

**ABSTRACT**

This user guide details the operation of the TCAN1043A-Q1 Controller Area Network (CAN) with *Flexible Data Rate* (FD) transceiver evaluation module (EVM). The TCAN1043A-Q1 EVM supports the TCAN1043A-Q1 SOT package. This user guide explains the EVM configurations for basic CAN FD and CAN evaluation, various loads, and termination settings.

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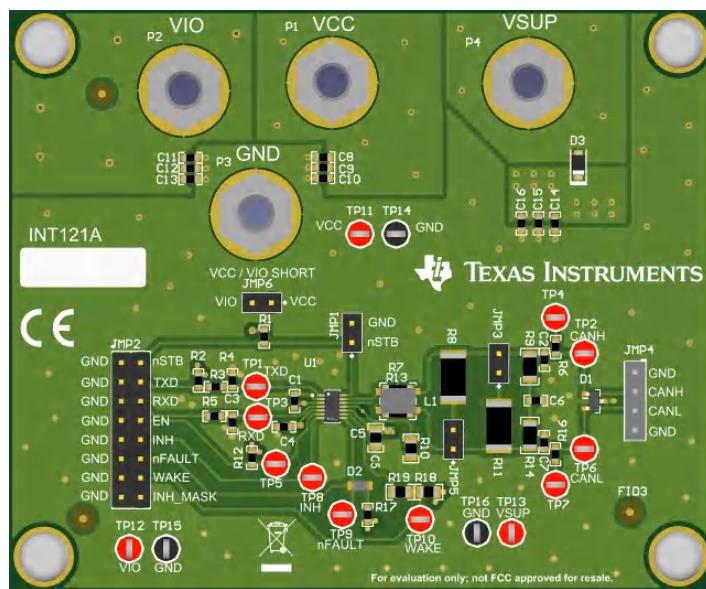
## 1 Introduction

Texas Instruments offers a broad portfolio of high-speed controller area network, CAN, transceivers compatible with the ISO 11898-2:2016 standards. These include 5-V  $V_{CC}$  only, 3.3-V  $V_{CC}$  only, 5-V  $V_{CC}$  with I/O level shifting, and galvanic-isolated CAN transceivers. These CAN transceiver families include product mixes with varying features such as low-power standby modes with and without wake up, silent modes, sleep modes, loop back, and diagnostic modes.

The TI TCAN1043AEVM helps designers evaluate the operation and performance of the TCAN1043A-Q1 CAN FD transceiver in the SOT package. The ability to perform system-level evaluation using the  $V_{IO}$ , EN, INH, nSTB,  $V_{SUP}$ , WAKE, and nFAULT pins can be realized on the EVM. It also provides bus termination, bus filtering, and protection concepts. Use the [TCAN Evaluation Module](#) to evaluate TI's 8-pin CAN and CAN FD transceiver families.

## 1.1 TCAN1043A-Q1 EVM

The TCAN1043A-Q1 EVM has simple connections to all necessary pins of the CAN transceiver device, and jumpers where necessary to provide flexibility for device pin and CAN bus configuration. There are test points (loops) for all main points where probing is necessary for evaluation such as GND, V<sub>CC</sub>, TXD, RXD, CANH, CANL, EN, nFAULT, and WAKE. The EVM supports many options for CAN bus configuration. It is pre-configured with two 120- $\Omega$  resistors connected on the bus via jumpers: a single resistor is used with the EVM as a terminated line end (CAN is defined for 120- $\Omega$  impedance twisted pair cable) or both resistors in parallel for electrical measurements representing the 60- $\Omega$  load the transceiver detects in a properly-terminated network (that is, 120- $\Omega$  termination resistors at both ends of the cable). If the application requires *split* termination, TVS diodes for protection, or a Common Mode (CM) Choke, the EVM has footprints available for this via customer installation of the desired components. [Figure 1-1](#) shows the EVM board image.



**Figure 1-1. TCAN1043A-Q1 Evaluation Module (EVM)**

## 1.2 Applications

The TCAN1043A-Q1 is designed to support CAN applications where ultra-low-power requirements exist. The applications include, but are not limited to: ( $\leq 1$  Mbps), CAN FD applications up to 8 Mbps:

- Classic CAN:
  - Supports CAN with data rates up to 1 Mbps
- CAN FD:
  - Supports CAN FD timing requirements at 2 Mbps
  - Supports CAN FD timing requirements at 5 Mbps
  - Supports CAN FD messaging at 8 Mbps
- 12-V and 24-V applications
- Automotive
- Transportation
- Industrial
- Telecom

## 2 Test Setup and Results

### 2.1 Overview and Basic Operation Settings

#### 2.1.1 Jumper Description

Table 2-1 shows a description of the jumper selections on the EVM with a short description of the function of each pin.

**Table 2-1. Jumper Definitions**

| Connection          | Type              | Transceiver Pin  | Description  |
|---------------------|-------------------|------------------|--|
| JMP1                | 2-pin jumper      | nSTB             | Mode control input, Standby input, integrated pull down  |
| JMP2                | 16-pin jumper     | nSTB             |  |
|                     |                   | TXD              | CAN transmit data input (LOW for dominant and HIGH for recessive bus states), integrated pull up   |
|                     |                   | RXD              | CAN receive data output (LOW for dominant and HIGH for recessive bus states), tri-state  |
|                     |                   | EN               | Mode control input, Enable Input, integrated pull down   |
|                     |                   | INH              | Inhibit output, controls system voltage regulators and supplies  |
|                     |                   | nFAULT           | Fault output, inverted logic   |
|                     |                   | WAKE             | Wake input terminal, high voltage input  |
|                     |                   | INH_MASK         | INH_MASK input   |
| JMP3                | 2-pin jumper      | CANH, CANL       | Connect 120- $\Omega$ CAN termination to the bus. Used separately for a single termination if EVM is at end of the CAN bus and termination is not in the cable. Used in combination with JMP5 to get to second CAN termination to represent the combined 60- $\Omega$ load for CAN transceiver parametric measurement. |
| JMP4                | 4-pin jumper      | CANH, CANL       | CAN bus connection (CANH, CANL) and GND  |
| JMP5                | 2-pin jumper      | CANH, CANL       | Connect 120- $\Omega$ CAN termination to the bus. Used in combination with JMP3 to get to second CAN termination to represent the combined 60- $\Omega$ load for CAN transceiver parametric measurement.   |
| TP1                 | Test point (loop) | TXD              | CAN transmit data input  |
| TP2, TP4            |                   | CANH             | High-level CAN bus I/O line  |
| TP3                 |                   | RXD              | CAN receive data output  |
| TP5                 |                   | EN               | Mode control input, Enable Input   |
| TP6, TP7            |                   | CANL             | Low-level CAN bus I/O line   |
| TP8                 |                   | INH              | Inhibit output, controls system voltage regulators and supplies  |
| TP9                 |                   | nFAULT           | Fault output, inverted logic   |
| TP10                |                   | WAKE             | Wake input terminal, high-voltage input  |
| TP11                |                   | V <sub>CC</sub>  | 5-V supply voltage   |
| TP12                |                   | V <sub>IO</sub>  | I/O supply voltage   |
| TP13                |                   | V <sub>SUP</sub> | Reverse blocked battery supply input   |
| TP14, TP15,<br>TP16 |                   | GND              | Ground connection  |

#### 2.1.2 Power Supply Inputs V<sub>SUP</sub>, V<sub>CC</sub>, and V<sub>IO</sub>

The TCAN1043A-Q1 is powered through the V<sub>SUP</sub>, V<sub>CC</sub>, and V<sub>IO</sub> supply pins via the EVM. Each supply pin must be connected to the appropriate supply voltage. V<sub>SUP</sub> can be connected to an automotive battery voltage directly with a reverse blocking diode and supports voltages from 4.5 V to 40 V. Banana jack P4 is used to connect this voltage to the EVM, use TP13 to monitor this voltage. V<sub>CC</sub> is the supply voltage and supports voltages from 4.5 V to 5.5 V. Banana jack P1 is used to connect this voltage to the EVM, monitor this voltage with TP11. V<sub>IO</sub> is the I/O supply voltage and supports voltages from 1.7 V to 5.5 V. Banana jack P2 is used to connect this voltage to the EVM, monitor this voltage with TP12.

#### 2.1.3 TXD Input

The TXD input of the transceiver, transmit data is routed to JMP2 and TP1. The signal path to the JMP2 header is pre-installed with a 0- $\Omega$  series resistor, R3, and also has an optional pullup, R2, to V<sub>IO</sub>.

## 2.1.4 RXD Output

The RXD output of the transceiver, receive data is routed to JMP2 and TP3. The signal path to the JMP2 header is pre-installed with a  $0\text{-}\Omega$  series resistor, R5, and also has an optional capacitor for filtering, C3.

## 2.1.5 nSTB and EN Mode Control

The device has four main operating modes: normal mode, standby mode, silent mode and sleep mode, and one transitional mode called go-to-sleep mode. Operating mode selection is made through the nSTB and EN input terminals in conjunction with supply conditions and wake events. [Table 2-2](#) lists the operational modes of the device and the associated pin configurations. [Figure 2-1](#) shows a state diagram of the various device modes with the associated pin configurations. Use [TCAN1043 Automotive Fault Protected CAN Transceiver With CAN FD](#) as an additional reference to the EVM.

**Table 2-2. Operational Modes**

| $V_{CC}$ and $V_{IO}$ | $V_{SUP}$ | EN | nSTB | WAKER Q Flag | Mode        | Driver         | Receiver                   | RXD                           | Bus Bias         | INH          |
|-----------------------|-----------|----|------|--------------|-------------|----------------|----------------------------|-------------------------------|------------------|--------------|
| Good                  | Good      | H  | H    | X            | Normal      | Enabled        | Enabled                    | Mirror Bus State              | $V_{CC}/2$       | On           |
| Good                  | Good      | L  | H    | X            | Silent      | Disabled (Off) | Enabled                    | Mirror Bus State              | $V_{CC}/2$       | On           |
| Good                  | Good      | H  | L    | Cleared      | Go to Sleep | Disabled (Off) | Low Power Bus Monitor (On) | High or High Z (No $V_{IO}$ ) | Weak pull to GND | On           |
|                       |           |    |      | Cleared      | Sleep       | Disabled (Off) | Low Power Bus Monitor (On) | High or High Z (No $V_{IO}$ ) | Weak pull to GND | Off          |
|                       |           |    |      | Set          | Standby     | Disabled (Off) | Low Power Bus Monitor (On) | High or High Z (No $V_{IO}$ ) | Weak pull to GND | On           |
| Good                  | Good      | L  | L    | X            | Standby     | Disabled (Off) | Low Power Bus Monitor (On) | High or High Z (No $V_{IO}$ ) | Weak pull to GND | On           |
| Bad                   | Good      | X  | X    | X            | Sleep       | Disabled (Off) | Low Power Bus Monitor (On) | High or High Z (No $V_{IO}$ ) | Weak pull to GND | Off (High Z) |
| X                     | Bad       | X  | X    | X            | Protected   | Disabled (Off) | Disabled (Off)             | High Z                        | High Z           | Off (High Z) |

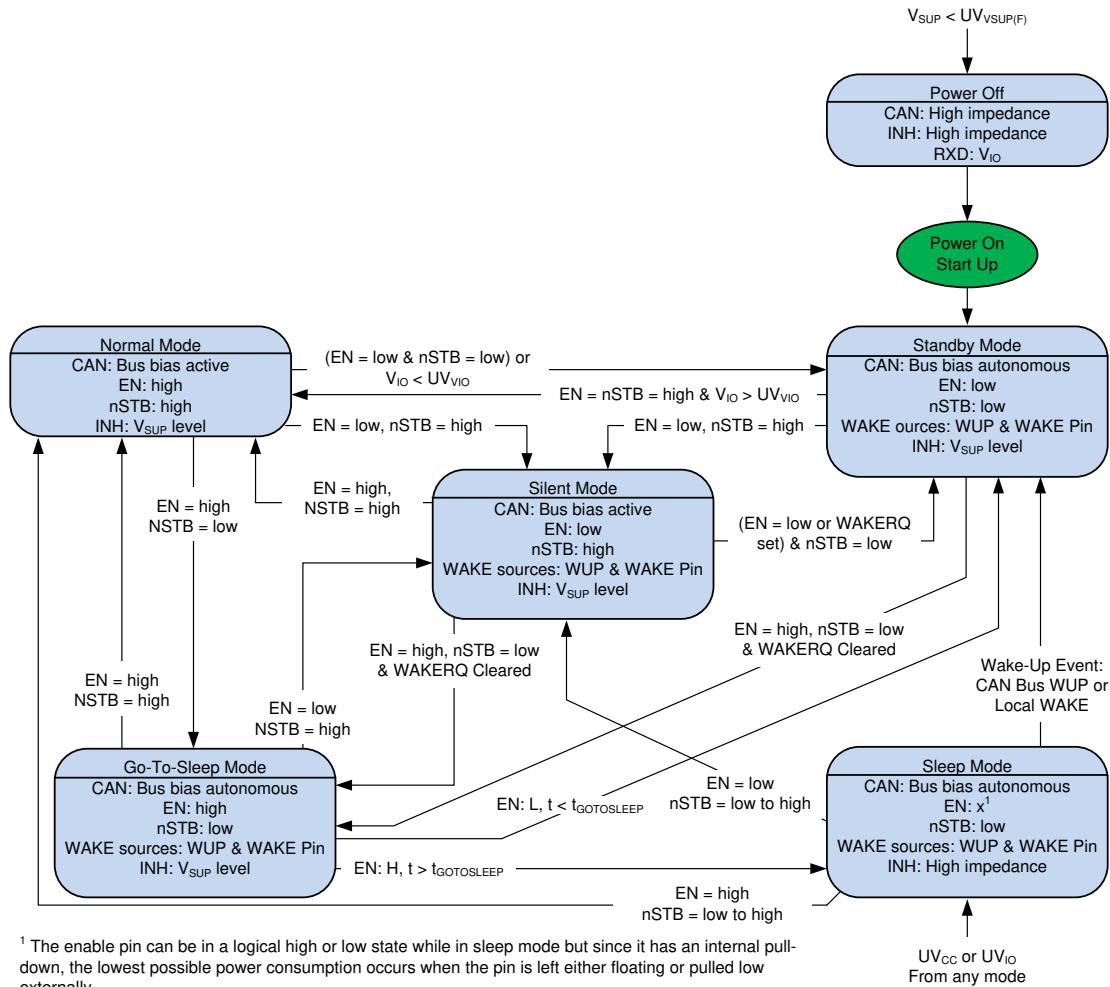


Figure 2-1. TCAN1043A-Q1 State Diagram

The EN signal is available via JMP2 position 4 and TP5.

The nSTB pin is available via JMP2 position 1 and JMP1. JMP1 and JMP2 provide a local GND connection next to the INH pin to enter standby mode. nSTB incorporates a 4.7-k $\Omega$  pullup resistor, R1.

## 2.1.6 Inhibit (INH) High Voltage Output

The inhibit output terminal is used to control system power management devices allowing for extremely low system current consumption in sleep mode. Use this terminal to enable and disable local power supplies. The pin has two states: driven high, and high impedance (High Z).

When high (on) the terminal will show  $V_{SUP}$  minus a diode voltage drop. In the high impedance state the output will be left floating. The INH pin will be high for normal, silent, go to sleep, and standby modes. It will be low when in sleep mode. INH is available via JMP2 position 10 and TP8.

## 2.1.7 CANH and CANL Bus Pins

The CANH and CANL pins are available via JMP4, TP2, and TP6. Ground connections are provided next the CAN lines on JMP4 allowing for easy measurements with oscilloscope probes.

## 2.1.8 WAKE Input

Use the WAKE terminal, a high-voltage input terminal, for local wake up (LWU) requests via a voltage transition. The terminal triggers a local wake up (LWU) event on either a low-to-high, or a high-to-low transition since it has a bi-directional input threshold (falling or rising edge). WAKE is available through JMP2 position 7 and TP10.

## 2.1.9 nFAULT Output

The nFAULT terminal is used to signal multiple fault condition and is available via JMP2 position 6 and TP0. [Table 2-3](#) shows the device status indicator flags implemented to allow for the system to determine the status and diagnose the device and system. In addition to faults, the nFAULT terminal also signals wake up requests and *cold* power-up sequence on the  $V_{SUP}$  battery supply terminal so the system can do any diagnostics or cold booting sequence necessary. The faults are multiplexed (ORed) to the nFAULT output.

**Table 2-3. Internal and External Indicator Flags (nFAULT)**

| Event                      | Flag Name          | Cause   | Indicators   | Flag Cleared  | Comment  |
|----------------------------|--------------------|---|--|---|--|
| Power up                   | PWRON              | Power up on $V_{SUP}$ and any return of $V_{SUP}$ after it has been below $UVV_{SUP}$ | nFAULT = L upon entering silent mode from standby, go-to-sleep, or sleep mode  | After transition to normal mode   |  |
| Wake-up request            | WAKERQ             | Wake-up event on CAN bus, state transition on WAKE pin, or initial power up           | nFAULT = RXD = L after wake up in standby mode, go-to-sleep mode, and sleep mode   | After transition to normal mode, or either a $UVV_{CC}$ or $UVV_{IO}$ event   | Wake-up request may only be set from standby, go-to-sleep, or sleep mode. Resets timers for $UVV_{CC}$ or $UVV_{IO}$ |
| Wake-up source recognition | WAKESR             | Wake-up event on CAN bus, state transition on WAKE pin, initial power up              | Available upon entering normal mode , nFAULT = L indicates wake from WAKE terminal, nFAULT = H indicates wake from CAN bus | After four recessive to dominant edges on TXD in normal mode, leaving normal mode, or either a $UVV_{CC}$ or $UVV_{IO}$ event       | A LWU source flag is set on initial power up   |
| Undervoltage               | UVV <sub>CC</sub>  | Undervoltage $V_{CC}$   | Not externally indicated   | $V_{CC}$ returns, or Wake-up request occurs   |  |
|                            | UVV <sub>IO</sub>  | Undervoltage $V_{IO}$   | Not externally indicated   | $V_{IO}$ returns, or Wake-up request occurs   |  |
|                            | UVV <sub>SUP</sub> | Undervoltage $V_{SUP}$  | Not externally indicated   | $V_{SUP}$ returns   | $V_{SUP}$ undervoltage event triggers the PWRON and WAKERQ flags upon return of $V_{SUP}$                            |
| CAN bus failures           | CBF                | CANH or CANL shorted to GND, $V_{CC}$ , $V_{SUP}$                                     | nFAULT = L in normal mode only   | If fault is not present for four consecutive dominant to recessive transitions or upon leaving normal mode                          | Failure must persist for four consecutive dominant to recessive transitions  |
| Local faults               | TXDCLP             | TXD low when CAN active mode is entered   | nFAULT = L upon entering silent mode from normal mode  | RXD = L and TXD = H, or upon transitioning into normal, standby, go-to-sleep, or sleep modes with TXD = H                           | CAN driver remains disabled until the TXDCLP is cleared. CAN receiver remains active during the TXDCLP fault         |
|                            | TXDDTO             | TXD dominant time out, dominant (low) signal for $t \geq t_{TXD\_DTO}$                |  |   | CAN driver remains disabled until the TXDDTO is cleared. CAN receiver remains active during the TXDDTO fault.        |
|                            | TXDRXD             | TXD and RXD pins are shorted together for $t \geq t_{TXD\_DTO}$                       |  |   | CAN driver remains disabled until the TXDRXD is cleared. CAN driver remains active during the TXDRXD fault.          |
|                            | CANDOM             | CAN bus dominant fault, when dominant bus signal received for $t \geq t_{BUS\_DOM}$   |  | RXD = H, or upon transitioning into normal, standby, go-to-sleep, or sleep modes  | Driver remains enabled   |
|                            | TSD                | Thermal shutdown, junction temperature $\geq T_{TSD}$                                 |  | $T_j$ drops below $T_{TSD}$ and either RXD = L and TXD = H, or upon transitioning into normal, standby, go-to-sleep, or sleep modes | CAN driver remains disabled until the TSD is cleared   |

## 2.2 Using CAN Bus Load, Terminations, and Protection Features

The TCAN1043AEVM is populated with two 120- $\Omega$  power resistors selectable via jumpers between CANH and CANL. When using one resistor, the EVM is used as a terminated end of a bus. For electrical measurements to represent the total loading of the bus, use both 120- $\Omega$  resistors in parallel to give the standard 60- $\Omega$  load for parametric measurement. The EVM also has footprints for split termination, if needed for the application. [Table 2-4](#) summarizes how to use these termination options. If using split termination, match the resistors. Calculate the CM filter frequency using:  $f_C = 1 / (2\pi RC)$ . Normally, the split capacitance is in the range of 4.7 nF to 100 nF. Keep in mind, this is the CM filter frequency, not a differential filter that impacts the differential CAN signal directly.

**Table 2-4. Bus Termination Configuration**

| Termination                        | 120- $\Omega$ Resistors |         | Split Termination Footprints |               |               |
|------------------------------------|-------------------------|---------|------------------------------|---------------|---------------|
| Jumper                             | JMP3                    | JMP4    | R9                           | R14           | C6            |
| No termination                     | Open                    | Open    | Not available                | Not available | Not available |
| 120- $\Omega$ standard termination | Shorted                 | Open    |                              |               |               |
| 60- $\Omega$ load                  | Shorted                 | Shorted |                              |               |               |
| Split termination                  | Open                    | Open    | 60 $\Omega$                  | 60 $\Omega$   | 4.7 nF        |

The EVM also has footprints for various protection schemes to enhance robustness for extreme system-level EMC requirements. [Table 2-5](#) summarizes these options.

**Table 2-5. Protection and Filtering Configuration**

| Configuration                                 | Footprint Reference             | Use Case  | Population and Description  |
|---|---------------------------------|---|---|
| Series resistors or CM choke                  | R7/R13 or L1 (common footprint) | Direct CAN transceiver to bus connection                        | R7 and R13 populated with 0 $\Omega$ (default population)   |
|   |                                 | Series-resistance protection, CAN transceiver to bus connection | R7 and R13 populated with MELF resistor as necessary for harsh EMC environment  |
|   |                                 | CM choke (bus filter)   | L1 populated with CM choke to filter noise as necessary for harsh EMC environment   |
| Bus filtering capacitors transient protection | C2/C7                           | Bus filter  | Filter noise as necessary for harsh EMC environment. Use filter capacitors in combination with L1 CM choke  |
| Transient protection                          | C2/C7 or D1                     | Transient and ESD protection                                    | To add extra protection for system level transients and ESD protection, TVS diode population option via D1 footprint or varistor population via C2/C7 footprint |

## 2.3 Using Customer-Installable I/O Options for Current Limiting, Pull Up and Pull Down, Noise Filtering

The TCAN1043AEVM has footprints on the PCB for installing various filtering and protection options to adapt the EVM to match CAN network topology requirements, if the EVM is being used as a CAN node.

Each digital input or output pin has footprints allowing for series current-limiting resistors (default populated with 0  $\Omega$ ), pull up or pull-down resistors (depending on pin used), and a capacitor to GND which allows for RC filters when configured with a series resistor. [Table 2-6](#) lists these features for each of the digital input and output pins of the EVM. Replace or populate the RC components as necessary for the application.

**Table 2-6. RC Filter and Protection List**

| Device Pin |             |                     | Jumper        |                 | Series R      | Pull Up and Pull Down      | C to GND      | Description                          |
|------------|-------------|---------------------|---------------|-----------------|---------------|----------------------------|---------------|--------------------------------------|
| No.        | Description | Type                | Pull Up       | Pull Down       |               |                            |               |                                      |
| 1          | TXD         | Input               | Not available | Not available   | R3            | R2 Pull Up<br>R4 Pull down | R4            | Use R4 to support a filter capacitor |
| 4          | RXD         | Output              | Not available | Not available   | R5            | Not available              | C3            |                                      |
| 6          | EN          | Input               | Not available | JMP2 Position 2 | Not available | R12 pull up                | Not available |                                      |
| 7          | INH         | High voltage output | Not available | Not available   | Not available | R15 pulldown               | Not available |                                      |
| 9          | WAKE        | Input               | Not available | Not available   | Not available | R18, R19 pull up           | Not available |                                      |
| 14         | nSTB        | Input               | Not available | JMP1            | Not available | R1 pull up                 | Not available |                                      |

## 3 EVM Setup and Basic Usage

### 3.1 Equipment

The following equipment may be used to evaluate the performance of the TCAN1043A-Q1 device.

- Power supply capable of supplying 5 V for  $V_{CC}$
- Power supply capable of supply 1.8V, 3.3V, or 5V for  $V_{IO}$
- Power supply capable of supplying 4.5 V to 40 V for  $V_{SUP}$
- If the CAN bus interface and IO voltage are to be observed using an oscilloscope, use high-impedance probes (1 MΩ or greater) or an oscilloscope with an internal high-impedance option. This prevents the CAN driver and IO buffers from becoming overloaded during normal operating conditions.

### 3.2 TCAN1043A-Q1 EVM Setup

Configure the TCAN1043A-Q1 EVM for normal operation by installing shunts on the EVM as described in [Table 3-1](#).

**Table 3-1. Basic Operation Jumper Settings**

| Jumper | Shunt   |
|--------|---|
| JMP3   | Installed – implements 120-Ω resistor between CANH and CANL   |
| JMP5   | Installed – implements 120-Ω resistor between CANH and CANL   |
| JMP6   | Installed – shorts $V_{CC}$ and $V_{IO}$ together<br>Use P2 to drive $V_{IO}$ independently from $V_{CC}$ |

Connect the power supplies to the EVM using the banana connector P1, P2, P3, and P4. If banana cables are unavailable, use test points TP11, TP12, TP13, TP14, TP15, and TP16 instead.

- Set P1 or TP11 to 5 V at 100 mA
- Set P2 or TP to 1.8 V or 3.3 V or 5 V at 100 mA for the IO buffer voltage
- Set P3 equal to GND
- Set P4 or TP13 to 12.5 V at 100 mA

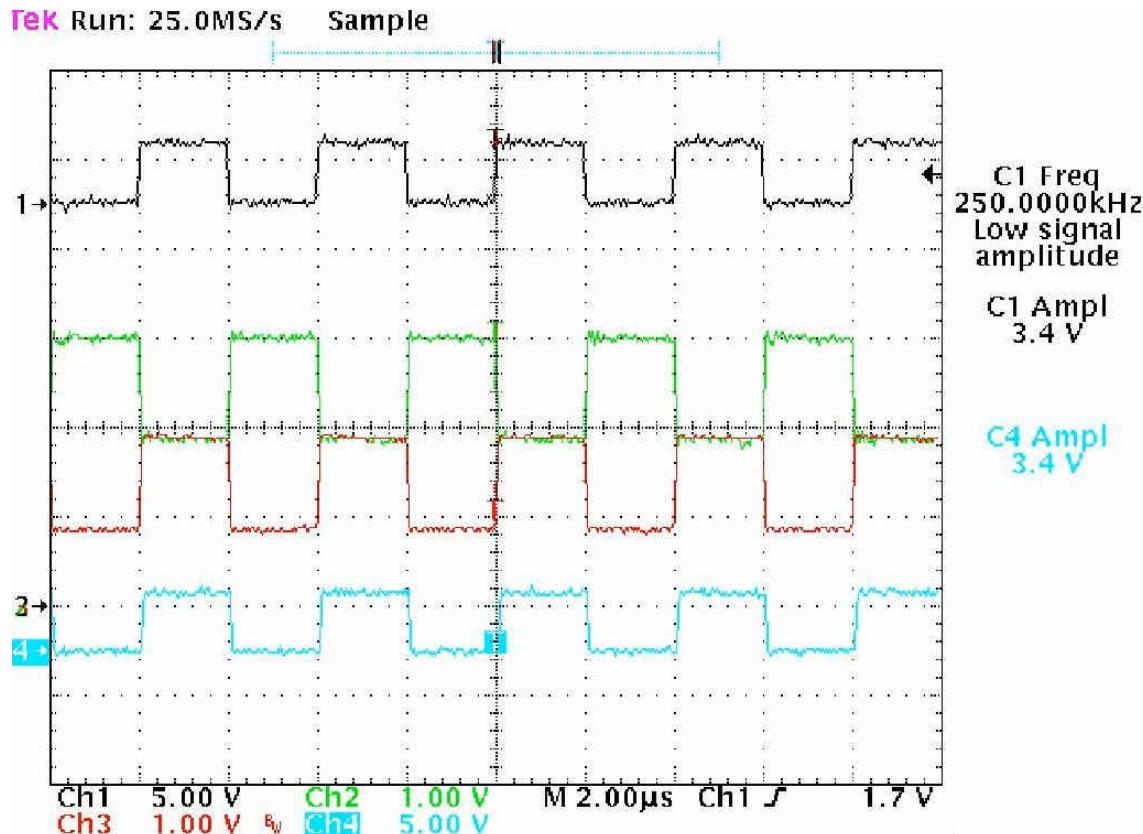
For more detailed information, see the schematic reference for power in [Figure 4-1](#).

Connect the EVM to the CAN bus for network evaluation. TXD and RXD can be jumper connected to the CAN controller through JMP2 position 1 and position 3, respectively. If evaluating the TCAN1043A-Q1 without a CAN network, connect a function generator to JMP2 position 1 with the desired data rate. The generator should be set to provide a 0 V to 5 V TTL square wave into the high impedance input TXD. Connect an oscilloscope with high-impedance probes or high-impedance input to the CAN bus line CANH and CANL. Use a third channel on the oscilloscope to monitor RXD.

### 3.3 TCAN1043A-Q1 Normal Operation 500 kbps Test Results

Figure 3-1 shows a 250-kHz (500 kbps) square wave in the following configuration on an oscilloscope:

- Channel 1 – TXD via TP1: vertical position = 2.5, vertical scale = 5 V per division
- Channel 2 – CANH via JMP4: vertical position = -2.5, vertical scale = 1 V per division
- Channel 3 – CANL via JMP4: vertical position = -2.5, vertical scale = 1 V per division
- Channel 4 – RXD via TP3 or JMP2 position 3: vertical position = -3.5, vertical scale = 5 V per division



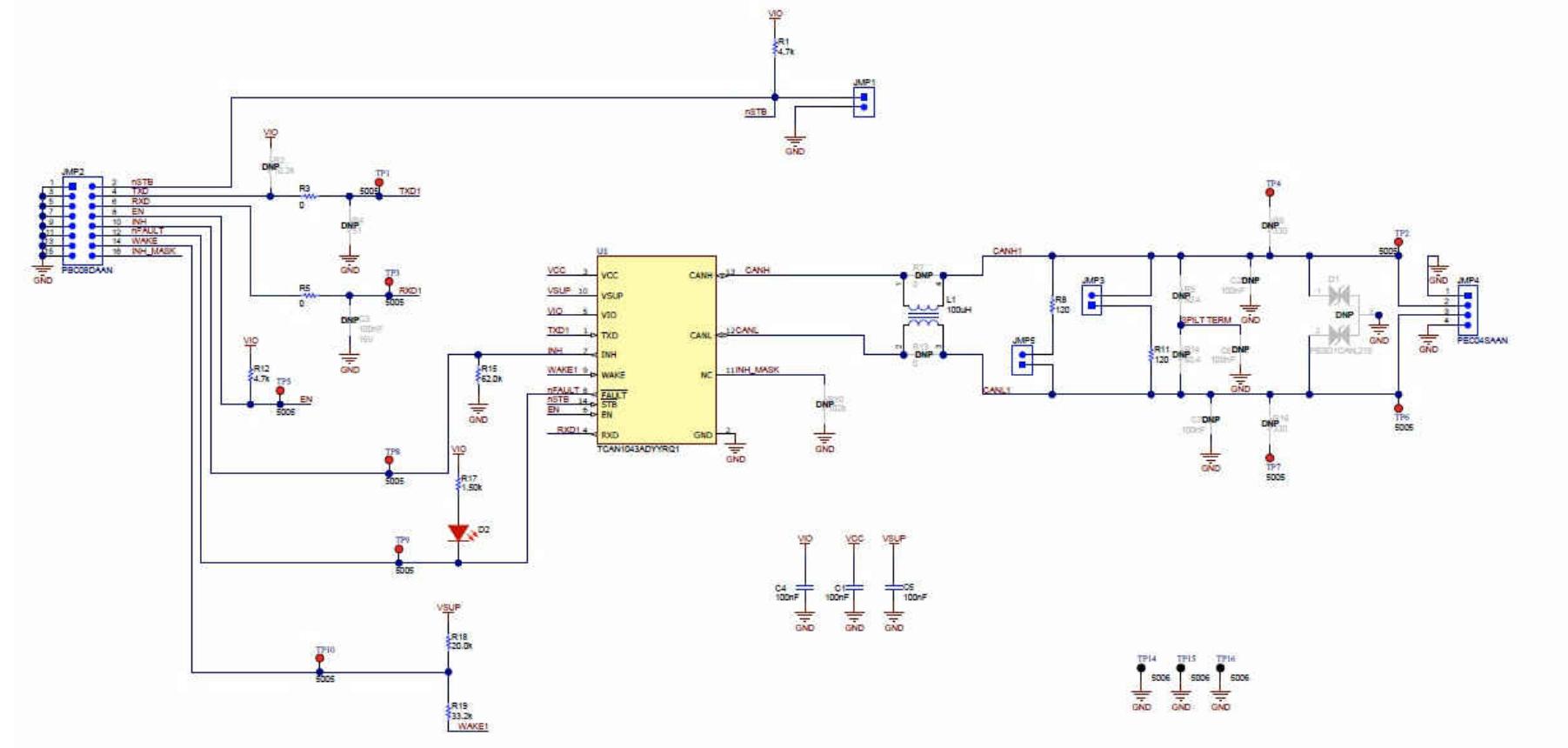
**Figure 3-1. TCAN1043A-Q1 Normal Operation 500 kbps**

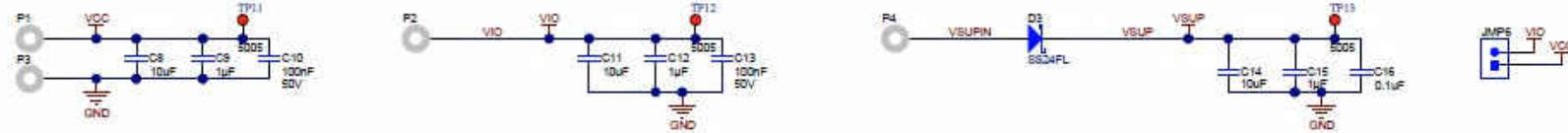
For more detailed operation information, refer to [TCAN1043A Automotive Fault Protected CAN Transceiver With CAN FD](#).

## 4 Schematic and Bill of Materials

### 4.1 TCAN1043A-Q1 EVM Schematic

Figure 4-1 and Figure 4-2 illustrate the EVM schematics.





**Figure 4-2. TCAN1043A-Q1 EVM Power Scheme**

## 4.2 TCAN1043AEVM Bill Of Materials

Section 4.2 shows the component list for the TCAN1043AEVM.

**Table 4-1. TCAN1043AEVM EVM BOM**

| Item | Qty | Reference  | Value               | Manufacturer                     | Manufacturer Part Number |
|------|-----|--|---------------------|----------------------------------|--------------------------|
| 1    | 4   | C1, C3, C4, C13  | 0.1 $\mu$ F         | Murata Electronics North America | GCM188R71C104KA37J       |
| 2    | 3   | C2, C6, C7   | DNI                 | —                                | DNI                      |
| 3    | 1   | C5   | 0.1 $\mu$ F         | Kemet                            | C0805C104J5RACTU         |
| 4    | 2   | C8, C11  | 10 $\mu$ F          | TDK Corporation                  | C1608X5R1A106M080AC      |
| 5    | 2   | C9, C12  | 1 $\mu$ F           | TDK Corporation                  | C1608X7R1C105K080AC      |
| 6    | 1   | C10  | 0.1 $\mu$ F         | Murata Electronics North America | GCM188R71H104KA57D       |
| 7    | 1   | C14  | 10 $\mu$ F          | Murata Electronics North America | GRM188R6YA106MA73D       |
| 8    | 1   | C15  | 1 $\mu$ F           | Murata Electronics North America | UMK107AB7105KA-T         |
| 9    | 1   | C16  | 0.1 $\mu$ F         | Taiyo Yuden                      | CGA3E3X7S2A104K080AB     |
| 10   | 1   | D1   | DNI (TVS Diode)     | —                                | DNI                      |
| 11   | 1   | D2   | Red                 | OSRAM                            | LS R976-NR-1             |
| 12   | 1   | D3   | 40V Schottky        | Fairchild Semiconductor          | SS24FL                   |
| 13   | 4   | JMP1, JMP3,<br>JMP5, JMP6  | Header, 1x2         | Samtec Inc                       | TSW-102-07-G-S           |
| 14   | 1   | JMP2   | Header, 8x2         | Sullins Connector Solutions      | PBC08DAAN                |
| 15   | 1   | JMP4   | Header, 1x4         | Sullins Connector Solutions      | PEC04SAAN                |
| 16   | 1   | L1   | 100 $\mu$ H         | TDK Corporation                  | ACT45B-101-2P-TL003      |
| 17   | 4   | P1, P2, P3, P4   | Banana Plug - Metal | Cinch Connectivity               | 108-0740-001             |
| 18   | 2   | R1, R12  | 4.7 k $\Omega$      | Vishay-Dale                      | CRCW06034K70JNEA         |
| 19   | 9   | R2, R4, R6, R7,<br>R9, R10, R13,<br>R14, R16                                   | DNI                 | —                                | DNI                      |
| 20   | 2   | R3, R5   | 0 $\Omega$          | Yageo                            | RC0603JR-070RL           |
| 21   | 2   | R8, R11  | 120 $\Omega$        | Vishay Dale                      | CRCW2512120RFKEG         |
| 22   | 1   | R15  | 62k $\Omega$        | Yageo                            | RC0603FR-0762KL          |
| 23   | 1   | R17  | 1.5 k $\Omega$      | Yageo                            | RC0603FR-071K5L          |
| 24   | 1   | R18  | 20 k $\Omega$       | Panasonic Electronic Components  | ERJ-6ENF2002V            |
| 25   | 1   | R19  | 33.2 k $\Omega$     | Vishay-Dale                      | CRCW080533K2FKEA         |
| 26   | 13  | TP1, TP2, TP3,<br>TP4, TP5, TP6<br>TP7, TP8, TP9,<br>TP10, TP11, TP12,<br>TP13 | Test Point - Red    | Keystone Electronics             | 5005                     |
| 27   | 3   | TP14,TP15,TP16   | Test Point - Black  | Keystone Electronics             | 5006                     |
| 28   | 1   | U1   | TCAN1043A-Q1        | Texas Instruments                | TCAN1043ADYYRQ1          |

## STANDARD TERMS FOR EVALUATION MODULES

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 DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

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### 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 isotope 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](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](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.

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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.

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6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

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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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