TCAN Evaluation Module

This user guide details the TCAN10xx CAN (Controller Area Network) EVM transceiver operation. The TCAN10xx CAN EVM is configurable for use with all TI CAN transceiver families: TCAN10xx, TCAN33x, SN65HVD23x, SN65HVD25x, SN65HVD10x0, and SN65HVDA54x by replacing the transceiver and setting jumpers on the EVM as outlined in this document. This user guide explains the EVM configurations for basic CAN evaluation, various load and termination settings.

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1 Introduction

1.1 Overview

TI offers a broad portfolio of high speed (HS) CAN transceivers compatible with the ISO11898-2 high speed CAN 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, loop back, and diagnostic modes.

TI's CAN EVM helps designers evaluate the operation and performance of various TI CAN transceivers. It also provides bus termination, bus filtering, and protection concepts. It is easily configured by the customer for the TCAN10xx, TCAN33x, SN65HVD23x, SN65HVD25x, SN65HVD10x0, and SN65HVDA54x CAN transceiver families as needed by jumper settings, simple soldering tasks, and replacement of standard components. A separate EVM is available for the galvanic-isolated CAN transceiver family.

1.2 CAN EVM

The CAN 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, pin 8 (mode pin), or pin 5 (various functions). The EVM supports many options for CAN bus configuration. It is pre-configured with two 120-Ω resistors that are connected on the bus via jumpers: a single resistor is used with the EVM as a terminated line end (CAN is defined for 120-Ω impedance twisted pair cable) or both resistors in parallel for electrical measurements representing the 60-Ω load the transceiver “sees” in a properly terminated network (that is, 120-Ω termination resistors at both ends of the cable). If the application requires “split” termination, TVS diodes for protection, or 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.

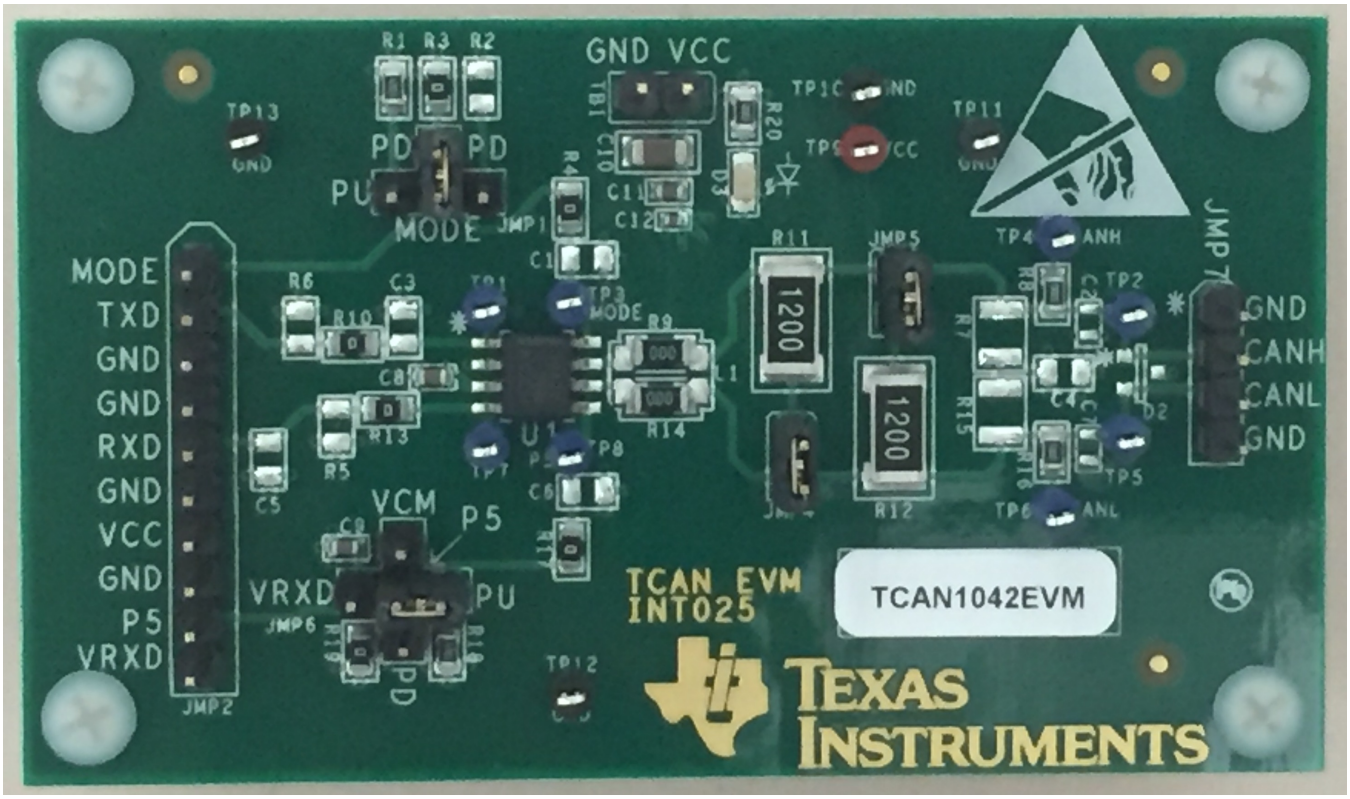

Figure 1. EVM PC Board

Figure 2 shows the EVM schematic.

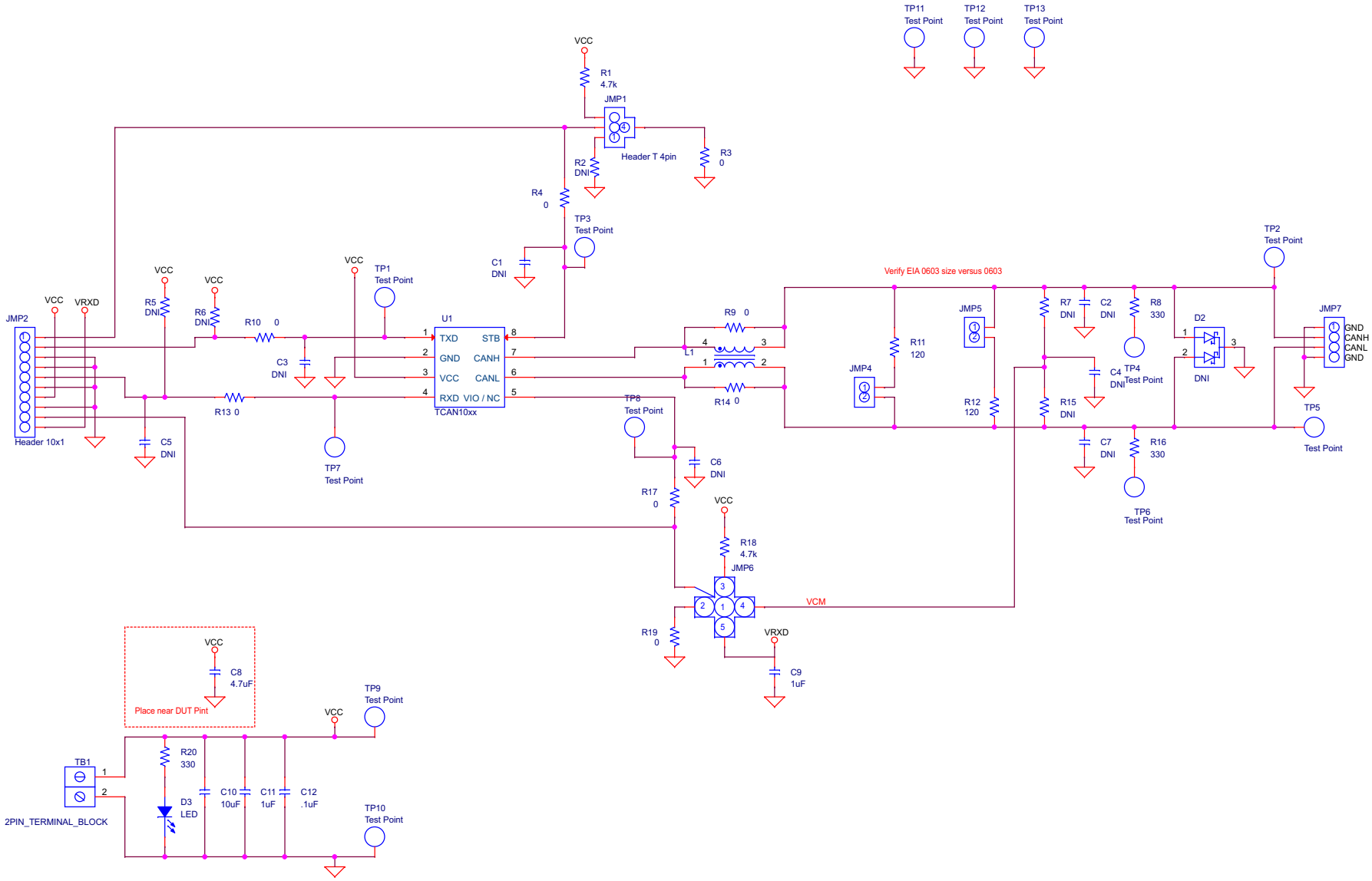

Figure 2. EVM Schematic

Table 1 lists the jumper connections for the EVM.

Table 1. Jumper Connections

Connection	Type	Description
JMP1	4-pin jumper	Used for mode selection on pin 8 (4.7-kΩ pullup to V_{CC}, 0-Ω pulldown to GND, customer-installable pulldown for devices with slew rate control R_S pin).
JMP2	10-pin header	Connection for access to all critical digital I/O, supply, and GND for driving the CAN transceiver externally with test equipment or interfaced to a processor EVM
JMP3	4-pin header	CAN bus connection (CANH, CANL) and GND
JMP4	2-pin jumper	Connect 120-Ω 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-Ω load for CAN transceiver parametric measurement.
JMP5	2-pin jumper	Connect 120-Ω CAN termination to the bus. Used in combination with JMP4 to get to second CAN termination to represent the combined 60-Ω load for CAN transceiver parametric measurement.
JMP6	5-pin jumper	Functional use of pin 5. Options for use are: A) 4.7-kΩ pullup to V_{CC} for transceiver with digital input on pin 5 B) 0-Ω pulldown to GND for transceiver with digital input on pin 5 C) Active split termination: for CAN transceiver with V_{REF} or SPLIT pin where active split termination is desired. Connect to V_{CM} and populate the components R7/R15 and C4 as required for the system. D) V_{RXD} (V_{IO}) for CAN transceivers with a separate V_{RXD} (V_{IO}) for I/O level shifting
TB1	2-pin jumper	V_{CC} supply and GND connection for the EVM
TP1	Test Point	TXD, Device pin 1 test point
TP2		CANH (bus) test point
TP3		Device pin 8 test point
TP4		CANH via 330-Ω serial resistor test point
TP5		CANL (bus) test point
TP6		CANL via 330-Ω serial resistor test point
TP7		RXD, Device pin 4 test point
TP8		Device pin 5 test point
TP9		V_{CC} test point
TP10		GND test point
TP11		
TP12		
TP13		

2 2 EVM Setup and Operation

This section describes the setup and operation of the EVM for parameter performance evaluation.

2.1 Overview and Basic Operation Settings

2.1.1 V_{CC} Power Supply (TB1, TP9, or JMP2)

The basic setup of the CAN EVM uses a single power supply required to evaluate standard 5-V or 3.3-V single-supply transceiver device performance. For single-supply transceivers, connect the 5 V or 3.3 V V_{CC} supply to the TB1 jumper header, or the V_{CC} and GND test-point loops. The power supplied should meet the required specification of V_{CC} for the transceiver being tested. LED D3 is used to indicate V_{CC} presence.

2.1.2 I/O Power Supply V_{RXD} or V_{IO} (JMP2, JMP6 ,or TP8)

For devices with I/O level shifting, a second supply pin for the I/O or RXD pin is on pin 5 of the transceiver device. A second power supply is needed to test one of these devices. Connect this power supply via JMP2, JMP6, or TP8. Install a local buffering and decoupling capacitor at C6 if the EVM is used for one of these devices.

2.1.3 Main Supply and I/O Header (JMP2)

All key I/O and supply GND functions are brought to this header. It may be used on either interface to test equipment or a short cable could be made to connect to an existing customer-application board with a CAN controller.

Table 2. JMP2 Pin Definitions

Pin	Connection	Description
1	MODE	Pin 8 of transceiver, normally used for mode control, examples: SHDN, FAULT, R_S, S, STB
2	TXD	Pin 1 of transceiver, TXD (transmit data)
3	GND	Pin 2 of transceiver, GND
4	GND	Pin 2 of transceiver, GND
5	RXD	Pin 4 of transceiver, RXD (receive data)
6	GND	Pin 2 of transceiver, GND
7	V_{CC}	Pin 3 of transceiver, V_{CC}
8	GND	Pin 2 of transceiver, GND
9	P5	Pin 5 of transceiver, various functions depending on transceiver, examples: V_{REF}, SPLIT, V_{RXD}, V_{IO}, LBK, EN, AB, and No Connect (NC)
10	V_{RXD}	Connects to Jumper JMP6 V_{RXD} header to allow flexibility in using the device with power supply for I/O on pin 5 of the transceiver

This header is arranged to provide a separate ground for each signal pair (TXD/GND and RXD/GND). If the EVM is being used with lab equipment, connect separate cables to these main points via simple 2-pin header connectors. If connecting the board to a processor-based system, connect a single cable with all power and signals via a 10-pin header cable to this port.

2.1.4 TXD Input (JMP2 or TP1)

The TXD (pin 1) 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, R10.

2.1.5 RXD Output (JMP2 or TP7)

The RXD (pin 4) of the transceiver, receive data is routed to JMP2 and TP7. The signal path to the JMP2 header is pre-installed with a 0-Ω series resistor, R13.

2.1.6 MODE Select or Pin 8 (JMP1, JMP2, or TP3)

Pin 8 of the transceiver is normally a mode control pin of the device. Pin 8 of the device is routed to JMP1, JMP2, and TP7.

2.1.7 MODE - JMP1 Configurations (3-Way Jumper)

If using separate I/O inputs JMP1 is used to configure pin 8 to a pullup to V_{CC} or pulldown to GND configuration. For most devices, when pin 8 is pulled to GND, the device is in “normal” or high speed mode. R3 is pre-installed with 0-Ω resistor to GND for this purpose. For most devices, when pin 8 is pulled to V_{CC} the device is in a silent or low power standby mode. Devices with slope control mode use the resistance to ground value to determine the slope of the driver output. R2 is left open for customers who want to install a resistance to ground and use slope mode.

2.1.8 JMP2 Configuration

Using header JMP2 which assumes all the digital I/O signals, V_{CC}, GND are routed to an external system. Ensure that the MODE (JMP1) jumper settings are not conflicting with signals to JMP2.

2.1.9 TP3 Configuration

This connects directly to device pin 8. Ensure JMP1 configuration is not conflicting if TP3 is used as the input connection.

2.1.10 Pin 5 (JMP6, JMP2 or TP8)

Pin 5 of the transceiver have various uses depending on the transceiver. Examples are V_{REF}, SPLIT, V_{RXD}, V_{IO}, LBK, EN, AB and No Connect (NC). Pin 5 of the device is routed to JMP6, JMP2 and TP8.

2.1.11 Pin 5 – JMP6 Configurations (4-Way Jumper)

If using separate I/O inputs, JMP6 is used to configure pin 5 to: pullup to V_{CC}, pulldown to GND, V_{RXD} or V_{IO} supply input, or V_{REF} or SPLIT termination output.

- **V_{REF} or SPLIT termination:** If the device and application support split termination, set JMP6 to V_{CM} (V common mode) to drive the V_{REF} or SPLIT pin common mode stabilizing voltage output to the center tap of the split termination capacitor. Install these components on the EVM as outlined in the CAN bus termination section.
- **No Connection:** If the device and application require no use of pin 5, leave it open. If the device has the V_{REF} or SPLIT pin but the application is not using the pin for split termination then add a capacitor on C6 to improve EMC performance.
- **2nd Mode or Control Input:** if the device and application use pin 5 as a second mode or control pin, then set JMP6 as either a pullup to V_{CC} or pulldown to GND, as necessary.
- **I/O and RXD level-shifting supply:** if the device and application used with V_{IO} or V_{RXD} to level shift I/O pins on the transceiver then set JMP6 to V_{RXD} connecting pin 5 of the device to the V_{RXD} pin on JMP2. Install local buffering and bypass capacitor C6.

2.1.12 JMP2 Configuration

Using header JMP2 assumes all the digital I/O signals, V_{CC}, and GND are routed to an external system. Ensure that pin 5 (JMP6) jumper settings are not conflicting with signals to JMP2. For power supply V_{RXD}, set the jumper to route JMP2 supply input to the transceiver pin.

2.1.13 TP8 Configuration

This connects directly to device pin 5. Ensure JMP6 configuration is not conflicting if TP8 is used as an input connection.

2.2 Using CAN Bus Load, Termination, and Protection Configurations

The CAN EVM is populated with two 120-Ω 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-Ω resistors in parallel to give the standard 60-Ω load for parametric measurement. The EVM also has footprints for split termination, if needed for the application. Table 3 summarizes how to use these termination options. If using split termination, match the resistors. Calculate the common mode 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 common-mode filter frequency, not a differential filter that impacts the differential CAN signal directly.

Table 3. Bus Termination Configuration

Termination Configuration	120-Ω Resistors		Split Termination Footprints		Split Termination Footprints
	JMP4	JMP5	R7	R15	C4
Standard termination (120 Ω)	shorted	open	N/A	N/A	N/A
60-Ω load - electrical parameterics	shorted	shorted			
Split termination (common mode stabilization)	open	open	60 Ω	60 Ω	populated

The EVM also has footprints for various protection schemes to enhance robustness for extreme system-level EMC requirements. Table 4 summarizes these options.

Table 4. Protection and Filtering Configuration

Configuration	Footprint Reference	Use Case	Population and Description
Series resistors or common mode choke	R9/R14 or L1 (common footprint)	Direct CAN transceiver to bus connection	R9 and R14 populated with 0 Ω (default population)
		Series resistance protection, CAN transceiver to bus connection	R9 and R14 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 caps transient protection	C2/C7	Bus filter	Filter noise as necessary for harsh EMC environment. Use filter caps in combination with L1 CM choke.
	C2/C7 or D1/D2	Transient and ESD protection	To add extra protection for system level transients and ESD protection, TVS diode population option via D1/D2 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 CAN EVM has footprints on the PCB for the installation of 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 Ω), pullup or down resistors (depending on pin use), and a capacitor to GND which allows for RC filters when configured with a series resistor. Table 5 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 5. RC Filter and Protection Lists

Device Pin			Jumperable		Series R	Pullup and Pulldown	C to GND	Description
No.	Description	Type	Pullup	Pulldown				
1	TXD	Input	N/A	N/A	R10	R6 PU	C3	
2	RXD	Output	N/A	N/A	R13	R5 PU	C5	
5	NC	No Connect	N/A	N/A	N/A	N/A	N/A	
	SHDN	Input	R18 (JMP6)	R19 (JMP6)	R17	N/A	C6	
	FAULT	Output	N/A	N/A	R17	N/A	C4/C6	
	V_{REF} and SPLIT	Output	N/A	N/A	R17	N/A	C4/C6	Split termination: JMP6 to route output to split termination center point capacitor C4. EMC for systems not using split termination: C6 to GND.
	V_{RXD} and V_{IO}	Supply Input	N/A	N/A	R17	N/A	C9/C6	Use TM6, JMP6, and JMP2 as necessary to provide supply input.
	AB, EN, and LBK	Input	R18 (JMP6)	R19 (JMP6)	R17	N/A	C6	
8	S, R_S, STB	Input	R1 (JMP1)	R2/R3 (JMP1)	R4	N/A	C1	R2 pulldown to GND (JMP1) user-installable for use with slope mode on devices with R_S pin.
	NC	No Connect	N/A	N/A	N/A	N/A	N/A	

3 CAN EVM Configuration for TCAN1042HGV-Q1 (Factory Installed)

The TCAN10xx family of devices interface CAN protocol controllers with the physical bus in accordance to the ISO 11898 standard. These devices are compatible with the ISO 11898 High Speed CAN (Controller Area Network) Physical Layer standards: 11898-2. Standard versions are designed for data rates of 1 megabit per second (Mbps) in CAN networks and additional devices are designed to meet at least 2 Mbps in CAN FD networks. The devices include many protection features providing device and CAN network robustness.

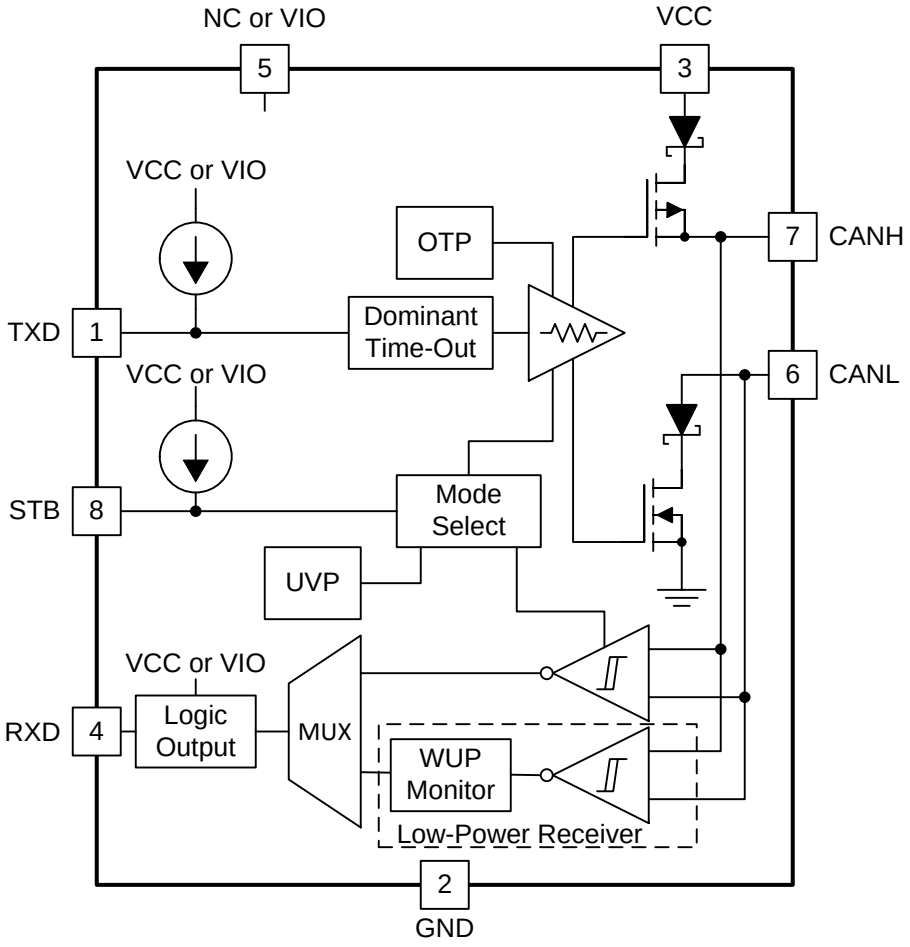

Figure 3. TCAN1042 Basic Block Diagram

Table 6. EVM Connection Settings for TCAN1042

Connection	Description
JMP1	Mode selection: Pullup to V_{CC} for silent mode, pulldown to GND for normal mode
JMP2	Connection for access to all critical digital I/O, supply, and GND if being externally driven by test equipment or interfaced to a processor EVM. Note: ensure that JMP1, JMP6, and TB1 settings do not conflict with JMP2, if it is used.
JMP3	CAN bus connection (CANH, CANL) and GND as necessary if interfacing EVM to a CAN network
JMP4	Connect if necessary for a single CAN network termination
JMP5	Connect if necessary for in parallel with JMP4 to get a 60-Ω load to measure CAN parametrics
JMP6	TCAN1042 V_{IO} - Level-shifting for applications that require 3.3-V operation. Connect to 5-V supply for 5-V applications and 3.3-V for 3.3-V applications.

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3 *Regulatory Notices:*

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

      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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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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.

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