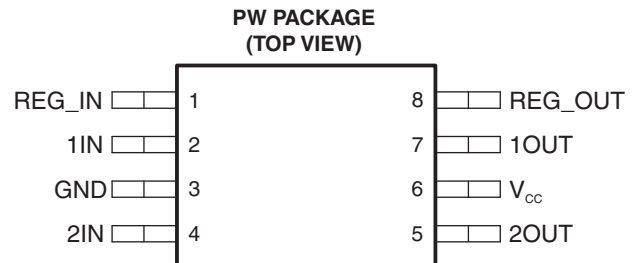


## DUAL HIGH-SPEED MOSFET DRIVER

Check for Samples: [TPS2811-Q1](#)

### FEATURES

- Qualified for Automotive Applications
- Industry-Standard Driver Replacement
- 25-ns Max Rise/Fall Times and 40-ns Max Propagation Delay With 1-nF Load,  $V_{CC} = 14\text{ V}$
- 2-A Peak Output Current,  $V_{CC} = 14\text{ V}$
- 5- $\mu\text{A}$  Supply Current With Input High or Low
- 4-V to 14-V Supply-Voltage Range; Internal Regulator Extends Range to 40 V
- -40°C to 125°C Ambient-Temperature Operating Range



### DESCRIPTION

The TPS2811 dual high-speed MOSFET driver is capable of delivering peak currents of 2 A into highly capacitive loads. This performance is achieved with a design that inherently minimizes shoot-through current and consumes an order of magnitude less supply current than competitive products.

The TPS2811 driver include a regulator to allow operation with supply inputs between 14 V and 40 V. The regulator output can power other circuitry, provided power dissipation does not exceed package limitations. When the regulator is not required, REG\_IN and REG\_OUT can be left disconnected or both can be connected to  $V_{CC}$  or GND.

TPS2811 driver is available in an 8-pin TSSOP package and operates over a ambient temperature range of -40°C to 125°C.

### ORDERING INFORMATION<sup>(1)</sup>

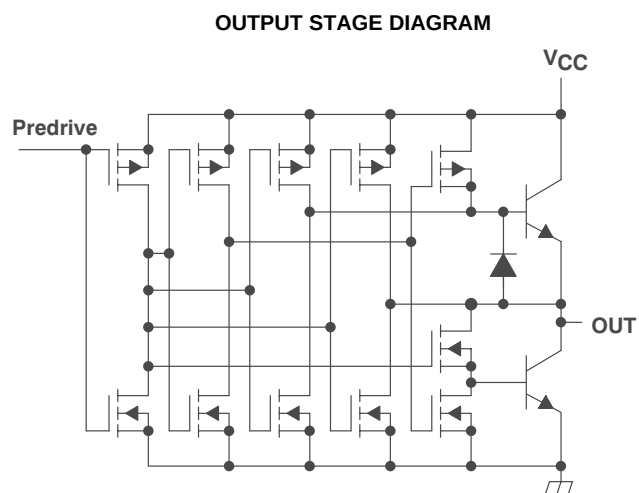
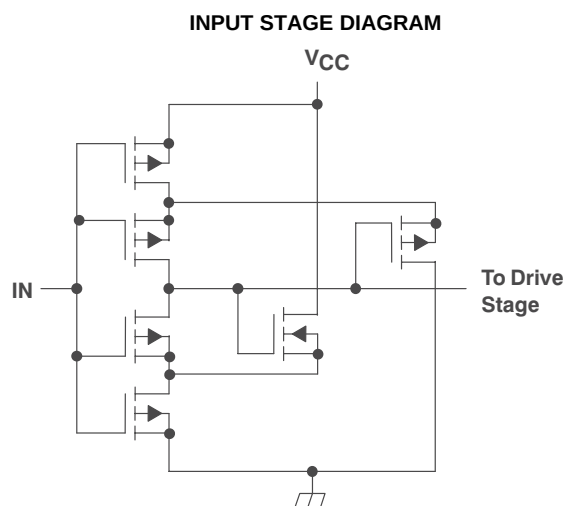
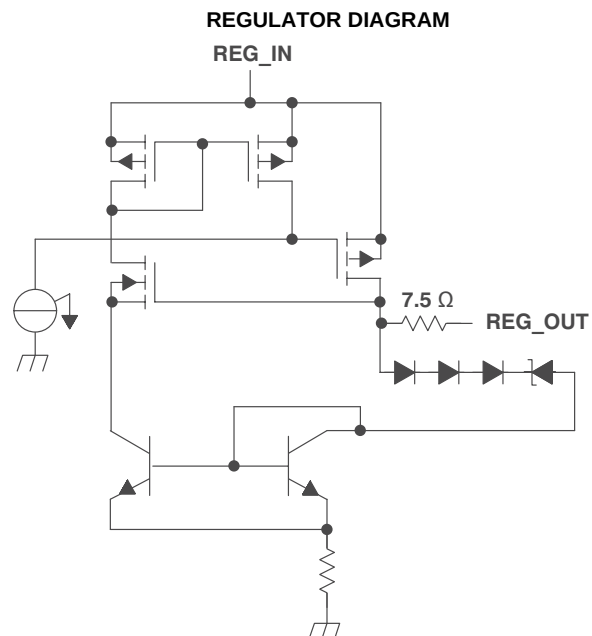
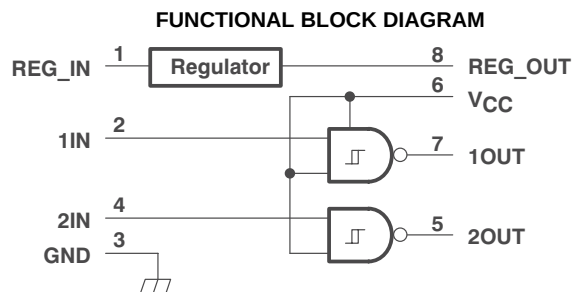
| $T_A$          | PACKAGE <sup>(2)</sup> |              | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|------------------------|--------------|-----------------------|------------------|
| -40°C to 125°C | TSSOP – PW             | Reel of 2000 | TPS2811QPWRQ1         | 2811Q            |

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).

(2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



## TERMINAL FUNCTIONS

| TERMINAL        |     | DESCRIPTION                       |
|-----------------|-----|-----------------------------------|
| NAME            | NO. |                                   |
| REG_IN          | 1   | Regulator input                   |
| 1IN             | 2   | Input 1                           |
| GND             | 3   | Ground                            |
| 2IN             | 4   | Input 2                           |
| 2OUT            | 5   | Output 2; $2OUT = \overline{2IN}$ |
| V <sub>CC</sub> | 6   | Supply voltage                    |
| 1OUT            | 7   | Output 1; $1OUT = \overline{1IN}$ |
| REG_OUT         | 8   | Regulator output                  |

## ABSOLUTE MAXIMUM RATINGS<sup>(1)(2)</sup>

over operating free-air temperature range (unless otherwise noted)

|                  |                                     |            |                                   |
|------------------|-------------------------------------|------------|-----------------------------------|
| V <sub>CC</sub>  | Supply voltage                      |            | –0.3 V to 15 V                    |
|                  | Regulator input voltage range       | REG_IN     | V <sub>CC</sub> –0.3 V to 42 V    |
|                  | Input voltage range                 | 1IN, 2IN   | –0.3 V to V <sub>CC</sub> +0.5 V  |
|                  | Output voltage range                | 1OUT, 2OUT | –0.5 < V < V <sub>CC</sub> +0.5 V |
|                  | Continuous regulator output current | REG_OUT    | 25 mA                             |
|                  | Continuous output current           | 1OUT, 2OUT | ±100 mA                           |
| T <sub>A</sub>   | Operating ambient temperature range |            | –40°C to 125°C                    |
| T <sub>stg</sub> | Storage temperature range           |            | –65°C to 150°C                    |

- (1) 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.
- (2) All voltages are with respect to device GND pin.

## RECOMMENDED OPERATING CONDITIONS

|                 |                                     | MIN      | MAX  | UNIT            |
|-----------------|-------------------------------------|----------|------|-----------------|
|                 | Regulator input voltage             | 8        | 40   | V               |
| V <sub>CC</sub> | Supply voltage                      | 4        | 14   | V               |
|                 | Input voltage                       | 1IN, 2IN | –0.3 | V <sub>CC</sub> |
|                 | Continuous regulator output current | REG_OUT  | 0    | 20              |
| T <sub>A</sub>  | Operating ambient temperature range | –40      | 125  | °C              |

## ELECTRICAL CHARACTERISTICS

over recommended operating ambient temperature range, V<sub>CC</sub> = 10 V, REG\_IN open, C<sub>L</sub> = 1 nF (unless otherwise noted)

| PARAMETER             | TEST CONDITIONS                        | MIN                                            | TYP <sup>(1)</sup> | MAX  | UNIT |
|-----------------------|----------------------------------------|------------------------------------------------|--------------------|------|------|
| <b>INPUTS</b>         |                                        |                                                |                    |      |      |
| V <sub>T+</sub>       | Positive-going input threshold voltage | V <sub>CC</sub> = 5 V                          | 3.3                | 4    | V    |
|                       |                                        | V <sub>CC</sub> = 10 V                         | 5.8                | 9    |      |
|                       |                                        | V <sub>CC</sub> = 14 V                         | 8.3                | 13   |      |
| V <sub>T–</sub>       | Negative-going input threshold voltage | V <sub>CC</sub> = 5 V                          | 1                  | 1.6  | V    |
|                       |                                        | V <sub>CC</sub> = 10 V                         | 1                  | 4.2  |      |
|                       |                                        | V <sub>CC</sub> = 14 V                         | 1                  | 6.2  |      |
|                       | Input hysteresis                       | V <sub>CC</sub> = 5 V                          | 1.6                |      | V    |
| I <sub>I</sub>        | Input current                          | Inputs = 0 V or V <sub>CC</sub>                | –1                 | 0.2  | 1    |
| C <sub>I</sub>        | Input capacitance                      |                                                | 5                  | 10   | pF   |
| <b>OUTPUTS</b>        |                                        |                                                |                    |      |      |
| V <sub>OH</sub>       | High-level output voltage              | I <sub>O</sub> = –1 mA                         | 9.75               | 9.9  | V    |
|                       |                                        | I <sub>O</sub> = –100 mA                       | 8                  | 9.1  |      |
| V <sub>OL</sub>       | Low-level output voltage               | I <sub>O</sub> = 1 mA                          | 0.18               | 0.25 | V    |
|                       |                                        | I <sub>O</sub> = 100 mA                        | 1                  | 2    |      |
| I <sub>O</sub>        | Peak output current                    | V <sub>CC</sub> = 10 V                         | 2                  |      | A    |
| <b>REGULATOR</b>      |                                        |                                                |                    |      |      |
| V <sub>O</sub>        | Output voltage                         | 14 ≤ REG_IN ≤ 40 V, 0 ≤ I <sub>O</sub> ≤ 20 mA | 10                 | 11.5 | 13   |
|                       | Output voltage in dropout              | I <sub>O</sub> = 10 mA, REG_IN = 10 V          | 9                  | 9.6  | V    |
| <b>SUPPLY CURRENT</b> |                                        |                                                |                    |      |      |
| I <sub>CC</sub>       | Supply current into V <sub>CC</sub>    | Inputs high or low                             | 0.2                | 5    | μA   |
|                       | Supply current into REG_IN             | REG_IN = 20 V, REG_OUT open                    | 40                 | 100  | μA   |

- (1) Typical values are at T<sub>A</sub> = 25°C unless otherwise noted.

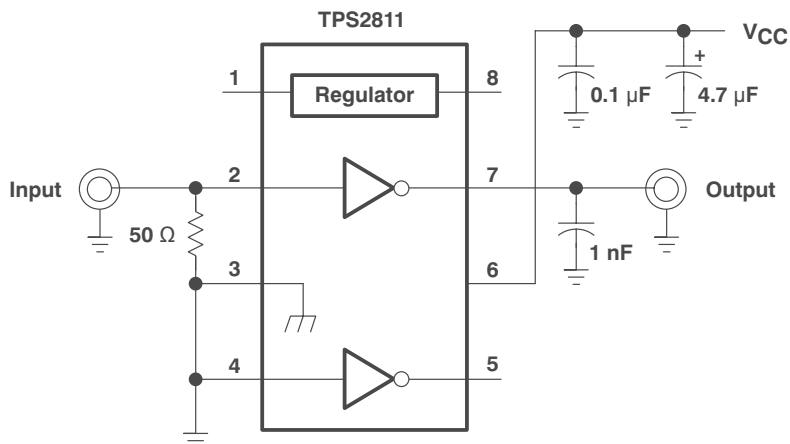
## SWITCHING CHARACTERISTICS

over recommended operating ambient temperature range, REG\_IN open,  $C_L = 1\text{ nF}$  (unless otherwise noted)

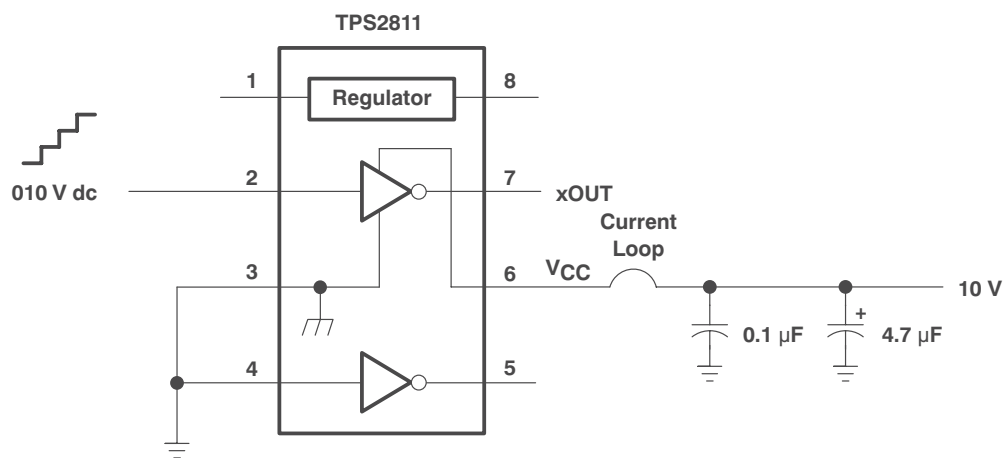
| PARAMETER |                                                  | TEST CONDITIONS        | MIN | TYP <sup>(1)</sup> | MAX | UNIT |
|-----------|--------------------------------------------------|------------------------|-----|--------------------|-----|------|
| $t_r$     | Rise time                                        | $V_{CC} = 14\text{ V}$ |     | 14                 | 25  | ns   |
|           |                                                  | $V_{CC} = 10\text{ V}$ |     | 15                 | 30  |      |
|           |                                                  | $V_{CC} = 5\text{ V}$  |     | 20                 | 35  |      |
| $t_f$     | Fall time                                        | $V_{CC} = 14\text{ V}$ |     | 15                 | 25  | ns   |
|           |                                                  | $V_{CC} = 10\text{ V}$ |     | 15                 | 30  |      |
|           |                                                  | $V_{CC} = 5\text{ V}$  |     | 18                 | 35  |      |
| $t_{PHL}$ | Propagation delay time, high-to-low-level output | $V_{CC} = 14\text{ V}$ |     | 25                 | 40  | ns   |
|           |                                                  | $V_{CC} = 10\text{ V}$ |     | 25                 | 45  |      |
|           |                                                  | $V_{CC} = 5\text{ V}$  |     | 34                 | 50  |      |
| $t_{PLH}$ | Propagation delay time low-to-high-level output  | $V_{CC} = 14\text{ V}$ |     | 24                 | 40  | ns   |
|           |                                                  | $V_{CC} = 10\text{ V}$ |     | 26                 | 45  |      |
|           |                                                  | $V_{CC} = 5\text{ V}$  |     | 36                 | 50  |      |

(1) Typical values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

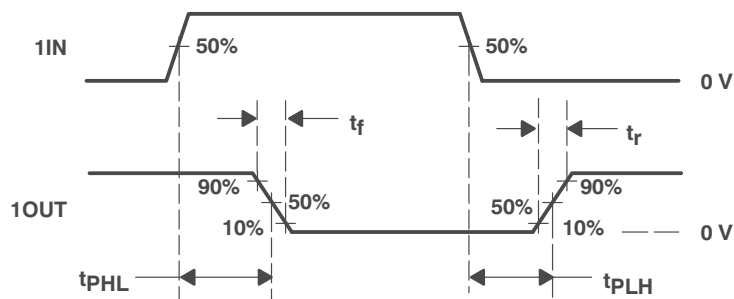
## PARAMETER MEASUREMENT INFORMATION



**Figure 1. Test Circuit For Measurement of Switching Characteristics**



**Figure 2. Shoot-Through Current Test Setup**



**Figure 3. Typical Timing Diagram**

## TYPICAL CHARACTERISTICS

**Table 1. Characteristics Graphs and Application Information**

| PARAMETER                                                  |                            | vs PARAMETER 2            |            | FIGURE |
|------------------------------------------------------------|----------------------------|---------------------------|------------|--------|
| Typical Characteristics                                    |                            |                           |            |        |
| Rise time                                                  | Supply voltage             |                           | 4          |        |
| Fall time                                                  | Supply voltage             |                           | 5          |        |
| Propagation delay time                                     | Supply voltage             |                           | 6, 7       |        |
| Supply current                                             | Supply voltage             |                           | 8          |        |
|                                                            | Load capacitance           |                           | 9          |        |
|                                                            | Ambient temperature        |                           | 0          |        |
| Input threshold voltage                                    | Supply voltage             |                           | 11         |        |
| Regulator output voltage                                   | Regulator input voltage    |                           | 12, 13     |        |
| Regulator quiescent current                                | Regulator input voltage    |                           | 14         |        |
| Peak source current                                        | Supply voltage             |                           | 15         |        |
| Peak sink current                                          | Supply voltage             |                           | 16         |        |
| Shoot-through current                                      | Input voltage, high-to-low |                           | 17         |        |
|                                                            | Input voltage, low-to-high |                           | 18         |        |
| General Applications                                       |                            |                           |            |        |
| Switching test circuits and application information        |                            |                           | 19, 20     |        |
| Voltage of 1OUT vs 2OUT                                    | Time                       | Low-to-high               | 21, 22, 23 |        |
|                                                            |                            | High-to-low               | 24, 25, 26 |        |
| Circuit for Measuring Paralleled Switching Characteristics |                            |                           |            |        |
| Switching test circuits and application information        |                            |                           | 27         |        |
| Input voltage vs output voltage                            | Time                       | Low-to-high               | 28, 30     |        |
|                                                            |                            | High-to-low               | 29, 31     |        |
| Hex-1 to Hex-4 Application Information                     |                            |                           |            |        |
| Driving test circuit and application information           |                            |                           | 32         |        |
| Drain-source voltage vs drain current                      | Time                       | Hex-1 size                | 33         |        |
|                                                            |                            | Hex-2 size                | 36         |        |
|                                                            |                            | Hex-3 size                | 39         |        |
|                                                            |                            | Hex-4 size                | 41         |        |
|                                                            |                            | Hex-4 size parallel drive | 45         |        |
|                                                            | Time                       | Hex-1 size                | 34         |        |
|                                                            |                            | Hex-2 size                | 37         |        |
|                                                            |                            | Hex-3 size                | 40         |        |
|                                                            |                            | Hex-4 size                | 43         |        |
|                                                            |                            | Hex-4 size parallel drive | 46         |        |
|                                                            | Time                       | Hex-1 size                | 35         |        |
|                                                            |                            | Hex-2 size                | 38         |        |
|                                                            |                            | Hex-3 size                | 42         |        |
|                                                            |                            | Hex-4 size                | 44         |        |
|                                                            |                            | Hex-4 size parallel drive | 47         |        |
| Synchronous Buck Regulator Application                     |                            |                           |            |        |
| 3.3-V 3-A Synchronous-Rectified Buck Regulator Circuit     |                            |                           | 48         |        |
| Q1 drain voltage vs gate voltage at turn-on                | Time                       |                           | 49         |        |
| Q1 drain voltage vs gate voltage at turn-off               | Time                       |                           | 50         |        |
| Q1 drain voltage vs Q2 gate-source voltage                 | Time                       |                           | 51, 52, 53 |        |
| Output ripple voltage vs inductor current                  | Time                       | 3 A                       | 54         |        |
|                                                            |                            | 5 A                       | 55         |        |

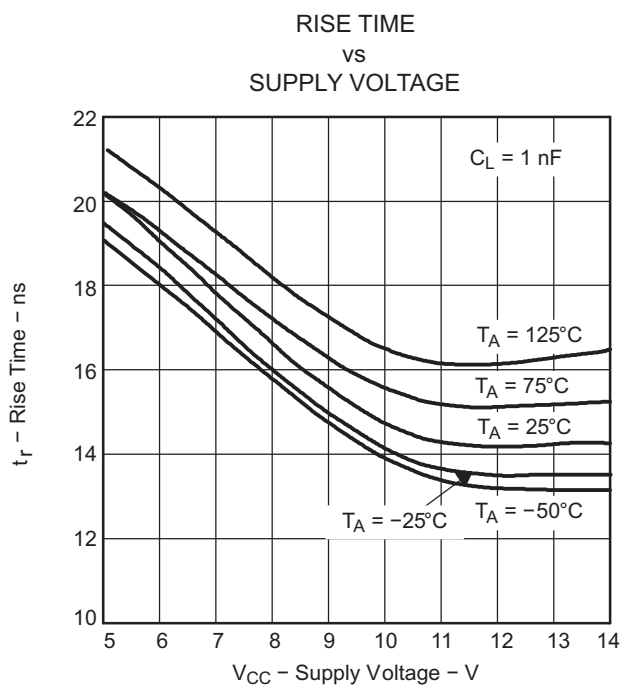


Figure 4.

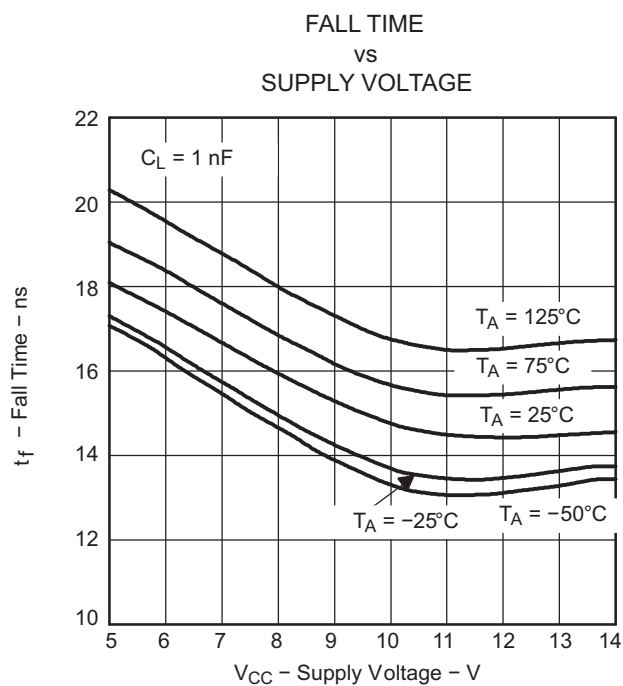


Figure 5.

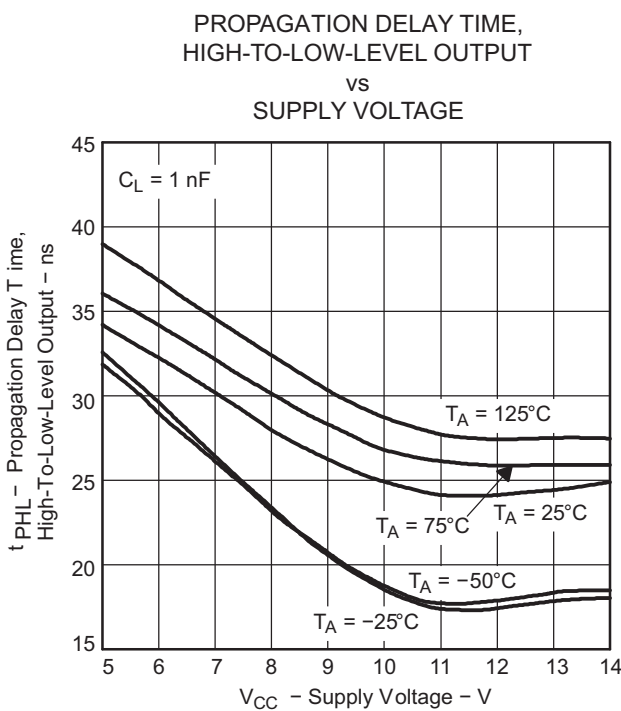


Figure 6.

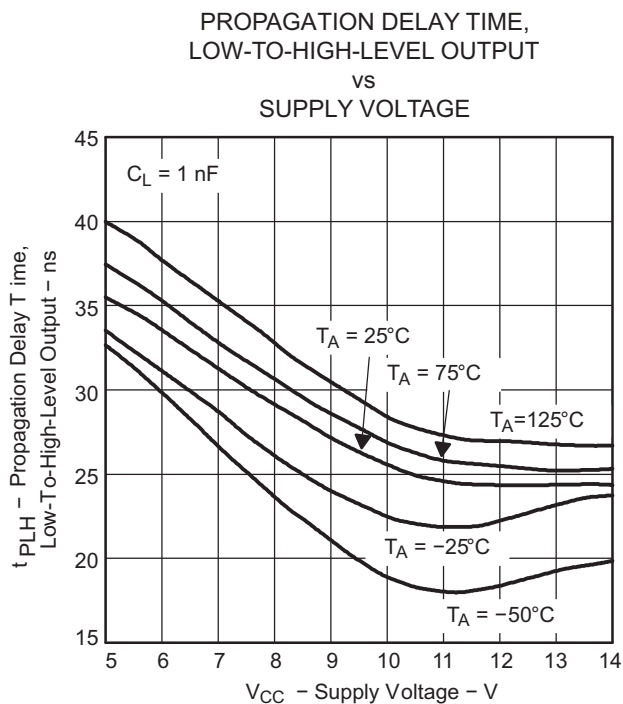


Figure 7.

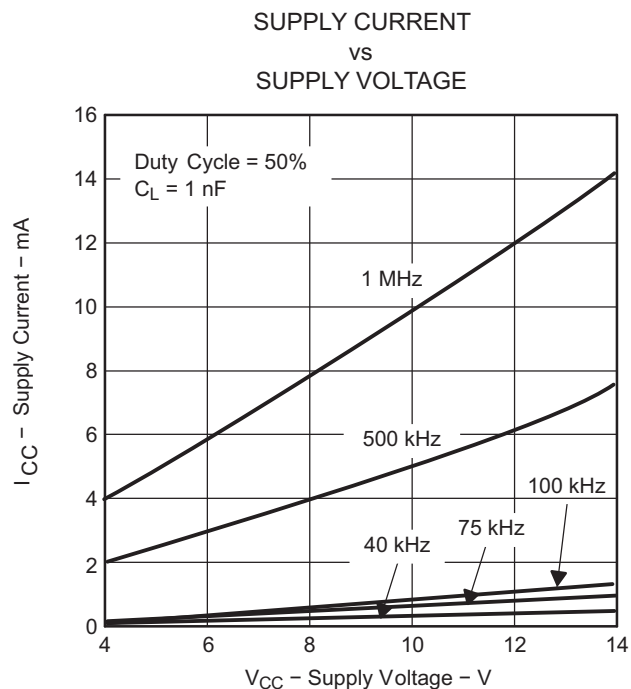


Figure 8.

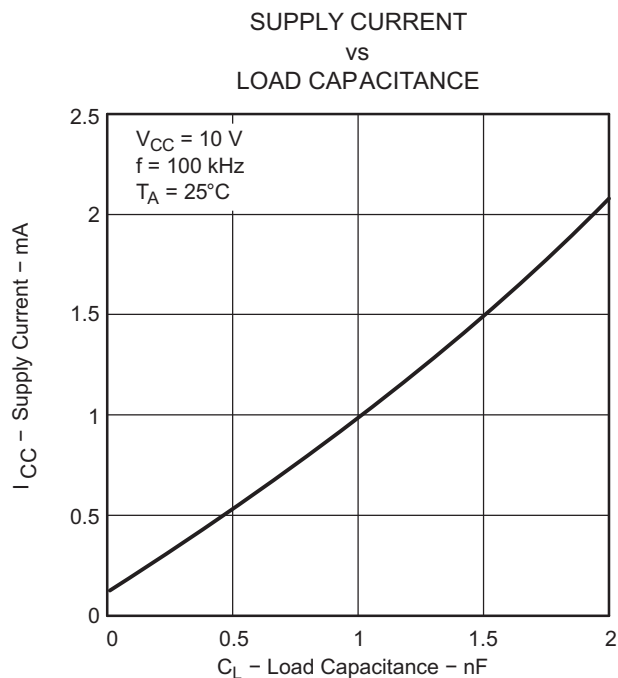


Figure 9.

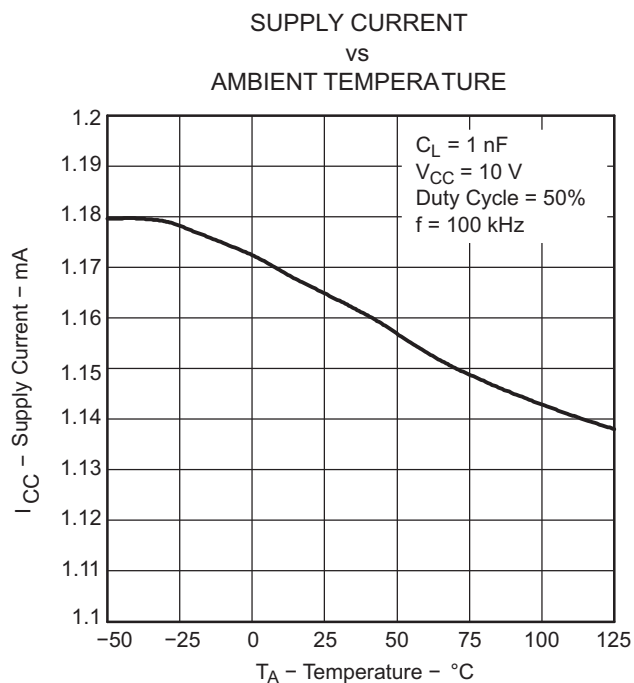


Figure 10.

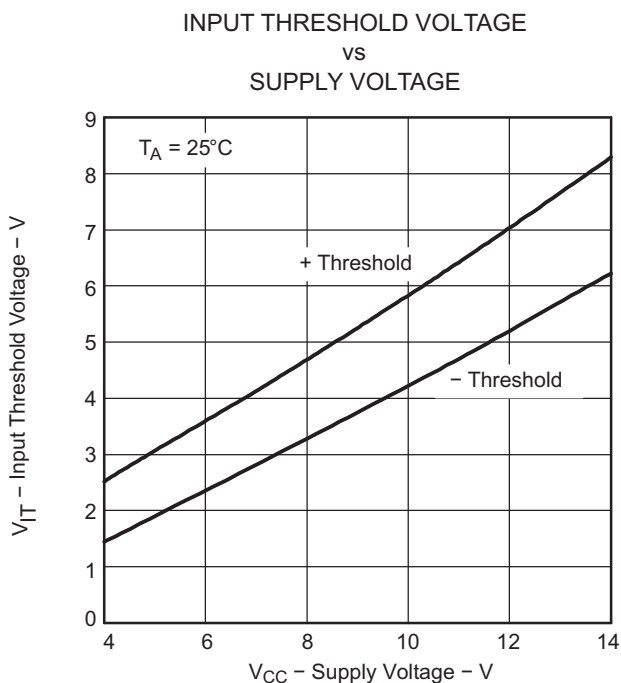


Figure 11.

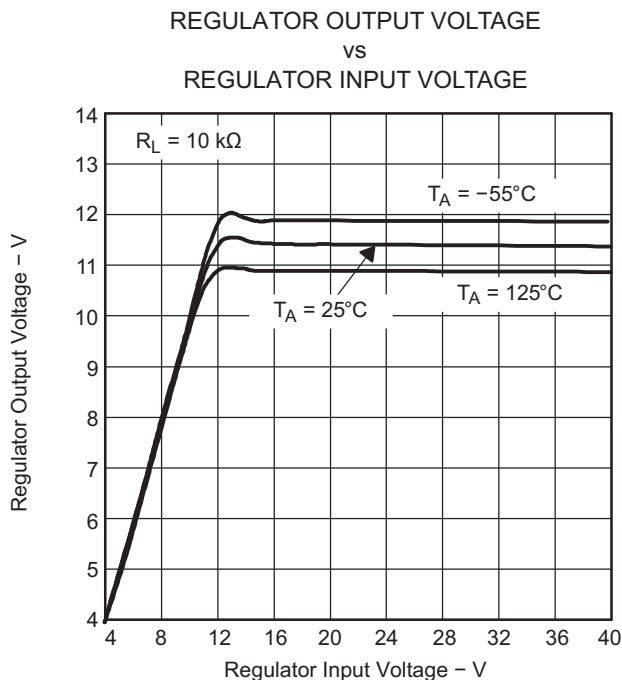


Figure 12.

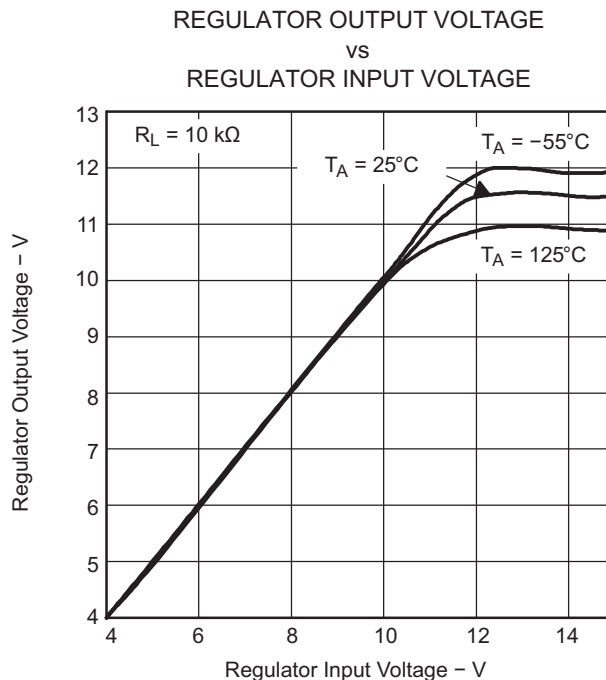


Figure 13.

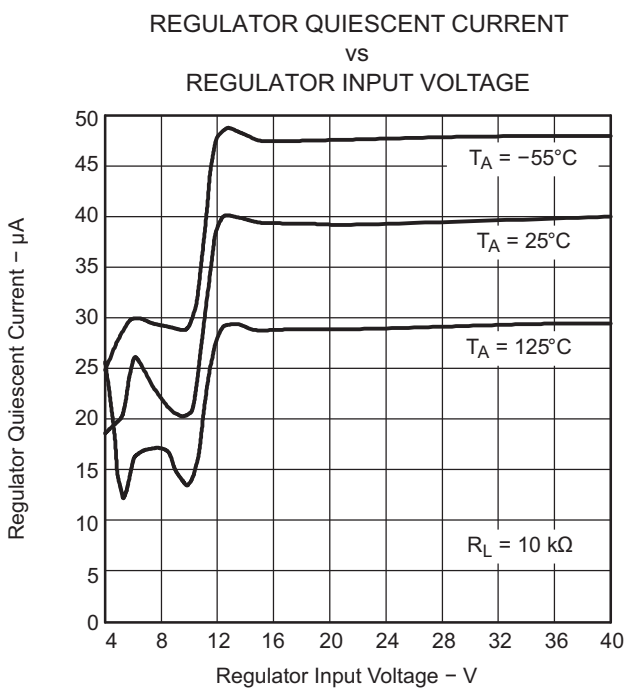


Figure 14.

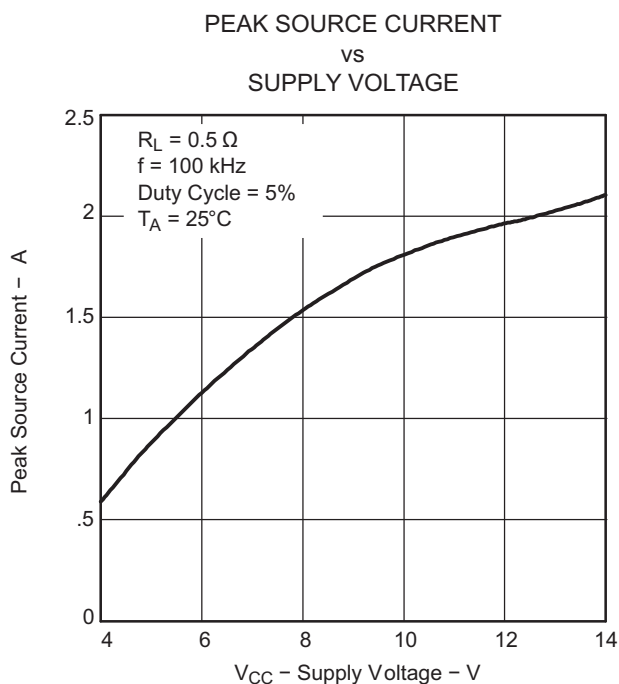
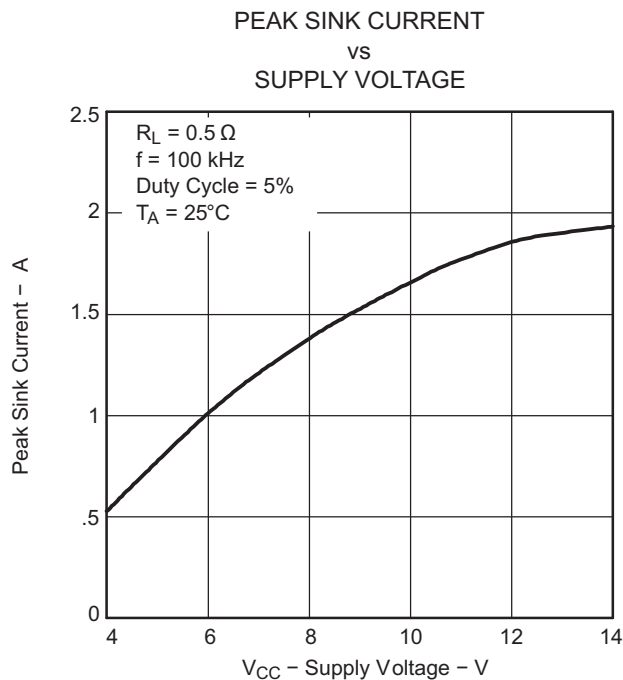
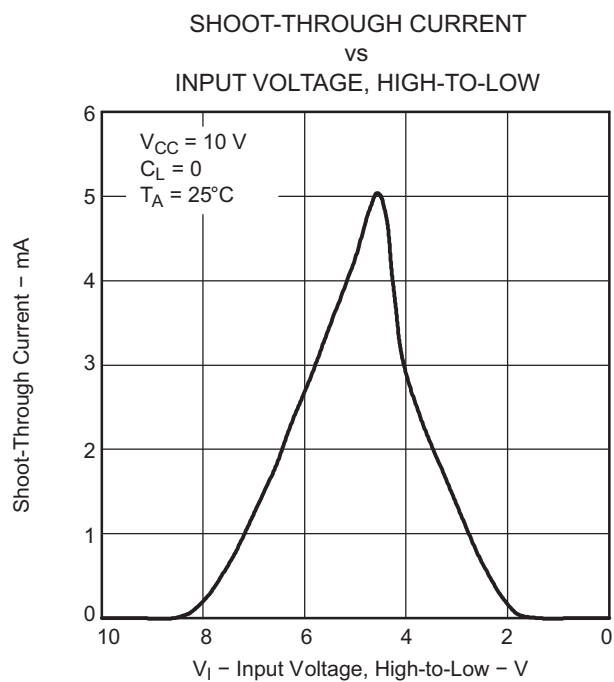
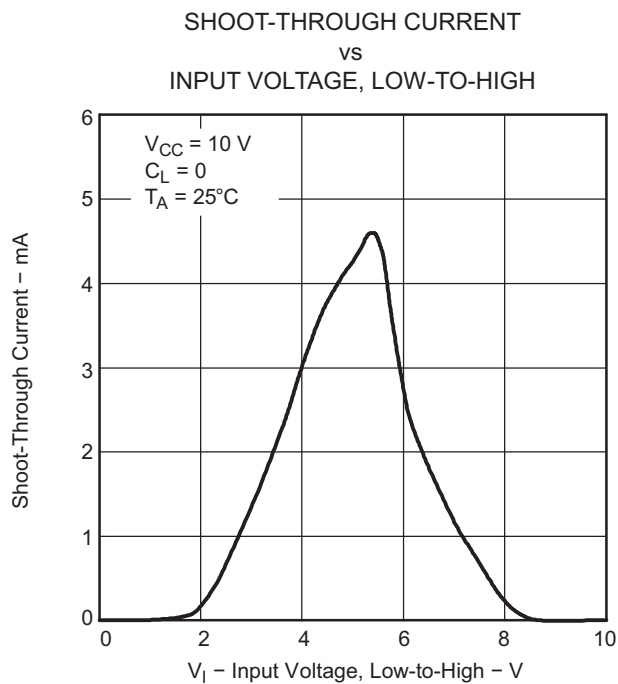


Figure 15.

**Figure 16.****Figure 17.****Figure 18.**

## APPLICATION INFORMATION

The TPS2811 circuits each contain one regulator and two MOSFET drivers. The regulator can be used to limit  $V_{CC}$  to between 10 V and 13 V for a range of input voltages from 14 V to 40 V, while providing up to 20 mA of dc drive. The TPS2811 has inverting drivers. These MOSFET drivers are capable of supplying up to 2.1 A or sinking up to 1.9 A (see Figures 15 and 16) of instantaneous current to n-channel or p-channel MOSFETs. The TPS2811 MOSFET drivers have very fast switching times combined with very short propagation delays. These features enhance the operation of today's high-frequency circuits.

The CMOS input circuit has a positive threshold of approximately  $2/3$  of  $V_{CC}$ , with a negative threshold of  $1/3$  of  $V_{CC}$ , and a very high input impedance in the range of  $109\Omega$ . Noise immunity is also very high because of the Schmitt-trigger switching. In addition, the design is such that the normal shoot-through current in CMOS (when the input is biased halfway between  $V_{CC}$  and ground) is limited to less than 6 mA. The limited shoot-through is evident in the graphs in Figures 17 and 18. The input stage shown in the functional block diagram better illustrates the way the front end works. The circuitry of the device is such that regardless of the rise and/or fall time of the input signal, the output signal will always have a fast transition speed; this basically isolates the waveforms at the input from the output. Therefore, the specified switching times are not affected by the slopes of the input waveforms.

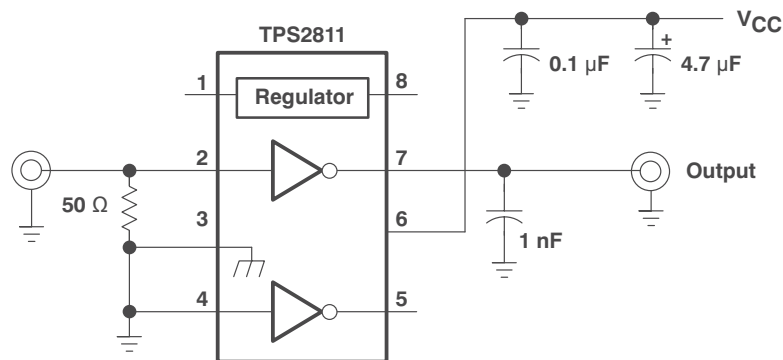
The basic driver portion of the circuits operate over a supply voltage range of 4 V to 14 V with a maximum bias current of 5  $\mu$ A. Each driver consists of a CMOS input and a buffered output with a 2-A instantaneous drive capability. They have propagation delays of less than 30 ns and rise and fall times of less than 20 ns each. Placing a 0.1- $\mu$ F ceramic capacitor between  $V_{CC}$  and ground is recommended; this will supply the instantaneous current needed by the fast switching and high current surges of the driver when it is driving a MOSFET.

The output circuit is also shown in the functional block diagram. This driver uses a unique combination of a bipolar transistor in parallel with a MOSFET for the ability to swing from  $V_{CC}$  to ground while providing 2 A of instantaneous driver current. This unique parallel combination of bipolar and MOSFET output transistors provides the drive required at  $V_{CC}$  and ground to guarantee turn-off of even low-threshold MOSFETs. Typical bipolar-only output devices don't easily approach  $V_{CC}$  or ground.

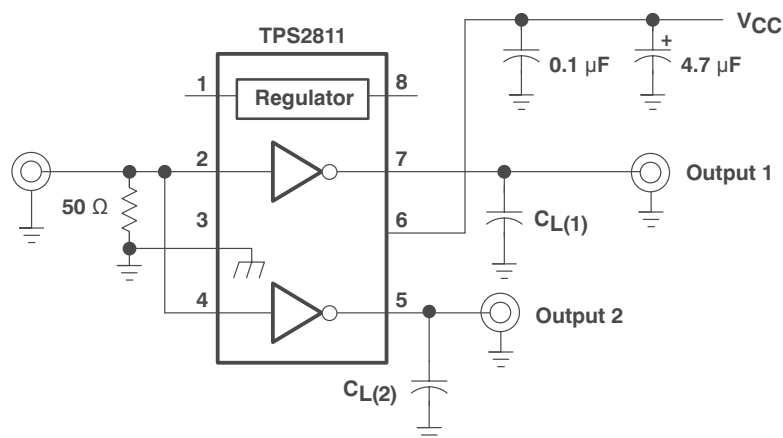
The regulator included in the TPS2811 has an input voltage range of 14 V to 40 V. It produces an output voltage of 10 V to 13 V and is capable of supplying from 0 to 20 mA of output current. In grounded source applications, this extends the overall circuit operation to 40 V by clamping the driver supply voltage ( $V_{CC}$ ) to a safe level for both the driver and the MOSFET gate. The bias current for full operation is a maximum of 150  $\mu$ A. A 0.1- $\mu$ F capacitor connected between the regulator output and ground is required to ensure stability. For transient response, an additional 4.7- $\mu$ F electrolytic capacitor on the output and a 0.1- $\mu$ F ceramic capacitor on the input will optimize the performance of this circuit. When the regulator is not in use, it can be left open at both the input and the output, or the input can be shorted to the output and tied to either the  $V_{CC}$  or the ground pin of the chip.

## Matching and Paralleling Connections

Figure 19 and Figure 20 show the delays for the rise and fall time of each channel. As can be seen on a 5-ns scale, there is very little difference between the two channels at no load. Figures 23 and 24 show the difference between the two channels for a 1-nF load on each output. There is a slight delay on the rising edge, but little or no delay on the falling edge. As an example of extreme overload, Figures 25 and 26 show the difference between the two channels, or two drivers in the package, each driving a 10-nF load. As would be expected, the rise and fall times are significantly slowed down. Figures 28 and 29 show the effect of paralleling the two channels and driving a 1-nF load. A noticeable improvement is evident in the rise and fall times of the output waveforms. Finally, Figures 30 and 31 show the two drivers being paralleled to drive the 10-nF load and as could be expected the waveforms are improved. In summary, the paralleling of the two drivers in a package enhances the capability of the drivers to handle a larger load. Because of manufacturing tolerances, it is not recommended to parallel drivers that are not in the same package.

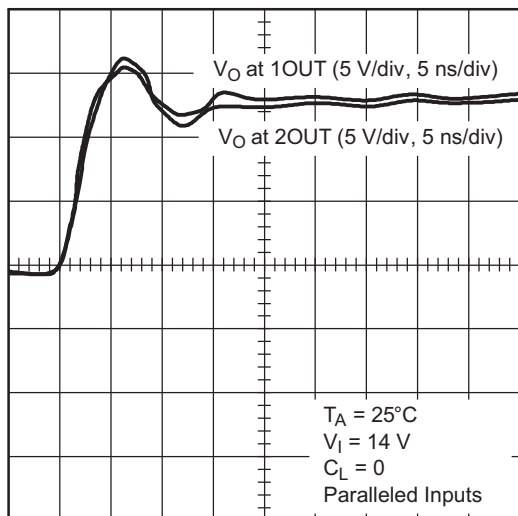


**Figure 19. Test Circuit for Measuring Switching Characteristics**



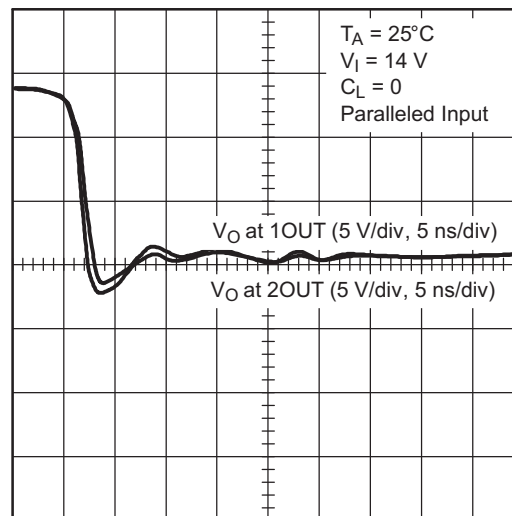
A. Input rise and fall times should be  $\leq 10$  ns for accurate measurement of ac parameters.

**Figure 20. Test Circuit for Measuring Switching Characteristics With the Inputs Connected in Parallel**



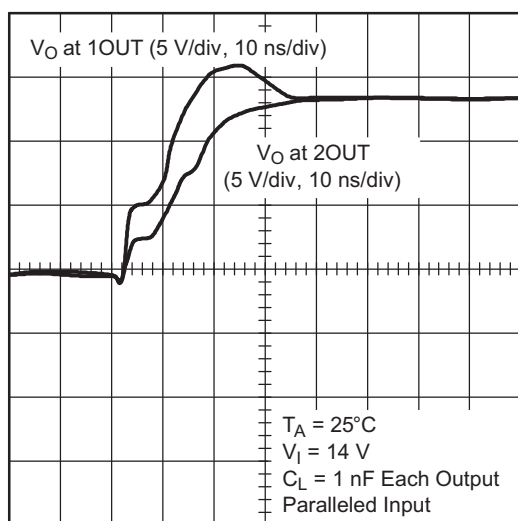
t – Time

**Figure 21. Voltage of 1OUT vs Voltage at 2OUT, Low-to-High Output Delay**



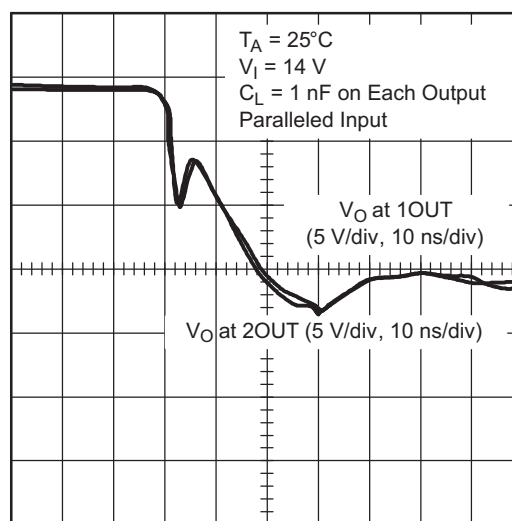
t – Time

**Figure 22. Voltage at 1OUT vs Voltage at 2OUT, High-to-Low Output Delay**



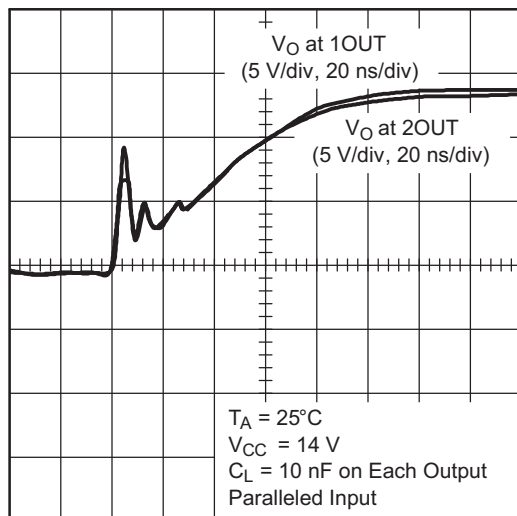
t – Time

**Figure 23. Voltage at 1OUT vs Voltage at 2OUT, Low-to-High Output Delay**



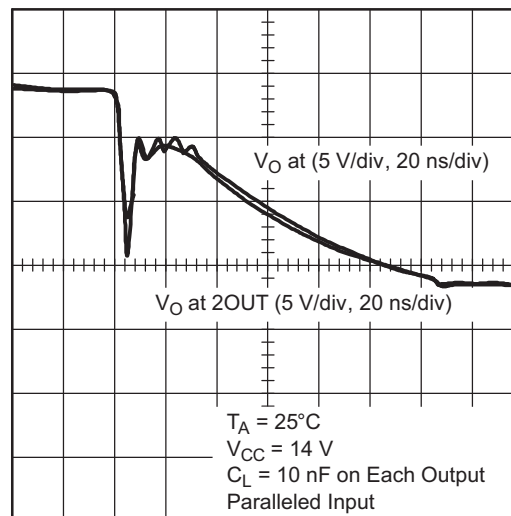
t – Time

**Figure 24. Voltage at 1OUT vs Voltage at 2OUT, High-to-Low Output Delay**



t – Time

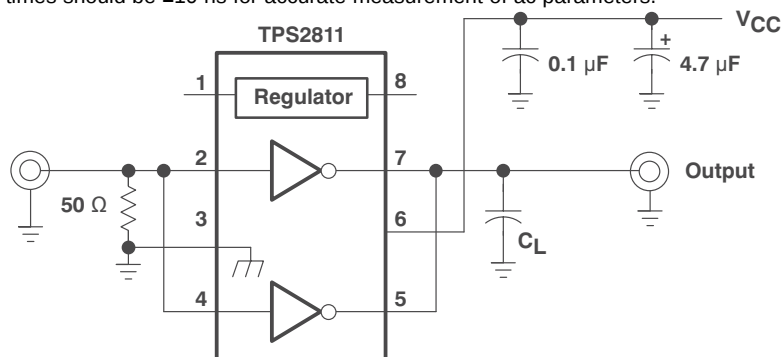
**Figure 25. Voltage at 10OUT vs Voltage at 20OUT, Low-to-High Output Delay**



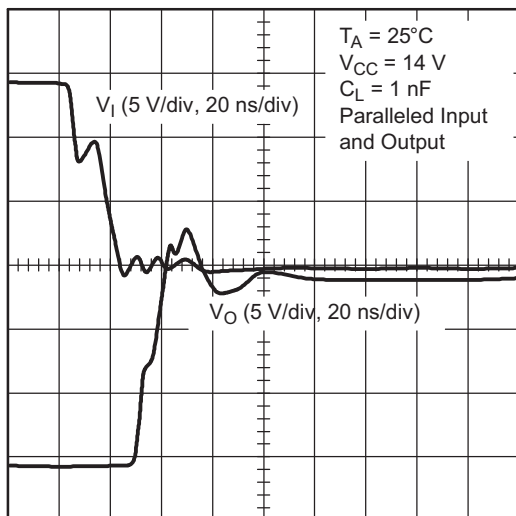
t – Time

**Figure 26. Voltage at 10OUT vs Voltage at 20OUT, High-to-Low Output Delay**

A. Input rise and fall times should be  $\leq 10\text{ ns}$  for accurate measurement of ac parameters.

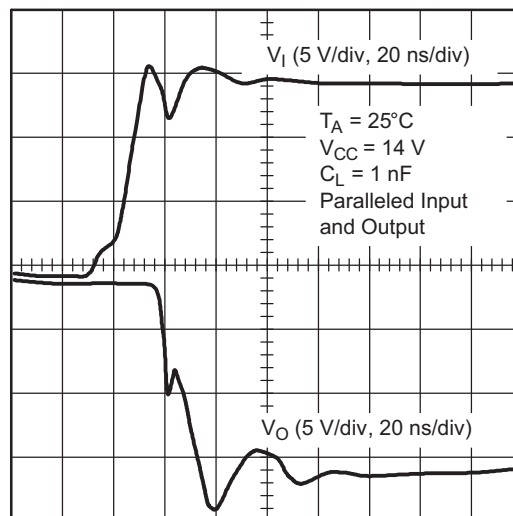


**Figure 27. Test Circuit for Measuring Paralleled Switching Characteristics**



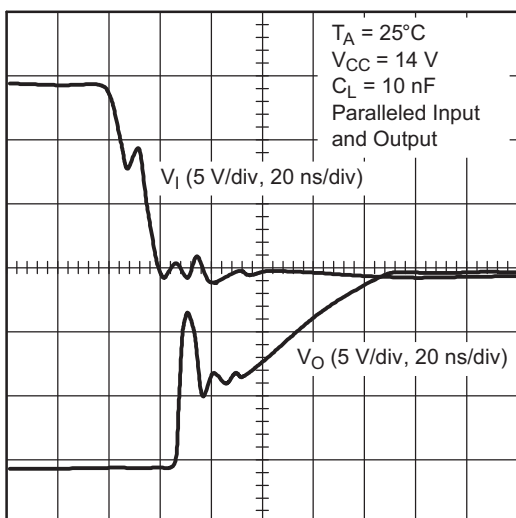
t – Time

**Figure 28. Input Voltage vs Output Voltage, Low-to-High Propagation Delay of Paralleled Drivers**



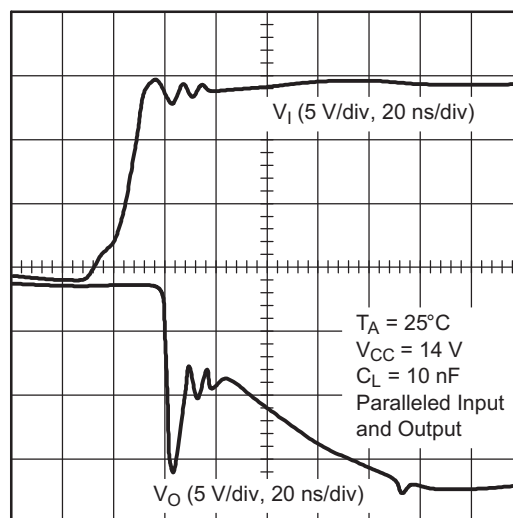
t – Time

**Figure 29. Input Voltage vs Output Voltage, High-to-Low Propagation Delay of Paralleled Drivers**



t – Time

**Figure 30. Input Voltage vs Output Voltage, Low-to-High Propagation Delay of Paralleled Drivers**



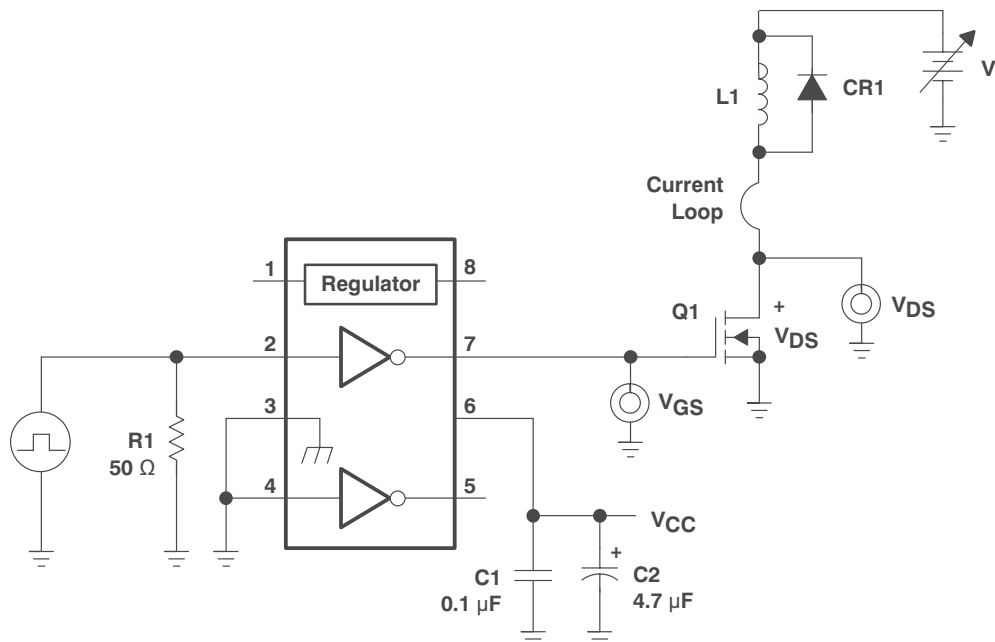
t – Time

**Figure 31. Input Voltage vs Output Voltage, High-to-Low Propagation Delay of Paralleled Drivers**

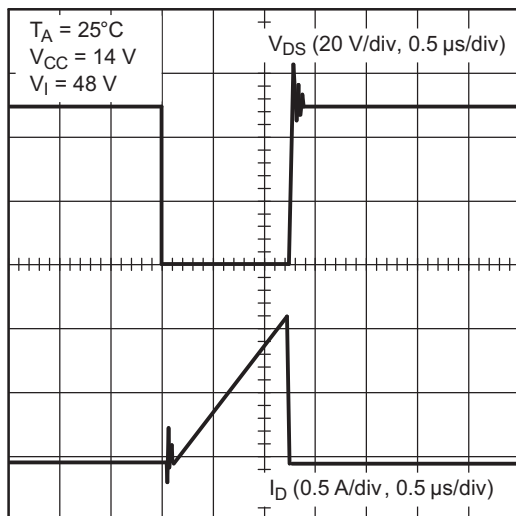
Figures 33 through 47 illustrate the performance of the TPS2811 driving MOSFETs with clamped inductive loads, similar to what is encountered in discontinuous-mode flyback converters. The MOSFETs that were tested range in size from Hex-1 to Hex-4, although the TPS28xx family is only recommended for Hex-3 or below.

The test circuit is shown in Figure 32. The layout rules observed in building the test circuit also apply to real applications. Decoupling capacitor C1 is a 0.1- $\mu$ F ceramic device, connected between  $V_{CC}$  and GND of the TPS2811, with short lead lengths. The connection between the driver output and the MOSFET gate, and between GND and the MOSFET source, are as short as possible to minimize inductance. Ideally, GND of the driver is connected directly to the MOSFET source. The tests were conducted with the pulse generator frequency set very low to eliminate the need for heat sinking, and the duty cycle was set to turn off the MOSFET when the drain current reached 50% of its rated value. The input voltage was adjusted to clamp the drain voltage at 80% of its rating.

As shown, the driver is capable of driving each of the Hex-1 through Hex-3 MOSFETs to switch in 20 ns or less. Even the Hex-4 is turned on in less than 20 ns. Figures 45, 46 and 47 show that paralleling the two drivers in a package enhances the gate waveforms and improves the switching speed of the MOSFET. Generally, one driver is capable of driving up to a Hex-4 size. The TPS2811 family is even capable of driving large MOSFETs that have a low gate charge.

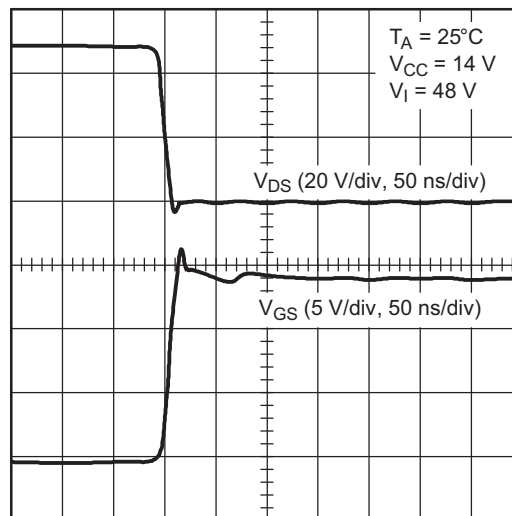


**Figure 32. TPS2811 Driving Hex-1 through Hex-4 Devices**



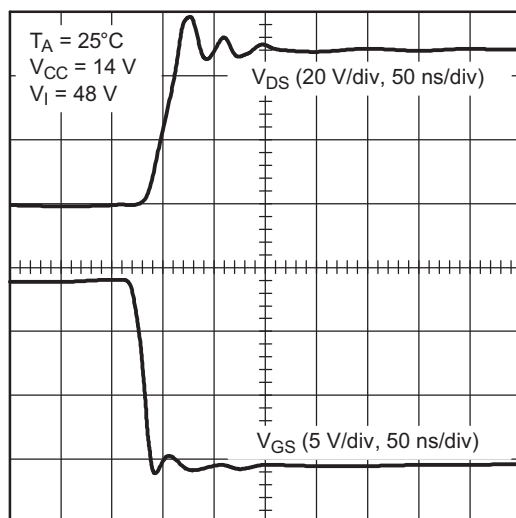
t – Time

**Figure 33. Drain-Source Voltage vs Drain Current, TPS2811 Driving an IRFD014 (Hex-1 Size)**



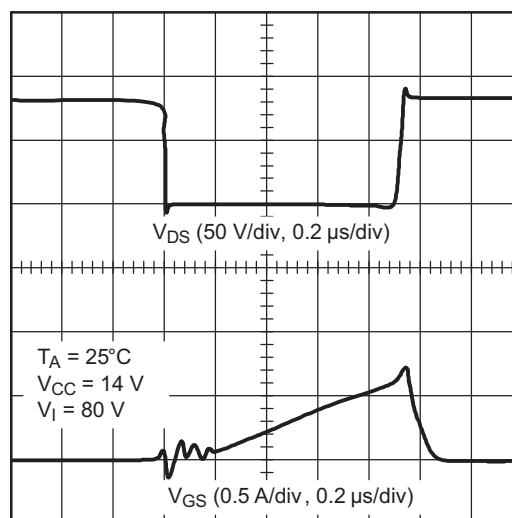
t – Time

**Figure 34. Drain-Source Voltage vs Gate-Source Voltage, at Turn-on, TPS2811 Driving an IRFD014 (Hex-1 Size)**



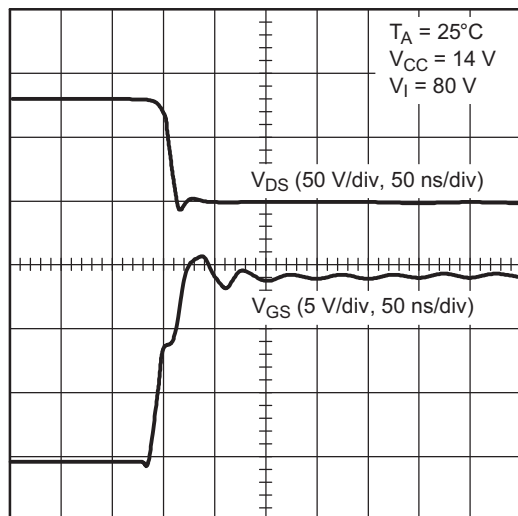
t – Time

**Figure 35. Drain-Source Voltage vs Gate-Source Voltage, at Turn-off, TPS2811 Driving an IRFD014 (Hex-1 Size)**



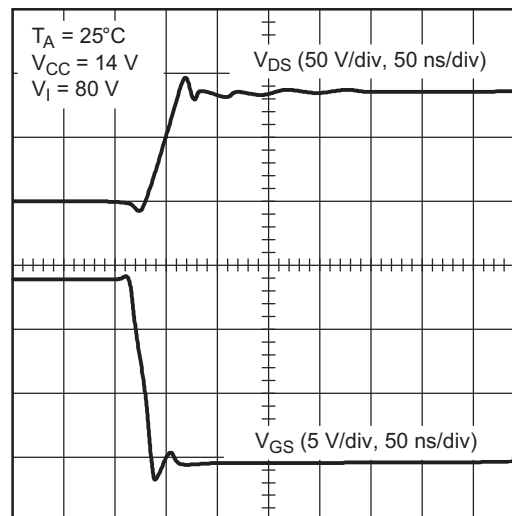
t – Time

**Figure 36. Drain-Source Voltage vs Drain Current, TPS2811 Driving an IRFD120 (Hex-2 Size)**



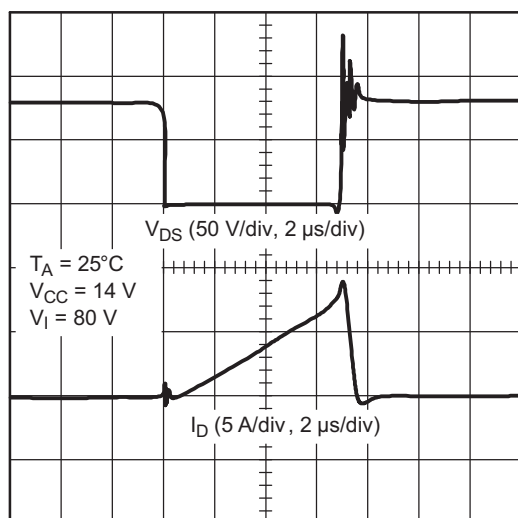
t – Time

**Figure 37. Drain-Source Voltage vs Gate-Source Voltage, at Turn-on, TPS2811 Driving an IRFD120 (Hex-2 Size)**



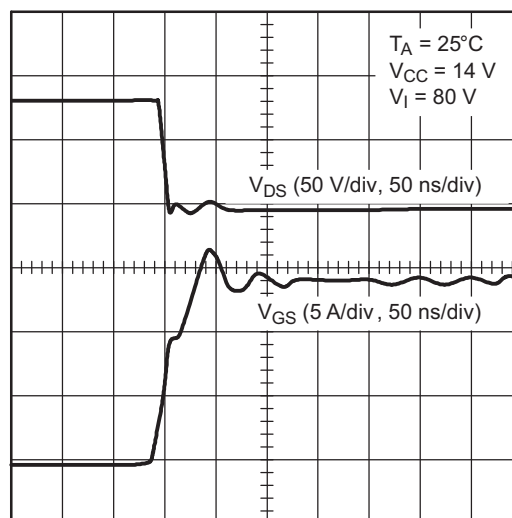
t – Time

**Figure 38. Drain-Source Voltage vs Gate-Source Voltage, at Turn-off, TPS2811 Driving an IRFD120 (Hex-2 Size)**



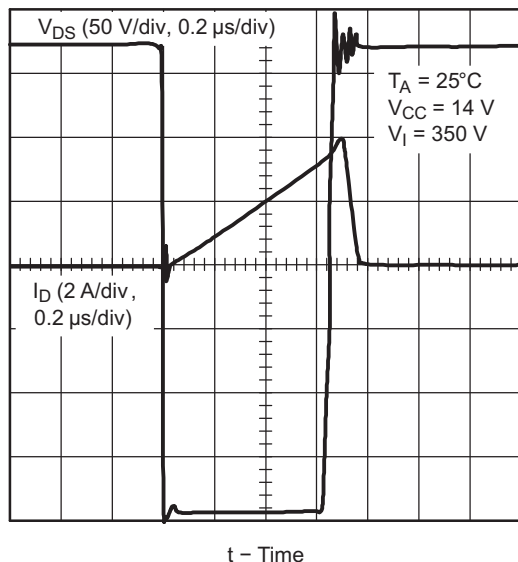
t – Time

**Figure 39. Drain-Source Voltage vs Drain Current, TPS2811 Driving an IRF530 (Hex-3 Size)**

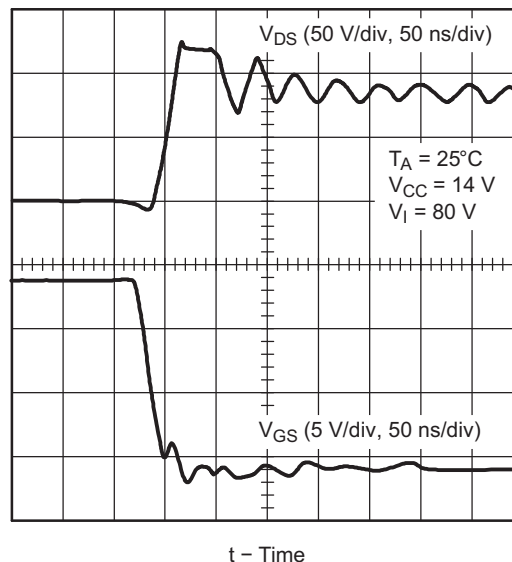


t – Time

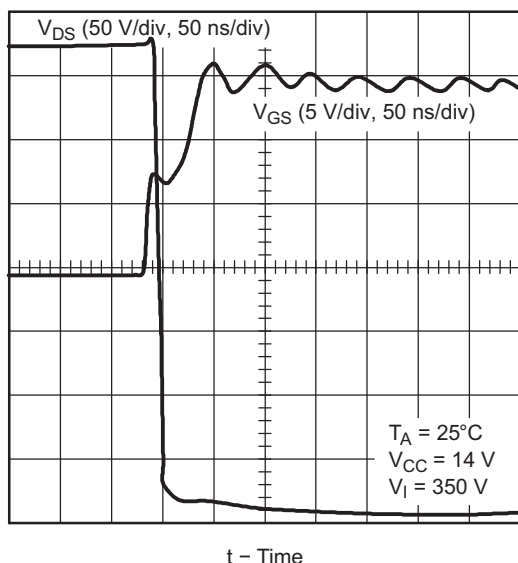
**Figure 40. Drain-Source Voltage vs Gate-Source Voltage, at Turn-on, TPS2811 Driving an IRF530 (Hex-3 Size)**



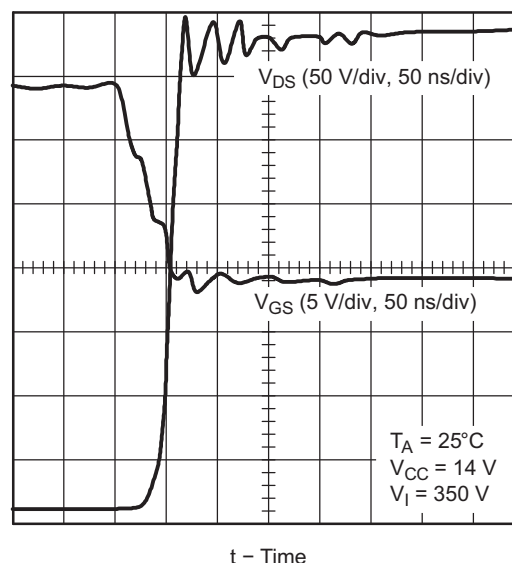
**Figure 41. Drain-Source Voltage vs Drain Current, One Driver, TPS2811 Driving an IRF840 (Hex-4 Size)**



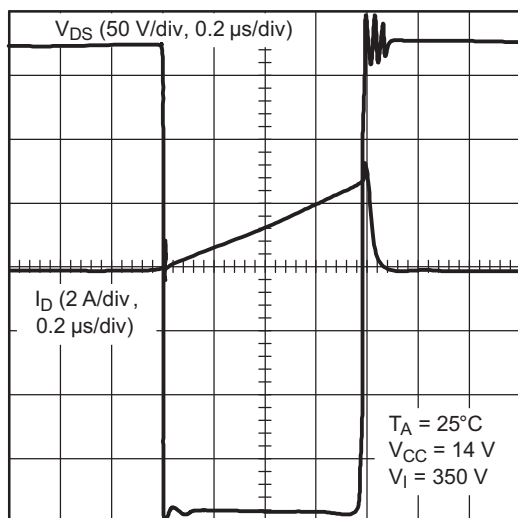
**Figure 42. Drain-Source Voltage vs Gate-Source Voltage, at Turn-off, TPS2811 Driving an IRF530 (Hex-3 Size)**



**Figure 43. Drain-Source Voltage vs Gate-Source Voltage, at Turn-on, One Driver, TPS2811 Driving an IRF840 (Hex-4 Size)**

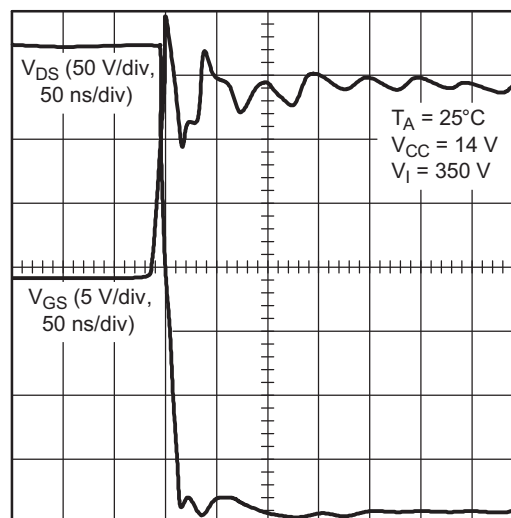


**Figure 44. Drain-Source Voltage vs Gate-Source Voltage, at Turn-off, One Driver, TPS2811 Driving an IRF840 (Hex-4 Size)**



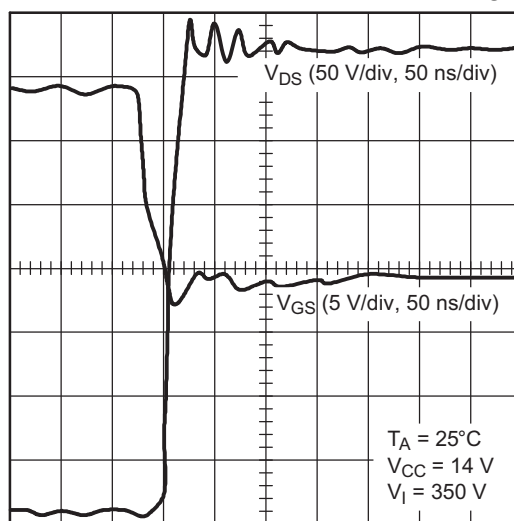
t – Time

**Figure 45. Drain-Source Voltage vs Drain Current, Parallel Drivers, TPS2811 Driving an IRF840 (Hex-4 Size)**



t – Time

**Figure 46. Drain-Source Voltage vs Gate-Source Voltage, at Turn-on, Parallel Drivers, TPS2811 Driving an IRF840 (Hex-4 Size)**



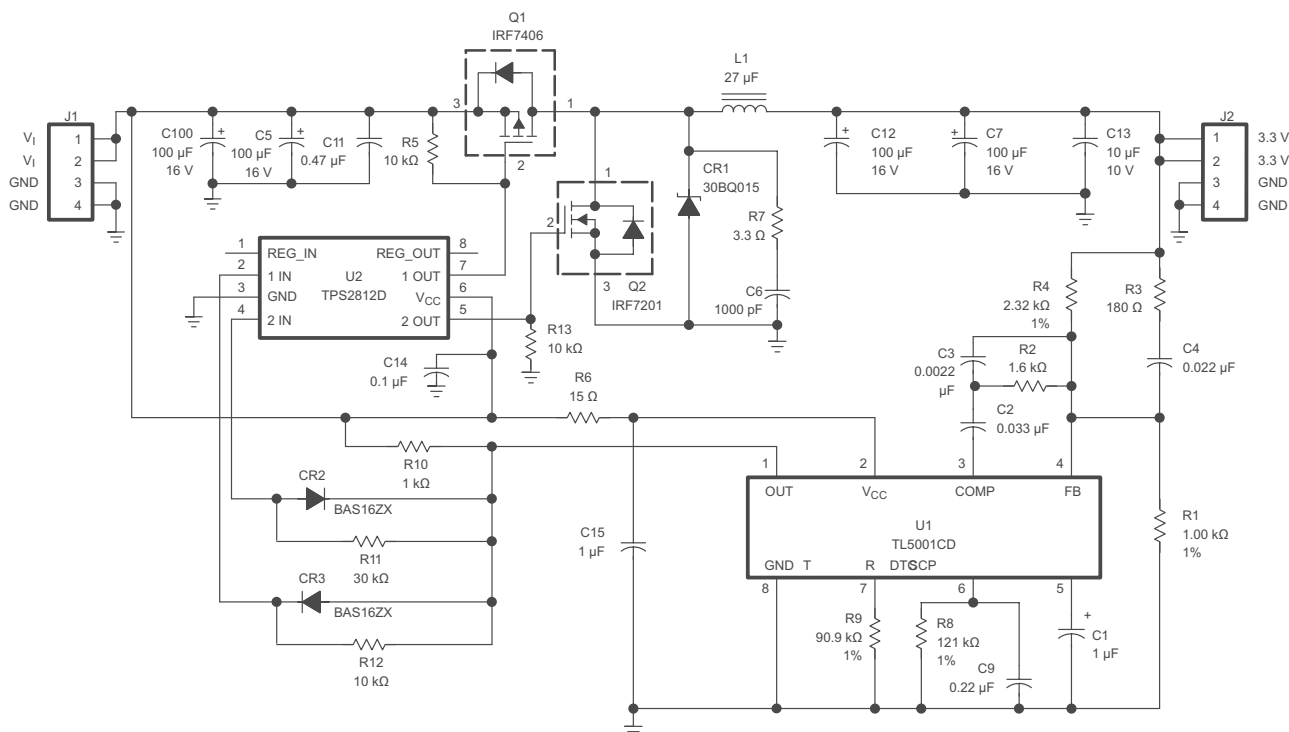
t – Time

**Figure 47. Drain-Source Voltage vs Gate-Source Voltage, at Turn-off, Parallel Drivers, TPS2811 Driving an IRF840 (Hex-4 Size)**

## Synchronous Buck Regulator

Figure 48 is the schematic for a 100-kHz synchronous-rectified buck converter implemented with a TL5001 pulse-width-modulation (PWM) controller and a TPS2812 driver. The bill of materials is provided in Table 1. The converter operates over an input range from 5.5 V to 12 V and has a 3.3-V output capable of supplying 3 A continuously and 5 A during load surges. The converter achieves an efficiency of 90.6% at 3 A and 87.6% at 5 A. Figures 49 and 50 show the power switch switching performance. The output ripple voltage waveforms are documented in Figures 54 and 55.

The TPS2812 drives both the power switch, Q2, and the synchronous rectifier, Q1. Large shoot-through currents, caused by power switch and synchronous rectifier remaining on simultaneously during the transitions, are prevented by small delays built into the drive signals, using CR2, CR3, R11, R12, and the input capacitance of the TPS2812. These delays allow the power switch to turn off before the synchronous rectifier turns on and vice versa. Figure 51 shows the delay between the drain of Q2 and the gate of Q1; expanded views are provided in Figures 52 and 53.



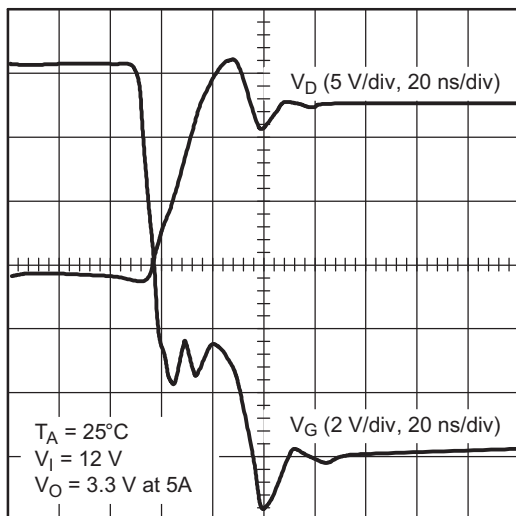
NOTE: If the parasitics of the external circuit cause the voltage to violate the Absolute Maximum Rating for the Output pins, Schottky diodes should be added from ground to output and from output to V<sub>CC</sub>.

**Figure 48. 3.3-V 3-A Synchronous-Rectified Buck Regulator Circuit**

**Table 2. Bill of Materials, 3.3-V, 3-A Synchronous-Rectified Buck Converter<sup>(1)</sup>**

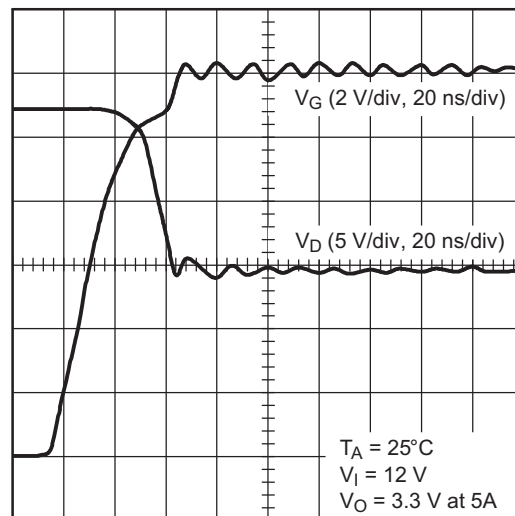
| REFERENCE     | DESCRIPTION                                   | VENDOR                  |              |
|---------------|-----------------------------------------------|-------------------------|--------------|
| U1            | TL5001CD, PWM                                 | Texas Instruments       | 972-644-5580 |
| U2            | TPS2812D, N.I. MOSFET Driver                  | Texas Instruments       | 972-644-5580 |
| CR1           | 3 A, 15 V, Schottky, 30BQ015                  | International Rectifier | 310-322-3331 |
| CR2,CR3       | Signal Diode, BAS16ZX                         | Zetex                   | 516-543-7100 |
| C1            | 1 $\mu$ F, 16 V, Tantalum                     |                         |              |
| C2            | 0.033 $\mu$ F, 50 V                           |                         |              |
| C3            | 0.0022 $\mu$ F, 50 V                          |                         |              |
| C4            | 0.022 $\mu$ F, 50 V                           |                         |              |
| C5,C7,C10,C12 | 100 $\mu$ F, 16 V, Tantalum, TPSE107M016R0100 | AVX                     | 800-448-9411 |
| C6            | 1000 pF, 50 V                                 |                         |              |
| C9            | 0.22 $\mu$ F, 50 V                            |                         |              |
| C11           | 0.47 $\mu$ F, 50 V, Z5U                       |                         |              |
| C13           | 10 $\mu$ F, 10 V, Ceramic, CC1210CY5V106Z     | TDK                     | 708-803-6100 |
| C14           | 0.1 $\mu$ F, 50 V                             |                         |              |
| C15           | 1.0 $\mu$ F, 50 V                             |                         |              |
| J1,J2         | 4-Pin Header                                  | Nova Magnetics, Inc.    | 972-272-8287 |
| L1            | 27 $\mu$ H, 3 A/5 A, SML5040                  | International Rectifier | 310-322-3331 |
| Q1            | IRF7406, P-FET                                | International Rectifier | 310-322-3331 |
| Q2            | IRF7201, N-FET                                |                         |              |
| R1            | 1.00 k $\Omega$ , 1%                          |                         |              |
| R2            | 1.6 k $\Omega$                                |                         |              |
| R3            | 180 $\Omega$                                  |                         |              |
| R4            | 2.32 k $\Omega$ , 1 %                         |                         |              |
| R5,R12,R13    | 10 k $\Omega$                                 |                         |              |
| R6            | 15 $\Omega$                                   |                         |              |
| R7            | 3.3 $\Omega$                                  |                         |              |
| R8            | 121 k $\Omega$ , 1%                           |                         |              |
| R9            | 90.9 k $\Omega$ , 1%                          |                         |              |
| R10           | 1 k $\Omega$                                  |                         |              |
| R11           | 30 k $\Omega$                                 |                         |              |

(1) Unless otherwise specified, capacitors are X7R ceramics, and resistors are 5%, 1/10 W.



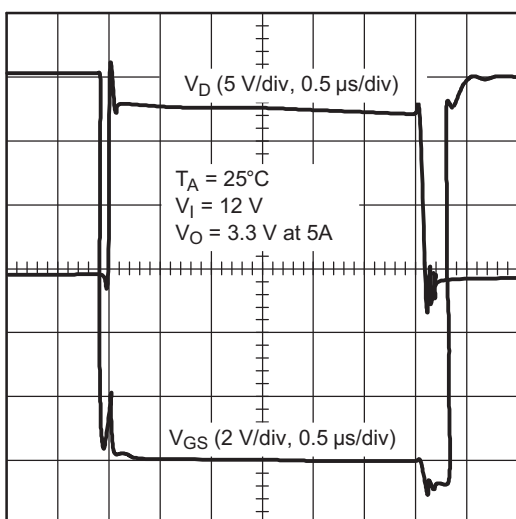
t – Time

**Figure 49. Q1 Drain Voltage vs Gate Voltage, at Switch Turn-on**



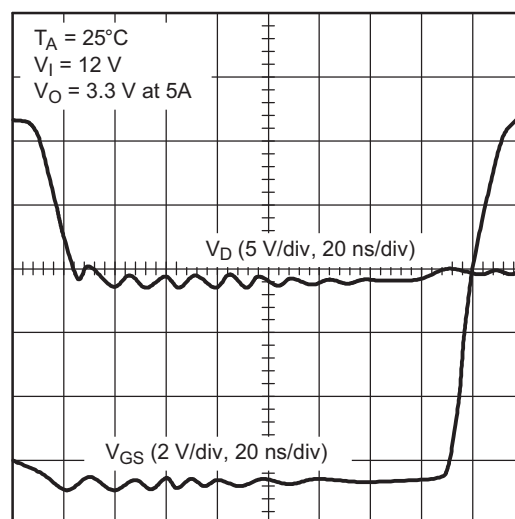
t – Time

**Figure 50. Q1 Drain Voltage vs Gate Voltage, at Switch Turn-off**



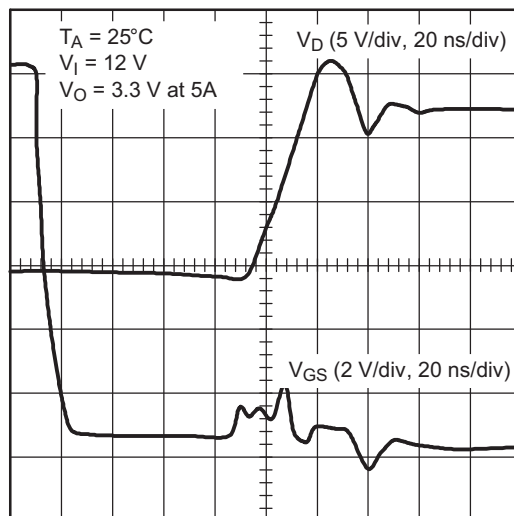
t – Time

**Figure 51. Q1 Drain Voltage vs Q2 Gate-Source Voltage**

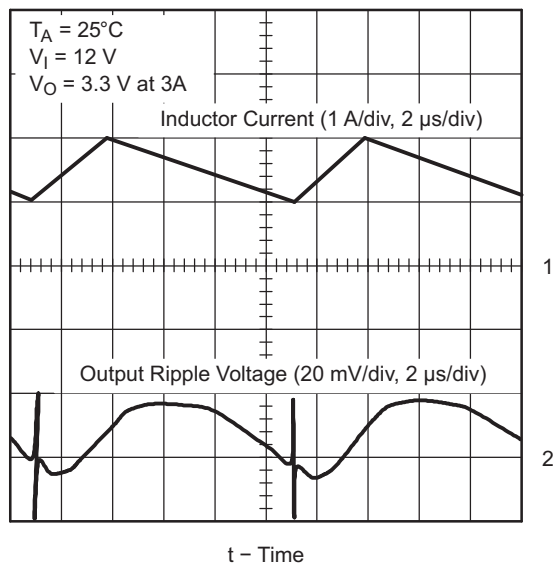


t – Time

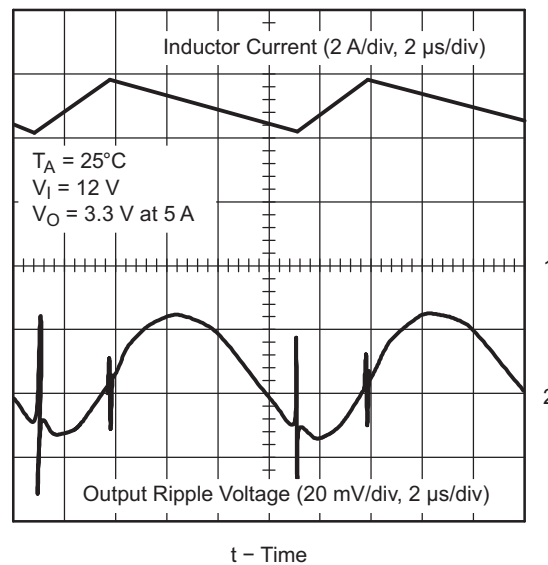
**Figure 52. Q1 Drain Voltage vs Q2 Gate-Source Voltage**



t – Time

**Figure 53. Q1 Drain Voltage vs Q2 Gate-Source Voltage**

t – Time

**Figure 54. Output Ripple Voltage vs Inductor Current, at 3 A**

t – Time

**Figure 55. Output Ripple Voltage vs Inductor Current, at 5 A**

## PACKAGING INFORMATION

| Orderable part number         | Status<br>(1) | Material type<br>(2) | Package   Pins | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|-------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">TPS2811QPWRQ1</a> | Active        | Production           | TSSOP (PW)   8 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 125   | 2811Q               |
| TPS2811QPWRQ1.A               | Active        | Production           | TSSOP (PW)   8 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 125   | 2811Q               |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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### OTHER QUALIFIED VERSIONS OF TPS2811-Q1 :

- Catalog : [TPS2811](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS2811QPWRQ1 | TSSOP        | PW              | 8    | 2000 | 330.0              | 12.4               | 7.0     | 3.6     | 1.6     | 8.0     | 12.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS2811QPWRQ1 | TSSOP        | PW              | 8    | 2000 | 353.0       | 353.0      | 32.0        |

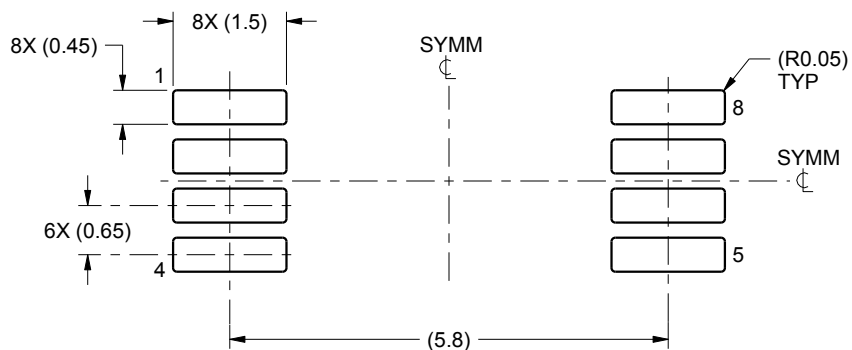


# EXAMPLE BOARD LAYOUT

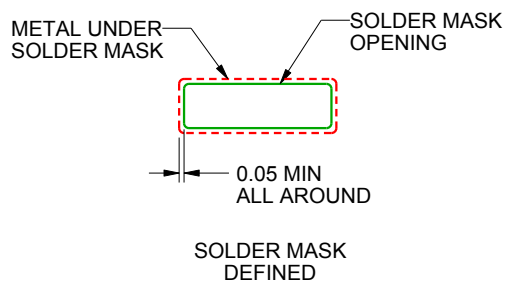
PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
SCALE:10X



SOLDER MASK DETAILS  
NOT TO SCALE

4221848/A 02/2015

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

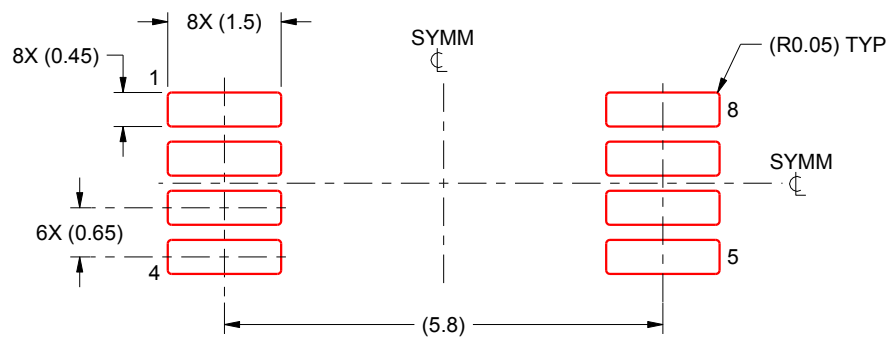
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:10X

4221848/A 02/2015

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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