User's Guide
SLLU281A–November 2017–Revised March 2019

TCAN4550 evaluation module

This user's guide describes the TCAN4550 evaluation module (EVM). This EVM helps designers evaluate device performance, support fast development, and analyze Controller Area Network with Flexible Data rate (CAN FD) systems using TCAN4550 CAN FD physical layer transceiver devices.

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1 Introduction

This user's guide describes the TCAN4550 EVM. This EVM helps designers evaluate device performance, support fast development, and analyze CAN FD systems using TCAN4550 CAN FD physical layer transceiver devices.

1.1 Features

The features of the TCAN4550 EVM follow:

- CAN FD controller with integrated CAN transceiver
- Operates from a battery voltage input V_{BAT} (6 V to 24 V)
- Polarity protected and EMC filtered supply voltage
- Dual-channel LDO
  - Selectable V_{IO} (5-V, or 3.3-V) supply rails
  - General-purpose 5-V supply rail
  - Error monitoring and current-sense features
- CAN bus header and industry-standard DB-9 connector
- TVS diode pad (not populated)
- CAN bus transient signal injection/monitoring header
- CAN bus termination with disconnect headers
- Common-mode choke (bypassed with 0-Ω resistors by default)
- Status LEDs
- MCU interface header (SPI, GPIO, V_{IO}, and 5-V)
- Reset push-button switch
- Configuration DIP switches for support of multiple use pins
- Crystal oscillator (40 MHz)
- External clock input and output SMA connectors
- High-voltage Inhibit and Wake signal header
- WAKE push-button switch

1.2 Description

The TCAN4550 EVM provides the user with the ability to evaluate the TI TCAN4550 CAN FD Controller with integrated CAN transceiver devices. Any MCU or SPI controller with an I/O voltage of 3.3 V or 5 V may be connected to the EVM through a standard interface header. The EVM features a polarity-protected and EMC-filtered supply voltage that allows the EVM to operate from an external voltage from 6 V to 24 V. A dual-channel LDO creates a 5-V, general-purpose voltage rail to source the LEDs and supporting ICs, and a variable V_{IO} voltage rail that can be set to 5 V or 3.3 V to match the MCU signal level requirements. The V_{IO} or 5-V rail is also designed to source the supply voltage for the connected MCU to evaluate sleep mode and wake-up events.

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2 EVM Features and Requirements

2.1 Power

2.1.1 EVM Supply Voltage

The TCAN4550 family of devices can operate across a wide recommended supply voltage range of 6 V to 24 V, with an absolute maximum voltage of 40 V. This makes the TCAN4550 device ideal for many different applications, including those in the automotive market. Typically, a wide array of tests must be performed throughout the qualification process specified in various standards, including reverse-polarity and EMC performance requirements. To accommodate these types of tests, a reverse-blocking diode and an EMC-filtering circuit have been added to the EVM based on a typical automotive ECU design to clean and protect the device voltage input supply V_{SUP} from the external, unprotected battery voltage V_{BAT_EXT}. The EVM uses a 30-V Zener diode as protection from excessive supply voltages.

Furthermore, it is common for a CAN node to receive power and CAN signals through a single wiring harness. The supply voltage of the EVM can be applied through pin 9 of the DB-9 connector consistent with the industry-standard pinout, or through header J9. Due to the reverse polarity blocking Schottky diode, a small voltage difference exists between the supplied voltage V_{BAT} and the voltage at the TCAN4550 VSUP pin. This small voltage difference can be monitored on header J8. For lab environment tests that do not require the polarity protection, the power supply voltage can be applied directly to J8. Figure 1 shows the EVM supply voltage connectors.

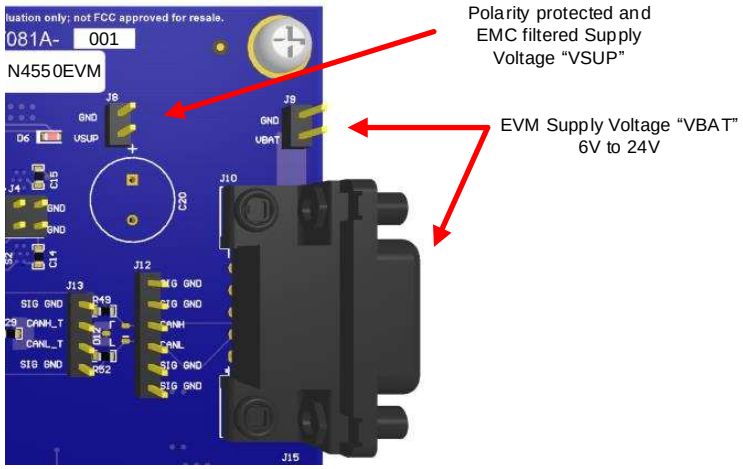


Figure 1. EVM Supply Voltage Connectors

2.1.2 TCAN4550

2.1.2.1 VSUP Pin

The TCAN4550 is powered through the VSUP pin and supplies the internal regulators for the digital core, CAN transceiver, and optional VCCOUT. A 330-nF capacitor is required on the LDO Filter pin FLTR for proper operation as described in the data sheet and seen in the schematics.

2.1.2.2 VIO Pin

The VIO pin provides the digital I/O voltage to match the MCU I/O voltage to prevent the need for level-shifting of signals across different MCUs. The VIO pin supports the SPI I/O pins, GPIO1 and GPO2 pins, as well as the oscillator block supporting the crystal oscillator or CLKIN pins.

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2.1.2.3 VCCOUT Pin

The TCAN4550 devices provide up to 70 mA of current on the VCCOUT pin from the 5-V internal LDO without impacting the CAN transceiver performance, except when in sleep mode and when the regulator is disabled. This voltage can be used to power an MCU or other supporting circuitry that is not needed during sleep mode. At least 10 µF of capacitance to ground is required on the VCCOUT pin, as described in the data sheet and seen in the schematic.

2.1.2.4 GND Pin

The thermal pad and pin 13 of the TCAN4550 devices are ground and are connected to the ground plane of the EVM to support heat dissipation.

2.1.3 External LDO (TPS7B7702-Q1)

Although it is not required for all applications, the EVM included:

- a dual-channel LDO to provide the V_{IO} voltage reference for TCAN4550
- a 5-V utility voltage to source the LEDs
- other devices on the EVM that have been added to enhance the evaluation of the TCAN4550 features.

The 5-V channel is configured to become enabled when the V_{SUP} voltage is present, and the VIO channel is configured to become enabled through the TCAN4550 INH pin.

When the V_{SUP} voltage is applied to the TCAN4550, the device enters standby mode and drives the INH pin to a high level (V_{SUP} minus a diode drop) and monitors the VIO pin for a proper input voltage. If the V_{IO} voltage fails to rise above the UV_{IO} undervoltage threshold, or ever drops below this threshold during normal operation, for longer than the t_{uv} undervoltage time, the TCAN4550 enters sleep mode and changes the INH pin to a high-impedance state. The Failsafe feature of the TCAN4550 can cause the device to enter Sleep Mode if the device is not configured for Normal mode or the PWRON flag is not cleared within four minutes of powering on or exiting Sleep Mode. This Hi-Z state disables the V_{IO} channel of the LDO. If this occurs, a Local Wake Up (LWU) request is required through a voltage transition on the WAKE pin or through a request on the CAN bus.

The TPS7B7702-Q1 LDO has several features that are available through the J2 header, such as current sensing, current limiting and fault detection, and error reporting. See the TPS7B7702-Q1 data sheet for more information on those features. Figure 2 shows the external LDO features.

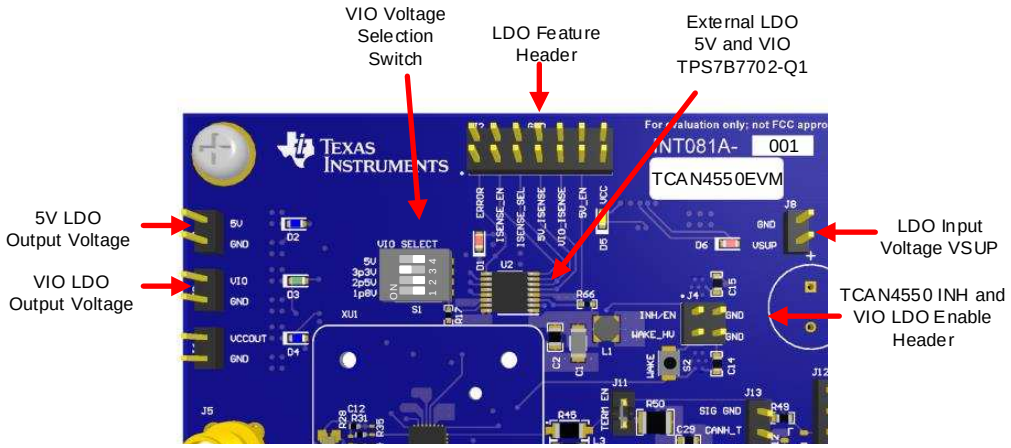


Figure 2. External LDO Features

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2.1.4 V_{IO} Voltage Selection Switch (S1)

The TPS7B7702-Q1 LDO is an adjustable LDO that uses a resistor divider between the output pin and a feedback pin to regulate the output voltage. Four different resistor divider options are provided on the EVM to allow V_{IO} to be set to 5 V, 3.3 V, 2.5 V, and 1.8 V through the change of the DIP switch configuration on switch S1. The TCAN4550 only supports V_{IO} levels of 5 V and 3.3 V. The 2.5 V and 1.8 V settings have been added to the board in case future versions of the TCAN4550 are developed with support for these common voltage levels. There is a common resistor between the output voltage pin, the feedback pin, and one side of all four DIP switch positions. A separate resistor has been placed between the other side of each DIP switch position and GND to create the voltage divider. Only one DIP switch at a time should be connected in the ON position (toward the silkscreen voltage labels). If more than one switch at a time is ON, the resistors to GND are in parallel and alter the voltage created by the resistor divider circuit and cause V_{IO} to be regulated to a voltage other than one of the four standard options.

2.2 CAN

The following sections describe the features of the CAN. Figure 3 shows the CAN bus features.

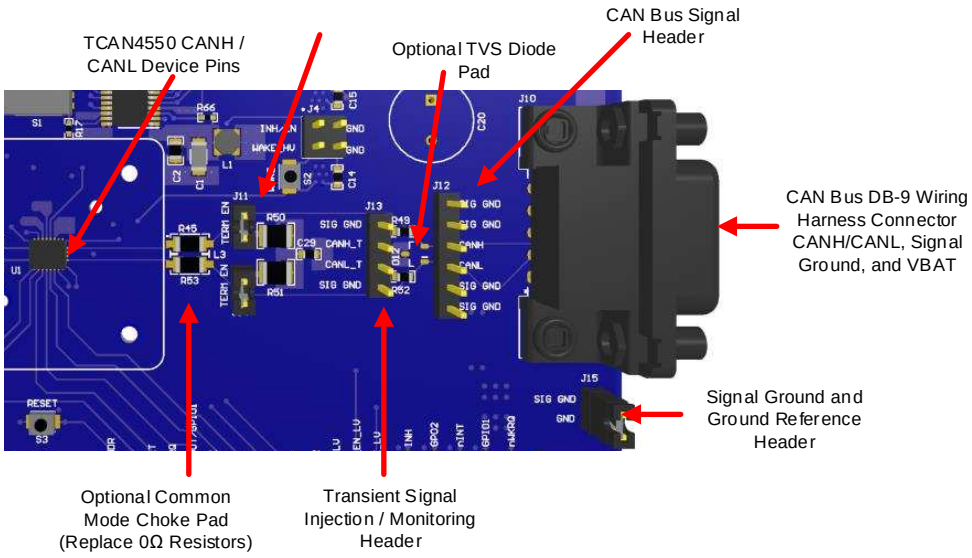


Figure 3. CAN Bus Features

2.2.1 CAN Bus DB-9 Connector (J10)

The CAN bus signals CANH and CANL are accessible through the DB-9 connector J10, which follows the industry-standard pin mapping. This mapping allows for easy integration into an existing system. The external supply voltage V_{BAT}, signal ground, and connector shield ground connections are also included in connector J10.

2.2.2 CAN Bus Signal Header (J12)

The CAN bus signals are also available on header J12. This may be more convenient in a lab environment or to attach scope probes to monitor the bus connected to the EVM through the DB-9 connector.

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2.2.3 CAN Bus Signal Ground Reference

The EVM contains a separate GND plane that is used as the reference for the CAN signals called Signal GND. Potential differences between the GND nodes often exist in systems with a bus architecture resulting in common-mode offsets of the CAN signals. The TCAN4550 is designed to handle these differences. A DC voltage can be injected onto the Signal GND plane relative to the GND plane to simulate this offset and shift the common-mode of the CAN signals through header J15. By default, the Signal GND and GND planes are shorted together by placing a shunt on header J15.

2.2.4 TVS Diode (D12)

A TVS diode footprint has been added to the EVM if evaluation with additional ESD protection is required, but this is not populated by default nor required in all applications.

2.2.5 Transient Signal Injection/Monitoring Header (J13)

Many tests are commonly run on CAN transceivers that require some form of transient signal injection, or some form of additional bus loading. To accommodate these types of tests, header J13 and series resistors R49 and R52 have been added to the EVM. These components are not required for a final application and can be used or modified as desired during the evaluation.

2.2.6 Termination

The CAN standard requires termination of the CAN bus at each end with 120 Ω of resistance between the CANH and CANL pins. A common technique, also used on this EVM, is to implement a split termination using two 60-Ω resistors in series and a 4.7-nF capacitor to ground. The capacitor to ground provides a path for filtering common-mode noise out of the signals that can come from sources such as asymmetry between the CANH and CANL signals. Common-mode noise is a result of unequal lengths between the CANH and CANL wires, asymmetrical loading, or other sources. If the EVM is used in a lab environment or as one of the end nodes of the CAN bus, the termination can be enabled by placing shunts on jumpers J11 and J14 to connect the termination resistors to the CANH and CANL lines. However, if the EVM is used on a bus with existing termination resistors or does not require local termination, removing the shunts on J11 and J14 disconnects the local termination from the CANH and CANL lines. It is also possible to evaluate the TCAN4550 with one 120-Ω resistor by removing the two 60-Ω resistors, R50 and R51, and installing one 120-Ω resistor in their place using one pad of R50 and one pad of R51.

2.2.7 Common-Mode Choke

Many applications have system-level electromagnetic compatibility (EMC) requirements that may require the use of a common-mode choke on the CAN pins. A typical common-mode choke pad has been added to the EVM for the user to add their desired choke. However, by default, 0-Ω resistors have been placed across the choke pins to connect the CANH and CANL pins of the TCAN4550 device with the rest of the CAN bus connectors and features of the EVM. To add a choke to the EVM, simply remove resistors R45 and R53 from the EVM and install the choke in their place.

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2.3 Clocking

Figure 4 shows the clocking features on the board.

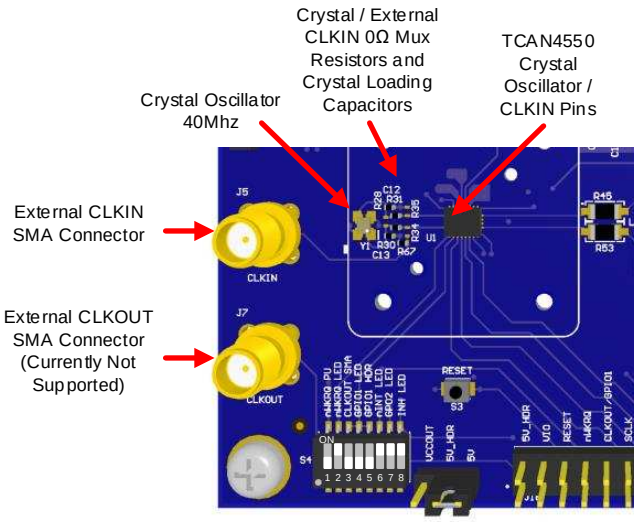


Figure 4. Clocking Features

2.3.1 Crystal/CLKIN

The TCAN4550 requires either a crystal oscillator, or a single-ended clock to run its digital core. A 40-MHz crystal oscillator is installed and connected to the OSC1/CLKIN and OSC2 pins by default and will be available whenever V_{IO} is present. However, a simple configuration change of two 0-Ω resistors allows use of an external CLKIN through the SMA connector J5. To enable the external clock source, remove resistors R30 and R31 and install them in the locations for resistors R34 and R35. The installation of R30 and R31 serve the purpose of a MUX, and all four resistors should not be installed simultaneously.

2.3.2 CLKOUT, SMA (J7)

The TCAN4550 does not currently support a CLKOUT feature, but the SMA connector is on the EVM in case future version of the device are developed with a CLKOUT feature.

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2.4 MCU Interface (SPI/GPIO)

Figure 5 shows the MCU interface.

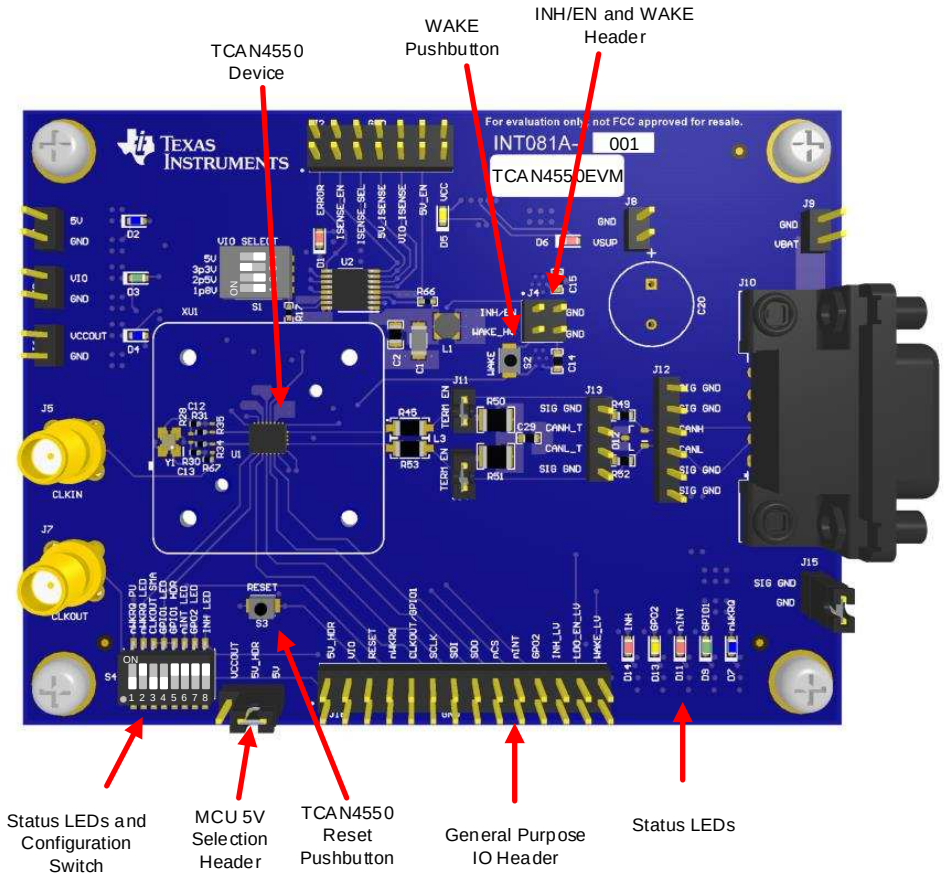


Figure 5. MCU Interface (SPI/GPIO) Features

2.4.1 General-Purpose I/O Header (J16)

The TCAN4550 requires a MCU or other SPI controller for configuration and operation. A specific MCU has not been included on the EVM to allow evaluation of the TCAN4550 device with any MCU board or SPI controller. All GPIO signals are available on a single header (J16), thus allowing a convenient connection to the MCU board through a ribbon cable or fly wires. A GND pin has been added next to each signal pin. These GND pins place a GND wire between each signal wire if a ribbon cable is used. Furthermore, 2-pin coax cables can be used for better signal integrity compared to unshielded fly wires, or for a convenient GND reference for scope probes and other test equipment. Both a 5-V reference and the V_{IO} voltages are available on this header and can be used as the power supply for the MCU board and evaluate sleep and wake events used in integrated designs. The 5-V source can be configured to come from either the 5-V utility rail of the EVM, which is always present when VSUP is present, or from VCCOUT, which is present only when the TCAN4550 is not in sleep mode through the shunt position of header J17.

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2.4.2 Status LEDs and Configuration Switch (S4)

Several TCAN4550 I/O pins have multiple functions that can be configured through the SPI registers, and a single multichannel DIP switch (S4) makes it easy to configure the EVM hardware to support the various I/O features. Most of the DIP switches are used to disconnect the traces to the LED circuits from the I/O signals to prevent stubs or extra loading on signals that might be sensitive to reflections and poor signal integrity. An example of when the LED should be disconnected is when the transceiver test mode is configured to use the GPIO1 pin for TXD and the GPO2 pin as RXD.

All I/O signals from the TCAN4550 device are connected directly to the general-purpose header J16, with the exception of the GPIO1 pin. The GPIO1 pin runs through switch positions 3, 4, and 5 of switch S4 to route the currently unsupported CLKOUT signal to the SMA connector (J7) and prevent creation of a stub by header J16 or status LED (D9).

All status LEDs on the EVM are sourced from the 5-V utility rail and buffered through a pair of transistors (CSD85301Q2). Because some of the signals where an LED is useful, such as nINT and nWKRQ, use negative logic, a second transistor has been added to invert the signals and allow the LED to be on when the IO pin voltage is in the active low state. All pullup resistors connected to the TCAN4550 side of the LED circuit are biased to the VIO rail to accommodate the desired I/O voltage of the MCU.

An LED has been added to each DC power rail on the EVM buffered through a transistor and sourced from the 5-V utility rail to not add to the current load of the individual rails more than the current needed for a 10-kΩ pullup resistor. For more precise current measurements on the VIO and VCCOUT rails, remove these resistors. Furthermore, to account for a large voltage range of VSUP, a large voltage divider is used on the gate of the FET that controls the VSUP LED (D6).

2.4.3 WAKE pin

The WAKE pin is considered a high-voltage input pin because it is referenced to the VSUP power rail and not the lower voltage VIO or VCC rail.

CAUTION

TI does not recommend connecting the WAKE signal directly to an MCU because the voltage rating of the IO pins is typically much lower than the V_{SUP} voltage and damage to the MCU may occur.

A high-voltage FET (CSD18543Q3A) has been placed between the WAKE pin and GND and the gate of the FET is connected to pin 28 of the general-purpose header (J16). This allows the MCU to use a regular IO pin to cause a high-to-low transition on the WAKE pin to wake up the TCAN4550 device from sleep mode. The EVM also has a momentary push-button switch (S2) that can be used for a manual wake event from a high-to-low transition when pressed. However, by default, the WAKE pin is configured to be a bidirectional edge trigger and to recognize any direction transition as a wake event. This can be reconfigured as a rising only or falling only trigger as described in the data sheet, and pin 3 on header J4 that can be used to monitor or control the WAKE signal.

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2.4.4 INH Pin and VIO Enable

The INH pin is considered a high-voltage output pin because it is referenced to the VSUP power rail and not the lower voltage VIO or VCCOUT rail. If the INH pin is used, it is typically connected to the enable pin of a regulator used to support the MCU and VIO rail. It outputs a voltage equal to VSUP, minus a diode drop, in all modes but sleep mode when the pin becomes high impedance. To ensure that a low voltage is applied to the enable pin of the regulator in sleep mode, a pulldown resistor is used to hold the line low when INH is high impedance.

The default configuration of the EVM has the INH pin of the TCAN4550 connected to the VIO enable pin. However, a 1-Ω resistor (R36) has been placed in series between these two pins and can be removed to isolate the enable and INH pins. If this is done, the 10-kΩ pullup resistor (R23) should be installed to provide a high-voltage reference for the VIO enable pin.

External control of the high-voltage LDO enable pin, or monitoring of the INH pin, can be done directly through pin 1 of header J4. A high-voltage FET (CSD18543Q3A) has been placed between the EN and GND pins with the gate of the FET connected to pin 26 of the general-purpose header (J16) to provide a low-voltage control option through the MCU. A low-voltage monitoring option of the INH pin is available through pin 24 of the general-purpose header (J16) and a status LED (D14). A voltage comparator (LMV331QDBVRQ1) is used to compare the INH voltage against a reference voltage generated with a voltage divider on the 5-V utility rail. The reference voltage divider is set to accommodate an INH signal with the maximum V_{SUP} voltage tolerated without any modification to the EVM. The eighth switch in the configuration DIP switch (S4) disconnects the low-voltage enable signal from the status LED (D14).

The low-voltage control and monitoring options of the EVM, along with the wake request pin (nWKRQ) of the TCAN4550, allow an alternative approach to placing the node into sleep and waking it up again. If the system is in sleep mode, and a wake event occurs either through a local wake event on the WAKE pin or though activity on the CAN bus, the MCU can detect the INH pin going high through the INH_LV signal on pin 24 of the general-purpose header (J16). The MCU can then change the state of the VIO enable pin through the LDO_EN_LV signal on pin 28 of the general-purpose header (J16) to enable the V_{IO} voltage rail for normal operation. However, this approach requires that the 5-V utility rail and the MCU remain on while TCAN4550 is in sleep mode to monitor for a wake event.

2.5 TCAN4550 Device

By default, the EVM comes installed with the TCAN4550 device soldered to the board, but it can also be used with a socket from RS Tech Incorporated (PN: SK02-0020QFN-CS-02A).

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3 Board Layout

Figure 6 and Figure 7 show the top and bottom, respectively, of the EVM.

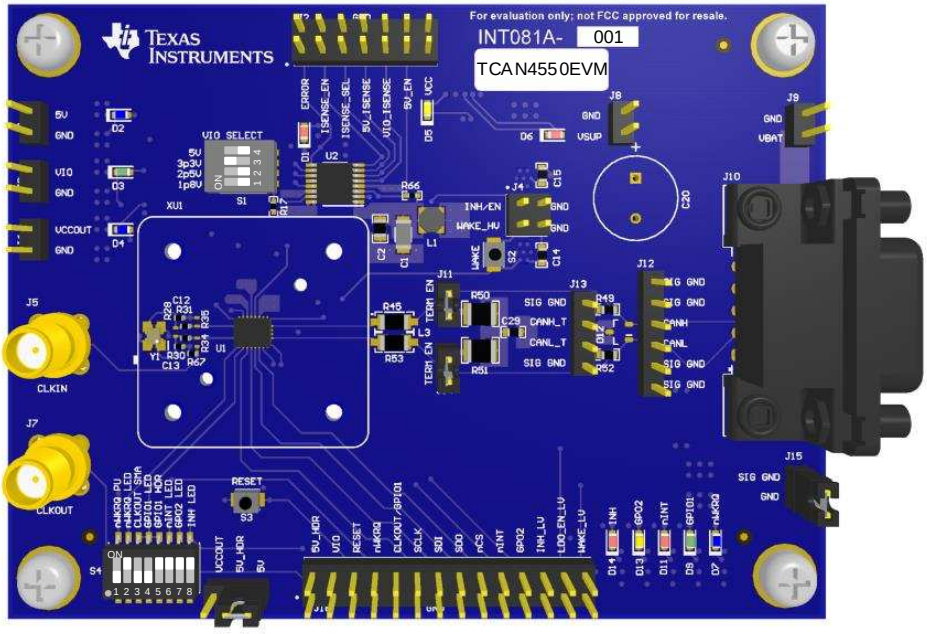


Figure 6. EVM Top

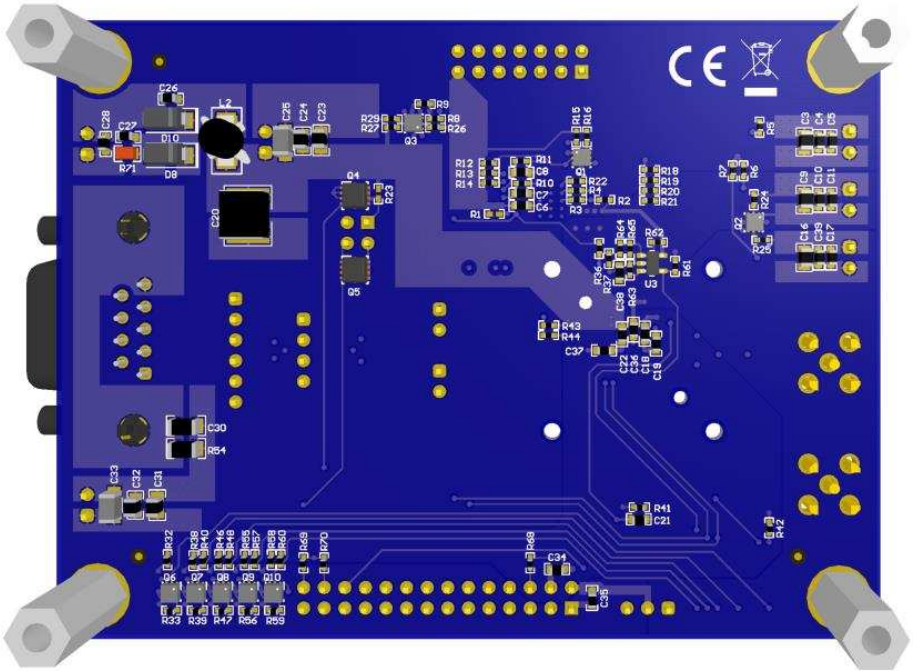


Figure 7. EVM Bottom

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4 Schematic and Bill of Materials

4.1 Schematic

Figure 8 is a schematic diagram of the EVM.

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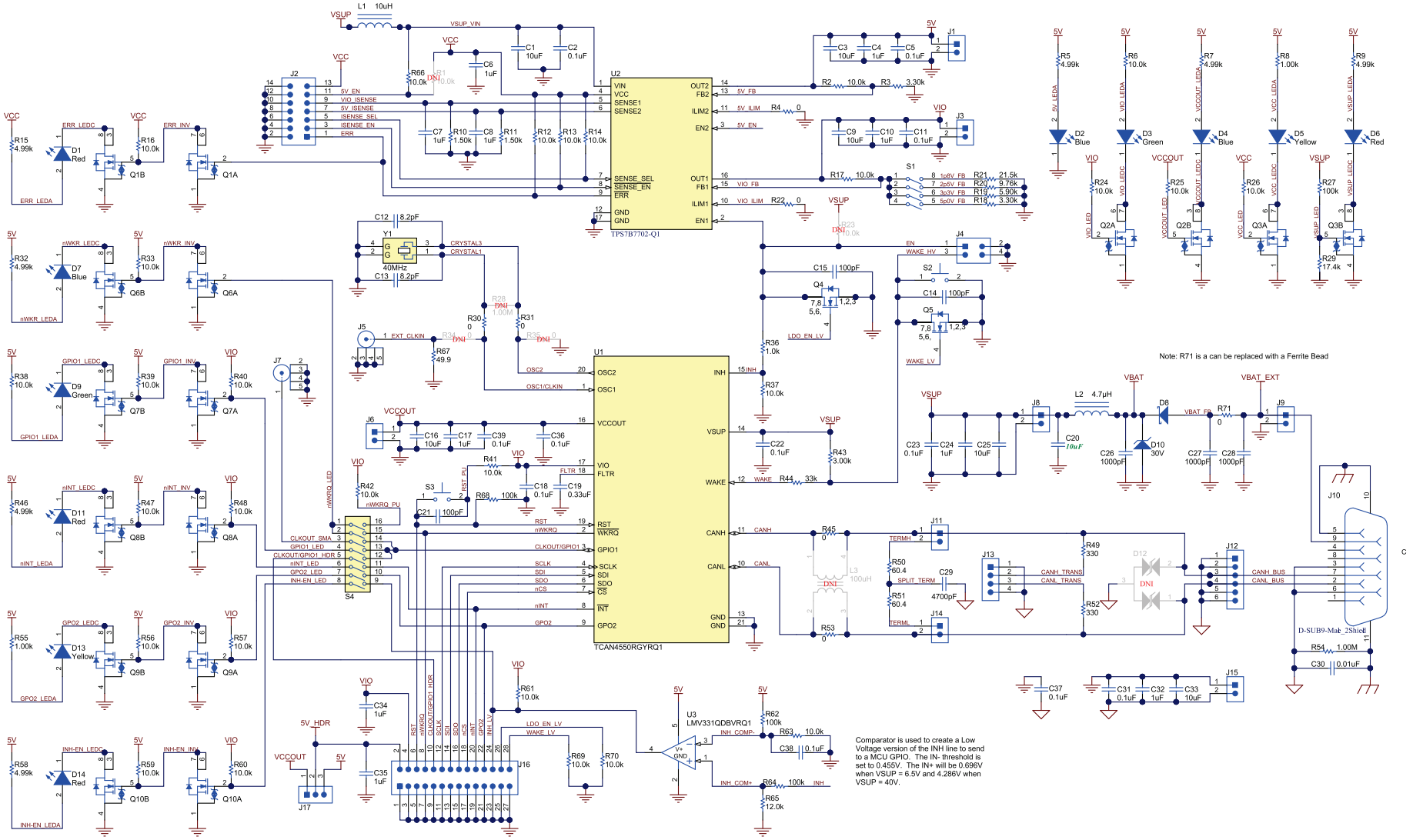


Figure 8. EVM Schematic

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4.2 Bill of Materials

Table 1 lists the bill of materials (BOM).

Table 1. Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number[1]	Alternate Manufacturer[1]
!PCB1	1		Printed Circuit Board		INT081	Any		
C1, C25, C33	3	10uF	CAP, CERM, 10 uF, 50 V, +/- 10%, X7R, 1206	1206	CL31B106KBHNNNE	Samsung		
C2, C23, C31	3	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 5%, X7R, 0805	0805	08055C104JAT2A	AVX		
C3, C9, C16	3	10uF	CAP, CERM, 10 uF, 16 V, +/- 10%, X7R, 0805	0805	CL21B106KOQNNNE	Samsung Electro-Mechanics		
C4, C6, C7, C8, C10, C17, C34, C35	8	1uF	CAP, CERM, 1 uF, 35 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E1X7R1V105K080AC	TDK		
C12, C13	2	8.2pF	CAP, CERM, 8.2 pF, 25 V, +/- 5%, C0G/NP0, 0402	0402	GRM1555C1E8R2CA01D	MuRata		
C14, C15, C21	3	100pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	06035A101JAT2A	AVX		
C19	1	0.33uF	CAP, CERM, 0.33 uF, 16 V, +/- 10%, X7R, 0603	0603	C0603C334K4RACTU	Kemet		
C20	1	10uF	CAP, CERM, 10 uF, 50 V, +/- 10%, X7R,		C5750X7R1H106K230KB	TDK		
C24, C32	2	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0805	0805	08055C105KAT2A	AVX		
C26, C27, C28	3	1000pF	CAP, CERM, 1000 pF, 100 V, +/- 5%, X7R, 0603	0603	06031C102JAT2A	AVX		
C29	1	4700pF	CAP, CERM, 4700 pF, 100 V, +/- 5%, X7R, 0603	0603	06031C472JAT2A	AVX		
C30	1	0.01uF	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, 1206	1206	12061C103KAT2A	AVX		
D1, D6, D11, D14	4	Red	LED, Red, SMD	LED_0603	150060RS75000	Wurth Elektronik		
D2, D4, D7	3	Blue	LED, Blue, SMD	LED_0603	150060BS75000	Wurth Elektronik		
D3, D9	2	Green	LED, Green, SMD	LED_0603	150060GS75000	Wurth Elektronik		
D5, D13	2	Yellow	LED, Yellow, SMD	LED_0603	150060YS75000	Wurth Elektronik		
D8	1	40V	Diode, Schottky, 40 V, 1 A, SMA	SMA	MBRA140T3G	ON Semiconductor		
D10	1	30V	Diode, Zener, 30 V, 3 W, SMA	SMA	3SMAJ5936B-TP	Micro Commercial Components		
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B& F Fastener Supply		
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone		
J1, J3, J6, J8, J9, J11, J14, J15	8		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec		
J2	1		Header, 100mil, 7x2, Gold, TH	7x2 Header	TSW-107-07-G-D	Samtec		
J4	1		Header, 100mil, 2x2, Gold, TH	2x2 Header	TSW-102-07-G-D	Samtec		
J5, J7	2		Connector, SMA, TH	SMA	142-0701-201	Cinch Connectivity		
J10	1		D-Sub, 2.74mm, 9 Position, R/A, TH	D-Sub, 2.74mm, 9 Position, R/A, TH	5747840-5	TE Connectivity		
J12	1		Header, 100mil, 6x1, Gold, TH	6x1 Header	TSW-106-07-G-S	Samtec		
J13	1		Header, 100mil, 4x1, Gold, TH	4x1 Header	TSW-104-07-G-S	Samtec		
J16	1		Header, 100mil, 14x2, Gold, TH	14x2 Header	TSW-114-07-G-D	Samtec		
J17	1		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec		
L1	1	10uH	Inductor, Shielded Drum Core, Ferrite, 10 uH, 1 A, 0.17 ohm, SMD	Inductor, 2.8x2.8x2.8mm	744025100	Wurth Elektronik		

(1) Unless otherwise noted in the Alternate PartNumber and/or Alternate Manufacturer columns, all parts may be substituted with equivalents.

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Table 1. Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number[1]	Alternate Manufacturer[1]
L2	1	4.7uH	Inductor, Wirewound, Ferrite, 4.7 µH, 1.65 A, 0.08 ohm, AEC-Q200 Grade 0, SMD	6x6mm	B82462A4472M000	TDK		
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady		
Q1, Q2, Q3, Q6, Q7, Q8, Q9, Q10	8	20V	MOSFET, 2-CH, N-CH, 20 V, 6.7 A, DQK0006B (WSON-6)	DQK0006B	CSD85301Q2	Texas Instruments		None
Q4, Q5	2	60V	MOSFET, N-CH, 60 V, 35 A, DNH0008A (VSONP-8)	DNH0008A	CSD18543Q3A	Texas Instruments		None
R2, R12, R13, R14, R16, R17, R24, R25, R26, R33, R37, R39, R40, R41, R42, R47, R48, R56, R57, R59, R60, R61, R63, R66, R69, R70	26	10.0k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RMCF0402FT10K0	Stackpole Electronics Inc		
R3, R18	2	3.30k	RES, 3.30 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF3301X	Panasonic		
R4, R22, R30, R31	4	0	RES, 0, 5%, 0.063 W, 0402	0402	RC0402JR-070RL	Yageo America		
R5, R7, R9, R15, R32, R46, R58	7	4.99k	RES, 4.99 k, 1%, 0.063 W, 0402	0402	RC0402FR-074K99L	Yageo America		
R6, R38	2	10.0k	RES, 10.0 k, .1%, .0625 W, 0402	0402	RT0402BRD0710KL	Yageo America		
R8, R55	2	1.00k	RES, 1.00 k, 1%, 0.0625 W, 0402	0402	RC0402FR-071KL	Yageo America		
R10, R11	2	1.50k	RES, 1.50 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021K50FKED	Vishay-Dale		
R19	1	5.90k	RES, 5.90 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04025K90FKED	Vishay-Dale		
R20	1	9.76k	RES, 9.76 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04029K76FKED	Vishay-Dale		
R21	1	21.5k	RES, 21.5 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040221K5FKED	Vishay-Dale		
R27, R62, R64, R68	4	100k	RES, 100 k, 1%, 0.0625 W, 0402	0402	RC0402FR-07100KL	Yageo America		
R29	1	17.4k	RES, 17.4 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040217K4FKED	Vishay-Dale		
R36	1	1.0k	RES, 1.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021K00JNED	Vishay-Dale		
R43	1	3.00k	RES, 3.00 k, 1%, 0.0625 W, 0402	0402	RC0402FR-073KL	Yageo America		
R44	1	33k	RES, 33 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040233K0JNED	Vishay-Dale		
R45, R53	2	0	RES, 0, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	ERJ-8GEY0R00V	Panasonic		
R49, R52	2	330	RES, 330, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603330RJNEA	Vishay-Dale		
R50, R51	2	60.4	RES, 60.4, 1%, 0.5 W, 1210	1210	RC1210FR-0760R4L	Yageo		
R54	1	1.00Meg	RES, 1.00 M, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	ERJ-8ENF1004V	Panasonic		
R65	1	12.0k	RES, 12.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040212K0FKED	Vishay-Dale		
R67	1	49.9	RES, 49.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040249R9FKED	Vishay-Dale		
R71	1	0	RES, 0, 1%, 0.5 W, 0805	0805	5106	Keystone		
S1	1		Switch, Slide, SPST 4 poles, SMT	SW, SMT Half Pitch 4SPST, 5.8x2.7x6.25 mm	218-4LPST	CTS Electrocomponents		
S2, S3	2		SWITCH TACTILE SPST-NO 0.05A 12V	3x1.6x2.5mm	B3U-1000P	Omron Electronic Components		
S4	1		Switch, 8SPST, 0.025 A, 24 VDC, SMD	11.28x6.2mm	1-1571983-1	TE Connectivity		
SH-J1, SH-J2, SH-J3, SH-J4	4		Shunt, 2.54mm, Gold, Black	Shunt, 2.54mm, Black	60900213421	Wurth Elektronik		
U1	1		CAN-FD Controller with Integrated Transceiver, RGY0020A (VQFN-20)	RGY0020A	TCAN4550RGYRQ1	Texas Instruments	TCAN4550RGYQ1	Texas Instruments

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Table 1. Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number[1]	Alternate Manufacturer[1]
U2	1		Dual-Channel Antenna LDO With Current Sense, PWP0016J (TSSOP-16)	PWP0016J	TPS7B7702QPWPRQ1	Texas Instruments		Texas Instruments
U3	1		GENERAL-PURPOSE LOW-VOLTAGE COMPARATOR, DBV0005A (SOT-23-5)	DBV0005A	LMV331QDBVRQ1	Texas Instruments		Texas Instruments
Y1	1		Crystal, 40 MHz, 10 ppm, 8 pF, AEC-Q200 Grade 0, SMD	2.0x0.45x1.6mm	NX2016SA-40M-STD-CZS-3	NDK		
D12	0	24V	Diode, TVS, Bi, 24 V, 70 Vc, AEC-Q101, SOT-23	SOT-23	PESD1CAN,215	NXP Semiconductor		
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A		
L3	0	100uH	Inductor, Ferrite, 100 uH, 0.15 A, 2 ohm, SMD	SMD, 4-Leads, Body 4.7 x 3.7 mm	ACT45B-101-2P-TL003	TDK		
R1, R23	0	10.0k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RMCF0402FT10K0	Stackpole Electronics Inc		
R28	0	1.00Meg	RES, 1.00 M, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021M00FKED	Vishay-Dale		
R34, R35	0	0	RES, 0, 5%, 0.063 W, 0402	0402	RC0402JR-070RL	Yageo America		
XU1	0		Socket, QFN-20, 0.5mm Pitch	Socket, QFN-20, 0.5mm Pitch	SK02-0020QFN-CS-02A	RS Tech Incorparated		

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Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (November 2017) to A Revision	Page
• Changed the document From: *Advanced Information* To: *Production* data	2

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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

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8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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