

1 Features

- Meets the ISO 11898-2:2016 and ISO 11898-5: 2007 physical layer standards
- support classic CAN and CAN FD
- I/O Voltage range supports 3.3V and 5V MCUs
- Ideal passive behavior when unpowered
- $\pm 15\text{kV}$ ESD Protection
- $\pm 70\text{V}$ Bus Fault protection
- Undervoltage protection on V_{CC} & V_{IO} supply terminals
- Driver dominant time out
- Thermal shutdown protection
- Receiver common mode input voltage: $\pm 30\text{V}$
- SOP8 package and DFN8-EP(3x3) package

2 Applications

- All devices support highly loaded CAN networks
- Industrial automation, control, sensors and drive systems
- Building, security and climate control automation
- Telecom base station status and control

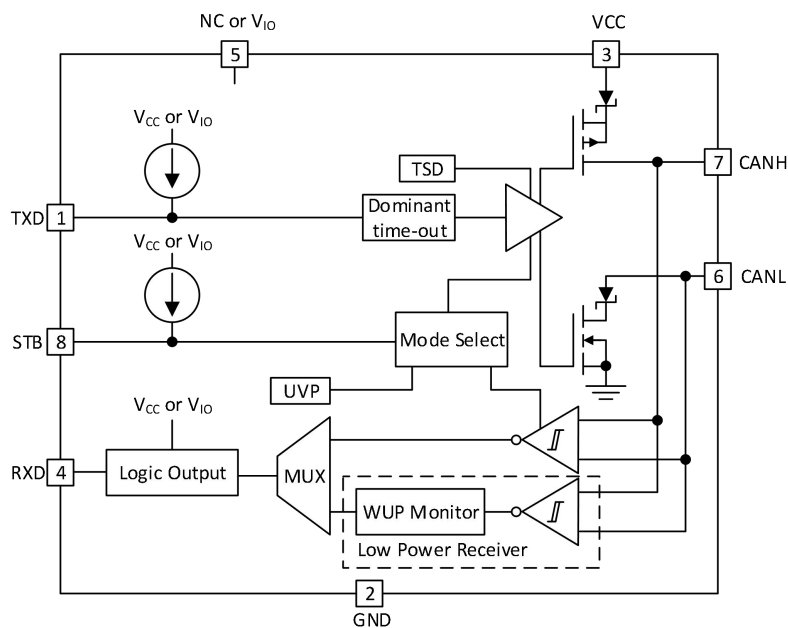
3 Description

The HMT1042 high-speed CAN transceiver provides an interface between a Controller Area Network (CAN) protocol controller and the physical two-wire CAN bus. The transceiver is designed for high-speed CAN applications in the automotive industry, providing the differential transmit and receive capability to a CAN protocol controller.

The HMT1042 offer offers improved EMC and ESD performance, and also features:

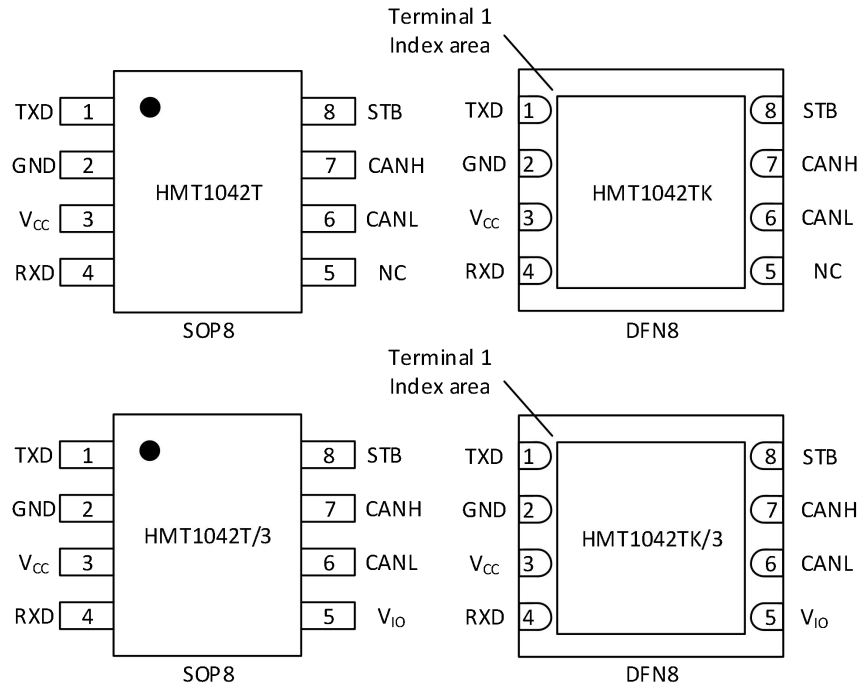
- Ideal passive behavior to the CAN bus when the supply voltage is off
- A very low-current Standby mode with bus wake-up capability
- Variants with a V_{IO} pin can be interfaced directly with microcontrollers with supply voltages from 3.3V to 5V

The HMT1042 implements the CAN physical layer as defined in ISO 11898-2:2016 and SAE J2284-1 to SAE J2284-5. This implementation enables reliable communication in the CAN FD fast phase at data rates up to 5Mbps.



Functional Block Diagram

4 Pin Configurations and Functions



Pin Functions

| Pins | | TYP ⁽¹⁾ | Description |
|-----------------|------------------|--------------------|--|
| Name | No. | | |
| TXD | 1 | I | CAN transmit data input (LOW for dominant and HIGH for recessive bus states) |
| GND | 2 ⁽²⁾ | GND | Ground connection |
| V _{CC} | 3 | POWER | Transceiver 5V supply voltage |
| RXD | 4 | DIGITAL OUTPUT | CAN receive data output (LOW for dominant and HIGH for recessive bus states) |
| NC | 5 | - | No Connect |
| V _{IO} | 5 | P | Transceiver I/O level shifting supply voltage |
| CANL | 6 | AIO | Low level CAN bus input/output line |
| CANH | 7 | AIO | High level CAN bus input/output line |
| STB | 8 | I | Standby Mode control input (active high) |

(1) I: digital input; O: digital output; AIO: analog input/output; P: power supply; G: ground.

(2) DFN8-EP(3x3) package die supply ground is connected to both the GND pin and the exposed center pad. The GND pin must be soldered to board ground. For enhanced thermal and electrical performance, it is recommended that the exposed center pad also be soldered to board ground.

5 Specifications

5.1 Absolute Maximum Ratings

See Note ⁽¹⁾

| Parameter | Description | MIN | MAX | UNIT |
|---------------------|---|------|-----|------|
| V _{CC} | 5V Supply Voltage Range ⁽²⁾ | -0.3 | 7 | V |
| V _{IO} | I/O Level-Shifting Voltage Range | -0.3 | 7 | V |
| V _{BUS} | CAN Bus I/O voltage range (CANH, CANL) | -70 | 70 | V |
| V _I | Logic input terminal voltage range (TXD, S) | -0.5 | 6 | V |
| V _O | Logic output terminal voltage range (RXD) | -0.5 | 6 | V |
| I _{O(RXD)} | RXD (Receiver) output current | -8 | 8 | mA |
| T _J | Junction temperature | -55 | 150 | °C |
| T _{STG} | Storage temperatur | -65 | 150 | °C |

(1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

(2) All voltage values, except differential I/O bus voltages, are with respect to ground terminal.

5.2 ESD Ratings

| | Test Conditions | VALUE | UNIT |
|---|--------------------------------|--------|------|
| Human Body Model (HBM) ESD stress voltage | All terminals | ±8000 | V |
| | CAN bus terminals (CANH, CANL) | ±15000 | |
| Charged Device Model (CDM) ESD stress voltage | All terminals | ±2000 | V |
| IEC Contact Discharge (IEC 61000-4-2) | CAN bus terminals (CANH, CANL) | ±8000 | |

5.3 Recommended Operating Conditions

| | | MIN | MAX | UNIT |
|----------------------|--|-----|-----|------|
| V _{CC} | 5V Bus Supply Voltage Range | 4.5 | 5.5 | V |
| V _{IO} | I/O Level-Shifting Voltage Range | 3 | 5.5 | |
| I _{OH(RXD)} | RXD terminal HIGH level output current | -2 | | mA |
| I _{OL(RXD)} | RXD terminal LOW level output current | | 2 | |

5.4 Electrical Characteristics

Over recommended operating conditions (unless otherwise noted).

| Parameter | | | Test Conditions | Min | Typ ⁽¹⁾ | Max | Unit |
|------------------------------------|--|---------------------------------------|---|--------------------|--------------------|--------------------|------|
| Supply Characteristics | | | | | | | |
| I _{CC} | 5V supply current | Normal mode (dominant) | See Figure 6-1 , TXD = 0V, R _L = 60Ω, C _L = open, R _{CM} = open, STB = 0V, Typical Bus Load | | 40 | 70 | mA |
| | | | See Figure 6-1 , TXD = 0V, R _L = 50Ω, C _L = open, R _{CM} = open, STB = 0V, High Bus Load | | 45 | 80 | |
| | | Normal mode (dominant-with bus fault) | See Figure 6-1 , TXD = 0V, STB = 0V, CANH = -12V, R _L = open, C _L = open, R _{CM} =open | | | 180 | |
| | | Normal mode (recessive) | See Figure 6-1 , TXD = V _{CC} or V _{IO} , R _L = 50Ω, C _L = open, R _{CM} = open, STB = 0V | | 0.6 | 1.0 | |
| | | Standby mode | V _{CC} not needed in Standby mode, See Figure 6-1 , TXD = V _{IO} , R _L = 50Ω, C _L = open, R _{CM} = open, STB = V _{IO} | | 2.2 | 5 | μA |
| I _{IO} | I/O supply current | Normal mode | RXD floating, TXD = STB = 0 or 5.5V | | 100 | 300 | μA |
| | | Standby mode | RXD floating, TXD = STB = V _{IO} , V _{CC} = 0 or 5.5V | | 12 | 17 | |
| UV _{VCC} | Rising undervoltage detection on V _{CC} for protected mode | | All devices | | 3.2 | 3.4 | V |
| | Falling undervoltage detection on V _{CC} for protected mode | | | 2.8 | 3.0 | 3.25 | |
| V _{HYS(UVCC)} | Hysteresis voltage on UV _{VCC} | | | | | 200 | |
| UV _{VIO} | Undervoltage detection on V _{IO} for protected mode | | Device with V _{IO} pin | 1.3 | | 2.75 | V |
| V _{HYS(UV_{VIO})} | Hysteresis voltage on UV _{VIO} for protected mode | | | | 80 | | mV |
| STB Terminal (Mode Select Input) | | | | | | | |
| V _{IH} | High-level input voltage | | Devices with V _{IO} pin | 0.7V _{IO} | | | V |
| | | | Devices without V _{IO} pin | 2 | | | |
| V _{IL} | Low-level input voltage | | Devices with V _{IO} pin | | | 0.3V _{IO} | V |
| | | | Devices without V _{IO} pin | | | 0.8 | |
| I _{IH} | High-level input leakage current | | STB = V _{CC} = V _{IO} = 5.5V | -2 | 0 | 2 | μA |
| I _{IL} | Low-level input leakage current | | STB = 0V, V _{CC} = V _{IO} = 5.5V | -15 | -10 | -2 | |
| I _{LKG(OFF)} | Unpowered leakage current | | STB = 5.5V, V _{CC} = V _{IO} = 0V | -1 | 0 | 1 | |

5.4 Electrical Characteristics (continued)

Over recommended operating conditions (unless otherwise noted).

Over recommended operating conditions (unless otherwise noted).

| Parameter | | Test Conditions | Min | Typ ⁽¹⁾ | Max | Unit |
|--|----------------------------------|---|--------------------|--------------------|--------------------|------|
| TXD Terminal (CAN Transmit Data Input) | | | | | | |
| V _{IH} | High-level input voltage | Devices with V _{IO} pin | 0.7V _{IO} | | | V |
| | | Devices without V _{IO} pin | 2 | | | |
| V _{IL} | Low-level input voltage | Devices with V _{IO} pin | | | 0.3V _{IO} | |
| | | Devices without V _{IO} pin | | | 0.8 | |
| I _{IH} | High-level input leakage current | TXD = V _{CC} = V _{IO} = 5.5V | -2.5 | 0 | 1 | μA |
| I _{IL} | Low-level input leakage current | TXD = 0V, V _{CC} = V _{IO} = 5.5V | -100 | -40 | -7 | |
| I _{LKG(OFF)} | Unpowered leakage current | TXD = 5.5V, V _{CC} = V _{IO} = 0V | -1 | 0 | 1 | |
| RXD Terminal (Can Receive Data Output) | | | | | | |
| V _{OH} | High-level output voltage | Devices with V _{IO} pin, See Figure 6-2 , I _O = -2mA. | 0.8V _{IO} | | | V |
| | | Devices without V _{IO} pin, See Figure 6-2 , I _O = -2mA. | 4 | 4.6 | | |
| V _{OL} | Low-level output voltage | Devices with V _{IO} pin, See Figure 6-2 , I _O = +2mA. | | | 0.2V _{IO} | |
| | | Devices without V _{IO} pin, See Figure 6-2 , I _O = +2mA. | | 0.2 | 0.4 | |
| I _{LKG(OFF)} | Unpowered leakage current | RXD = 5.5V, V _{CC} = 0V, V _{IO} = 0V | -1 | 0 | -1 | μA |

5.4 Electrical Characteristics (continued)

Over recommended operating conditions (unless otherwise noted).

| Parameter | | | Test Conditions | Min | Typ ⁽¹⁾ | Max | Unit |
|-----------------------------------|--|---------------|--|------|--------------------|------|------|
| Driver Electrical Characteristics | | | | | | | |
| V _{O(DOM)} | Bus output voltage (dominant) | CANH | See Figure 6-1 and Figure 7-3 , TXD = 0V, STB = 0V, 50Ω ≤ R _L ≤ 65Ω, C _L = open, R _{CM} = open | 2.75 | 3.6 | 4.5 | V |
| | | CANL | STB = 0V, 50Ω ≤ R _L ≤ 65Ω, C _L = open, R _{CM} = open | 0.5 | 1.4 | 2.25 | |
| V _{O(REC)} | Bus output voltage(recessive) | CANH and CANL | See Figure 6-1 and Figure 7-3 , TXD = V _{CC} or V _{IO} , V _{IO} = V _{CC} , STB = 0V, R _L = open (no load), R _{CM} = open | 2 | 0.5V _{CC} | 3 | |
| V _{O(STB)} | Bus output Voltage (Standby mode) | CANH | See Figure 6-1 and Figure 7-3 , STB = V _{IO} , R _L = open (no load), R _{CM} = open | -0.1 | 0 | 0.1 | |
| | | CANL | | -0.1 | 0 | 0.1 | |
| | | CANH - CANL | | -0.2 | 0 | 0.2 | |
| V _{OD(DOM)} | Differential output voltage (dominant) | CANH - CANL | See Figure 6-1 and Figure 7-3 , TXD = 0V, STB = 0V, 45Ω ≤ R _L < 50Ω, C _L = open, R _{CM} = open | 1.4 | | 3 | |
| | | | See Figure 6-1 and Figure 7-3 , TXD = 0V, STB = 0V, 50Ω ≤ R _L ≤ 65Ω, C _L = open, R _{CM} = open | 1.5 | 2.2 | 3 | |
| | | | See Figure 6-1 and Figure 7-3 , TXD = 0V, STB = 0V, R _L = 2240Ω, C _L = open, R _{CM} = open | 1.5 | | 5 | |
| V _{OD(REC)} | Differential output voltage (recessive) | CANH - CANL | See Figure 6-1 and Figure 7-3 , TXD = V _{CC} , STB = 0V, R _L = 60Ω, C _L = open, R _{CM} = open | -120 | | 20 | mV |
| | | | See Figure 6-1 and Figure 7-3 , TXD = V _{CC} , STB = 0V, R _L = open (no load), C _L = open, R _{CM} = open | -50 | | 50 | |
| V _{SYM} | Output symmetry (dominant or recessive) (V _{O(CANH)} + V _{O(CANL)}) / V _{CC} | | See Figure 6-1 and Figure 8-2 , STB at 0V, R _{term} = 60Ω, C _{split} = 4.7nF, C _L = open, R _{CM} = open, T _{XD} = 250kHz, 1MHz | 0.9 | | 1.1 | V/V |
| V _{SYM_DC} | DC Output symmetry (dominant or recessive) (V _{CC} - V _{O(CANH)} - V _{O(CANL)}) | | See Figure 6-1 and Figure 7-3 , STB = 0V, R _L = 60Ω, C _L = open, R _{CM} = open | -0.4 | | 0.4 | V |
| I _{OS(SS_DOM)} | Short-circuit steady-state output current, dominant, Normal mode | | See Figure 7-3 , STB at 0V, V _{CANH} = -5V to 40V, CANL = open, TXD = 0V | -100 | | | mA |
| | | | See Figure 7-3 , STB at 0V, V _{CANL} = -5V to 40V, CANH = open, TXD = 0V | 100 | | | |
| I _{OS(SS_REC)} | Short-circuit steady-state output current, recessive, Normal mode | | See Figure 7-3 , STB at 0V, -27V ≤ V _{BUS} ≤ 32V, Where V _{BUS} = CANH = CANL, TXD = V _{CC} | -5 | | 5 | mA |

5.4 Electrical Characteristics (continued)

Over recommended operating conditions (unless otherwise noted).

| Parameter | | Test Conditions | Min | Typ ⁽¹⁾ | Max | Unit |
|--|---|--|-----|--------------------|------|------|
| Receiver Electrical Characteristics | | | | | | |
| V _{CM} | Common mode range, Normal mode | See Figure 6-2 and Table 6-1 , STB = 0V | -30 | | +30 | V |
| V _{IT+} | Positive-going input threshold voltage, Normalmode | See Figure 6-2 , Table 7-5 and Table 6-1 , STB = 0V, -20V ≤ V _{CM} ≤ +20V | | | 900 | mV |
| V _{IT-} | Negative-going input threshold voltage, Normalmode | | 500 | | | |
| V _{IT+} | Positive-going input threshold voltage, Normalmode | See Figure 6-2 , Table 7-5 and Table 6-1 , STB = 0V, -30V ≤ V _{CM} ≤ +30V | | | 1000 | |
| V _{IT-} | Negative-going input threshold voltage, Normalmode | | 400 | | | |
| V _{HYS} | Hysteresis voltage (V _{IT+} - V _{IT-}), Normal mode | See Figure 6-2 , Table 7-5 and Table 6-1 , STB = 0V | | 120 | | |
| V _{CM} | Common mode range, Standby mode | Devices with V _{IO} pin, See Figure 6-2 , Table 7-5 and Table 6-1 , STB = V _{IO} , 4.5V ≤ V _{IO} ≤ 5.5V | -12 | | 12 | V |
| | | Devices with V _{IO} pin, See Figure 6-2 , Table 7-5 and Table 6-1 , STB = V _{IO} , 3.0V ≤ V _{IO} ≤ 4.5V | -2 | | 7 | |
| | | Devices without V _{IO} pin, See Figure 6-2 , Table 7-5 and Table 6-1 , STB = V _{CC} | -12 | | 12 | |
| V _{IT(STANDBY)} | Input threshold voltage, Standby mode | STB = V _{CC} or V _{IO} | 400 | | 1150 | mV |
| I _{LKG(IOFF)} | Power-off (unpowered) bus input leakage current | CANH = CANL = 5V, V _{CC} = V _{IO} = 0V | | | 4.8 | μA |
| R _{ID} | Differential input resistance | TXD = V _{CC} = V _{IO} = 5V, STB = 0V, | 20 | 30 | 50 | kΩ |
| R _{IN} | Input resistance (CANH or CANL) | -30V ≤ V _{CM} ≤ +30V | 10 | 15 | 25 | |
| R _{IN(M)} | Input resistance matching: [1 - (R _{IN(CANH)} / R _{IN(CANL)})] × 100% | V _{CANH} = V _{CANL} = 5V | -2% | | +2% | |

(1) All typical values are at 25°C and supply voltages of V_{CC} = 5V and V_{IO} = 5V (if applicable), R_L = 60Ω.

5.5 Switching Characteristics

Over recommended operating conditions (unless otherwise noted)

| Parameter | | Test Conditions | Min | Typ ⁽¹⁾ | Max | Unit |
|------------------------------------|--|--|-----|--------------------|-----|------|
| Device Switching Characteristics | | | | | | |
| t _{PROP(LOOP1)} | Total loop delay, driver input (TXD) to receiver output (RXD), recessive to dominant | STB = 0V, R _L = 60Ω | | 110 | 160 | ns |
| t _{PROP(LOOP2)} | Total loop delay, driver input (TXD) to receiver output (RXD), dominant to recessive | C _L = 100pF C _{L(RXD)} = 15pF | | 130 | 200 | |
| t _{MODE} | Mode change time, from Normal to Standby or from Standby to Normal | | | 20 | 45 | μs |
| t _{filter(wake)bus} | Bus wake-up filter time | Version with NC pin Standby mode | 0.5 | 1 | 35 | μs |
| | | Version with V _{IO} pin Standby mode | 0.5 | 1.5 | 5 | |
| Driver Switching Characteristics | | | | | | |
| t _{pHR} | Propagation delay time, high TXD to driver recessive (dominant to recessive) | See Figure 6-1 STB = 0V, R _L = 60Ω C _L = 100pF R _{CM} = open | | 80 | | ns |
| t _{pLD} | Propagation delay time, low TXD to driver dominant (recessive to dominant) | | | 65 | | |
| t _{sk(p)} | Pulse skew (t _{pHR} - t _{pLD}) | | | 15 | | |
| t _R | Differential output signal rise time | | | 45 | | |
| t _F | Differential output signal fall time | | | 45 | | |
| t _{TXD_DTO} | Dominant timeout | STB = 0V,R _L = 60Ω C _L = open | 1.2 | 2 | 3.8 | ms |
| Receiver Switching Characteristics | | | | | | |
| t _{pRH} | Propagation delay time, bus recessive input to high output (Dominant to Recessive) | See Figure 6-2 STB = 0V C _{L(RXD)} = 15pF | | 55 | | ns |
| t _{pDL} | Propagation delay time, bus dominant input to low output (Recessive to Dominant) | | | 55 | | ns |
| t _R | RXD Output signal rise time | | | 10 | | ns |
| t _F | RXD Output signal fall time | | | 10 | | ns |

(1) All typical values are at 25°C and supply voltages of $V_{CC} = 5V$ and $V_{IO} = 5V$ (if applicable), $R_L = 60\Omega$

6 Parameter Measurement Information

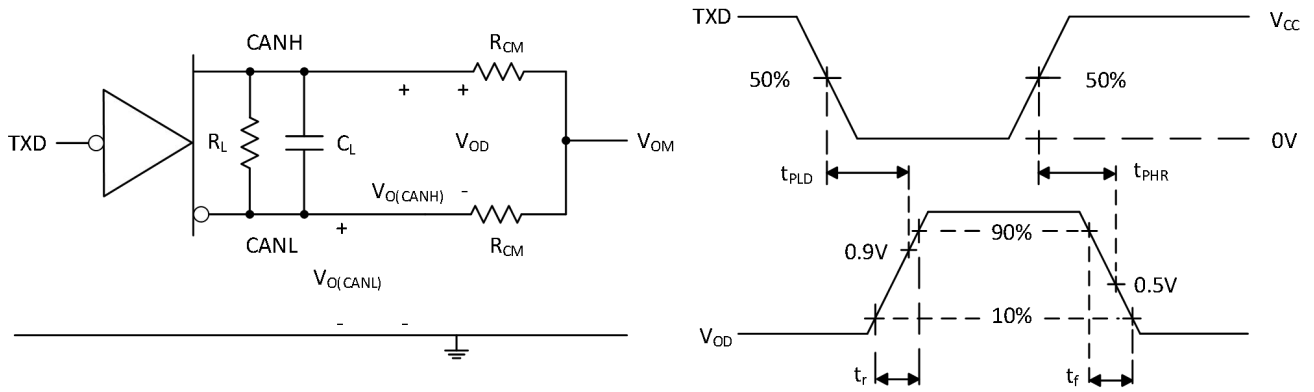


Figure 6-1. Driver Test Circuit and Measurement

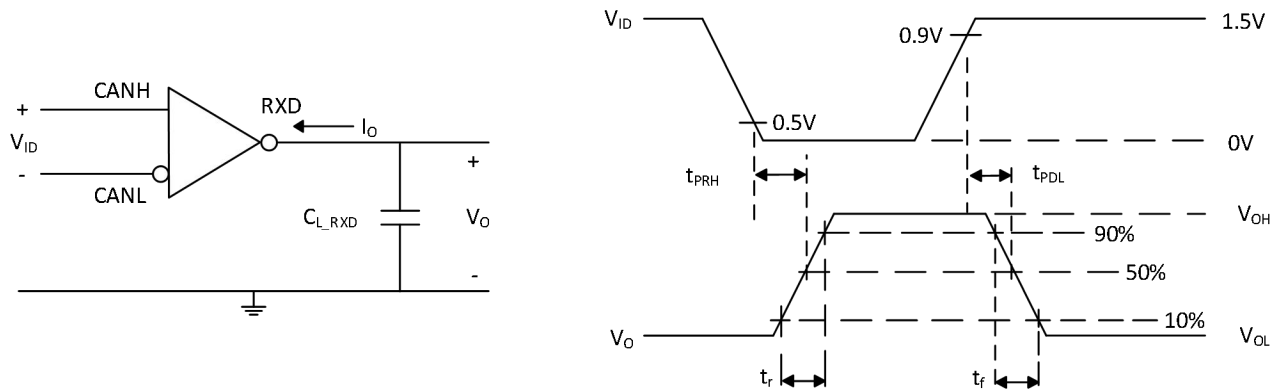


Figure 6-2. Receiver Test Circuit and Measurement

Table 6-1. Receiver Differential Input Voltage Threshold Test

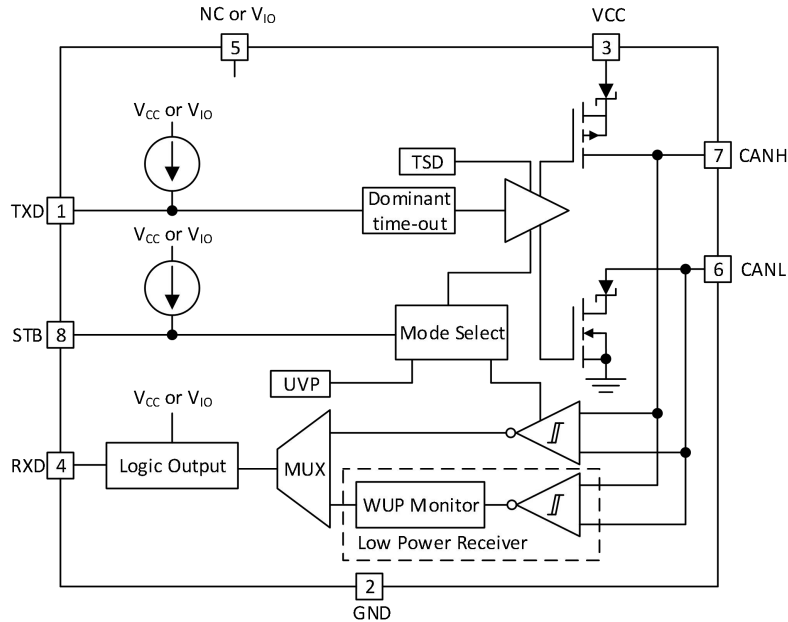
| INPUT | | | OUTPUT | |
|------------|------------|------------|--------|----------|
| V_{CANH} | V_{CANL} | $ V_{ID} $ | RXD | |
| -29.5 V | -30.5 V | 1000 mV | L | V_{OL} |
| 30.5 V | 29.5 V | 1000 mV | L | |
| -19.55 V | -20.45 V | 900 mV | L | |
| 20.45 V | 19.55 V | 900 mV | L | |
| -19.75 V | -20.25 V | 500 mV | H | V_{OH} |
| 20.25 V | 19.75 V | 500 mV | H | |
| -29.8 V | -30.2 V | 400 mV | H | |
| 30.2 V | 29.8 V | 400 mV | H | |
| Open | Open | X | H | |

7 Detailed Description

7.1 Overview

These CAN transceivers meet the ISO11898-2 (2016) High Speed CAN (Controller Area Network) physical layer standard. They are designed for data rates in excess of 1 Mbps for CAN FD and enhanced timing margin/higher data rates in long and highly-loaded networks. These devices provide many protection features to enhance device and CAN robustness.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 TXD Dominant Timeout (DTO)

During normal mode (the only mode where the CAN driver is active), the TXD DTO circuit prevents the transceiver from blocking network communication in the event of a hardware or software failure where TXD is held dominant longer than the timeout period t_{TXD_DTO} . The DTO circuit timer starts on a falling edge on TXD. The DTO circuit disables the CAN bus driver if no rising edge is seen before the timeout period expires. This frees the bus for communication between other nodes on the network. The CAN driver is re-activated when a recessive signal is seen on the TXD terminal, thus clearing the TXD DTO condition. The receiver and RXD terminal still reflect activity on the CAN bus, and the bus terminals are biased to the recessive level during a TXD dominant timeout.

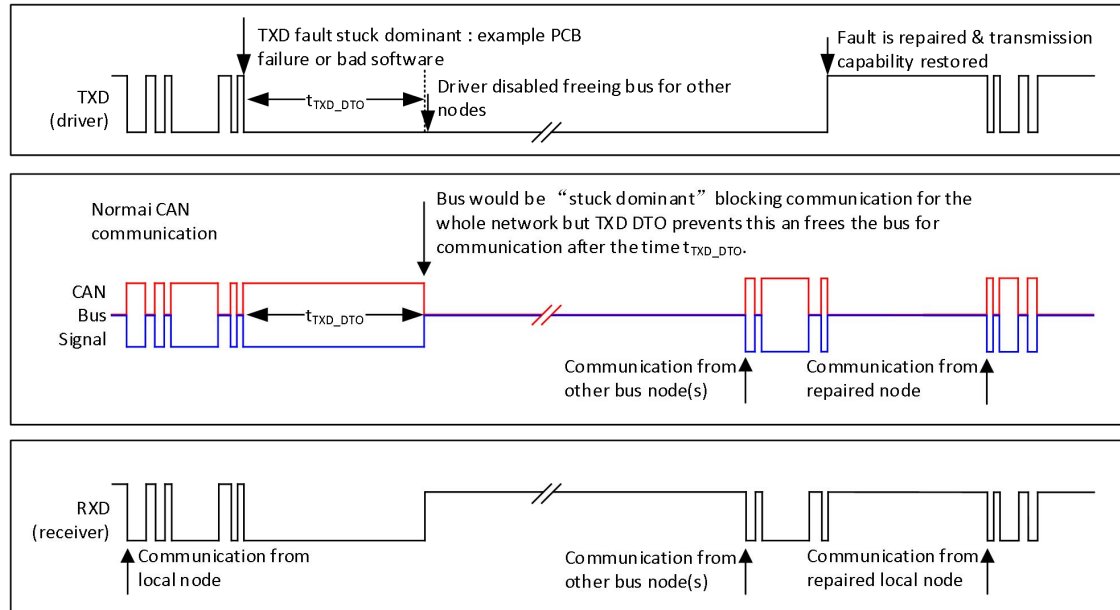


Figure 7-1. Example Timing Diagram for TXD DTO

7.3.2 Thermal Shutdown (TSD)

If the junction temperature of the device exceeds the thermal shutdown threshold (T_{TSD}), the device turns off the CAN driver circuits thus blocking the TXD-to-bus transmission path. The CAN bus terminals are biased to the recessive level during a thermal shutdown, and the receiver-to-RXD path remains operational. The shutdown condition is cleared when the junction temperature drops at least the thermal shutdown hysteresis temperature (T_{TSD_HYS}) below the thermal shutdown temperature (T_{TSD}) of the device.

7.3.3 Undervoltage Lockout

The supply terminals have undervoltage detection that places the device in protected mode. This protects the bus during an undervoltage event on either the V_{CC} or V_{IO} supply terminals.

Table 7-1. Undervoltage Lockout 5V Only Devices without V_{IO} pin

| V_{CC} | Device State ⁽¹⁾ | Bus Output | RXD |
|--------------|-----------------------------|----------------|----------------------------|
| $> UV_{VCC}$ | Normal | Per TXD | Mirrors Bus ⁽²⁾ |
| $< UV_{VCC}$ | Protected | High Impedance | High Impedance |

(1) See the V_{IT} section of the Electrical Characteristics.

(2) Mirrors bus state: low if CAN bus is dominant, high if CAN bus is recessive.

Table 7-2. Undervoltage Lockout only I/O Devices with V_{IO} pin

| V_{CC} | V_{IO} | Device State | Bus Output | RXD |
|--------------|--------------|---------------------------|----------------|-------------------------------------|
| $> UV_{VCC}$ | $> UV_{VIO}$ | Normal | Per TXD | Mirrors Bus ⁽¹⁾ |
| $< UV_{VCC}$ | $> UV_{VIO}$ | STB = High: Standby Mode | Recessive | Bus Wake RXD Request ⁽²⁾ |
| | | STB = Low: Protected Mode | High Impedance | High (Recessive) |
| $> UV_{VCC}$ | $< UV_{VIO}$ | Protected | High Impedance | High Impedance |
| $< UV_{VCC}$ | $< UV_{VIO}$ | Protected | High Impedance | High Impedance |

(1) Mirrors bus state: low if CAN bus is dominant, high if CAN bus is recessive.

(2) Refer to Section 7.4.3.1

7.3.4 Unpowered Device

The device is designed to be 'ideal passive' or 'no load' to the CAN bus if it is unpowered. The bus terminals (CANH, CANL) have extremely low leakage currents when the device is unpowered to avoid loading down the bus. This is critical if some nodes of the network are unpowered while the rest of the of network remains in operation. The logic terminals also have extremely low leakage currents when the device is unpowered to avoid loading down other circuits that may remain powered.

7.3.5 Floating Terminals

These devices have internal pull ups on critical terminals to place the device into known states if the terminals float. The TXD terminal is pulled up to V_{CC} or V_{IO} to force a recessive input level if the terminal floats. The STB terminal is also pulled up to force the device into low power Standby mode if the terminal floats.

7.3.6 CAN Bus Short Circuit Current Limiting

The device has two protection features that limit the short circuit current when a CAN bus line is short-circuit fault condition: driver current limiting (both dominant and recessive states) and TXD dominant state time out to prevent permanent higher short circuit current of the dominant state during a system fault. During CAN communication the bus switches between dominant and recessive states, thus the short circuit current may be viewed either as the instantaneous current during each bus state or as an average current of the two states.

7.3.7 Digital Inputs and Outputs

7.3.7.1 Devices without V_{IO} pin:

The 5V V_{CC} only devices are supplied by a single 5V rail. The digital inputs have TTL input thresholds and are therefore 5V and 3.3V compatible. The RXD outputs on these devices are driven to the V_{CC} rail for logic high output. Additionally, the TXD and STB pins are internally pulled up to V_{CC} . The internal bias of the mode pins may only place the device into a known state if the terminals float, they may not be adequate for system-level biasing during transients or noisy environments.

7.3.7.2 Devices with V_{IO} pin:

These devices use a 5V V_{CC} power supply for the CAN driver and high speed receiver blocks. These transceivers have a second power supply for I/O level-shifting (V_{IO}). This supply is used to set the CMOS input thresholds of the TXD and STB pins and the RXD high level output voltage. Additionally, the internal pull ups on TXD and STB are pulled up to V_{IO} .

7.4 Device Functional Modes

The device has two main operating modes: Normal mode and Standby mode. Operating mode selection is made via the STB input terminal.

Table 7-3. Operating Modes

| Mode | STB Terminal | RXD | |
|--------------|--------------|--------------------------|-----------------------------|
| | | LOW | HIGH |
| Normal Mode | LOW | Bus dominant | Bus recessive |
| Standby Mode | HIGH | Wake-up request detected | No wake-up request detected |

7.4.1 CAN Bus States

The CAN bus has two states during powered operation of the device: dominant and recessive. A dominant bus state is when the bus is driven differentially, corresponding to a logic low on the TXD and RXD terminal. A recessive bus state is when the bus is biased to $V_{CC}/2$ via the high-resistance internal input resistors R_{IN} of the receiver, corresponding to a logic high on the TXD and RXD terminals.

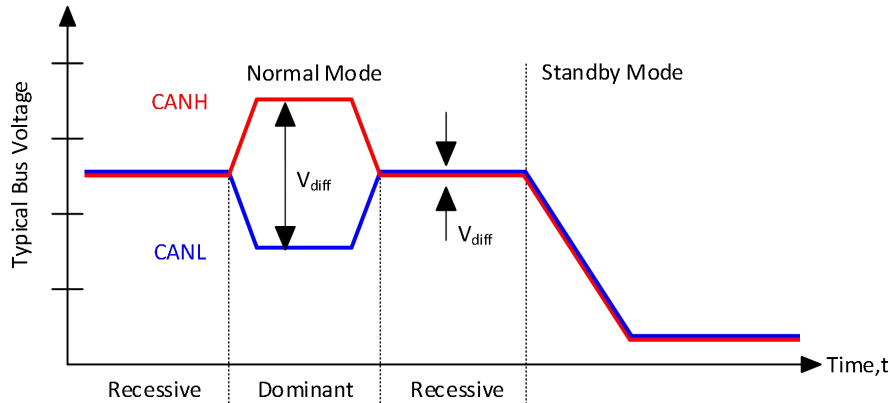
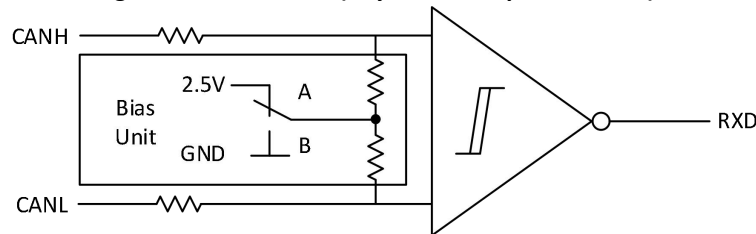


Figure 7-2. Bus States (Physical Bit Representation)



A: Normal Modes
B: Standby Mode (Low Power)

Figure 7-3. Bias Unit (Recessive Common Mode Bias) and Receiver

7.4.2 Normal Mode

Select the Normal mode of device operation by setting STB terminal low. The CAN driver and receiver are fully operational and CAN communication is bi-directional. The driver translates a digital input on TXD to a differential output on CANH and CANL. The receiver translates the differential signal from CANH and CANL to a digital output on RXD.

7.4.3 Standby Mode

A HIGH level on pin STB selects Standby mode. In Standby mode, the transceiver is not able to transmit or correctly receive data via the bus lines. The transmitter and Normal-mode receiver blocks are switched off to reduce supply current, and only a low-power differential receiver monitors the bus lines for activity. The wake-up filter on the output of the low-power receiver does not latch bus dominant states, but ensures that only bus dominant and bus recessive states that persist longer than $t_{\text{filtr(wake)bus}}$ are reflected on pin RXD.

In Standby mode, the bus lines are biased to ground to minimize the system supply current. The low-power receiver is supplied by V_{IO} , and is capable of detecting CAN bus activity even if V_{IO} is the only supply voltage available. When pin RXD goes LOW to signal wake-up request, a transition to Normal mode will not be triggered until STB is forced LOW.

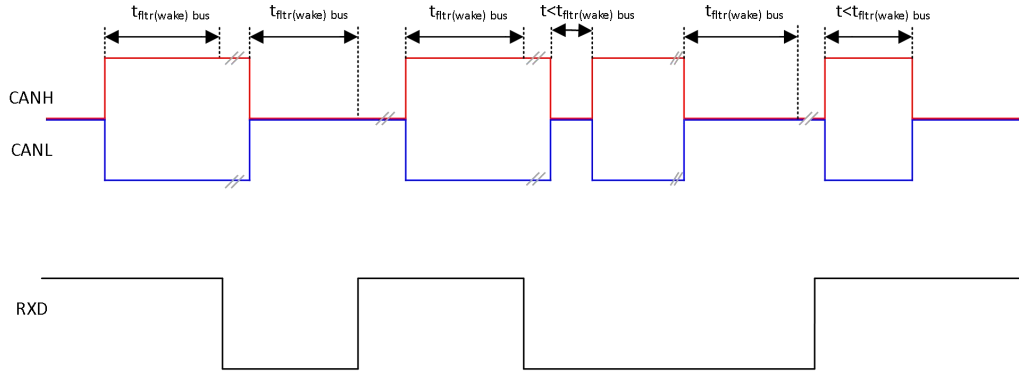


Figure 7-4. Wake Up Pattern (WUP)

7.4.4 Driver and Receiver Function Tables

Table 7-4. Driver Function Table

| Device | Inputs | | Outputs | | Driven Bus State |
|-------------|--------------------|------------------------|---------------------|---------------------|------------------|
| | STB ⁽¹⁾ | TXD ^{(1) (2)} | CANH ⁽¹⁾ | CANL ⁽¹⁾ | |
| All Devices | L | L | H | L | Dominant |
| | | H or Open | Z | Z | Recessive |
| | H or Open | X | Z | Z | Recessive |

(1) H = high level, L = low level, X = irrelevant, Z = common mode (recessive) bias to $V_{CC}/2$. See CAN Bus States for bus state and common mode bias information.

(2) Devices have an internal pull up to V_{CC} or V_{IO} on TXD terminal. If the TXD terminal is open, the terminal is pulled high and the transmitter remain in recessive (non-driven) state.

Table 7-5. Receiver Function Table

| Device mode | CAN Differential Inputs $V_{ID}=V_{CANH} - V_{CANL}$ | Bus State | RXD Terminal ⁽¹⁾ |
|-------------|--|-----------|-----------------------------|
| Normal | $V_{ID} \geq V_{IT+(MAX)}$ | Dominant | L ⁽²⁾ |
| | $V_{IT-(MIN)} < V_{ID} < V_{IT+(MAX)}$ | ? | ? ⁽²⁾ |
| | $V_{ID} \leq V_{IT-(MIN)}$ | Recessive | H ⁽²⁾ |
| | Open ($V_{ID} \approx 0V$) | Open | H |

(1) H = high level, L = low level, ? = indeterminate.

(2) See Receiver Electrical Characteristics section for input thresholds.

8 Application and Implementation

8.1 Application Information

These CAN transceivers are typically used in applications with a host microprocessor or FPGA that includes the data link layer portion of the CAN protocol. Below are typical application configurations for both 5V and 3.3V microprocessor applications. The bus termination is shown for illustrative purposes.

8.2 Typical Applications

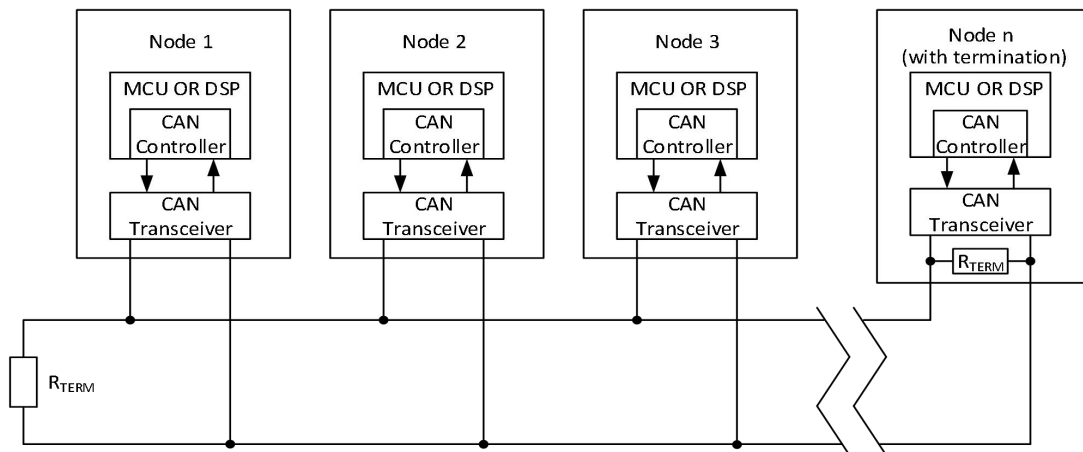


Figure 8-1. Typical CAN Bus Application

8.2.1 Design Requirements

8.2.1.1 Bus Loading, Length and Number of Nodes

The ISO 11898-2 Standard specifies a maximum bus length of 40 m and maximum stub length of 0.3 m. However, with careful design, users can have longer cables, longer stub lengths, and many more nodes to a bus. A large number of nodes requires transceivers with high input impedance such as the HMT1042 family of transceivers.

Many CAN organizations and standards have scaled the use of CAN for applications outside the original ISO 11898-2. They have made system-level trade-offs for data rate, cable length, and parasitic loading of the bus. Examples of some of these specifications are ARINC825, CANopen, DeviceNet and NMEA2000.

The HMT1042 family is specified to meet the 1.5V requirement with a 50Ω load, incorporating the worst case including parallel transceivers. The differential input resistance of the HMT1042 family is a minimum of 30kΩ. If 100 HMT1042 family transceivers are in parallel on a bus, this is equivalent to a 300Ω differential load worst case. That transceiver load of 300Ω in parallel with the 60Ω gives an equivalent loading of 50Ω. Therefore, the HMT1042 family theoretically supports up to 100 transceivers on a single bus segment. However, for CAN network design margin must be given for signal loss across the system and cabling, parasitic loadings, network imbalances, ground offsets and signal integrity thus a practical maximum number of nodes is typically much lower. Bus length may also be extended beyond the original ISO 11898 standard of 40 m by careful system design and data rate tradeoffs. For example, CANopen network design guidelines allow the network to be up to 1 km with changes in the termination resistance, cabling, less than 64 nodes and significantly lowered data rate.

This flexibility in CAN network design is one of the key strengths of the various extensions and additional standards that have been built on the original ISO 11898-2 CAN standard. In using this flexibility comes the responsibility of good network design and balancing these tradeoffs.

8.2.2 Detailed Design Procedures

8.2.2.1 CAN Termination

The ISO 11898 standard specifies the interconnect to be a twisted pair cable (shielded or unshielded) with 120Ω characteristic impedance (Z_0). Resistors equal to the characteristic impedance of the line should be used to terminate both ends of the cable to prevent signal reflections. Unterminated drop lines (stubs) connecting nodes to the bus should be kept as short as possible to minimize signal reflections. The termination may be on the cable or in a node, but if nodes may be removed from the bus, the termination must be carefully placed so that two terminations always exist on the network.

Termination may be a single 120Ω resistor at the end of the bus, either on the cable or in a terminating node. If filtering and stabilization of the common mode voltage of the bus is desired, then split termination may be used. (See [Figure 8-2](#)). Split termination improves the electromagnetic emissions behavior of the network by eliminating fluctuations in the bus common-mode voltages at the start and end of message transmissions.

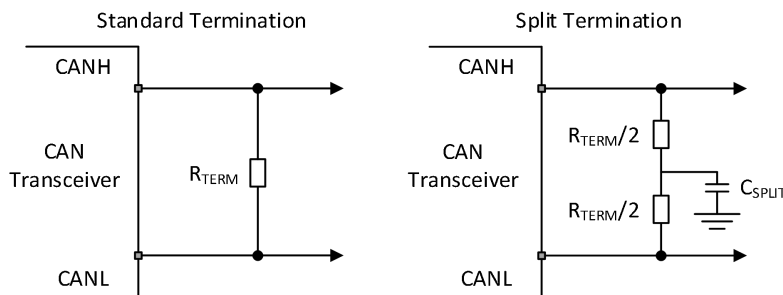


Figure 8-2. CAN Bus Termination Concepts

The family of transceivers have variants for both 5V only applications and applications where level shifting is needed for a 3.3V microcontroller.

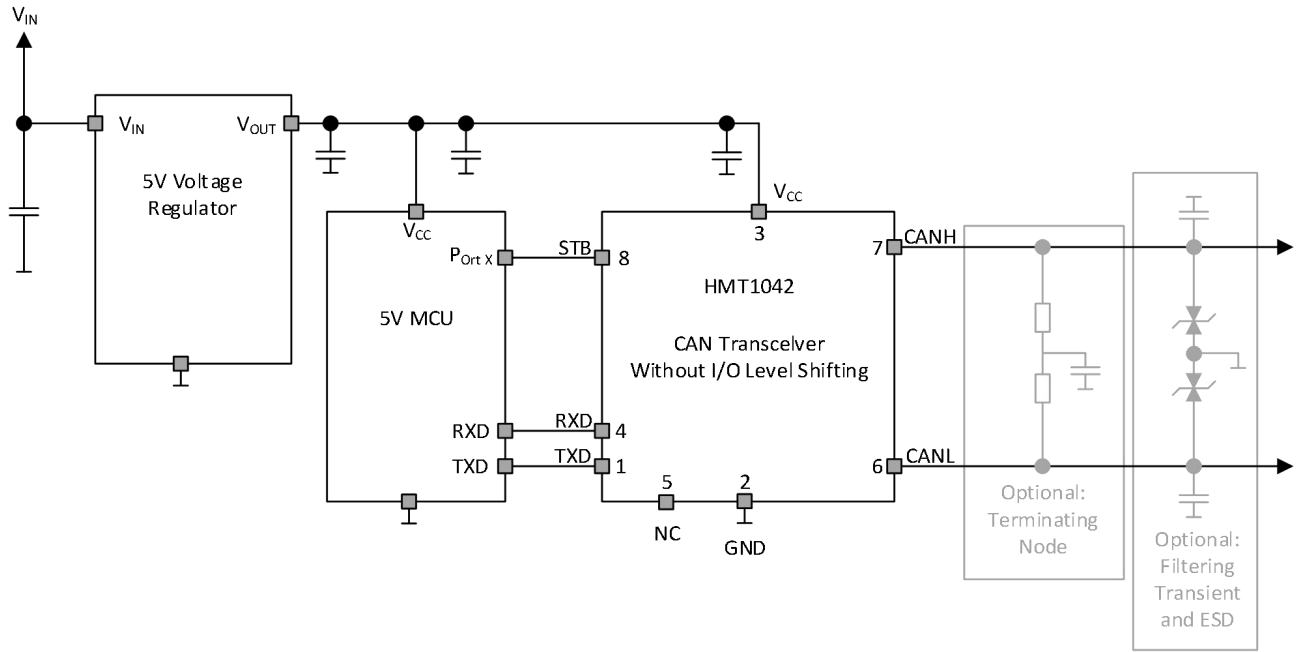


Figure 8-3. Typical CAN Bus Application Using 5V CAN Controller

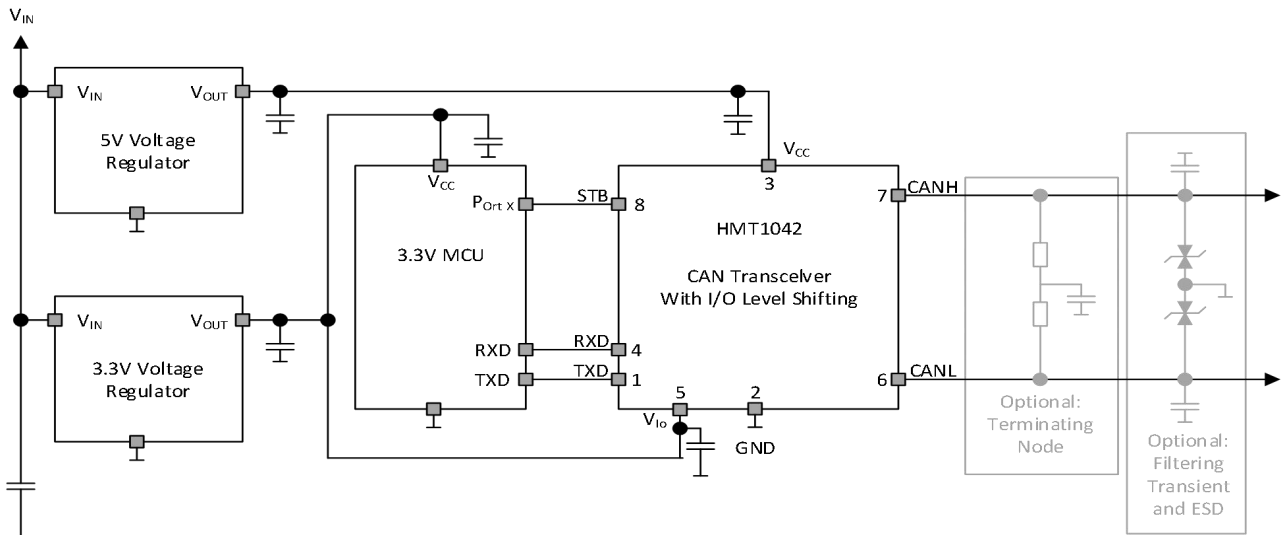


Figure 8-4. Typical CAN Bus Application Using 3.3V CAN Controller

9 Power Supply Recommendations

These devices are designed to operate from a V_{CC} input supply voltage range between 4.5V and 5.5V. Some devices have an output level shifting supply input, V_{IO} , designed for a range between 3V and 5.5V. Both supply inputs must be well regulated. A bulk capacitance, typically 4.7 μ F, should be placed near the CAN transceiver's main V_{CC} supply output, and in addition a bypass capacitor, typically 0.1 μ F, should be placed as close to the device V_{CC} and V_{IO} supply terminals. This helps to reduce supply voltage ripple present on the outputs of the switched-mode power supplies and also helps to compensate for the resistance and inductance of the PCB power planes and traces.

10 Layout

Robust and reliable bus node design often requires the use of external transient protection device in order to protect against EFT and surge transients that may occur in industrial environments. Because ESD and transients have a wide frequency bandwidth from approximately 3 MHz to 3 GHz, high-frequency layout techniques must be applied during PCB design. The family comes with high on-chip IEC ESD protection, but if higher levels of system level immunity are desired external TVS diodes can be used. TVS diodes and bus filtering capacitors should be placed as close to the on-board connectors as possible to prevent noisy transient events from propagating further into the PCB and system.

10.1 Layout Guidelines

- Place the protection and filtering circuitry as close to the bus connector, J1, to prevent transients, ESD and noise from propagating onto the board. In this layout example a transient voltage suppression (TVS) device, D1, has been used for added protection. The production solution can be either bi-directional TVS diode or varistor with ratings matching the application requirements. This example also shows optional bus filter capacitors C4 and C5. Additionally (not shown) a series common mode choke (CMC) can be placed on the CANH and CANL lines between the transceiver U1 and connector J1.
- Design the bus protection components in the direction of the signal path. Do not force the transient current to divert from the signal path to reach the protection device.
- Use supply (V_{CC}) and ground planes to provide low inductance.
- Use at least two vias for supply (V_{CC}) and ground connections of bypass capacitors and protection devices to minimize trace and via inductance.
- Bypass and bulk capacitors should be placed as close as possible to the supply terminals of transceiver, examples are C1, C2 on the V_{CC} supply and C6 and C7 on the V_{IO} supply.
- Bus termination: this layout example shows split termination. This is where the termination is split into two resistors, R6 and R7, with the center or split tap of the termination connected to ground via capacitor C3. Split termination provides common mode filtering for the bus. When bus termination is placed on the board instead of directly on the bus, additional care must be taken to ensure the terminating node is not removed from the bus thus also removing the termination. See the application section for information on power ratings needed for the termination resistor(s).
- To limit current of digital lines, serial resistors may be used. Examples are R2, R3, and R4. These are not required.
- Terminal 1: R1 is shown optionally for the TXD input of the device. If an open drain host processor is used, this is mandatory to ensure the bit timing into the device is met.
- Terminal 5: For devices in this series with V_{IO} ports, bypass capacitors should be placed as close to the pin as possible (example C6 and C7). For device options without V_{IO} I/O level shifting, this pin is not internally connected and can be left floating or tied to any existing net, for example a split pin connection.
- Terminal 8: is shown assuming the mode terminal, STB, will be used. If the device will only be used in normal mode, R4 is not needed and R5 could be used for the pull down resistor to GND.

10.2 Layout Example

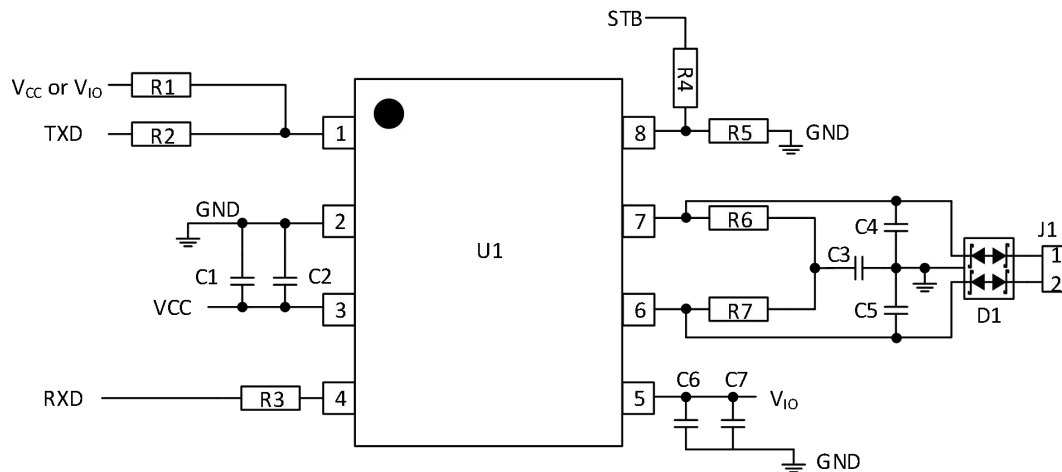
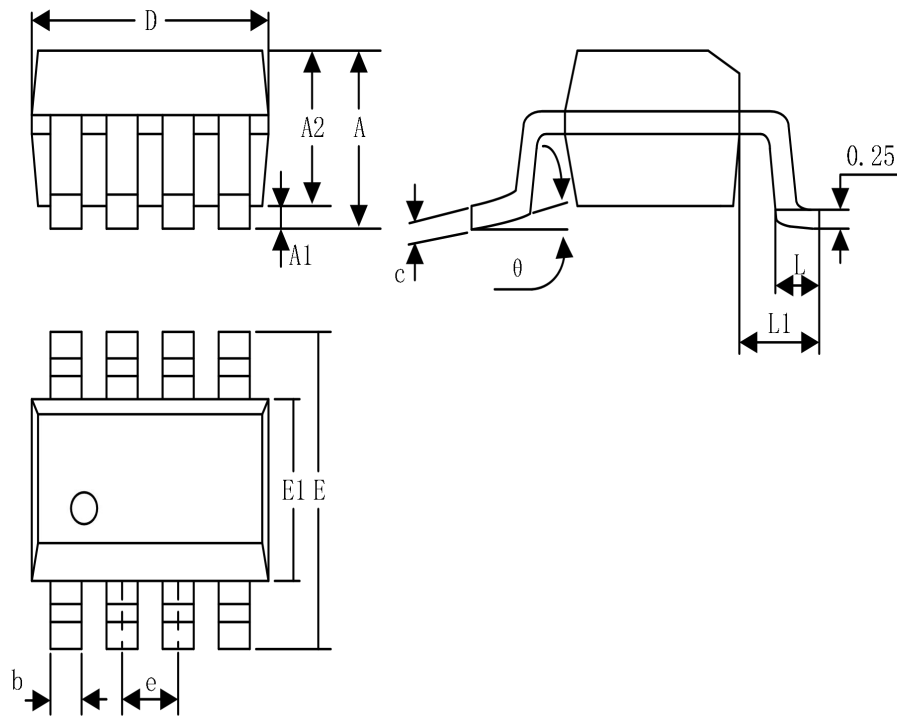


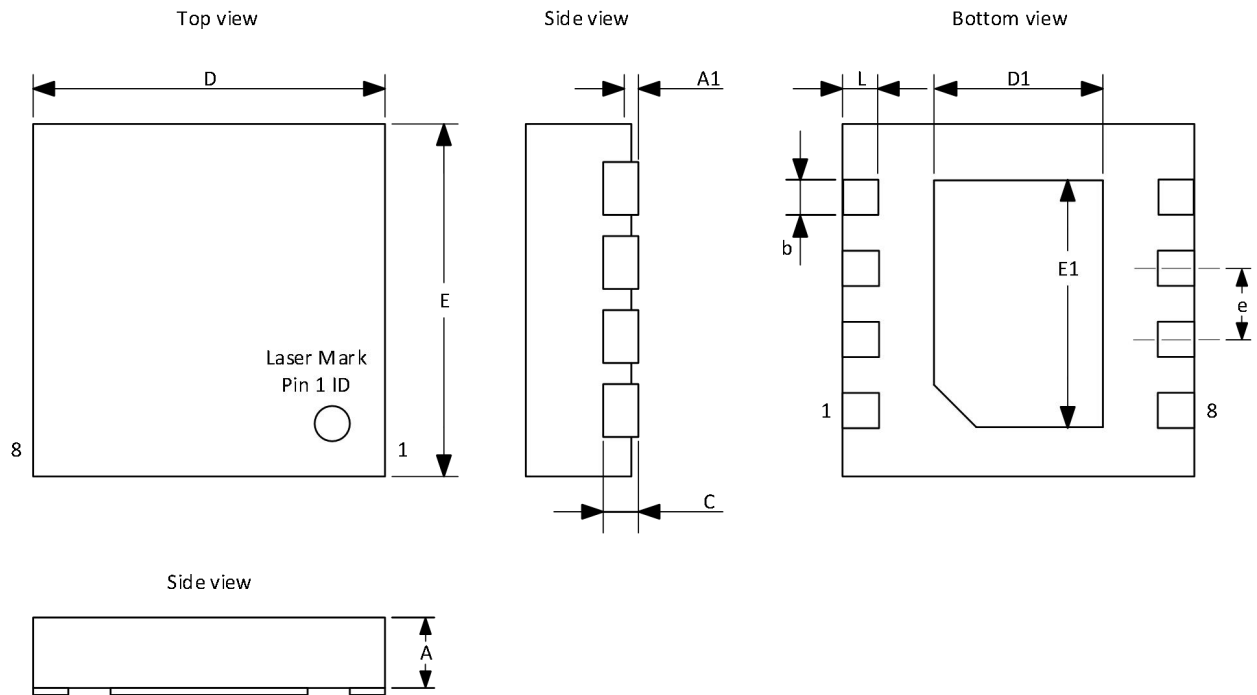
Figure 10-1. Layout Example

PACKAGE DIMENSION
SOP8



| SYMBOLS | MILLIMETER | | |
|---------|------------|-----|------|
| | MIN | NOM | MAX |
| A | 1.5 | - | 1.7 |
| A1 | 0.1 | - | 0.25 |
| A2 | 1.3 | 1.4 | 1.5 |
| b | 0.33 | 0.4 | 0.47 |
| C | 0.2 | - | 0.25 |
| D | 4.7 | 4.9 | 5.1 |
| E | 5.9 | 6 | 6.1 |
| E1 | 3.8 | 3.9 | 4 |
| e | 1.27(BSC) | | |
| L | 0.55 | 0.6 | 0.75 |
| L1 | 1.05(BSC) | | |
| θ | 0° | 4° | 8° |

DFN8-EP(3x3)



**COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)**

| SYMBOL | MIN | NOM | MAX |
|--------|----------|------|-------|
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0.00 | - | 0.05 |
| b | 0.23 | 0.28 | 0.33 |
| c | 0.203REF | | |
| D | 2.925 | 3.00 | 3.075 |
| D1 | 1.40 | 1.50 | 1.60 |
| E | 2.925 | 3.00 | 3.075 |
| E1 | 2.20 | 2.30 | 2.40 |
| e | 0.650BSC | | |
| L | 0.25 | 0.30 | 0.35 |

Order Information

| Order number | Package | Marking information | Operation Temperature Range | MSL Grade | Ship, Quantity | Green |
|--------------|--------------|---------------------|-----------------------------|-----------|----------------|-------|
| HMT1042T | SOP8 | HMT1042T | -40 to 125°C | 3 | T&R, 2500 | RoHS |
| HMT1042T/3 | SOP8 | HMT1042T/3 | -40 to 125°C | 3 | T&R, 2500 | RoHS |
| HMT1042TK | DFN8-EP(3x3) | HMT1042TK | -40 to 125°C | 3 | T&R, 3000 | RoHS |
| HMT1042TK/3 | DFN8-EP(3x3) | HMT1042TK/3 | -40 to 125°C | 3 | T&R, 3000 | RoHS |