TI TECH DAYS
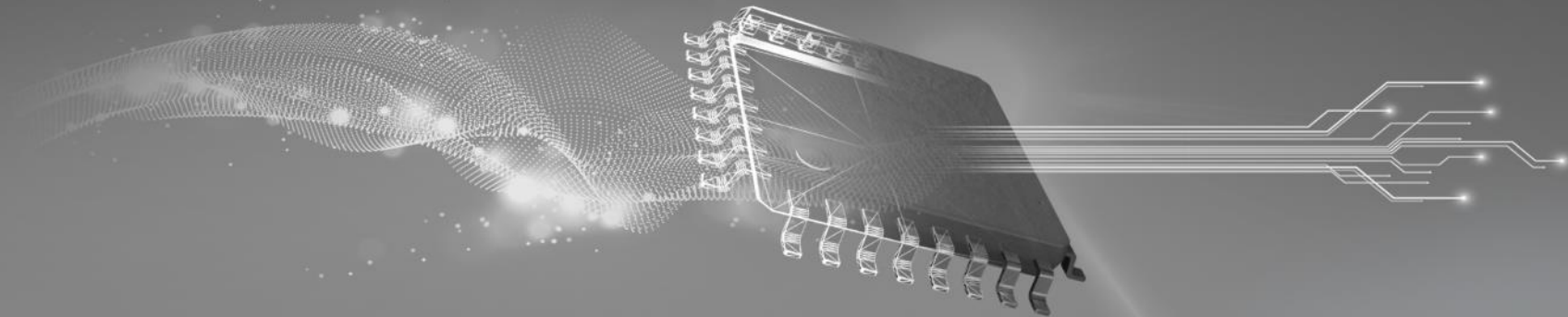
Improve your system performance by replacing optocouplers with digital isolators

Koteshwar Rao
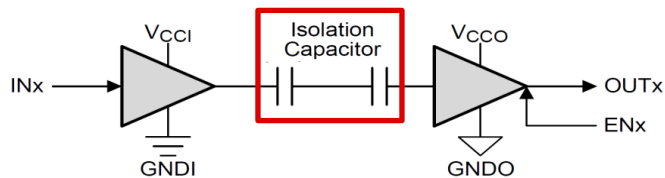
Isolation products

TEXAS INSTRUMENTS

Agenda

- Capacitive SiO_2 digital isolator vs optocoupler technologies

- Lifetime comparison

- Electrical comparison
  - Switching performance and current consumption
  - CMTI
  - Current vs voltage input
  - Aging and reliability

- Typical use cases
  - UART
  - SPI
  - I2C
  - RS-485
  - CAN
  - Industrial digital input

TEXAS INSTRUMENTS

TI's capacitive SiO_2 isolation technology

TI's reinforced isolators use a logic input and output buffer separated by a **double capacitive SiO_2 insulation barrier**

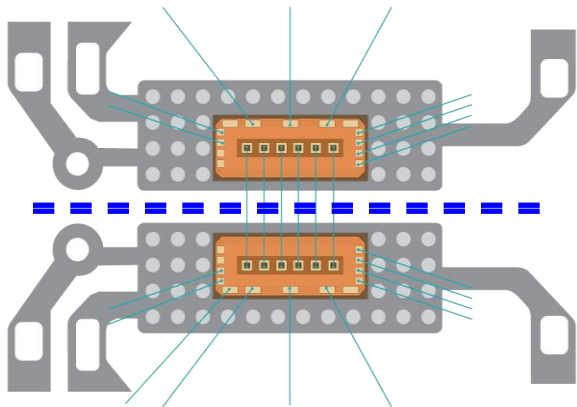Manufactured and thoroughly tested in a controlled environment to ensure highest quality of isolation products

Silicon dioxide (SiO_2) offers the **highest** dielectric strength in the industry

Insulator Materials	Dielectric Strength
Air	~1 Vrms/µm
Epoxies	~20 Vrms/µm
Silica filled Mold Compounds	~100 Vrms/µm
Polyimide	~300 Vrms/µm
SiO_2	~500 Vrms/µm

Unlike polyimide and other polymer based insulators, the reliability of an SiO_2-insulated capacitor does not degrade with exposure to ambient moisture.

TEXAS INSTRUMENTS

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4

TEXAS INSTRUMENTS

Optocoupler construction

Optocouplers use an LED to transmit signals across an isolation barrier (**often just an air gap**).
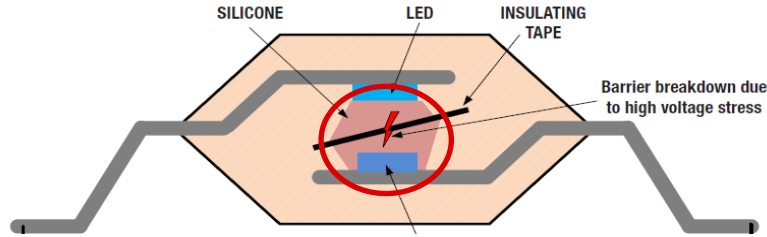
Optocoupler dielectrics are built in an assembly house, not in the controlled environment of a controlled process manufacturing facility.

Are AIR & epoxy good dielectrics?

Air and epoxy have the **LOWEST** dielectric strength of ANY isolator.

Insulator Materials	Dielectric Strength
Air	~1 Vrms/μm
Epoxies	~20 Vrms/μm
Silica filled Mold Compounds	~100 Vrms/μm
Polyimide	~300 Vrms/μm
SiO₂	~500 Vrms/μm

TEXAS INSTRUMENTS

Isolation lifetime – Time Dependent Dielectric Breakdown (TDDB)

The main <u>isolation</u> electrical lifetime test is <u>TDDB</u>

– Standard methodology for determining the lifetime of a dielectric as a function of voltage
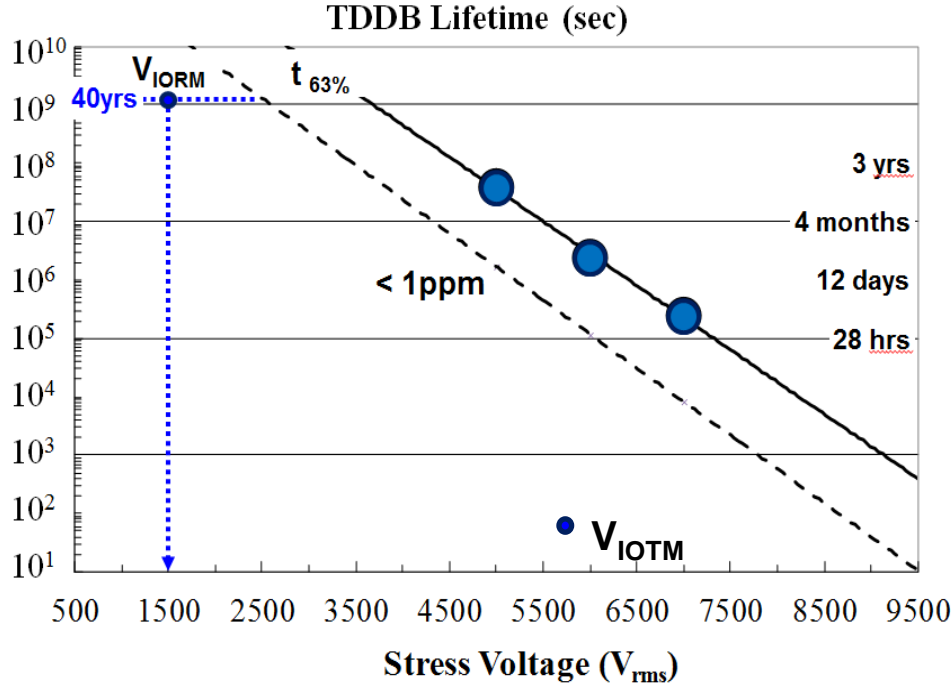

- TDDB is accelerated lifetime testing of the isolation barrier

- TDDB verifies the lifetime of an isolator for a given working voltage

- TDDB is required for VDE 0884-11 component level certification

TDDB: TI vs optocouplers

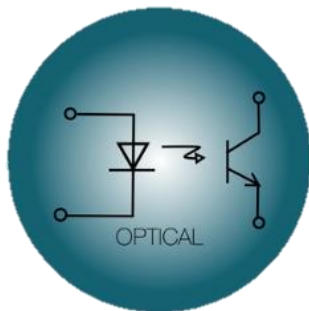**The main <u>isolation</u> electrical lifetime test is <u>TDDB</u>**

– Standard methodology for determining the lifetime of a dielectric as a function of voltage
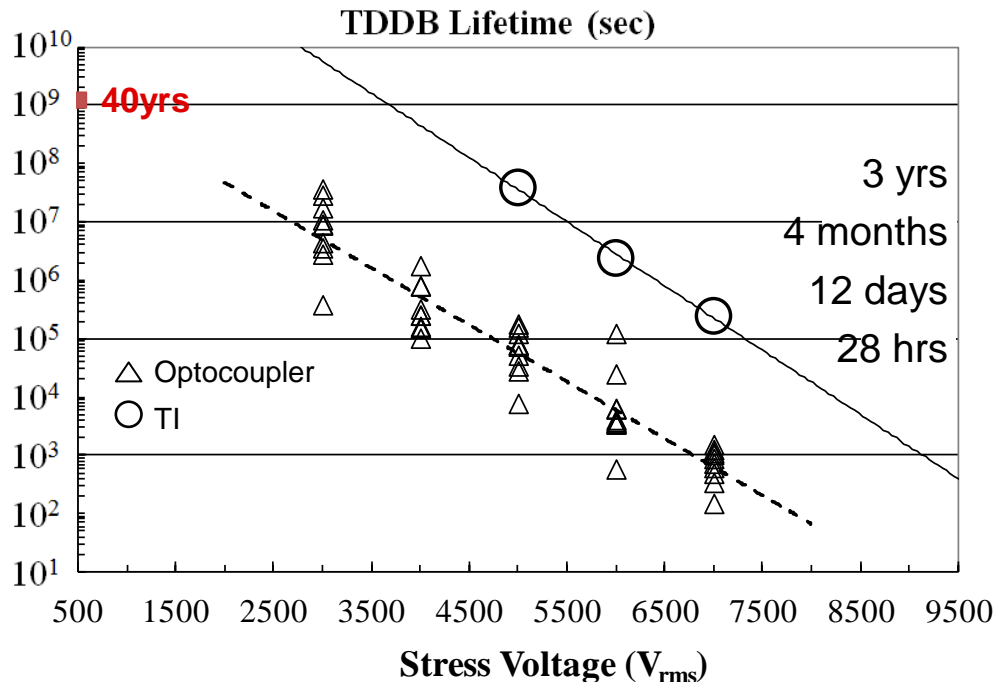
- Like all dielectric materials, optocouplers do degrade over time under high voltage stress

- TDDB testing is needed for all high voltage isolation technologies, in addition to partial discharge testing on each unit

- Wide variety of failure results for optocouplers due to assembly process

TEXAS INSTRUMENTS

Comparing electrical characteristics

Optocouplers

OPTICAL

SiO$_2$ capacitive digital isolators

CAPACITIVE

TEXAS INSTRUMENTS
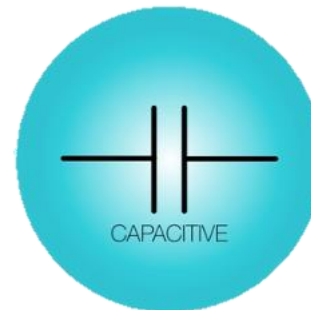
Comparing electrical characteristics

Switching performance and power consumption

It is critical for an isolator to have optimum switching characteristics minimizing its impact on the overall system timing performance.

Optocouplers

- Usually do not have any supported data rates mentioned in their data sheets
- Need their input biasing and output current to be significantly increased to support reasonable data rates
- Pull-up resistors lead to very high power consumption
- Even the fastest optocouplers have poor propagation delays
- Low maximum data rates

SiO$_2$ capacitive digital isolators

- Do not need any change in biasing or output current to support data sheet guaranteed data rates
- Low power consumption
- Low propagation delay
- Support very high-speed data rates with ease

TEXAS INSTRUMENTS

Switching performance and power consumption

Part number	General-purpose optocoupler		ISO7741	ISO6741
Parameter	RL = 100Ω	RL = 1.9kΩ	VCC = 5V	VCC = 5V
Input forward current / ICC1 per channel (typ, mA)	2.0	16.0	2.2	1.8
On state current / ICC2 per channel (typ, mA)	50.0	2.6	4.5	3.2
Rise time, tr (typ, µs)	2.0	0.8*	0.002	0.005
Fall time, tf (typ, µs)	3.0	35.0*	0.002	0.005
Turn on time / propagation delay, tpHL (typ, µs)	3.0	0.5	0.011	0.011
Turn off time / propagation delay, tpLH (typ, µs)	3.0	40.0	0.011	0.011
Propagation delay skew, tsk (max, µs)	-	-	0.004	0.006
Max asynchronous data rate (T = max(tr, tf) * 2/0.6 + tsk, typ, Mbps)	0.1	0.008	80.6	47.6
Max synchronous data rate (T = max(tpHL, tpLH) * 4, typ, Mbps)	0.028	0.006	23.4	22.7

Part number	High-speed optocoupler		ISO7741	ISO6741
Parameter	IF = 14mA	IF = 6mA	VCC = 5V	VCC = 5V
Input forward current / ICC1 per channel (typ, mA)	14.0	6.0	2.2	1.8
Rise time, tr (typ, ns)	15.0	15.0	2.4	4.5
Fall time, tf (typ, ns)	15.0	15.0	2.4	4.5
Turn on time / propagation delay, tpHL (typ, ns)	33.0	40.0	10.7	11
Turn off time / propagation delay, tpLH (typ, ns)	27.0	30.0	10.7	11
Propagation delay skew, tsk (max, ns)	30.0	30.0	4.4	6
Max asynchronous data rate (T = max(tr, tf) * 2/0.6 + tsk, typ, Mbps)	12.5	12.5	80.6	47.6
Max synchronous data rate (T = max(tpHL, tpLH) * 4, typ, Mbps)	7.6	6.3	23.4	22.7

*Estimated values

TEXAS INSTRUMENTS

Comparing electrical characteristics

Common-mode transient immunity (CMTI)

Common-mode noises appearing across an isolator can couple into the device internal circuit and disrupt their normal operation.

Optocouplers

- Typical CMTI of 15 – 25 kV/µs
- Internal single-ended channel design
- Internal parasitic noise coupling cannot be rejected
- CMTI failure leads to data corruption

SiO$_2$ capacitive digital isolators

- Typical CMTI of 100 kV/µs
- Internal differential-ended channel design
- All receivers inherently designed to support high CMR
- All internal coupling is rejected due to high CMR

TEXAS INSTRUMENTS

Comparing electrical characteristics

Current input vs CMOS voltage input

Optocoupler inputs are current driven while digital isolators are voltage driven (CMOS/TTL).

Optocouplers

- No digital devices support current input / outputs
- Needs buffer to drive current inputs
- High power consumption (>10 mA for better performance)
- Low voltage operation will lead to large current variations
- Low switching speeds due to high input capacitance (~60pF)

SiO_2 capacitive digital isolators

- All digital devices support voltage input / outputs
- No buffer needed to drive voltage inputs
- Very low power consumption (<10 µA standby current)
- Can reliably be operated at low voltages (<1.8 V)
- High switching speeds due to low input capacitance (~2 pF)

TEXAS INSTRUMENTS

Comparing electrical characteristics

Aging and reliability

The light output of LEDs used in optocouplers degrades over time, affecting many device parameters. Current transfer ration (CTR) is a prime example.

Optocouplers

- CTR degrades as a function of time due to mold compound color changes
- Eventually CTR falls to a level at which the device fails to operate normally leading to poor reliability
- High FIT rate & low MTBF
- Degradation affects not mentioned in data sheet

SiO$_2$ capacitive digital isolators

- Control circuits are very well trimmed minimizing their performance variation due to aging
- The highly controlled manufacturing process of digital isolators achieves very high reliability
- Low FIT rate & high MTBF
- Aging is already considered as part of device min/max specifications in the data sheet

TEXAS INSTRUMENTS

ISO77xx:
## Robust 5 kVrms and 3 kVrms Digital Isolators

Features

- **Isolation, immunity and certifications**
  - Integrated SiO_2 dielectric capacitors
  - Reinforced and basic isolation (DIN V VDE V 0884-11)
  - V_{ISO} rating: up to 5,000 V_{RMS}
  - V_{IOSM} surge: up to 12,800 V_{PK}
  - V_{IOWM} working voltage: up to 1,500 V_{RMS}
  - CMTI: 100 kV/µs (typ) 85 kV/µs (min)

- **Electrical characteristics**
  - Data rate: 100 Mbps (max)
  - Propagation delay: 11 ns (typ)
  - Ch-Ch skew: 4 ns (max)
  - Wide supply range: 2.25 V to 5.5 V
  - Low power: 1.5 mA / channel (typ) at 1 Mbps
  - High and low default states available
  - Operating temperature range: -55˚C to 125˚C

- **Package**
  - SOIC-16: 8 mm creepage / clearance (6, 4, 3, 2 and 1 channels)
  - SOIC-8DWV: 8 mm creepage / clearance (2 channels)
  - Small QSOP-16: 3.7 mm creepage / clearance (6, 4 and 3 channels)
  - Small SOIC-8: 4 mm creepage / clearance (2 and 1 channels)

Applications

- Power delivery
- Grid
- Motor drives
- Factory automation
- Building automation
- Appliances

Benefits

- Robust SiO_2 dielectric does not degrade with moisture or temperature, providing industry's longest isolation barrier lifetime

- Component level certifications → simplified system level certification

- High CMTI provides low voltage side protection from high switching transients in harsh environments

- Low propagation delay and tight skew improves data transfer efficiency

- Allows use with 2.5 V, 3.3 V and 5.0 V FPGAs and MCUs

- Thoroughly tested in a controlled environment to ensure high quality

- Pin to pin compatible with TI and competitor parts for ease of upgrade
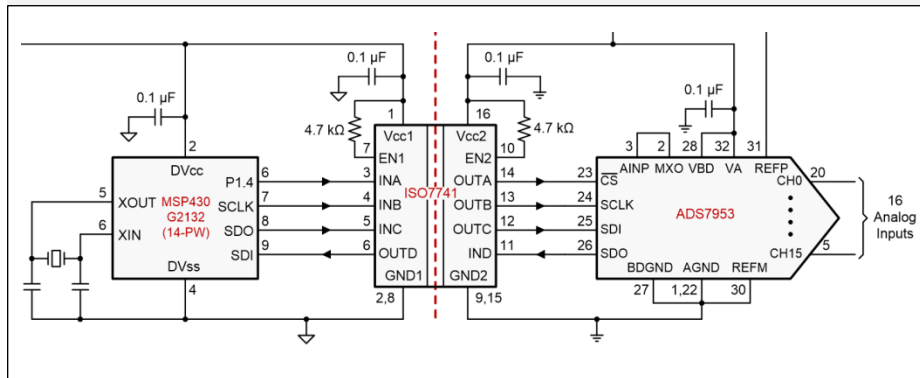

Q100 – Automotive Qualified

TEXAS INSTRUMENTS

ISO67xx

Cost Optimized 5 kVrms and 3 kVrms Digital Isolators

Features

- **Isolation, immunity and certifications**
  - Integrated SiO_2 dielectric capacitors
  - Reinforced and basic isolation (DIN V VDE V 0884-11)
  - V_{ISO} rating: up to 5,000 V_{RMS}
  - V_{IOSM} surge: up to 10,000 V_{PK}
  - V_{IOWM} working voltage: up to 1,000 V_{RMS}
  - CMTI: 75 kV/µs (typ) 50 kV/µs (min)

- **Electrical characteristics**
  - Data rate: 50 Mbps (max)
  - Propagation delay: 11 ns (typ)
  - Wide supply range: 1.71 V to 5.5 V
  - Low power: 1.9 mA / channel (typ) at 1 Mbps
  - High and low default states available
  - Operating temperature range: -40˚C to 125˚C

- **Package**
  - SOIC-16: 8 mm creepage / clearance (6, 4 and 3 channels)
  - SOIC-8DWV: 8 mm creepage / clearance (2 channels)
  - Small SOIC-8: 4 mm creepage / clearance (2 channels)

Applications

- HEV/EV
- Power delivery
- Grid
- Factory automation
- Building automation
- Appliances

Benefits

- Robust SiO_2 dielectric does not degrade with moisture or temperature, providing industry's longest isolation barrier lifetime

- Component level certifications → simplified system level certification

- High CMTI provides low voltage side protection from high switching transients in harsh environments

- Low propagation delay and tight skew improves data transfer efficiency

- Allows use with 1.8 V, 2.5 V, 3.3 V and 5.0 V FPGAs and MCUs

- Thoroughly tested in a controlled environment to ensure high quality

- Pin to pin compatible with TI and competitor parts for ease of upgrade
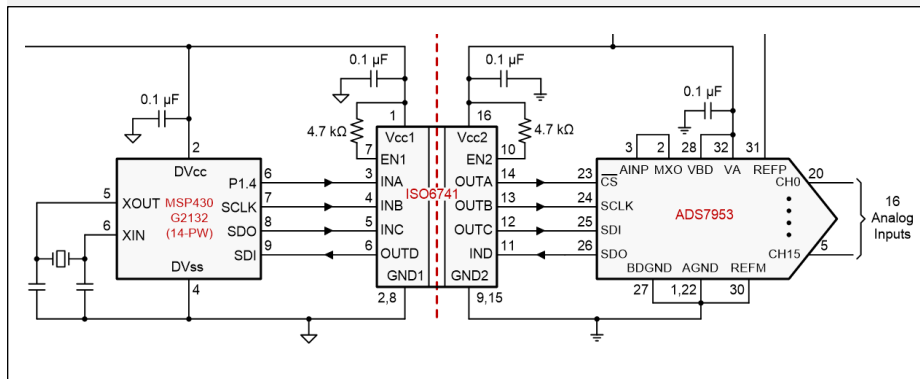
Q100 – Automotive Qualified

TEXAS INSTRUMENTS

Universal Asynchronous Receiver and Transmitter (UART) isolation

Very simple two-wire serial interface that allows for low-speed (<100 kbps) communication between two devices

Optocoupler drawbacks:

- **Additional resistors (R_i, R_L) required** to limit current flow and create a logic high state

- Large R_i and R_L lead to **high current consumption** in order to maintain robust signal integrity and account for future CTR degrading

- Optocoupler circuit footprint is roughly **two times larger than a dual-channel digital isolator**
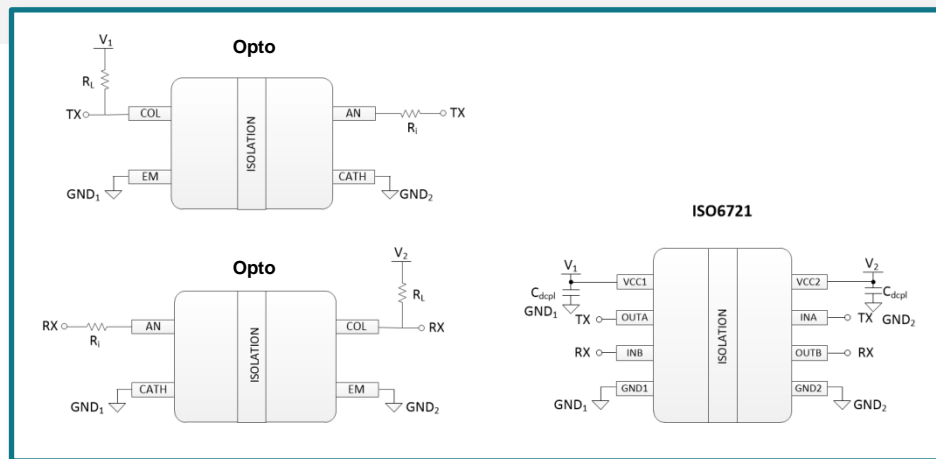
	Optocoupler	ISO6721 digital isolator
Primary side	10 mA	0.725 mA/ch
Secondary side	2 mA	0.725 mA/ch
Total current	**12 mA/ch**	**1.45 mA/ch**

TEXAS INSTRUMENTS

Serial Peripheral Interface (SPI) isolation

CMOS logic serial interface that requires four unidirectional data lines with data rates from 1 to 30 Mbps

Optocoupler drawbacks:

- High-speed open collector output or totem-pole output optocouplers must be used for SPI

- **Additional resistors (Ri, RL) and capacitors required** (15 with open collector output)

- **Propagation delay limits SPI speeds**
  - Optocouplers trade off tight timing with higher power consumption by adjusting R_L, commonly limited to 7-MHz SPI

- Optocoupler circuit footprint is roughly **four times larger than a dual channel digital isolator**

Serial Peripheral Interface (SPI) isolation

CMOS logic serial interface that requires four unidirectional data lines with data rates from 1 to 30 Mbps

Optocoupler drawbacks:

- High-speed open collector output or totem-pole output optocouplers must be used for SPI

- **Additional resistors (Ri, RL) and capacitors required** (15 with open collector output)

- **Propagation delay limits SPI speeds**
  – Optocouplers trade off tight timing with higher power consumption by adjusting R_L, commonly limited to 7-MHz SPI

- Optocoupler circuit footprint is roughly **four times larger than a dual channel digital isolator**

	Open collector optocoupler	Totem-pole output optocoupler	ISO7741 digital isolator (@ 1 Mbps)
Primary side	10 mA	2 mA	1.15 mA/ch
Secondary side	14 mA	1 mA/ch	1.025 mA/ch
Total current	**24 mA/ch**	**3 mA/ch**	**2.175 mA/ch**

TEXAS INSTRUMENTS

Inter-Integrated Circuit (I2C) isolation

Two-wire serial interface which efficiently allows multiple devices to be connected on the same bus

Optocoupler drawbacks:

- Channels must support bidirectional data
  - **Optocoupler solutions require up to 16 discrete components (resistors, capacitors, diodes and transistors) to properly operate** and avoid bus glitches or latch up conditions

  - In contrast, digital isolators can integrate I2C functionality while only requiring 6 components (pull-up resistors and decoupling capacitors)

- Optocoupler circuit footprint is roughly **three times larger than an I2C digital isolator**

TEXAS INSTRUMENTS
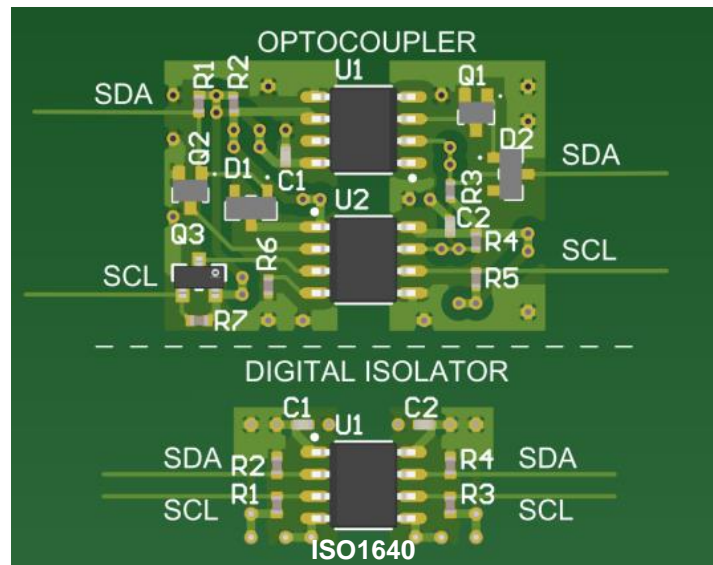
ISO1640
Robust bidirectional functional, 3-kV$_{RMS}$ and 5-kV$_{RMS}$ I2C digital isolators

Features

- **Isolation, immunity and certifications**
  - Integrated SiO2 dielectric capacitors
  - Basic isolation (DIN V VDE V 0884-11)
  - V$_{ISO}$ rating: 3,000 V$_{RMS}$
  - V$_{IOSM}$ surge: up to 8,000 V$_{PK}$
  - V$_{IOWM}$ working voltage: up to 500 V$_{RMS}$
  - CMTI: 100 kV/µs (typ)

- **Electrical characteristics**
  - I2C isolators supporting hot-swap
  - Bidirectional clock
  - Data rate: Up to 1.7 MHz operation
  - Wide supply range: 2.25 V to 5.5 V
  - Low power: 2.4 mA / channel (typ) when channels high
  - Operating temperature range: -40˚C to 125˚C

- **Package**
  - Small SOIC-8: 4 mm creepage / clearance (3,000 V$_{RMS}$)

Applications

Q100 – Automotive qualified version available

- Isolated I2C, SMBus, PMBus interfaces
- Open-drain network interfaces
- Power over Ethernet
- Power supplies
- Battery management
- Motor control systems
- Level shifting

Benefits

- Plug or unplug the device into a system without disruption on the I2C bus

- Reduce cost and board space by not requiring external logic devices for bidirectional I2C support

- Single & multi-master applications enabling clock stretching

- High CMTI provides low-voltage side protection from high switching transients in harsh environments

- Allows use with 2.5-V, 3.3-V and 5.0-V FPGAs and MCUs

- Industry standard footprint - Compatible with ISO1540/1 and industry standard packages
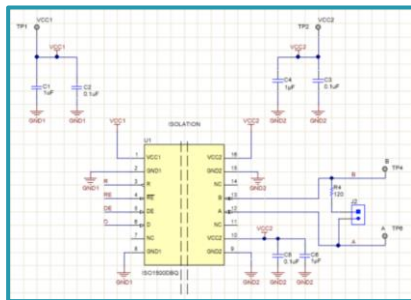

TEXAS INSTRUMENTS
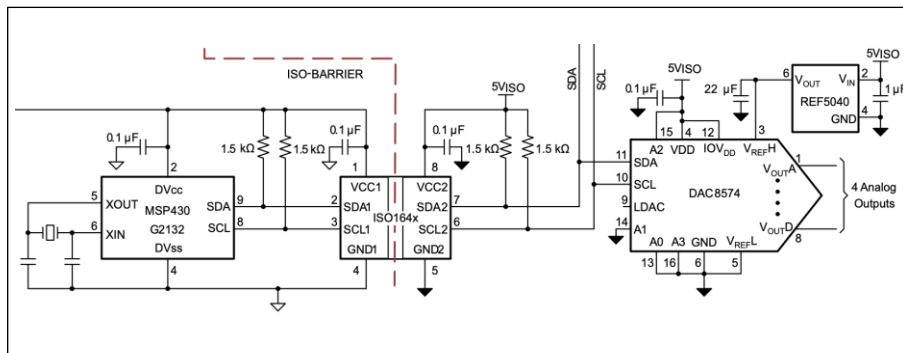
RS-485 isolation

Optocoupler + non-isolated RS-485 transceiver-based solution
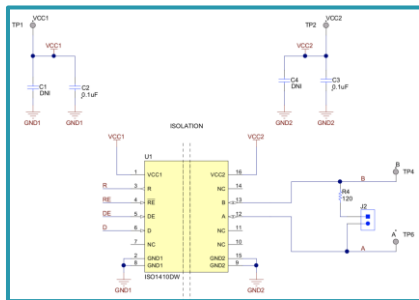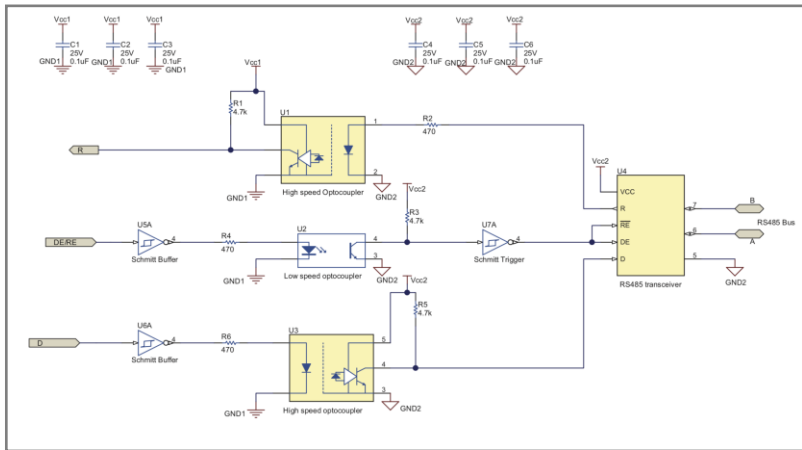
ISO1410

ISO1500

Solution size

- Optocoupler solution: 43 mm x 21 mm
- TI RS-485 reinforced isolation: 19 mm x 14 mm
  - **70% size reduction**
- TI RS-485 basic isolation: 12 mm x 10 mm
  - **86% size reduction**

Reliability

- Isolation barrier
  - Optocoupler solution: Poor isolation lifetime (no TDDB data)
  - TI RS-485 isolation: Very high TDDB isolation lifetime
- Higher temperature
  - Optocoupler solution: -40ºC to 85ºC (rarely 125ºC)
  - TI RS-485 isolation: -40ºC to 125ºC
- Transient noise
  - Optocoupler solution:15 – 25 kV/µs typical
  - TI RS-485 isolation: Typical CMTI of 100 kV/µs

Data rate

- Optocoupler solution: 50-Mbps optocouplers are rare and expensive
- TI RS-485 isolation: Supports up to 50 Mbps

Technical resource:
How to Isolate RS-485 for Smallest Size and Highest Reliability

TEXAS INSTRUMENTS

RS-485 isolation

An integrated solution saves up to 85% board area compared to an optocoupler discrete solution

ISO1500

TEXAS INSTRUMENTS
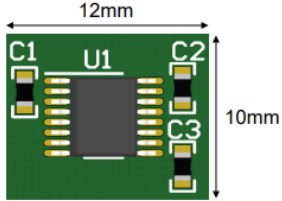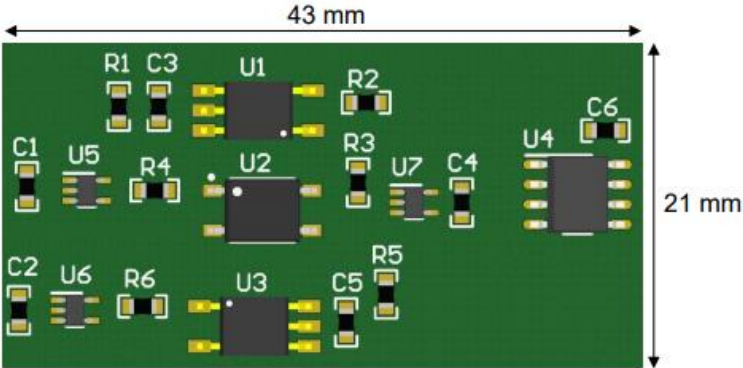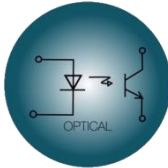
ISO14xx:

5kVrms basic/reinforced isolated RS-485/RS-422 transceiver with robust EMC
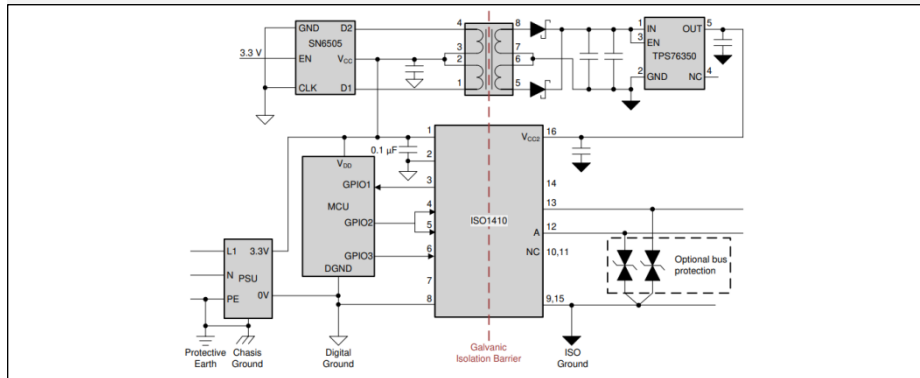
Features

- **Isolation, immunity and certifications**
  - Integrated SiO_2 dielectric capacitors
  - Reinforced and basic isolation (DIN V VDE V 0884-11)
  - V_{ISO} rating: 5,000 V_{RMS}
  - V_{IOSM} surge: up to 10,000 V_{PK}
  - V_{IOWM} working voltage: 1,060 V_{RMS}

- **Electrical characteristics**
  - Compatible with TIA/EIA-485-A and Profibus at 5V (Vcc2)
  - Data rate: 500kbps/ 12Mbps/ 50Mbps
  - Full and half duplex transceivers
  - Wide supply range: 1.71 to 5.5V logic side, 3 to 5.5V bus side
  - Fail-safe receiver for bus open, short and idle
  - 1/8 unit load- up to 256 nodes on bus
  - Bus I/O Protection (w.r.t. GND2)
    - ± 30kV HBM
    - ± 16kV IEC61000-4-2 Contact Discharge
    - ± 4kV IEC61000-4-4 Fast Transient Burst
  - Operating temperature range: -40˚C to 125˚C

- **Package**
  - SOIC-16: 8 mm creepage / clearance

Applications

- Motor drives
- Grid
- Power delivery
- Factory automation
- Building automation
- Lighting

Benefits

- Robust isolation barrier ensures reliable high voltage performance

- CMOS logic level support to interface with 1.8V/3.3V/5V controllers and ASICs

- Profibus compliant transceiver provides higher signal to noise ratio

- Industry's leading IEC ESD and EFT on bus pins allows for reliable communication in harsh industrial environment

- Pin compatible to most competition isolated RS-485 transceivers in market

TEXAS INSTRUMENTS

ISO1500:

3kVrms basic isolated RS-485/RS-422 transceiver in ultra small package

Features

- **Isolation, immunity and certifications**
  - Integrated SiO_2 dielectric capacitors
  - Basic isolation (DIN V VDE V 0884-11)
  - V_{ISO} rating: 3,000 V_{RMS}
  - V_{IOSM} surge: up to 6,000 V_{PK}
  - V_{IOWM} working voltage: 400 V_{RMS}

- **Electrical characteristics**
  - Meets or exceeds TIA/EIA RS-485 standard
  - Data rate: 1Mbps
  - Half duplex transceiver
  - Wide supply range: 1.71 to 5.5V logic side, 4.5 to 5.5V bus side
  - Fail-safe receiver for bus open, short and idle
  - 1/8 unit load- up to 256 nodes on bus
  - Bus I/O protection (w.r.t. GND2)
    - ± 16kV HBM
    - >± 7kV IEC61000-4-2 contact discharge
    - ± 2kV IEC61000-4-4 fast transient burst
  - Operating temperature range: -40˚C to 125˚C

- **Package**
  - Small QSOP-16: 3.7 mm creepage / clearance

Applications

- Motor drives
- Grid
- Power delivery
- Factory automation
- Building automation
- Lighting

Benefits

- Robust isolation barrier to withstand harsh industrial environment

- CMOS logic level support to interface with 1.8V/3.3V/5V controllers and ASICs

- 85% board space reduction compared to optocoupler discrete solutions

- 50% board space reduction compared to 16-SOIC industry standard isolated RS-485 footprint
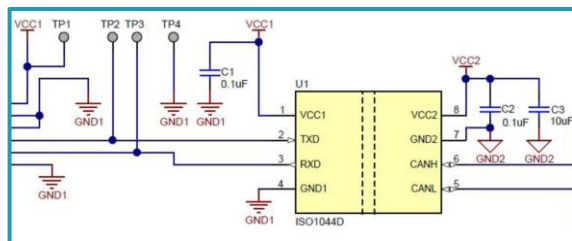
- Most robust transceiver in ultra small QSOP package

TEXAS INSTRUMENTS
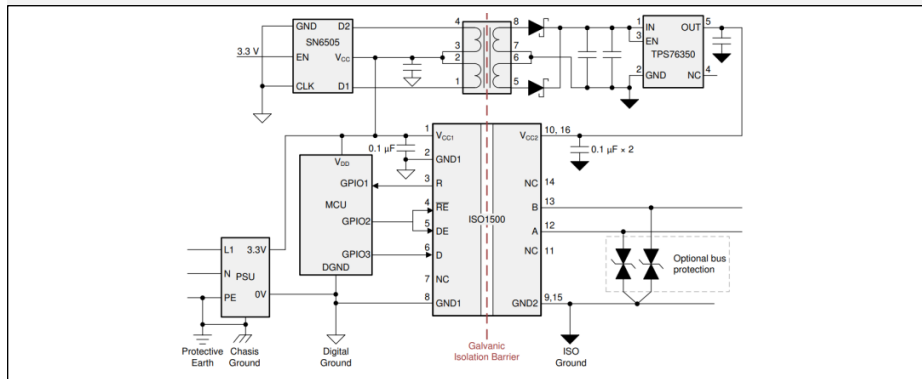
Isolated CAN application

Optocoupler + non-isolated CAN transceiver-based solution
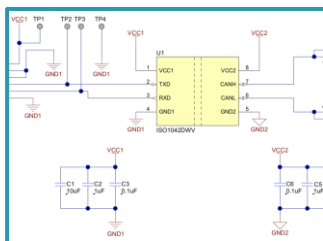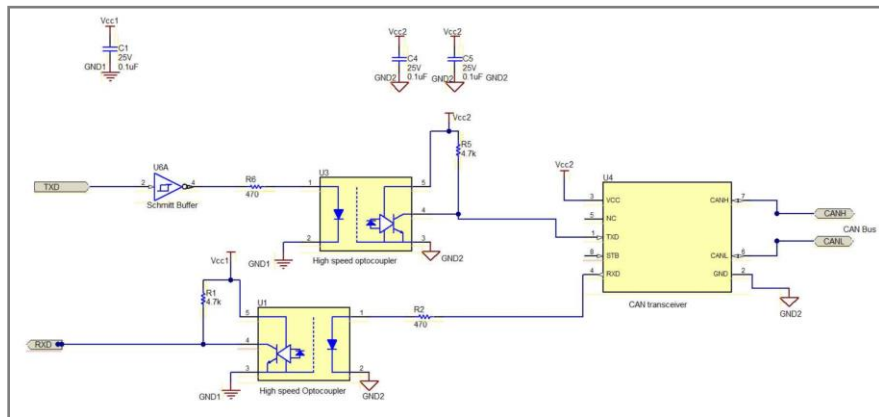
ISO1042

ISO1044

Solution size

- Optocoupler solution: 35mm x 15mm
- TI CAN reinforced isolation: 17 mm x 12 mm
  - **61% size reduction**
- TI CAN reinforced isolation: 12 mm x 7 mm
  - **84% size reduction**

Reliability

- Isolation barrier
  - Optocoupler solution: Poor isolation lifetime (no TDDB data)
  - TI CAN reinforced isolation: Very high TDDB isolation lifetime
- Higher temperature
  - TI CAN reinforced isolation: -40ºC to 125ºC
  - Optocoupler solution: -40ºC to 85ºC (rarely 125ºC)
- Transient noise
  - TI CAN reinforced isolation: Typical CMTI of 100 kV/µs
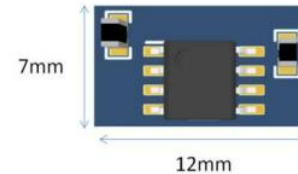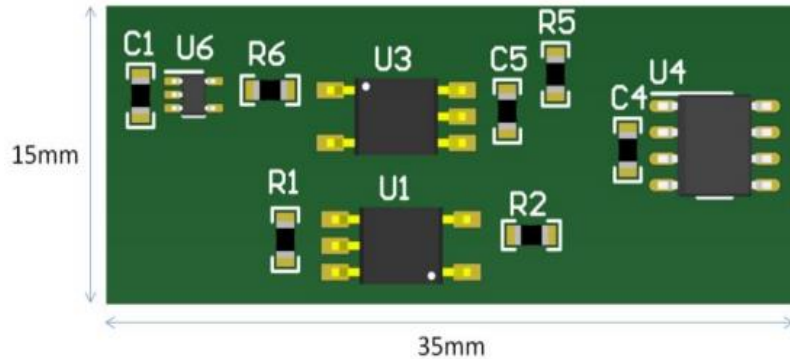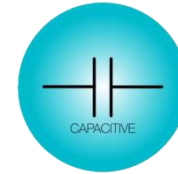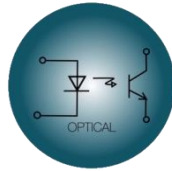 - Optocoupler solution: 15 – 25 kV/µs typical

Propagation delay

- TI CAN reinforced isolation: Low loop delay of 152 ns
- Optocoupler solution: Even high-speed optocouplers offer very high prop delay, limiting the max data rate

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Technical resource:
How to Design an Isolated CAN Port for Space-Constrained Industrial Applications

TEXAS INSTRUMENTS

Controller Area Network (CAN) isolation

An integrated solution saves up to 84% board area compared to an optocoupler discrete solution

ISO1044

TEXAS INSTRUMENTS

ISO1042:

EMC optimized isolated CAN transceiver w/ 70V bus fault protection, CAN FD

Features

- **Isolation, immunity and certifications**
  - Integrated SiO_2 dielectric capacitors
  - Reinforced and basic isolation (DIN V VDE V 0884-11)
  - V_{ISO} rating: up to 5,000 V_{RMS}
  - V_{IOSM} surge: up to 10,000 V_{PK}
  - V_{IOWM} working voltage: up to 1,060 V_{RMS}
  - CMTI: 100 kV/µs (typ) 85 kV/µs (min)

- **Electrical characteristics**
  - Data rate: 5 Mbps (max) supports CAN classic and FD (flexible data rate)
  - Fast loop times: 152ns (typical), 215ns (max)
  - DC bus-fault protection: ± 70V
  - Common mode range: ± 30V
  - IEC ESD on bus pins: ± 8kV
  - Ideal passive – high impedance I/Os when unpowered
  - TXD dominant timeout protection
  - Wide supply range: 1.71 to 5.5V logic side, 4.5 to 5.5V bus side
  - Operating temperature range: -40˚C to 125˚C

- **Package**
  - SOIC-16DW: 8 mm creepage / clearance
  - SOIC-8DWV: 8 mm creepage / clearance

Applications

- Motor Control
- Grid Infrastructure
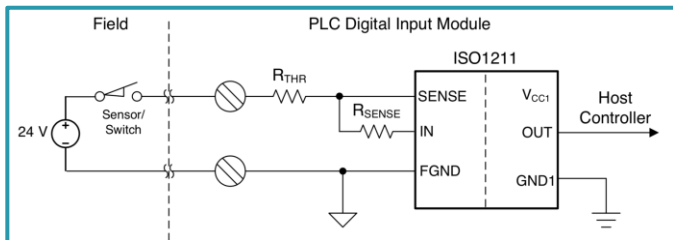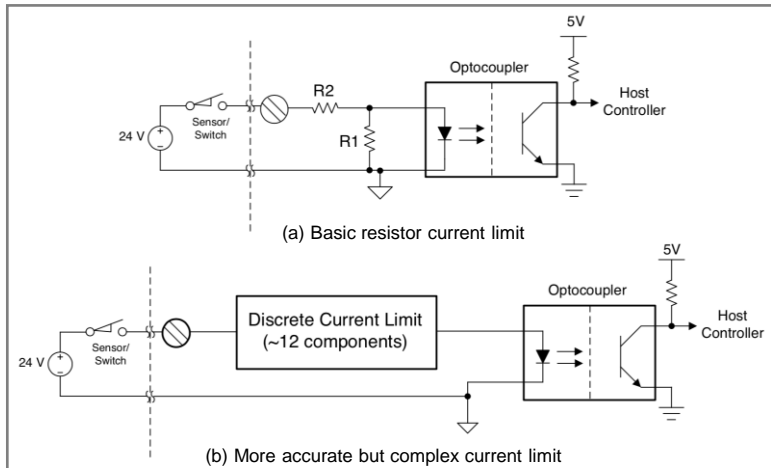- Industrial Automation
- Isolated Power Supplies
- Elevators
- Drones

Benefits

- Meets industry standards to ensure reliable operation in safety critical applications

- Higher speed, faster loop times allow for increased communication throughput for higher bandwidth applications.

- Maintains signal integrity in noisy environments

- Allows use of the device with 1.8V, 2.5V, 3.3V, 5V micro-controllers.

- Integrated solution enables smaller BOM, reduced board space and helps with easier system certification.

Q100 – Automotive Qualified

TEXAS INSTRUMENTS

ISO1044:
Smallest size, basic isolated CAN FD transceiver

Features

- **Isolation, immunity and certifications**
  - Integrated SiO_2 dielectric capacitors
  - Basic isolation (DIN V VDE V 0884-11)
  - V_{ISO} rating: 3,000 V_{RMS}
  - V_{IOSM} surge: 5,000 V_{PK}
  - V_{IOWM} working voltage: 450 V_{RMS}
  - CMTI: 100 kV/µs (typ) 85 kV/µs (min)

- **Electrical characteristics**
  - Data rate: 5 Mbps (max), supports CAN classic and FD (flexible data rate)
  - Fast loop times: 150 ns (typical), 225 ns (max)
  - IEC ESD on bus pins: ± 8 kV, HBM ESD on bus pins: ± 10 kV
  - Bus standoff: ± 58 V, Common mode range: ± 12 V
  - Ideal passive – high impedance I/Os when unpowered
  - TXD dominant timeout protection
  - UVLO protection
  - Thermal shutdown
  - Wide supply range: 1.71 to 5.5 V logic side, 4.5 to 5.5 V bus side
  - Operating temperature range: -40˚C to 125˚C

- **Package**
  - Small SOIC-8D: 4 mm creepage / clearance

Applications

- Motor control
- Grid infrastructure
- Industrial automation
- Isolated power supplies
- Elevators
- Drones

Benefits

- Higher speed, faster loop times allow for increased communication throughput for higher bandwidth applications

- Industry leading CMTI enables signal integrity in noisy environments

- Hot swap support with glitch free bus I/O on power-up / down

- Allows use of the device with 1.8-V, 2.5-V, 3.3-V, 5-V microcontrollers

- Wide Vcc2 range enables easy power supply design

- Integrated solution enables smaller BOM and reduces board space by up to 60% compared to industry standard 16-SOIC package

TEXAS INSTRUMENTS
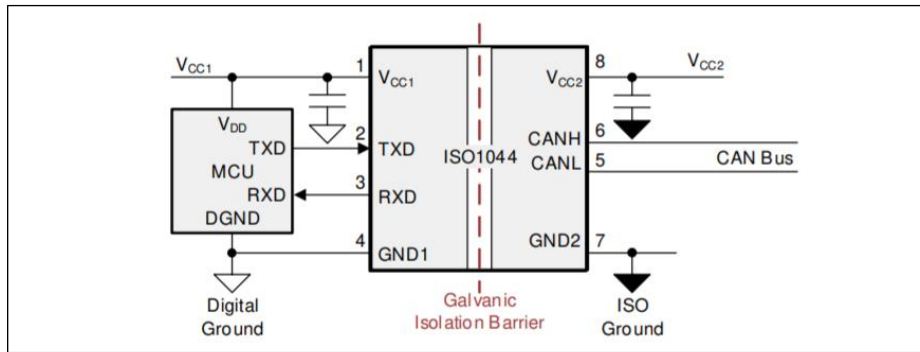
12-V or 24-V industrial digital inputs

Optocoupler solution

(a) Basic resistor current limit

(b) More accurate but complex current limit

ISO1211 with built-in current limit

Solution size (for 8-channels)
– Optocoupler solution: 100 mm x 64 mm
– ISO1211 solution: 50.8 mm x 32.7 mm
  • **74% size reduction**

Reliability
– Isolation barrier
  • Optocoupler solution: Poor isolation lifetime (no TDDB data)
  • ISO1211 solution: Very high TDDB isolation lifetime
– Higher temperature
  • ISO1211 solution: -40ºC to 125ºC
  • Optocoupler solution: -40ºC to 85ºC (rarely 125ºC)
– Transient noise
  • ISO1211 solution: Typical CMTI of 100 kV/µs
  • Optocoupler solution: 15 – 25 kV/µs typical

Current limit
– ISO1211 solution: Very accurate in-built current limit
– Optocoupler solution: Optocouplers do not have built-in current limit and require large external circuit to limit current whose accuracy depends on the tolerances of external circuit & components.

Technical resource:
How To Simplify Isolated 24-V PLC Digital Input Module Designs

TEXAS INSTRUMENTS

ISO121x

2.5 kV$_{RMS}$ isolated 24-V digital input receiver with 60-V standoff on input pin

Features

- **Isolation, immunity and certifications**
  - Integrated SiO$_2$ dielectric capacitors
  - V$_{ISO}$ rating: 2,500 V$_{RMS}$
  - V$_{IOSM}$ surge: up to 5,200 V$_{PK}$
  - V$_{IOWM}$ working voltage: up to 400 V$_{RMS}$
  - CMTI: 70 kV/µs (typ) 25 kV/µs (min)
  - +/-60 V stand-off on input pins

- **Electrical characteristics**
  - Does not need field side supply
  - IEC 61131-2 Type 1/2/3 characteristics
  - 2.1 mA to 2.5 mA precise current limit, resistor programmable up to 6mA for V$_{IN}$ = 6 V to 36 V
  - 6 V to 11 V, voltage transition thresholds
  - Data rate: 4 Mbps (max)
  - Propagation delay: 125 ns (max)
  - Wide supply range: 2.25 V to 5.5 V
  - Operating temperature range: -55˚C to 125˚C

- **Package**
  - Small SOIC-8: 4 mm creepage / clearance (1 channel)
  - Small SSOP-16: 3.7 mm creepage / clearance (2 channels)

Applications

- PLC
- Servo
- Motor control
- Sensors

Benefits

- Robust SiO$_2$ dielectric does not degrade with moisture or temperature, providing industry's longest isolation barrier lifetime

- Replace a 2-mA current limit + optocoupler circuit with a single device

  - Does not need field side power supply

  - Integrated current limit saves power and lower board temperatures

  - Well controlled thresholds for noise immunity

  - Higher speed for faster interfaces, encoders and position feedback

  - Stable performance over lifetime – no drastic aging

- Can be used for 48-V, 110-V, and 240-V DC and AC digital input design

TEXAS INSTRUMENTS
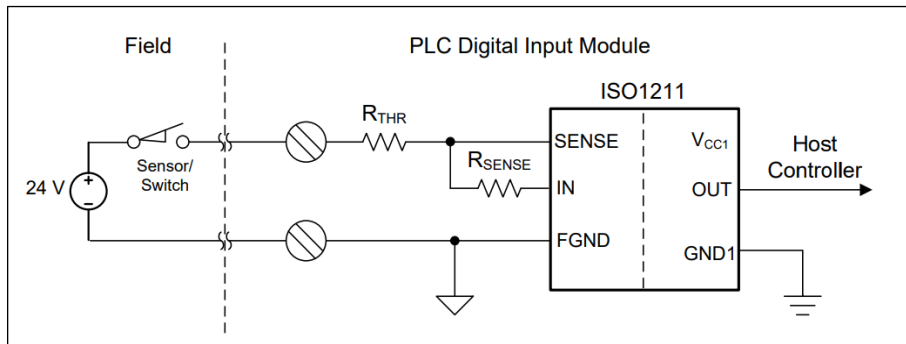
Additional resources
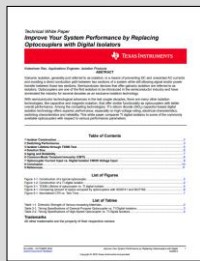
Improve your system performance by replacing optocouplers with digital isolators

How to replace optocouplers with digital isolators in standard interface circuits

Top 9 design questions about digital isolators
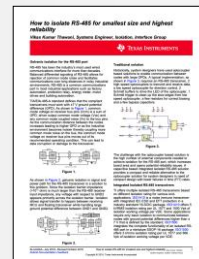
How to isolate RS-485 for smallest size and highest reliability

How to design an isolated CAN port for space-constrained industrial applications

www.ti.com/isolation

TEXAS INSTRUMENTS