SERIAL INTERFACES

Application Notes

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1. PRODUCTS AND APPLICATIONS

In the age of the "Internet of Things" (IoT) it's easy to believe that only Ethernet for wired systems exists as a data communication bus, but other communications still persist within the wired infrastructure of devices and machines, particularly in industrial and building control applications, within Programmable Logic Controllers (PLC's) and in-vehicle networks.

These other serial interfaces do not only exist in small networks or internal communications within an enclosure, they are found extensively in building automation communications, industrial automation, data distribution and monitoring environments and are the backbone of many industrial and commercial communication processes.

The reason these networks persist is that they can offer simplicity compared to Ethernet, particularly over their addressing and data package protocols (Table 1). This simplicity can limit their application, but can also reduce their costs as the processing power required to run the interface protocol can be handled by very low power, low-cost microprocessors with limited memory. Likewise not all data needs to go at high speeds and high data integrity with relatively small packet information can be better for longer distance communications, especially when coupled with isolation, hence distances in excess of 1200m can be achieved for remote sensing and/or processing operations (e.g. large buildings or industrial operations). Isolation also enables high data integrity to be maintained in electrically noisy environments such as factories or office building plant rooms, where multiple motors and inductive loads are switching and where heavy electrical loads are being managed close to measurement, monitoring and control equipment.

Table 1: Serial interface standards performance data

Parameter	RS232C	EIA485	SPI	I2C[3]	USB 2.0[1]
Mode of operation	single ended	differential	single ended	single ended	differential
No of drivers/receivers	1 driver 1 receiver	32 drivers 32 receivers	Note 2 (6 is typical)	128	127
Maximum cable length (m)	15	1200	10	10	5
Maximum data rate (bits/s)	20k	10M	20M	3.4M	480M
Maximum common mode voltage (V)	±25.0	–7.0 to +12.0	+8.0 to +2.0	$+0.3V_{DD}$ to $+.07V_{DD}$	+0.8 to +2.5
Minimum driver signal level (V)	±5.0	±1.5	0.0 to +0.8	$–0.5V_{DD}$ to $+0.3V_{DD}$	–0.1 to +0.8
Maximum driver signal level (V)	±15.0	±5.0	+2.0 to +5.5	$0.7V_{DD}$ to V_{DD}	+2.5 to +5.0
Load resistance (capacitance) (Ω(pF))	3k to7k (2500)	54	50 to 70	(550)	45 (4)
Driver slew rate (V/µs)	30	Note 2	100	300	2100
Driver impedance (Ω)	300 (power on)	-	15 to 30	50	90
High impedance state	300Ω (power off)	±100µA (–7Vs Vcm ≤12V)	-	±10µA ($0.1V_{DD} < VI < 0.9V_{DD}$)	-
Minimum receiver resistance (Ω)	3.0k	12.0k	33 to 100	50k	-
Receiver sensitivity (V)	±3.0	±0.2	±0.4	$±0.1V_{DD}$	±0.15

1. Higher speed USB interfaces support USB 2.0, but are generally used for higher speed (>5Gbps) non-isolated interfacing.
2. Determined by IC used and data rate.
3. V_{DD} being the primary supply voltage to the IC.

2. EIA485: INDUSTRY DOMINANT STANDARD

While other serial interfaces do still exist, EIA485 (or RS485) has become the most dominant physical serial interface for monitoring, sensing and control in industrial and building automation systems, and extended into lighting controls. Sometimes the use of this physical interface is obscured by the reference to the communications or control protocols that are used, but all the following network protocols support EIA485 at the physical interface level:

BACnet	Buildings Automation and Control Network
CAN	Controller Area Network (used in-vehicle communications)
DeviceNet	CAN for Industrial Automation
DMX512	Digital Multiplex (primarily for lighting controls)
Modbus	Modicon (founder company) – commonly used in PLC's
ProfiBus	Process Field Bus (and hence ProfiNet)
SCADA	Supervisory Control and Data Acquisition (high level layer)

Hence, the applications for the physical interface of EIA485 is extensive and Murata Power Solutions have a range of products to support these implementations in both non-isolated and isolated applications.

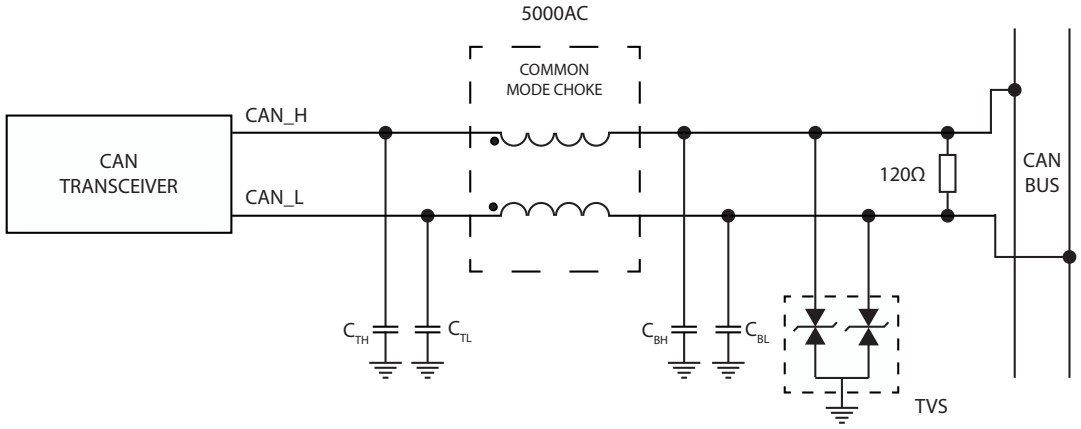
3. CAN BUS AND DEVICENET NOISE SUPPRESSION

The 5000AC series of Common Mode Chokes are designed specifically for use on EIA485 networks in CAN and DeviceNet applications (Figure 1).

The 5000AC ensures any offset of the ground between connected signals, or any interference on the network bus is self-cancelled at the transceiver before the message is received. The capacitors on the high-and low signals have to be small to avoid signal skew (typically less than 1nF) and are often omitted from the bus side. The transient voltage suppressor (TVS) is used to minimize electrostatic discharge (ESD) from users and installers at the connector and also extremely fast transients (EFT) interfering, the later mainly required if the bus is exposed to high motor noise or external to a building (e.g. roadside equipment or rooftop weather sensors).

The choice of 5000AC device will be based on the data rate or the exposed noise frequency signature (rarely known at point of design). All give suppression up to 100MHz of noise, but the lower inductance versions are best suited to higher speed busses.

Figure 1: Non-isolated CAN or DeviceNet interface using 5000A common mode choke



4. ISOLATED EIA485 SERIAL INTERFACES

Isolation can be used to improve the integrity of the EIA485 signal since it breaks the ground connections, and hence potential ground loop, between any transceivers on the network. This permits ease of use in high noise environments, across different primary supply systems (e.g. operating from a different phase of a 3-phase supply or different buildings primary supply) and permits operation generally over greater distances, although the distances themselves are not generally qualified or stated. It also may be required for safety when connecting a low power system to a higher power controller or process, preventing galvanic connection between the 2 systems.

As already noted one of the primary reasons for the popularity of EIA485 is the simplicity of its physical interface as well as the protocols it supports. Hence isolated interfaces for remote sensing and inter-system communication is relatively common and again low cost compared to other solutions due to its simplicity and robustness (Figure 2 and Figure 3).

There are many isolated RS485 transceiver chips on the market that simply require an isolated DC-DC converter to complete the circuit (Figure 2). These are almost as straightforward to implement as the non-isolated versions (Figure 1) and can be implemented as full-duplex (Figure 2) or half-duplex (Figure 3).

There are also a range of IC's that offer the push-pull driver for the isolation power within the EIA485 isolated transceiver IC, enabling the interface to be implemented by adding a low power isolation transformer and auxiliary rectification and regulation components (as shown in Figure 3).

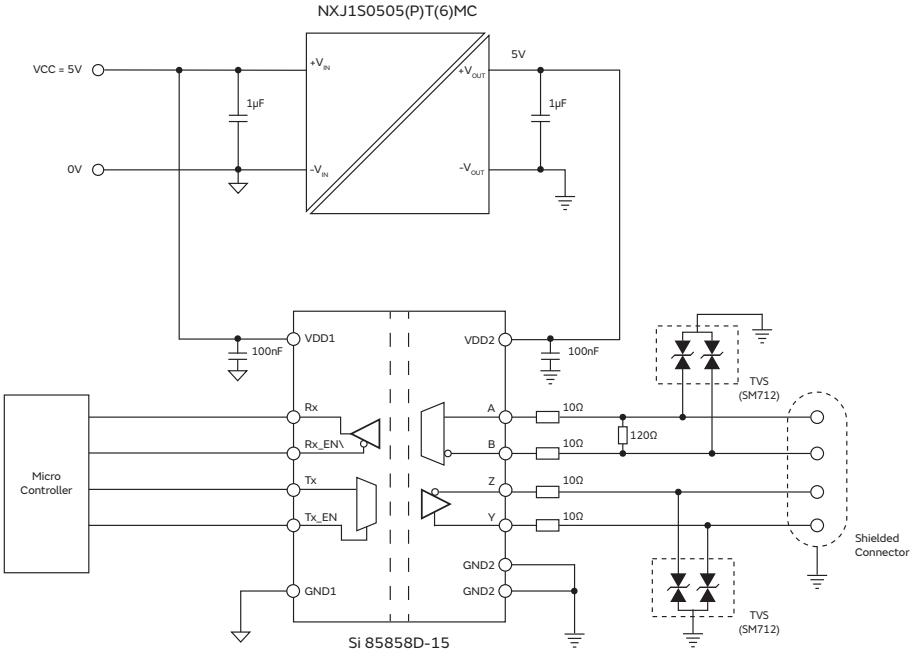
The choice of whether to use an IC driver and transformer isolator, or DC-DC converter and isolated IC, may come down to the auxiliary circuits attached to the network side. With a DC-DC converter there is usually sufficient excess power available to power some peripherals as well as the transceiver, and possibly the remote monitoring activity itself (e.g. temperature or pressure sensing). Whereas with the transformer and IC driver, the driver is usually specified to power the transceiver only and not any auxiliary circuits, although the transformer itself is generally capable of supplying higher output power.

Murata produce a range of isolation transformers specifically designed to match with most of the isolated transceiver IC's that have push-pull drivers. A list is provided below in Table 2.

Table 2: Serial interfaces and Murata support transformers

Interface	Transformer series	IC Reference	IC Manufacturer
RS232C	78250	MAX250/MAX251	Texas Instruments
RS232C/EIA485	78253	MAX253	Texas Instruments
EIA485	782482 782485	ADM2482/ADM2487 ADM2485	Analog Devices Inc
IEC958/AES3/EBU	DA100	Multiple	Multiple

Figure 2: Full-duplex EIA485 isolated interface using NXJ DC-DC converter



Note: 10Ω series resistors provide over current protection, TVS diodes provide ESD and EFT protection

4. ISOLATED EIA485 SERIAL INTERFACE (Continued)

It is also possible to implement an isolated EIA485 interface using a digital isolator and standard EIA485 transceiver IC (Figure 4). This may be a preference where the physical interface may need to change at a later date, hence the physical layout up to the transceiver can remain the same and only the transceiver IC changed for an alternative serial interface. This is an application where the use of a DC-DC converter would be preferred as the power requirements for other interface IC's are likely to be different.

The circuit shown in Figure 4 is for a 12V battery powered EIA485/CAN interface, where the power comes in from the network side and the DC-DC converter powers the whole processing node.

Figure 3: Half-duplex EIA485 isolated interface using 782485 transformer

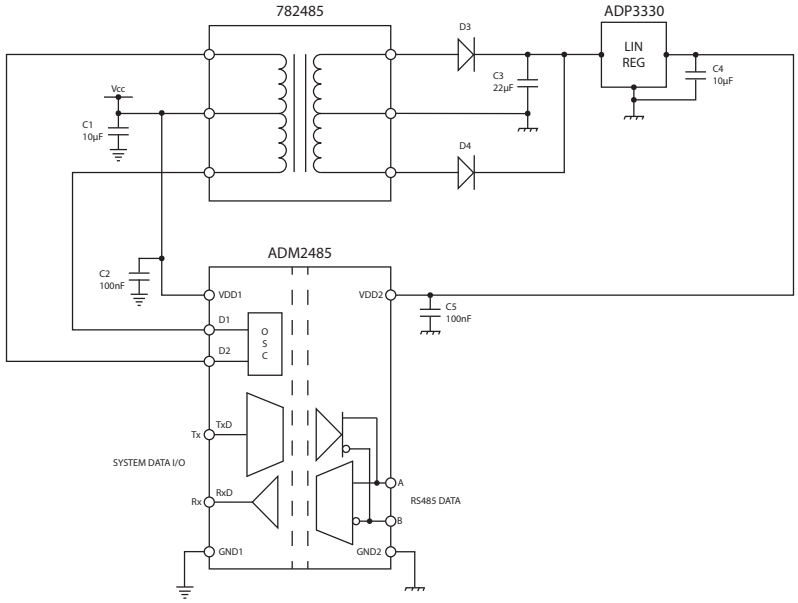
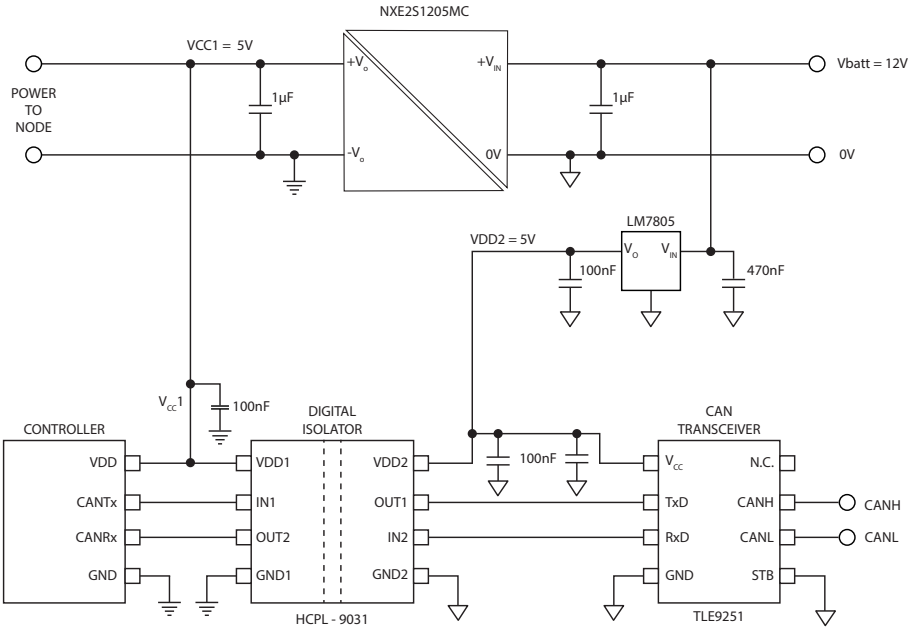


Figure 4: 12V battery powered isolated EIA485/CAN interface



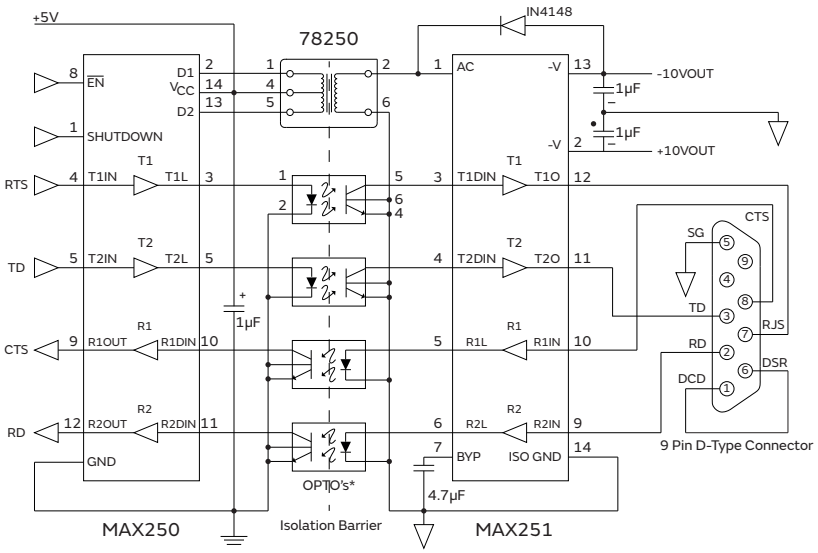
5. OTHER SERIAL INTERFACES

RS232C serial interface

At one time RS232C was the defacto serial interface for many applications, but today it is mainly used to support legacy systems and some inter-bus interfacing. While few new applications are developed, there is still a range of IC's and isolation products available (Figure 5).

Murata still support the standard with both transformers and DC-DC converters for isolated power and offer high isolation parts for this interface.

Figure 5: Isolated RS232 using MAX250/251 IC's and 78250 transformer

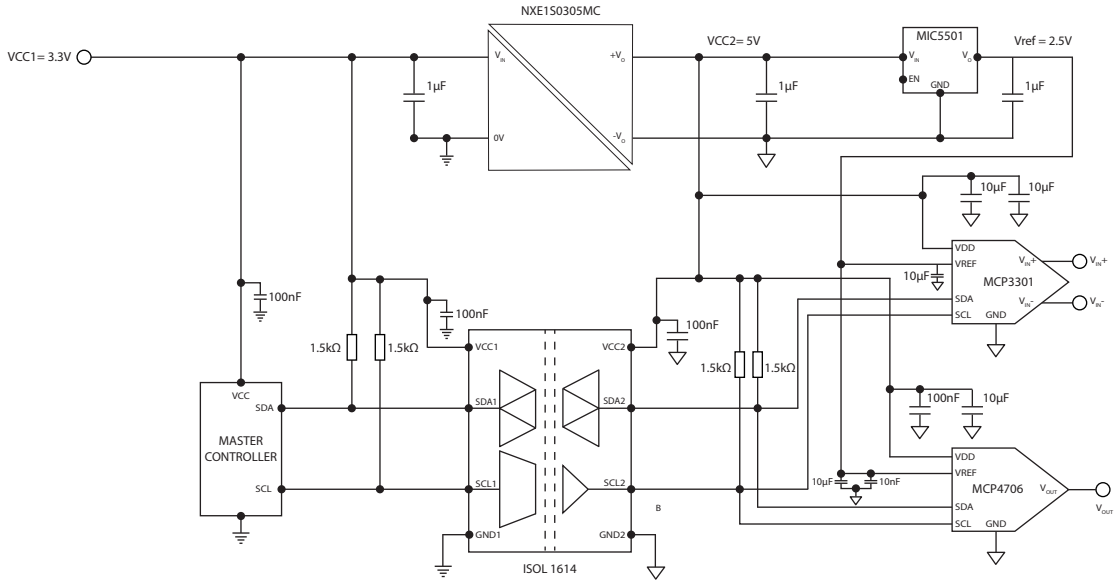


OPTO's* - 4 x 4N26 (78250), 4x CNY17-3 or 4 x SFH610 (78250V & 76250EN).

Inter-integrated circuit communications (I2C)

I2C is used, as the name suggests, mainly for serial data exchange between IC's hence is used for relatively short distances (within a PCB for example) and is rarely isolated. However, there are situations where the digital processing itself is the primary source of noise and that an internal sensor or data acquisition needs to be isolated to break the ground loop and isolate the digital noise from the local sensing or data system. This is not uncommon within a PC plug-in card for an analogue-to-digital (ADC) or digital-to-analogue (DAC) type system (Figure 6).

Figure 6: Simple isolated I2C data acquisition system utilising NXE DC-DC converter

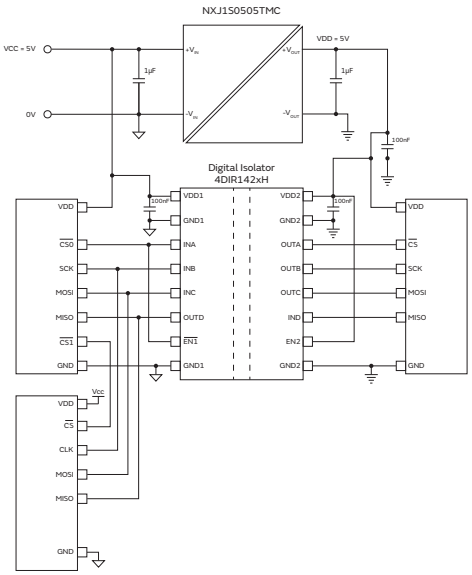


5. OTHER SERIAL INTERFACES (Continued)

Serial Peripheral Interface (SPI)

The Serial Peripheral Interface (SPI) is a common bus for low-cost digital data exchange between various digital processing units within a system. When digital data from a remote or "exposed" (i.e. outside of the system enclosure) needs to be processed an isolated SPI communication bus is a simple and relatively low-cost way of implementing an isolated digital interface (Figure 7). As with I2C this may primarily be because the main noise is from the digital processing system itself, hence is used for relatively short communication lines, but within systems with a high processing capacity, hence high load demand on the digital power rail and subsequent noise signature this generates.

Figure 7: Isolated SPI bus with NXJ DC-DC convrter

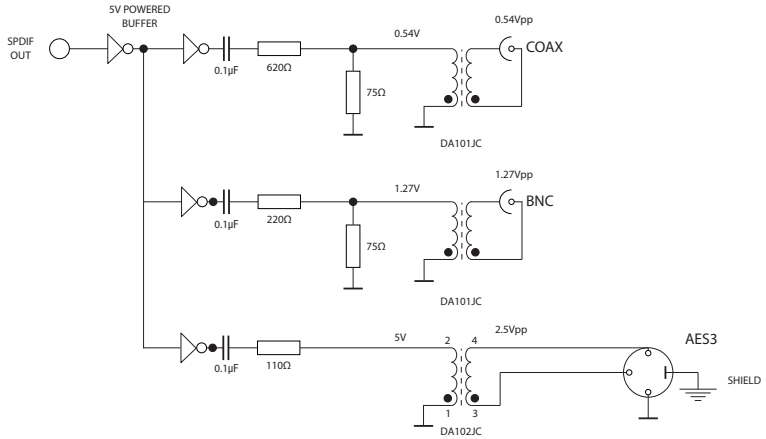


Digital Audio Standard

The S/PDIF (Sony/Philips Digital Interface Format) was designed to permit high quality digital stereo audio to be transmitted from a source to a receiver (usually an amplifier or other sound processing system) with no loss in quality of the source signal, in stereo using a multiplexed single transmission line. This was adopted as an International Standard (IEC958, AES3/EBU) and used extensively in high end audio for home and theatre use, including gaming and high-definition audio interfaces embedded within other communications systems.

Different connectors can be used for the S/PDIF signal, providing the appropriate matching impedance and signalling voltage is maintained. This can be simply implemented using biasing resistors, the values of which will depend on the supply and output voltage of the S/PDIF buffers (Figure 8).

Figure 8: S/PDIF buffered outputs to co-axial, BNC and AES3/XLR connectors utilising DA100 transformers



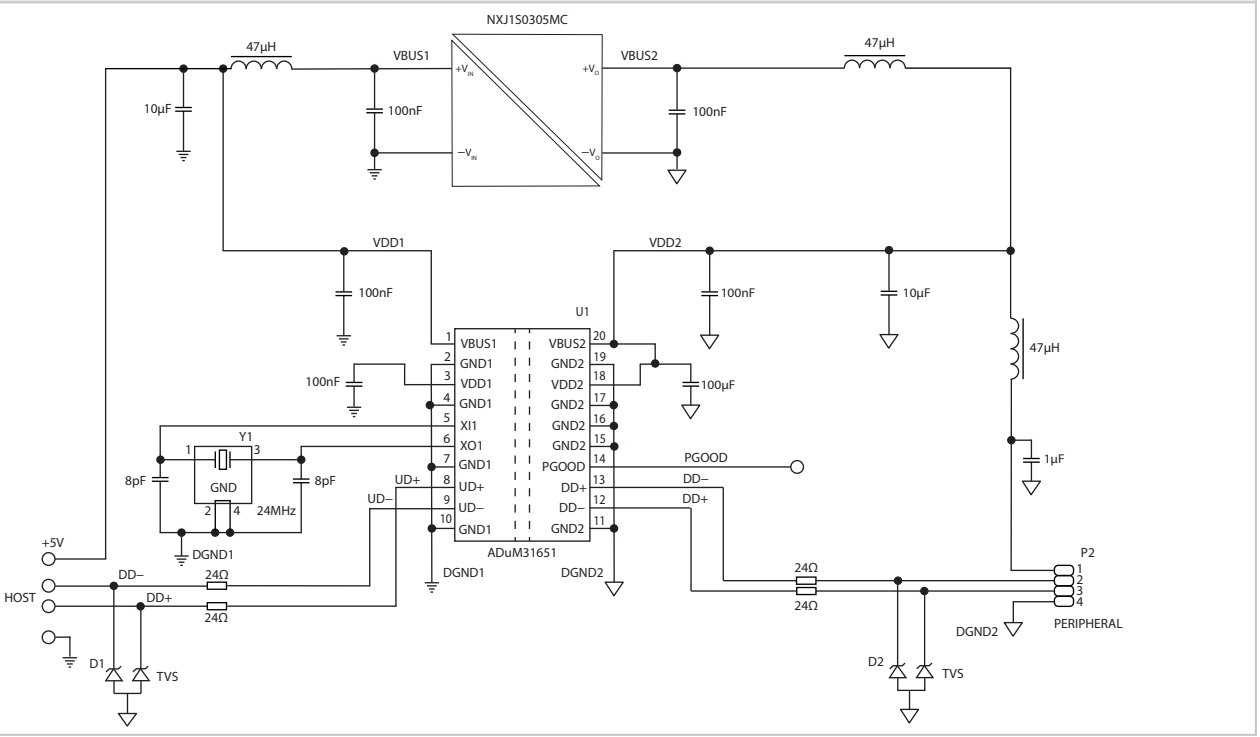
5. OTHER SERIAL INTERFACES (Continued)

Universal Serial Bus

The Universal Serial Bus (USB) standard has taken over a lot of other proprietary digital interface standard in more recent times and this too can be simply interfaced to most of the other serial interfaces listed here, or even in place of the I2C bus in the above data acquisition system (Figure 6) when operating over greater separation of controller and point of data acquisition. The reason for isolating the USB will mainly be the potential for digital noise on the power and ground, plus it is unlikely the actual control system to be connected will be well known or well defined (could be a desk PC, laptop or an embedded PLC in a cabinet).

The advantage of USB is that it does bring the power supply to the interface itself and for many low power signal acquisition interfaces, this is a relatively easy bus from which to produce an isolated data interface.

Figure 9: Isolated USB interface using NXJ2S0505MC DC-DC converter



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