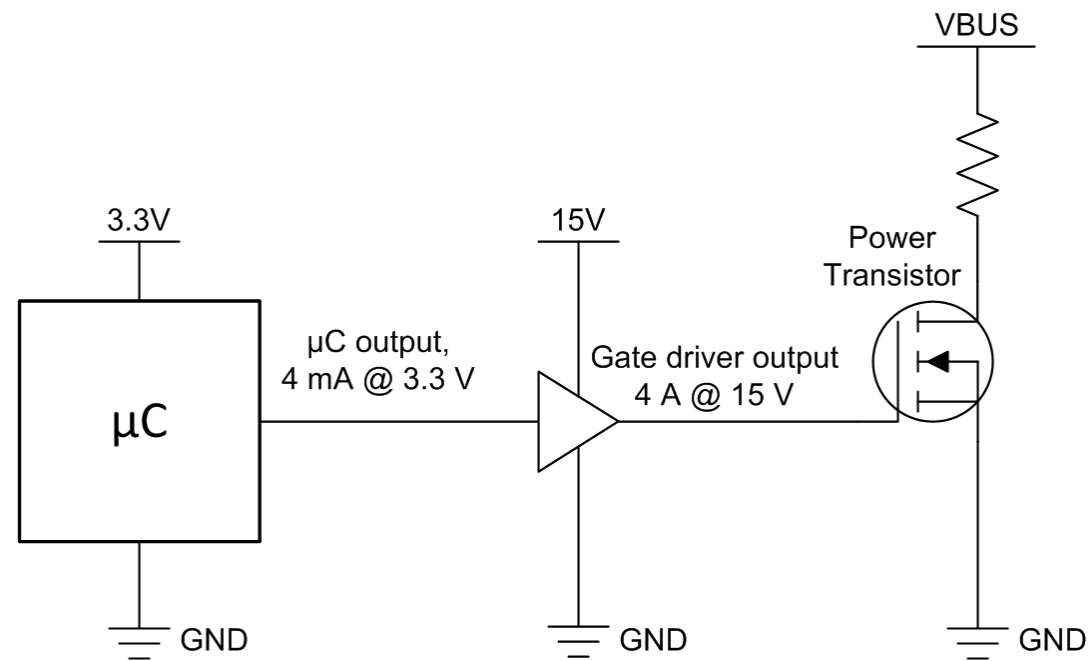


Introduction – What is an isolated gate driver?

TIPL 501

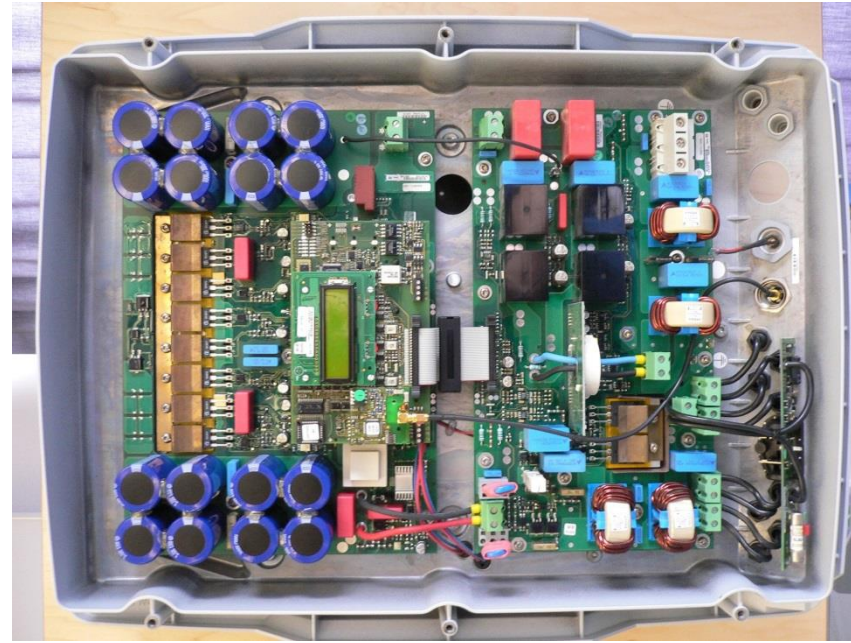
TI Precision Labs – Isolated Gate Drivers

Presented and Prepared by Derek Payne

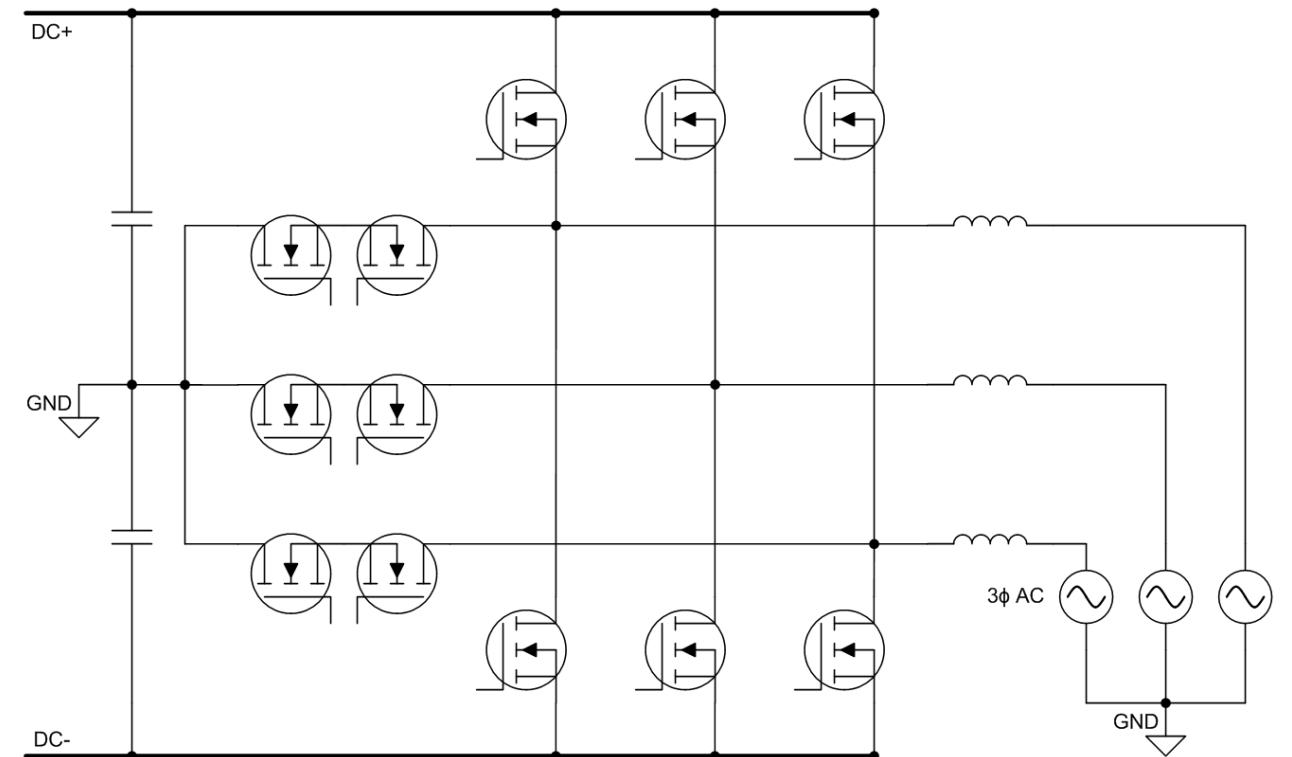
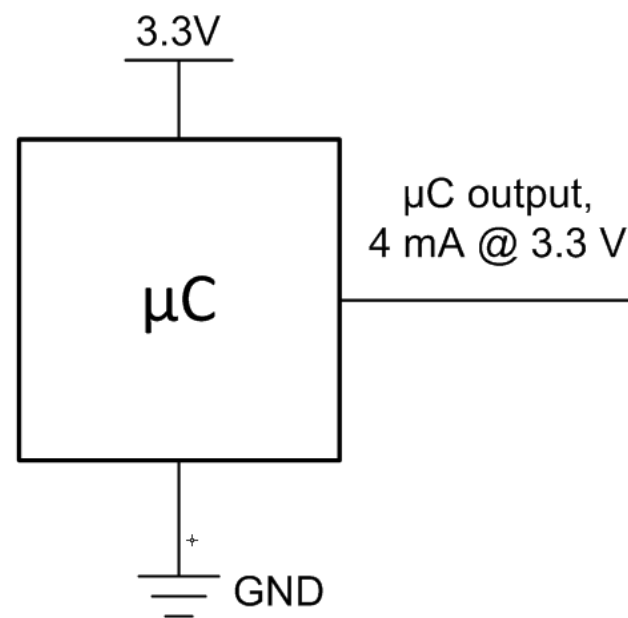


WHAT IS A GATE DRIVER?

Gate drivers and switching power supplies



- 12x Transistor with:
 - **> 5 V threshold voltage**
 - > 10 nF capacitive load
 - > 40 kHz switching
 - Not all ground referenced



Gate drivers and power transistors

Table 1 Key Performance Parameters

| Parameter | Value | Unit |
|----------------------|-------|------------------|
| $V_{DS} @ T_{j,max}$ | 700 | V |
| $R_{DS(on),max}$ | 45 | m Ω |
| $Q_{g,typ}$ | 93 | nC (9.3nF @ 10V) |
| $I_{D,pulse}$ | 212 | A |

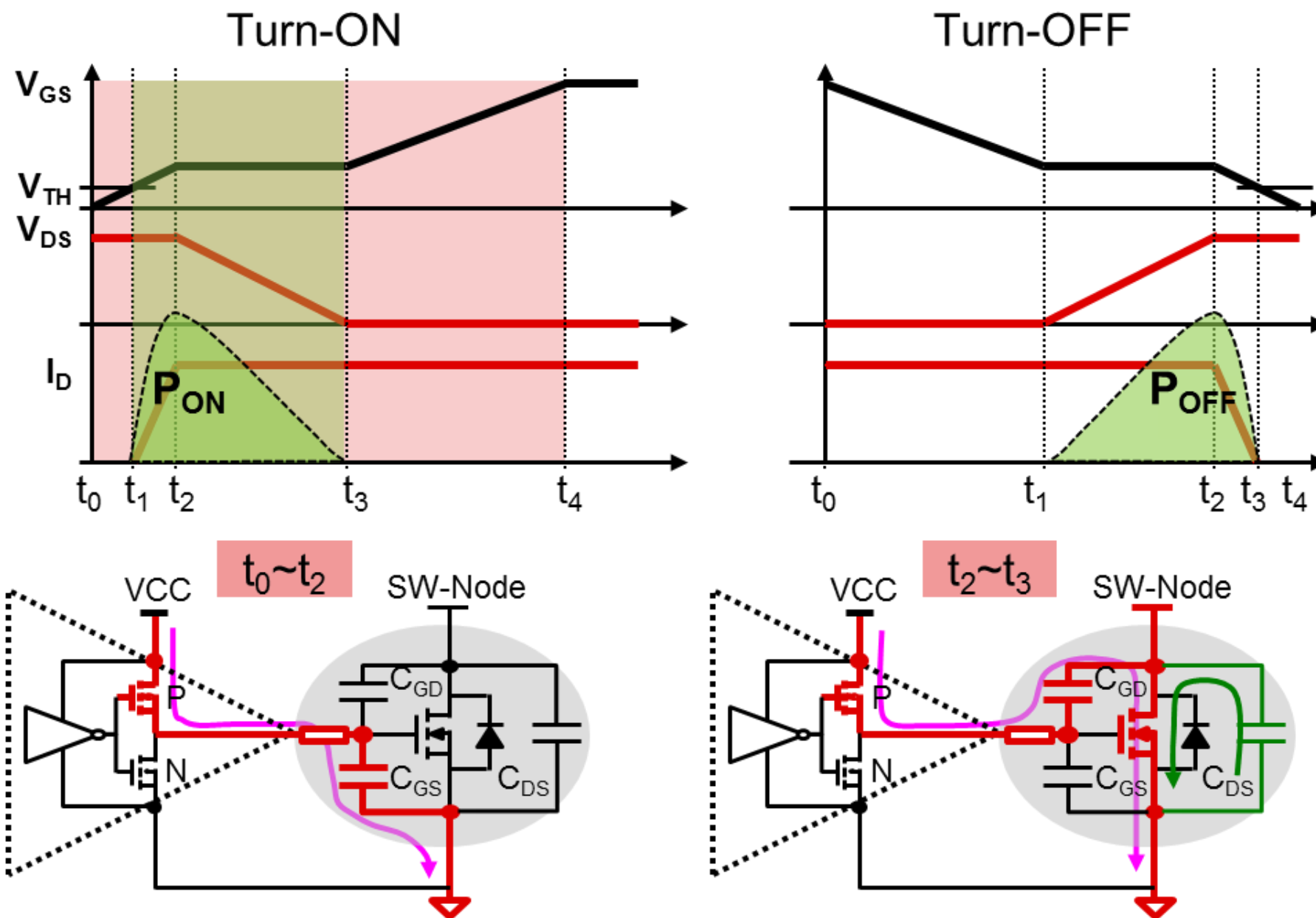
Power MOSFET

| | | | | | |
|-----------------------------------|---|---------------|----|------------|----------|
| Drain-Source Breakdown Voltage | $(V_{GS} = 0, I_D = 10 \mu A_{dc})$ | $V_{(BR)DSS}$ | 60 | - | Vdc |
| Static Drain-Source On-Resistance | $(V_{GS} = 10 V_{dc}, I_D = 0.5 A_{dc})$ $(V_{GS} = 4.5 V_{dc}, I_D = 75 mA_{dc})$ | $r_{DS(on)}$ | - | 5.0 6.0 | Ω |
| Input Capacitance | $(V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)$ | C_{iss} | - | 60 | pF |
| Output Capacitance | | C_{oss} | - | 25 | |
| Reverse Transfer Capacitance | | C_{rss} | - | 5.0 | |

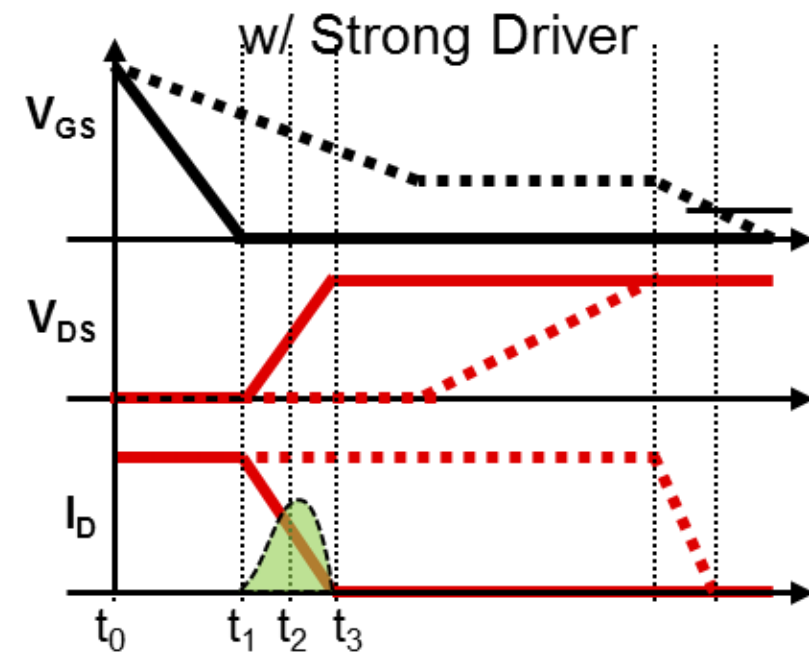
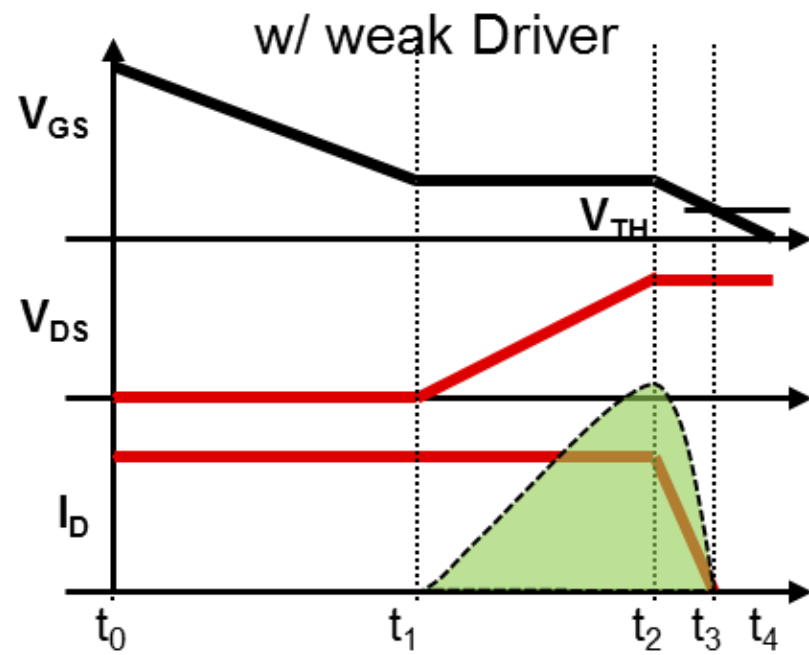
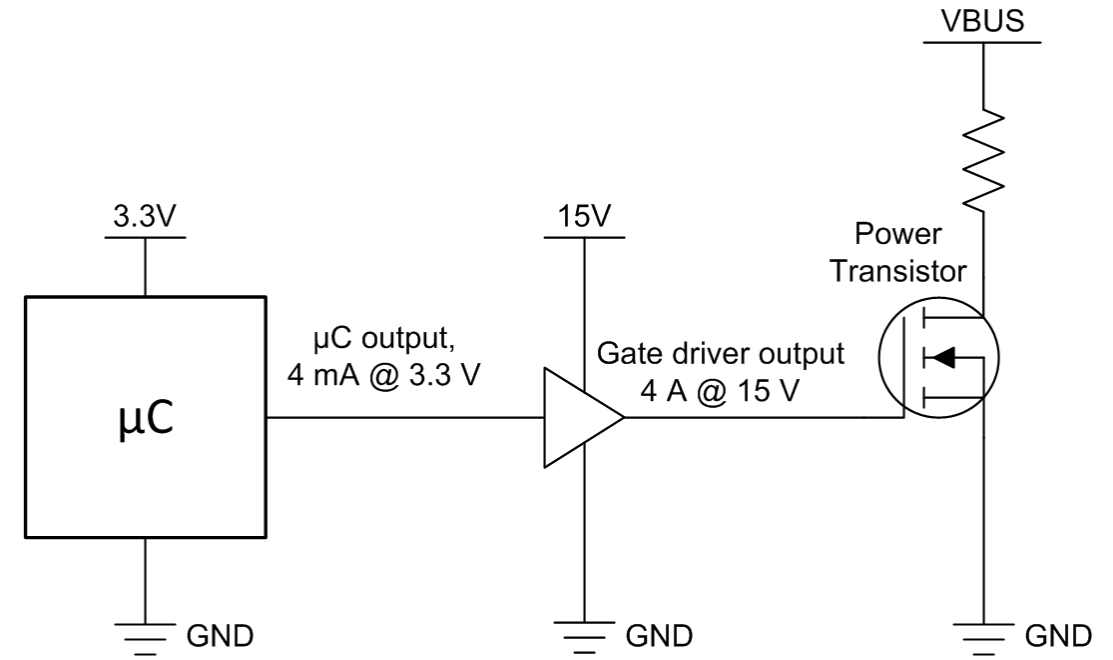
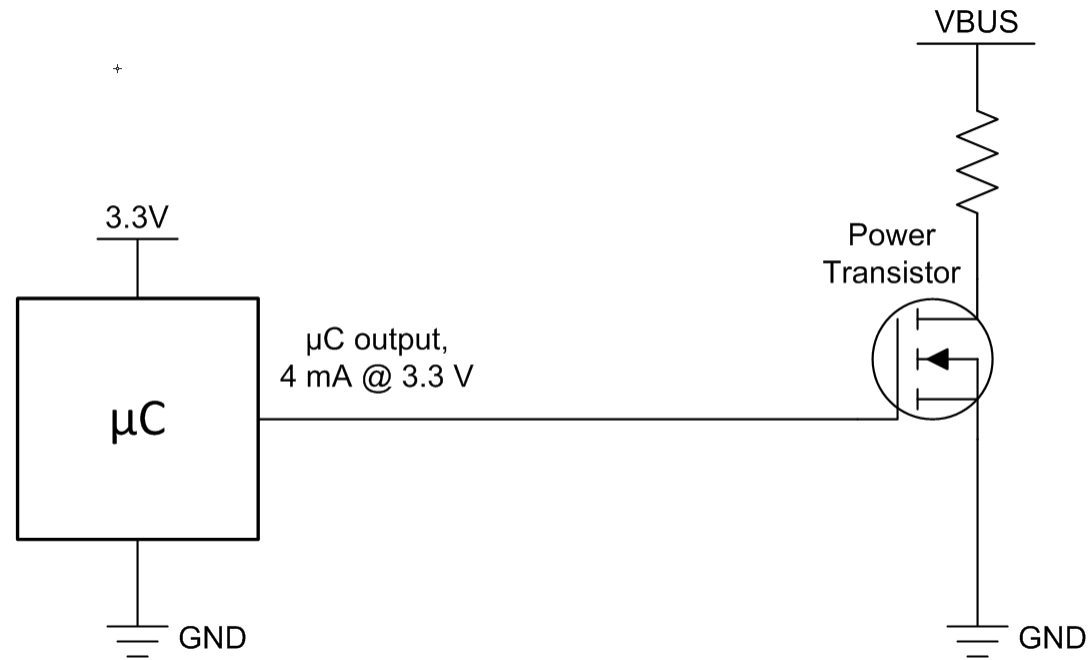
Small Signal MOSFET

- $E_C = \frac{1}{2} \times C \times V^2$
- $P_{SW} = C_G \times V_{DD}^2 \times F_{SW}$
- Example:
 - $C_G = 15nF$
 - $F_{SW} = 200kHz$
 - $V_{DD} = 12V$
- $P_{SW} = 15 \times 10^{-9} F \times (12 V)^2 \times 2 \times 10^5 Hz$
- $P_{SW} = \mathbf{0.48W}$

Switching losses

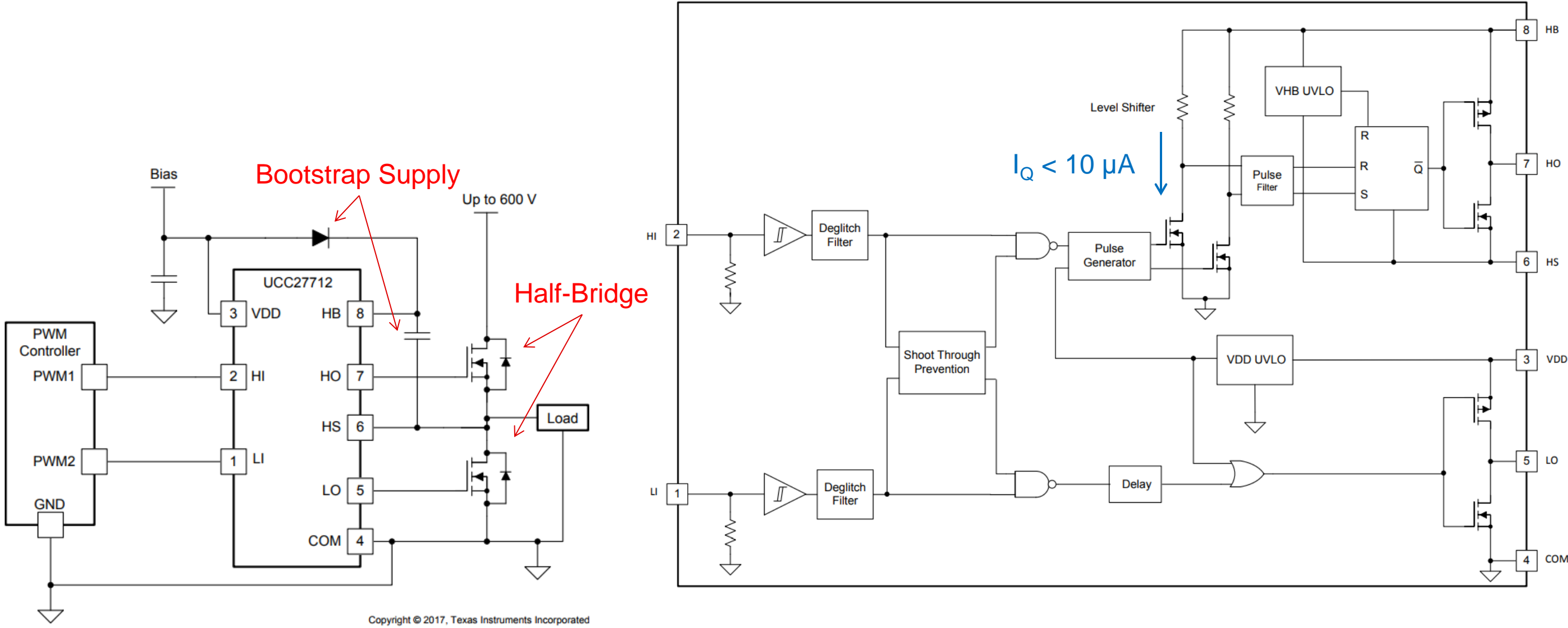


What is a gate driver?



NON-ISOLATED AND ISOLATED GATE DRIVERS

Non-isolated gate drivers



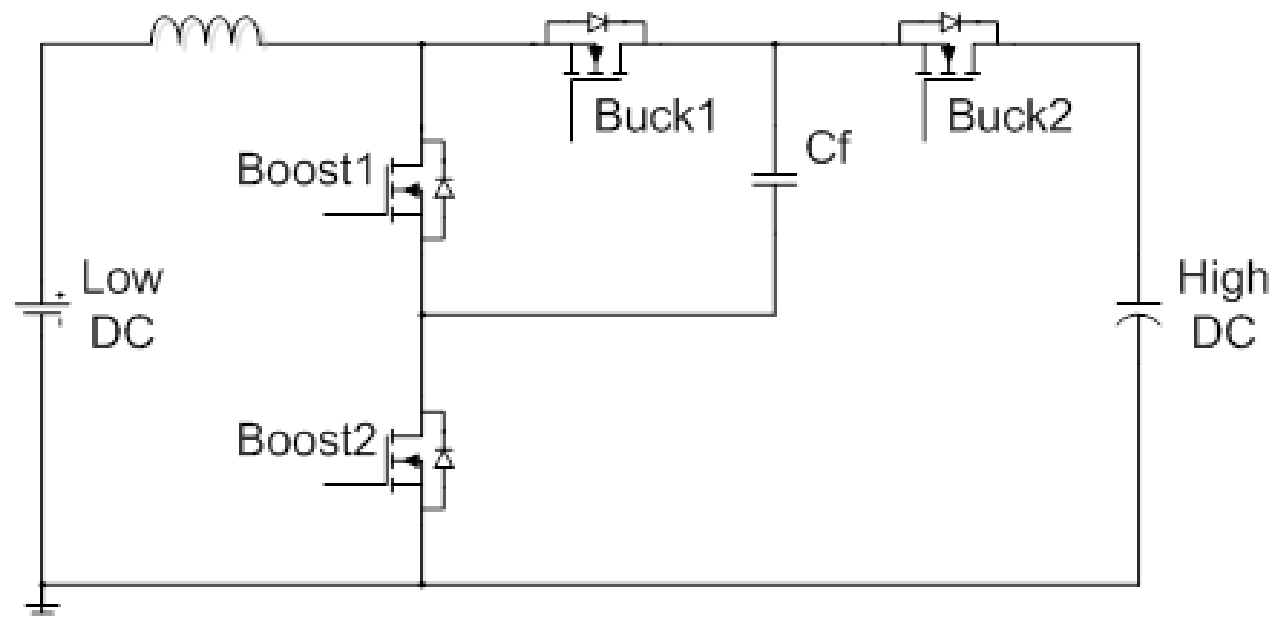
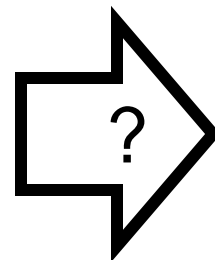
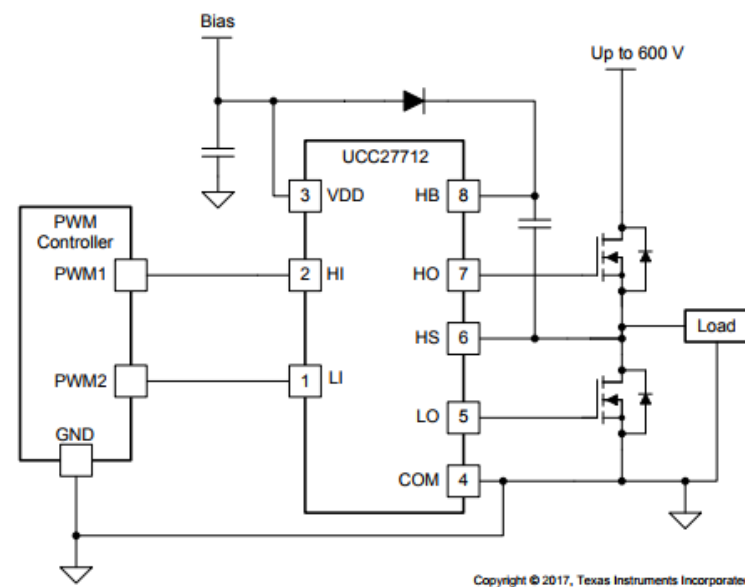
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Non-isolated gate drivers – Limitations

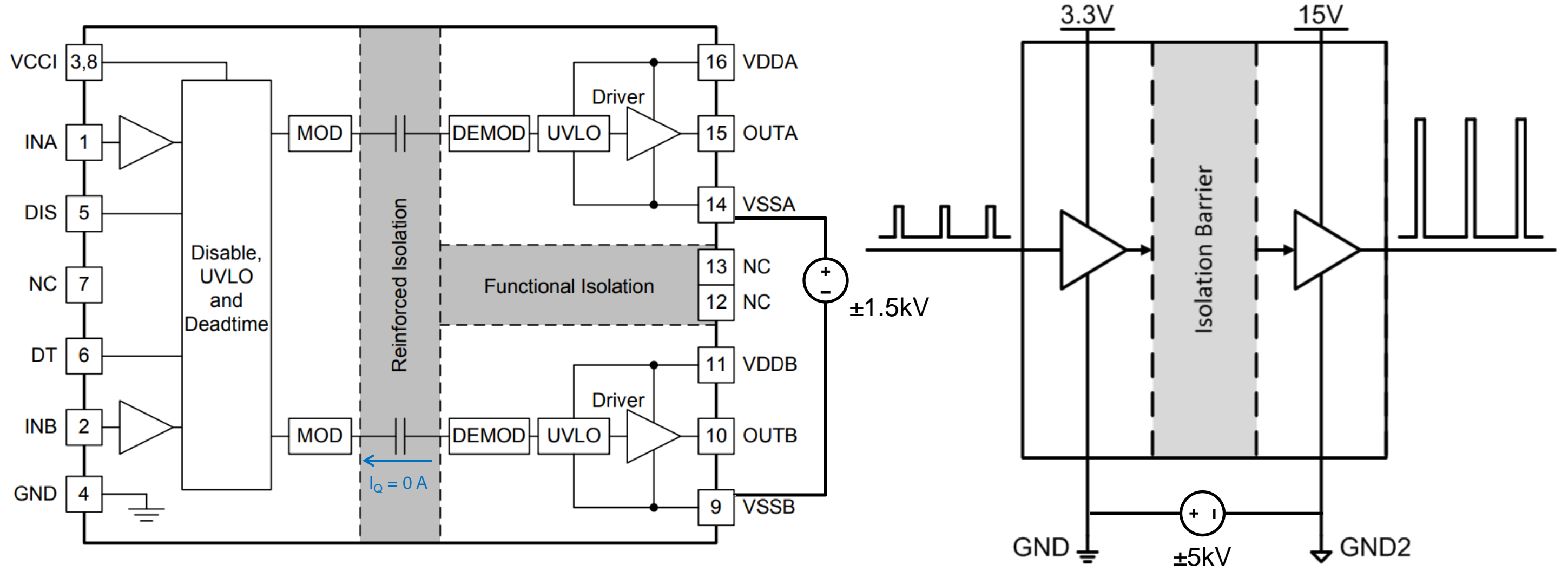
7.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted), all voltages are with respect to COM (unless otherwise noted), currents are positive into and negative out of the specified terminal. ⁽¹⁾⁽²⁾

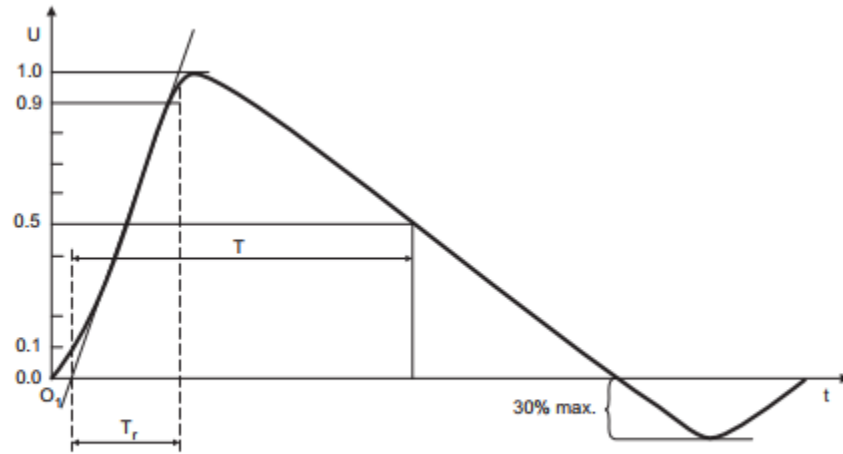
| PARAMETER | | MIN | MAX | UNIT | |
|--------------------------------|---|------------------------------------|-----|------|----|
| Input voltage | HI, LI ⁽³⁾ | -5 | 22 | V | |
| | VDD supply voltage | -0.3 | 22 | | |
| | HB | -0.3 | 700 | | |
| DYNAMIC CHARACTERISTICS | | | | | |
| t_{PDLH} | Turn-on propagation delay (without deadtime) | LI to LO, HI to HO, HS = COM = 0 V | 100 | 160 | ns |
| t_{PDHL} | Turn-off propagation delay | LI to LO, HI to HO, HS = COM = 0 V | 100 | 160 | |



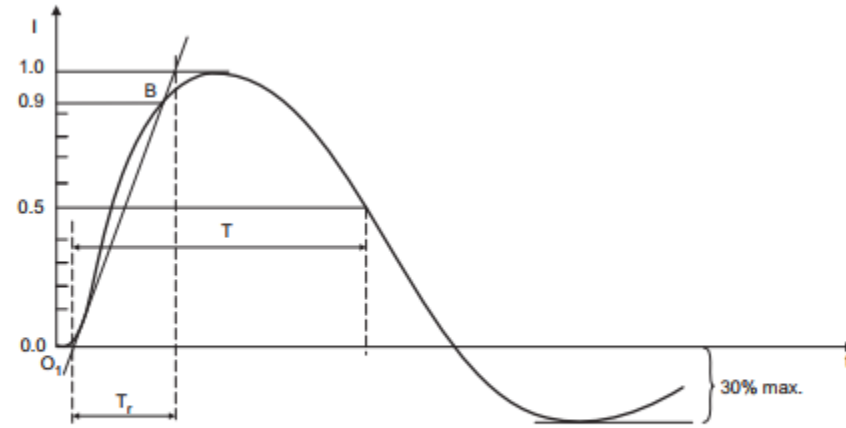
Isolated gate drivers



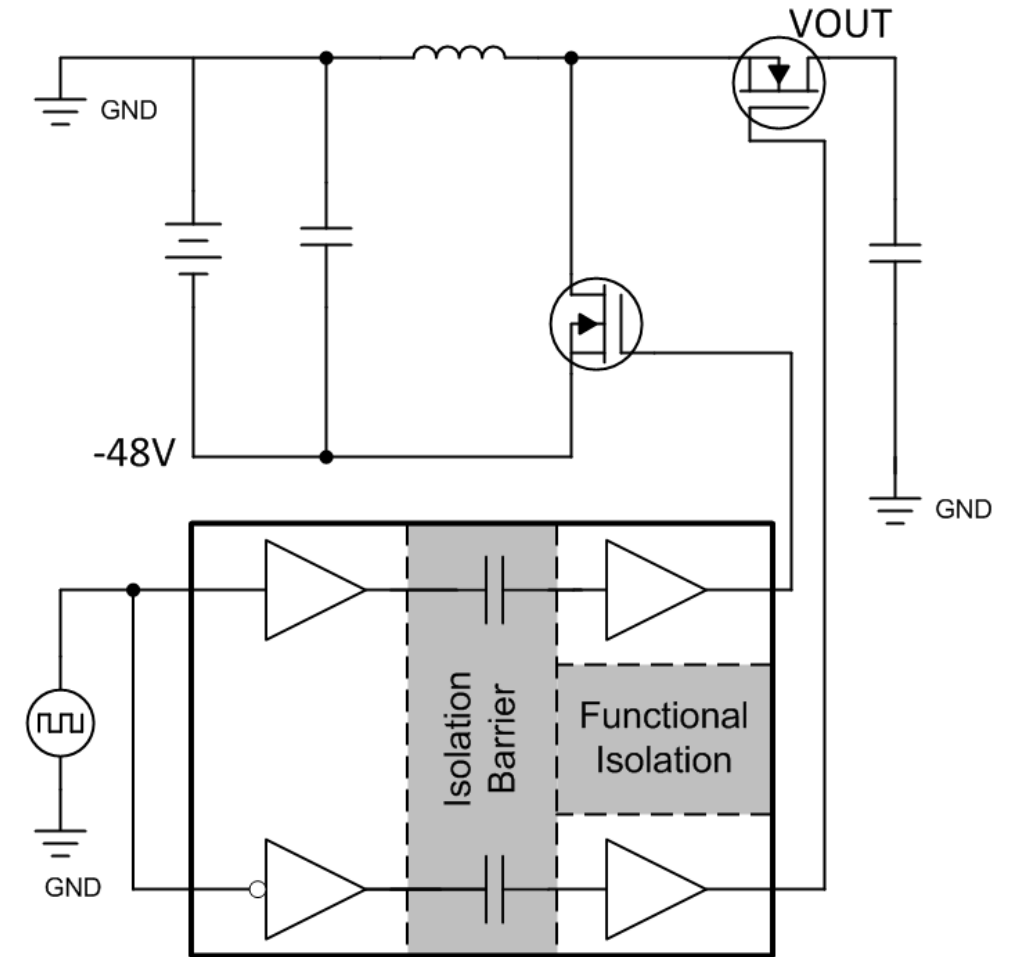
Why use isolation in gate drivers?



Front time: $T_r = 1.2 \mu\text{s} \pm 30\%$
Time to half-value: $T = 50 \mu\text{s} \pm 20\%$

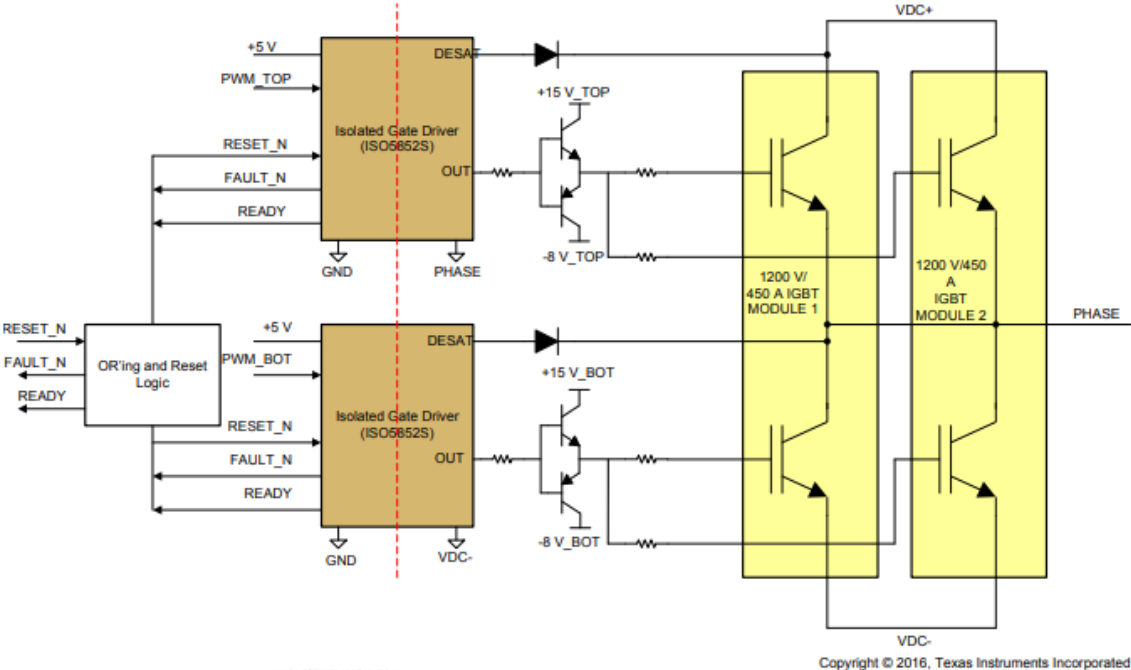


Front time: $T_r = 8 \mu\text{s} \pm 20\%$
Time to half-value: $T = 20 \mu\text{s} \pm 20\%$

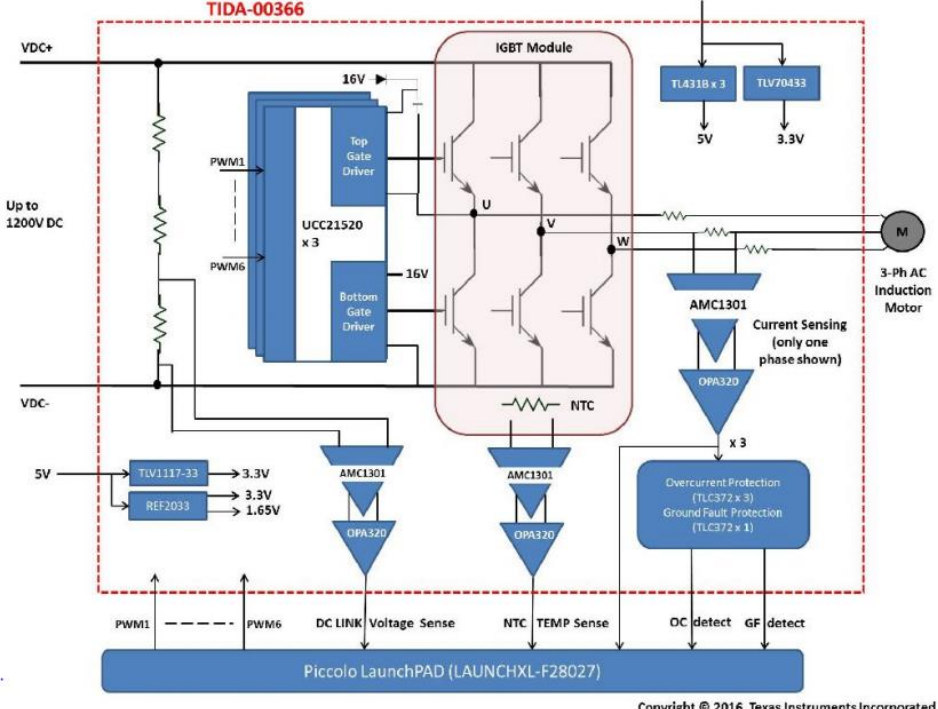
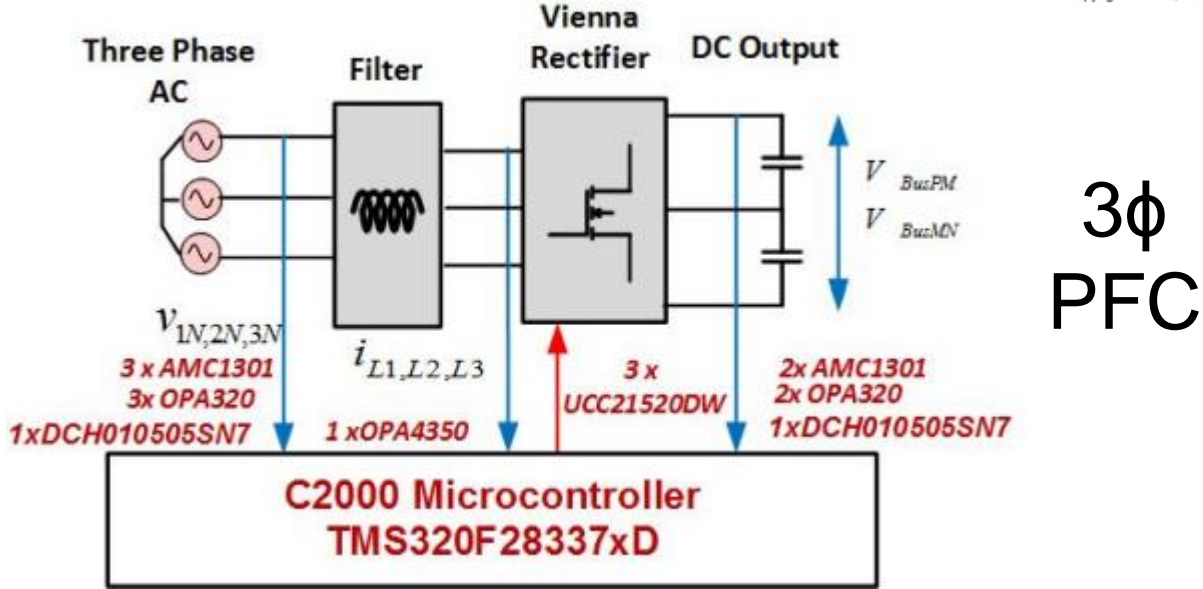
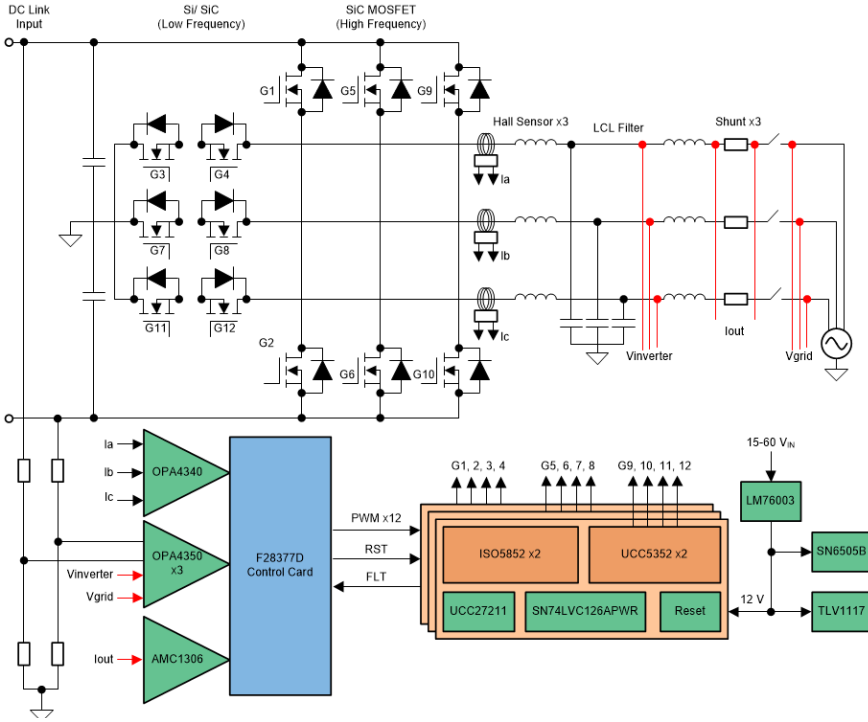


Example Topologies

Traction Inverter



Solar String Inverter



Motor Drive

Thanks for your time!
Please try the quiz.

Introduction – What is an Isolated Gate Driver?

Multiple Choice Quiz

TI Precision Labs – Isolation

Quiz: What is an Isolated Gate Driver?

1. **Gate drivers can be found in these electrical systems**
 - a. Commercial
 - b. Automotive
 - c. Industrial
 - d. All of the above

2. **Gate drivers are used in switching power supplies because _____**
 - a. They orchestrate the carefully timed switching of an array of high-power transistors.
 - b. They can drive power transistors at hundreds of megahertz
 - c. They amplify a low-voltage or low-current signal from a microcontroller
 - d. They are not used, because they are prohibitively slow and inefficient

3. **Could a typical power MOSFET reasonably function in a switching converter at 200MHz?**
 - a. Yes, because of the reduced voltage and capacitance
 - b. Yes, given a large enough heatsink
 - c. Yes, if I just try extra hard and believe in my high bandwidth power amplifier
 - d. Probably not...

Quiz: What is an Isolated Gate Driver?

4. **Non-isolated gate drivers need to use a(n) _____ inside the IC to operate at high voltage**
- a. Bootstrap Supply
 - b. Level-Shifter
 - c. Deglitch Filter
 - d. Isolated Gate Driver
5. **Which of these is NOT true about isolated gate drivers, compared to non-isolated?**
- a. Isolated gate drivers can be more flexible than non-isolated gate drivers; the output common is not wired to the control common
 - b. Isolated gate drivers can have significantly more leakage across the barrier than non-isolated gate drivers, when working properly
 - c. Isolated gate drivers can be used at much greater voltages than non-isolated drivers, up to the limits of the isolation technology
 - d. Isolated gate drivers can be faster and more robust than non-isolated gate drivers
6. **Which of these is NOT a reason to use isolated gate drivers?**
- a. Regulatory requirements may call for isolation
 - b. Some topologies are simplified by the presence of an isolation barrier
 - c. Isolated gate drivers may have better performance than non-isolated gate drivers in some cases
 - d. Isolated gate drivers are guaranteed to solve issues with surge, lightning strikes, etc

Introduction – What is an Isolated Gate Driver?

Multiple Choice Quiz – Solutions

TI Precision Labs – Isolation

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