

LOW-POWER DC/DC BOOST CONVERTER IN SOT-23 AND SON PACKAGES

FEATURES

- 1.8-V to 6-V Input Voltage Range
- Adjustable Output Voltage Range up to 28 V
- 400-mA (TPS61040) and 250-mA (TPS61041) Internal Switch Current
- Up to 1-MHz Switching Frequency
- 28- μ A Typical No-Load Quiescent Current
- 1- μ A Typical Shutdown Current
- Internal Soft Start
- Available in SOT23-5 and 2 x 2 x 0.8-mm SON Packages

APPLICATIONS

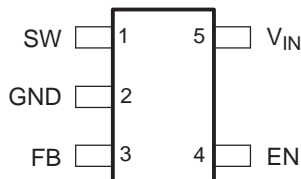
- LCD Bias Supply
- White-LED Supply for LCD Backlights
- Digital Still Camera
- PDAs, Organizers, and Handheld PCs
- Cellular Phones
- Internet Audio Player
- Standard 3.3-V/5-V to 12-V Conversion

DESCRIPTION

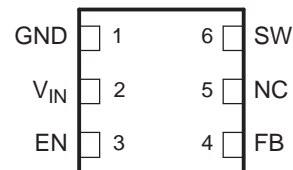
The TPS61040/41 is a high-frequency boost converter dedicated for small to medium LCD bias supply and white LED backlight supplies. The device is ideal to generate output voltages up to 28 V from a dual cell NiMH/NiCd or a single cell Li-Ion battery. The part can also be used to generate standard 3.3-V/5-V to 12-V power conversions.

The TPS61040/41 operates with a switching frequency up to 1 MHz. This allows the use of small external components using ceramic as well as tantalum output capacitors. Together with the thin SON package, the TPS61040/41 gives a very small overall solution size. The TPS61040 has an internal 400 mA switch current limit, while the TPS61041 has a 250-mA switch current limit, offering lower output voltage ripple and allows the use of a smaller form factor inductor for lower power applications. The low quiescent current (typically 28 μ A) together with an optimized control scheme, allows device operation at very high efficiencies over the entire load current range.

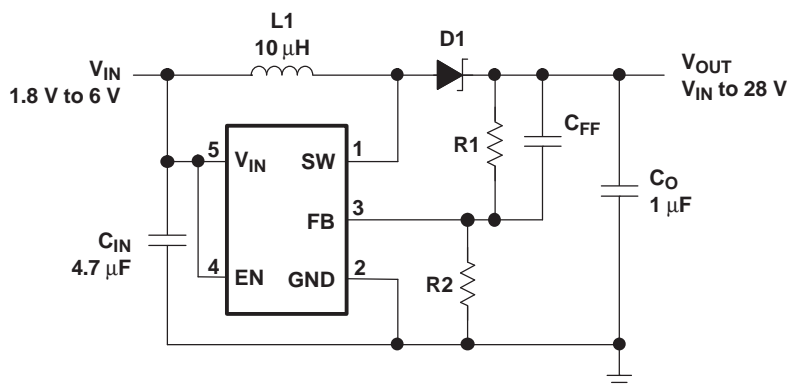
**DBV PACKAGE
(Top View)**



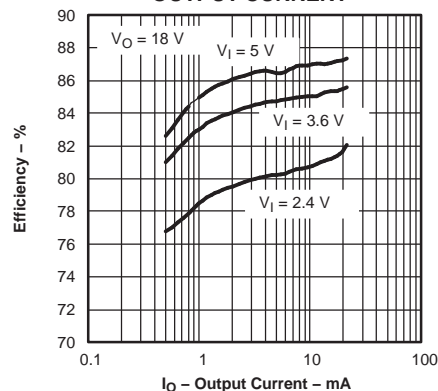
**DRV PACKAGE
(Top View)**



TYPICAL APPLICATION



**EFFICIENCY
vs
OUTPUT CURRENT**



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.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ORDERING INFORMATION (1)

T _A	PART NUMBER (2)	SWITCH CURRENT LIMIT, mA	PACKAGE	PACKAGE MARKING
-40°C to 85°C	TPS61040DBV	400	SOT23-5	PHOI
	TPS61041DBV	250	SOT23-5	PHPI
	TPS61040DRV	400	SON-6 2x2	CCL
	TPS61041DRV	250	SON-6 2x2	CAW

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.
- (2) The devices are available in tape and reel and in tubes. Add R suffix to the part number (e.g., TPS61040DRVR) to order quantities of 3000 parts in tape and reel or add suffix T (e.g., TPS61040DRVT) to order a tube with 250 pieces..

FUNCTIONAL BLOCK DIAGRAM

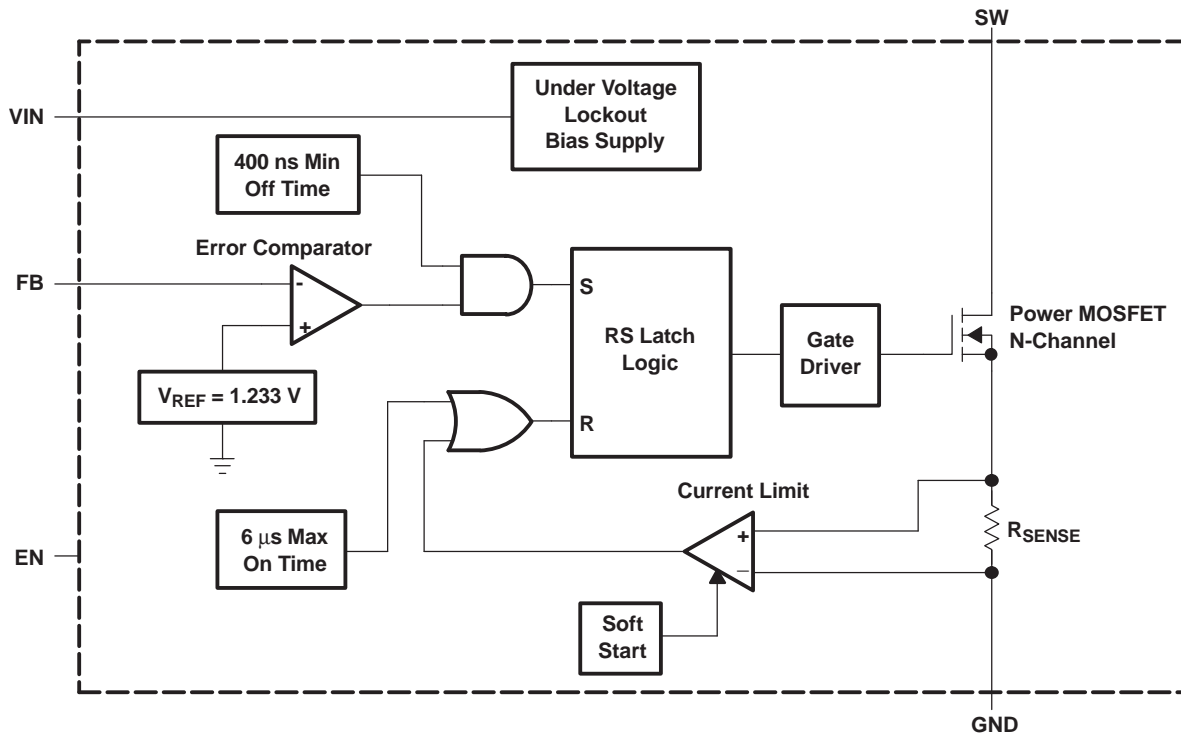


Table 1. Terminal Functions

TERMINAL NAME	TERMINAL		I/O	DESCRIPTION
	DBV NO.	DRV NO.		
EN	4	3	I	This is the enable pin of the device. Pulling this pin to ground forces the device into shutdown mode reducing the supply current to less than 1 μ A. This pin should not be left floating and needs to be terminated.
FB	3	4	I	This is the feedback pin of the device. Connect this pin to the external voltage divider to program the desired output voltage.
GND	2	1	–	Ground
NC	–	5	–	No connection
SW	1	6	I	Connect the inductor and the Schottky diode to this pin. This is the switch pin and is connected to the drain of the internal power MOSFET.
V _{IN}	5	2	I	Supply voltage pin

DETAILED DESCRIPTION

OPERATION

The TPS61040/41 operates with an input voltage range of 1.8 V to 6 V and can generate output voltages up to 28 V. The device operates in a pulse-frequency-modulation (PFM) scheme with constant peak current control. This control scheme maintains high efficiency over the entire load current range, and with a switching frequency up to 1 MHz, the device enables the use of very small external components.

The converter monitors the output voltage, and as soon as the feedback voltage falls below the reference voltage of typically 1.233 V, the internal switch turns on and the current ramps up. The switch turns off as soon as the inductor current reaches the internally set peak current of typically 400 mA (TPS61040) or 250 mA (TPS61041). See the [Peak Current Control](#) section for more information. The second criteria that turns off the switch is the maximum on-time of 6 μ s (typical). This is just to limit the maximum on-time of the converter to cover for extreme conditions. As the switch is turned off the external Schottky diode is forward biased delivering the current to the output. The switch remains off for a minimum of 400 ns (typical), or until the feedback voltage drops below the reference voltage again. Using this PFM peak current control scheme the converter operates in discontinuous conduction mode (DCM) where the switching frequency depends on the output current, which results in very high efficiency over the entire load current range. This regulation scheme is inherently stable, allowing a wider selection range for the inductor and output capacitor.

PEAK CURRENT CONTROL

The internal switch turns on until the inductor current reaches the typical dc current limit (I_{LIM}) of 400 mA (TPS61040) or 250 mA (TPS61041). Due to the internal propagation delay of typical 100 ns, the actual current exceeds the dc current limit threshold by a small amount. The typical peak current limit can be calculated:

$$\begin{aligned}
 I_{\text{peak(typ)}} &= I_{LIM} + \frac{V_{IN}}{L} \times 100 \text{ ns} \\
 I_{\text{peak(typ)}} &= 400 \text{ mA} + \frac{V_{IN}}{L} \times 100 \text{ ns} \text{ for the TPS61040} \\
 I_{\text{peak(typ)}} &= 250 \text{ mA} + \frac{V_{IN}}{L} \times 100 \text{ ns} \text{ for the TPS61041}
 \end{aligned} \tag{1}$$

The higher the input voltage and the lower the inductor value, the greater the peak.

By selecting the TPS61040 or TPS61041, it is possible to tailor the design to the specific application current limit requirements. A lower current limit supports applications requiring lower output power and allows the use of an inductor with a lower current rating and a smaller form factor. A lower current limit usually has a lower output voltage ripple as well.

SOFT START

All inductive step-up converters exhibit high inrush current during start-up if no special precaution is made. This can cause voltage drops at the input rail during start up and may result in an unwanted or early system shut down.

The TPS61040/41 limits this inrush current by increasing the current limit in two steps starting from $\frac{I_{LIM}}{4}$ for 256 cycles to $\frac{I_{LIM}}{2}$ for the next 256 cycles, and then full current limit (see [Figure 14](#)).

ENABLE

Pulling the enable (EN) to ground shuts down the device reducing the shutdown current to 1 μ A (typical). Because there is a conductive path from the input to the output through the inductor and Schottky diode, the output voltage is equal to the input voltage during shutdown. The enable pin needs to be terminated and should not be left floating. Using a small external transistor disconnects the input from the output during shutdown as shown in [Figure 18](#).

UNDERVOLTAGE LOCKOUT

An undervoltage lockout prevents misoperation of the device at input voltages below typical 1.5 V. When the input voltage is below the undervoltage threshold, the main switch is turned off.

THERMAL SHUTDOWN

An internal thermal shutdown is implemented and turns off the internal MOSFETs when the typical junction temperature of 168°C is exceeded. The thermal shutdown has a hysteresis of typically 25°C. This data is based on statistical means and is not tested during the regular mass production of the IC.

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature (unless otherwise noted) ⁽¹⁾

	UNIT
Supply voltages on pin V_{IN} ⁽²⁾	–0.3 V to 7 V
Voltages on pins EN, FB ⁽²⁾	–0.3 V to $V_{IN} + 0.3$ V
Switch voltage on pin SW ⁽²⁾	30 V
Continuous power dissipation	See Dissipation Rating Table
T_J Operating junction temperature	–40°C to 150°C
T_{stg} Storage temperature	–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 voltage values are with respect to network ground terminal.

DISSIPATION RATING TABLE

PACKAGE	$R_{\theta JA}$	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING
DBV	250°C/W	357 mW	3.5 mW/°C	192 mW	140 mW
DRV	76°C/W	1300 mW	13 mW/°C	688 mW	500 mW

RECOMMENDED OPERATING CONDITIONS

		MIN	TYP	MAX	UNIT
V_{IN}	Input voltage range	1.8		6	V
V_{OUT}	Output voltage range			28	V
L	Inductor ⁽¹⁾	2.2	10		μH
f	Switching frequency ⁽¹⁾			1	MHz
C_{IN}	Input capacitor ⁽¹⁾		4.7		μF
C_{OUT}	Output capacitor ⁽¹⁾	1			μF
T_A	Operating ambient temperature	-40		85	°C
T_J	Operating junction temperature	-40		125	°C

(1) See application section for further information.

ELECTRICAL CHARACTERISTICS

$V_{IN} = 2.4$ V, $EN = V_{IN}$, $T_A = -40^{\circ}\text{C}$ to 85°C , typical values are at $T_A = 25^{\circ}\text{C}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT		
SUPPLY CURRENT							
V_{IN}	Input voltage range	1.8		6	V		
I_Q	Operating quiescent current	$I_{OUT} = 0$ mA, not switching, $V_{FB} = 1.3$ V		28	50	μA	
I_{SD}	Shutdown current	EN = GND		0.1	1	μA	
V_{UVLO}	Under-voltage lockout threshold		1.5	1.7	V		
ENABLE							
V_{IH}	EN high level input voltage	1.3			V		
V_{IL}	EN low level input voltage			0.4	V		
I_I	EN input leakage current	EN = GND or V_{IN}		0.1	1	μA	
POWER SWITCH AND CURRENT LIMIT							
V_{sw}	Maximum switch voltage			30	V		
t_{off}	Minimum off time	250	400	550	ns		
t_{on}	Maximum on time	4	6	7.5	μs		
$R_{DS(on)}$	MOSFET on-resistance	$V_{IN} = 2.4$ V; $I_{SW} = 200$ mA; TPS61040		600	1000	mΩ	
$R_{DS(on)}$	MOSFET on-resistance	$V_{IN} = 2.4$ V; $I_{SW} = 200$ mA; TPS61041		750	1250	mΩ	
	MOSFET leakage current	$V_{SW} = 28$ V		1	10	μA	
I_{LIM}	MOSFET current limit	TPS61040		350	400	450	mA
I_{LIM}	MOSFET current limit	TPS61041		215	250	285	mA
OUTPUT							
V_{OUT}	Adjustable output voltage range		V_{IN}	28	V		
V_{ref}	Internal voltage reference		1.233		V		
I_{FB}	Feedback input bias current	$V_{FB} = 1.3$ V		1	μA		
V_{FB}	Feedback trip point voltage	1.8 V $\leq V_{IN} \leq 6$ V		1.208	1.233	1.258	V
	Line regulation ⁽¹⁾	1.8 V $\leq V_{IN} \leq 6$ V; $V_{OUT} = 18$ V; $I_{load} = 10$ mA; $C_{FF} =$ not connected		0.05		%/V	
	Load regulation ⁽¹⁾	$V_{IN} = 2.4$ V; $V_{OUT} = 18$ V; 0 mA $\leq I_{OUT} \leq 30$ mA		0.15		%/mA	

(1) The line and load regulation depend on the external component selection. See the application section for further information.

TYPICAL CHARACTERISTICS

Table 2. Table of Graphs

			FIGURE
η	Efficiency	vs Load current	1, 2, 3
		vs Input voltage	4
I_Q	Quiescent current	vs Input voltage and temperature	5
V_{FB}	Feedback voltage	vs Temperature	6
I_{SW}	Switch current limit	vs Temperature	7
I_{CL}	Switch current limit	vs Supply voltage, TPS61041	8
		vs Supply voltage, TPS61040	9
$R_{DS(on)}$	$R_{DS(on)}$	vs Temperature	10
		vs Supply voltage	11
	Line transient response		12
	Load transient response		13
	Start-up behavior		14

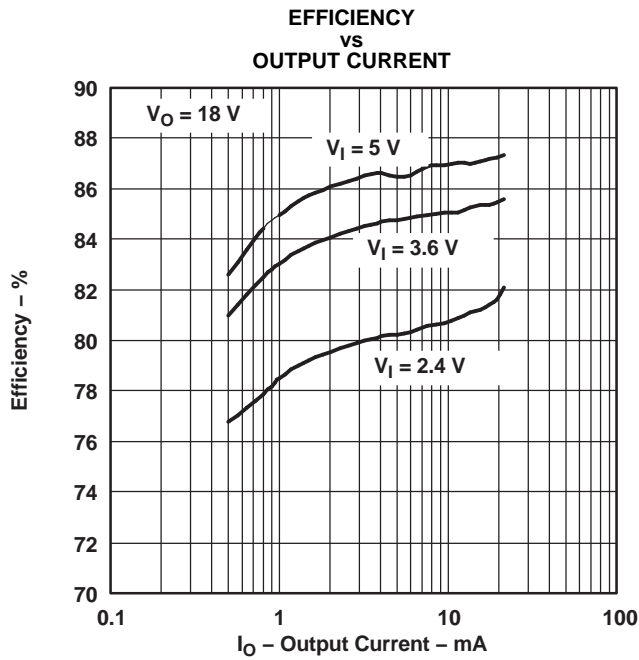


Figure 1.

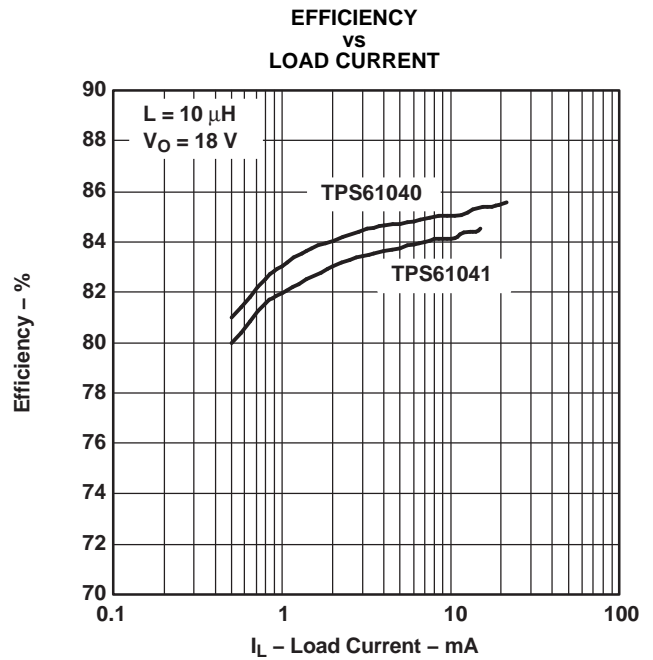
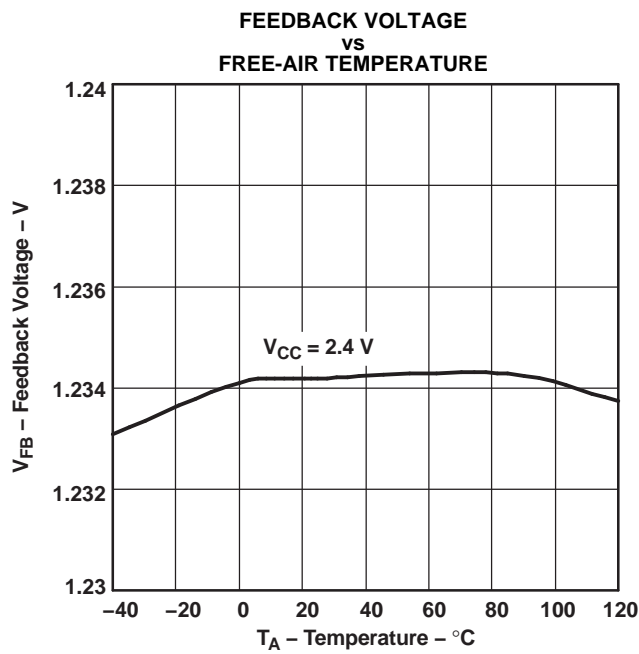
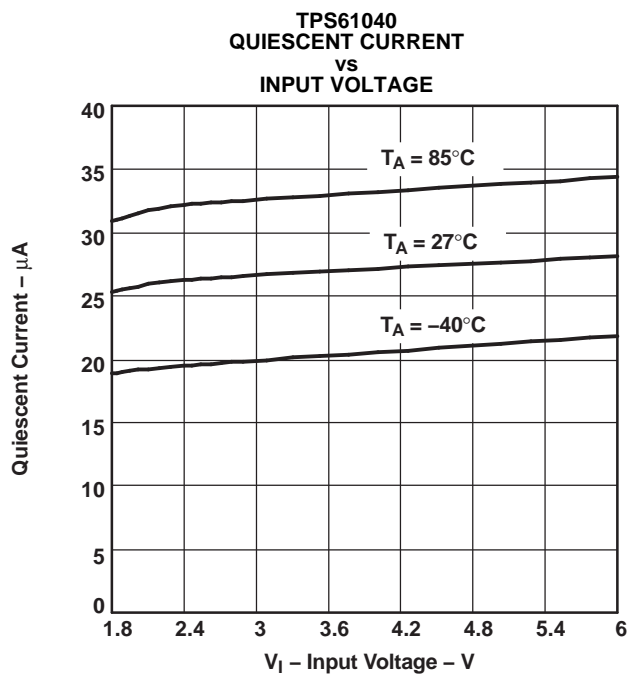
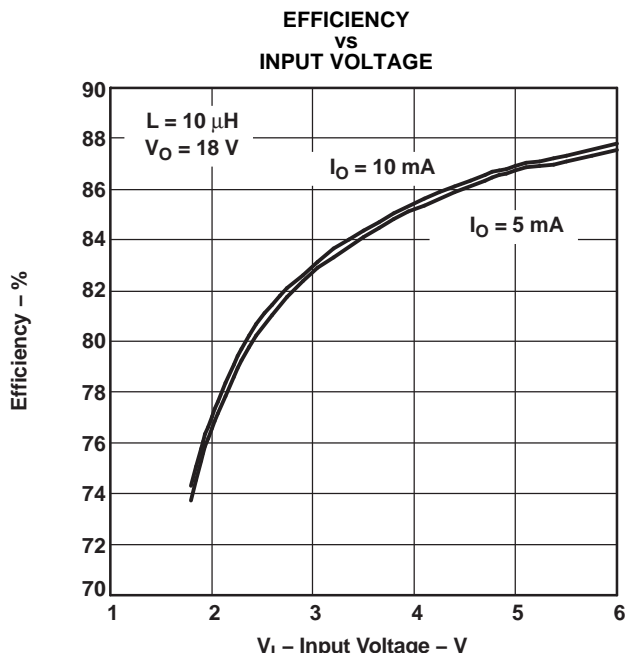
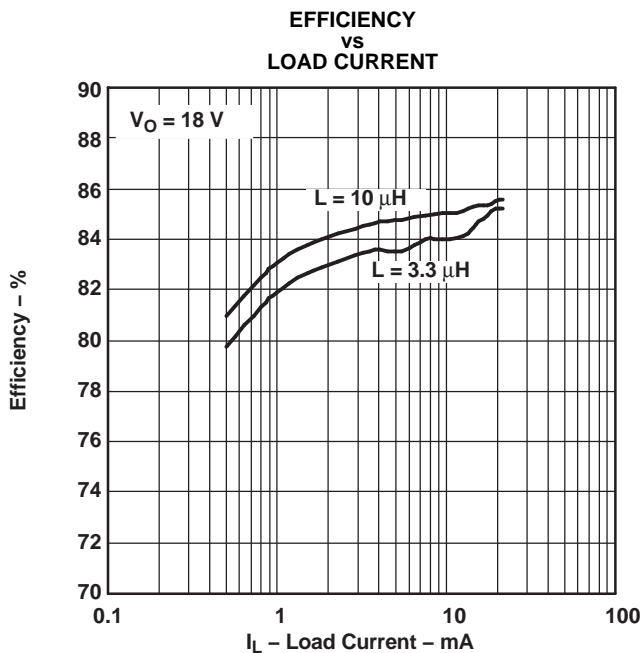


Figure 2.



TPS61040/41
SWITCH CURRENT LIMIT
vs
FREE-AIR TEMPERATURE

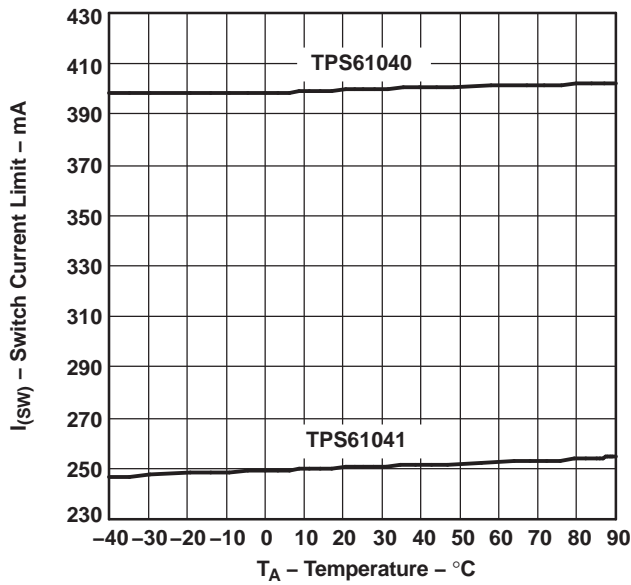


Figure 7.

TPS61041
CURRENT LIMIT
vs
SUPPLY VOLTAGE

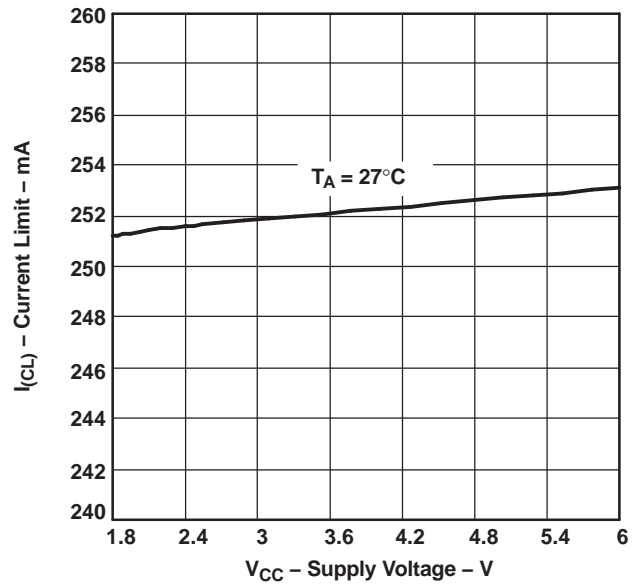


Figure 8.

TPS61040
CURRENT LIMIT
vs
SUPPLY VOLTAGE

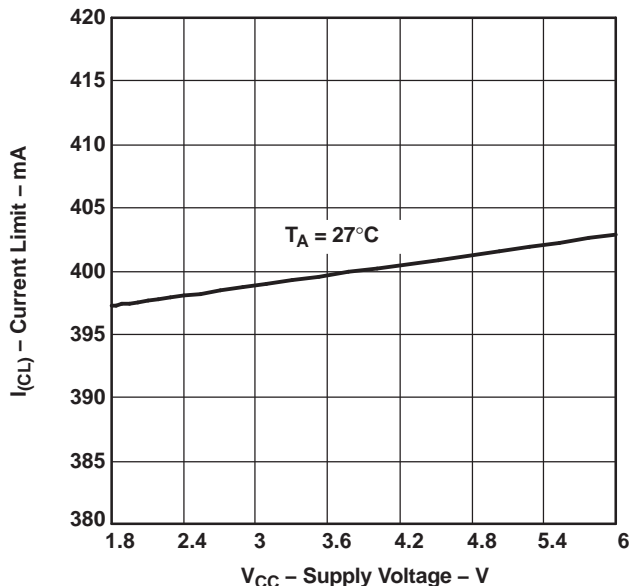


Figure 9.

TPS61040/41
STATIC DRAIN-SOURCE ON-STATE RESISTANCE
vs
FREE-AIR TEMPERATURE

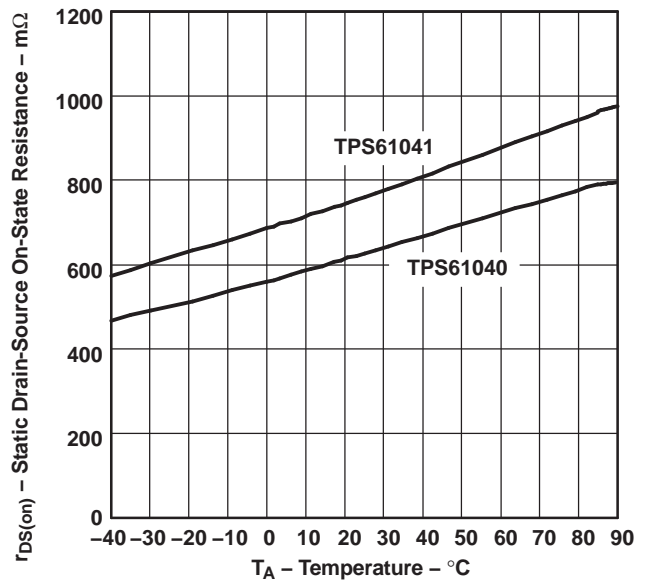


Figure 10.

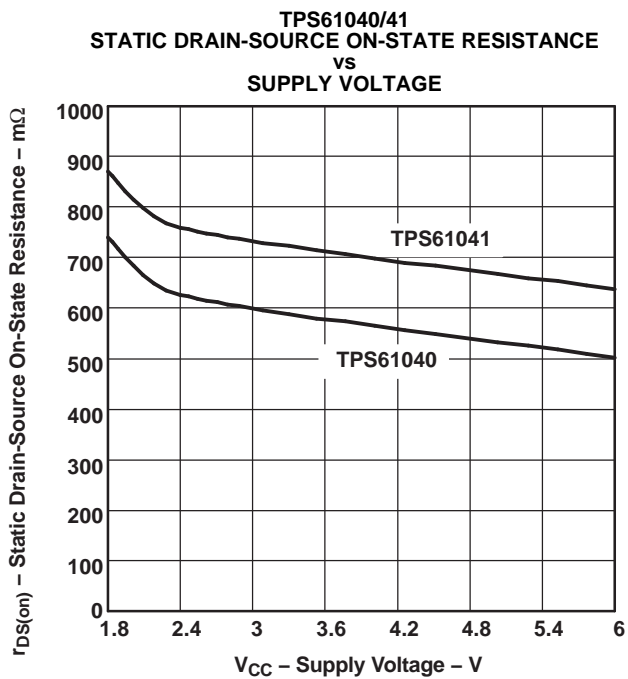


Figure 11.

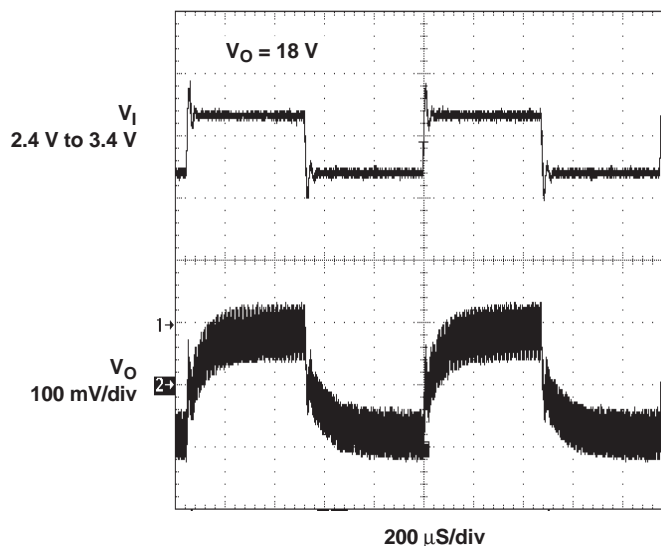


Figure 12. Line Transient Response

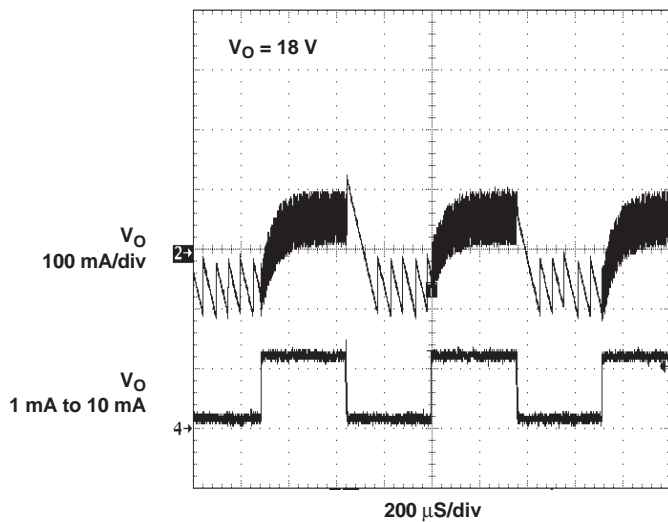


Figure 13. Load Transient Response

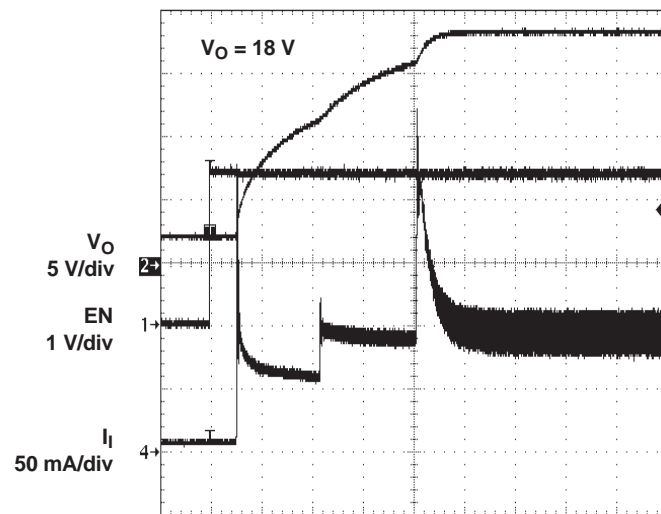


Figure 14. Start-Up Behavior

APPLICATION INFORMATION

INDUCTOR SELECTION, MAXIMUM LOAD CURRENT

Because the PFM peak current control scheme is inherently stable, the inductor value does not affect the stability of the regulator. The selection of the inductor together with the nominal load current, input and output voltage of the application determines the switching frequency of the converter. Depending on the application, inductor values between 2.2 μH and 47 μH are recommended. The maximum inductor value is determined by the maximum on time of the switch, typically 6 μs . The peak current limit of 400 mA/250 mA (typically) should be reached within this 6- μs period for proper operation.

The inductor value determines the maximum switching frequency of the converter. Therefore, select the inductor value that ensures the maximum switching frequency at the converter maximum load current is not exceeded. The maximum switching frequency is calculated by the following formula:

$$fS_{\max} = \frac{V_{\text{IN}(\min)} \times (V_{\text{OUT}} - V_{\text{IN}})}{I_{\text{P}} \times L \times V_{\text{OUT}}} \quad (2)$$

Where:

I_{P} = Peak current as described in the [Peak Current Control](#) section

L = Selected inductor value

$V_{\text{IN}(\min)}$ = The highest switching frequency occurs at the minimum input voltage

If the selected inductor value does not exceed the maximum switching frequency of the converter, the next step is to calculate the switching frequency at the nominal load current using the following formula:

$$fS(I_{\text{load}}) = \frac{2 \times I_{\text{load}} \times (V_{\text{OUT}} - V_{\text{IN}} + V_{\text{d}})}{I_{\text{P}}^2 \times L} \quad (3)$$

Where:

I_{P} = Peak current as described in the [Peak Current Control](#) section

L = Selected inductor value

I_{load} = Nominal load current

V_{d} = Rectifier diode forward voltage (typically 0.3V)

A smaller inductor value gives a higher converter switching frequency, but lowers the efficiency.

The inductor value has less effect on the maximum available load current and is only of secondary order. The best way to calculate the maximum available load current under certain operating conditions is to estimate the expected converter efficiency at the maximum load current. This number can be taken out of the efficiency graphs shown in [Figure 1](#) through [Figure 4](#). The maximum load current can then be estimated as follows:

$$I_{\text{load max}} = \eta \frac{I_{\text{P}}^2 \times L \times fS_{\max}}{2 \times (V_{\text{OUT}} - V_{\text{IN}})} \quad (4)$$

Where:

I_{P} = Peak current as described in the [Peak Current Control](#) section

L = Selected inductor value

fS_{\max} = Maximum switching frequency as calculated previously

η = Expected converter efficiency. Typically 70% to 85%

The maximum load current of the converter is the current at the operation point where the converter starts to enter the continuous conduction mode. Usually the converter should always operate in discontinuous conduction mode.

Last, the selected inductor should have a saturation current that meets the maximum peak current of the converter (as calculated in the [Peak Current Control](#) section). Use the maximum value for I_{LIM} for this calculation.

Another important inductor parameter is the dc resistance. The lower the dc resistance, the higher the efficiency of the converter. See [Table 3](#) and the typical applications for the inductor selection.

Table 3. Recommended Inductor for Typical LCD Bias Supply (see [Figure 15](#))

DEVICE	INDUCTOR VALUE	COMPONENT SUPPLIER	COMMENTS
TPS61040	10 μ H	Sumida CR32-100	High efficiency
	10 μ H	Sumida CDRH3D16-100	High efficiency
	10 μ H	Murata LQH4C100K04	High efficiency
	4.7 μ H	Sumida CDRH3D16-4R7	Small solution size
	4.7 μ H	Murata LQH3C4R7M24	Small solution size
TPS61041	10 μ H	Murata LQH3C100K24	High efficiency Small solution size

SETTING THE OUTPUT VOLTAGE

The output voltage is calculated as:

$$V_{OUT} = 1.233 \text{ V} \times \left(1 + \frac{R1}{R2} \right) \quad (5)$$

For battery-powered applications, a high-impedance voltage divider should be used with a typical value for R2 of $\leq 200 \text{ k}\Omega$ and a maximum value for R1 of $2.2 \text{ M}\Omega$. Smaller values might be used to reduce the noise sensitivity of the feedback pin.

A feedforward capacitor across the upper feedback resistor R1 is required to provide sufficient overdrive for the error comparator. Without a feedforward capacitor, or one whose value is too small, the TPS61040/41 shows *double pulses* or a pulse burst instead of single pulses at the switch node (SW), causing higher output voltage ripple. If this higher output voltage ripple is acceptable, the feedforward capacitor can be left out.

The lower the switching frequency of the converter, the larger the feedforward capacitor value required. A good starting point is to use a 10-pF feedforward capacitor. As a first estimation, the required value for the feedforward capacitor at the operation point can also be calculated using the following formula:

$$C_{FF} = \frac{1}{2 \times \pi \times \frac{fS}{20} \times R1} \quad (6)$$

Where:

R1 = Upper resistor of voltage divider

fS = Switching frequency of the converter at the nominal load current (See the [Inductor Selection, Maximum Load Current](#) section for calculating the switching frequency)

C_{FF} = Choose a value that comes closest to the result of the calculation

The larger the feedforward capacitor the worse the line regulation of the device. Therefore, when concern for line regulation is paramount, the selected feedforward capacitor should be as small as possible. See the following section for more information about line and load regulation.

LINE AND LOAD REGULATION

The line regulation of the TPS61040/41 depends on the voltage ripple on the feedback pin. Usually a 50 mV peak-to-peak voltage ripple on the feedback pin FB gives good results.

Some applications require a very tight line regulation and can only allow a small change in output voltage over a certain input voltage range. If no feedforward capacitor C_{FF} is used across the upper resistor of the voltage feedback divider, the device has the best line regulation. Without the feedforward capacitor the output voltage ripple is higher because the TPS61040/41 shows output voltage bursts instead of single pulses on the switch pin (SW), increasing the output voltage ripple. Increasing the output capacitor value reduces the output voltage ripple.

If a larger output capacitor value is not an option, a feedforward capacitor C_{FF} can be used as described in the previous section. The use of a feedforward capacitor increases the amount of voltage ripple present on the feedback pin (FB). The greater the voltage ripple on the feedback pin (≥ 50 mV), the worse the line regulation. There are two ways to improve the line regulation further:

1. Use a smaller inductor value to increase the switching frequency which will lower the output voltage ripple, as well as the voltage ripple on the feedback pin.
2. Add a small capacitor from the feedback pin (FB) to ground to reduce the voltage ripple on the feedback pin down to 50 mV again. As a starting point, the same capacitor value as selected for the feedforward capacitor C_{FF} can be used.

OUTPUT CAPACITOR SELECTION

For best output voltage filtering, a low ESR output capacitor is recommended. Ceramic capacitors have a low ESR value but tantalum capacitors can be used as well, depending on the application.

Assuming the converter does not show double pulses or pulse bursts on the switch node (SW), the output voltage ripple can be calculated as:

$$\Delta V_{out} = \frac{I_{out}}{C_{out}} \times \left(\frac{1}{fS(I_{out})} - \frac{I_P \times L}{V_{out} + V_d - V_{in}} \right) + I_P \times ESR \tag{7}$$

where:

I_P = Peak current as described in the [Peak Current Control](#) section

L = Selected inductor value

I_{out} = Nominal load current

$fS(I_{out})$ = Switching frequency at the nominal load current as calculated previously

V_d = Rectifier diode forward voltage (typically 0.3 V)

C_{out} = Selected output capacitor

ESR = Output capacitor ESR value

See [Table 4](#) and the *typical applications* section for choosing the output capacitor.

Table 4. Recommended Input and Output Capacitors

DEVICE	CAPACITOR	VOLTAGE RATING	COMPONENT SUPPLIER	COMMENTS
TPS61040/41	4.7 μ F/X5R/0805	6.3 V	Tayo Yuden JMK212BY475MG	C_{IN}/C_{OUT}
	10 μ F/X5R/0805	6.3 V	Tayo Yuden JMK212BJ106MG	C_{IN}/C_{OUT}
	1 μ F/X7R/1206	25 V	Tayo Yuden TMK316BJ105KL	C_{OUT}
	1 μ F/X5R/1206	35 V	Tayo Yuden GMK316BJ105KL	C_{OUT}
	4.7 μ F/X5R/1210	25 V	Tayo Yuden TMK325BJ475MG	C_{OUT}

INPUT CAPACITOR SELECTION

For good input voltage filtering, low ESR ceramic capacitors are recommended. A 4.7 μF ceramic input capacitor is sufficient for most of the applications. For better input voltage filtering this value can be increased. See [Table 4](#) and typical applications for input capacitor recommendations.

DIODE SELECTION

To achieve high efficiency a Schottky diode should be used. The current rating of the diode should meet the peak current rating of the converter as it is calculated in the [Peak Current Control](#) section. Use the maximum value for I_{LIM} for this calculation. See [Table 5](#) and the typical applications for the selection of the Schottky diode.

Table 5. Recommended Schottky Diode for Typical LCD Bias Supply (see [Figure 15](#))

DEVICE	REVERSE VOLTAGE	COMPONENT SUPPLIER	COMMENTS
TPS61040/41	30 V	ON Semiconductor MBR0530	
	20 V	ON Semiconductor MBR0520	
	20 V	ON Semiconductor MBRM120L	High efficiency
	30 V	Toshiba CRS02	

LAYOUT CONSIDERATIONS

Typical for all switching power supplies, the layout is an important step in the design; especially at high peak currents and switching frequencies. If the layout is not carefully done, the regulator might show noise problems and duty cycle jitter.

The input capacitor should be placed as close as possible to the input pin for good input voltage filtering. The inductor and diode should be placed as close as possible to the switch pin to minimize the noise coupling into other circuits. Because the feedback pin and network is a high-impedance circuit, the feedback network should be routed away from the inductor. The feedback pin and feedback network should be shielded with a ground plane or trace to minimize noise coupling into this circuit.

Wide traces should be used for connections in bold as shown in [Figure 15](#). A star ground connection or ground plane minimizes ground shifts and noise.

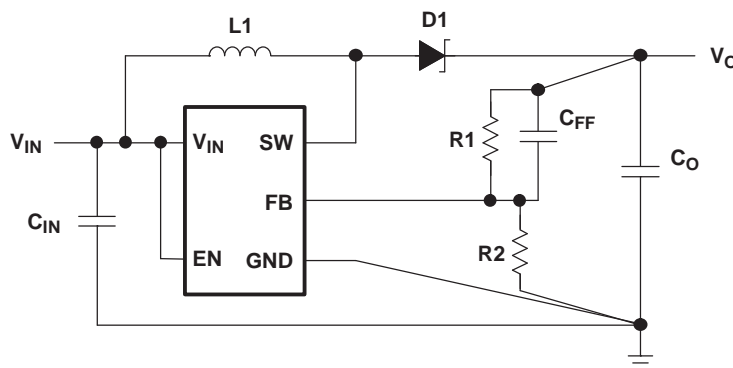


Figure 15. Layout Diagram

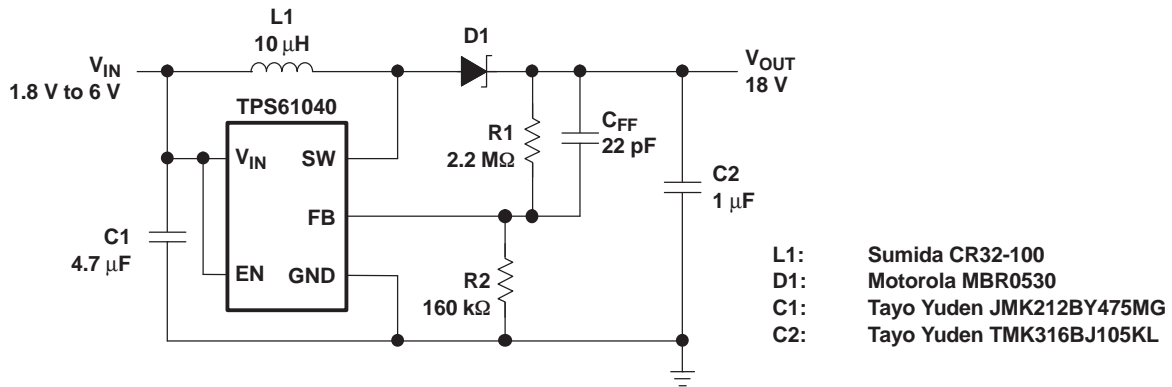


Figure 16. LCD Bias Supply

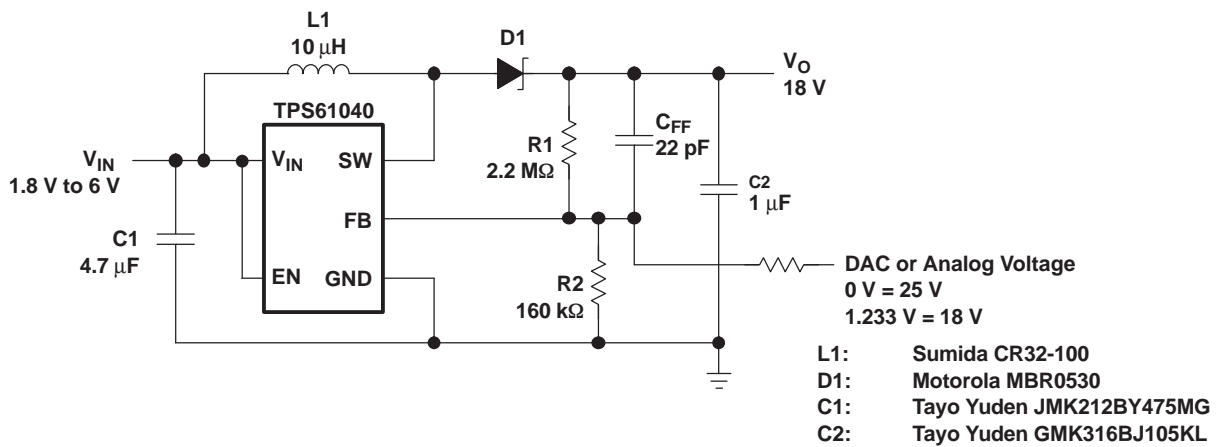


Figure 17. LCD Bias Supply With Adjustable Output Voltage

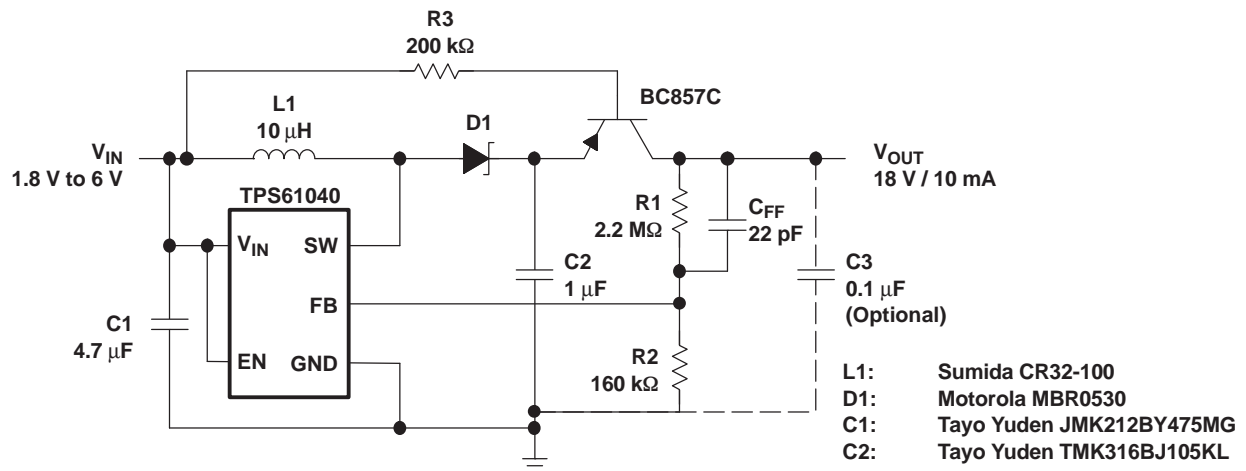


Figure 18. LCD Bias Supply With Load Disconnect

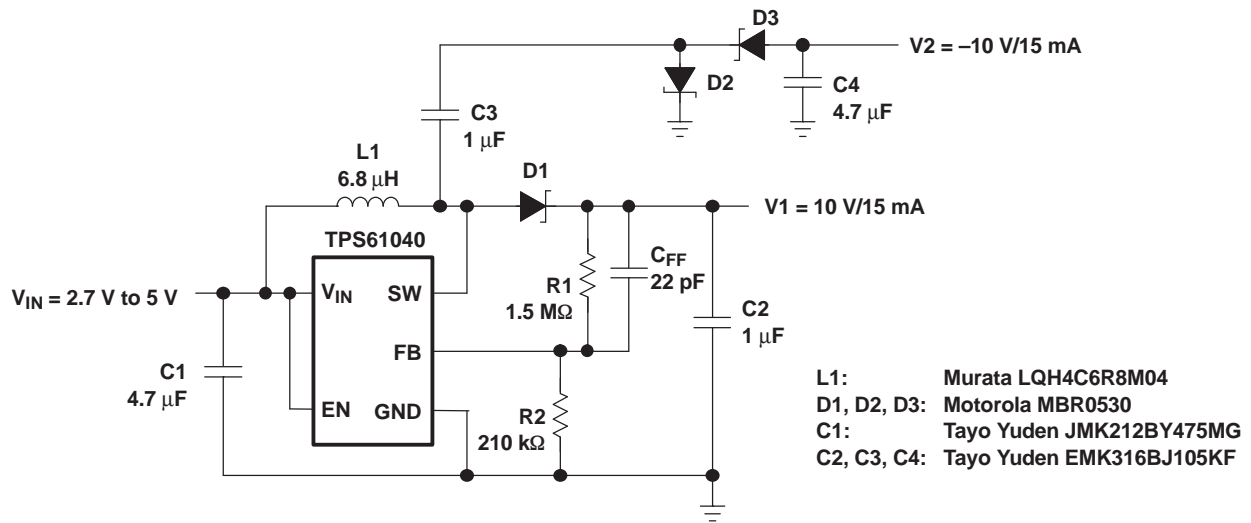


Figure 19. Positive and Negative Output LCD Bias Supply

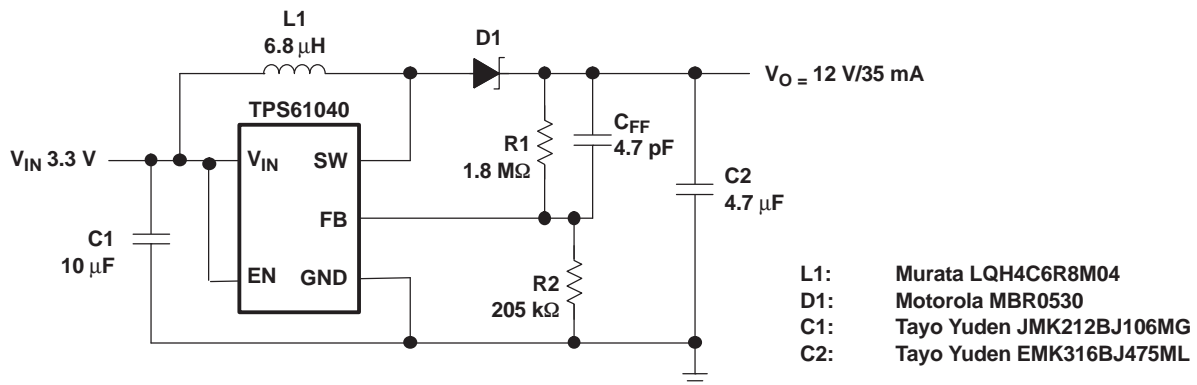


Figure 20. Standard 3.3-V to 12-V Supply

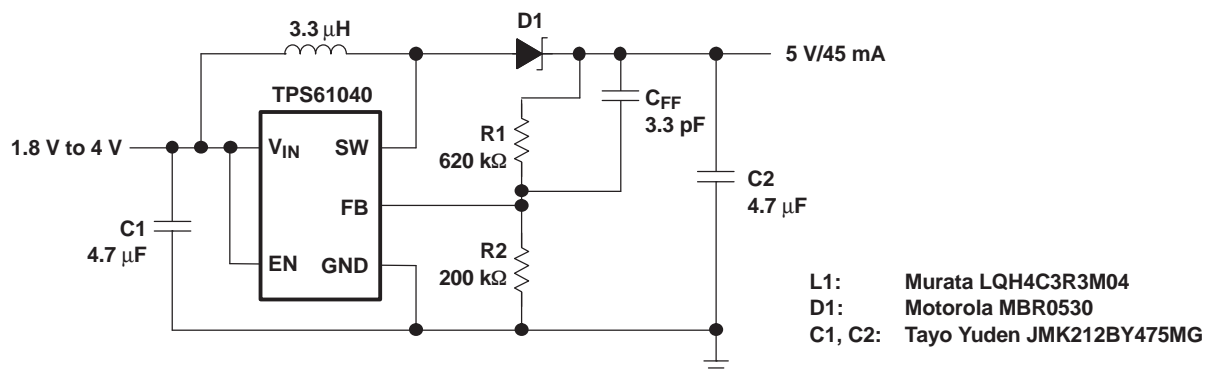


Figure 21. Dual Battery Cell to 5-V/50-mA Conversion
Efficiency Approx. Equals 84% at $V_{IN} = 2.4\text{ V}$ to $V_O = 5\text{ V}/45\text{ mA}$

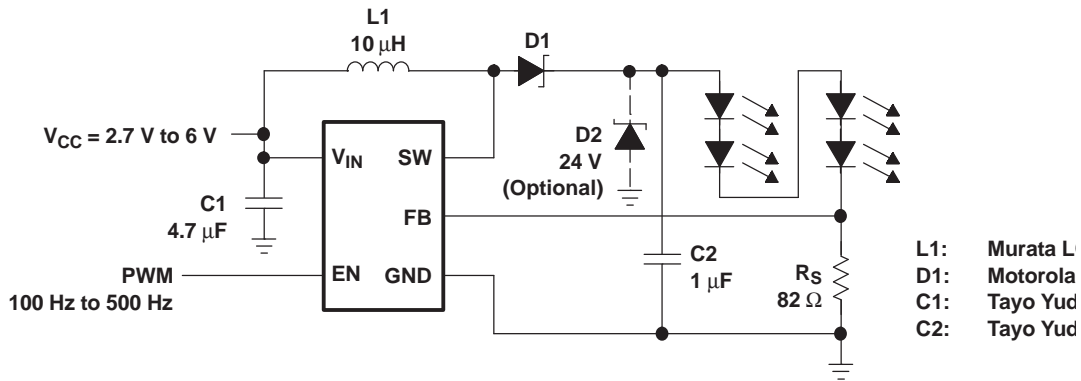
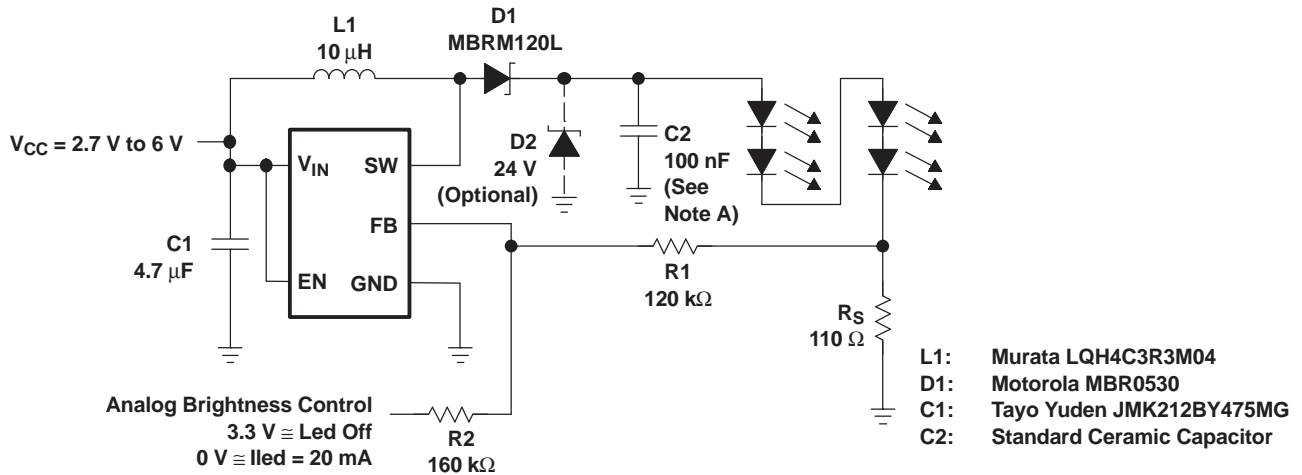


Figure 22. White LED Supply With Adjustable Brightness Control
Using a PWM Signal on the Enable Pin, Efficiency Approx. Equals 86% at $V_{IN} = 3\text{ V}$, $I_{LED} = 15\text{ mA}$



A. A smaller output capacitor value for C2 causes a larger LED ripple.

Figure 23. White LED Supply With Adjustable Brightness Control
Using an Analog Signal on the Feedback Pin

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TPS61040DBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS61040DBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS61040DRVR	ACTIVE	SON	DRV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS61040DRVRG4	ACTIVE	SON	DRV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS61040DRVT	ACTIVE	SON	DRV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS61040DRVTG4	ACTIVE	SON	DRV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS61041DBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS61041DBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS61041DRVR	ACTIVE	SON	DRV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS61041DRVRG4	ACTIVE	SON	DRV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS61041DRVT	ACTIVE	SON	DRV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS61041DRVTG4	ACTIVE	SON	DRV	6	250	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.

OTHER QUALIFIED VERSIONS OF TPS61040, TPS61041 :

- Automotive: [TPS61040-Q1](#), [TPS61041-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

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
TPS61040DBVR	SOT-23	DBV	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPS61040DRVR	SON	DRV	6	3000	179.0	8.4	2.2	2.2	1.2	4.0	8.0	Q2
TPS61040DRVT	SON	DRV	6	250	179.0	8.4	2.2	2.2	1.2	4.0	8.0	Q2
TPS61041DBVR	SOT-23	DBV	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPS61041DRVR	SON	DRV	6	3000	179.0	8.4	2.2	2.2	1.2	4.0	8.0	Q2
TPS61041DRVT	SON	DRV	6	250	179.0	8.4	2.2	2.2	1.2	4.0	8.0	Q2

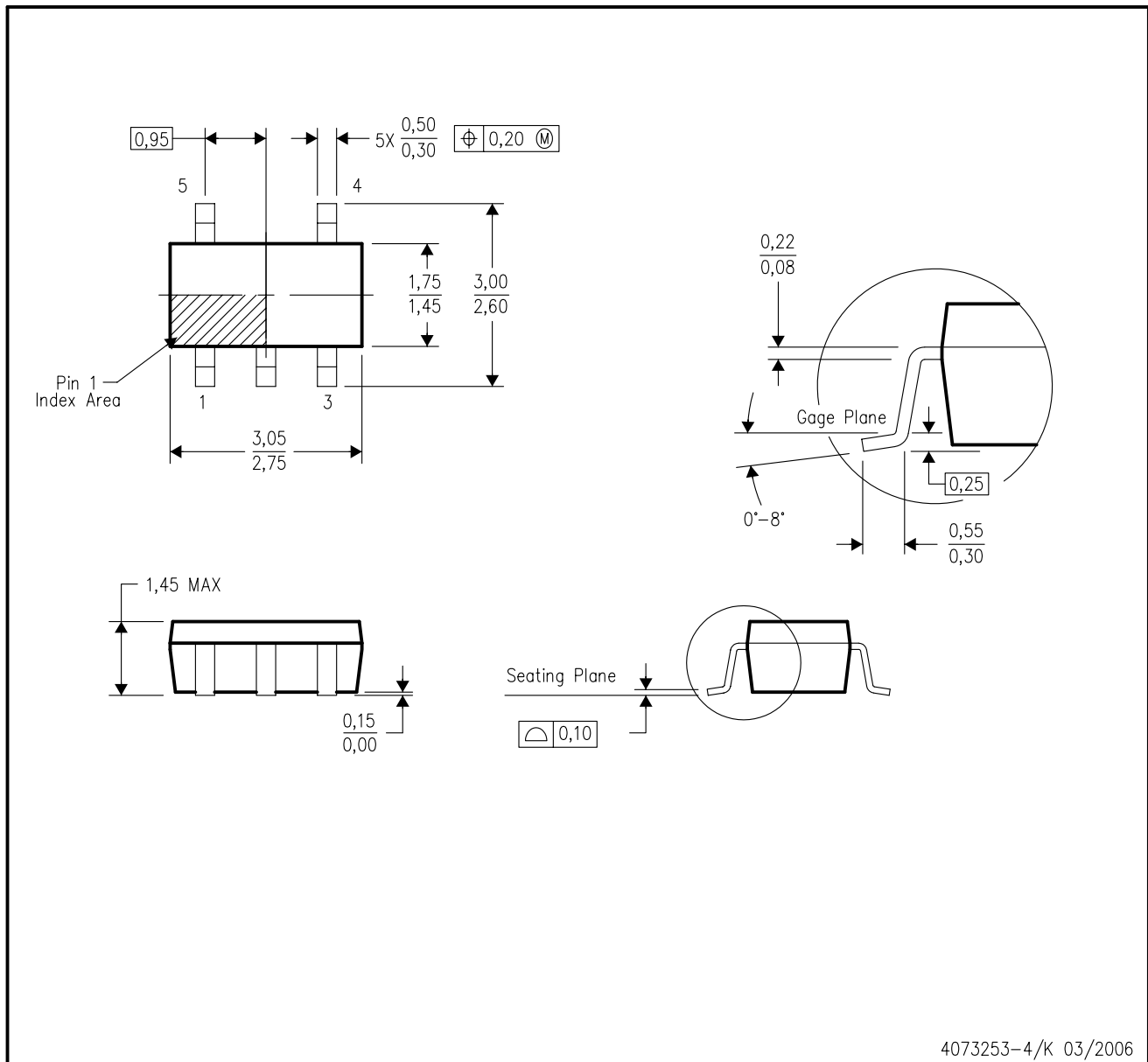
TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS61040DBVR	SOT-23	DBV	5	3000	195.0	200.0	45.0
TPS61040DRVR	SON	DRV	6	3000	195.0	200.0	45.0
TPS61040DRVT	SON	DRV	6	250	195.0	200.0	45.0
TPS61041DBVR	SOT-23	DBV	5	3000	195.0	200.0	45.0
TPS61041DRVR	SON	DRV	6	3000	195.0	200.0	45.0
TPS61041DRVT	SON	DRV	6	250	195.0	200.0	45.0

DBV (R-PDSO-G5)

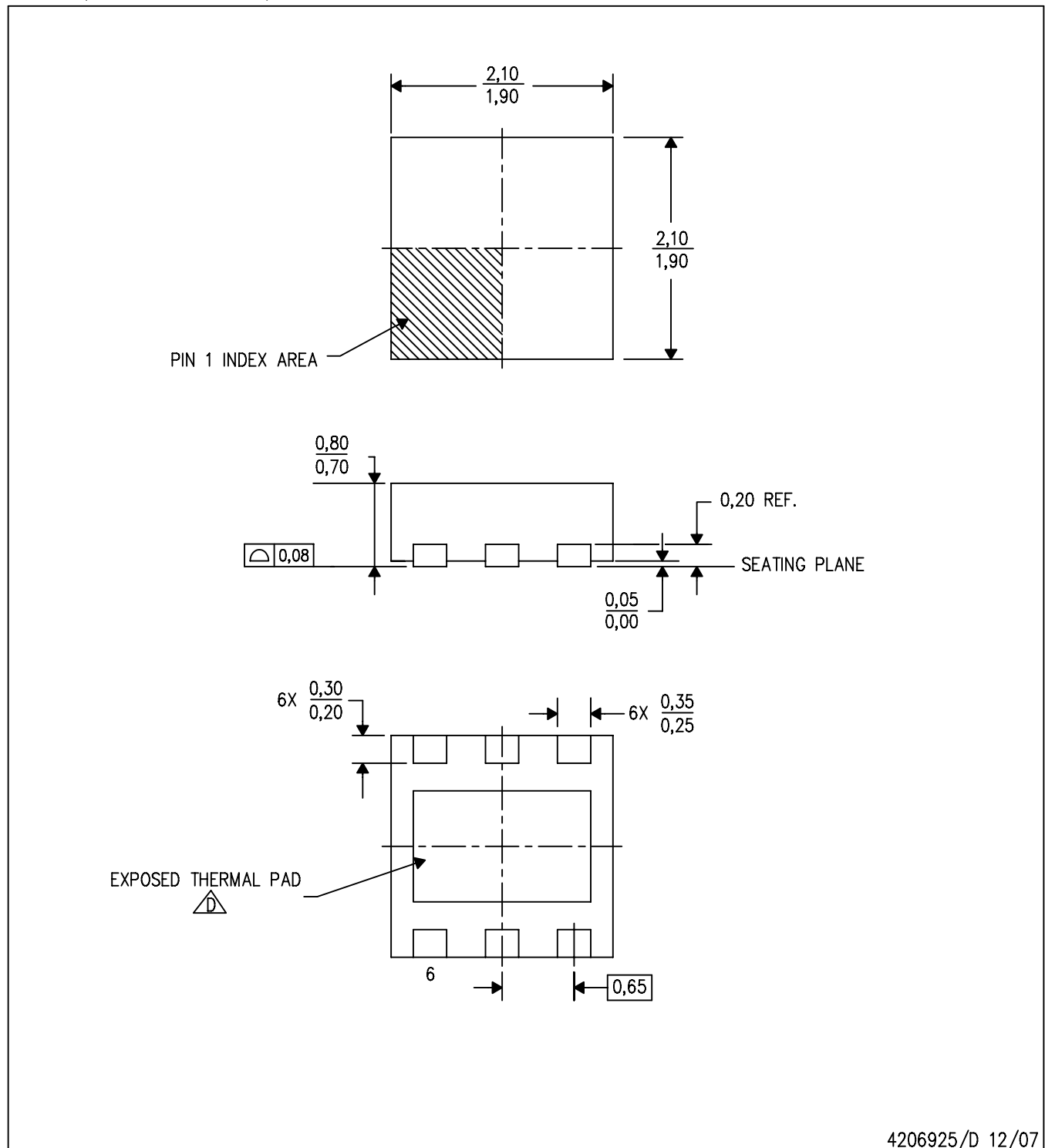
PLASTIC SMALL-OUTLINE PACKAGE




- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
 - D. Falls within JEDEC MO-178 Variation AA.

DRV (S-PDSO-N6)

PLASTIC SMALL OUTLINE



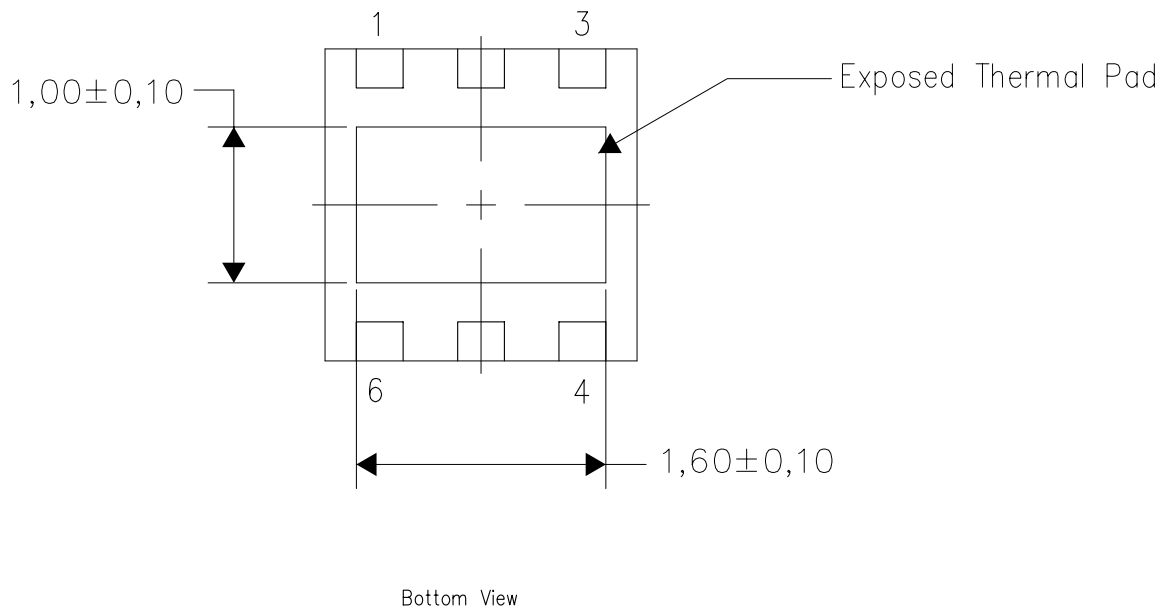
- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. Small Outline No-Lead (SON) package configuration.
-  The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, Quad Flatpack No-Lead Logic Packages, Texas Instruments Literature No. SCBA017. This document is available at www.ti.com.

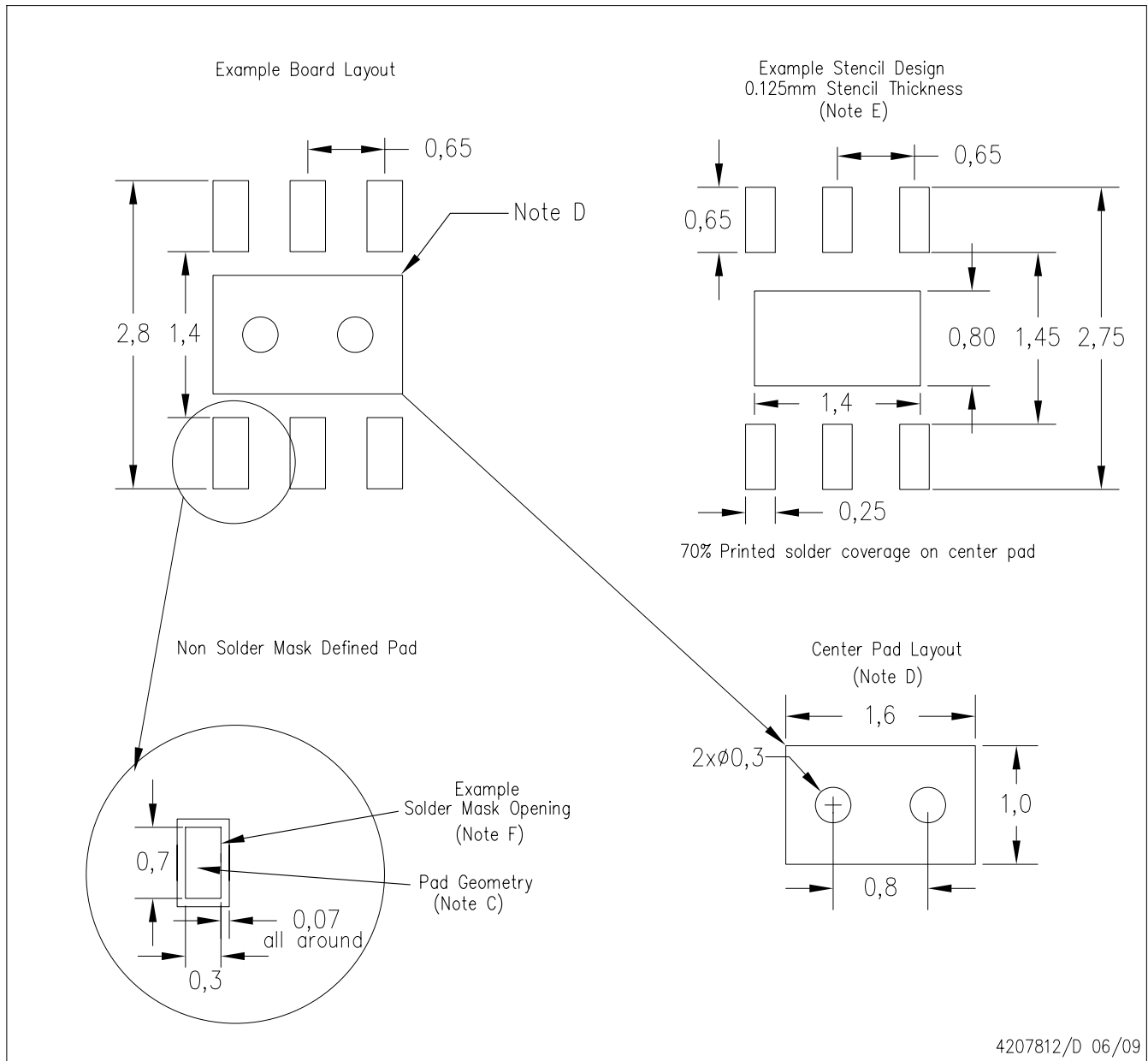
The exposed thermal pad dimensions for this package are shown in the following illustration.



NOTE: All linear dimensions are in millimeters

Exposed Thermal Pad Dimensions

DRV (S-PWSON-N6)



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>.
 - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
 - F. Customers should contact their board fabrication site for solder mask tolerances.

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		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DLP® Products	www.dlp.com	Communications and Telecom	www.ti.com/communications
DSP	dsp.ti.com	Computers and Peripherals	www.ti.com/computers
Clocks and Timers	www.ti.com/clocks	Consumer Electronics	www.ti.com/consumer-apps
Interface	interface.ti.com	Energy	www.ti.com/energy
Logic	logic.ti.com	Industrial	www.ti.com/industrial
Power Mgmt	power.ti.com	Medical	www.ti.com/medical
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
RFID	www.ti-rfid.com	Space, Avionics & Defense	www.ti.com/space-avionics-defense
RF/IF and ZigBee® Solutions	www.ti.com/lprf	Video and Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless-apps