Galvanic-isolated CAN FD transceivers

Analog Devices and Texas Instruments offer galvanic-isolated transceivers for CAN FD networks. These components comply with ISO 11898-2:2016.

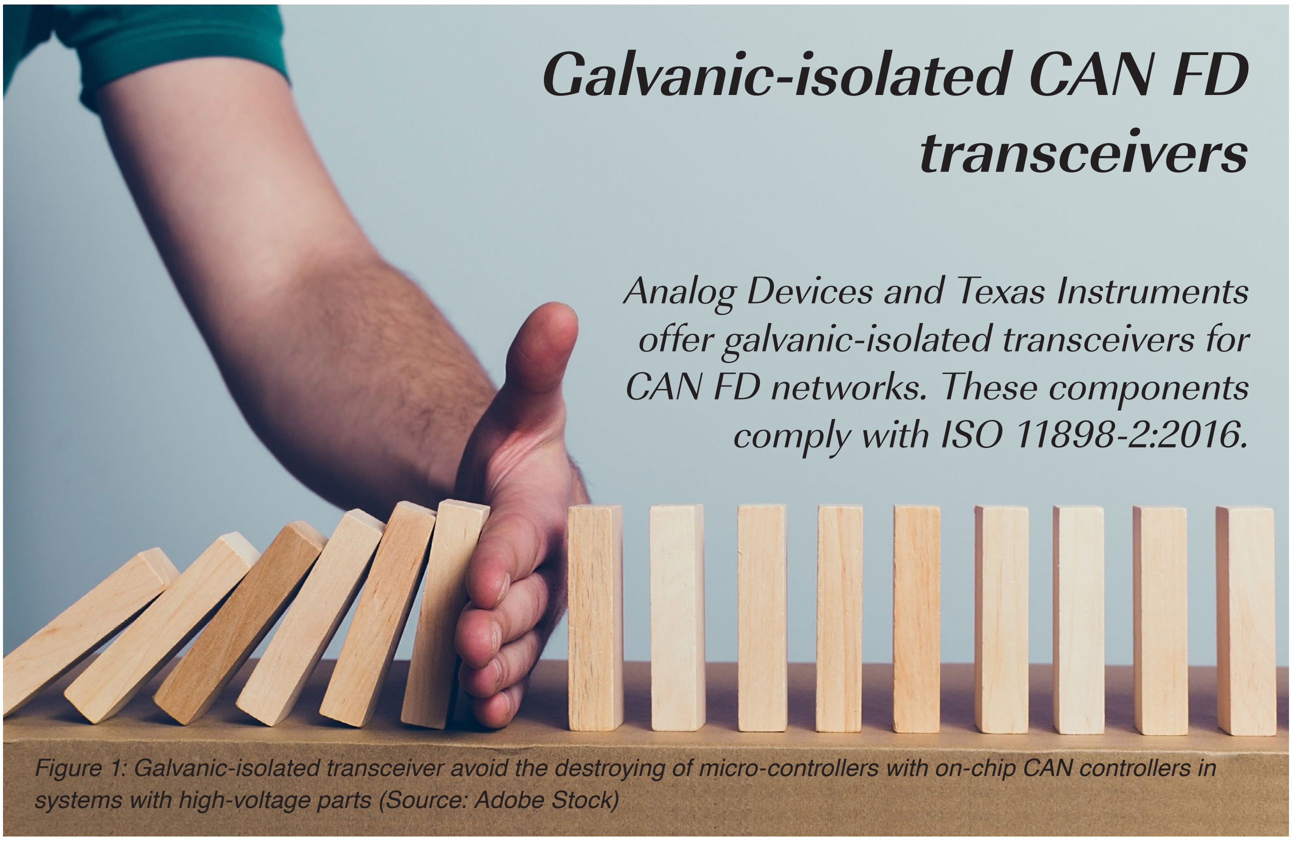

Figure 1: Galvanic-isolated transceiver avoid the destroying of micro-controllers with on-chip CAN controllers in systems with high-voltage parts (Source: Adobe Stock)

In many non-automotive applications with long networks galvanic-isolated transceivers are required. In such long networks, connected devices can have differences in local earth potential. Additionally, different supplies may power the devices. But also in electrical-powered vehicles there is an increasing demand on isolating high-energy components from the low-power ECU (electronic control unit) circuitry. Therefore, in some Classical CAN as well as CAN FD networks bus-signals as well as power-lines needs to be isolated. This can be achieved by different methods. External optocouplers or transformers are widely in use. In order to reduce the number of physical interface components, semiconductor manufacturers have launched since some years CAN transceivers with on-chip isolation circuitry.

Recently, Analog Devices and Texas Instruments have improved their galvanic-isolated CAN transceivers to meet the requirements of ISO 11898-2:2016 regarding the new symmetry parameters. The ISO standard specifies two sets of symmetry parameters. Depending on the network design, you can achieve data-phase bit-rates of 2 Mbit/s respectively 5 Mbit/s or more. If your requirement regarding the temperature range is not challenging, you can run your CAN FD network at bit-rates up to 12 Mbit/s. But temperatures below 0 °C limit the transmission speed in the data-phase dramatically.

Besides the network topology, the cable selection is critical depending on the impedance over the specified temperature range. CiA has released the CiA 601-6 CAN FD cable recommendation. The most suitable topology is a bus-line with very short stubs. The sample-point setting in the data-phase is an important issue to achieve a high bit-rate in the data-phase. The CiA 601-3 recommendations give some guidelines for an optimized sample-point setting including the secondary sample-point.

The offered galvanic-isolated CAN transceivers conform to the improved set of symmetry parameter set. The products by Analog Devices specify a minimum of 50 ns and maximum of 91,6 ns for the loop-delay symmetry. This is better than what ISO 11898-2:2016 requires (120 ns minimum and 220 ns maximum). The loop-delay symmetry of the Texas Instruments product is typically 150 ns.

Products by Analog Devices

The galvanic-isolated transceiver by Analog Devices employs the iCoupler technology to combine a 2-channel isolator and a transceiver into a single small outline integrated circuit (SOIC) surface-mount package. This technology is based on on-chip dc/dc converters. The launched transceivers (ADM3050E, ADM3055E/57E, and ADM3056E) feature a 5-kV respectively 5,7-kV RMS (root-means-spare) bus-signal isolation voltage. They provide the usual protection circuitry for ±40-V on the bus-lines as well as over-temperature and permanent dominant bus-states. The chips also provide an extended common-mode range of ±25 V.

The CAN FD connectable devices must add protection against harsh operating environments while also should be as small as possible. To reduce board space and the design effort needed to meet the system-level ESD standards. Therefore, the introduced transceivers provide protection circuitry on chip for the CAN_H and CAN_L pins.

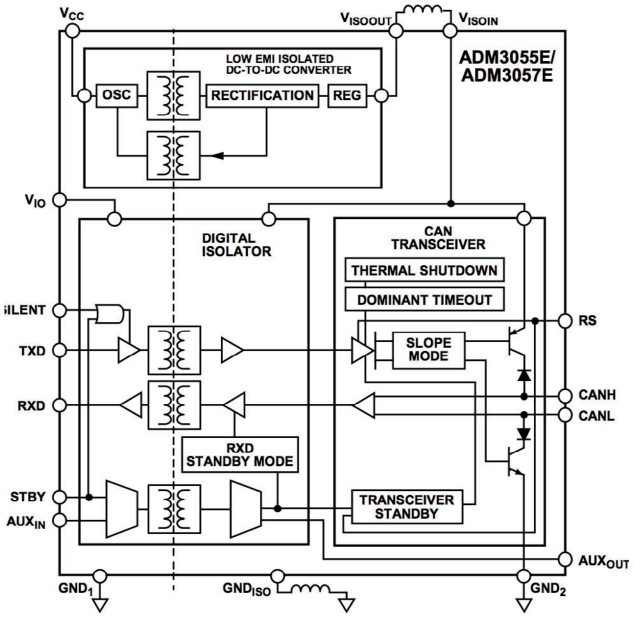

Figure 2: Block diagram of the ADM3055E/57E transceiver (Source: Texas Instruments)

Wiring accidently high-voltage to bus-lines is frequently made mistake in production lines. Supplies can also be short-circuited by accidental damage to the cables while the system is operating. Accounting for inductive kickback and switching effects, the bus lines are protected with up to nominal 24-V supplies. The signal lines can withstand a continuous supply short with respect to GND2 or between the bus lines without damage.

In cases, in which the TXD input pin is allowed to float – to prevent bus traffic interruption – the TXD input channel has an internal pull-up to the VDD1 pin. The pull-up holds the transceiver in the recessive state. The transceivers also feature a dominant timeout. A TXD line shorted to ground or malfunctioning CAN controller are examples of how a single-node can indefinitely prevent further bus traffic. The dominant timeout limits how long the transceiver can transmit in the dominant state. When the TXD pin is presented with a logical high, normal TXD functionality is restored.

The minimum transmit dominant-timeout also inherently determines a minimum bit rate. Under normal operation, the CAN protocol allows five consecutive bits of the same polarity before stuffing a bit of the opposite polarity into the transmitting bit sequence. When an error is detected, the CAN controller purposely violates the bit-stuffing rules by producing six consecutive dominant bits. At any given bit rate, the CAN controller must transmit as many as 11 consecutive dominant bits to effectively limit the transceivers minimum data rate to 9600 bit/s.

The transceivers comprise thermal shutdown circuitry that protects them from excessive power dissipation during fault conditions. Shorting the driver outputs to a low-impedance source can result in high driver currents. The thermal sensing circuitry detects the increase in die temperature under this condition and disables the driver outputs. The ▷

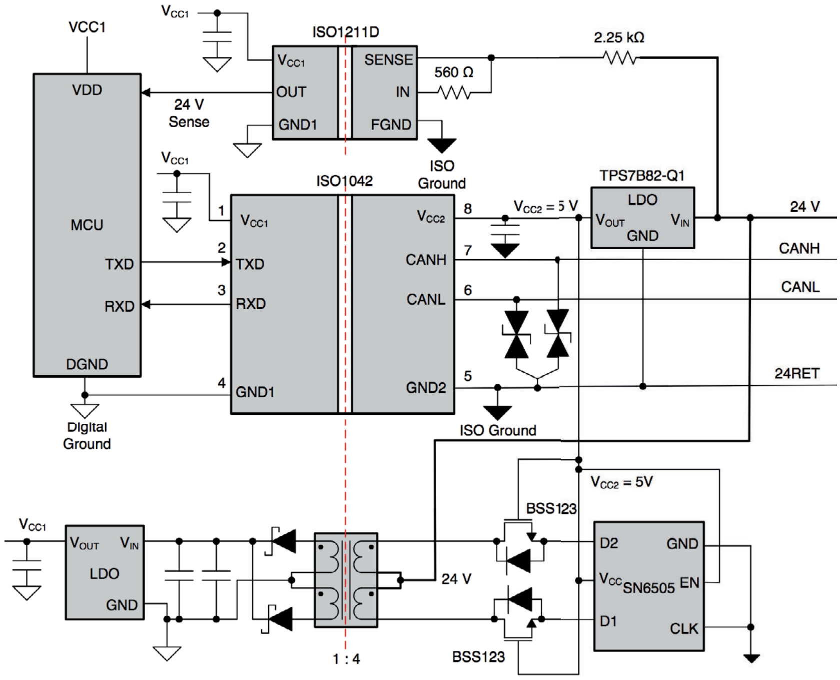

Figure 3: Typical interface for Devicenet nodes using the ISO1042 transceiver (Source: Texas Instruments)

circuitry disables the driver outputs when the die temperature reaches 175 °C. When the die has cooled, the drivers are enabled again.

The ADM3056E and the ADM3055E/57E transceivers support the optional low-power mode as specified in ISO 11898-2:2016. Formerly, there was a separate standard for this function, but now it has been included in the updated ISO standard. In the stand-by mode the TXD signal isolation channel is disabled. The transmitter output is set to a high-impedance state loosely biased to GND2. While in stand-by mode, the receiver filters bus data and responds only after the remote wake-up sequence is received. When entering or exiting stand-by mode, the TXD input must be kept high and the RXD output must be ignored. When the remote pattern as specified in the ISO standard are on the bus, the transceiver is still in low-power mode as long as the STBY pin is high.

The ADM3055E/57E transceivers feature a non-standardized silent mode. In this mode, the TXD digital isolation channel is disabled. Any inputs to the TXD pin are ignored, and the transceiver drives a recessive bus state. The operation of the RXD channel is unaffected. The RXD channel continues to output data received from the internal CAN transceiver monitoring the bus. This mode is useful when paired with a CAN controller using automatic bit rate detection. A CAN controller must be set to the same bit rate as all attached nodes. The CAN controller produces an error frame and ties up the bus with a dominant state when the received data rate is different from expected. Other CAN nodes then echo this error frame. While in silent mode, the error frames produced by the CAN controller are kept from interrupting bus traffic, and the controller can continue listening to bus traffic to tune.

Recently, Analog Devices acquired Linear Technology and inherited the LTM2889 galvanic-isolated transceiver. It is suitable for CAN FD applications and features symmetry parameters above the basic set and below the extended set as specified in ISO 11898-2:2016. According to the CiA 601-3 bit-timing recommendations it fits for 4-Mbit/s data-phase bit-rates using a bus-line topology with short stubs. The transceiver can be powered with 3,3 V or 5 V. It also provides a dominant time-out function (0,5 ms to 4 ms).

Products by Texas Instruments

Texas Instruments has developed the ISO1042 transceiver chips, which features a ±70-V protection. It also conforms to ISO 11898-2:2016 and provides the optional low-power capability. If sleeping, it can be woken up by bit-pattern as specified in ISO 11898-2:2016. The loop-delay is 152 ns. The common-mode voltage range has been extended to ±30 V. The transceiver suitable for a temperature range from -40 °C to +125 °C comes in an SOIC-16 or an SOIC-8 package.

The transceiver uses a silicon dioxide (SiO_2) insulation barrier with a withstand voltage of 5000 VRMS and a working voltage of 1060 VRMS. Electromagnetic compatibility has been enhanced to enable system-level ESD, EFT, surge, and emissions compliance. Used in conjunction with isolated power supplies, the chip protects against high voltage, and prevents noise currents from the bus from entering the local ground.

The TXD DTO (dominant time-out) circuit prevents the transceiver from blocking network communication in the event of a hardware or software failure, which helds the TXD pin dominant longer than the timeout period (1,2 ms to 2,8 ms). The DTO circuit timer starts on a falling edge on the TXD pin. The DTO circuit disables the CAN transmitter, if no rising edge occurs before the timeout period expires, which frees the bus for communication between other nodes on the network. The CAN driver circuitry is activated again when a recessive signal occurs on the TXD pin, clearing the TXD DTO condition. The receiver and RXD pin still reflect activity on the CAN bus-lines, and the bus terminals are biased to the recessive level during a TXD dominant timeout.

Of course, the transceiver is protected against over-temperatures (170 °C). If the junction temperature of the component exceeds the thermal shutdown threshold, it turns off the CAN driver circuitry, blocking the TXD-to-bus transmission path. The CAN 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 (5 °C) below the thermal shutdown temperature.

Unlike an optocoupler-based solution, which requires several external components to improve performance, provide bias, or limit current, the ISO1042 only needs an external bypass capacitors to operate. The transceiver is available in an industrial version and in a Q1-qualified version for automotive applications. The non-automotive CAN-based system approaches (e.g. Arinc850, CANopen, Devicenet, and NMEA 2000) add system-design aspects. They lead to system-level tradeoffs for bit rate, cable length, and parasitic loading of the bus-lines.

The ISO1042 components are specified to meet the 1,5-V requirement with a 50-Ω load, incorporating the worst-case including parallel transceivers. The differential input resistance of the transceiver is in minimum 30 kΩ. If 100 of such transceivers are in parallel on a network segment, this requirement is equivalent to a 300-Ω differential load in worst-case. That transceiver load of 300 Ω in parallel with the 60 Ω gives an equivalent loading of 50 Ω. Therefore, the transceiver 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: Therefore a practical maximum number of nodes is typically much lower. Bus length may also be extended beyond 40 m by careful system design and bit-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 a bit-rate of 50 kbit/s.

System design optimization

This flexibility in network system-design is one of the key strengths of the CAN technology. Optimizing the CAN network system to different criteria requires a deep knowledge in electronics, in order to balance the mentioned tradeoffs. Standardized solutions unburden the individual system designers from this.

The launched transceivers with galvanic-isolation capability, simplifies the CAN interface design on the device-level. But mixing of such transceivers from different vendors in the same network needs additional investigation to meet the system-design requirements. ◀

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based on information of Analog Devices and Texas Instruments