- **Floating Bootstrap or Ground-Reference High-Side Driver**
- **Adaptive Dead-Time Control**
- **50-ns Max Rise/Fall Times With 3.3-nF Load**
- **2.4-A Typical Output Current**
- **4.5-V to 15-V Supply Voltage Range**
- **TTL-Compatible Inputs**
- **Internal Schottky Bootstrap Diode**
- **Low Supply Current....3 mA Typical**
- **Ideal for High-Current Single or Multiphase Power Supplies**
- **– 40°C to 125°C Operating Virtual Junction-Temperature Range**

D PACKAGE
(TOP VIEW)

IN	1	BOOT 8
PGND	2	HIGHDR 7
DT	3	BOOTLO 6
V_{CC}	4	LOWDR 5
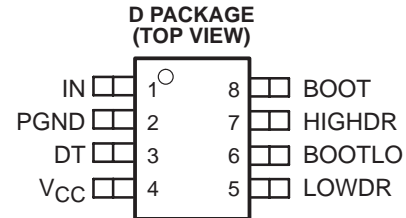
description

The TPS2836 and TPS2837 are MOSFET drivers for synchronous-buck power stages. These devices are ideal for designing a high-performance power supply using switching controllers that do not have MOSFET drivers. The drivers are designed to deliver minimum 2-A peak currents into large capacitive loads. The high-side driver can be configured as ground-reference or as floating-bootstrap. An adaptive dead-time control circuit eliminates shoot-through currents through the main power FETs during switching transitions and provides high efficiency for the buck regulator.

The TPS2836 has a noninverting input, while the TPS2837 has an inverting input. These drivers, available in 8-terminal SOIC packages, operate over a junction temperature range of – 40°C to 125°C.

AVAILABLE OPTIONS

T_J	PACKAGED DEVICES
	SOIC (D)
– 40°C to 125°C	TPS2836D TPS2837D

The D package is available taped and reeled. Add R suffix to device type (e.g., TPS2836DR)

Related Synchronous MOS FET Drivers

DEVICE NAME	ADDITIONAL FEATURES	INPUTS	
TPS2830	ENABLE, SYNC and CROWBAR	CMOS	Noninverted
TPS2831	ENABLE, SYNC and CROWBAR	CMOS	Inverted
TPS2832	W/O ENABLE, SYNC and CROWBAR	CMOS	Noninverted
TPS2833	W/O ENABLE, SYNC and CROWBAR	CMOS	Inverted
TPS2834	ENABLE, SYNC and CROWBAR	TTL	Noninverted
TPS2835	ENABLE, SYNC and CROWBAR	TTL	Inverted

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.

TEXAS INSTRUMENTS

functional block diagram
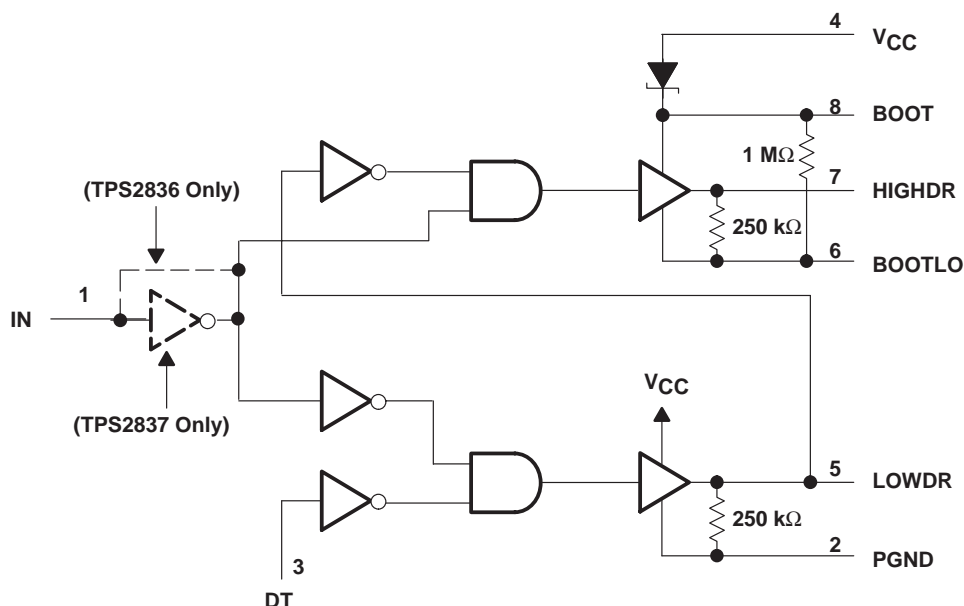
Terminal Functions

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
BOOT	8	I	Bootstrap terminal. A ceramic capacitor is connected between BOOT and BOOTLO to develop the floating bootstrap voltage for the high-side MOSFET. The capacitor value is typically between 0.1 μF and 1 μF.
BOOTLO	6	O	This terminal connects to the junction of the high-side and low-side MOSFETs.
DT	3	I	Dead-time control terminal. Connect DT to the junction of the high-side and low-side MOSFETs
HIGHDR	7	O	Output drive for the high-side power MOSFET
IN	1	I	Input signal to the MOSFET drivers (noninverting input for the TPS2836; inverting input for the TPS2837).
LOWDR	5	O	Output drive for the low-side power MOSFET
PGND	2		Power ground. Connect to the FET power ground.
V$_{CC}$	4	I	Input supply. Recommended that a 1 μF capacitor be connected from V$_{CC}$ to PGND.

![TEXAS INSTRUMENTS]

detailed description

low-side driver

The low-side driver is designed to drive low $r_{DS(on)}$ N-channel MOSFETs. The current rating of the driver is 2 A, source and sink.

high-side driver

The high-side driver is designed to drive low $r_{DS(on)}$ N-channel MOSFETs. The current rating of the driver is 2 A, source and sink. The high-side driver can be configured as a ground-reference driver or a floating bootstrap driver. The internal bootstrap diode is a Schottky for improved drive efficiency. The maximum voltage that can be applied between the BOOT terminal and ground is 30 V.

dead-time (DT) control

Dead-time control prevents shoot-through current from flowing through the main power FETs during switching transitions by controlling the turnon times of the MOSFET drivers. The high-side driver is not allowed to turn on until the gate drive voltage to the low-side FET is low, and the low-side driver is not allowed to turn on until the voltage at the junction of the power FETs (Vdrain) is low; the TTL-compatible DT terminal connects to the junction of the power FETs.

IN

The IN terminal is a TTL-compatible digital terminal that is the input control signal for the drivers. The TPS2836 has a noninverting input; the TPS2837 has an inverting input.

absolute maximum ratings over operating free-air temperature (unless otherwise noted)[†]

Supply voltage range, V_{CC} (see Note 1) . . . . −0.3 V to 16 V
Input voltage range: BOOT to PGND (high-side driver ON) . . . . −0.3 V to 30 V
  BOOTLO to PGND . . . . −0.3 V to 16 V
  BOOT to BOOTLO . . . . −0.3 V to 16 V
  IN . . . . −0.3 V to 16 V
  DT . . . . −0.3 V to 30 V
Continuous total power dissipation . . . . See Dissipation Rating Table
Operating virtual junction temperature range, T_J . . . . −40°C to 125°C
Storage temperature range, T_{stg} . . . . −65°C to 150°C
Lead temperature soldering 1,6 mm (1/16 inch) 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: Unless otherwise specified, all voltages are with respect to PGND.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING
D	600 mW	6.0 mW/°C	330 mW	240 mW

recommended operating conditions

		MIN	NOM	MAX	UNIT
Supply voltage, V_{CC}		4.5		15	V
Input voltage	BOOT to PGND	4.5		28	V

electrical characteristics over recommended operating virtual junction temperature range, V_{CC} = 6.5 V, C_L = 3.3 nF (unless otherwise noted)

supply current

	PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_{CC}	Supply voltage range			4.5		15	V
	Quiescent current	V_{CC} =15 V,	$V_{(ENABLE)}$ = LOW			100	μA
	Quiescent current	V_{CC} =15 V,	$V_{(ENABLE)}$ = HIGH		300	400	
	Quiescent current	V_{CC} =12 V, f_{SWX} = 200 kHz, C_{HIGHDR} = 50 pF,	BOOTLO grounded, C_{LOWDR} = 50 pF, See Note 2		3		mA

NOTE 2: Ensured by design, not production tested.

output drivers

PARAMETER			TEST CONDITIONS		MIN	TYP	MAX	UNIT
Peak output-current	High-side sink (see Note 4)	Duty cycle < 2%, t_{pw} < 100 μs (see Note 3)	$V_{BOOT} - V_{BOOTLO}$ = 4.5 V,	V_{HIGHDR} = 4 V	0.7	1.1		A
			$V_{BOOT} - V_{BOOTLO}$ = 6.5 V,	V_{HIGHDR} = 5 V	1.1	1.5		
			$V_{BOOT} - V_{BOOTLO}$ = 12 V,	V_{HIGHDR} = 10.5 V	2	2.4		
	High-side source (see Note 4)	Duty cycle < 2%, t_{pw} < 100 μs (see Note 3)	$V_{BOOT} - V_{BOOTLO}$ = 4.5 V,	V_{HIGHDR} = 0.5V	1.2	1.4		A
			$V_{BOOT} - V_{BOOTLO}$ = 6.5 V,	V_{HIGHDR} = 1.5 V	1.3	1.6		
			$V_{BOOT} - V_{BOOTLO}$ = 12 V,	V_{HIGHDR} = 1.5 V	2.3	2.7		
	Low-side sink (see Note 4)	Duty cycle < 2%, t_{pw} < 100 μs (see Note 3)	V_{CC} = 4.5 V,	V_{LOWDR} = 4 V	1.3	1.8		A
			V_{CC} = 6.5 V,	V_{LOWDR} = 5 V	2	2.5		
			V_{CC} = 12 V,	V_{LOWDR} = 10.5 V	3	3.5		
	Low-side source (see Note 4)	Duty cycle < 2%, t_{pw} < 100 μs (see Note 3)	V_{CC} = 4.5 V,	V_{LOWDR} = 0.5V	1.4	1.7		A
			V_{CC} = 6.5 V,	V_{LOWDR} = 1.5 V	2	2.4		
			V_{CC} = 12 V,	V_{LOWDR} = 1.5 V	2.5	3		
Output resistance	High-side sink (see Note 4)		$V_{BOOT} - V_{BOOTLO}$ = 4.5 V,	V_{HIGHDR} = 0.5 V			5	Ω
			$V_{BOOT} - V_{BOOTLO}$ = 6.5 V,	V_{HIGHDR} = 0.5 V			5	
			$V_{BOOT} - V_{BOOTLO}$ = 12 V,	V_{HIGHDR} = 0.5 V			5	
	High-side source (see Note 4)		$V_{BOOT} - V_{BOOTLO}$ = 4.5 V,	V_{HIGHDR} = 4 V			75	Ω
			$V_{BOOT} - V_{BOOTLO}$ = 6.5 V,	V_{HIGHDR} = 6 V			75	
			$V_{BOOT} - V_{BOOTLO}$ = 12 V,	V_{HIGHDR} =11.5 V			75	
	Low-side sink (see Note 4)		V_{DRV} = 4.5 V,	V_{LOWDR} = 0.5 V			9	Ω
			V_{DRV} = 6.5 V	V_{LOWDR} = 0.5 V			7.5	
			V_{DRV} = 12 V,	V_{LOWDR} = 0.5 V			6	
	Low-side source (see Note 4)		V_{DRV} = 4.5 V,	V_{LOWDR} = 4 V			75	Ω
			V_{DRV} = 6.5 V,	V_{LOWDR} = 6 V			75	
			V_{DRV} = 12 V,	V_{LOWDR} = 11.5 V			75	

NOTES: 3. Ensured by design, not production tested.
4. The pullup/pulldown circuits of the drivers are bipolar and MOSFET transistors in parallel. The peak output current rating is the combined current from the bipolar and MOSFET transistors. The output resistance is the $r_{DS(on)}$ of the MOSFET transistor when the voltage on the driver output is less than the saturation voltage of the bipolar transistor.

![Texas Instruments logo] **TEXAS INSTRUMENTS**

electrical characteristics over recommended operating virtual junction temperature range, V_{CC} = 6.5 V, C_L = 3.3 nF (unless otherwise noted) (continued)

dead-time

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IH} High-level input voltage	LOWDR	Over the V_{CC} range (see Note 3)	$0.7V_{CC}$			V
V_{IL} Low-level input voltage					1	V
V_{IH} High-level input voltage	DT	Over the V_{CC} range	2			V
V_{IL} Low-level input voltage					1	V

NOTE 3: Ensured by design, not production tested.

digital control terminals (IN)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IH} High-level input voltage	Over the V_{CC} range	2			V
V_{IL} Low-level input voltage				1	V

switching characteristics over recommended operating virtual junction temperature range, C_L = 3.3 nF (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Rise time	HIGHDR output (see Note 3)	V_{BOOT} = 4.5 V,	V_{BOOTLO} = 0 V			60	ns
		V_{BOOT} = 6.5 V,	V_{BOOTLO} = 0 V			50	
		V_{BOOT} = 12 V,	V_{BOOTLO} = 0 V			50	
	LOWDR output (see Note 3)	V_{CC} = 4.5 V				40	ns
		V_{CC} = 6.5 V				30	
		V_{CC} = 12 V				30	
Fall time	HIGHDR output (see Note 3)	V_{BOOT} = 4.5 V,	V_{BOOTLO} = 0 V			50	ns
		V_{BOOT} = 6.5 V,	V_{BOOTLO} = 0 V			40	
		V_{BOOT} = 12 V,	V_{BOOTLO} = 0 V			40	
	LOWDR output (see Note 3)	V_{CC} = 4.5 V				40	ns
		V_{CC} = 6.5 V				30	
		V_{CC} = 12 V				30	
Propagation delay time	HIGHDR going low (excluding dead-time) (see Note 3)	V_{BOOT} = 4.5 V,	V_{BOOTLO} = 0 V			95	ns
		V_{BOOT} = 6.5 V,	V_{BOOTLO} = 0 V			80	
		V_{BOOT} = 12 V,	V_{BOOTLO} = 0 V			65	
	LOWDR going high (excluding dead-time) (see Note 3)	V_{BOOT} = 4.5 V,	V_{BOOTLO} = 0 V			80	ns
		V_{BOOT} = 6.5 V,	V_{BOOTLO} = 0 V			70	
		V_{BOOT} = 12 V,	V_{BOOTLO} = 0 V			60	
Propagation delay time	LOWDR going low (excluding dead-time) (see Note 3)	V_{CC} = 4.5 V				80	ns
		V_{CC} = 6.5 V				70	
		V_{CC} = 12 V				60	
Driver nonoverlap time	DT to LOWDR and LOWDR to HIGHDR (see Note 3)	V_{CC} = 4.5 V		40		170	ns
		V_{CC} = 6.5 V		25		135	
		V_{CC} = 12 V		15		85	

NOTE 3: Ensured by design, not production tested.

![Texas Instruments logo]

TYPICAL CHARACTERISTICS

RISE TIME
vs
SUPPLY VOLTAGE

C_L = 3.3 nF
T_J = 25°C

High Side

Low Side

t_r – Rise Time – ns

V_{CC} – Supply Voltage – V

Figure 1

FALL TIME
vs
SUPPLY VOLTAGE

C_L = 3.3 nF
T_J = 25°C

High Side

Low Side

t_f – Fall Time – ns

V_{CC} – Supply Voltage – V

Figure 2

RISE TIME
vs
JUNCTION TEMPERATURE

V_{CC} = 6.5 V
C_L = 3.3 nF

High Side

Low Side

t_r – Rise Time – ns

T_J – Junction Temperature – °C

Figure 3

FALL TIME
vs
JUNCTION TEMPERATURE

V_{CC} = 6.5 V
C_L = 3.3 nF

High Side

Low Side

t_f – Fall Time – ns

T_J – Junction Temperature – °C

Figure 4

TEXAS INSTRUMENTS

TYPICAL CHARACTERISTICS

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

Figure 5

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

Figure 6

LOW-TO-HIGH PROPAGATION DELAY TIME
vs
JUNCTION TEMPERATURE

Figure 7

HIGH-TO-LOW PROPAGATION DELAY TIME
vs
JUNCTION TEMPERATURE
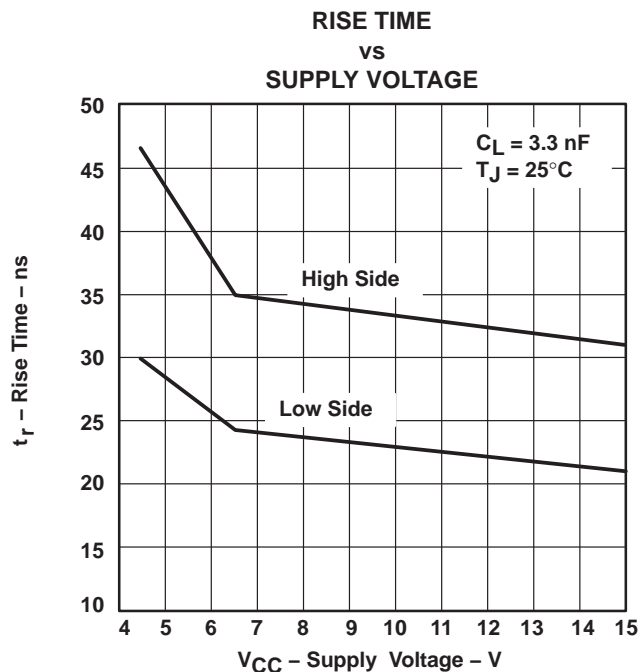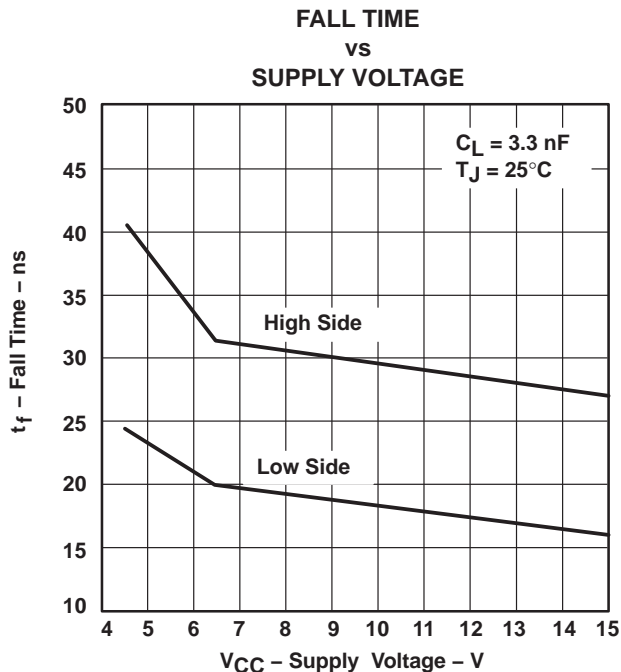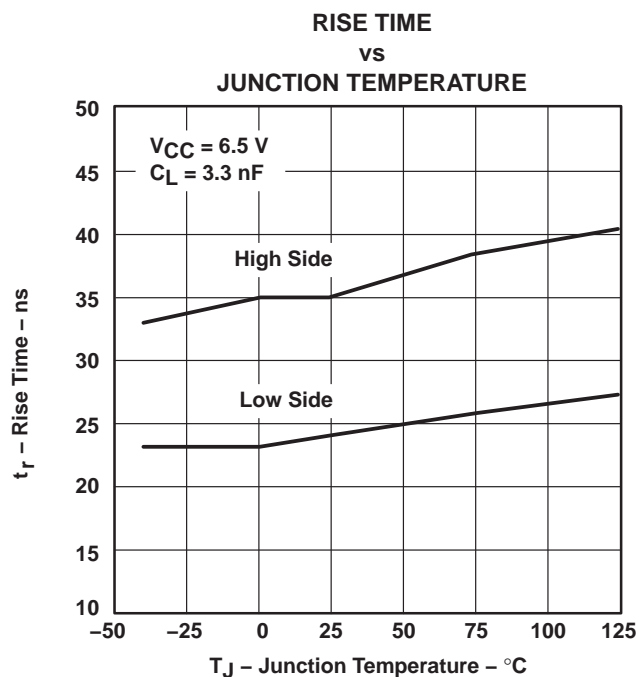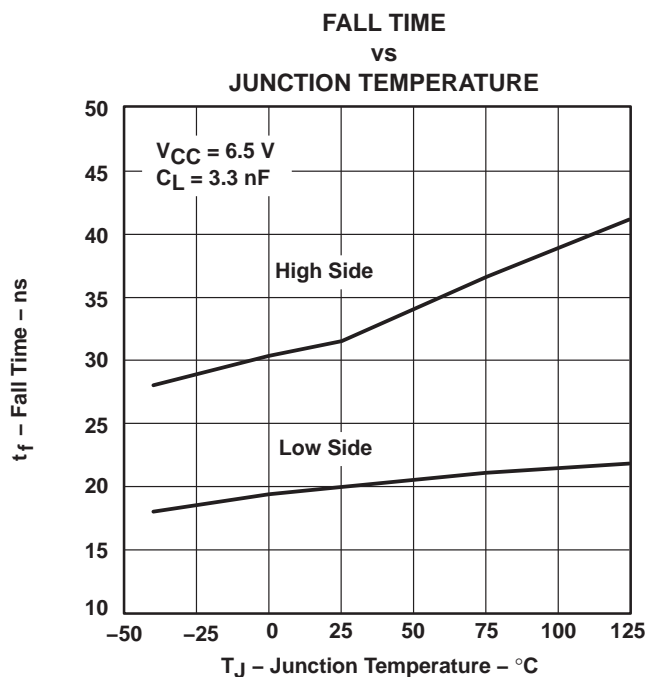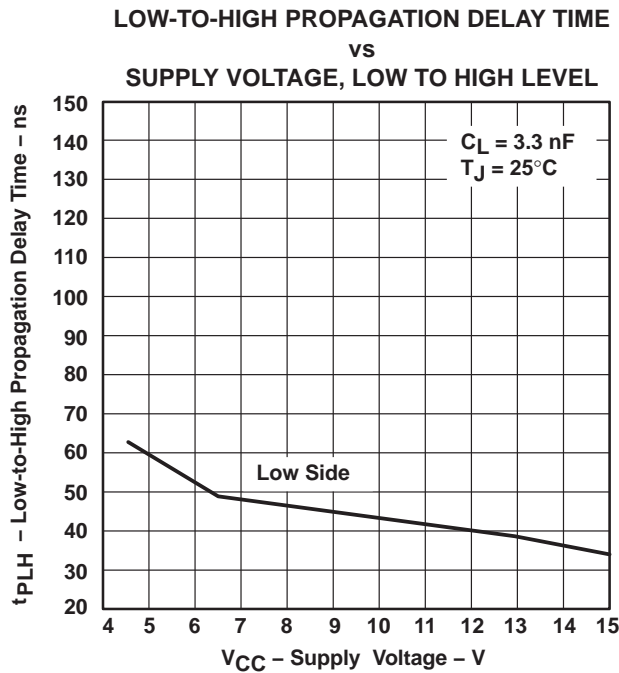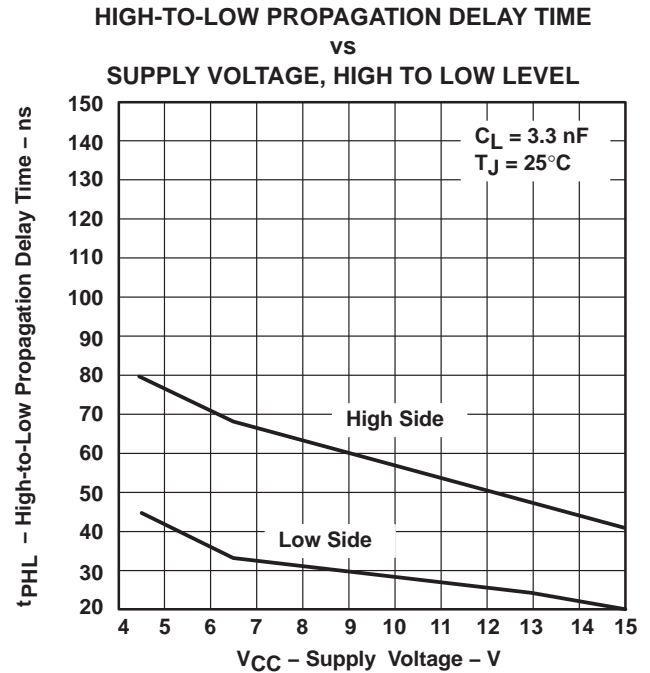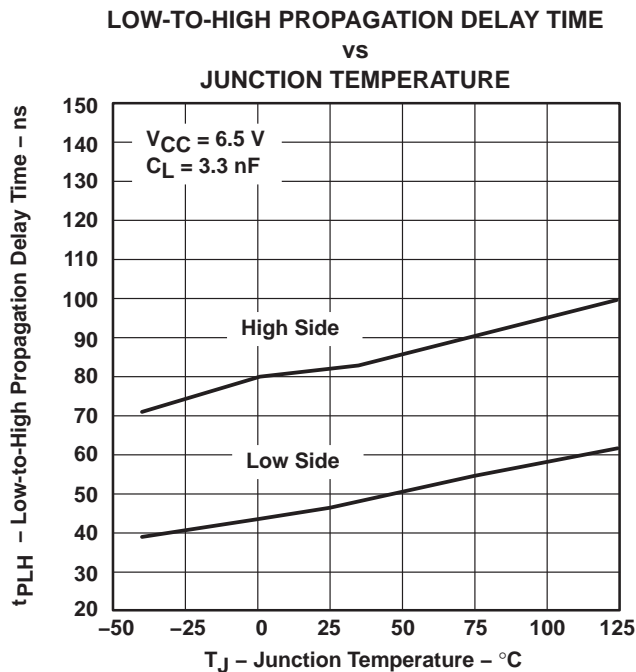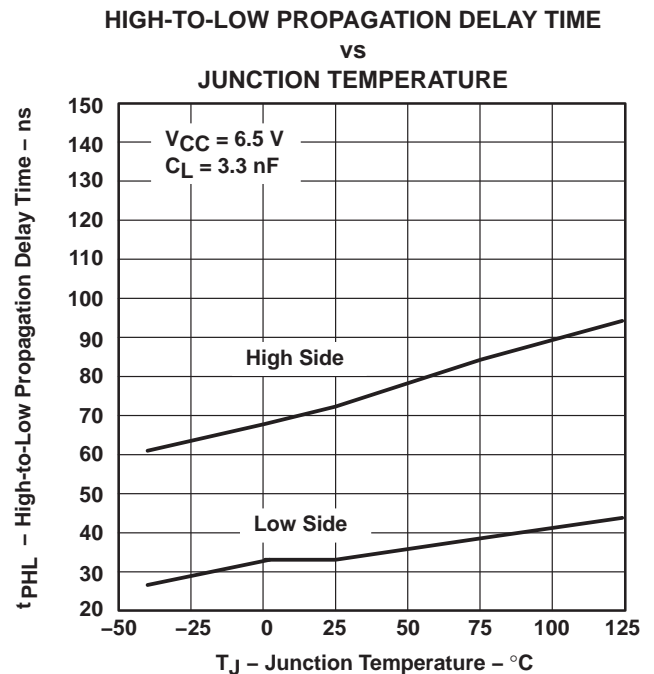
Figure 8

TYPICAL CHARACTERISTICS

DRIVER-OUTPUT RISE TIME
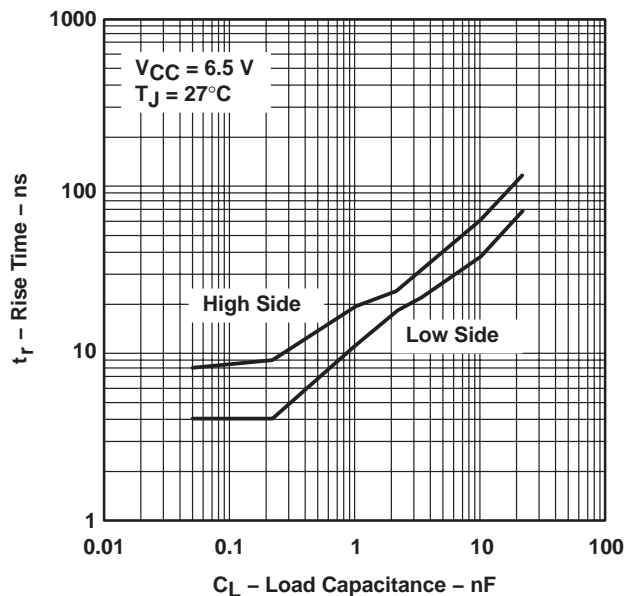vs
LOAD CAPACITANCE
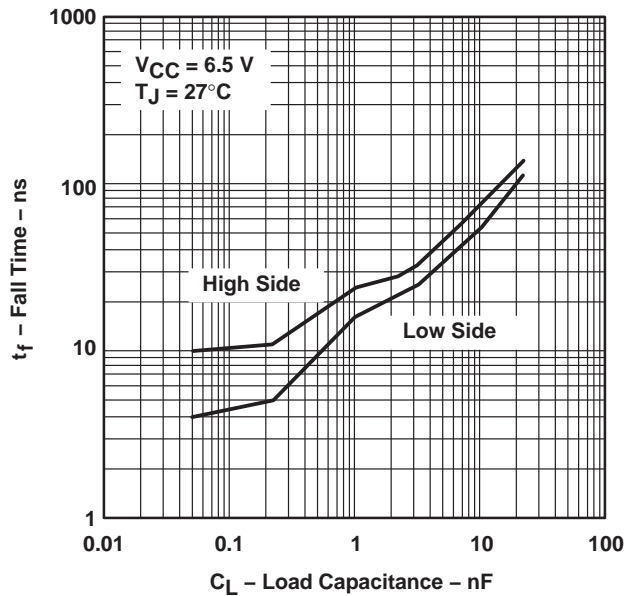

Figure 9

DRIVER-OUTPUT FALL TIME
vs
LOAD CAPACITANCE

Figure 10

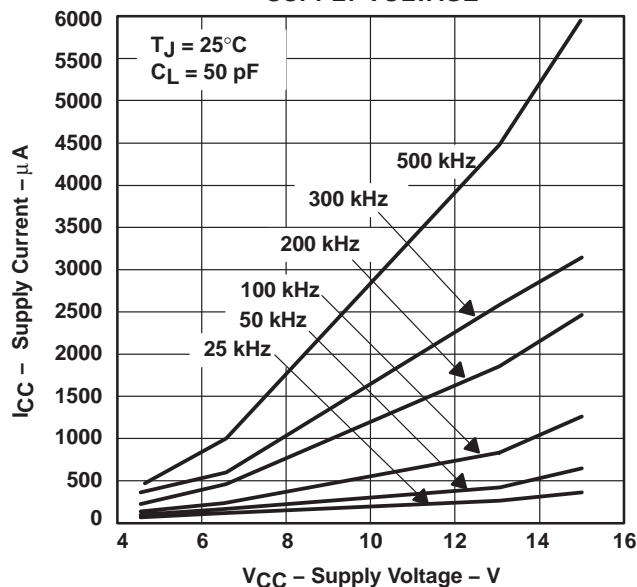SUPPLY CURRENT
vs
SUPPLY VOLTAGE

Figure 11

SUPPLY CURRENT
vs
SUPPLY VOLTAGE
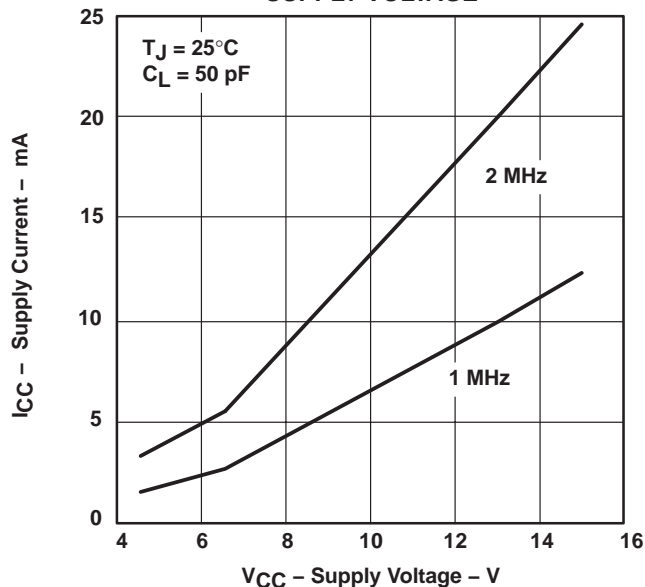
Figure 12

TEXAS
INSTRUMENTS
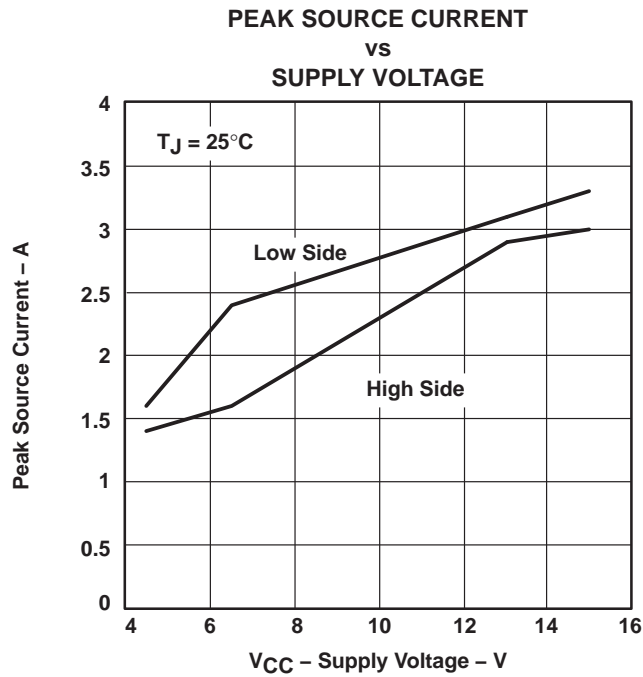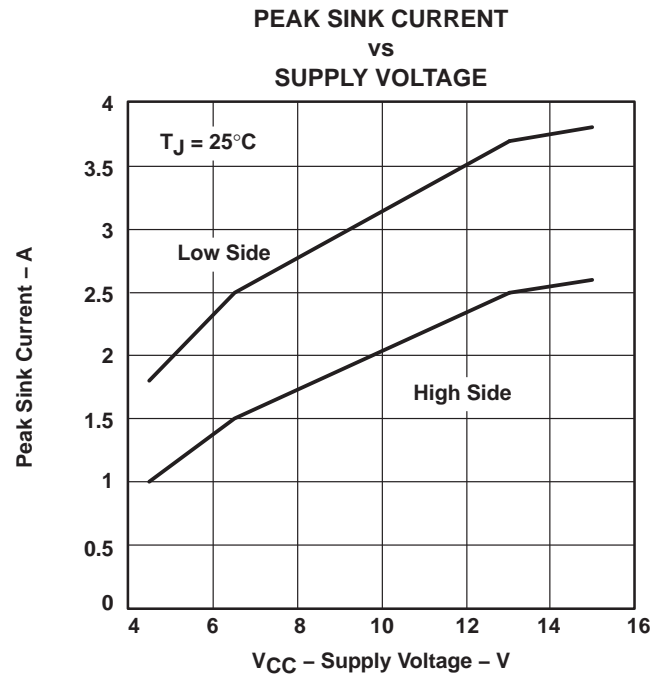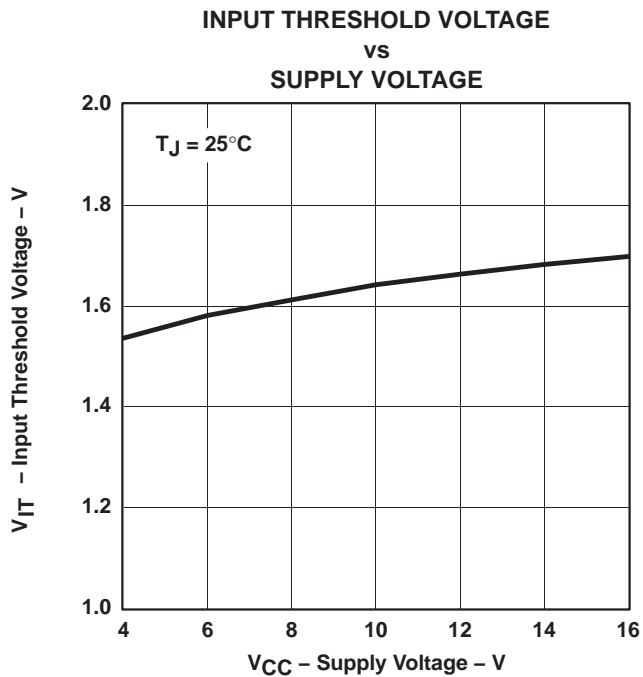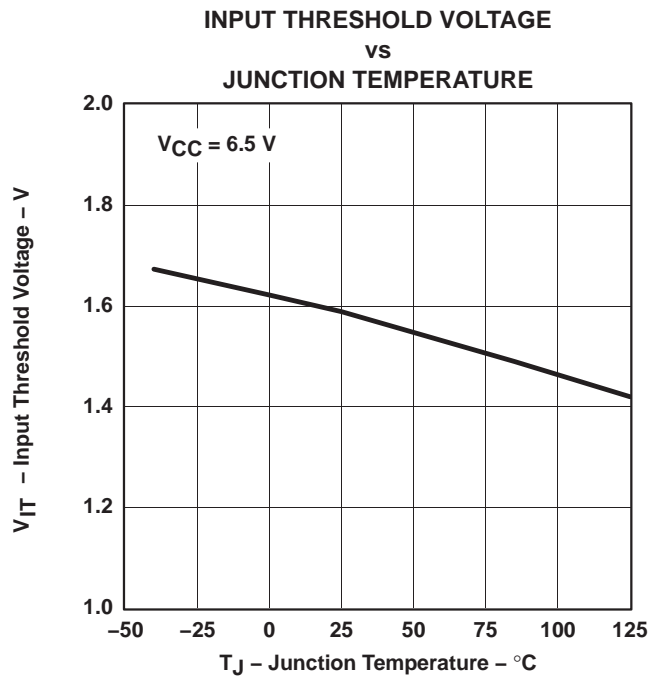
POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265

TYPICAL CHARACTERISTICS

PEAK SOURCE CURRENT
vs
SUPPLY VOLTAGE

Figure 13

PEAK SINK CURRENT
vs
SUPPLY VOLTAGE

Figure 14

INPUT THRESHOLD VOLTAGE
vs
SUPPLY VOLTAGE

Figure 15

INPUT THRESHOLD VOLTAGE
vs
JUNCTION TEMPERATURE

Figure 16

APPLICATION INFORMATION

Figure 17 shows the circuit schematic of a 100-kHz synchronous-buck converter implemented with a TL5001A pulse-width-modulation (PWM) controller and a TPS2837 driver. The converter operates over an input range from 4.5 V to 12 V and has a 3.3-V output. The circuit can supply 3 A continuous load and the transient load is 5 A. The converter achieves an efficiency of 94% for V_{IN} = 5 V, I_{load}=1 A, and 93% for V_{IN} = 5 V, I_{load} = 3 A.

Figure 17. 3.3 V 3 A Synchronous-Buck Converter Circuit

APPLICATION INFORMATION

Great care should be taken when laying out the PC board. The power-processing section is the most critical and will generate large amounts of EMI if not properly configured. The junction of Q1, Q2, and L1 should be very tight. The connection from Q1 dra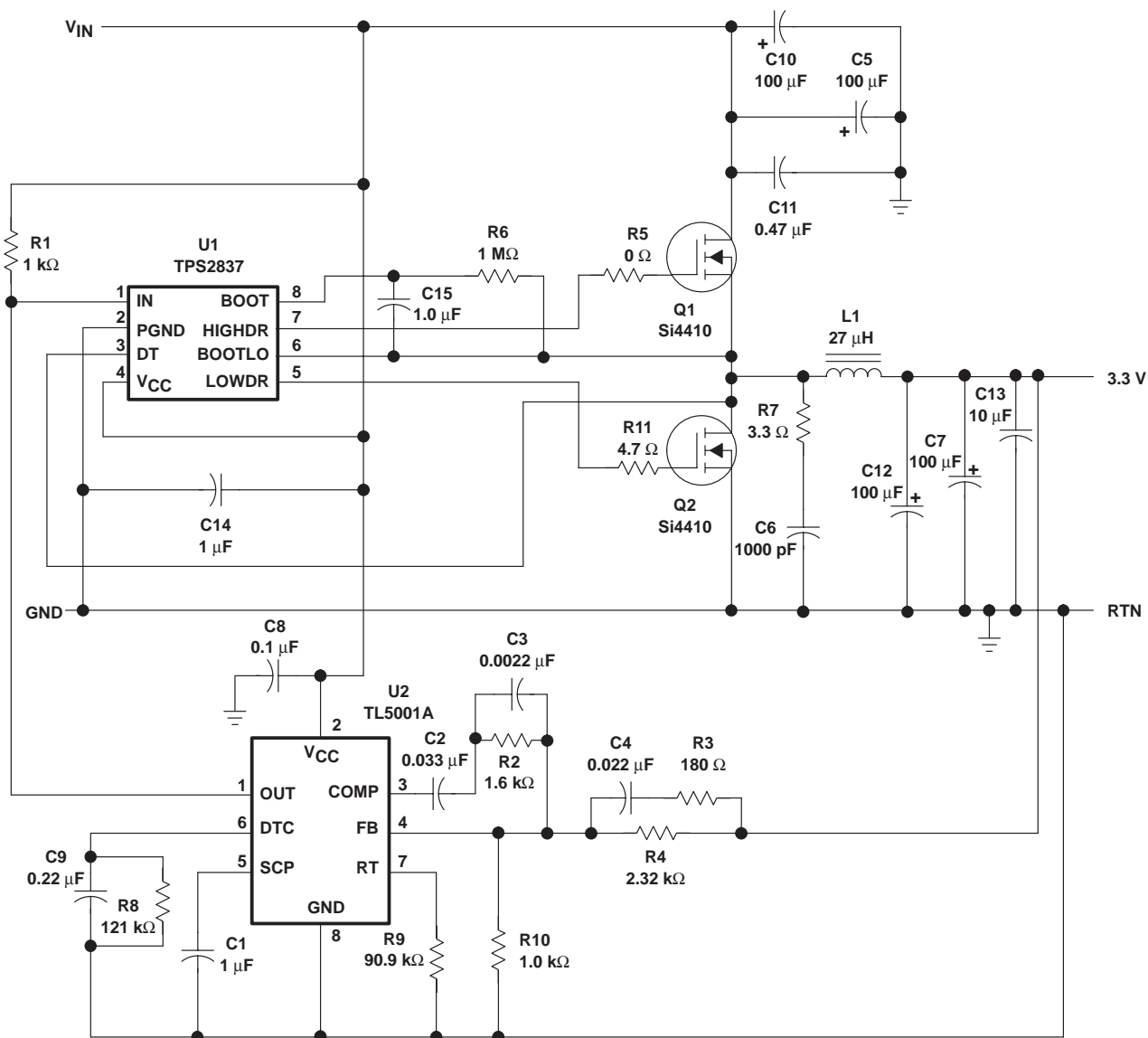in to the positive sides of C5, C10, and C11 and the connection from Q2 source to the negative sides of C5, C10, and C11 should be as short as possible. The negative terminals of C7 and C12 should also be connected to Q2 source.

Next, the traces from the MOSFET driver to the power switches should be considered. The BOOTLO signal from the junction of Q1 and Q2 carries the large gate drive current pulses and should be as heavy as the gate drive traces. The bypass capacitor (C14) should be tied directly across V_{CC} and PGND.

The next most sensitive node is the FB node on the controller (terminal 4 on the TL5001A). This node is very sensitive to noise pickup and should be isolated from the high-current power stage and be as short as possible. The ground around the controller and low-level circuitry should be tied to the power ground as the output. If these three areas are properly laid out, the rest of the circuit should not have other EMI problems and the power supply will be relatively free of noise.

TEXAS
INSTRUMENTS

MECHANICAL DATA

D (R-PDSO-G)**   **PLASTIC SMALL-OUTLINE PACKAGE**

14 PIN SHOWN

PINS ** DIM	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

4040047 / D 10/96
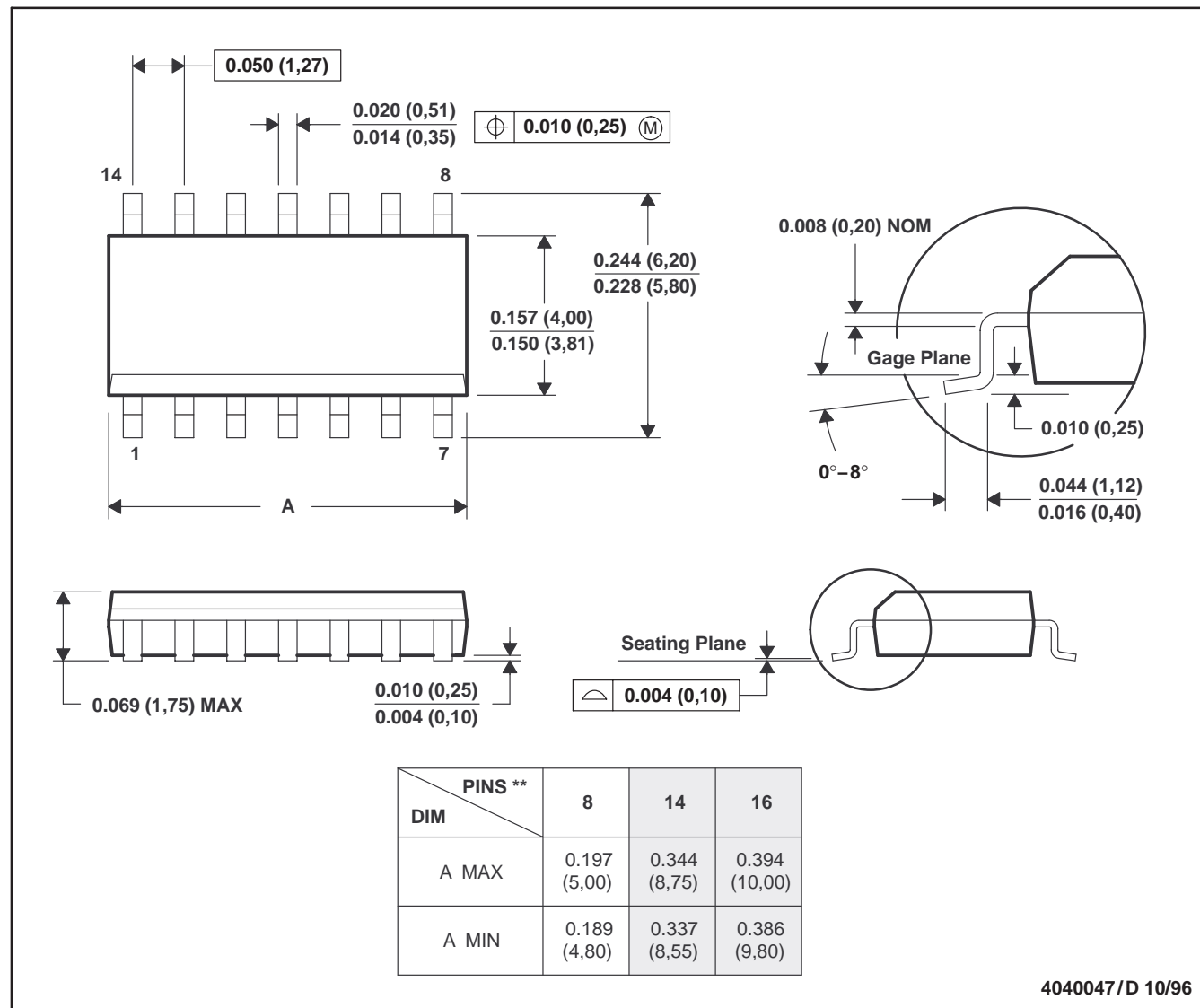
NOTES: A. All linear dimensions are in inches (millimeters).
  B. This drawing is subject to change without notice.
  C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
  D. Falls within JEDEC MS-012

![Texas Instruments logo] **TEXAS INSTRUMENTS**

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
TPS2836D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2836	Samples
TPS2836DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2836	Samples
TPS2836DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2836	Samples
TPS2836DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2836	Samples
TPS2837D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2837	Samples
TPS2837DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2837	Samples
TPS2837DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2837	Samples
TPS2837DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2837	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

PACKAGE MATERIALS INFORMATION

TAPE AND REEL INFORMATION

REEL DIMENSIONS

TAPE DIMENSIONS

A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE

*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
TPS2836DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TPS2837DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	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)
TPS2836DR	SOIC	D	8	2500	340.5	338.1	20.6
TPS2837DR	SOIC	D	8	2500	340.5	338.1	20.6

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have *not* been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		Applications	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		