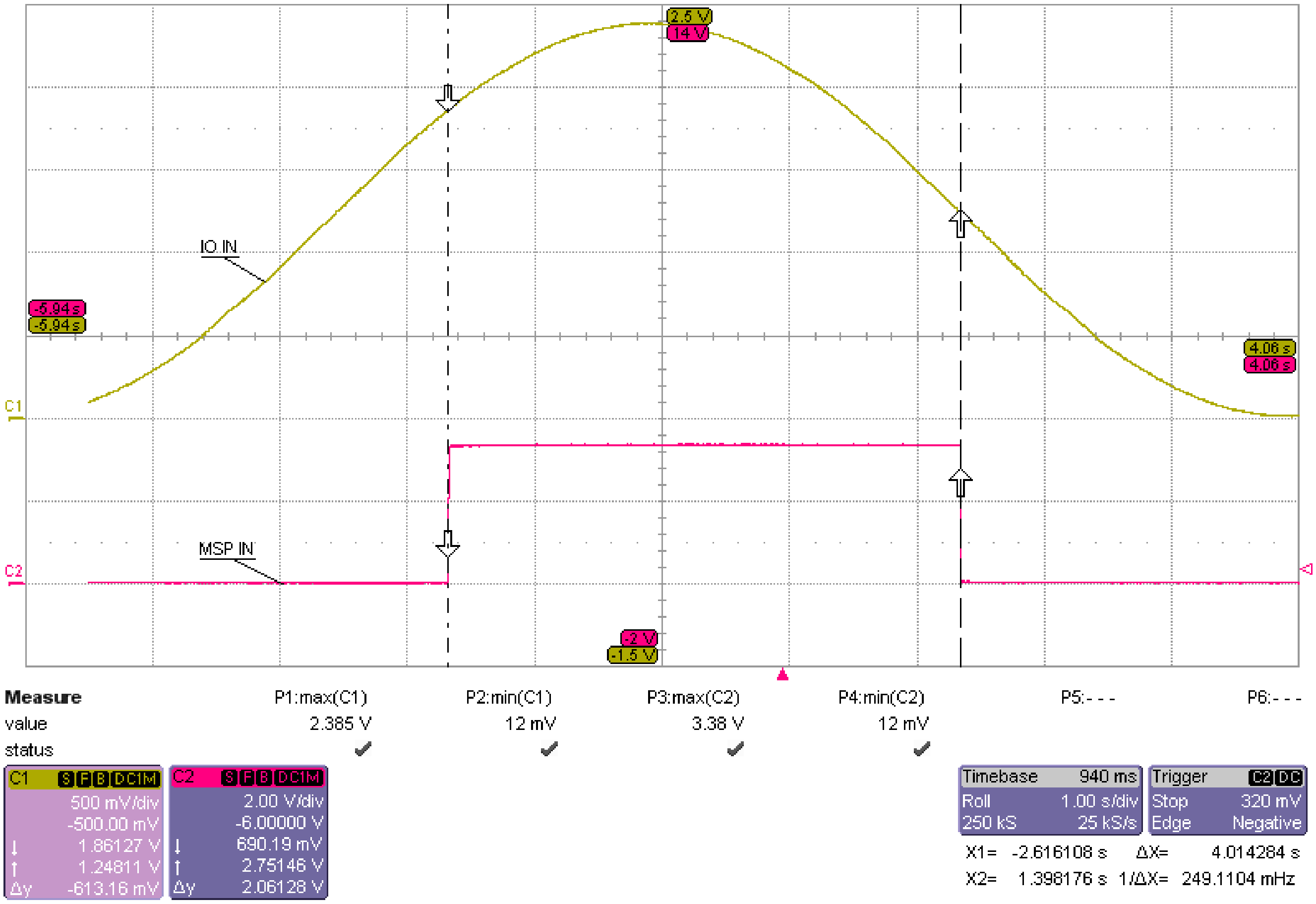
Figure 3-12. CC1 Signal Voltage Accuracy State D

3.3.3 Digital and Analog Input

This section shows test data for the digital and analog input.

3.3.3.1 Digital In

Figure 3-13 shows the threshold voltage *digital in* for the circuit.



Measure	P1:max(C1)	P2:min(C1)	P3:max(C2)	P4:min(C2)	P5:- - -	P6:- - -
value	2.385 V	12 mV	3.38 V	12 mV		
status	✓	✓	✓	✓		

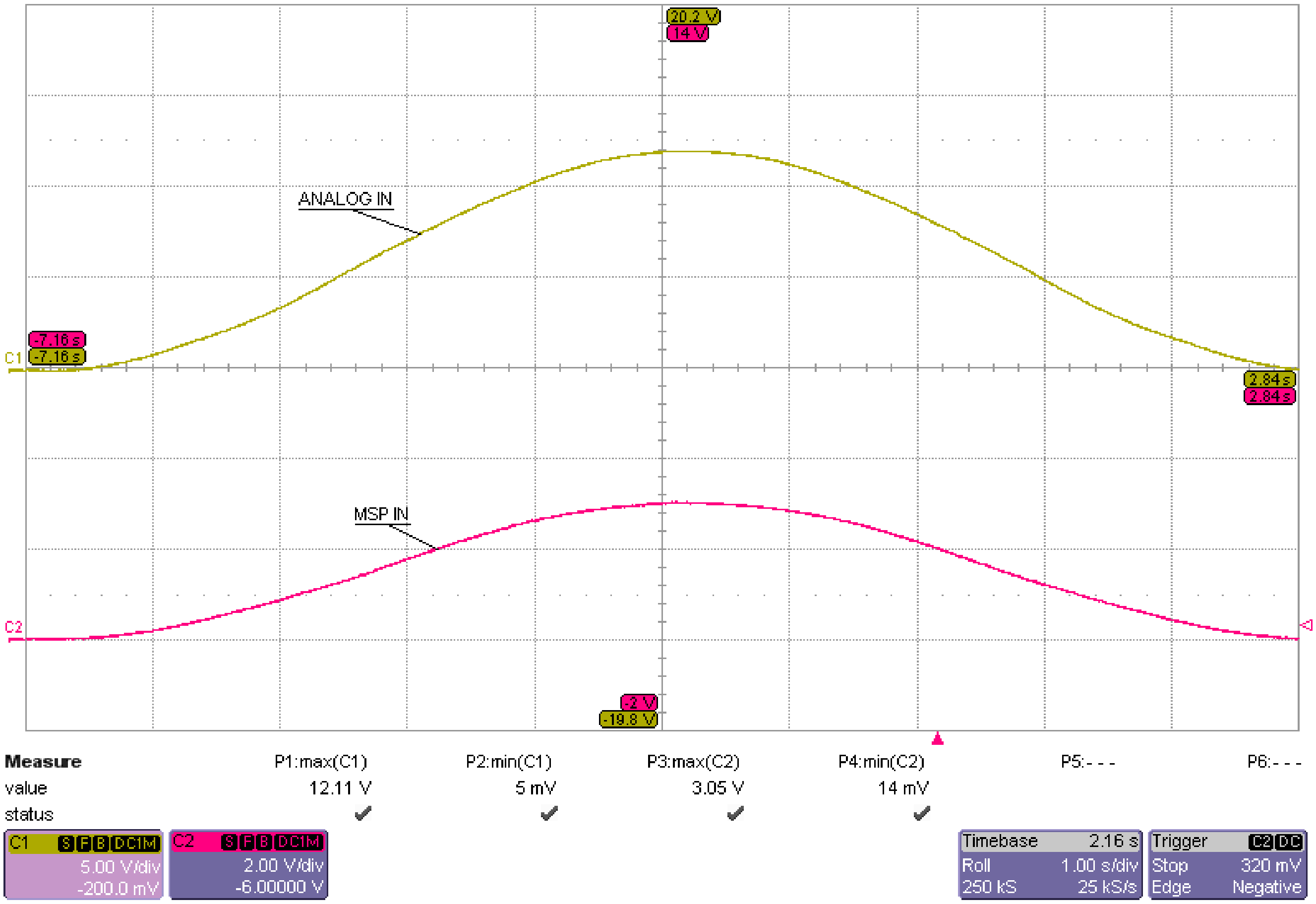
```
C1      S F B DC1M     C2      S F B DC1M
        500 mV/div             2.00 V/div
        -500.00 mV             -6.00000 V
↓       1.86127 V      ↓       690.19 mV
↑       1.24811 V      ↑       2.75146 V
Δy      -613.16 mV     Δy      2.06128 V
```

```
Timebase      940 ms   Trigger     C2 DC
Roll      1.00 s/div   Stop       320 mV
250 kS      25 kS/s    Edge     Negative
X1=  -2.616108 s    ΔX=      4.014284 s
X2=   1.398176 s  1/ΔX=   249.1104 mHz
```

Figure 3-13. Threshold Voltage Digital In the Circuit

3.3.3.2 Analog In

Figure 3-14 shows the *analog in* voltage vs ADC input voltage for the circuit.



Measure	P1:max(C1)	P2:min(C1)	P3:max(C2)	P4:min(C2)	P5:- - -	P6:- - -
value	12.11 V	5 mV	3.05 V	14 mV		
status	✓	✓	✓	✓		

C1 S F B DC1M
5.00 V/div
-200.0 mV

C2 S F B DC1M
2.00 V/div
-6.00000 V

Timebase 2.16 s
Roll 1.00 s/div
250 kS 25 kS/s

Trigger C2 DC
Stop 320 mV
Edge Negative

Figure 3-14. Analog in Voltage vs ADC Input Voltage

4 Design and Documentation Support

4.1 Design Files

4.1.1 Schematics

To download the schematics, see the design files at TIDA-010939.

4.1.2 BOM

To download the bill of materials (BOM), see the design files at TIDA-010939.

4.2 Tools and Software

Tools

CCSTUDIO	Code Composer Studio™ integrated development environment (IDE)
SYSCONFIG	System configuration tool with an intuitive graphical user interface for configuring pins, peripherals, radios, software stacks, RTOS, clock tree, and other components.

Software

MSPM0-SDK	The MSPM0 SDK provides the ultimate collection of software, tools, and documentation to accelerate the development of applications for the MSPM0 MCU platform under a single software package.
AM62L-SDK	The AM62L processor Linux and TI FreeRTOS software development kits (SDKs) are unified software platforms for embedded processors providing easy setup and fast out-of-box access to benchmarks and demonstrations.

4.3 Documentation Support

1. Texas Instruments, *MSPM0G350x Mixed-Signal Microcontrollers With CAN-FD Interface Data Sheet*
2. Texas Instruments, *AM62Lx Sitara™ Processors Data Sheet*
3. Texas Instruments, *AM62L Evaluation Module User's Guide*

4.4 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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