

## **TCAN1043HG-Q1 Evaluation Module**

This user guide details the operation of the TCAN1043HG-Q1 *Controller Area Network (CAN)* with *Flexible Datarate (FD)* transceiver evaluation module (EVM). The TCAN1043HG-Q1 EVM supports the TCAN1043HG-Q1, TCAN1043G-Q1, TCAN1043H-Q1, and the TCAN1043-Q1 by simply replacing the installed TCAN1043HG-Q1 transceiver with another variant. This user guide explains the EVM configurations for basic CAN FD and CAN evaluation, various loads, and termination settings.

### **Contents**

1	Introduction .....	2
1.1	TCAN1043HG-Q1 EVM.....	2
1.2	Applications.....	3
2	Test Setup and Results .....	3
2.1	Overview and Basic Operation Settings .....	3
2.2	Using CAN Bus Load, Terminations, and Protection Features .....	8
2.3	Using Customer-Installable I/O Options for Current Limiting, Pullup and Pulldown, Noise Filtering ....	8
3	EVM Setup and Basic Usage .....	9
3.1	Equipment .....	9
3.2	TCAN1043HG-Q1 EVM Setup.....	9
3.3	TCAN1043HG-Q1 Normal Operation 500 kbps Test Results .....	10
4	Schematic and Bill of Materials.....	11
4.1	TCAN1043HG-Q1 EVM Schematic.....	11
4.2	TCAN1043HG-Q1 Bill Of Materials .....	13

### **List of Figures**

1	TCAN1043HG-Q1 Evaluation Module (EVM).....	2
2	TCAN1043HG-Q1 State Diagram .....	5
3	TCAN1043HG-Q1 Normal Operation 500 kbps.....	10
4	TCAN1043HG-Q1 EVM Schematic .....	11
5	TCAN1043HG-Q1 EVM Power Scheme .....	12

### **List of Tables**

1	Jumper Definitions.....	3
2	Operational Modes .....	5
3	Internal and External Indicator Flags (nFAULT) .....	7
4	Bus Termination Configuration.....	8
5	Protection and Filtering Configuration .....	8
6	RC Filter and Protection List .....	8
7	Basic Operation Jumper Settings.....	9
8	TCAN1043HG-Q1 EVM BOM .....	13

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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 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 TCAN1043HG-Q1 EVM helps designers evaluate the operation and performance of the TCAN1043HG-Q1 CAN FD transceiver. 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 TCAN1043HG-Q1 EVM

The TCAN1043HG-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,  $V_{CC}$ , 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](#) shows the EVM board image.

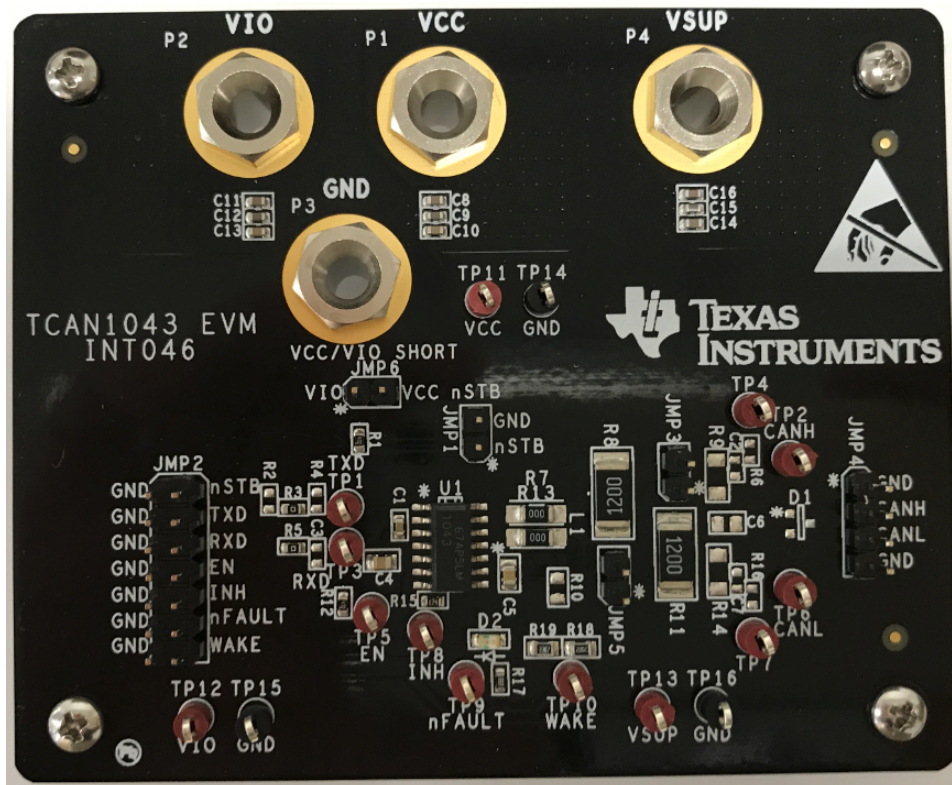


Figure 1. TCAN1043HG-Q1 Evaluation Module (EVM)

## 1.2 Applications

The TCAN1043HG-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 at 2 Mbps:

- Classic CAN:
  - Supports CAN with datarates up to 1 Mbps
- CAN FD:
  - Supports CAN FD timing requirements at 2 Mbps
  - Supports CAN FD timing requirements at 5 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 1](#) shows a description of the jumper selections on the EVM with a short description of the function of each pin.

**Table 1. Jumper Definitions**

Connection	Type	Transceiver Pin	Description
JMP1	2-pin jumper	nSTB	Mode control input, Standby input, integrated pulldown
		nSTB	
JMP2	14-pin jumper	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 pulldown
		INH	Inhibit output, controls system voltage regulators and supplies
		nFAULT	Fault output, inverted logic
	WAKE	Wake input terminal, high voltage 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.

**Table 1. Jumper Definitions (continued)**

Connection	Type	Transceiver Pin	Description
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, TP16		GND	Ground connection

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

The TCAN1043HG-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 60 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 2.8 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-Ω 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-Ω 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 via the nSTB and EN input terminals in conjunction with supply conditions and wake events. [Table 2](#) lists the operational modes of the device and the associated pin configurations. [Figure 2](#) 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. Operational Modes

V <sub>CC</sub> and V <sub>IO</sub>	V <sub>SUP</sub>	EN	nSTB	WAKERQ Flag	Mode	Driver	Receiver	RXD	Bus Bias	INH
Good	Good	H	H	X	Normal	Enabled	Enabled	Mirror Bus State	V <sub>CC</sub> /2	On
Good	Good	L	H	X	Silent	Disabled (Off)	Enabled	Mirror Bus State	V <sub>CC</sub> /2	On
Good	Good	H	L	Cleared	Go to Sleep	Disabled (Off)	Low Power Bus Monitor (On)	High or High Z (No V <sub>IO</sub> )	Weak pull to GND	On
				Cleared	Sleep	Disabled (Off)	Low Power Bus Monitor (On)	High or High Z (No V <sub>IO</sub> )	Weak pull to GND	Off
				Set	Standby	Disabled (Off)	Low Power Bus Monitor (On)	High or High Z (No V <sub>IO</sub> )	Weak pull to GND	On
Good	Good	L	L	X	Standby	Disabled (Off)	Low Power Bus Monitor (On)	High or High Z (No V <sub>IO</sub> )	Weak pull to GND	On
Bad	Good	X	X	X	Sleep	Disabled (Off)	Low Power Bus Monitor (On)	High or High Z (No V <sub>IO</sub> )	Weak pull to GND	Off (High Z)
X	Bad	X	X	X	Protected	Disabled (Off)	Disabled (Off)	High Z	High Z	Off (High Z)

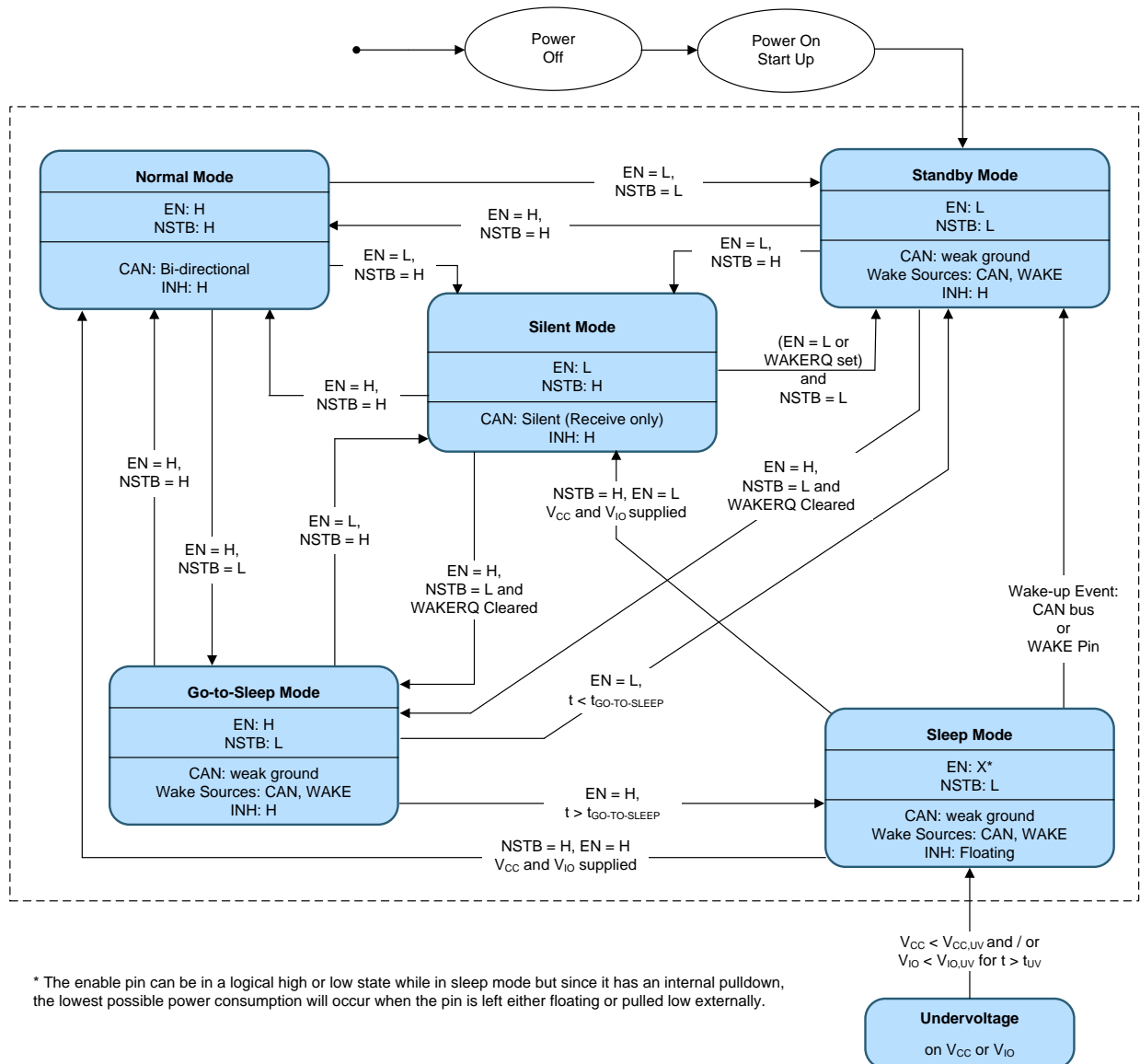


Figure 2. TCAN1043HG-Q1 State Diagram

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-kΩ 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 5 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 to the CAN lines on JMP4 allowing for easy measurements.

### 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 via 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 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<sub>SUP</sub> 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 3. Internal and External Indicator Flags (nFAULT)**

Event	Flag Name	Cause	Indicators	Flag Cleared	Comment
Power up	PWRON	Power up on VSUP and any return of VSUP after it has been below UVVSUP	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 <sub>CC</sub> or UVV <sub>IO</sub> event	Wake-up request may only be set from standby, go-to-sleep, or sleep mode. Resets timers for UVV <sub>CC</sub> or UVV <sub>IO</sub>
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 <sub>CC</sub> or UVV <sub>IO</sub> event	A LWU source flag is set on initial power up
Undervoltage	UVV <sub>CC</sub>	Undervoltage V <sub>CC</sub>	Not externally indicated	V <sub>CC</sub> returns, or Wake-up request occurs	
	UVV <sub>IO</sub>	Undervoltage V <sub>IO</sub>	Not externally indicated	V <sub>IO</sub> returns, or Wake-up request occurs	
	UVV <sub>SUP</sub>	Undervoltage V <sub>SUP</sub>	Not externally indicated	V <sub>SUP</sub> returns	V <sub>SUP</sub> undervoltage event triggers the PWRON and WAKERQ flags upon return of V <sub>SUP</sub>
CAN bus failures	CBF	CANH or CANL shorted to GND, V <sub>CC</sub> , V <sub>SUP</sub>	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	TXDDTO	TXD dominant time out, dominant (low) signal for t ≥ t <sub>TXD_DTO</sub>	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 TXDDTO is cleared
	TXDRXD	TXD and RXD pins are shorted together for t ≥ t <sub>TXD_DTO</sub>			CAN driver remains disabled until the TXDRXD is cleared
	CANDOM	CAN bus dominant fault, when dominant bus signal received for t ≥ t <sub>BUS_DOM</sub>		RXD = H, or upon transitioning into normal, standby, go-to-sleep, or sleep modes	Driver remains enabled
	TSD	Thermal shutdown, junction temperature ≥ T <sub>TSD</sub>		T <sub>J</sub> drops below T <sub>TSD</sub> 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 CAN EVM 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 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 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 5 summarizes these options.

**Table 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, Pullup and Pulldown, Noise Filtering

The TCAN1043HG-Q1 EVM 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  $\Omega$ ), pullup or pulldown resistors (depending on pin used), and a capacitor to GND which allows for RC filters when configured with a series resistor. Table 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 6. RC Filter and Protection List**

Device Pin			Jumper		Series R	Pullup and Pulldown	C to GND	Description
No.	Description	Type	Pullup	Pulldown				
1	TXD	Input	Not available	Not available	R3	R2 Pullup R4 pulldown	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 pullup	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 pullup	Not available	
14	nSTB	Input	Not available	JMP1	Not available	R1 pullup	Not available	



### 3 EVM Setup and Basic Usage

#### 3.1 Equipment

The following equipment may be used to evaluate the performance of the TCAN1043HG-Q1 device.

- Power supply capable of supplying 3.3 V and 5 V for  $V_{CC}$  and  $V_{IO}$
- Power supply capable of supplying 4.5 V to 60 V for  $V_{SUP}$
- If the CAN bus interface and IO voltage are to be observed using an oscilloscope, use high-impedance probes (1  $\Omega$ M $\Omega$  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 TCAN1043HG-Q1 EVM Setup

Configure the TCAN1043HG-Q1 EVM for normal operation by installing shunts on the EVM as described in [Table 7](#).

**Table 7. Basic Operation Jumper Settings**

Jumper	Shunt
JMP3	Installed – implements 120- $\Omega$ resistor between CANH and CANL
JMP5	Installed – implements 120- $\Omega$ resistor between CANH and CANL
JMP6	Installed – shorts $V_{CC}$ and $V_{IO}$ together 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 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](#).

Connect the EVM to the CAN bus for network evaluation. TXD and RXD can be jumpered to the CAN controller via JMP2 position 1 and position 3, respectively. If evaluating the TCAN1043HG-Q1 without a CAN network, connect a function generator to JMP2 position 1 with the desired datarate. 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 TCAN1043HG-Q1 Normal Operation 500 kbps Test Results

Figure 3 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

Tek Run: 25.0MS/s Sample

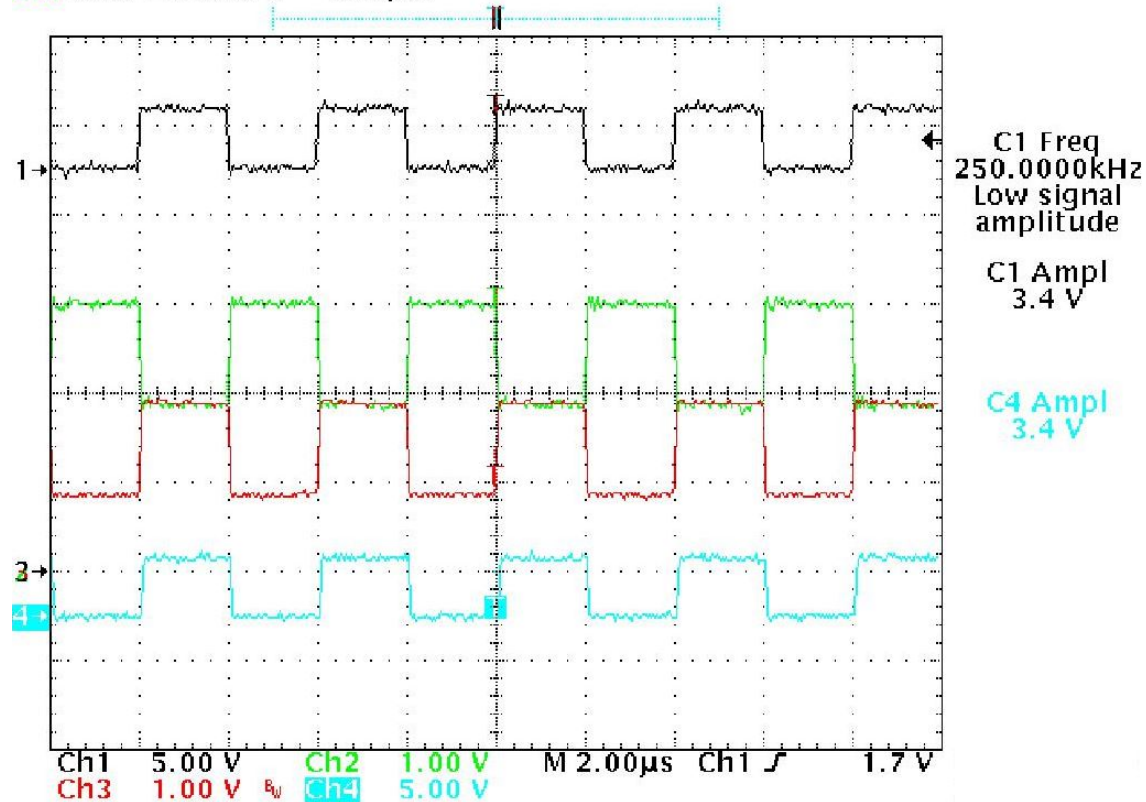


Figure 3. TCAN1043HG-Q1 Normal Operation 500 kbps

For more detailed operation, refer to [TCAN1043 Automotive Fault Protected CAN Transceiver With CAN FD](#).

## 4 Schematic and Bill of Materials

### 4.1 TCAN1043HG-Q1 EVM Schematic

Figure 4 and Figure 5 illustrate the EVM schematics.

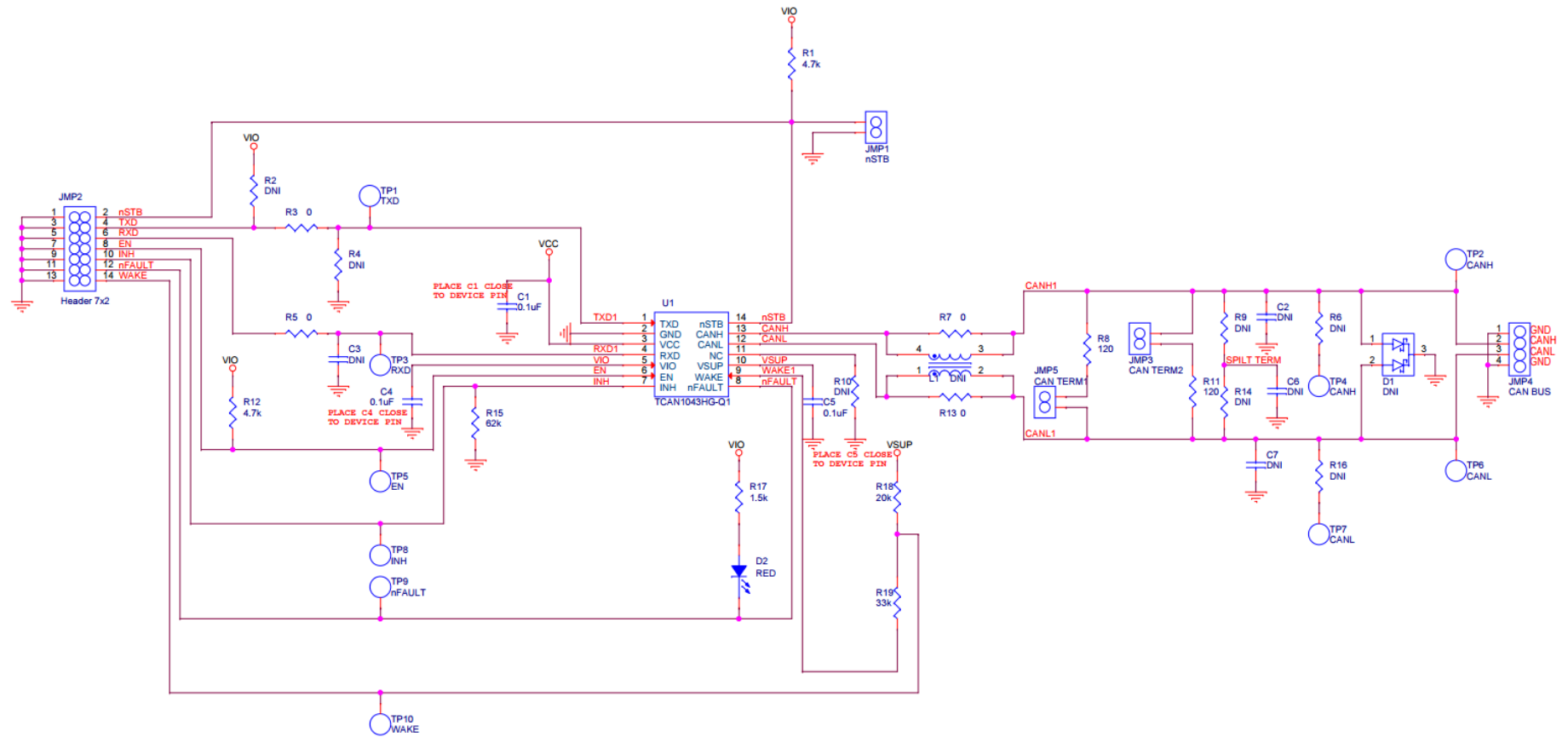


Figure 4. TCAN1043HG-Q1 EVM Schematic

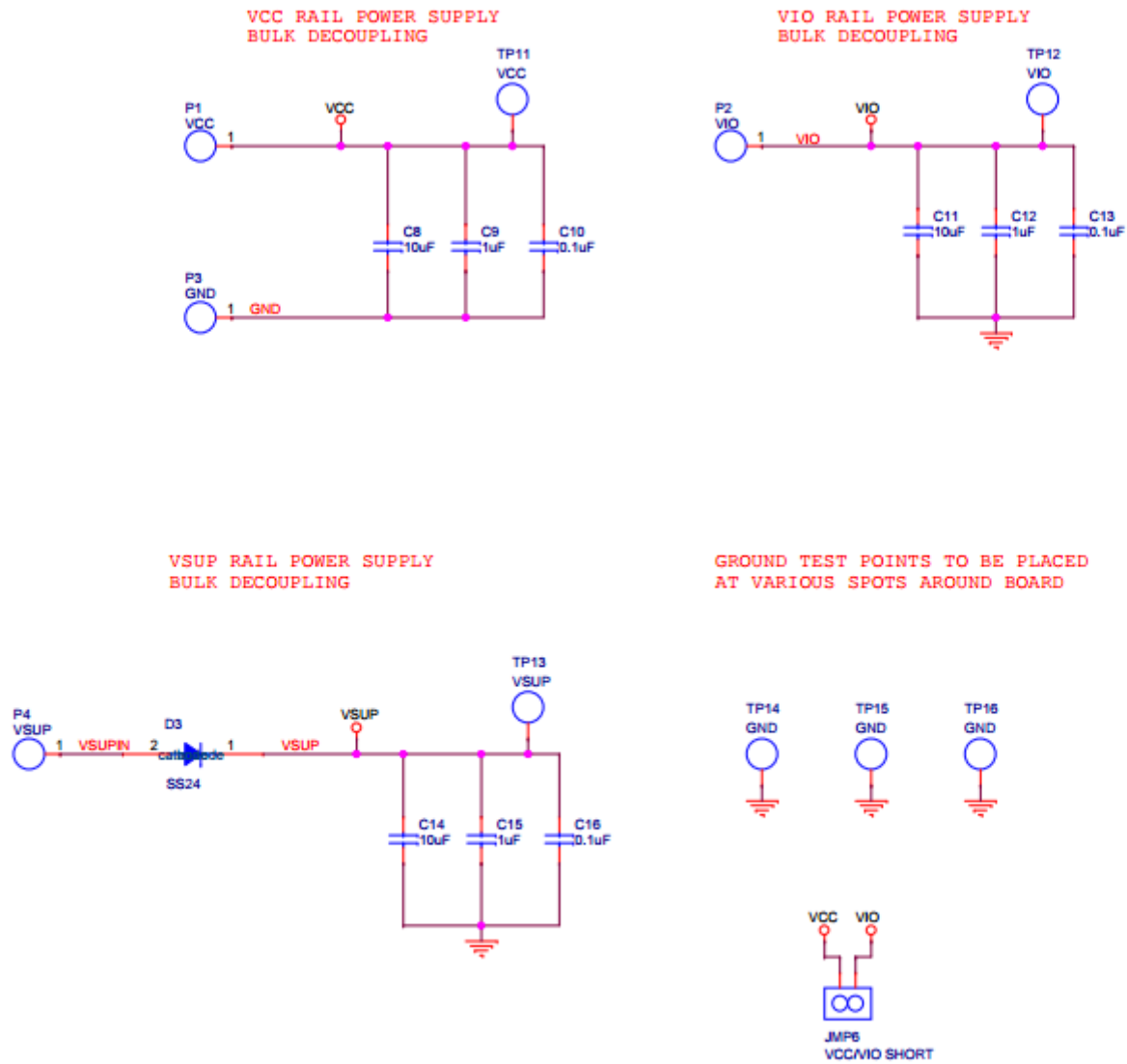


Figure 5. TCAN1043HG-Q1 EVM Power Scheme

## 4.2 TCAN1043HG-Q1 Bill Of Materials

Table 8 shows the component list for the TCAN1043HG-Q1 EVM.

**Table 8. TCAN1043HG-Q1 EVM BOM**

Item	Qty	Reference	Value	Manufacturer	Manufacturer Part Number
1	3	C1, C10, C13	0.1 $\mu$ F	Murata Electronics North America	GRM188R71H104KA93D
2	3	C2, C3, C6, C7	DNI	—	DNI
3	2	C4, C5	0.1 $\mu$ F	Kemet	C0805C104J5RACTU
4	2	C8, C11	10 $\mu$ F	TDK Corporation	C1608X5R1A106KT
5	2	C9, C12	1 $\mu$ F	TDK Corporation	C1608X7R1C105K080AC
6	1	C16	0.1 $\mu$ F	TDK Corporation	CGA3E3X7S2A104K080AB
7	1	C14	10 $\mu$ F	Murata Electronics North America	GRM188R6YA106MA73D
8	1	C15	1 $\mu$ F	Taiyo Yuden	UMK107BJ105KA-T
9	1	D1	DNI (TVS Diode)	—	DNI
10	1	D2	Red	Lite-On Inc	LTST-C170KRKT
11	1	JMP1	Header, 1x2	Samtec Inc	HTSW-150-07-G-S
12	1	JMP2	Header, 7x2	Samtec Inc	HTSW-150-07-G-D
13	1	JMP4	Header, 1x4	Samtec Inc	HTSW-150-07-G-S
14	1	L1	DNI (CM Choke)	—	DNI
15	4	P1, P2, P3, P4	Banana Plug - Metal	Emerson Network Power	108-0740-001
16	2	R1, R12	4.7 k $\Omega$	Rohm Semiconductor	MCR03ERTF4701
17	7	R2, R4, R6, R16, R9, R10, R14	DNI	—	DNI
18	2	R3, R5	0 $\Omega$	Yageo	RC0603JR-070RL
19	2	R7, R13	0 $\Omega$	Vishay Dale	CRCW12060000Z0EA
20	2	R8, R11	120 $\Omega$	Vishay Dale	CRCW2512120RFKEG
21	1	R15	62 k $\Omega$	Yageo	RC0603FR-0762KL
22	1	R17	1.5 k $\Omega$	Yageo	RC0603FR-071K5L
23	1	R18	20 k $\Omega$	Panasonic Electronic Components	ERJ-6ENF2002V
24	1	R19	33 k $\Omega$	Venkel	CR0805-10W-3302FT
25	13	TP1, TP2, TP3, TP4, TP5, TP6 TP7, TP8, TP9, TP10, TP11, TP12, TP13	Test Point - Red	Keystone Electronics	5005
26	3	TP14,TP15,TP16	Test Point - Black	Keystone Electronics	5006
27	1	U1	TCAN1043HG-Q1	Texas Instruments	TCAN1043HGDRQ1
28	4	H1, H2, H3, H4	0.75" Al Round	Keystone Electronics	2029
29	4	H5, H6, H7, H8	0.25"- Stainless Steel 4-40 Phillips Panhead	Building Fasteners	PMSSS 440 0025 PH
30	3	SH1, SH2, SH3	Shunt	TE Connectivity AMP Connectors	382811-16
31	1	PCB	—	Texas Instruments	INT046

## STANDARD TERMS FOR EVALUATION MODULES

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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.
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/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/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/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/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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2. 実験局の免許を取得後ご使用いただく。
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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:*

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.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

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, INDEMNITY 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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