

CAN FD circuit board reference design

Analog Devices (AD) provides printed circuit boards (PCB) and components for development of CAN FD based applications. This article shows details and evaluation of a CAN FD circuit board.

CN-0401 circuit evaluation board (EVAL-ADM3055E-ARDZ) is an Arduino Uno compatible isolated CAN FD communications port. It offers a possibility to add CAN FD communication to new and existing designs. The described evaluation procedure of the CN-0401 is performed using the Arduino-based development board (EVAL-ADICUP3029).

Circuit function

The circuit (Figure 1) shows the CN-0401 Arduino Uno form-factor platform connected via an existing serial peripheral interface (SPI) to the standalone MCP2518FD controller from Microchip and the ADM3055E CAN FD transceiver from Analog Devices. According to the manufacturers, this circuit enables CAN FD bit-rates of up to 8 Mbit/s. The CAN FD controller can operate in the Classical CAN or CAN FD mode. It is tolerant to CAN FD frames when operating in the Classical CAN mode.

The transceiver provides integrated signal and power reinforced isolation. The integrated DC-to-DC converter draws power from the logic side to power the CAN channels and the transceiver. Thus, no external power on the CAN lines is required. The EMC-robust (electromagnetic compatibility) transceiver has a common-mode range of $\pm 25 V_{DC}$, which exceeds the corresponding requirement given in ISO 11898-2:2016. It also offers a high tolerance to localized ground potential differences when receiving

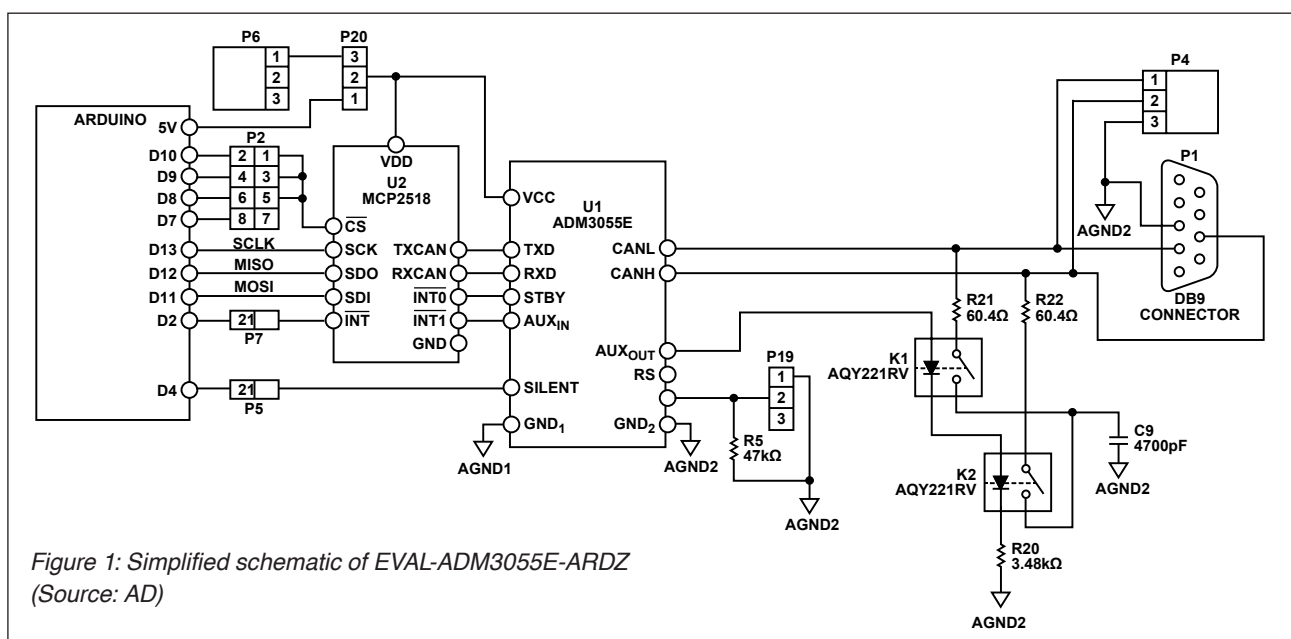
CAN frames. Integrated ESD (electrostatic discharge) protection on CAN-High and CAN-Low pins complies with IEC 61000-4-2. Providing a $\pm 40-V_{DC}$ fault protection, the pins can withstand erroneous wiring and short circuits to $24-V_{DC}$ systems.

Depending on application requirements, CAN connections may be made with different cable types e.g. unshielded twisted-pair or shielded cables. An ideal CAN network daisy chains one node to the next and has terminations at both ends. The CiA 303-1 document gives recommendations for CAN(open) cabling and connector pin assignment e.g. for the 9-pin D-Sub connector, as used in the shown circuit.

The switchable termination circuitry connects a 120-Ohm split-termination with a common-mode filtering capacitor between the CAN lines. Switchable termination allows to configure (via software) the termination location when the conditions on the CAN network have changed. Additionally, the circuit can be configured at the runtime to enter a reduced power stand-by mode. In this state, the transceiver responds only on a defined wake-up sequence from a remote node according to ISO 11898-2:2016.

Circuit description

Fast loop delay and bit-rate: During the arbitration phase of a CAN FD frame, the maximum bit-rate is limited by the



longest total signal propagation time between two furthest nodes on the network. As illustrated in Figure 2, the signal path starts when the Node A CAN controller begins with the transmission. This signal first passes through the Node A transmitter, then propagates over the cables, then through the receiver of the furthest node B, and finally reaches the furthest CAN controller. As the receiving node B may also transmit during the same bit, the signal propagation delay from Node B to Node A has to be considered as well. The highest propagation delay determines the possible maximum bit-rate of the arbitration phase.

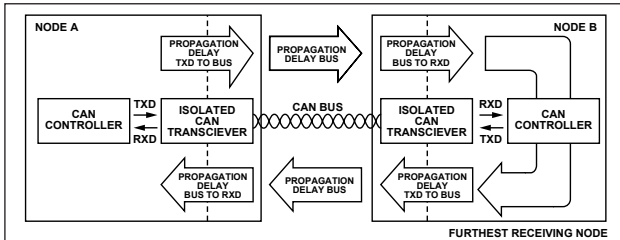


Figure 2: Total signal propagation delay (Source: AD)

Propagation delay along the bus lines increases with the cable length and enlarged construction. Cable lengths are typically determined by the nodes' mounting locations. Therefore, this portion of signal propagation delay becomes basically fixed. The propagation delay through the transceiver's receive and transmit circuitry is called loop delay. The ADM3055E transceiver has a maximum loop delay of 150 ns, which is an industry-leading small value, claims AD. This allows the network designer to dedicate less of the bit time to the transceiver. These time savings can contribute to higher arbitration bit-rates, longer bus cables, or longer bus signal settling time for added communication robustness at any arbitration bit-rate.

The maximum bit-rate in the data phase of a CAN FD frame, by contrast, is not determined by the propagation delay, but rather by the network signal quality. Reflections, due to impedance mismatches and cable stubs, are among the factors limiting the data-phase bit-rate in multiple-node networks. Data-phase bit-rates of 2 Mbit/s are a popular conservative choice for multiple-node CAN FD networks. The ADM3055E transceiver can operate at up to 12 Mbit/s in the data phase. This enables fast data transfers for point-to-point connections, and is suited for future bit-rate requirements.

Standby mode and remote wake-up: The CAN FD controller and the CAN FD transceiver can be set to the standby mode with commands issued by the development platform over the SPI bus. On receipt of the standby command, CAN FD controller sets itself and the transceiver to the standby mode. Here, the transmit functionality of the transceiver is disabled and its output is set to a high-impedance state.

The transceiver can only be taken out of the standby mode by the local CAN FD controller. However, the transceiver responds to the remote wake-up calls made by other nodes. The remote wake-up pattern is defined in ISO11898-2:2016. It can be sent in the arbitration field or in the data field of a CAN FD frame and has to meet the timing requirements of the transceiver. When the remote wake-up pattern is received, the RxD pin of the transceiver toggles in response to the data on the CAN FD bus.

CiA e-learning



CiA seminars online

	Date	Language
CAN	2021-09-14	English
CANopen	2021-09-15	English
CAN	2021-11-03	English
CANopen	2021-11-04	English

CiA seminars

Having the Covid-19 pandemic in mind, we are looking forward to welcome you to our on-site seminars at CiA office.

	Date	Language
CAN for newcomers	2021-10-05	German
CANopen for newcomers	2021-10-06	German

CiA in-house seminars online

CiA engineers discuss your urgent CAN-related issues that are currently of high interest with regard to your projects.

For more details please contact
CiA office: events@can-cia.org

www.can-cia.org

The state changes on the RxD pin are used to trigger an interrupt to the CAN FD controller. When the transceiver receives the remote wake-up pattern, it does not exit the standby mode. While development it can be determined whether to respond, or to toggle the standby pin of the transceiver to discontinue reception of the low-speed data and to return to the standby mode until the remote wake-up pattern is received again. In the standby mode, the isolated auxiliary channel of the transceiver latches in the last state. Transceiver's integrated DC-to-DC converter continues to operate providing power to the bus side circuitry.

Isolation: Harsh environments, lengthy physical separation, and different power supply sources between nodes can (and often do) have different local ground potentials. The different potentials cause currents flowing through the ground wire causing common-mode offsets and noises. Isolation of the physical bus lines breaks the ground loops and eliminates these problems. The ADM3055E transceiver breaks ground loops and carries system level safety certification for the 5-kVRMS signal and power isolation between the CAN FD node and the CAN bus lines. For applications requiring lower isolation capabilities, the ADM3057E is available. For applications where bus-side power is available, ADM3056E is a reinforced signal isolated solution.

Switchable termination: For the best signal integrity, termination has to be implemented at both ends of a CAN network. Switchable termination allows to configure the termination location via software. This is useful for on-the-fly network reconfiguration when nodes are removed or added.

To keep the network reliability as high as possible, termination circuitry may not restrict the common-mode range. The termination circuitry may also not be affected by the common-mode range of the signal i.e. the termination circuitry must remain off when set to off and remain on when set to on. To meet the required circuit characteristics, the termination circuitry on the EVAL-ADM3055E-ARDZ evaluation board floats with the transmitting node using very compact optically-isolated SPST (single pole single throw) solid state relays (SSR).

Controlling the relays from the auxiliary isolated channel of the transceiver means that the relays do not bridge the isolation gap. Thus, the relays are not required to provide a safety isolation function and can have the smallest possible package to save the printed circuit board (PCB) area.

The 120-Ohm termination resistance (Figure 3) can be accomplished with a single resistor. However, splitting the resistor into two 60-Ohm resistors offers an inexpensive measure of electrostatic discharge (ESD) protection to both relay pins exposed to the

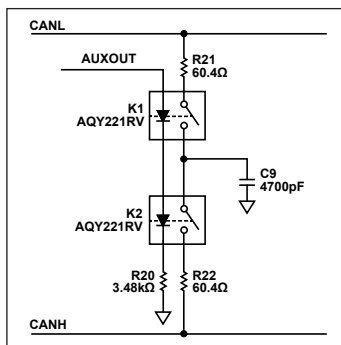


Figure 3: Switchable 120-Ohm termination resistance using Photomos relays controlled via an auxiliary channel (Source: AD)

CAN. Implementing the switchable termination circuit with a second SSR allows for addition of a filter capacitor. The latter interacts with the split termination resistors to provide a low-pass filter, reducing the common-mode noise on the bus.

Silent mode and slope control mode: The CN-0401 circuit supports bit-rate detection via a software-configurable trial and error function. This is possible in conjunction with the silent mode of the transceiver. Silent mode disables the transceiver's transmit channel and allows a CAN controller to produce error frames while attempting to synchronize to the bus bit-rate without to interrupt the bus traffic. The CN-0401 circuit provides access to the transceiver's slope control mode. For low-speed signaling, slope control decreases the slew rate of the CAN-High and CAN-Low recessive-to-dominant transitions. Decreasing of the slew rate minimizes ringing and electromagnetic interference (EMI) caused by fast edges. The slope control mode should not be used for high-speed signaling.

Circuit evaluation and test

This section outlines a simple evaluation procedure for the EVAL-ADM3055E-ARDZ using the EVAL-ADICUP3029 development board. More information on the hardware and software setup is available on the company's website.

Equipment needed

- ◆ PC with a USB port and operating system Windows 7 (32-bit) or higher
- ◆ Serial terminal (e.g. Putty or Tera Term)
- ◆ Two EVAL-ADM3055E-ARDZ circuit evaluation boards
- ◆ Two EVAL-ADICUP3029 development boards
- ◆ Crosscore Embedded Studio or pre-built .hex file

Getting started

1. Open the CN0401 project in Crosscore Embedded Studio
2. Check that all user-defined settings are correct, as detailed in the EVAL-ADM3055E-ARDZ user guide
3. Build the project and upload the project to the ADICUP3029 board (alternatively, copy (drag and drop) the pre-built .hex file into the ADICUP3029 board mass storage device).

Functional test block diagram: Figure 4 shows the functional block diagram of the test setup. The PCB-tethered node software sets up a command line interface (CLI), which is commanded via a serial terminal running on a PC. Through the serial terminal, the user is able to command other nodes and send a remote wake-up message.

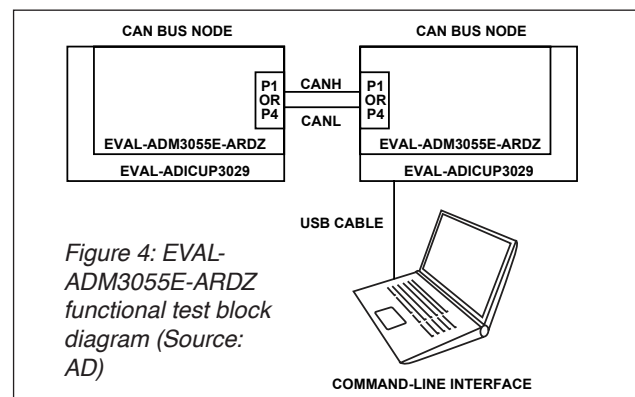


Figure 4: EVAL-ADM3055E-ARDZ functional test block diagram (Source: AD)

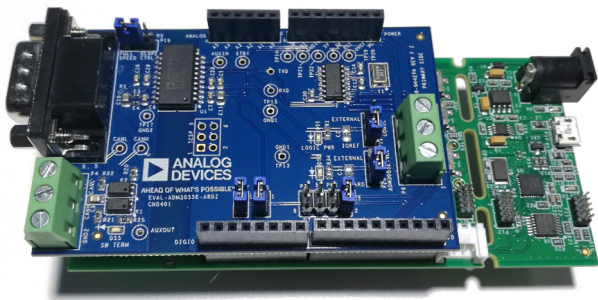


Figure 5: CAN node setup using EVAL-ADM3055E-ARDZ and EVAL-ADICUP3029 (Source: AD)

Test setup: A CAN node is set up by mounting the EVAL-ADM3055E-ARDZ atop the EVAL-ADICUP3029 using the Arduino-compatible headers, as shown in Figure 5.

Communication and remote wake-up test: With the sample software built and loaded on two different CAN nodes, the two boards (when connected) communicate with each other through a CAN FD connection. Figure 6 shows a two-node CAN connection.

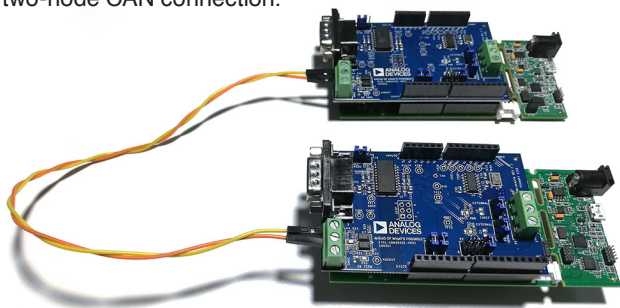


Figure 6: Two-node CAN connection test setup (Source: AD)

Default arbitration and data bit-rates are 500 kbit/s and 2 Mbit/s, respectively. The boards are connected to the PC via a USB cable. Each node has its own CLI running on a serial terminal. This configuration sets up a two-way CAN FD communication between the devices acting as two independent CAN nodes.

At first, the nodes are in sleep mode. Via the CLI a node can be commanded to wake up and to send an Ascii message via CAN. The message transmission has a timeout of 5 s and is cyclically sent until it is acknowledged by the other node. The message, particularly the slower arbitration phase, wakes up the other node. The latter acknowledges the message and displays it on the serial terminal connected to its node. Then, both nodes reenter the sleep mode.



Figure 7: Screenshot of a message displayed on the serial terminal (Source: AD)

When connected to a PC, each CAN node can be commanded to perform a communication loopback test. The CAN controller is placed in external loopback mode wherein the transmit line is internally connected to the receive line. The CAN node transmits a custom message and checks if it receives the same message. If the loopback message is received, the message is displayed in Ascii art on the CLI and the LEDs on the ADICUP3029 flash. A screenshot of the received message in the serial terminal is shown in Figure 7.

◀ of

Source

Analog Devices
adi-germany@analog.com
www.analog.com