Gate Driver Selection

APEC 2017
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Overview

Topics:

• Isolation technologies pros and cons
• Isolation voltage ratings
• Output drive current capability
• I/O delay time
• Additional features
Isolation Technologies (Optical)

Advantages:
- Mature technology (oldest)
- Physical barrier utilizing dielectric insulating material
- Used by Avago (Broadcom), Fairchild (ON Semi), and others

Disadvantages:
- Relatively large drive current for primary LED
- Unable to implement ‘Exclusive OR’ shoot through feature
- Relatively large variation in propagation delay with temperature change
- Aging (decreased LED output) over time
Isolation Technologies (RF)

Advantages:
- Requires less input power than optoisolator technologies
- Lower propagation delay than optoisolators
- Total immunity to magnetic fields
- No LED to wear out

Disadvantages:
- Higher current consumption than magnetic isolation
- Carrier frequency limits pulse position accuracy(?)
Isolation Technologies (Capacitive)

Advantages:
- Physical barrier utilizing dielectric insulating material
- No LED to wear out
- Total immunity to magnetic fields
- Used by Texas Instruments (developed by Burr Brown)

Disadvantages:
- Higher current consumption than transformer isolation
Isolation Technologies (Coreless Transformer)

Principal suppliers: Analog Devices, Infineon, ROHM

Advantages:
- No LED to wear out
- Used by many suppliers
- Consistent propagation delay vs. temperature
- Lowest current consumption
- Generally higher CMR than optical isolators
- Lower part-to-part skew than optical

Disadvantages:
- Some sensitivity to magnetic fields
ROHM’s Isolation Configuration

- **SSOP-B20W**
- **Cu Island**
- **Coreless Transformer**
- **Low Voltage**
- **High Voltage**
- **Cu Coil**
- **SiO₂**
- **Si Substrate**
- **Bonding PAD**
Isolation Performance

Figure 3

For insulation tests isolators are treated as two-terminal devices.
Various Component Standards for Isolators

- Component Standards Scope -
  Optical and Digital Isolators

**IEC 60747-5-5: Optoisolators:**
This component standard gives the terminology, essential ratings, characteristics, safety tests as well as the measuring methods for photocouplers (optocouplers). Photocoupler is an optoelectronic device designed for the transfer of the electrical signals by utilizing optical radiation to provide the coupling with electrical isolation between the input and the output. Reinforced insulation.¹

**VDE 0884-10: Non-Opto (Digital) Isolators:**
This component standard gives the terminology, essential ratings, characteristics, safety test and the measuring methods of magnetic and capacitive couplers. Magnetic and capacitive couplers consist of a transmitter stage and a receiver stage on either side of a galvanic insulation barrier. The device transmits a signal across the insulation boundary where a receiver stage is able to detect the transmitted signal and uses the information to generate the electrical output signal. This standard specifies magnetic and capacitive isolation barrier mechanisms and the insulation functions for Basic and Reinforced insulation.¹

**UL 1577: Optocouplers and Digital Isolators:**
This component standard covers optical isolators, also called optical couplers or photocouplers: a) intended to provide unidirectional signal transfer between dielectrically isolated circuits and, b) intended for use in equipment with a supply voltage not exceeding 600 Vac (rms or dc). These requirements evaluate the electrical isolation properties of single and double [reinforced]¹ (protection) insulation between the isolated circuits of the optical isolator.

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¹ Refer to the specific standard for detailed specifications and requirements.
Creepage and Clearance

- Required distances depend on the ‘Pollution Degree’ of the environment
- Creepage requirements can be reduced by using conformal coating
- Creepage between PCB traces can be increased by milling slots
Output Current

- Required current is directly related to the Gate Charge (Qg) Operating Speed (AN-944 International Rectifier, APT0103 Advanced Power Technology)
- Output current from Gate Driver ICs ranges from about 1A to about 5A
- Generally driving a single TO-220 or TO-247 device does not require buffering
- Driving power modules almost always requires buffering

![Diagram of IXYS IXDN614 (14A)](image)

**Figure 8**
Input-Output Delay Time (Propagation Delay)

- All technologies introduce propagation delay
- Other variables may be more important than the actual delay
  - Propagation distortion (difference between turn-on and turn-off)
  - Propagation change from part to part
  - Propagation change over temperature
Propagagation Delay Comparison example

Conditions: BM6105FW, ROHM Eval Board, VCC1=5.0V, VCC2=15V, VEE2=0V, INA=10kHz, OUT1_H/L=No Load
Temperature Monitoring

- IGBT and SiC Power Modules often contain either an NTC thermistor or a diode to monitor temperature.
- In the event of catastrophic failure, plasma or the DC Bus may contact the temperature sensor.

![Figure 9](image)

- Many systems need to continuously monitor the baseplate temperature.
- For safety reasons, there must be isolation back to the primary side.
- ROHM offers Gate Drivers with a current source for the sensor and either a comparator with isolation or a PWM signal back to the primary side.
Miller Clamp and Negative Power Supply

- Most high-power applications will need a Miller clamp, negative turn-off voltage, or both.
- Some gate drivers include the Miller clamp transistor, while others require an external transistor.
- The industry trend is to try to avoid the cost and complexity of a negative supply.
Separated Outputs

- This feature makes it easy to choose optimal times for turn-on and turn-off
- Eliminates the need to add one or two diodes for asymmetrical switching
- Requires an extra pin
- Offered by several manufacturers
Safety Features

- Under Voltage Lock Out (UVLO) for both primary and secondary sides
- Desaturation (Desat) functionality
- Slow turn-off for Desat or over-current (prevents overshoot)
- Exclusive-OR input stage
- Temperature monitoring (of the power module)
- Output state feedback (what’s delivered to the gate matches the input)
Desaturation (Desat) Function

- When OUT = HIGH a 500uA current source tries to pull up the DESAT pin
- During normal operation the Drain (or Collector) is just a few volts above GND
- If the IGBT Collector (or MOSFET Drain) exceeds 9V the comparator will trip
- Output will remain OFF and FLT is asserted until user sends XRST
Built-In Flyback Controller

- How to provide isolated power to the ‘6-pack’ of power devices?
- One method is to use a ‘centralized’ power supply with 4 secondary windings
- Each High Side driver requires its own supply (x3)
- The 3 Low-Side drivers can share a single supply (x1)

The disadvantage is that longer wires may be needed to prevent coupling between supplies and routing gets complicated

The alternative method is to buy 6 small supplies or BUILD YOUR OWN
- Built-in controller makes the job easier and takes up less real estate on the PCB
- Uses 6 small transformers instead of 1 large transformer
- Isolated supply is available exactly where you need it, not 6” away from the Driver
- Transformer manufacturers can provide off-the-shelf parts for this application
# Gate Driver Comparison

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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<tr>
<td>Item</td>
<td>ISO5500</td>
<td>ADuM4223</td>
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<td>Number of channels</td>
<td>1</td>
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<td>1</td>
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<td>2.5 A</td>
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<td>2 A</td>
<td>1.0 A</td>
<td>3 A</td>
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<td>12</td>
<td>Propagation Delay (max)</td>
<td>300 nsec</td>
<td>59 nsec</td>
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<td>Maximum Output voltages</td>
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<td>Common Mode Transient immunity</td>
<td>50 kV / usec</td>
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<td>5000 VRMS</td>
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<td>5000 VRMS</td>
<td>2500 VRMS</td>
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<td>680 V peak (was 1200)</td>
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<td>1420V peak</td>
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References

Figure 1 : Ching, Vincent (Jan 2013) Avago Technologies “Use Dynamic Common-Mode Rejection Test To Evaluate Industrial Isolator Performance”, Electronic Design
Figure 2 : Alfano, Don, Silicon Labs “Pin-Compatible Digital Isolated Gate Drivers Make Life Easy for Power Designers”
Figure 3 : Gingerich, Kevin and Sterzik, Chris (Jan 2006) Texas Instruments “The ISO72x Family of High-Speed Digital Isolators” Application Report SLLA198
Figure 4 : Kugelstadt, Thomas, (May 2009) Texas Instruments “How to design with capacitive digital isolators” EE times
Figure 5 : Kugelstadt, Thomas, Texas Instruments “Capacitive isolators: functional principle, internal construction”
Figure 6 : Lohbeck, David, National Instruments “Understanding isolator standards and certification to meet safety requirements” EDN January 26, 2016
Figure 7 : Cantrell, Mark, Analog Devices “Reinforced Isolation in Data Couplers” Technical Article MS-2242
Figure 8 : ROHM Semiconductor (August 2014) “SiC Power Devices and Modules” Application Note
Figure 9 : Infineon Technologies (Nov 2009) “Using the NTC inside a power electronic module” AN2009-10
Figure 10 : Infineon Technologies (June 2015) “Separate output variant for MOSFET” 1EDI60N12AF Data Sheet