Digital Capacitive Isolators: Operation, Benefits, and Applications

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Agenda

• Introduction:
  – What is Isolation?
  – Why Isolate?

• Standards that apply to Isolation

• Isolation Terminology and Key Parameters

• Different Isolation technologies
  – TI’s isolation technology
  – Comparison of key parameters

• Application examples and Portfolio

• Electro Magnetic Compatibility (EMC) for Isolated Systems

• Q & A

• Feedback on TI devices: what do you want to see us do?
Introduction

What is Isolation?

Is a means of preventing DC or uncontrolled transient current from flowing between two communicating points.

Why Isolate?

1. Where there is the potential for voltage surges that may damage equipment or harm humans.
2. Where interconnections involve large ground potential differences (GPDs) and disruptive ground loops are to be avoided.
3. Communication to high side components in motor drive systems.

*Isolation enables communication between a transmitter and a receiver, referenced to very different ground potentials*
1) Electrical Installation can cause large GPDs (ground potential difference) between two remote nodes.

2) A direct ground connection between the nodes closes the ground loop.

3) Noise sources (i.e. electric motors) injecting large currents into the ground modulate the ground loop current.

4) This ground noise then appears in the signal path.

5) An isolator breaks the ground loop, thus removing signal path noise.

6) The GPD yet still exists and the isolator must be robust enough to withstand the large voltage differences.
GPD Can be Mitigated

Without biasing the differential input stage will not work without a ground wire.

Therefore every RS-485 receiver has internal biasing through $R_2$ and $R_3$.

Hence, no ground wire is needed!
GPD Can be Mitigated but Only to Limited Extend

**Common-mode voltage range - V**

-4000 \(\Rightarrow\) -20 -15 -10 -5 0 5 10 15 20 25 \(\Rightarrow\) 4000

**RS-485**

**SUPER RS-485**

**ISOLATED RS-485**

ISO3080/82, ISO35/15, ISO3086/88, ISO1176
ISO35T, ISO3086T, ISO1176T

\(T = \text{integrated transformer driver}\)

LBC184, HVD308x, HVD7x, HVD8x transceivers

HVD2x, HVD17xx transceivers
Protection against high voltage

1) Industrial equipment running of 100s of volts, temporary overvoltage of 1000s of volts, and 10000v surges.

2) Isolation barrier is required to protect low voltage circuitry and human operators.
1) Communication to high side device requires isolation as part of the construction of the motor drive system.

2) The Emitters of high side IGBTs switch between 0 to HV DC rail – this is the same as the secondary side GND for the isolated Gate Driver.
Data Isolation: Common-Mode Transient Event

CMTI – The change in ground 1 relative ground 2. Measured in kV / μSec.
Why Isolate?? - Other reasons

- Other reasons

1. **Noise isolation**
2. **Ground loop isolation**

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**Data**

- **SN65HVD233**
- **DSP with CAN Controller**
- **SN65HVD233**

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**Growth High Voltage**

- **TMS 320 F2810**
- **ISO7421**

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**Motor 480V**

- **SN75477**
- **ISO7220M**

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**Amp**

- **LVC2G06**
- **ISO721**

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**Sensor**

- **TMP101**

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**Fan**

- **120V**

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**Amp**

- **120Ω**

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**Noise isolation**

- **ISO721**
- **ISO7421**

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**Ground loop isolation**

- **ISO7421**

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**Texas Instruments**
Questions

- Where do you isolate?
- Why do you isolate?
- What voltages do you see?
Standards that apply to Isolation

• Component level Standards:
  – IEC 60747-5-2 (VDE 0884-5-2) for Opto Isolators, basic
  – IEC 60747-5-5 (VDE 0884-5-5) for Opto Isolators, reinforced
  – VDE 0884-10 Ed 2.0 for Capacitive/Magnetic isolators, reinforced
  – IEC 60747-17
  – UL 1577
  – ---

• System Level / End Equipment Standards
  – IEC 61800-5-1, safety requirements for adjustable speed drives
  – IEC 60601, Medical equipment standard
  – IEC 61010, safety standard for measurement, control and Lab equipment
  – IEC 60950, Telecom equipment standard
  – ---

• EMC and Emissions
  – IEC 61000-4-x , ESD, EFT, Surge, RF immunity
  – CISPR22 or equivalent, EM emissions
What do standards regulate?

• Essentially Isolation Requirements and Performance.

• How well can the isolator handle:
  – Steady high voltage over lifetime
  – Occasional Overvoltage
  – Surges

• What isolation ratings are required for a given system voltage

• How “reliable” is the isolation:
  – Basic or Reinforced?
Isolation Terminology (1)

- **Creepage Distance** – The shortest path between two conductive parts across the isolation barrier measured along the surface of the insulation. The shortest distance path is found around the end of the package body.

- **Clearance** – The shortest path between conductive input and output leads measured through air.

- **Isolation Capacitance** \( (C_{io}) \) – Total capacitance between the terminals on a first side connected together and the terminals on a second side of the isolation barrier connected together forming a 2-terminal device. Typical value is 1 or 2 pF.

- **Isolation Resistance** \( (R_{io}) \) – Resistance between the terminals on a first side connected together and the terminals on a second side of the isolation barrier connected together forming a 2-terminal device. Typical value is \( >10^{12} \) Ohms.
Creepage and Clearance

Discusses the surface-distance that may conduct if wet/polluted, respectively the air-distance. For 560V/4kV mostly 5mm is sufficient, for 890V/6kV mostly 8mm is needed. Depends on pollution degree.

<table>
<thead>
<tr>
<th>Package/ designation</th>
<th>Creepage mm</th>
<th>Clearance mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrow body SOIC/ D</td>
<td>4.3</td>
<td>4.8</td>
</tr>
<tr>
<td>Gull wing / DUB</td>
<td>6.8</td>
<td>6.1</td>
</tr>
<tr>
<td>Wide body SOIC/ DW</td>
<td>8.1</td>
<td>8.34</td>
</tr>
</tbody>
</table>

**Creepage distance**

Shortest distance between two conductive leads, across isolation barrier, measured along surface of insulation.

**Clearance distance**

Shortest distance between two conductive leads, across isolation barrier, measured through air.
Can we tell the Min Clearance from Package Dimension?

- Min Clearance = 9.97 - 1.27*2 = 7.43mm
- Red Arrow Distance = (9.97mm - 7.6mm) / 2 - 1.27mm = -0.085mm
Isolation Terminology (2)

• **Comparative Tracking Index (CTI)** – Measure of how easily the packaging material or mold compound will erode under electric discharge. Higher CTI values of the insulating material requires smaller minimum Creepage distance.

• **Material Group (per CTI)** - Materials are separated into four groups according to their CTI (Comparative Tracking Index) values. For isolators, this is based on the mold compound properties of packages.
  - Material group I: $600V < \text{CTI}$
  - Material group II: $400V < \text{CTI} < 600V$
  - Material group IIIa: $175V < \text{CTI} < 400V$
  - Material group IIIb: $100V < \text{CTI} < 175V$

• **Common Mode Transient Immunity (CMTI)** – Refers to the ability of a circuit to maintain signal integrity during quick changes in reference potential between the primary and secondary sides. It is specified as the $dV/dt$ up to which no false toggling of the output will occur (e.g. 25 kV/us).

• **Repetitive Voltage ($V_{IORM}$)** – *Definition: Voltage input to output repetitive maximum.* A repetitive peak value of withstand voltage that may be applied across the Isolation barrier through its lifetime. It includes all repetitive transient voltages but excludes all non-repetitive transient voltages; e.g., $560 V_{PK}$, $891 V_{PK}$, or $1414 V_{PK}$.

• **Transient Overvoltage ($V_{IOTM}$)** – *Definition: Voltage input to output transient maximum.* Voltage that may occur temporarily across the barrier (tested per VDE for 1 minute during certification and 1 sec during production), e.g., $4 kV_{PK}$ or $6 kV_{PK}$.
Isolation Terminology (3)

• **Isolation or Withstand Voltage** \( (V_{\text{ISO}}) \) - Voltage that may occur temporarily across the barrier (tested per UL for 1 minute during certification and 1 sec during production at 120% of the rated voltage), mostly 2.5 \( kV_{\text{RMS}} \) or 5 \( kV_{\text{RMS}} \).

  Transient, Isolation, Withstand, Dielectric voltage or rating is sometimes used interchangeably.

• **Surge Voltage** \( (V_{\text{IOSM}}) \) – The highest instantaneous value of an isolation voltage pulse with short time duration and of specified waveshape. Surge testing replicates lightning strikes. Each device is subjected to 50 discharges in each polarity. For reinforced insulation, VDE requires a minimum of 10 \( kV_{\text{PK}} \) rating.

![Graph of Surge Voltage](image)

• **Partial Discharge** – Partial discharge is localized electrical discharge which occurs in the insulation between all terminals of the first side and all terminals of the second side of the coupler. \( V_{\text{PD}} \) is partial discharge voltage at which less than 5 pico columbs of electrons are detected across insulation barrier. It is tested at 1.875 \( x V_{\text{IORM}} \) for 1 second during production.
Isolation Terminology (4)

• Insulation:
  - Functional insulation – Insulation needed for the correct operation of the equipment.
  - Basic insulation – Insulation that provides basic protection against electric shock.
  - Supplementary insulation – Independent insulation applied in addition to Basic insulation in order to ensure protection against electric shock in the event of a failure of the Basic insulation.
  - Double insulation – Insulation comprising both Basic and Supplementary insulation.
  - Reinforced insulation – A single insulation system which provides a degree of protection against electric shock equivalent to Double insulation under the conditions specified by the standard.

• Pollution Degree:
  - Pollution Degree 1 – No pollution, or only dry, non-conductive pollution occurs. The pollution has no influence, e.g. a circuit in a hermetically sealed box such as IC chip.
  - Pollution Degree 2 – Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected, e.g. a circuit used in an office environment such as circuitry inside a computer.
  - Pollution Degree 3 – Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation which is expected, e.g. a circuit that is exposed to outside air but not in direct contact with precipitation such as circuitry inside a garage door opener.
  - Pollution Degree 4 – The pollution generates persistent conductivity caused by conductive dust or by rain or snow, e.g. an exposed outdoor control box for a water pump.
Questions?

• What standards do you need to certify to?
• What standards are giving you grief?
Which technology is better (1)

• Working Voltage (VIORM):
  – Magnetic isolators limited to <500V r.m.s.
  – Opto and Capacitive can do 1kV r.m.s. and beyond.

• Transient Overvoltage (VIOTM)
  – Comparable, 5kV r.m.s. and beyond.

• Surge Voltage:
  – Traditionally Opto and Magnetic better (>10kV)
  – Capacitor based fast catching up.

• CMTI:
  – Magnetic and Capacitive at 25kV/us minimum.
  – Optical worse at 15kV/us minimum.
  – We are looking to push this up.
Which technology is better (2)

• Timing parameters (Propagation delay and skew):
  – Capacitive the best (10ns prop delay), Opto and Magnetic worse (>25ns)

• Parameter stability with time:
  – Capacitive and Magnetic very stable
  – Opto performance known to degrade with time as LED ages.

• Power Consumption at Low Data rate:
  – Magnetic the best (at the expense of high emissions, and power at high data rates).
  – Opto the worst (LED power itself very high)
  – Capacitor in between.

• Power at high data rates:
  – Capacitive the best, followed by Opto, magnetic the worst.
## Specs and Reliability Comparison

<table>
<thead>
<tr>
<th></th>
<th>Opto (Avago)</th>
<th>Magnetic (ADI)</th>
<th>Capacitive (Si Labs)</th>
<th>Capacitive (TI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Data Rate (Mbps)</td>
<td>50</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Typ Power Consumed/Ch @ 25Mbps &amp; 3.3V (mA)</td>
<td>16</td>
<td>3.4</td>
<td>2.7</td>
<td>2</td>
</tr>
<tr>
<td>Max Propagation Delay Time (ns)</td>
<td>22</td>
<td>32</td>
<td>13</td>
<td>12</td>
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<tr>
<td>Pulse Width Distortion (ns)</td>
<td>2</td>
<td>2</td>
<td>4.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Channel-to-Channel skew (ns)</td>
<td>16</td>
<td>2.0</td>
<td>2.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Part-to-Part Skew (ns)</td>
<td>20</td>
<td>10</td>
<td>4.5</td>
<td>2</td>
</tr>
<tr>
<td>ESD on all Pins (kV)</td>
<td>± 2</td>
<td>± 2</td>
<td>± 4</td>
<td>± 4</td>
</tr>
<tr>
<td>Minimum CM Transient Immunity (kV/us)</td>
<td>20</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Temperature Range (°C)</td>
<td>-45..125</td>
<td>-40..125</td>
<td>-40..125</td>
<td>-40..125</td>
</tr>
<tr>
<td>MTBF @ 125°C, 90% Confidence (Hrs)</td>
<td>6.92E+04</td>
<td>3.17E+07</td>
<td>-</td>
<td>1.65E+09</td>
</tr>
<tr>
<td>FIT@ 125°C, 90% Confidence (per 1E+09 hrs)</td>
<td>14391</td>
<td>31.55</td>
<td>-</td>
<td>0.6</td>
</tr>
<tr>
<td>Radiated Electromagnetic-Field Immunity</td>
<td>IEC61000-4-3 (80MHz-1000MHz)</td>
<td>-</td>
<td>Fails*</td>
<td>Fails*</td>
</tr>
<tr>
<td></td>
<td>MIL-STD 461E RS103 (30MHz-1000MHz)</td>
<td>-</td>
<td>Fails*</td>
<td>Fails*</td>
</tr>
<tr>
<td>High-Voltage Lifetime Expectancy (yrs)</td>
<td>-</td>
<td>&lt; 10</td>
<td>&gt; 60*</td>
<td>&gt; 28</td>
</tr>
</tbody>
</table>

* Devices passed the minimum criteria set by some standards. See details later in the presentation.
Competitive Analysis: Dielectric Material

- **SiO2: ISO72x Typical BV is 800 Vpeak/μm**
  - DTI of 16μm => 12.8kV isolation
  - DTI of 32μm => 25.6kV isolation

- **Polyimide: Transformer core Typical BV is 250 Vpeak/μm**
  - DTI of 16μm => 4kV isolation
  - DTI of 32μm => 8kV isolation
  - DTI of 80μm needed to achieve 20kV isolation

- **Epoxy: Opto-couplers: Typical BV is 50 Vpeak/μm**
  - DTI of 16μm => 0.8kV isolation
  - DTI of 32μm => 1.6kV isolation
  - DTI of 400μm needed to achieve 20kV isolation.

- Epoxy based dielectric needs to be 16 x larger than SiO2 based dielectric to be as strong!
Capacitive Isolators have slightly higher channel currents only in the lower 5% of the bandwidth spectrum
How are capacitive isolators constructed?

Cross Sectional View

- **Transmit Chip**
- **Receive Chip**

**High Voltage Capacitor Detail**

- **Top plate = Al**
- **Inter Level Dielectric (Tons of SiO2)**
- **Bottom Plate = Silicon Substrate (doped)**
- **Bond wire**
- **Mold compound**

- **8-14 µm**
How do our capacitive Isolators work?

DC-Path

Signal

OSC
PWM

Duty Cycle
90% | 10%

DC

AC

Signal

AC-Path

Signal

Transient

Pulse

90% | 10%

Signal

Transmit

Pulse

Signal

Duty Cycle
90% | 10%

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Questions

• Which isolation technology would you use?
## Digital Isolators Portfolio & Roadmap

### >5kV RMS
- **ISO7810**
  - VDE Reinforced
  - High Immunity
  - FS Lo/Hi, Low EMI
  - 100 Mbps
  - SOIC-16W
- **ISO7820**
  - VDE Reinforced
  - High Immunity
  - FS Lo/Hi, Low EMI
  - 100 Mbps
  - SOIC-16W
- **ISO7821**
  - VDE Reinforced
  - High Immunity
  - FS Lo/Hi, Low EMI
  - 100 Mbps
  - SOIC-16W
- **ISO7830**
  - VDE Reinforced
  - High Immunity
  - FS Lo/Hi, Low EMI
  - 100 Mbps
  - SOIC-16W
- **ISO7831**
  - VDE Reinforced
  - High Immunity
  - FS Lo/Hi, Low EMI
  - 100 Mbps
  - SOIC-16W
- **ISO7840**
  - VDE Reinforced
  - High Immunity
  - FS Lo/Hi, Low EMI
  - 100 Mbps
  - SOIC-16W
- **ISO7841**
  - VDE Reinforced
  - High Immunity
  - FS Lo/Hi, Low EMI
  - 100 Mbps
  - SOIC-16W
- **ISO7842**
  - VDE Reinforced
  - High Immunity
  - FS Lo/Hi, Low EMI
  - 100 Mbps
  - SOIC-16W

### 5kV RMS
- **ISO7520**
  - Low Power
  - Fail Safe High
  - 1 Mbps
  - SOIC-16W
- **ISO7521**
  - Low Power
  - Fail Safe High
  - 1 Mbps
  - SOIC-16W
- **ISO7640FM**
  - Low Power
  - Fail Safe Low
  - 150 Mbps
  - SOIC-16W
- **ISO7641FM**
  - Low Power
  - Fail Safe Low
  - 150 Mbps
  - SOIC-16W

### 3kV RMS
- **ISO7310C**
  - Lower Power
  - Fail Safe High*
  - 25 Mbps
  - SOIC-8N
- **ISO7320(F)C**
  - Lower Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-8N
- **ISO7321(F)C**
  - Lower Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-8N
- **ISO7330(F)C**
  - Lower Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-8N
- **ISO7331(F)C**
  - Lower Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-16W
- **ISO7340(F)C**
  - Lower Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-16W
- **ISO7341(F)C**
  - Lower Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-16W
- **ISO7342C**
  - Lower Power
  - Fail Safe High*
  - 25 Mbps
  - SOIC-16W
- **ISO7321(F)C**
  - Lower Power
  - Fail Safe Low
  - 50 Mbps
  - SOIC-8N
- **ISO7322**
  - O/P Enable
  - Fail Safe High
  - 100 &150 Mbps
  - SOIC-8N
- **ISO7420(F)C**
  - Lower Power
  - Fail Safe Low
  - 25 Mbps
  - SOIC-8N
- **ISO7422(F)C**
  - Lower Power
  - Fail Safe Low
  - 1.5,25,150 Mbps
  - SOIC-8N
- **ISO7423(F)C**
  - Lower Power
  - Fail Safe Low
  - 1.5,25,150 Mbps
  - SOIC-16W
- **ISO7631F**
  - Selectable FS
  - Fail Safe High/Lo
  - 25 &150 Mbps
  - SOIC-16W
- **ISO7641FC**
  - Low Power
  - Fail Safe High
  - 50 Mbps
  - SOIC-16W
- **ISO7640FM**
  - Low Power
  - Fail Safe Low
  - 150 Mbps
  - SOIC-16W

### 2.5kV RMS
- **ISO7310C**
  - Low Power
  - Fail Safe High*
  - 25 Mbps
  - SOIC-8N
- **ISO7320(F)C**
  - Low Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-8N
- **ISO7321(F)C**
  - Low Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-8N
- **ISO7330(F)C**
  - Low Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-8N
- **ISO7331(F)C**
  - Low Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-16W
- **ISO7340(F)C**
  - Low Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-16W
- **ISO7341(F)C**
  - Low Power
  - Fail Safe High/Low
  - 25 Mbps
  - SOIC-16W
- **ISO7342C**
  - Low Power
  - Fail Safe High*
  - 25 Mbps
  - SOIC-16W
- **ISO7322**
  - O/P Enable
  - Fail Safe High
  - 100 &150 Mbps
  - SOIC-8N
- **ISO7420(F)C**
  - Low Power
  - Fail Safe Low
  - 50 Mbps
  - SOIC-8N
- **ISO7421**
  - Low Power
  - Fail Safe Low
  - 1.5,25,150 Mbps
  - SOIC-8N
- **ISO7422(F)C**
  - Low Power
  - Fail Safe Low
  - 1.5,25,150 Mbps
  - SOIC-8N
- **ISO7423(F)C**
  - Low Power
  - Fail Safe Low
  - 1.5,25,150 Mbps
  - SOIC-16W
- **ISO7631F**
  - Selectable FS
  - Fail Safe High/Lo
  - 25 &150 Mbps
  - SOIC-16W
- **ISO7641FC**
  - Low Power
  - Fail Safe High
  - 50 Mbps
  - SOIC-16W
- **ISO7640FM**
  - Low Power
  - Fail Safe Low
  - 150 Mbps
  - SOIC-16W

### CHANNEL COUNT
- SINGLE: 1 / 0
- DUAL: 2 / 0
- TRIPLE: 3 / 1
- QUAD: 4 / 0

### Roadmap
- Existing
- New
- Preview
- Roadmap

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*High Immunity: 100 & 150 Mbps*

*Fail Safe (Low): 25 Mbps*
## Isolated Functions

<table>
<thead>
<tr>
<th>5kV RMS</th>
<th>2.5kV RMS</th>
<th></th>
<th>2.5kV RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ISO3086T</strong>&lt;br&gt;<strong>w/ Xfmr Driver</strong>&lt;br&gt;BUS VCC = 5V 20 Mbps, SOIC-16W</td>
<td><strong>ISO3086</strong>&lt;br&gt;BUS VCC = 5V 20 Mbps, SOIC-16W</td>
<td><strong>ISO1050DW</strong>&lt;br&gt;BUS VCC = 5V 1 Mbps SOIC-16W</td>
<td><strong>ISO3086T</strong>&lt;br&gt;<strong>w/ Xfmr Driver</strong>&lt;br&gt;BUS VCC = 5V 20 Mbps, SOIC-16W</td>
</tr>
<tr>
<td><strong>ISO3088</strong>&lt;br&gt;BUS VCC = 5V 20 Mbps, SOIC-16W</td>
<td><strong>ISO3088</strong>&lt;br&gt;BUS VCC = 5V 20 Mbps, SOIC-16W</td>
<td><strong>ISO5000</strong>&lt;br&gt;2.5A, VCC2= 15-30V DESAT, UVLO, SOIC-16W</td>
<td><strong>ISO3086</strong>&lt;br&gt;BUS VCC = 5V 20 Mbps, SOIC-16W</td>
</tr>
<tr>
<td><strong>ISO3082</strong>&lt;br&gt;BUS VCC = 5V 200 Kbps 5V, SOIC-16W</td>
<td><strong>ISO3082</strong>&lt;br&gt;BUS VCC = 5V 200 Kbps 5V, SOIC-16W</td>
<td><strong>ISO1541</strong>&lt;br&gt;Bi-directional Data Uni-directional Clk VCC = 3.3 - 5V, 1MHz, SOIC-8N</td>
<td></td>
</tr>
<tr>
<td><strong>ISO35T</strong>&lt;br&gt;<strong>w/ Xfmr Driver</strong>&lt;br&gt;BUS VCC = 3.3V 1 Mbps, SOIC-16W</td>
<td><strong>ISO35</strong>&lt;br&gt;BUS VCC = 3.3V 1 Mbps, SOIC-16W</td>
<td><strong>ISO1540</strong>&lt;br&gt;Bi-directional Data Bi-directional Clk VCC = 3.3 - 5V, 1MHz, SOIC-8N</td>
<td></td>
</tr>
<tr>
<td><strong>ISO1176</strong>&lt;br&gt;BUS VCC = 5V 40 Mbps SOIC-16W</td>
<td><strong>ISO1176</strong>&lt;br&gt;BUS VCC = 5V 40 Mbps SOIC-16W</td>
<td></td>
<td><strong>ISO35T</strong>&lt;br&gt;<strong>w/ Xfmr Driver</strong>&lt;br&gt;BUS VCC = 3.3V 1 Mbps, SOIC-16W</td>
</tr>
<tr>
<td><strong>ISO1050DWB</strong>&lt;br&gt;BUS VCC = 5V 1 Mbps SOIC-16W</td>
<td><strong>ISO1050DUB</strong>&lt;br&gt;BUS VCC = 5V 1 Mbps SOP-8GW</td>
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<td><strong>ISO1176</strong>&lt;br&gt;BUS VCC = 5V 40 Mbps SOIC-16W</td>
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<tr>
<td><strong>ISO1540</strong>&lt;br&gt;Bi-directional Data Bi-directional Clk VCC = 3.3 - 5V, 1MHz, SOIC-8N</td>
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<td></td>
<td><strong>ISO150</strong>&lt;br&gt;2-ch, Prog direction 80 MBd 1.5kV isolation SO-28</td>
</tr>
<tr>
<td><strong>ISO3086</strong>&lt;br&gt;BUS VCC = 3.3V 1 Mbps, SOIC-16W</td>
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<td><strong>SN6505</strong>&lt;br&gt;Low Noise Xmer SOT-23 (6 pin)</td>
</tr>
<tr>
<td><strong>ISO3088</strong>&lt;br&gt;BUS VCC = 3.3V 1 Mbps, SOIC-16W</td>
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<td></td>
<td><strong>SN6501-Q1</strong>&lt;br&gt;Xmer drv: Auto qual 3.3V or 5V supply Idrive = 350mA (5V) SOT-23 (5 pin)</td>
</tr>
<tr>
<td><strong>ISO1176</strong>&lt;br&gt;BUS VCC = 3.3V 1 Mbps, SOIC-16W</td>
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<td><strong>SN6501</strong>&lt;br&gt;Transformer Driver 3.3V or 5V supply Idrive = 350mA (5V) SOT-23 (5 pin)</td>
</tr>
<tr>
<td><strong>ISO35</strong>&lt;br&gt;BUS VCC = 3.3V 1 Mbps, SOIC-16W</td>
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</tr>
<tr>
<td><strong>ISO15</strong>&lt;br&gt;BUS VCC = 3.3V 1 Mbps, SOIC-16W</td>
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</tbody>
</table>

**CAN** | **I2C** | **GATE DRIVERS** | **Others**

**Full Duplex** | **Half Duplex** | **Half Duplex** | **CAN** | **I2C** | **GATE DRIVERS** | **Others**

RS-485 | RS-485 | Profibus | | | | |

**ISO58xx**<br>VDE Reinforced 2.5/5A w/ High CMTI & Miller Clamp

**ISO5500**<br>2.5A, VCC2= 15-30V DESAT, UVLO, SOIC-16W

**SN6505**<br>Low Noise Xmer SOT-23 (6 pin)

**SN6501-Q1**<br>Xmer drv: Auto qual 3.3V or 5V supply Idrive = 350mA (5V) SOT-23 (5 pin)

**SN6501**<br>Transformer Driver 3.3V or 5V supply Idrive = 350mA (5V) SOT-23 (5 pin)

**ISO150**<br>2-ch, Prog direction 80 MBd 1.5kV isolation SO-28

**TI Confidential – NDA Restrictions**
**Bullet-proof EMC (Electro Magnetic Compatibility)**

- EMC is equivalent to Robustness and critical to the Industrial Market
- TI’s Reinforced Capacitive Isolation sets new levels for EMC & CMTI.
  - Exceeds WW EMC requirements
  - 100kV/us CMTI enables next-gen driver technology - GaN/SiC FETs

<table>
<thead>
<tr>
<th>EMC Metric</th>
<th>Standard</th>
<th>Class</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiated Immunity</td>
<td>IEC-61000-4-3</td>
<td>Class A</td>
<td>&gt; 20V/m @ &lt; 1GHz, &gt; 16V/m @ &gt; 1GHz</td>
</tr>
<tr>
<td>Conducted Immunity</td>
<td>IEC-61000-4-6</td>
<td>Class A</td>
<td>&gt; 15Vrms @ &lt; 80MHz</td>
</tr>
<tr>
<td>Power frequency,</td>
<td>IEC-61000-4-8,9</td>
<td>Class 5</td>
<td>&gt;4kA/m</td>
</tr>
<tr>
<td>Pulse magnetic</td>
<td>IEC-61000-4-2</td>
<td>Level 4</td>
<td>8kV Contact</td>
</tr>
<tr>
<td>ESD</td>
<td>IEC-61000-4-4</td>
<td></td>
<td>Supply/IO 4kV/2kV</td>
</tr>
<tr>
<td>EFT/Burst</td>
<td>IEC-61000-4-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surge</td>
<td>IEC-61000-4-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions</td>
<td>EN55022/CISPR2 2B / SAE J1752-3 / FCC15</td>
<td>Class X -</td>
<td>&gt; 10kV</td>
</tr>
<tr>
<td>Static CMTI</td>
<td>IEC-60747-17</td>
<td>Class B</td>
<td>At least 4dB better than competition</td>
</tr>
<tr>
<td>Dynamic CMTI</td>
<td>IEC-60747-17</td>
<td></td>
<td>&gt; 50kV/us min 100 kV/us typ</td>
</tr>
</tbody>
</table>

> 35kV/us
Isolated RS-485 Bus Design

Node 1

Node 2

Node 3

Termination Plug with Failsafe Biasing

Termination Plug
Isolated RS-485 Node Design

PSU

+ 3.3V

- 0V

L1

N

PE

Short thick Earth wire or Chassis

Protective Earth Ground, Equipment Safety Ground

Non-isolated Ground

Floating RS-485 Common

PSU

L1

N

PE

Protective Earth Ground, Equipment Safety Ground

Non-isolated Ground

Floating RS-485 Common
Isolating the I²C Bus

SDA channel design and voltage levels at SDA1

SDA channel timing in receive and transmit directions
Isolated $I^2C$ DACQ System

$V_s = 3.3V$

$0.1\mu F$

1:2.0, 11V$\mu$s from Wuerth-Electronics / Midcom

Order No: 760390015

ISO-BARRIER

T1 = 1:2.0, 11V$\mu$s from Wuerth-Electronics / Midcom

Order No: 760390015

4 Analog Inputs

4 Analog Outputs

MSP430 G2132

ISO1541

LP2981-50

Vcc1 Vcc2

GND1 GND2

8

7

4 5

O.1\mu F 0.1\mu F

M80520L

10\mu F 0.1\mu F

10\mu F

22\mu F

1\mu F

DAC8574

VDD

A1

A0 A3 GND VREF

VOUTA

VOUTD

VOUT

VIN

VREFH

IOVDD

5VISO

5VISO

5VISO

5VISO

5VISO

5VISO

5VISO

5VISO

5VISO

5VISO

5VISO

5VISO

5VISO
Isolated Power Supply Design

Push-pull transformer driver,
can drive one to two transformers,
with and without linear regulators.
Isolated CAN with ISO1050
Isolated Gate Driver for Motor Control
**ESD**

- IEC 61000-4-2.
- Key specifications (level 4):
  - Voltage peak: 8kV.
  - Current peak: 30A
  - Current rise time: 0.7ns to 1ns.
  - Current at 30ns: 16A.
  - Current at 60ns: 8A.

**EFT**

- IEC 61000-4-4.
- Key specifications (level 4):
  - Voltage peak: 4kV (supply), 2kV(IO).
  - Output impedance: 50 Ohms.

**SURGE**

- IEC 61000-4-5.
- Key specifications (level 4):
  - Voltage peak: 4kV.
  - Output impedance: 2 Ohms.
ESD/EFT/Surge – non-isolation case

- ESD/EFT/Surge protection involves on-board and on-chip protection circuitry and overvoltage suppressors.
- These convey ESD/EFT/Surge currents safely to GND and protect circuitry.
- AC path to Protection Earth (PE) prevents bounce on GND.
  - GND bounce is not a reliability concern for IC.
ESD/EFT/Surge – isolation case

**Case 1:**
- $C_{HV}$ provides an AC path to PE for ESD current.
- Bounce on GND2 is limited $\Rightarrow$ less stress across the isolation barrier.

**Case 2:**
- GND on strike side is floating.
- Bounce on GND2 is very high, limited only by board parasitic capacitance $\Rightarrow$ high stress and current across the isolation barrier.
- Entire magnitude of the stress suffered by isolation barrier
- External ESD structures won’t help
Questions?

- What applications do you see in your systems?
- What EMC problems have you faced?
Thank You!

http://e2e.ti.com/