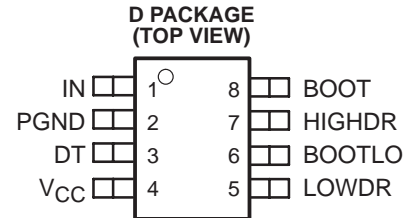


TPS2836, TPS2837 SYNCHRONOUS-BUCK MOSFET DRIVER WITH DEAD-TIME CONTROL

SLVS224B – NOVEMBER 1999 – REVISED AUGUST 2002

- 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



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			Inverted
TPS2832	W/O ENABLE, SYNC and CROWBAR	CMOS	Noninverted
TPS2833			Inverted
TPS2834	ENABLE, SYNC and CROWBAR	TTL	Noninverted
TPS2835			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.

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.



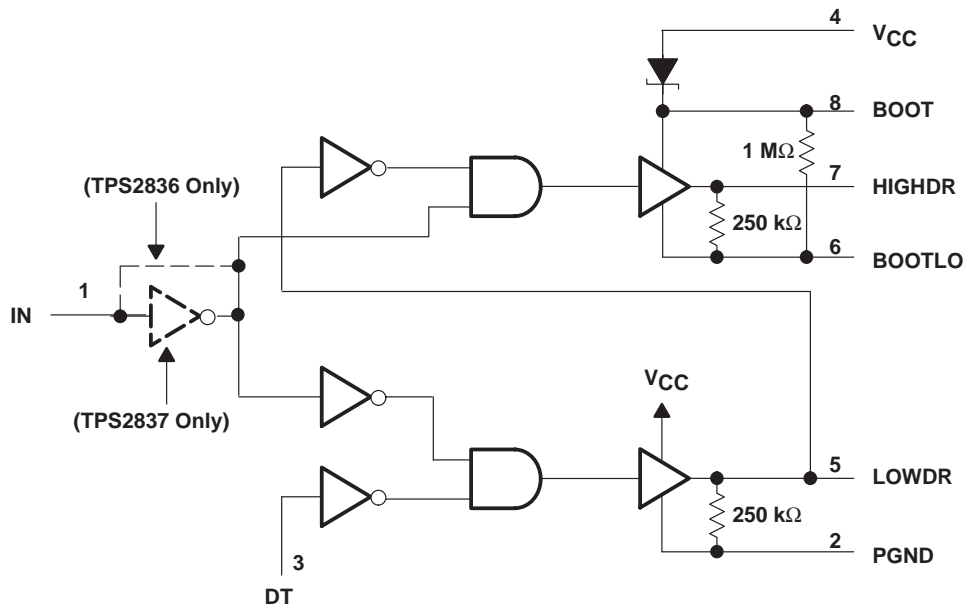
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 2002, Texas Instruments Incorporated

TPS2836, TPS2837 SYNCHRONOUS-BUCK MOSFET DRIVER WITH DEAD-TIME CONTROL

SLVS224B – NOVEMBER 1999 – REVISED AUGUST 2002

functional block diagram



Terminal Functions

TERMINAL NAME	NO.	I/O	DESCRIPTION
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.
VCC	4	I	Input supply. Recommended that a 1 μF capacitor be connected from VCC to PGND.

TPS2836, TPS2837 SYNCHRONOUS-BUCK MOSFET DRIVER WITH DEAD-TIME CONTROL

SLVS224B – NOVEMBER 1999 – REVISED AUGUST 2002

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 (V_{drain}) 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 ≤ 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



TPS2836, TPS2837 SYNCHRONOUS-BUCK MOSFET DRIVER WITH DEAD-TIME CONTROL

SLVS224B – NOVEMBER 1999 – REVISED AUGUST 2002

electrical characteristics over recommended operating virtual junction temperature range,
 $V_{CC} = 6.5\text{ V}$, $C_L = 3.3\text{ nF}$ (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 _{LOWDR} = 50 pF, C _{HIGHDR} = 50 pF, BOOTLO grounded, 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} = 0.5 V	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} = 0.5 V	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)	Duty cycle < 2%, t _{pw} < 100 μs (see Note 3)	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)	Duty cycle < 2%, t _{pw} < 100 μs (see Note 3)	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)	Duty cycle < 2%, t _{pw} < 100 μs (see Note 3)	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.



TPS2836, TPS2837
SYNCHRONOUS-BUCK MOSFET DRIVER
WITH DEAD-TIME CONTROL

SLVS224B – NOVEMBER 1999 – REVISED AUGUST 2002

electrical characteristics over recommended operating virtual junction temperature range, $V_{CC} = 6.5\text{ V}$, $C_L = 3.3\text{ nF}$ (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)	0.7 V_{CC}		
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_{IL}	Low-level input voltage				1 V	

switching characteristics over recommended operating virtual junction temperature range, $C_L = 3.3\text{ nF}$ (unless otherwise noted)

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

NOTE 3: Ensured by design, not production tested.



TPS2836, TPS2837
SYNCHRONOUS-BUCK MOSFET DRIVER
WITH DEAD-TIME CONTROL

SLVS224B – NOVEMBER 1999 – REVISED AUGUST 2002

TYPICAL CHARACTERISTICS

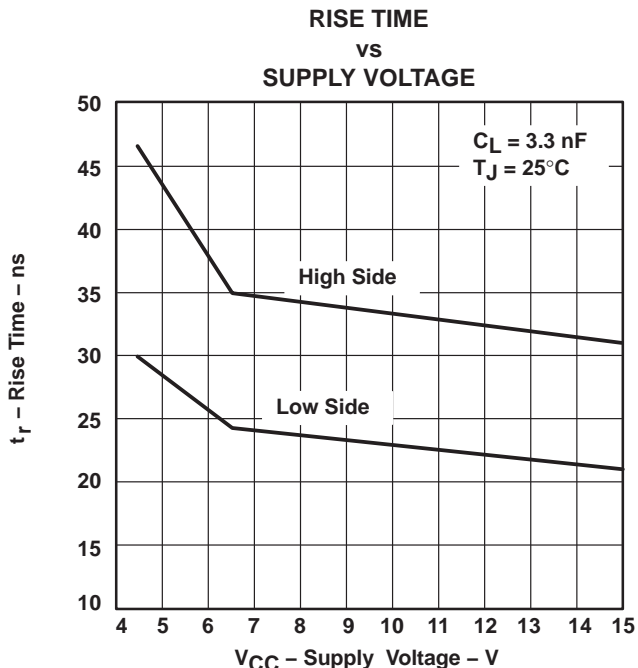


Figure 1

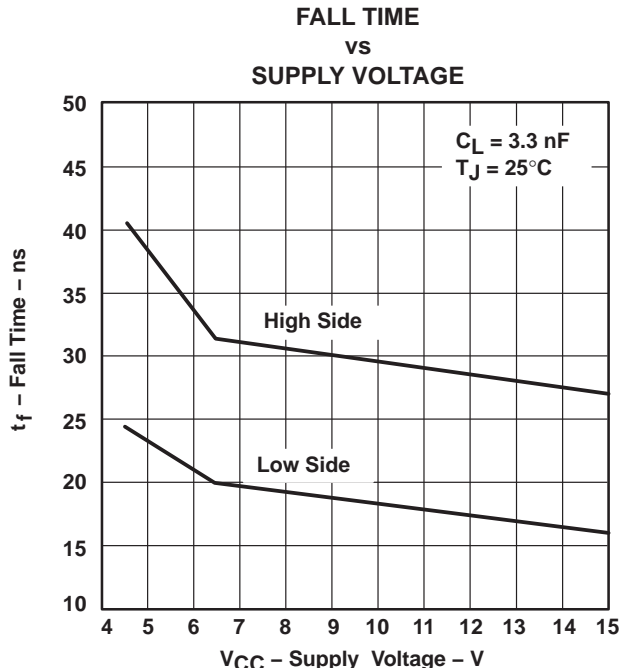


Figure 2

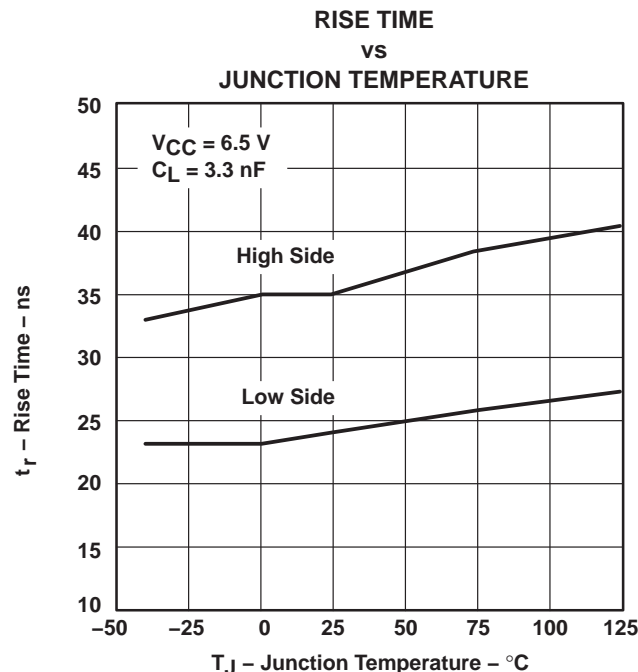


Figure 3

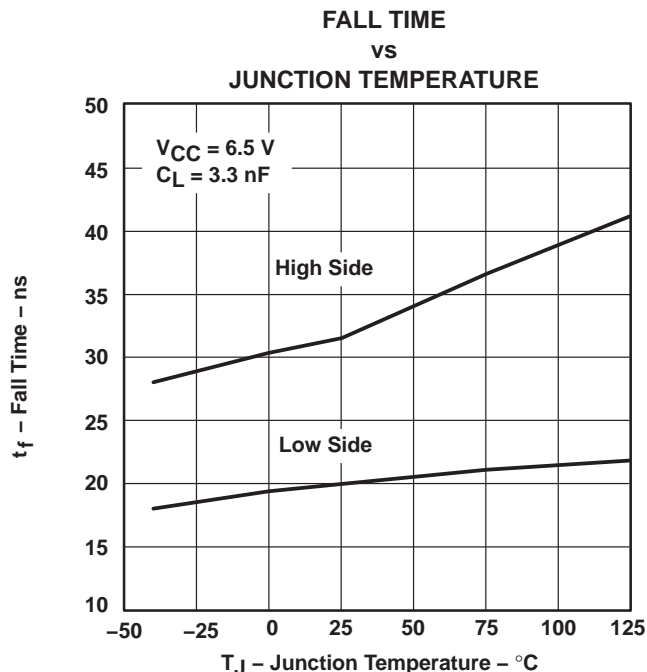


Figure 4



TYPICAL CHARACTERISTICS

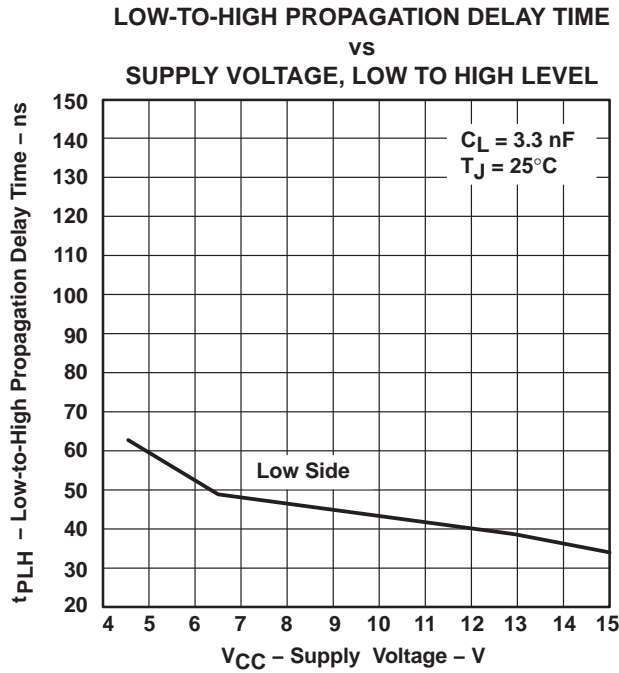


Figure 5

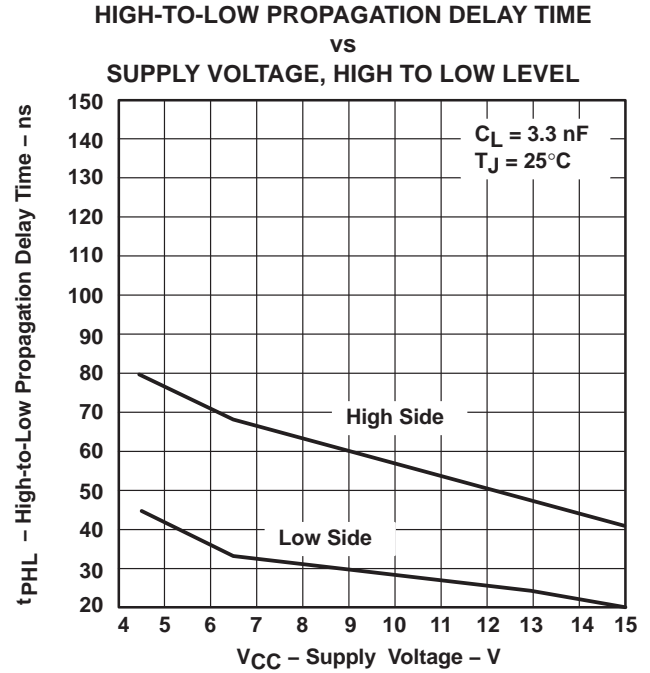


Figure 6

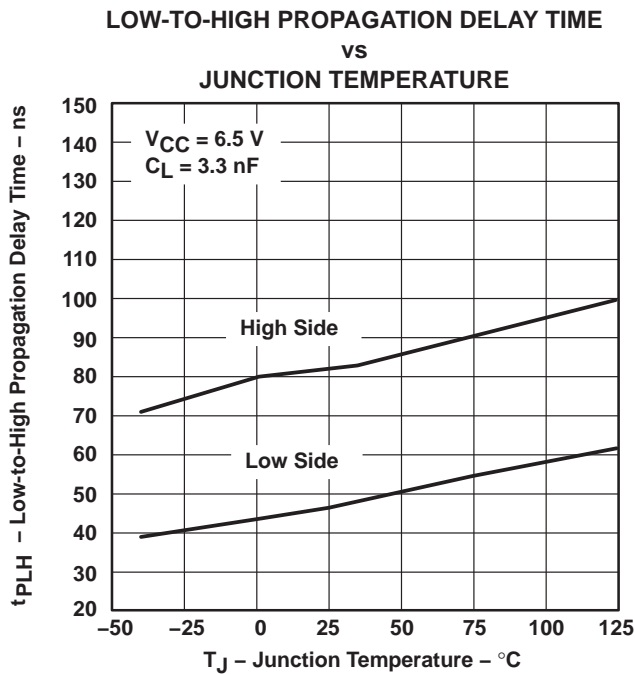


Figure 7

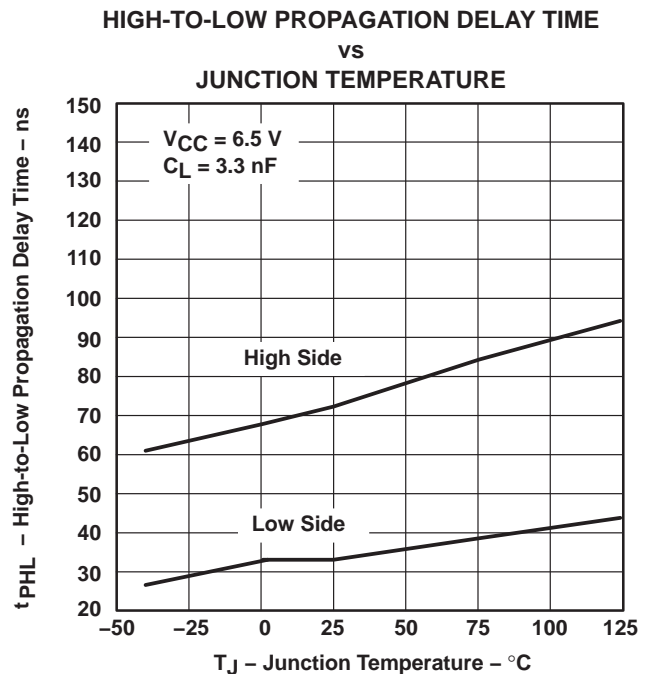


Figure 8

TPS2836, TPS2837 SYNCHRONOUS-BUCK MOSFET DRIVER WITH DEAD-TIME CONTROL

SLVS224B – NOVEMBER 1999 – REVISED AUGUST 2002

TYPICAL CHARACTERISTICS

DRIVER-OUTPUT RISE TIME
vs
LOAD CAPACITANCE

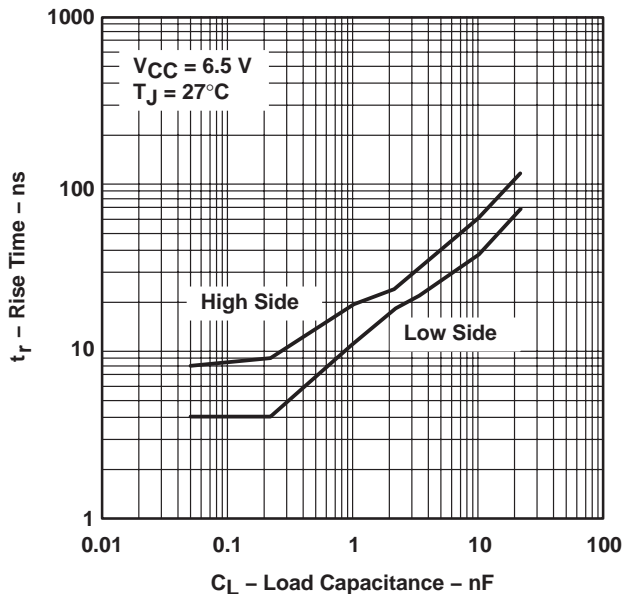


Figure 9

DRIVER-OUTPUT FALL TIME
vs
LOAD CAPACITANCE

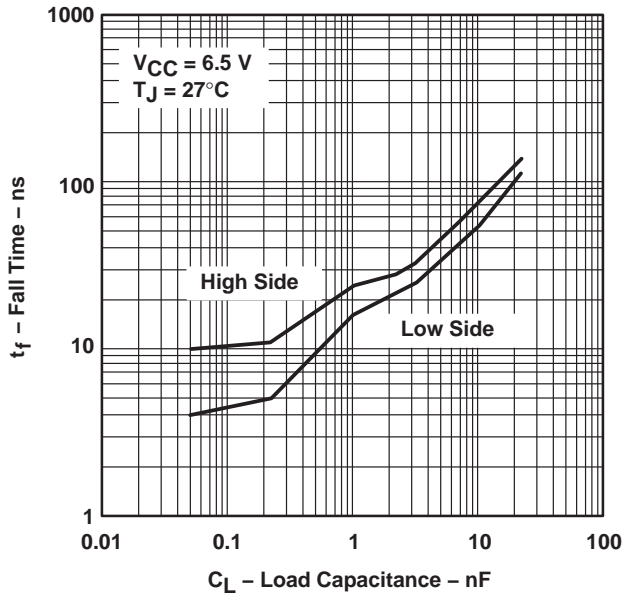


Figure 10

SUPPLY CURRENT
vs
SUPPLY VOLTAGE

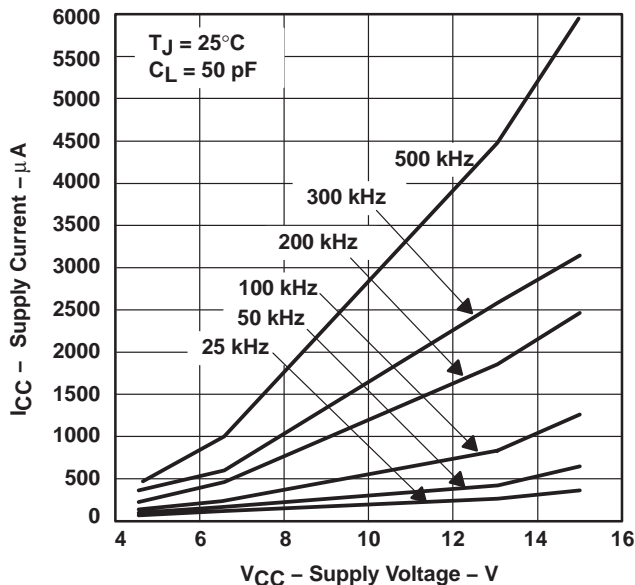


Figure 11

SUPPLY CURRENT
vs
SUPPLY VOLTAGE

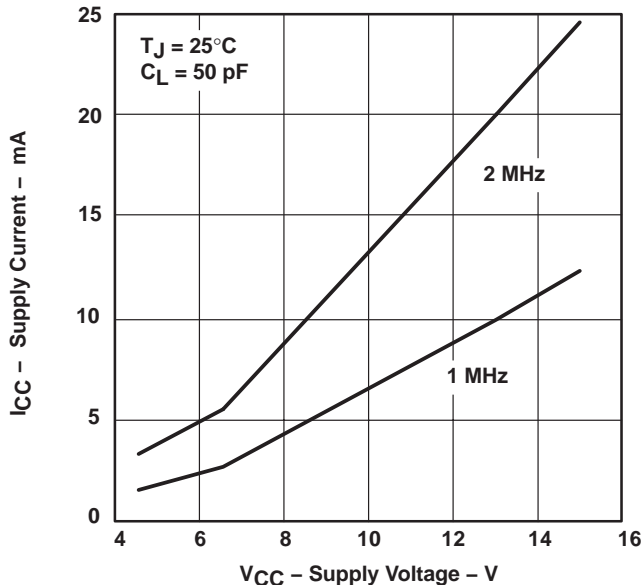


Figure 12



TYPICAL CHARACTERISTICS

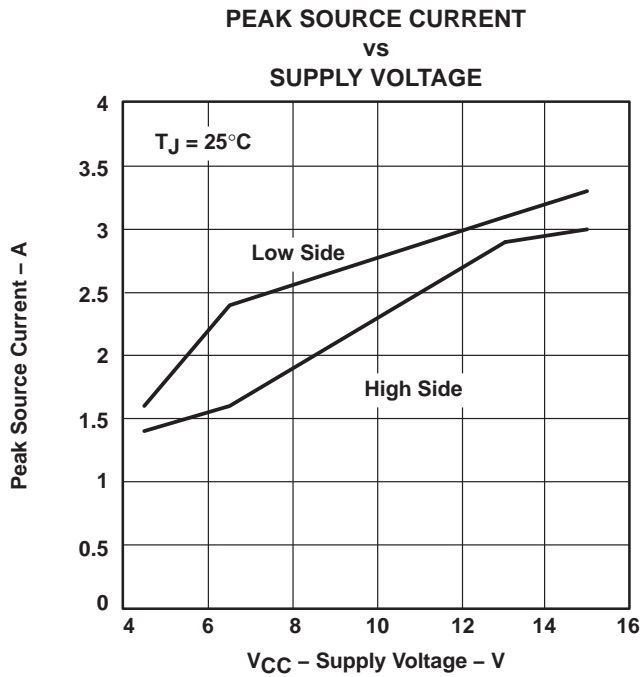


Figure 13

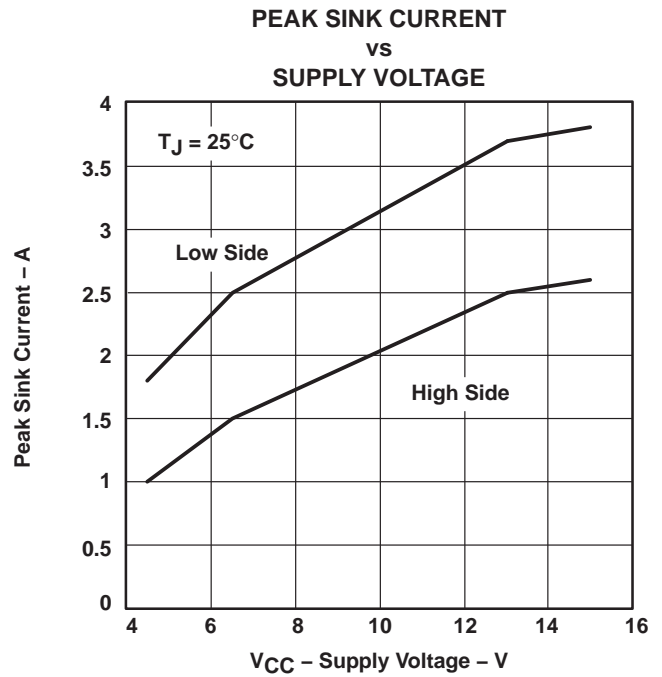


Figure 14

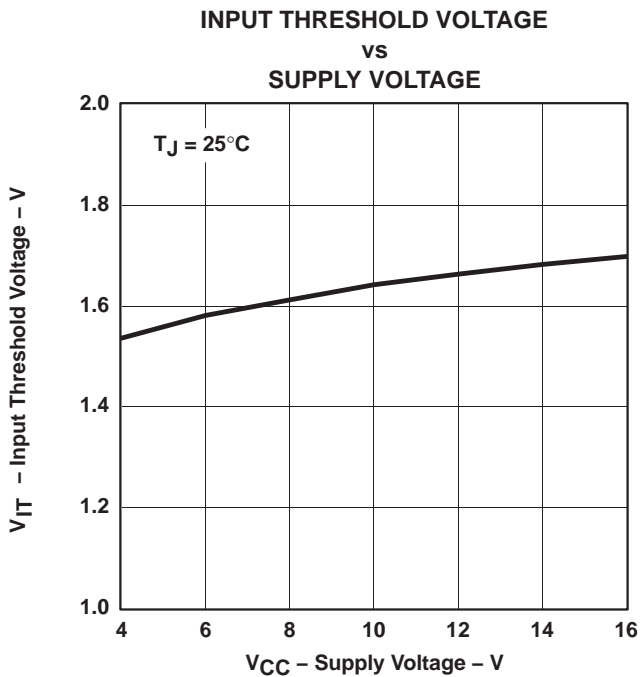


Figure 15

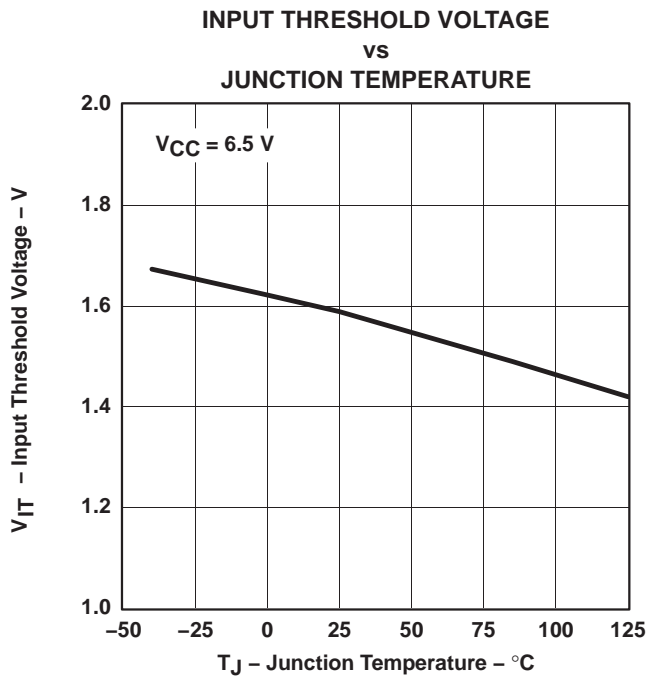


Figure 16

TPS2836, TPS2837 SYNCHRONOUS-BUCK MOSFET DRIVER WITH DEAD-TIME CONTROL

SLVS224B – NOVEMBER 1999 – REVISED AUGUST 2002

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 $V_{IN} = 5\text{ V}$, $I_{load} = 1\text{ A}$, and 93% for $V_{IN} = 5\text{ V}$, $I_{load} = 3\text{ A}$.

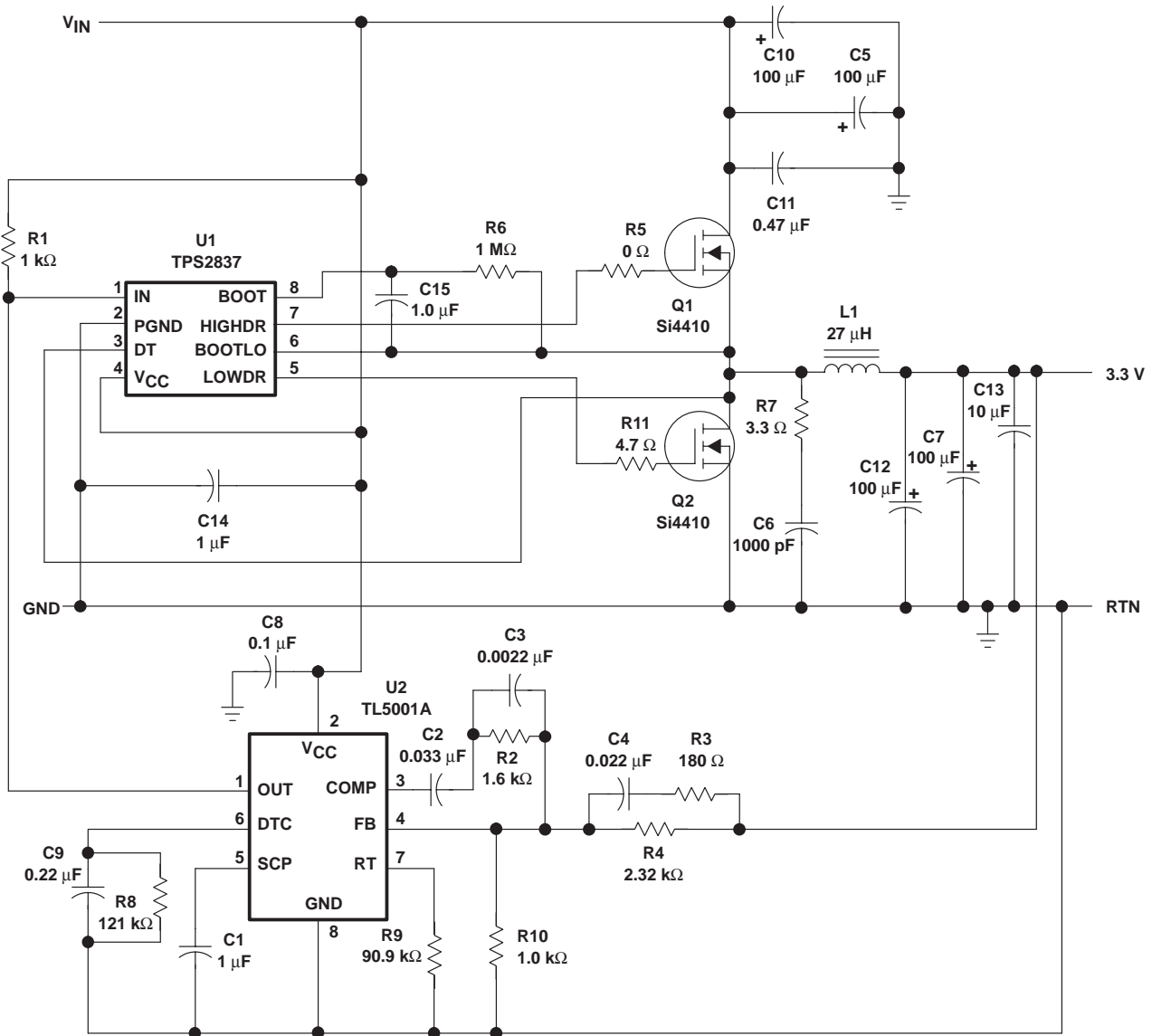


Figure 17. 3.3 V 3 A Synchronous-Buck Converter Circuit

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 drain 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.

TPS2836, TPS2837 SYNCHRONOUS-BUCK MOSFET DRIVER WITH DEAD-TIME CONTROL

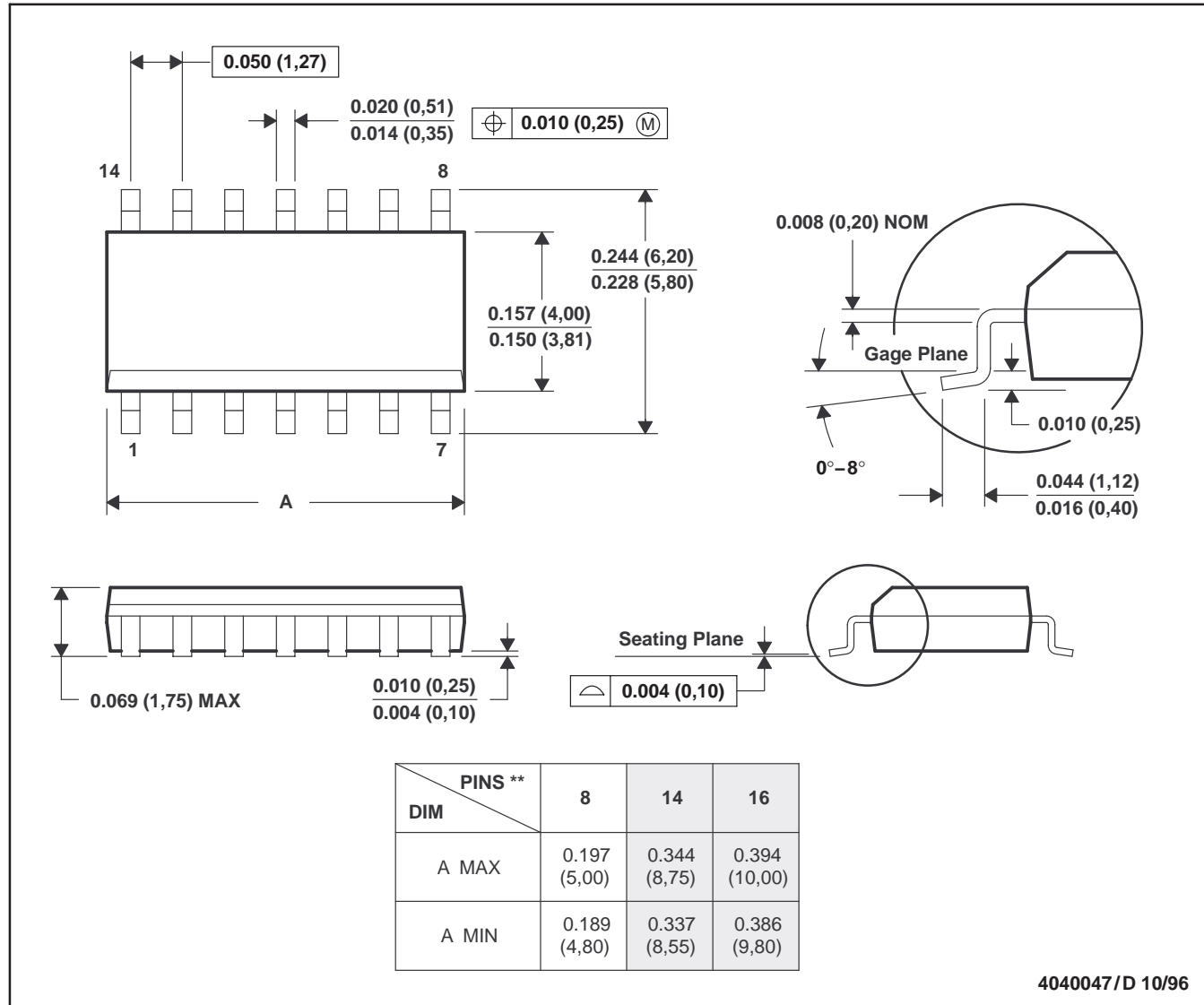
SLVS224B – NOVEMBER 1999 – REVISED AUGUST 2002

MECHANICAL DATA

D (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PIN SHOWN



- 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

PACKAGING INFORMATION

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

⁽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.

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.

TAPE AND REEL INFORMATION



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, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI 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 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. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
RF/IF and ZigBee® Solutions	www.ti.com/lprf

Applications

Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Transportation and Automotive	www.ti.com/automotive
Video and Imaging	www.ti.com/video
Wireless	www.ti.com/wireless-apps

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated