

TPS2816, TPS2817, TPS2818, TPS2819, TPS2828, TPS2829 SINGLE-CHANNEL HIGH-SPEED MOSFET DRIVER

SLVS160A – FEBRUARY 1997 – REVISED NOVEMBER 1997

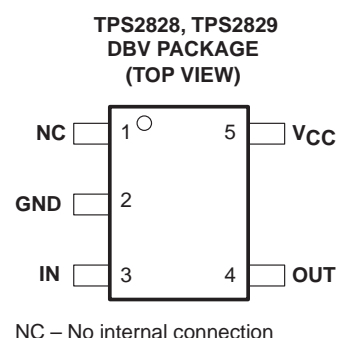
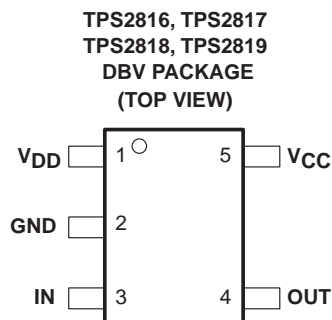
- Low-Cost Single-Channel High-Speed MOSFET Driver
- I_{CC} . . . 15- μ A Max (TPS2828, TPS2829)
- 25-ns Max Rise/Fall Times and 40-ns Max Propagation Delay . . . 1-nF Load
- 2-A Peak Output Current
- 4-V to 14-V Driver Supply Voltage Range; Internal Regulator Extends Range to 40 V (TPS2816, TPS2817, TPS2818, TPS2819)
- 5-pin SOT-23 Package
- -40°C to 125°C Ambient-Temperature Operating Range
- Highly Resistant to Latch-ups

description

The TPS28xx single-channel high-speed MOSFET drivers are capable of delivering peak currents of up to 2 A into highly capacitive loads. High switching speeds (t_r and $t_f = 14$ ns typ) are obtained with the use of BiCMOS outputs. Typical threshold switching voltages are $2/3$ and $1/3$ of V_{CC} . The design inherently minimizes shoot-through current.

A regulator is provided on TPS2816 through TPS2819 devices to allow operation with supply inputs between 14 V and 40 V. The regulator output can be used to power other circuits, provided power dissipation does not exceed package limitations. If the regulator is not required, V_{DD} (the regulator input) should be connected to V_{CC} . The TPS2816 and TPS2817 input circuits include an active pullup circuit to eliminate the need for an external resistor when using open-collector PWM controllers. The TPS2818 and TPS2819 are identical to the TPS2816 and TPS2817, except that the active pullup circuit is omitted. The TPS2828 and TPS2829 are identical to the TPS2818 and TPS2819, except that the internal voltage regulator is omitted, allowing quiescent current to drop to less than 15 μ A when the inputs are high or low.

The TPS28xx series devices are available in 5-pin SOT-23 (DBV) packages and operate over an ambient temperature range of -40°C to 125°C .



AVAILABLE OPTIONS

| T_A | FUNCTION | PACKAGED DEVICES | CHIP FORM |
|--|--|------------------|-----------|
| | | SOT-23-5 (DBV) | (Y) |
| -40°C to 125°C | Inverting driver with active pullup input | TPS2816DBV | TPS2816Y |
| | Noninverting driver with active pullup input | TPS2817DBV | TPS2817Y |
| | Inverting driver | TPS2818DBV | TPS2818Y |
| | Noninverting driver | TPS2819DBV | TPS2819Y |
| | Inverting driver, no regulator | TPS2828DBV | TPS2828Y |
| | Noninverting driver, no regulator | TPS2829DBV | TPS2829Y |

The DBV package is available taped and reeled only.



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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS
INSTRUMENTS**

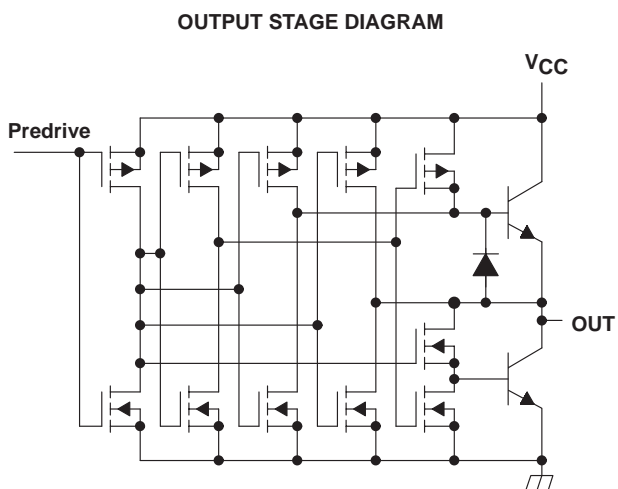
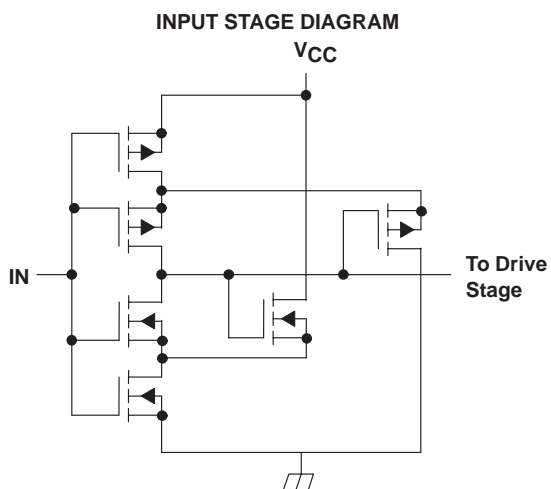
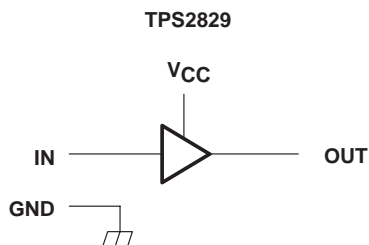
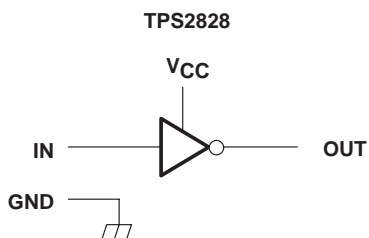
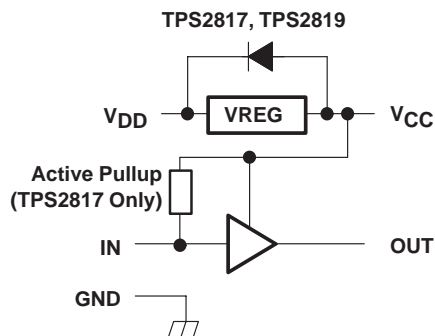
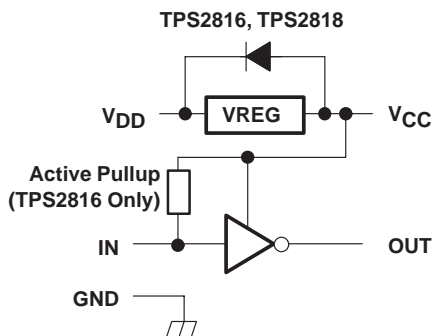
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functional block diagram

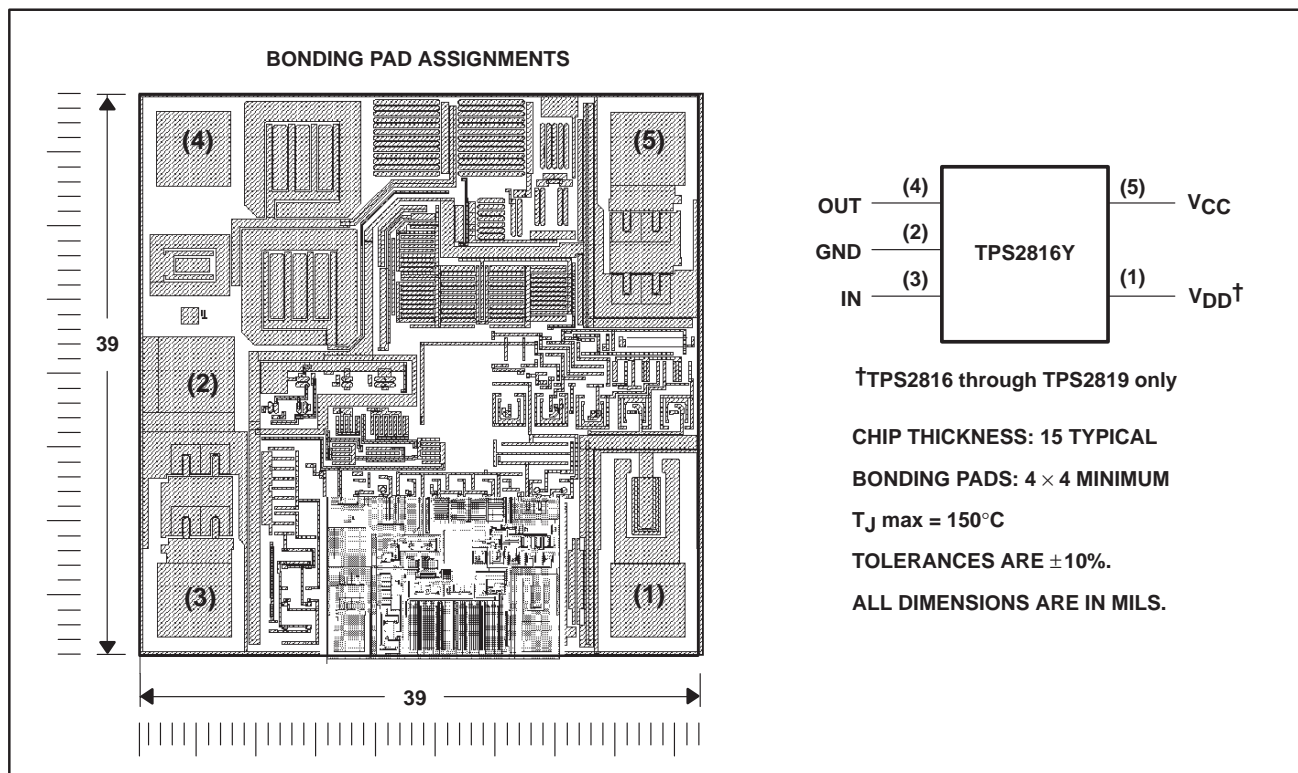


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TPS28xxY chip information

This chip, when properly assembled, displays characteristics similar to those of the TPS28xx. Thermal compression or ultrasonic bonding may be used on the doped aluminum bonding pads. The chip may be mounted with conductive epoxy or a gold-silicon preform.



Terminal Functions

TPS2816, TPS2818, TPS2828 (inverting driver)

| TERMINAL | | DESCRIPTION |
|-----------------|-----|--|
| NAME | NO. | |
| V _{DD} | 1 | Regulator supply voltage input. (Not connected on TPS2828) |
| GND | 2 | Ground |
| IN | 3 | Driver input. |
| OUT | 4 | Driver output, OUT = $\overline{\text{IN}}$ |
| V _{CC} | 5 | Driver supply voltage/regulator output voltage |

TPS2817, TPS2819, TPS2829 (noninverting driver)

| TERMINAL | | DESCRIPTION |
|-----------------|-----|--|
| NAME | NO. | |
| V _{DD} | 1 | Regulator supply voltage input. (Not connected on TPS2829) |
| GND | 2 | Ground |
| IN | 3 | Driver input. |
| OUT | 4 | Driver output, OUT = IN |
| V _{CC} | 5 | Driver supply voltage/regulator output voltage |



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DISSIPATION RATING TABLE

| PACKAGE | $T_A \leq 25^\circ\text{C}$ POWER RATING | DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 70^\circ\text{C}$ POWER RATING | $T_A = 80^\circ\text{C}$ POWER RATING |
|---------|---|---|--|--|
| DBV | 437 mW | 3.5 mW/°C | 280 mW | 227 mW |

These dissipation ratings are based upon EIA specification JESD51-3, "Low Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages," in tests conducted in a zero-airflow, wind tunnel environment.

absolute maximum ratings over operating temperature range (unless otherwise noted)†

| | |
|---|------------------------------|
| Regulator supply voltage range, V_{DD} | –0.3 V to 42 V |
| Supply voltage range, V_{CC} | –0.3 V to 15 V |
| Input voltage range, IN | –0.3 V to 15 V |
| Continuous regulator output current, V_{CC} | 25 mA |
| Continuous output current, OUT | ±100 mA |
| Continuous total power dissipation | See Dissipation Rating Table |
| Operating ambient temperature range, T_A | –40°C to 125°C |
| Storage temperature range, T_{stg} | –65°C to 150°C |
| Lead temperature 1,6 mm (1/16inch) from case for 10 seconds | 260°C |

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltages are with respect to device GND terminal.

recommended operating conditions

| | MIN | MAX | UNIT |
|---|------|----------|------|
| Regulator input voltage range, V_{DD} , TPS2816 through TPS2819 | 8 | 40 | V |
| Supply voltage, V_{CC} | 4 | 14 | V |
| Input voltage, IN | –0.3 | V_{CC} | V |
| Continuous regulator output current, I_{CC} | 0 | 20 | mA |
| Operating ambient temperature range, T_A | –40 | 125 | °C |



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TPS28xx electrical characteristics over recommended operating ambient temperature range, $V_{CC} = 10\text{ V}$, V_{DD} tied to V_{CC} , $C_L = 1\text{ nF}$ (unless otherwise specified)

Inputs

| PARAMETER | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|--|-------------------------|-----|------|-----|---------------|
| Positive-going input threshold voltage | $V_{CC} = 5\text{ V}$ | | 3.3 | 4 | V |
| | $V_{CC} = 10\text{ V}$ | | 6.6 | 7 | |
| | $V_{CC} = 14\text{ V}$ | | 9.3 | 10 | |
| Negative-going input threshold voltage | $V_{CC} = 5\text{ V}$ | 1 | 1.7 | | V |
| | $V_{CC} = 10\text{ V}$ | 2 | 3.3 | | |
| | $V_{CC} = 14\text{ V}$ | 2.5 | 4.6 | | |
| Input voltage hysteresis | | | 1.3 | | V |
| Input current, TPS2818/19/28/29 | Input = 0 V or V_{CC} | | 0.2 | | μA |
| Input current, TPS2816/17 | Input = 0 V | | 650 | | μA |
| | Input = V_{CC} | | 15 | | |
| Input capacitance | | | 5 | 10 | pF |

† Typical values are for $T_A = 25^\circ\text{C}$ unless otherwise noted.

Outputs

| PARAMETER | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|---------------------------|------------------------|------|------|------|------|
| High-level output voltage | $I_O = -1\text{ mA}$ | 9.75 | 9.9 | | V |
| | $I_O = -100\text{ mA}$ | 8 | 9.1 | | |
| Low-level output voltage | $I_O = 1\text{ mA}$ | | 0.18 | 0.25 | V |
| | $I_O = 100\text{ mA}$ | | 1 | 2 | |

† Typical values are for $T_A = 25^\circ\text{C}$ unless otherwise noted.

regulator, TPS2816 through TPS2819

| PARAMETER | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|---------------------------|---|-----|------|-----|------|
| Output voltage | $14 \leq V_{DD} \leq 40\text{ V}$, $0 \leq I_O \leq 20\text{ mA}$ | 10 | 11.5 | 13 | V |
| Output voltage in dropout | $I_O = 10\text{ mA}$, $V_{DD} = 10\text{ V}$ | 8 | | 10 | V |

† Typical values are for $T_A = 25^\circ\text{C}$ unless otherwise noted.

supply current

| PARAMETER | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|------------------------------|---------------------|---|---------------------|------|---------------|
| Supply current into V_{CC} | TPS2816, TPS2817 | IN = high = 10 V | 150 | 250 | μA |
| | | IN = low = 0 V | 650 | 1000 | |
| | TPS2818, TPS2819 | IN = high or low, High = 10 V, Low = 0 V | 25 | 50 | |
| | | | TPS2828, TPS2829 | 0.1 | |
| Supply current into V_{DD} | TPS2816, TPS2817 | $V_{DD} = 20\text{ V}$, IN = high = 10 V or low = 0 V | 650 | 1000 | μA |
| | TPS2818, TPS2819 | $V_{DD} = 20\text{ V}$, IN = high = 10 V or low = 0 V | 50 | 150 | |

† Typical values are for $T_A = 25^\circ\text{C}$ unless otherwise noted.



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TPS28xxY electrical characteristics at $T_A = 25^\circ\text{C}$, $V_{CC} = 10\text{ V}$, V_{DD} tied to V_{CC} , $C_L = 1\text{ nF}$ (unless otherwise specified)

Inputs

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|-------------------------|-----|------|-----|------------------|
| Positive-going input threshold voltage | $V_{CC} = 5\text{ V}$ | | 3.3 | | V |
| | $V_{CC} = 10\text{ V}$ | | 6.6 | | |
| | $V_{CC} = 14\text{ V}$ | | 9.3 | | |
| Negative-going input threshold voltage | $V_{CC} = 5\text{ V}$ | | 1.7 | | V |
| | $V_{CC} = 10\text{ V}$ | | 3.3 | | |
| | $V_{CC} = 14\text{ V}$ | | 4.6 | | |
| Input voltage hysteresis | | | 1.3 | | V |
| Input current, TPS2818/19/28/29 | Input = 0 V or V_{CC} | | 0.2 | | μA |
| Input current, TPS2816/17 | Input = 0 V | | 650 | | μA |
| | Input = V_{CC} | | 15 | | |
| Input resistance | | | 1000 | | $\text{M}\Omega$ |
| Input capacitance | | | 5 | | pF |

outputs

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------------------|------------------------|-----|------|-----|------|
| High-level output voltage | $I_O = -1\text{ mA}$ | | 9.9 | | V |
| | $I_O = -100\text{ mA}$ | | 9.1 | | |
| Low-level output voltage | $I_O = 1\text{ mA}$ | | 0.18 | | V |
| | $I_O = 100\text{ mA}$ | | 1 | | |

regulator, TPS2816 through TPS2819

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------------------|---|-----|------|-----|------|
| Output voltage | $14 \leq V_{DD} \leq 40\text{ V}$, $0 \leq I_O \leq 20\text{ mA}$ | | 11.5 | | V |
| Output voltage in dropout | $I_O = 10\text{ mA}$, $V_{DD} = 10\text{ V}$ | | 9 | | V |

supply current

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------------------------|--|-----|-----|-----|---------------|
| Supply current into V_{CC} | TPS2816, TPS2817 IN = high = 10 V | | 150 | | μA |
| | IN = low = 0 V | | 650 | | |
| | TPS2818, TPS2819 IN = high or low, High = 10 V, Low = 0 V | | 25 | | |
| Supply current into V_{DD} | TPS2816, TPS2817 $V_{DD} = 20\text{ V}$, IN = high = 10 V or low = 0 V | | 650 | | μA |
| | TPS2818, TPS2819 $V_{DD} = 20\text{ V}$, IN = high = 10 V or low = 0 V | | 50 | | |



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switching characteristics for all devices over recommended operating ambient temperature range, $V_{CC} = 10\text{ V}$, V_{DD} tied to V_{CC} , $C_L = 1\text{ nF}$ (unless otherwise specified)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-----------|--|------------------------|-----|-----|-----|------|
| t_r | Rise time | $V_{CC} = 14\text{ V}$ | | | 25 | ns |
| | | $V_{CC} = 10\text{ V}$ | | 14 | 30 | |
| | | $V_{CC} = 5\text{ V}$ | | | 35 | |
| t_f | Fall time | $V_{CC} = 14\text{ V}$ | | | 25 | ns |
| | | $V_{CC} = 10\text{ V}$ | | 14 | 30 | |
| | | $V_{CC} = 5\text{ V}$ | | | 35 | |
| t_{PHL} | Propagation delay time, high-to-low-level output | $V_{CC} = 14\text{ V}$ | | | 40 | ns |
| | | $V_{CC} = 10\text{ V}$ | | 24 | 45 | |
| | | $V_{CC} = 5\text{ V}$ | | | 50 | |
| t_{PLH} | Propagation delay time, low-to-high-level output | $V_{CC} = 14\text{ V}$ | | | 40 | ns |
| | | $V_{CC} = 10\text{ V}$ | | 24 | 45 | |
| | | $V_{CC} = 5\text{ V}$ | | | 50 | |

PARAMETER MEASUREMENT INFORMATION

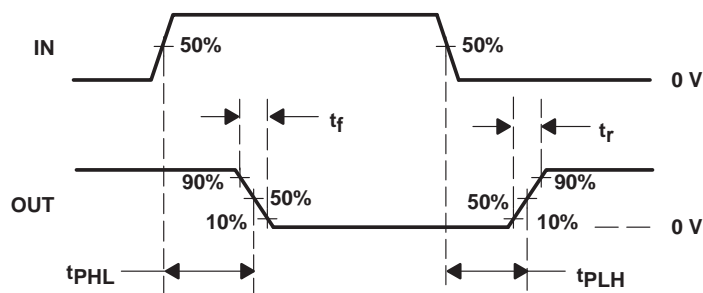


Figure 1. Typical Timing Diagram (TPS2816)



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PARAMETER MEASUREMENT INFORMATION

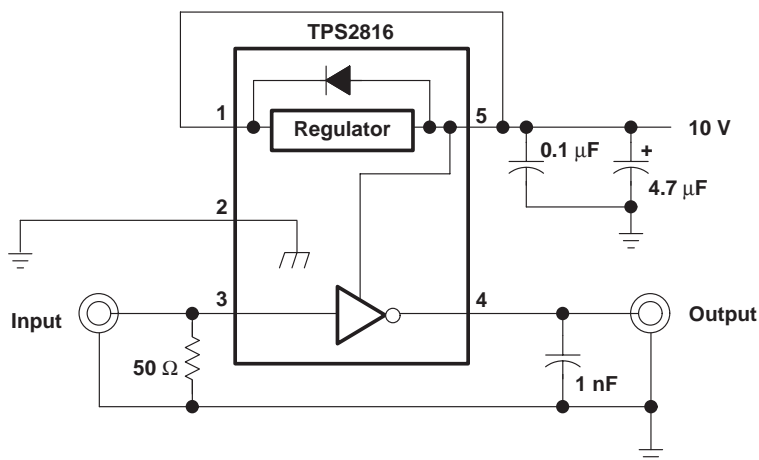


Figure 2. Switching Time Test Setup

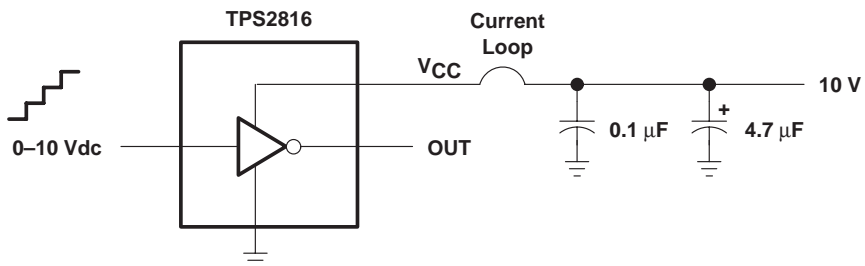


Figure 3. Shoot-Through Current Test Setup

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TYPICAL CHARACTERISTICS

Table of Graphs

| | | FIGURE |
|-----------------------------|-----------------------------|--------|
| Rise time | vs Supply voltage | 4 |
| Fall time | vs Supply voltage | 5 |
| Propagation time (L>H) | vs Supply voltage | 6 |
| Propagation Time (H>L) | vs Supply voltage | 7 |
| Rise time | vs Ambient temperature | 8 |
| Fall time | vs Ambient temperature | 9 |
| Propagation time (L>H) | vs Supply voltage | 10 |
| Propagation time (H>L) | vs Ambient temperature | 11 |
| Supply current (V_{CC}) | vs Supply voltage | 12 |
| Supply current (V_{CC}) | vs Load capacitance | 13 |
| Supply current (V_{CC}) | vs Ambient temperature | 14 |
| Input threshold voltage | vs Supply voltage | 15 |
| Regulator output voltage | vs Regulator supply voltage | 16 |
| Regulator quiescent current | vs Regulator supply voltage | 17 |
| Shoot-through current | vs Input voltage (L>H) | 18 |
| Shoot-through current | vs Input voltage (H>L) | 19 |

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TYPICAL CHARACTERISTICS

RISE TIME
vs
SUPPLY VOLTAGE

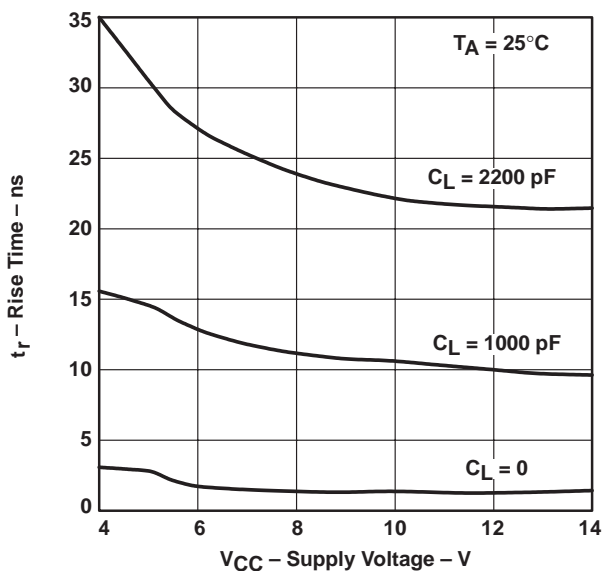


Figure 4

FALL TIME
vs
SUPPLY VOLTAGE

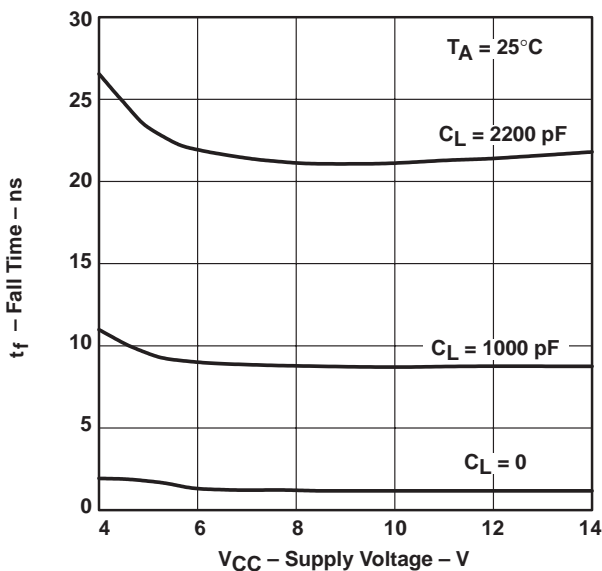


Figure 5

PROPAGATION DELAY TIME,
LOW-TO-HIGH-LEVEL OUTPUT
vs
SUPPLY VOLTAGE

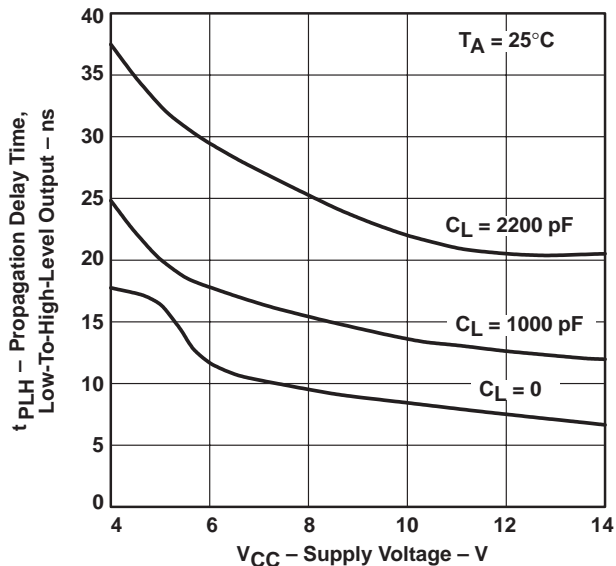


Figure 6

PROPAGATION DELAY TIME,
HIGH-TO-LOW-LEVEL OUTPUT
vs
SUPPLY VOLTAGE

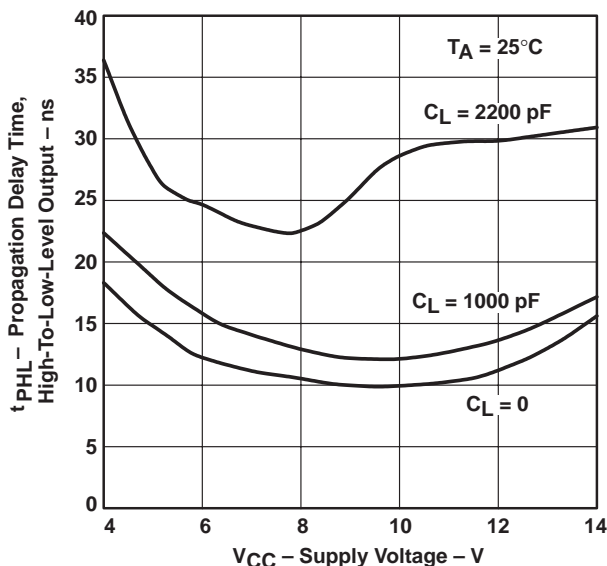


Figure 7



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TYPICAL CHARACTERISTICS

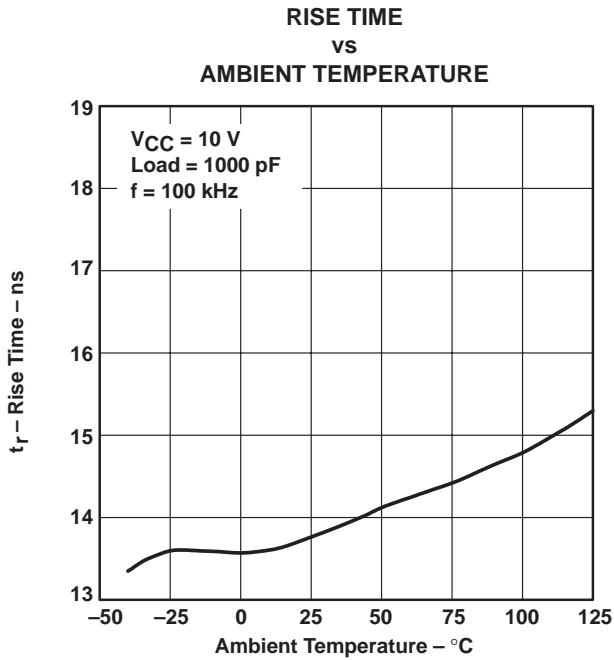


Figure 8

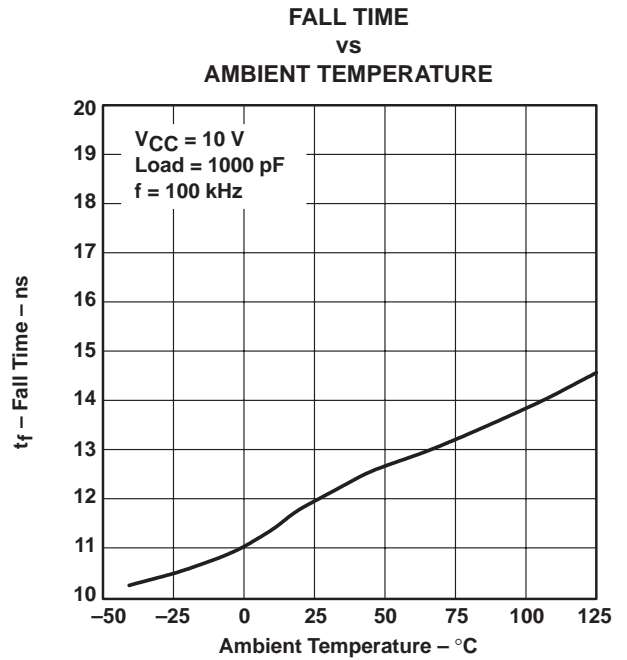


Figure 9

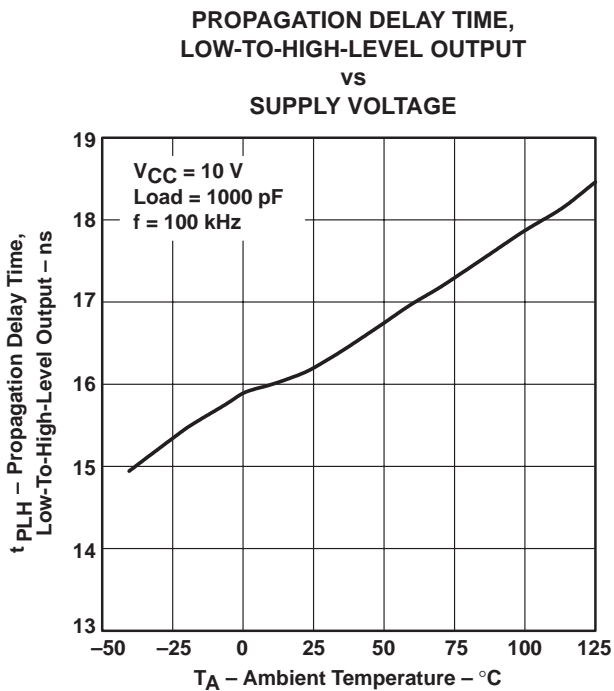


Figure 10

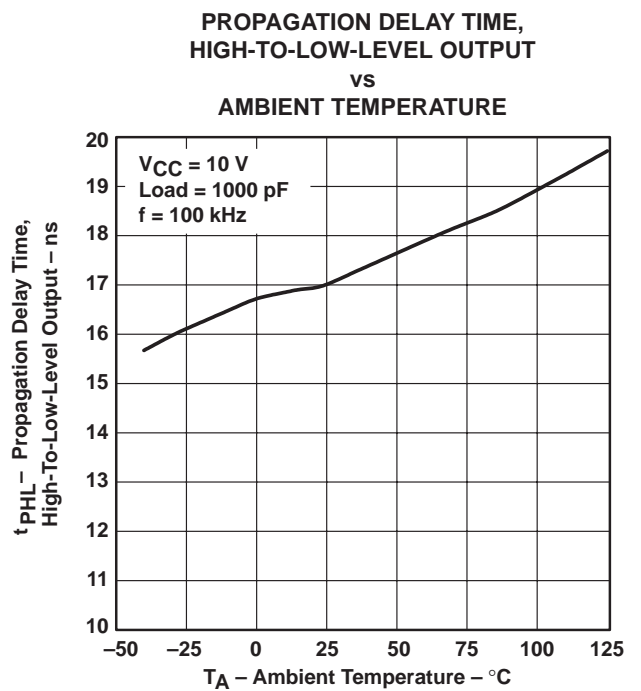


Figure 11



TPS2816, TPS2817, TPS2818, TPS2819, TPS2828, TPS2829 SINGLE-CHANNEL HIGH-SPEED MOSFET DRIVER

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TYPICAL CHARACTERISTICS

SUPPLY CURRENT
vs
SUPPLY VOLTAGE

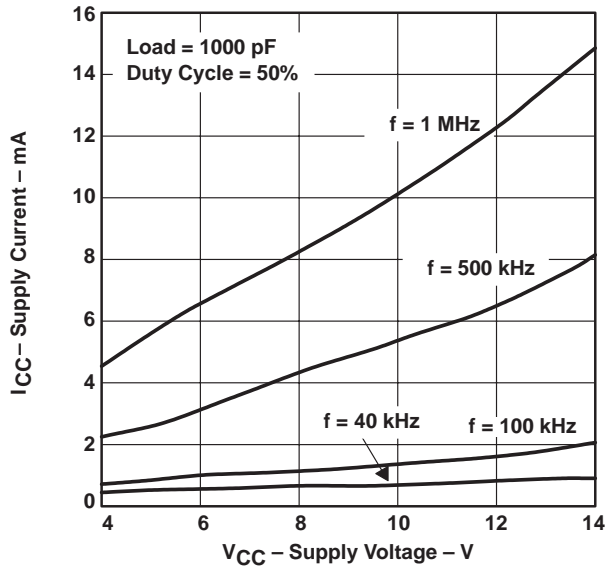


Figure 12

SUPPLY CURRENT
vs
LOAD CAPACITANCE

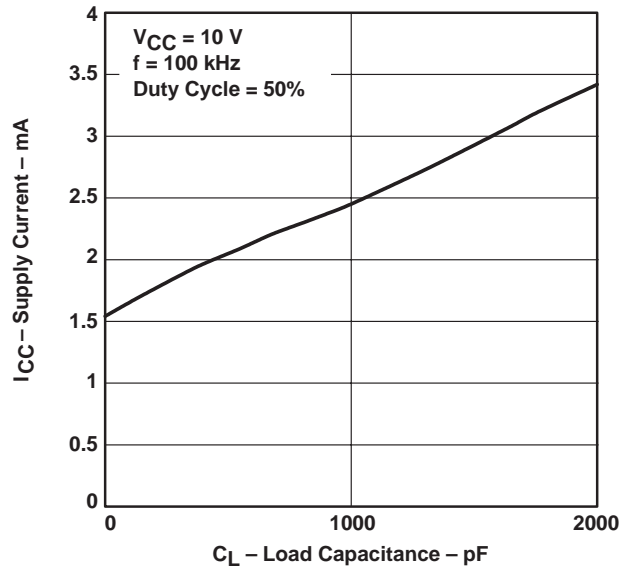


Figure 13

SUPPLY CURRENT
vs
AMBIENT TEMPERATURE

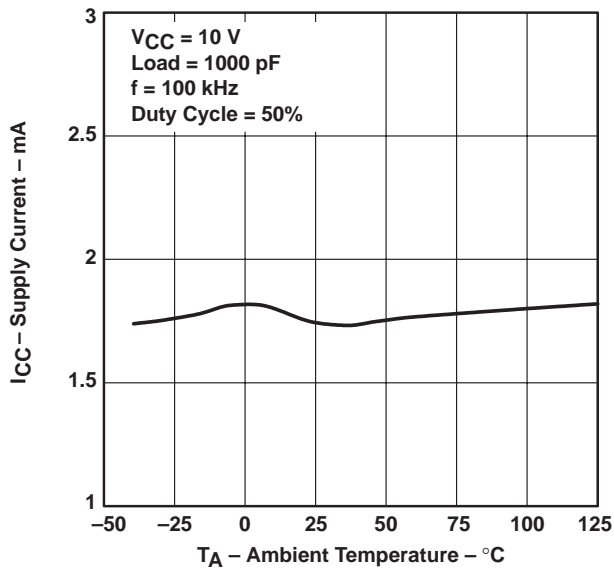


Figure 14

INPUT THRESHOLD VOLTAGE
vs
SUPPLY VOLTAGE

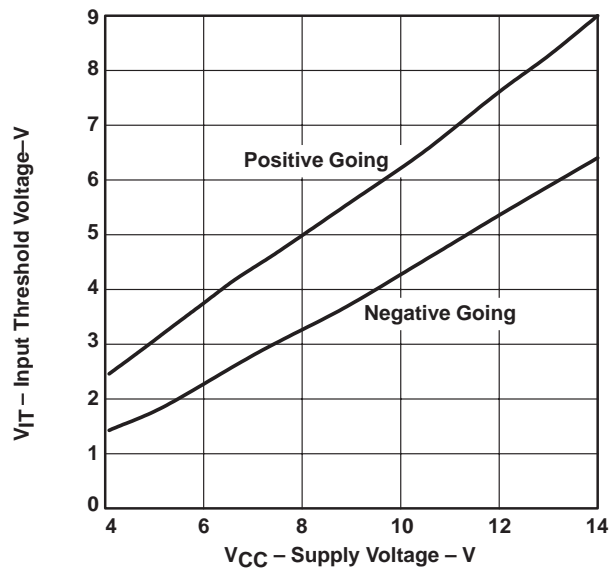


Figure 15



TYPICAL CHARACTERISTICS

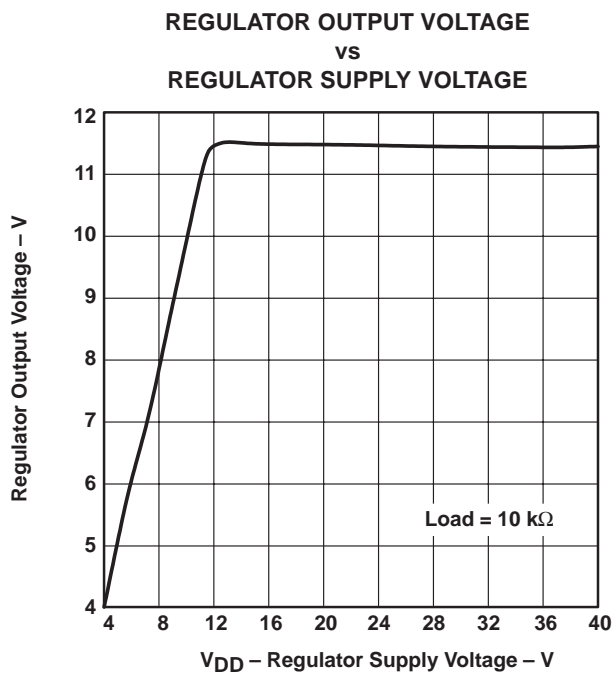


Figure 16

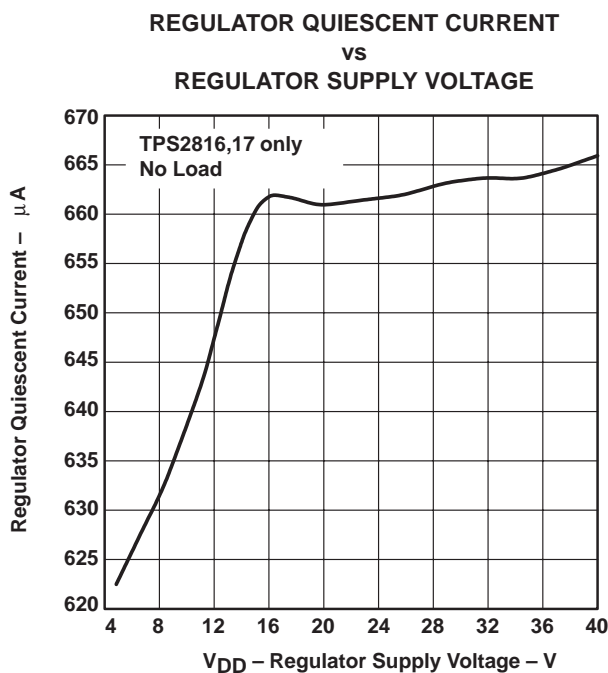


Figure 17

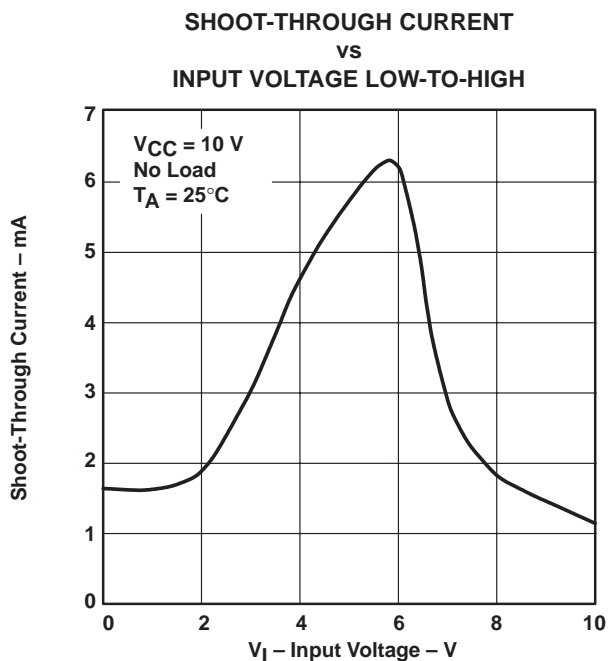


Figure 18

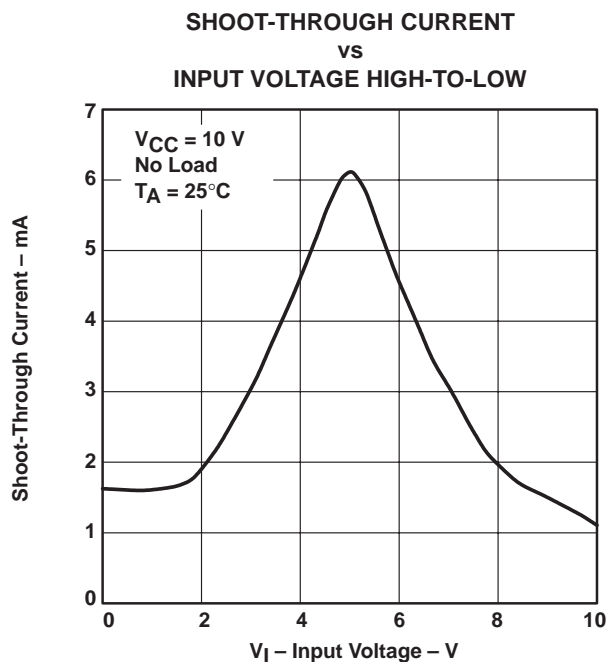


Figure 19

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APPLICATION INFORMATION

MOSFETs are voltage-driven devices that require very little steady-state drive current. However, the large input capacitance (200 pF to 3000 pF or greater) of these devices requires large current surges to reduce the turn-on and turn-off times. The TPS2816 series of high-speed drivers can supply up to 2 A to a MOSFET, greatly reducing the switching times. The fast rise times and fall times and short propagation delays allow for operation in today's high-frequency switching converters.

In addition, MOSFETs have a limited gate-bias voltage range, usually less than 20 V. The TPS2816 series of drivers extends this operating range by incorporating an on-board series regulator with an input range up to 40 V. This regulator can be used to power the drivers, the PWM chip, and other circuitry, providing the power dissipation rating is not exceeded.

When using these devices, care should be exercised in the proper placement of the driver, the switching MOSFET, and the bypass capacitor. Because of the large input capacitance of the MOSFET, the driver should be placed close to the gate to eliminate the possibility of oscillations caused by trace inductance ringing with the gate capacitance of the MOSFET. When the driver output path is longer than approximately 2 inches, a resistor in the range of 10 Ω should be placed in series with the gate drive as close as possible to the MOSFET. A ceramic bypass capacitor is also recommended to provide a source for the high-speed current transients that the MOSFET requires. This capacitor should be placed between V_{CC} and GND of the driver (see Figures 20 and 21).

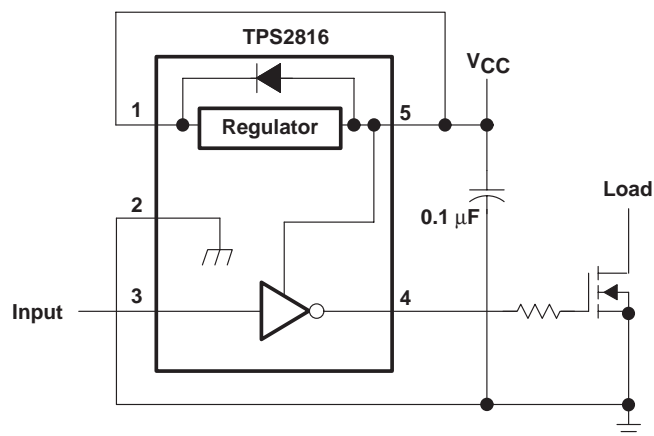


Figure 20. $V_{CC} < 14\text{ V}$

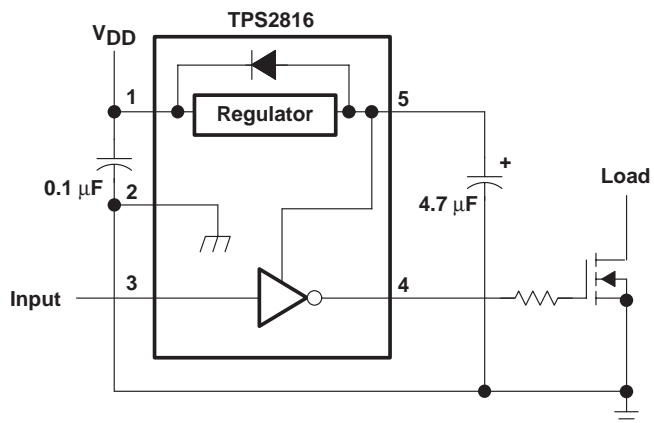


Figure 21. $V_{CC} > 14\text{ V}$

TPS2816, TPS2817, TPS2818, TPS2819, TPS2828, TPS2829 SINGLE-CHANNEL HIGH-SPEED MOSFET DRIVER

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APPLICATION INFORMATION

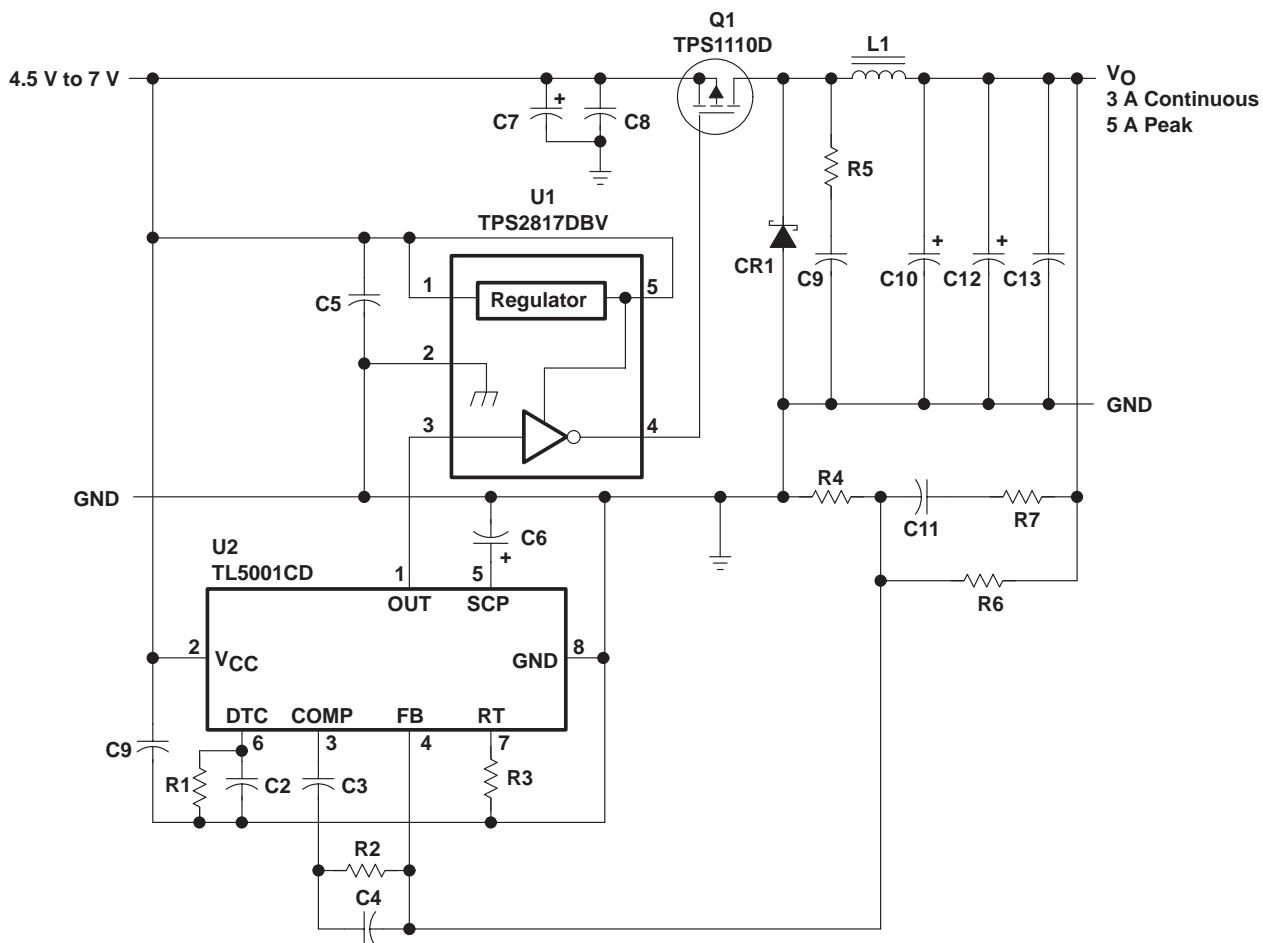


Figure 23. Step-Down Application

TPS2816, TPS2817, TPS2818, TPS2819, TPS2828, TPS2829 SINGLE-CHANNEL HIGH-SPEED MOSFET DRIVER

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APPLICATION INFORMATION

Table 1. Bill of Materials

| REF DES | PART NO. | DESCRIPTION | MFR |
|----------------|--------------|--|----------------|
| U1 | TPS2817DBV | IC, MOSFET driver, single noninverting | TI |
| U2 | TL5001CD | IC, PWM controller | TI |
| Q1 | TPS1110D | MOSFET, p-channel, 6 A, 7 V, 75 m Ω | TI |
| C1, C2, C5, C8 | | Capacitor, ceramic, 0.1 μ F, 50 V, X7R, 1206 | |
| C3 | | Capacitor, ceramic, 0.033 μ F, 50 V, X7R, 1206 | |
| C4 | | Capacitor, ceramic, 2200 pF, 50 V, X7R, 0805 | |
| C6 | ECS-T1CY105R | Capacitor, tantalum, 1.0 μ F, 16 V, A case | Panasonic |
| C7 | 10SC47M | Capacitor, OS-Con, 47 μ F, 10 V | Sanyo |
| C9 | | Capacitor, ceramic, 1000 pF, 50 V, X7R, 0805 | |
| C10, C12 | 10SA220M | Capacitor, OS-Con, 220 μ F, 10 V | Sanyo |
| C11 | | Capacitor, ceramic, 0.022 μ F, 50 V, X7R, 0805 | |
| C13 | | Capacitor, ceramic, 47 μ F, 50 V, X7R | |
| CR1 | 50WQ03F | Diode, Shottky, D-pak, 5 A 30 V | IR |
| L1 | SML3723 | Inductor, 27 μ H, \pm 20%, 3 A | Nova Magnetics |
| R1 | | Resistor, CF, 47 k Ω , 1/10 W, 5%, 0805 | |
| R2 | | Resistor, CF, 1.5 k Ω , 1/10 W, 5%, 0805 | |
| R3 | | Resistor, MF, 30.1 k Ω , 1/10 W, 1%, 0805 | |
| R4 | | Resistor, MF, 1.00 k Ω , 1/10 W, 1%, 0805 | |
| R5 | | Resistor, CF, 47 Ω , 1/10 W, 5%, 0805 | |
| R6 (3.3-V) | | Resistor, MF, 2.32 k Ω , 1/10 W, 1%, 0805 | |
| R6 (2.5-V) | | Resistor, MF, 1.50 k Ω , 1/10 W, 1%, 0805 | |
| R7 | | Resistor, CF, 100 Ω , 1/10 W, 5%, 0805 | |

As shown in Figures 24 and 25, the TPS2817 turns on the TPS1110 power switch in less than 20 ns and off in 25 ns.

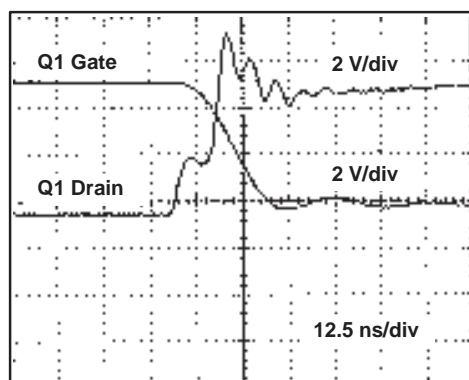


Figure 24. Q1 Turn-On Waveform

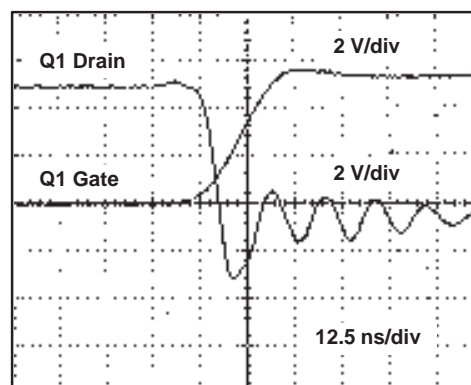


Figure 25. Q1 Turn-Off Waveform

TPS2816, TPS2817, TPS2818, TPS2819, TPS2828, TPS2829 SINGLE-CHANNEL HIGH-SPEED MOSFET DRIVER

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APPLICATION INFORMATION

The efficiency for various output currents, with a 5.25-V input, is shown in Figure 26. For a 3.3-V output, the efficiency is greater than 90% for loads up to 2 A – exceptional for a simple, inexpensive design.

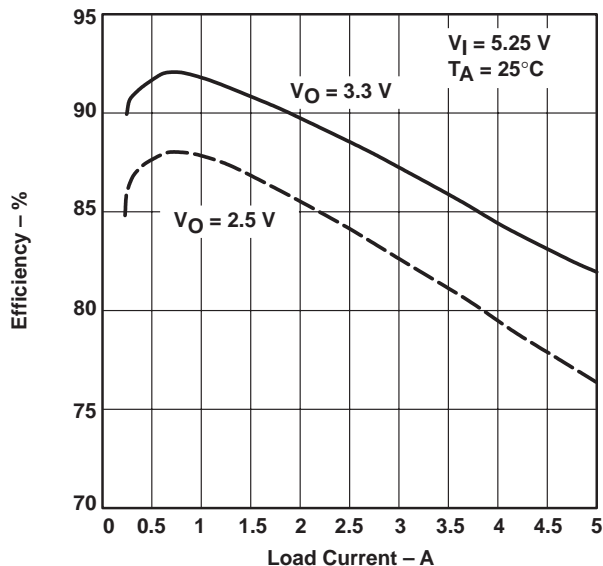


Figure 26. Converter Efficiency

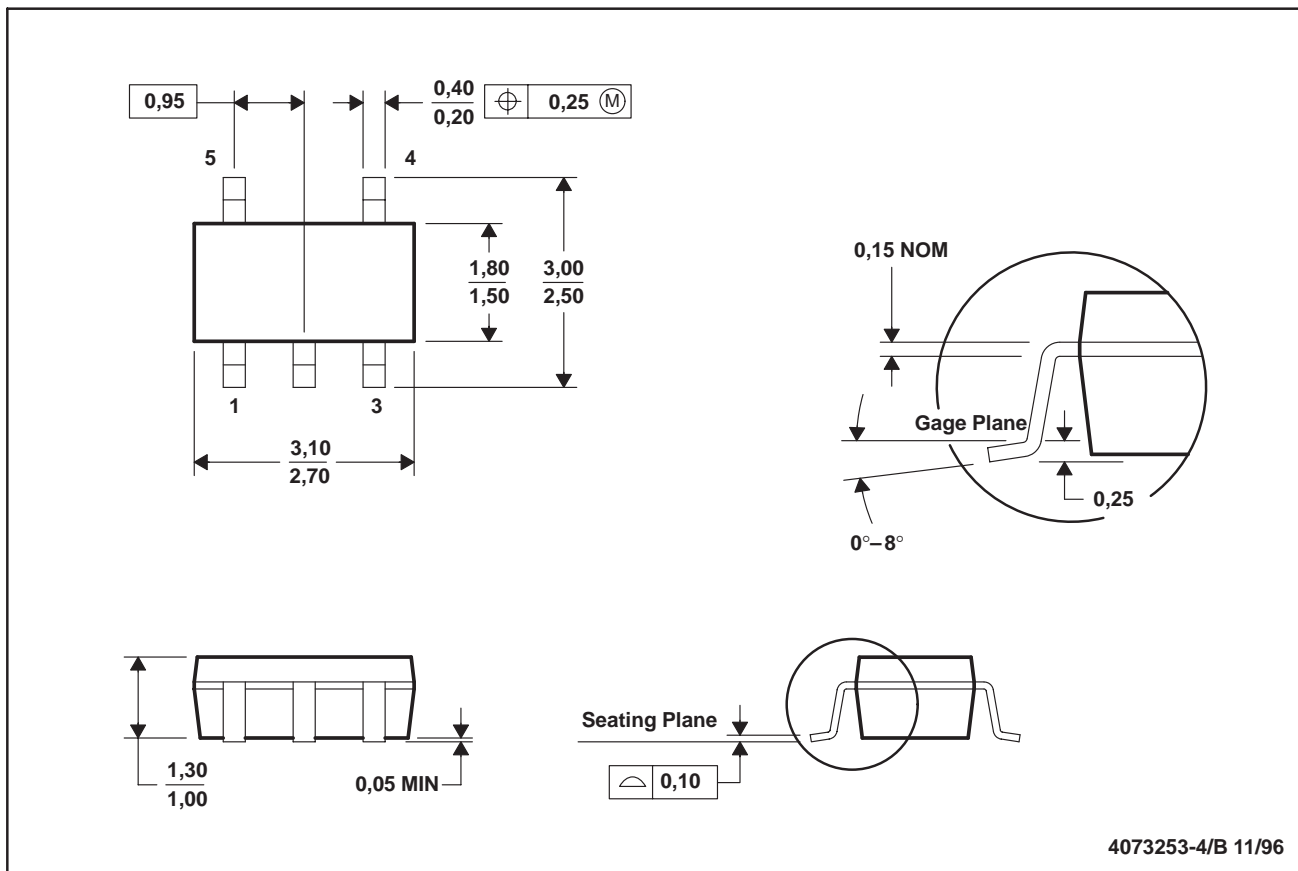
TPS2816, TPS2817, TPS2818, TPS2819, TPS2828, TPS2829
SINGLE-CHANNEL HIGH-SPEED MOSFET DRIVER

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MECHANICAL DATA

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions include mold flash or protrusion.

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