Isolated RS-485 transceivers support DMX512 stage lighting and special-effects applications

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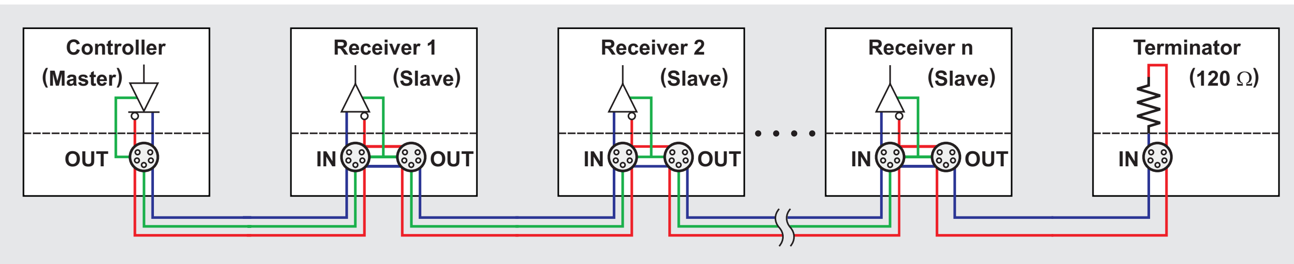
Figure 1. Daisy-chained topology of DMX512 network



Stage lighting and special-effects applications in modern theaters, opera houses, sports arenas, and concert halls utilize complex data-transmission networks. These networks, often reaching distances of up to 1200 m, provide communication between several hundreds of network nodes that control dimmers, moving lights, fog machines, and other special-effects equipment.

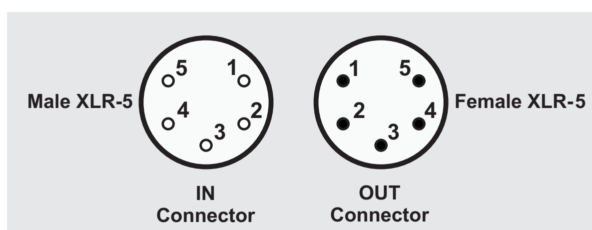
The first standard ensuring reliable intercommunication for these applications was known as DMX512 and was originally developed in 1986 by the United States Institute for Theatre Technology (USITT) Engineering Commission. In 1998, the Entertainment Services and Technology Association (ESTA) took over maintenance of this standard. A revised version was approved by the American National Standards Institute (ANSI) in 2004. The standard was revised again in 2008 and is now officially known as ANSI E1.11-2008, entitled *Entertainment Technology—USITT DMX512-A—Asynchronous Serial Digital Data Transmission Standard for Controlling Lighting Equipment and Accessories,* or DMX512-A in short.

Topology

A DMX512 network utilizes a multidrop topology similar to RS-422, where a single controller (master node) sends repetitive control data to multiple receivers (slave nodes). Within the network, all nodes are connected through daisy-chaining; that is, each slave node has an IN connector as well as an OUT connector. The controller, which has only an OUT connector, connects to the IN connector of the first slave. The OUT connector of the first slave connects to the IN connector of the next slave, and so on (see Figure 1). The OUT connector of the last slave in the chain connects to a 100-Ω or 120-Ω terminator plug.

So that the ingoing and outgoing data signals of a DMX512 port can be distinguished, the IN connectors are male XLR-5, and the OUT connectors are female XLR-5 (see Figure 2).

Figure 2. DMX512 standard connectors



Protocol

A DMX512 controller transmits packets of asynchronous serial data at 250 kbps (see Figure 3). A data packet starts with a break (logic low) and is followed by a mark (logic high), a sequence known as mark-after-break (MAB). Following MAB is a time slot consisting of a start bit, eight data bits, and two stop bits. The entire packet consists of a maximum of 513 time slots, 512 of which are actual data slots. The first slot, known as the start code, specifies the type of data in the packet.

Physical layer

The DMX512-A standard specifies EIA-485 as the network's physical layer, thus allowing for a maximum common-mode loading of up to 32 unit loads and a maximum bus length of 1200 m. Network wiring typically consists of twisted-pair cable with a characteristic impedance of either 120 Ω for RS-485 cable or 100 Ω for CAT5 cable, with a termination resistor of equal impedance at the end of the bus.

In addition to EIA-485, DMX512-A recommends earth-grounded transmitter ports and isolated receiver ports to avoid the formation of disruptive ground loops (see Figure 4).

Furthermore, DMX512-A makes provisions for enhanced-functionality (EF) topologies that enable the use of responders. The responders are receiving nodes that can return status information to the controller. The two EF topologies most often applied are EF1 and EF2. EF1 provides a half-duplex link between the DMX512 network's controller and responders. EF2 provides a full-duplex link between the network nodes. In both cases, the I/O port of responders, falling under the category of receiving devices, must have isolated transmit and receive ports.

Full-duplex RS-485 transceivers are the devices best suited for these applications because simple rewiring of the A,B and Y,Z bus terminals can accommodate not only the receiver-only configuration in standard DMX512 systems but also the half- and full-duplex configurations used respectively in EF1 and EF2 systems.

Legacy receiver designs often used a non-isolated transceiver in combination with opto-isolators. However, the mold compound in these isolators, basically representing the dielectric between the light-emitting diode and the receiving photo transistor, absorbed moisture over time, reducing the long-term stability of the isolation barrier.

A further drawback of legacy designs was the use of an isolated power supply that was required to provide the

Figure 3. DMX512 packet timing

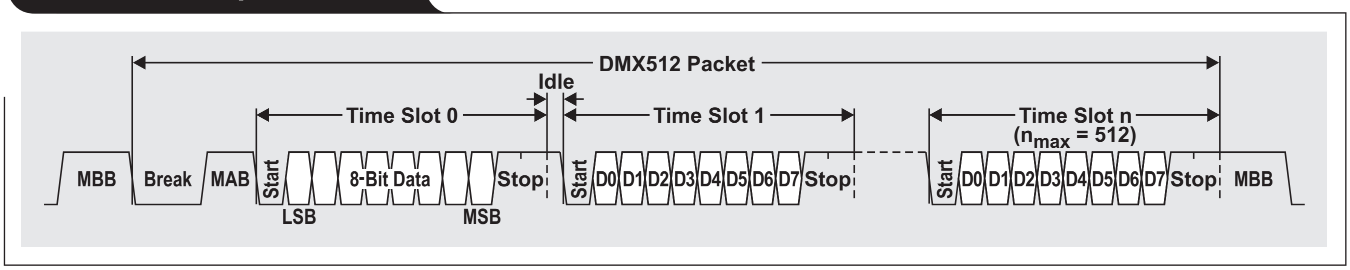
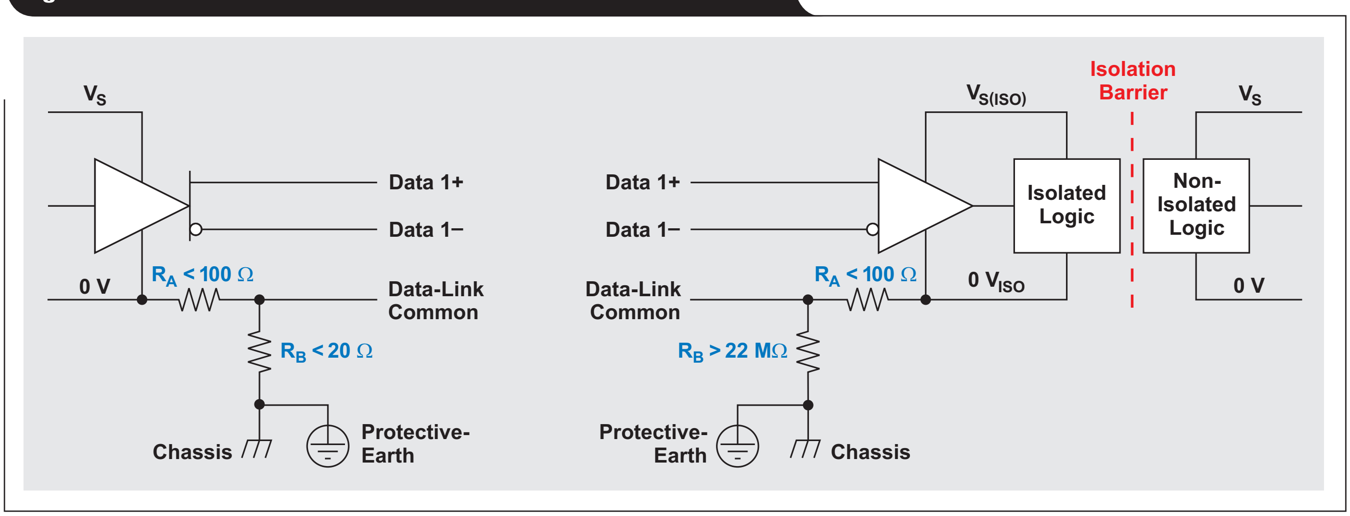


Figure 4. Ground-referenced transmitter and isolated receiver



supply voltage across the isolation barrier. Bulky DC/DC-converter modules were often applied whose cost exceeded that of all the signal-path components—including the transceiver, isolators, and UARTs—by up to 300%.

With the recent introduction of digital capacitive-isolation technology, the issue of long-term reliability has been solved. The isolation barrier, consisting of small, high-voltage capacitors in the range of 120 fF, uses silicon dioxide (SiO_2) as the isolation dielectric. SiO_2 is one of the hardest isolation materials with little moisture absorption, thus providing extremely high, long-term reliability and long life.

Furthermore, the new Texas Instruments (TI) family of isolated RS-485 transceivers possesses integrated transformer drivers that drastically simplify the design of the isolated power supply. The on-chip transformer driver is basically a free-running oscillator with a typical frequency, f_{OSC}, of 400 kHz. This oscillator drives two powerful output transistors, which in turn drive an external center-tapped transformer in a push-pull configuration. The relative high frequency allows for the use of small transformers that enable an overall small-form-factor design.

Figure 5 shows a complete solution for a responder circuit that complies with DMX512-A. As an isolated, 3.3-V, low-power transceiver, TI's ISO35T provides RS-485-compliant bus signals with a 1.5-V minimum and a 2-V typical differential output voltage at full differential and common-mode loading. The device's maximum data rate of 1 Mbps satisfies the 250-kbps requirement of DMX512-A, and the longer rise and fall times of 200 ns ensure low electromagnetic interference.

Here the incoming control data from the DMX512 bus is signal-conditioned by the input comparator and sent across the isolation barrier towards the receiver output. Output data at the R terminal enters the UART interface of TI's MSP430F2132, a low-power microcontroller. The microcontroller converts the UART data into a synchronous, high-speed serial data stream to feed an eight-channel, high-voltage-output digital-to-analog converter (DAC). TI's DAC7718 allows for bipolar outputs of up to ±16.5 V and unipolar outputs of up to 33 V.

Because stage special-effects equipment uses unipolar control voltages in the range of 0 to 10 V, the DAC7718 is an ideal analog interface for this type of application, enabling the control of up to eight light dimmers per network node.

The remaining node circuitry, including the DAC, the microcontroller, and the transceiver, operates from a single 3.3-V supply. The 3.3-V low-dropout regulator (TI's TPS76333) on the isolated side provides up to 150 mA of output current along with overcurrent limiting and thermal protection.

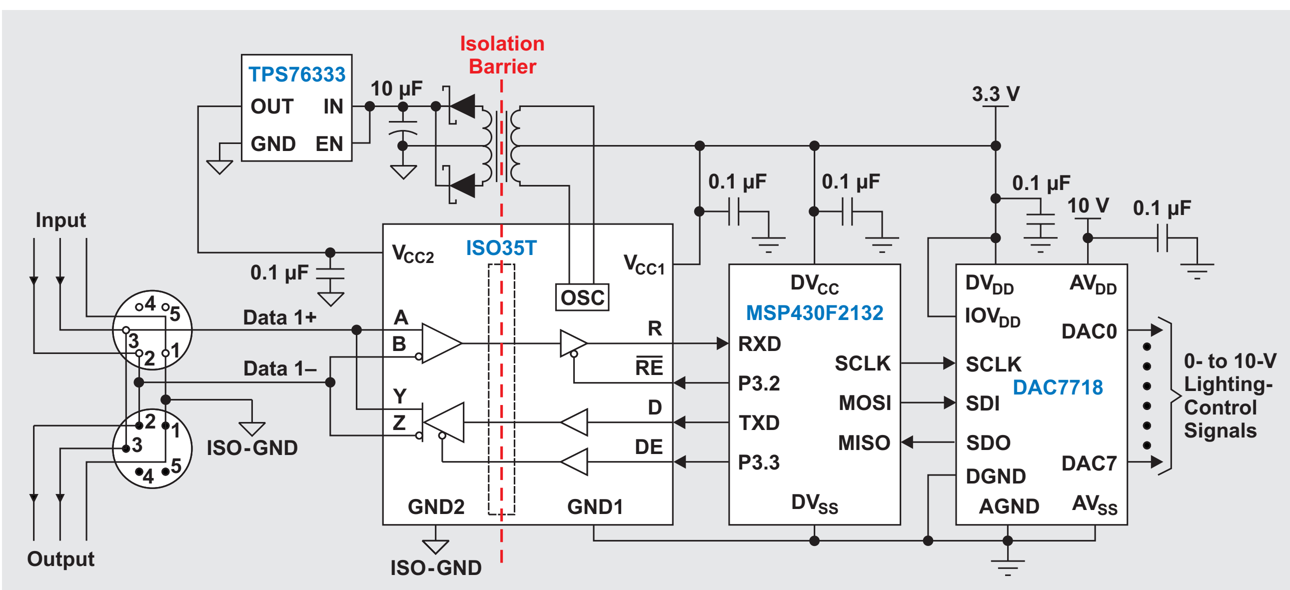
Related Web sites

interface.ti.com

www.ti.com/sc/device/*partnumber*

Replace *partnumber* with DAC7718, ISO35T, ISO1176T, ISO3086T, MSP430F2132, or TPS76333

Figure 5. Isolated DMX512 responder node



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