Single-Inductor, Multiple-Output (SIMO) Regulator

Check for Samples: TPS65135

FEATURES

- **SIMO Regulator Technology**
- **2.5 V to 5.5 V Input Voltage Range**
- **750 mW Output Power at V_{IN} = 2.9 V**
- **Positive Output Voltage up to 6 V**
- **Negative Output Voltage Down to –7 V**
- **1% Output Voltage Accuracy**
- **Output current missmatch of pos and neg rail up to 50%**
- **Excellent Line Regulation**
- **Advanced Power-Save Mode for Light-Load Efficiency**
- **Low-Noise Operation**
- **Out-of-Audio Mode**
- **Short-Circuit Protection**
- **Thermal Shutdown**
- **3-mm × 3-mm Thin QFN Package**

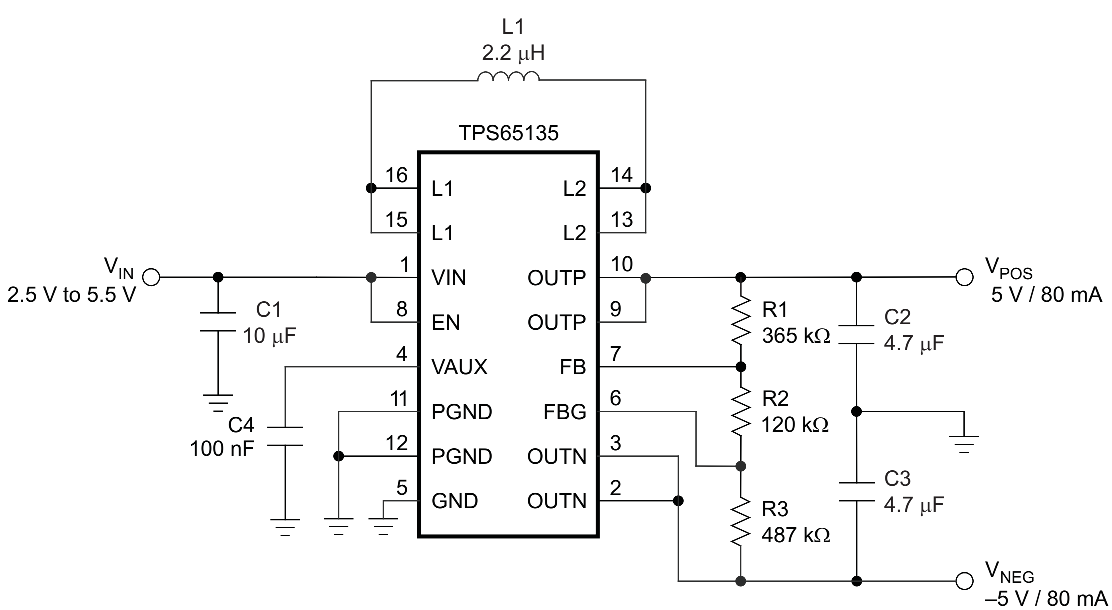
APPLICATIONS

- **Active-Matrix OLED Power Supply**
- **LCD Power Supply**
- **General dual power supply applications**

DESCRIPTION

The TPS65135 is a high efficient single inductor dual output converter. Due to its single-inductor multiple-output (SIMO) technology the converter uses a minimum of external components. The device operates with a buck-boost topology and generates a positive and a negative output voltage above or below the input voltage rail. The SIMO technology enables excellent line and load regulation which is for instance required to avoid disturbance of a mobile phone display as a result of input voltage variations that occur during transmit periods in mobile communication systems. The device can also be used as a standard +/- supply as long as the output current missmatch between the rails is smaller than 50%.

TYPICAL APPLICATION



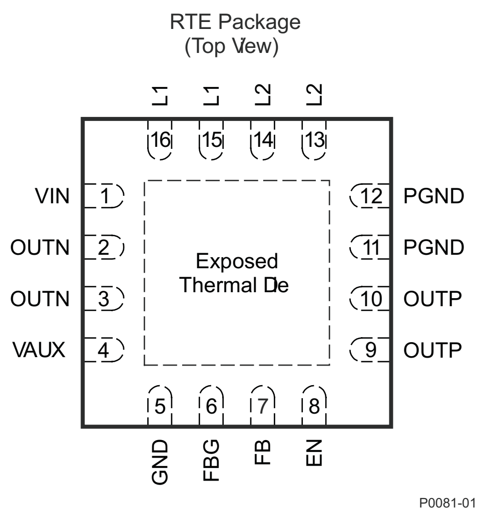
These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ORDERING INFORMATION(1)

T_A	ORDERING P/N	PACKAGE	PACKAGE MARKING
–40°C to 85°C	TPS65135RTE	RTE	CCR

(1) The RTE package is available in tape and reel. Add R suffix (TPS65135RTER) to order quantities of 3000 parts per reel. For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI Web site at www.ti.com.

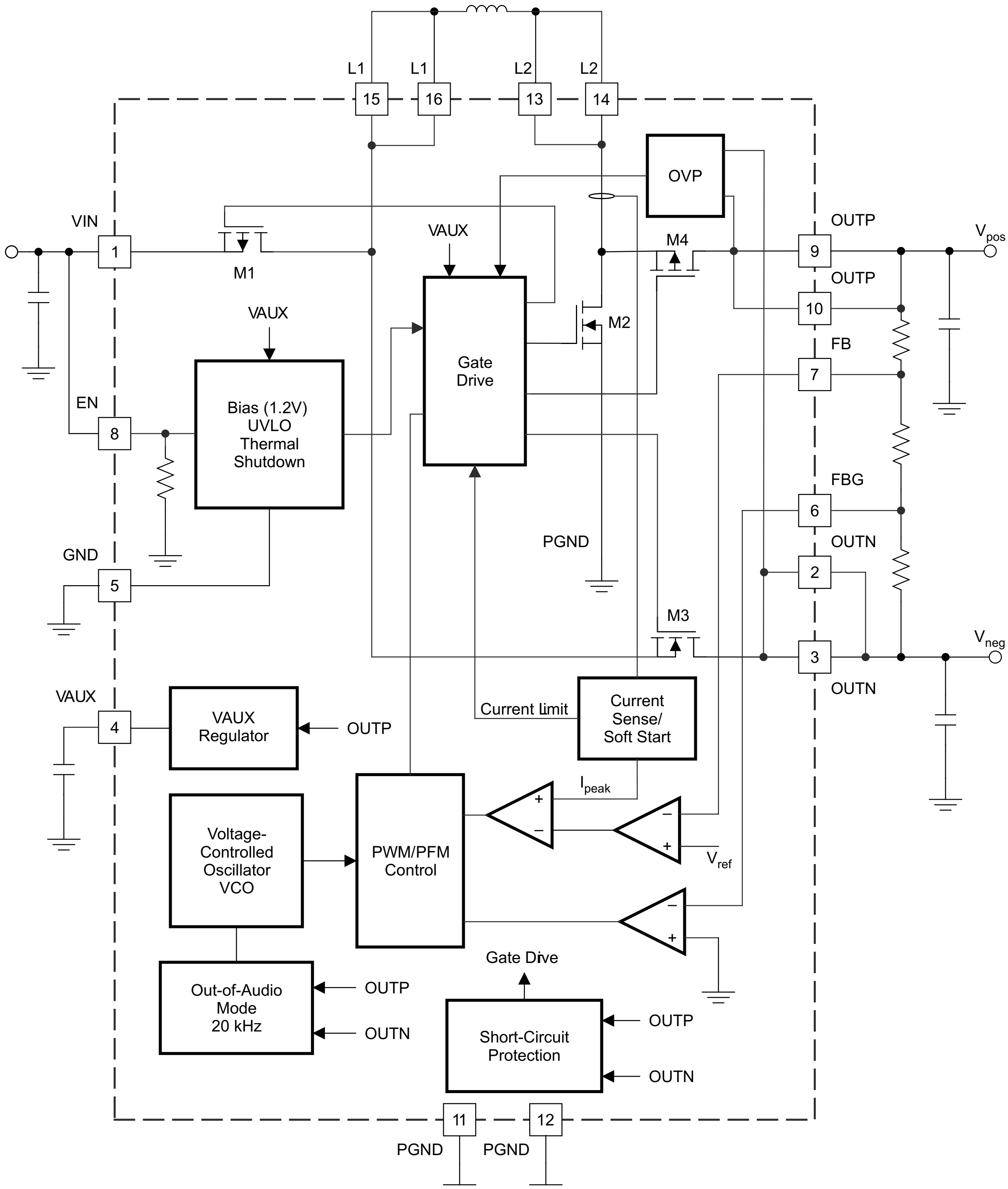
16-PIN TQFN PACKAGE



PIN FUNCTIONS

PIN		I/O	DESCRIPTION
NAME	NO.		
EN	8	I	Input pin to enable the device. Pulling this pin high enables the device. This pin has an internal 500 kΩ pulldown resistor.
FB	7	I	Feedback regulation input for the positive output voltage rail
FBG	6	I	Feedback regulation input for GND reference (regulation of the negative output voltage rail)
GND	5	–	Analog ground
L1	15, 16	I/O	Inductor terminal
L2	13, 14	I/O	Inductor terminal
OUTN	2, 3	O	Negative output
OUTP	9, 10	O	Positive output
PGND	11, 12	–	Power GND
VAUX	4	I/O	Reference voltage output. This pin requires a 100-nF capacitor for stability.
VIN	1	I	Input supply
Exposed thermal die		–	Connect this pad to analog GND.

FUNCTIONAL BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS[1][2]

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

		VALUE		UNIT
		MIN	MAX	
Voltage range	VIN, EN, VAUX, FB, OUTP, L2	–0.3	7	V
	L1, OUTN	–8	7	V
	FBG	–0.3	0.3	V
ESD rating	Human Body Model		2	kV
	Machine Model		200	V
	Charged Device Model		1	kV
Continuous total power dissipation		See Dissipation Ratings Table		
Operating junction temperature range, T_J		–40	150	°C
Operating ambient temperature range, T_A		–40	85	°C
Storage temperature range, T_{stg}		–65	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 ground.

THERMAL INFORMATION

THERMAL METRIC[1]		VALUE	UNIT
θ_{JA}	Junction-to-ambient thermal resistance	44.8	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance	42.0	
θ_{JCbot}	Junction-to-case (bottom) thermal resistance	4.3	
θ_{JB}	Junction-to-board thermal resistance	16.9	
ψ_{JT}	Junction-to-top characterization parameter	0.4	
ψ_{JB}	Junction-to-board characterization parameter	16.8	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.

RECOMMENDED OPERATING CONDITIONS

		MIN	TYP	MAX	UNIT
V_{IN}	Input voltage range	2.5		5.5	V
L	Inductor[1]	1	2.2	4.7	µH
C_{IN}	Input Capacitor[1]	4.7	10		µF
C_{OUTP}, C_{OUTN}	Output Capacitors[1]	4.7	10	20	µF
T_A	Operating ambient temperature	–40		85	°C
T_J	Operating junction temperature	–40		125	°C

(1) Please refer to DETAILED DESCRIPTION for further information

ELECTRICAL CHARACTERISTICS

V_{IN} = 3.7 V, EN = V_{IN}, OUTP = 5 V, OUTN = –5 V, T_A = –40°C to 85°C; typical values are at T_A = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY CURRENT						
V_{IN}	Input voltage range		2.5		5.5	V
I_Q	Operating quiescent current into V_{IN}			7		mA
I_{SD}	Shutdown current into V_{IN}	EN = low		0.1	2	µA
V_{UVLO}	Undervoltage lockout threshold	V_{IN} falling		1.8	2.1	V
		V_{IN} rising		2	2.3	
	Thermal shutdown			140		°C
	Thermal shutdown hysteresis			5		°C
ENABLE						
V_H	Logic high-level voltage	V_{IN} = 2.5 V to 5.5 V	1.2			V
V_L	Logic low-level voltage	V_{IN} = 2.5 V to 5.5 V			0.4	V
R_{EN}	Enable pulldown resistor		200	500	900	kΩ
OUTPUT						
V_{OUTP}	Positive output voltage range		3		6	V
OVP_P	Positive overvoltage protection	I_{OUT} = 10 mA	6.1	7		V
V_{OUTN}	Negative output voltage range		–2.5		–7	V
OVP_N	Negative overvoltage protection	I_{OUT} = 10 mA	-7.1	–7.6		V
I_{mis}	Output current mismatch I_{pos} to I_{neg} (1)		–50%		50%	
V_{OUTP}	Positive output voltage regulation		-1 %	1.24	+1 %	V
V_{FBG}	Feedback ground regulation		–10	0	10	mV
$r_{DS(on)}$	M1 MOSFET on-resistance	I_{L1} = 100 mA		250		mΩ
	M2 MOSFET on-resistance	I_{L2} = 100 mA		200		
	M3 MOSFET on-resistance	I_{L1} = 100 mA		500		
	M4 MOSFET on-resistance	I_{L2} = 100 mA		300		
I_{SW}	Switch current limit (M2)	V_{IN} = 3.7 V	0.9	1.2	1.6	A
		V_{IN} = 2.5 V	1	1.5	1.9	
P_{OUT}	Output power	$V_{pos} – V_{neg} \leq 10$ V; V_{IN} = 2.9 V	750			mW
f_s	Switching frequency	I_{OUT} neg = I_{OUT} pos = 30 mA		1		MHz
	Line regulation positive output OUTP	V_{IN} = 2.5V to 5.5V, I_{OUTN} = I_{OUTP} = 5 mA		0		%/V
	Line regulation negative output OUTN	V_{IN} = 2.5V to 5.5V, I_{OUTN} = I_{OUTP} = 5 mA		0		%/V
	Load regulation positive output OUTP	I_{OUTN} = I_{OUTP} = 0 mA to 80 mA		0		%/A
	Load regulation negative output OUTN	I_{OUTN} = I_{OUTP} = 0 mA to 80 mA		0		%/A

(1) See TYPICAL CHARACTERISTICS and DETAILED DESCRIPTION for more detail

Application for Typical Characteristics Measurements

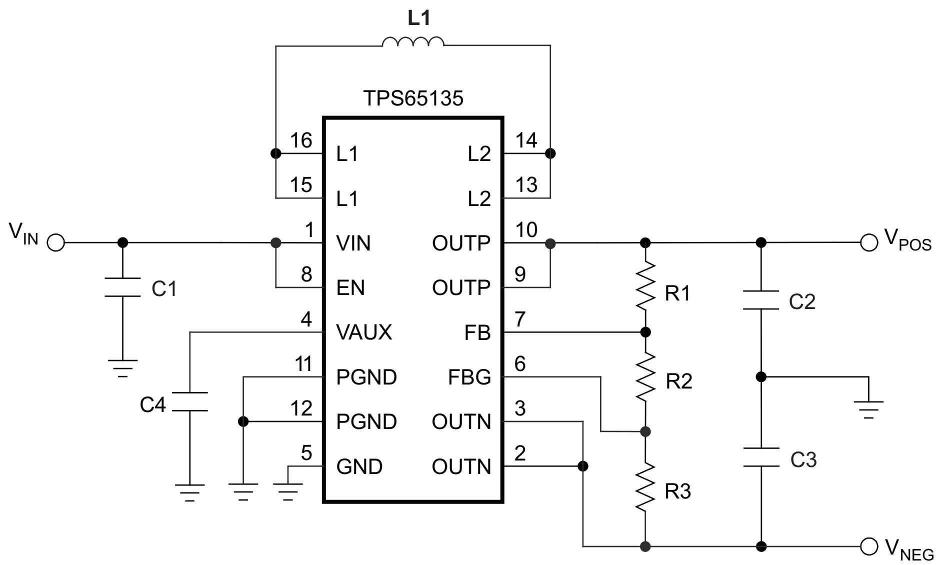


Figure 1. Application Circuit for Typical Characteristics Measurements

Table 1. Component List for Typical Characteristics Circuit

Reference	Description	Manufacturer and Part Number
C1, C2, C3	10 µF, 6.3 V, 0603, X5R, ceramic	Murata, GRM188R60J106ME84D
C4	100 nF, 10 V, 0603, X7R, ceramic	Murata, GRM188R71H104KA93D
L1	2.2 µH, 2.2 A, 90 mΩ, 2.5 mm * 2.0 mm * 1.2 mm	Toko, DFE252012C
R1	Depending on the output voltage, 1%, (all measurements with +/-5 V output voltage uses 365 kΩ)	
R2	Depending on the output voltage, 1%, (all measurements with +/-5 V output voltage uses 120 kΩ)	
R3	Depending on the output voltage, 1%, (all measurements with +/-5 V output voltage uses 487 kΩ)	
U1	TPS65135RTE	Texas Instruments

TYPICAL CHARACTERISTICS

TABLE OF GRAPHS

V_{POS}= 5 V, V_{NEG}= -5 V, unless otherwise noted

		Figure
Efficiency	vs. load current with TOKO DFE252012C 2.2 μH inductor	Figure 2
Efficiency	vs. load current with TOKO DFE252012C 4.7 μH inductor	Figure 3
Typical Output Current Window (Mismatch)	I_{OUTP} vs. I_{OUTN}	Figure 4
Operation at light load current (10mA)	DCM operation	Figure 5
Operation at high load current (80mA)	CCM operation	Figure 6
Line transient response	I_{OUT} = 10 mA	Figure 7
Line transient response	I_{OUT} = 50 mA	Figure 8
Start-up	V_{IN} rising, no load	Figure 9
Start-up	EN = high, no load	Figure 10
Shut-down	V_{IN} falling, no load	Figure 11
Shut-down	EN = low, no load	Figure 12
Transient Response	I_{OUT} = 10mA to 50mA (load between V_{NEG} and V_{POS})	Figure 13
Transient Response	I_{OUT} = 20mA to 80mA (load between V_{NEG} and V_{POS})	Figure 14
Switching frequency	vs. load current	Figure 15
Quiescent current	vs. input voltage	Figure 16

EFFICIENCY vs LOAD CURRENT (TOKO DFE252012C, 2.2 μH)

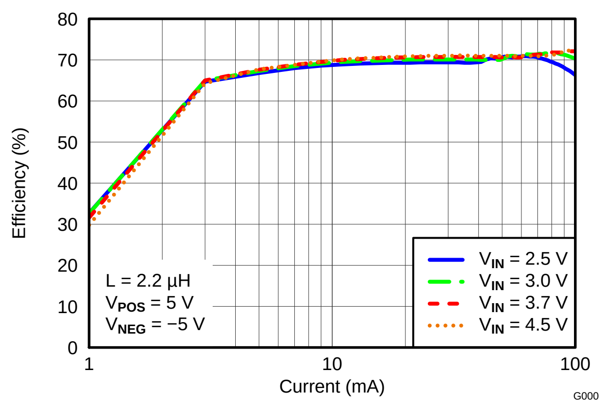


Figure 2.

EFFICIENCY vs. LOAD CURRENT (TOKO DFE252012C, 4.7 μH)

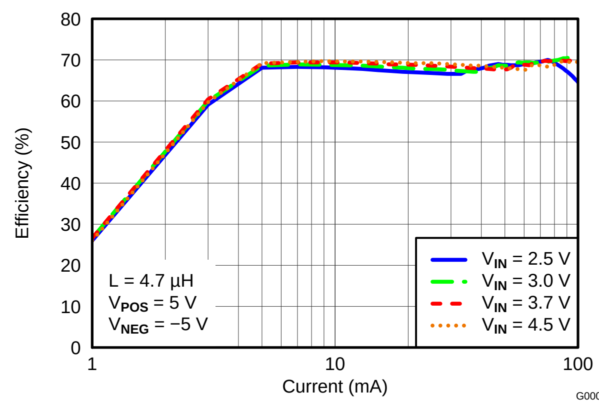


Figure 3.

OUTPUT CURRENT MISMATCH
Positive Output Current
vs.
Negative Output Current

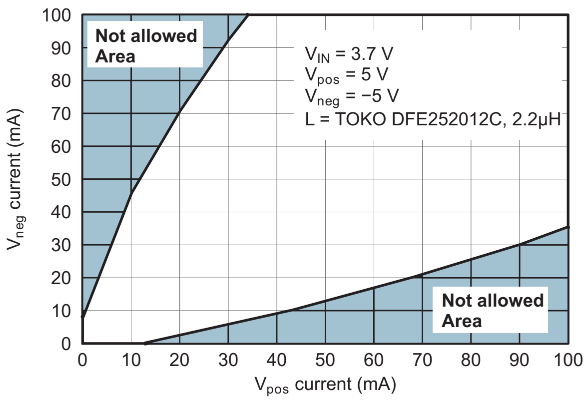


Figure 4.

OPERATION AT LIGHT LOAD CURRENT, DCM OPERATION

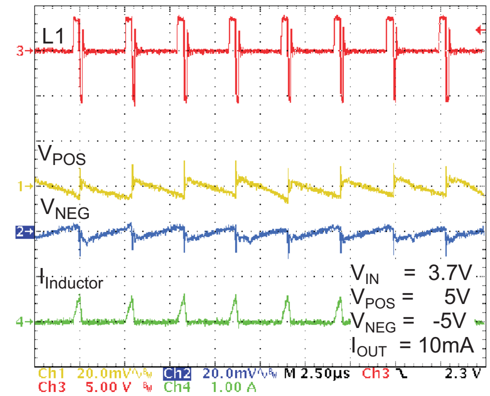


Figure 5.

OPERATION AT HIGH LOAD CURRENT, CCM OPERATION

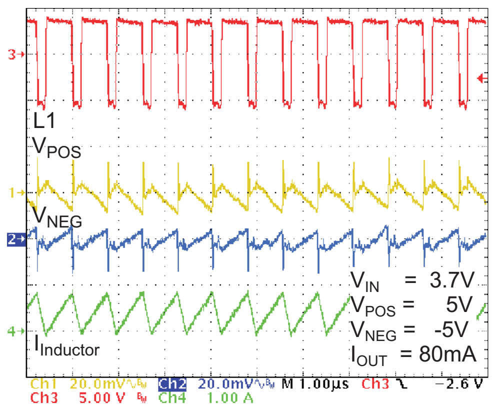


Figure 6.

LINE TRANSIENT RESPONSE
I_{OUT} = 10 mA

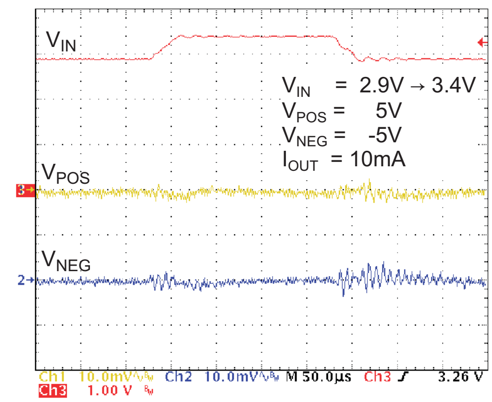


Figure 7.

LINE TRANSIENT RESPONSE
I_{OUT} = 50 mA

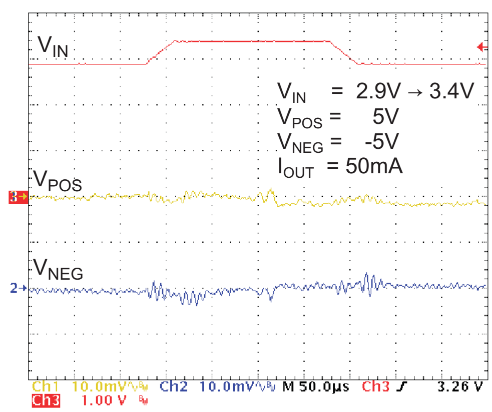


Figure 8.

START UP VIN RISING

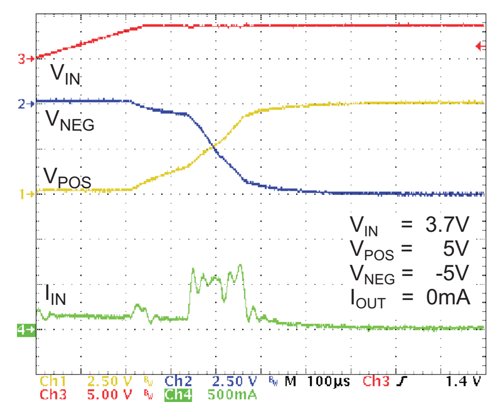


Figure 9.

START UP EN = HIGH

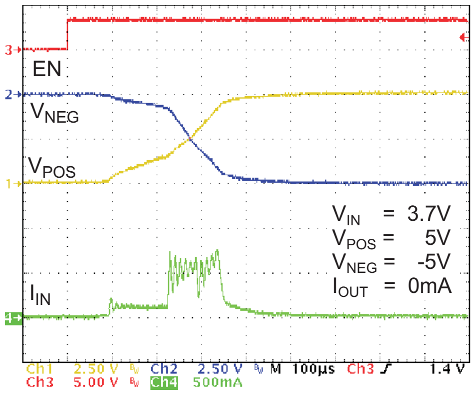


Figure 10.

SHUTDOWN VIN FALLING

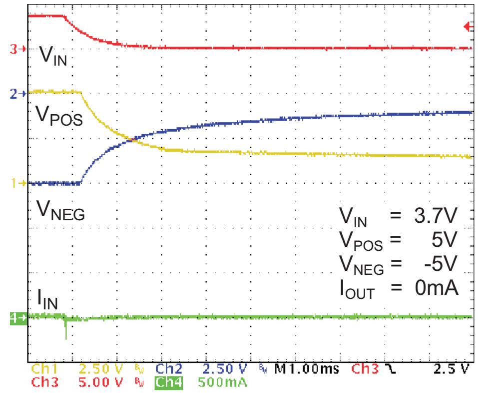


Figure 11.

SHUTDOWN EN = LOW

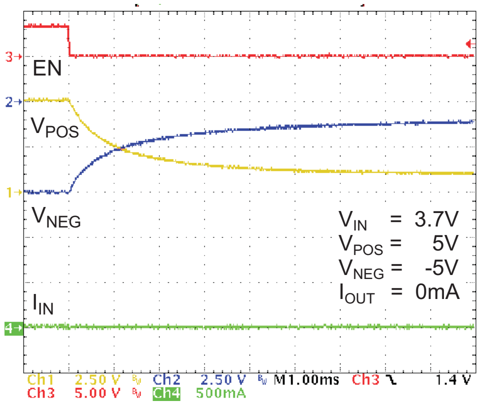


Figure 12.

TRANSIENT RESPONSE I_{OUT} = 10mA to 50mA

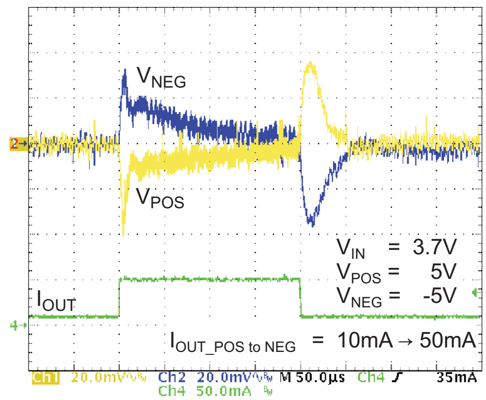


Figure 13.

TRANSIENT RESPONSE I_{OUT} = 20mA to 80mA

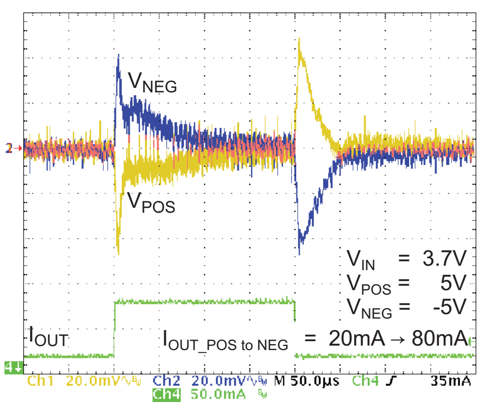


Figure 14.

SWITCHING FREQUENCY vs LOAD CURRENT

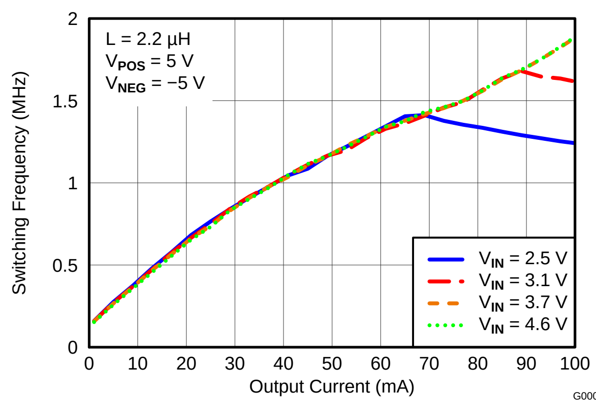


Figure 15.

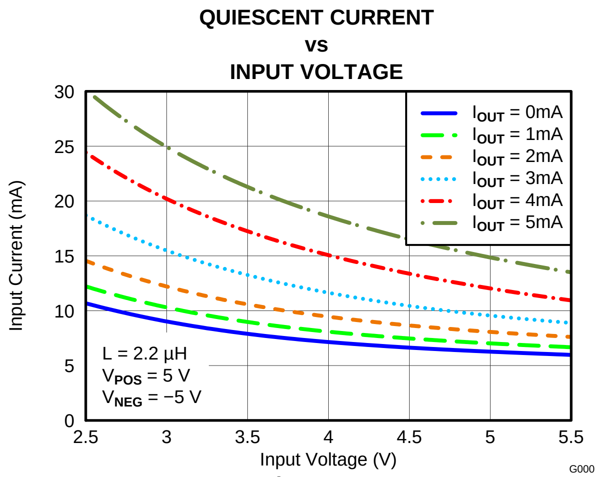

QUIESCENT CURRENT
vs
INPUT VOLTAGE
Input Current (mA)
Input Voltage (V)
I_{OUT} = 0mA
I_{OUT} = 1mA
I_{OUT} = 2mA
I_{OUT} = 3mA
I_{OUT} = 4mA
I_{OUT} = 5mA
L = 2.2 µH
V_{POS} = 5 V
V_{NEG} = −5 V
G000

Figure 16.

DETAILED DESCRIPTION

The TPS65135 operates with a four-switch buck-boost converter topology, generating a negative and a positive output voltage with a single inductor. The device uses the SIMO regulator technology featuring best-in-class line-transient regulation, buck-boost mode for the positive and negative outputs, and highest efficiency over the entire load-current range. High efficiency over the entire load-current range is implemented by reducing the converter switching frequency. Out-of-audio mode avoids the switching frequency going below 20 kHz.

As illustrated in the FUNCTIONAL BLOCK DIAGRAM, the converter operates with two control loops. One error amplifier sets the output voltage for the positive output OUTP. The ground error amplifier regulates FBG to typically 0 V. Using the external feedback divider allows setting both output voltages, OUTP and OUTN. In principle the converter topology operates just like any other buck-boost converter topology with the difference that the output voltage across the inductor is the sum of the positive and negative output voltage. With this consideration all calculations of the buck-boost converter apply for this topology as well. During the first switch cycle M1 and M2 are closed, connecting the inductor from VIN to GND. During the second switch cycle the inductor discharges to the positive and negative outputs by closing switches M4 and M3. Because the inductor is discharged to both of the outputs simultaneously, the output voltages can be higher or lower than the input voltage. Because of this the converter operates best when the current out of OUTP is equal to the current flowing into OUTN. This is for example the case when driving an AMOLED panel. Asymmetries in load current can be canceled out by the used topology. However this is only possible for current asymmetries of up to 50%. During light load the converter operates in discontinuous conduction mode. The converter operates in peak-current-mode control with the switching cycle given by an internal voltage-controlled oscillator (VCO). As the load current increases the converter operates in continuous-conduction mode. In this mode, the converter moves to peak-current control with the switch cycle given by the fixed off-time. The SIMO regulator topology has excellent line transient regulation when operating in discontinuous conduction mode. As the load current increases, entering continuous conduction mode, the line transient performance is linearly decreased.

Advanced Power-Save Mode for Light-Load Efficiency

In order to maintain high efficiency over the entire load-current range, the converter reduces its switching frequency as the load current decreases. The advanced power-save mode controls the switching frequency using a voltage-controlled oscillator (VCO). The VCO frequency is proportional to the inductor peak current, with a lower frequency limit of 20 kHz in typical applications the frequency does not go below 100 kHz. This avoids disturbance of the audio band and minimizes audible noise coming from the ceramic input and output capacitors. By maintaining a controlled switching frequency, possible EMI is minimized. This is especially important when using the device in mobile phones. See Figure 15 for typical switching frequency versus load current. For zero load an internal shunt regulator ensures stable output voltage regulation.

Buck-Boost Mode Operation

Buck-boost mode operation allows the input voltage to be higher or lower than the output voltage. This mode allows the use of batteries and supply voltages that are above the output voltage of OUTP.

Inherent Excellent Line-Transient Regulation

The SIMO regulator achieves inherent superior line-transient regulation when operating in discontinuous conduction mode, shown in Figure 7 and Figure 8. In discontinuous conduction mode the current delivered to the output is given by the inductor peak current and falling slope of the inductor current. This is shown in Figure 17, where the output current, given by the area A, is the same for different input voltages. Because the converter uses peak-current-mode control, the peak current is fixed as long as the load current is fixed. The falling slope of the inductor current is given by the sum of the output voltage and inductor value. This is also a fixed value and independent of the input voltage. Because of this, any change in input voltage changes the converter duty cycle but does not change the inductor peak current or the falling slope of the inductor current. Therefore the output current, given by the area A (Figure 17), remains constant over any input voltage variation. Because the area A is constant, the converter has an inherently perfect line regulation when operating in discontinuous conduction mode. Entering continuous conduction mode (CCM) linearly decreases the line-transient performance. However the line-transient response in CCM is still as good as for any standard current-mode-controlled switching converter. The following formulas detail the relations of the TPS65135 converter topology operating in CCM.

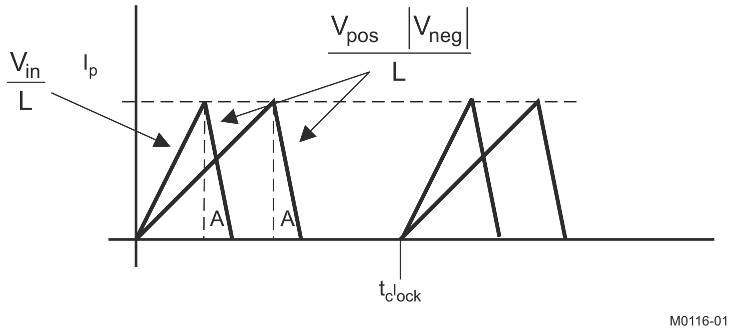


Figure 17. Inherently Perfect Line-Transient Regulation

The converter always sees the sum of the negative and positive output voltage, which is calculated as:

$$V_O = V_{OUTP} + |V_{OUTN}| \quad (1)$$

The converter duty cycle is calculated using the efficiency estimation from the data sheet curves or from real application measurements. A 70% efficiency value is a good value to go through the calculations.

$$D = \frac{V_O}{\eta \cdot V_{IN} + V_O} \quad (2)$$

The output current for entering continuous conduction mode can be calculated. The switching frequency can be obtained from the data sheet graphs. A frequency of 1.5 MHz is usually sufficient for these types of calculations.

$$I_C = \frac{V_O \cdot (1 - D)^2}{f_S \cdot 2 \cdot L} \quad (3)$$

The inductor ripple current when operating in CCM can also be calculated.

$$\Delta I_L = \frac{V_{IN} \cdot D}{L \cdot f_S} \quad (4)$$

Last but not least, the converter switch peak current is calculated as follows.

$$I_{L\_peak} = \frac{I_{OUT}}{1 - D} + \frac{1}{2} \cdot \Delta I_L \quad (5)$$

Overvoltage Protection

The device monitors the positive and negative output voltage. The regulators monitor the outputs and reduce the current limit when the output voltages exceed the overvoltage protection limit. They are clamped using a zener diode, the positive output to typically 7V and the negative to –7.6 V.

Short-Circuit Protection

Both outputs are protected against short circuits either to GND or against the other output. The device switching frequency and the current limit are reduced in case of a short circuit.

Soft-Start Operation

The device increases the current limit during soft-start operation to avoid high inrush currents during start-up. The current limit typically ramps up to its full-current limit within 100 µs.

Output-Current Mismatch

The device operates best when the current of the positive output is similar to the current of the negative output. However the device is able to regulate an output-current mismatch between the outputs of up to 50% (See Figure 4 for typically allowed currents, only 50% missmatch is guaranteed). If the output-current mismatch becomes much larger one of the outputs goes out of regulation and finally the IC shuts down. In case of zero load of one output the other output can support up to 5mA. The IC automatically recovers when the mismatch is reduced. The below formula is used to calculate the maximum supported current missmatch.

$$1 - \frac{\text{Smaller } I_{OUT}}{\text{Bigger } I_{OUT}} \leq 50\% \tag{6}$$

Input Capacitor Selection

The device typically requires a 10 µF ceramic input capacitor. Larger values can be used to lower the input voltage ripple. Table 2 lists capacitors suitable for use on the TPS65135 input.

Table 2. Input Capacitor Selection

CAPACITOR	COMPONENT SUPPLIER	SIZE
10 µF / 6.3V	Murata GRM188R60J106ME84D	0603
10 µF / 6.3 V	Taiyo Yuden JMK107BJ106	0603

Inductor Selection/Efficiency/Line-Transient Response

The device is internally compensated and operates best with a 2.2 µH inductor. For this type of converter the inductor selection is a key element in the design process because it has a big impact on several application parameters. The inductor selection influences the converter efficiency a lot, also the line and load transient response as well as the maximum output current. Because the inductor ripple current is fairly large in this type of application, the inductor has a major impact on the overall converter efficiency. Having large inductor ripple current causes the inductor core and magnetizing losses to become dominant. Due to this, an inductor with a larger dc winding resistance can achieve higher converter efficiencies when having lower core and magnetizing losses. The used inductance influences the line transient regulation, it influences the current range entering continuous conduction mode (CCM). As discussed, the line transient performance decreases when entering CCM. The larger the inductor value, the lower the load current when entering CCM. The formula to calculate the current entering CCM is shown in Equation 3. The inductors listed in Table 3 achieve a good overall converter efficiency while having a low device profile. The first two TOKO inductors achieve the highest efficiency (almoust identical) followed by the LPS3008. The best compromize between efficiency and inductor size is given by the XFL2006 inductor . The inductor saturation current should be 1A or higher, depending on the maximum output current of the application it can also be lower. See Equation 5, where the converter switch current limit is calculated. The converter switch current is equal to the peak inductor current.

Table 3. Inductor Selection

INDUCTOR VALUE	COMPONENT SUPPLIER	DIMENSIONS in mm	I_{sat} / R_{DC}
2.2 µH	TOKO DFE252010C	2.5 x 2 x 1	1.9 A / 130 mΩ
2.2 µH	TOKO DFE252012C	2.5 x 2 x 1.2	2.2 A / 90 mΩ
2.2 µH	Coilcraft XFL2006-222	2 × 1.9 × 0.6	0.8 A / 278 mΩ
2.2 µH	Coilcraft LPS3008-222	3 × 3 × 0.8	1.1 A / 175 mΩ
2.2 µH	Samsung CIG2MW2R2NNE	2 × 1.6 × 1	1.2 A / 110 mΩ
2.2 µH	TOKO FDSE0312-2R2	3.3 × 3.3 × 1.2	1.2 A / 160 mΩ
2.2 µH	ABCO LPF3010T-2R2	2.8 × 2.8 × 1	1.0 A / 100 mΩ
2.2 µH	Maruwa CXFU0208-2R2	2.65 × 2.65 × 0.8	0.85 A / 185 mΩ

Output Capacitor Selection

A 4.7-µF output capacitor is generally sufficient for most applications, but larger values can be used as well for improved load- and line-transient response at higher load currents. The capacitors of Table 4 is recommended for use with the TPS65135.

Table 4. Output Capacitor Selection

CAPACITOR	COMPONENT SUPPLIER	SIZE
10 µF / 6.3V	Murata GRM188R60J106ME84D	0603
4.7 µF / 10V	Taiyo Yuden LMK107BJ475	0603
10 µF / 6.3 V	Taiyo Yuden JMK107BJ106	0603

Setting the Output Voltages OUTP and OUTN

The feedback divider R1, R2, R3 sets the positive and negative output voltage. The device regulates the feeback voltage FB to typically 1.24 V and the feedback FBG to typically 0V. R2 is selected to have at least 10 µA through the feedback divider.

$$R2 = \frac{1.24V}{10\mu A} \approx 120k\Omega \quad (7)$$

The positive output voltage and R1 are calculated as:

$$V_{POS} = 1.24V \cdot \frac{R1 + R2}{R2} \quad (8)$$

$$R1 = R2 \cdot \left(\frac{V_{POS}}{1.24V} - 1 \right) \quad (9)$$

The negative output voltage is calculated as:

$$V_{NEG} = -\left(V_{FB} + V_{FBG}\right) \cdot \frac{R3}{R2} \quad (10)$$

Since V_{FBG} is typically regulated to 0 V, the formula can be simplified and R3 is then calculated as:

$$R3 = \frac{\left|V_{NEG}\right|}{1.24V} \cdot R2 \quad (11)$$

PCB Layout Guidelines

PCB layout is an important task in the power supply design. Good PCB layout minimizes EMI and allows very good output voltage regulation. For the TPS65135 the following PCB layout guidelines are recommended.

Place the power components first. The inductor and the input and output capacitors must be as close as possible to the IC pins. Place the bypass capacitor for the reference output voltage VAUX as close as possible to pin 4. Use bold and wide traces for power traces connecting the inductor and input and output capacitors. Use a common ground plane or a start ground connection.

See the TPS65135EVM-063 user's guide (SLVU244) and evaluation module for a PCB layout example.

TYPICAL APPLICATION

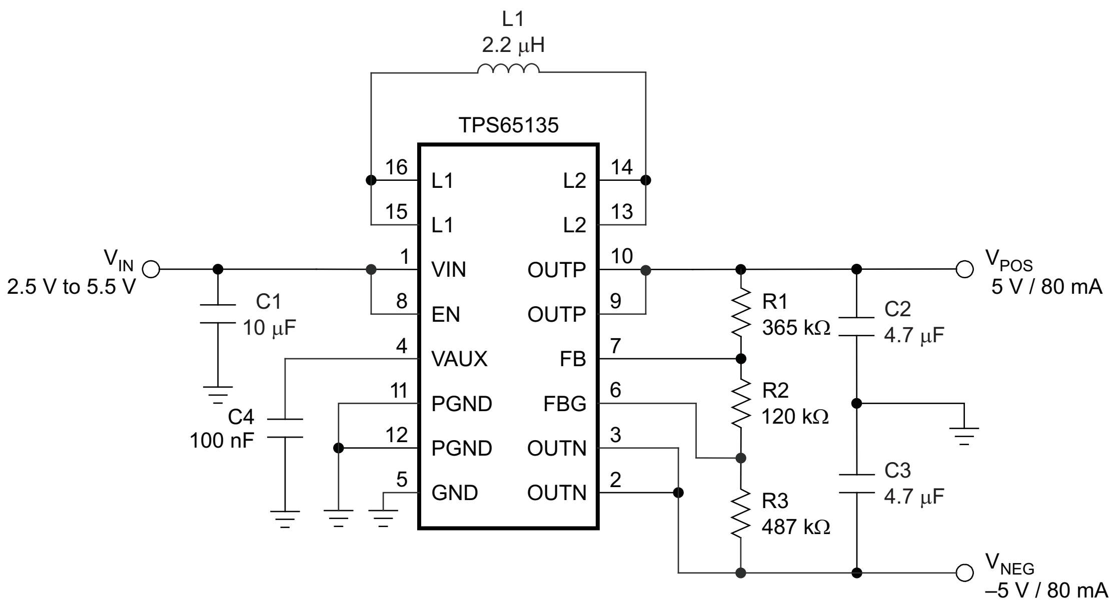


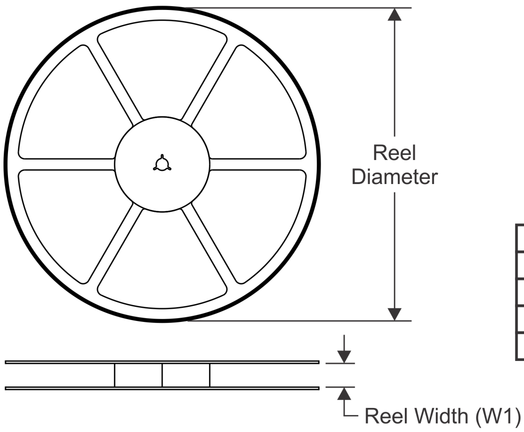
Figure 18. Standard Application +/- 5 V Supply

REVISION HISTORY

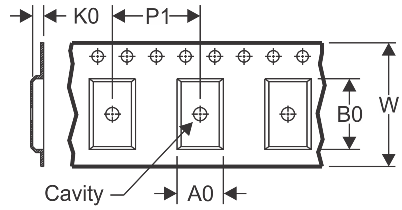
Changes from Original (November 2011) to Revision A	Page
• Changed the UVLO threshould max value for V_{IN} falling From: 2 V To 2.1 V	5

TAPE AND REEL INFORMATION

REEL DIMENSIONS

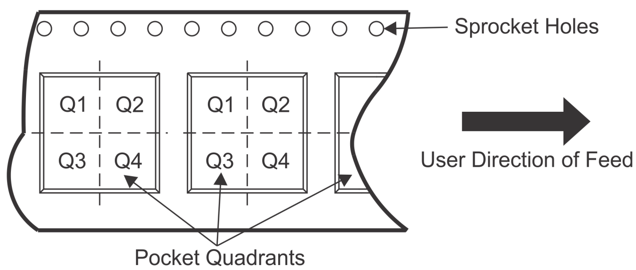


TAPE DIMENSIONS



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

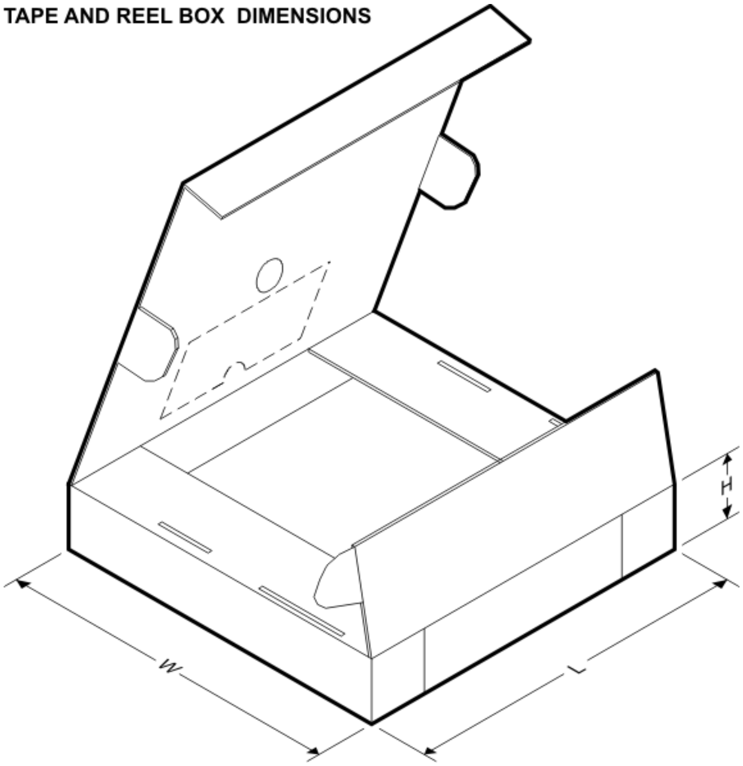
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TPS65135RTER	WQFN	RTE	16	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2

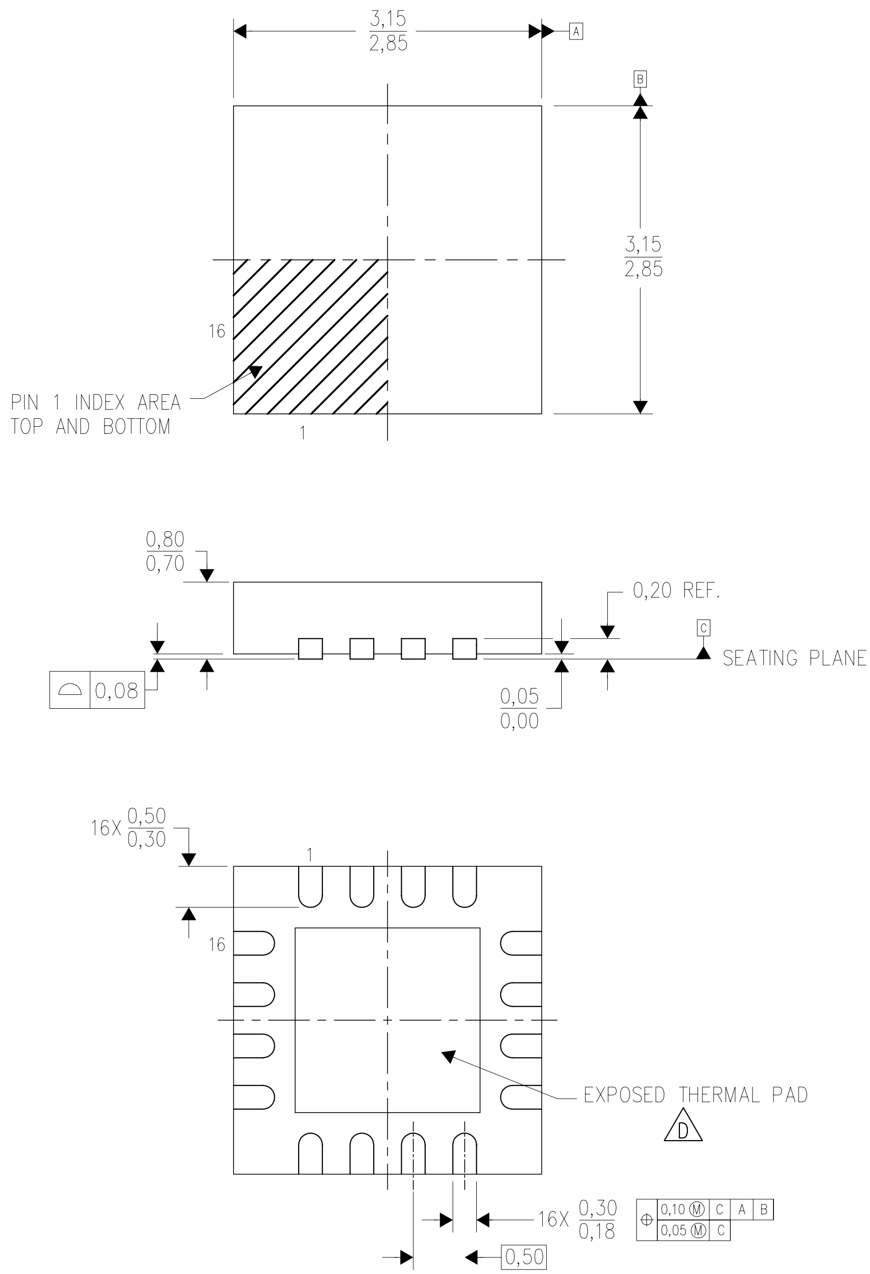
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS65135RTER	WQFN	RTE	16	3000	367.0	367.0	35.0

RTE (S-PWQFN-N16) PLASTIC QUAD FLATPACK NO-LEAD



4205254/D 01/11

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. Quad Flatpack, No-leads (QFN) package configuration.
D. 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.
E. Falls within JEDEC MO-220.

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