

## Application Brief

# Meeting the Timing Requirements of CAN FD in Isolated CAN Systems for HEV/EVs



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For automotive applications, Controller Area Network Flexible Data Rate (CAN FD) has become the de facto standard for most automakers. Unquestionably, the higher speed of CAN FD over Classical CAN enables faster communication of data allowing for more bandwidth, lower latency for the messages, or increased nodes on the CAN bus. Additionally, if the CAN communication is used between different voltage domains as in hybrid electric vehicles (HEVs) and electric vehicles (EVs), digital isolators are often used to help with protection of the low-voltage side from high-voltage side and improve noise immunity.

The CAN protocol is preferred in automotive applications due to its prioritization and arbitration features, making it popular in time-critical applications, such as belt starter generators, traction inverters, battery management systems. Hence the timing specifications of the CAN device become critical when selecting the right device for your system. [Table 1](#) shows the main specifications to consider when designing a system that meets the physical layer requirements of the ISO 11898-2:2016 high-speed CAN specification.

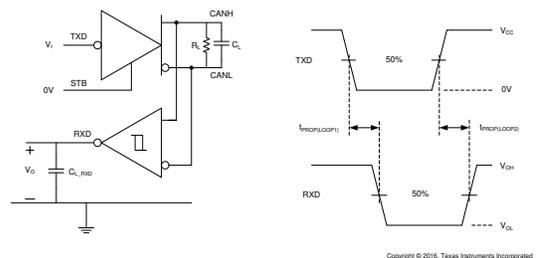
**Table 1. ISO 11898-2:2016 high-speed CAN timing specifications**

Parameter	MIN	MAX
$t_{PROP(LOOP1)}$		255 ns
$t_{PROP(LOOP2)}$		255 ns
$t_{BIT(BUS)}$	Bit time on CAN bus output pins with $t_{BIT(TXD)} = 500$ ns (for 2 Mbps CAN FD)	435 ns
	Bit time on CAN bus output pins with $t_{BIT(TXD)} = 200$ ns (for 5 Mbps CAN FD)	155 ns
$t_{BIT(RXD)}$	Bit time on RXD output pins with $t_{BIT(TXD)} = 500$ ns (for 2 Mbps CAN FD)	550 ns

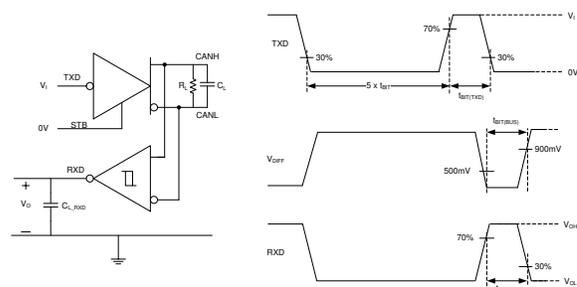
**Table 1. ISO 11898-2:2016 high-speed CAN timing specifications (continued)**

Parameter	MIN	MAX
Bit time on RXD output pins with $t_{BIT(TXD)} = 200$ ns (for 5 Mbps CAN FD)	120 ns	220 ns

[Figure 1](#) and [Figure 2](#) show the test setup for the measurement of these parameters for the CAN transceiver by itself. [Figure 1](#) shows the measurement of the total loop delay from the driver input (TXD) to receiver output (RXD). This measurement is done in the recessive to dominant state as shown by  $t_{PROP(LOOP1)}$  and the dominant to recessive state as shown by  $t_{PROP(LOOP2)}$ . [Figure 2](#) measures the variation in the bit width as it propagates through the transmitter to the output and back through the receiver to the receiver output.



**Figure 1.  $t_{PROP(LOOP)}$  Test Circuit and Measurement**



**Figure 2. CAN FD Bit Timing Parameter Measurement**

CAN devices such as the Grade 0 CAN FD transceiver [TCAN1044EV-Q1](#) can meet the

requirements over the temperature range of -40 °C to 150 °C as shows in [Table 2](#) .

**Table 2. CAN transceiver timing specifications**

Parameter	ISO 11898-2:2016		TCAN1044EV-Q1	
	MIN	MAX	MIN	MAX
$t_{PROP}(LOOP1)$		255 ns		210 ns
$t_{PROP}(LOOP2)$		255 ns		210 ns
$t_{BIT}(BUS)$ 2 Mbps CAN FD	435 ns	530 ns	460 ns	510 ns
$t_{BIT}(BUS)$ 5 Mbps CAN FD	155 ns	210 ns	160 ns	210 ns
$t_{BIT}(RXD)$ 2 Mbps CAN FD	400 ns	550 ns	445 ns	515 ns
$t_{BIT}(RXD)$ 5 Mbps CAN FD	120 ns	220 ns	145 ns	215 ns

For applications that require isolation between the CAN transceiver and the microcontroller, simply looking at the CAN transceiver timing performance is not enough. It is important to add the timing performance of the digital isolator that is in series with the CAN transceiver to ensure the two-chip solution still meets the timing specification. Isolator datasheets provide the propagation delay and pulse width distortion specifications.

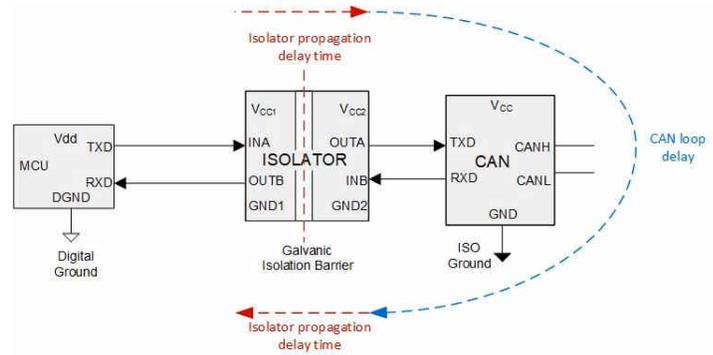
For example, these timing specifications for the Grade 0 [ISO7741E-Q1](#) are shown in [Table 3](#):

**Table 3. Digital isolator timing specifications**

ISO7741E-Q1 (-40 °C to +150 °C)			
Parameter		MIN	MAX
$t_{PLH}, t_{PHL}$	Propagation delay time	6 ns	16.5 ns
PWD	Pulse width distortion $ t_{PHL} - t_{PLH} $		4.9 ns

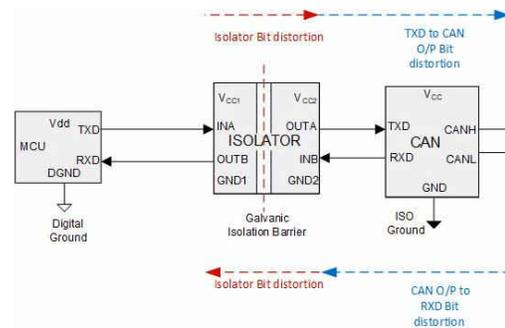
Based on the individual timing specifications for the digital isolator and the CAN transceiver, the combined data can be calculated as follows (as shown in [Figure 3](#) and [Figure 4](#)):

Total loop delay from the driver input to the receiver output: CAN loop delay + 2 x Isolator propagation delay time



**Figure 3. Total loop delay for isolated CAN system**

Minimum bit time on the bus output pins = Minimum CAN  $t_{BIT}(BUS)$  time - Maximum Isolator pulse width distortion. Maximum bit time on the bus output pins = Maximum CAN  $t_{BIT}(BUS)$  time + Maximum Isolator pulse width distortion. Minimum bit time on the receiver output pins = Minimum CAN  $t_{BIT}(RXD)$  time - 2 x Maximum Isolator pulse width distortion. Maximum bit time on the receiver output pins = Maximum CAN  $t_{BIT}(RXD)$  time + 2 x Maximum Isolator pulse width distortion.



**Figure 4. Total bit time for isolated CAN**

Based on the formulae discussed above, the combined timing specifications of the two-chip isolated CAN solution is shown in [Table 4](#).

**Table 4. Discrete isolated CAN timing specifications**

Parameter	ISO 11898-2:2016		ISO7741E-Q1 + TCAN1044EV-Q1 (-40 °C to +150 °C)	
	MIN	MAX	MIN	MAX
$t_{PROP}(LOOP1)$		255 ns		243 ns
$t_{PROP}(LOOP2)$		255 ns		243 ns
$t_{BIT}(BUS)$ 2 Mbps CAN FD	435 ns	530 ns	455.1 ns	514.9 ns
$t_{BIT}(BUS)$ 5 Mbps CAN FD	155 ns	210 ns	155.1 ns	214.9 ns
$t_{BIT}(RXD)$ 2 Mbps CAN FD	400 ns	550 ns	435.2 ns	524.8 ns

**Table 4. Discrete isolated CAN timing specifications (continued)**

Parameter	ISO 11898-2:2016		ISO7741E-Q1 + TCAN1044EV-Q1 (-40 °C to +150 °C)	
	MIN	MAX	MIN	MAX
t <sub>BIT(RXD)</sub> 5 Mbps CAN FD	120 ns	220 ns	135.2 ns	224.8 ns

From the table it is clear that the Grade 0 isolator [ISO7741E-Q1](#) when used along with the Grade 0 CAN FD transceiver TCAN1044EV-Q1, can meet the ISO 11898-2:2016 specifications up to CAN FD speed for 2 Mbps.

This article discussed the key timing specs and calculation examples to determine if the chosen discrete isolator and CAN transceiver can meet the CAN standards. Selecting the right components upfront will ensure the proper CAN system operation and speed up release to production.

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