5-V, THREE-PHASE, SENSORLESS BLDC MOTOR DRIVER

FEATURES

- Input Voltage Range: 1.65 V to 5.5 V
- Six Integrated MOSFETS With 680-mA Peak Output Current
- Ultralow Quiescent Current: 5 µA (typ) in Standby Mode
- Total Driver H+L R_{DSOn} 900 mΩ
- Sensorless Proprietary BMEF Control Scheme
- 150° Commutation
- Synchronous Rectification PWM Operation
- Selectable FG and ½ FG Open-Drain Output
- PWM_{IN} Input from 15 kHz to 50 kHz
- Lock Detection
- Voltage Surge Protection
- UVLO
- Thermal Shutdown

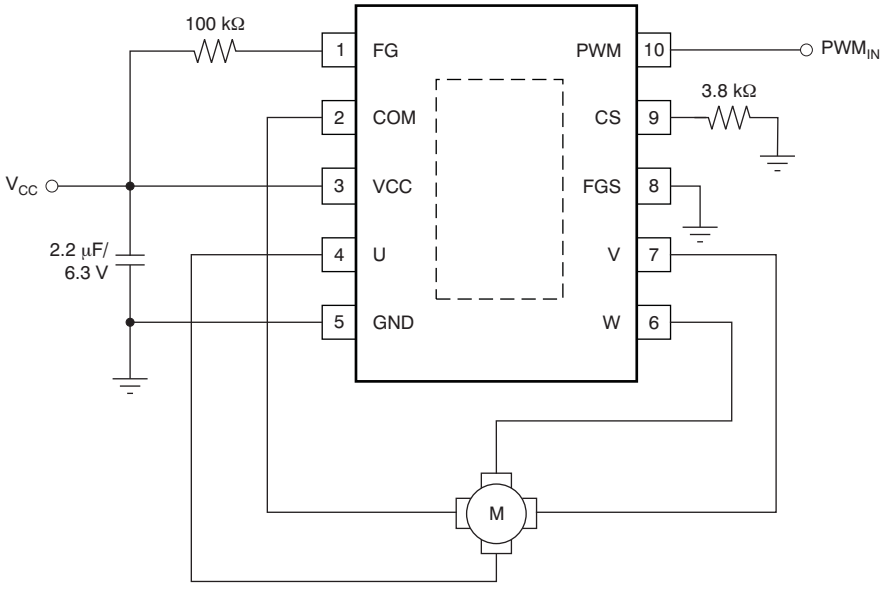
APPLICATIONS

- Notebook CPU Fans
- Game Station CPU Fans
- ASIC Cooling Fans

DESCRIPTION

DRV10866 is a three phase, sensorless motor driver with integrated power MOSFETs with drive current capability up to 680 mA peak. DRV10866 is specifically designed for low noise and low external component count fan motor drive applications. DRV10866 has built in over-current protection with no external current sense resistor needed. The synchronous rectification mode of operation achieves increased efficiency for motor driver applications. DRV10866 outputs either FG or ½ FG to indicate motor speed with open drain output. A 150° sensorless BEMF control scheme is implemented for a three phase motor. DRV10866 is available in the thermally efficient 10-pin, 3-mm x 3-mm x 0.75-mm SON (DSC) package. The operating temperature is specified from -40°C to 125°C.

TYPICAL APPLICATION



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.

All trademarks are the property of their respective owners.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

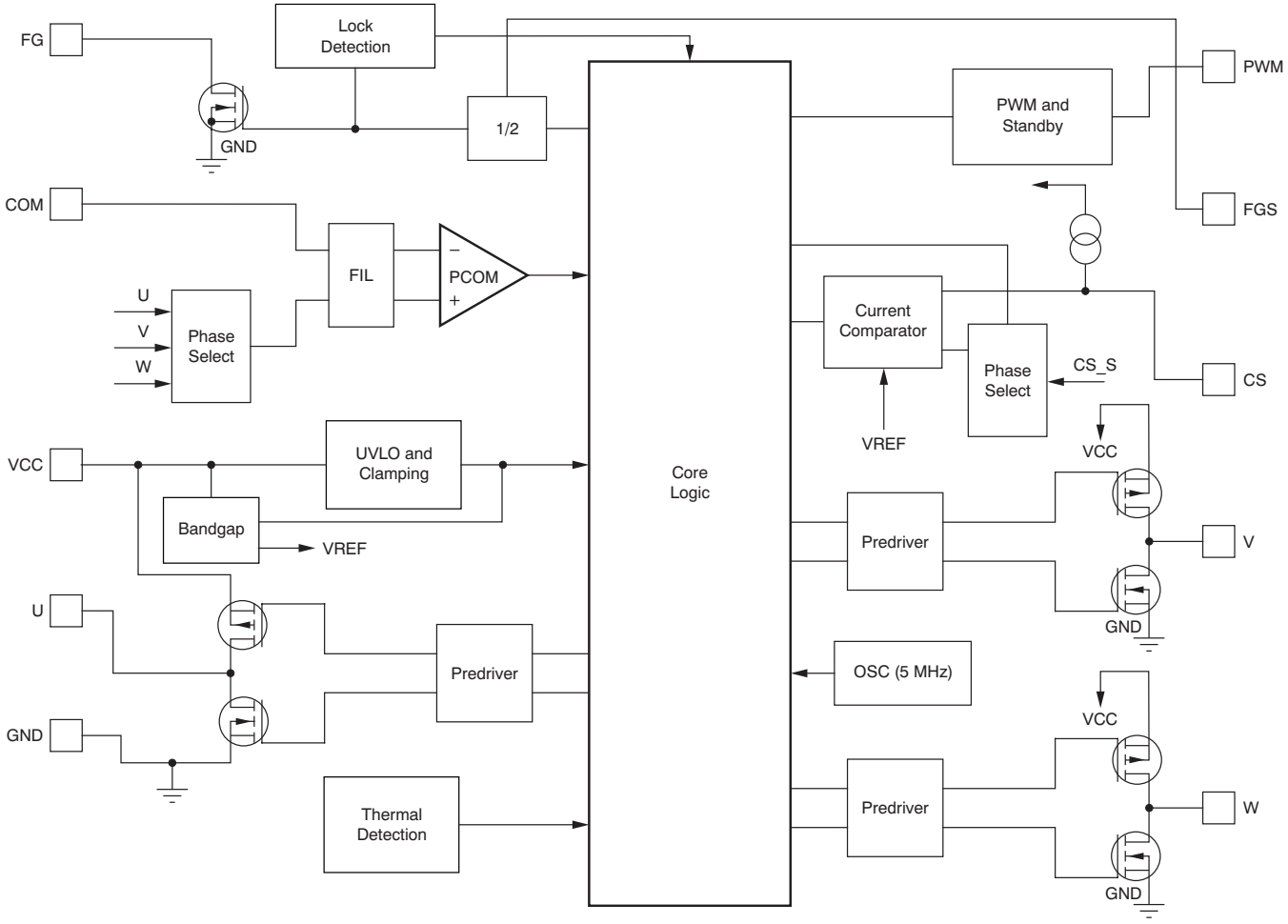
Copyright © 2012, Texas Instruments Incorporated

ORDERING INFORMATION(1)(2)

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
DRV10866	SON-10	DSC	–40°C to +125°C	DRV10866	DRV10866DSC	Tape and Reel, 3000

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
(2) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/package.

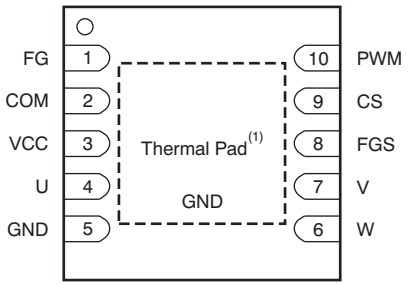
FUNCTIONAL BLOCK DIAGRAM



Copyright © 2012, Texas Instruments Incorporated

PIN DESIGNATION

DSC PACKAGE
3-mm × 3-mm SON
(TOP VIEW)



(1). Thermal pad connected to ground.

Table 1. PIN DESCRIPTIONS

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
FG	1	O	Frequency generator output. If the FGS pin is connected to ground, the output has a period equal to six electrical states (FG). If the FGS pin is connected to VCC, the output has a period equal to 12 electrical states (1/2FG).
COM	2	I	Motor common terminal input
VCC	3	I	Input voltage for motor and chip-supply voltage; the internal clamping circuit clamps the V_{CC} voltage.
U	4	O	Phase U output
GND	5	—	Ground pin
W	6	O	Phase W output
V	7	O	Phase V output
FGS	8	I	FG and 1/2FG control pin. Latched upon wake-up signal from the PWM pin. For details, refer to the FG pin description section.
CS	9	I	Overcurrent threshold setup pin. The constant current of the internal constant current source flows through the resistor connected to this pin. The other side of the resistor is connected to ground. The voltage across the resistor compares with the voltage converted from the bottom MOSFET current. If the MOSFET current is high, the part enters the overcurrent protection mode by turning off the top PWM MOSFET and holding the bottom MOSFET on. I (mA) = 3120/R_{CS}(kΩ). Equation valid range: 300 mA < I_{LIMIT}< 850 mA
PWM	10	I	PWM input pin. The PWM input signal is converted to a fixed 156-kHz switching frequency on the MOSFET driver. The PWM input signal resolution is less than 1%. This pin can also control the device and put it in or out of standby mode. After the signal at the PWM stays low (up to 500 µs), the device goes into low-power standby mode. Standby current is approximately 5 µA. The rising edge of the PWM signal wakes up the device and puts it into active mode, where it is ready to start to turn the motor.

Copyright © 2012, Texas Instruments Incorporated

ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature range (unless otherwise noted).

		VALUE		UNIT
		MIN	MAX	
Input voltage range(1)	VCC	–0.3	+6.0	V
	CS, FGS, PWM	–0.3	+6.0	V
	GND	–0.3	+0.3	V
	COM	–1.0	+6.0	V
Output voltage range(1)	U, V, W	–1.0	+7.0	V
	FG	–0.3	+6.0	V
Temperature	Operating junction temperature, T_J	–40	+125	°C
	Storage, T_{stg}	–55	+150	°C
Electrostatic discharge (ESD)	Human body model, HBM		4	kV
	Charge device model, CDM		500	V

(1) All voltage values are with respect to network ground terminal unless otherwise noted.

THERMAL INFORMATION

THERMAL METRIC(1)		DRV10866 DSC 10 PINS	UNITS
θ_{JA}	Junction-to-ambient thermal resistance(2)	42.3	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance(3)	44.5	
θ_{JB}	Junction-to-board thermal resistance(4)	17.1	
ψ_{JT}	Junction-to-top characterization parameter(5)	0.3	
ψ_{JB}	Junction-to-board characterization parameter(6)	17.3	
θ_{JCbot}	Junction-to-case (bottom) thermal resistance(7)	4.3	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.
(2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.
(3) The junction-to-case (top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.
(4) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.
(5) The junction-to-top characterization parameter, ψ_{JT}, estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA}, using a procedure described in JESD51-2a (sections 6 and 7).
(6) The junction-to-board characterization parameter, ψ_{JB}, estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA} , using a procedure described in JESD51-2a (sections 6 and 7).
(7) The junction-to-case (bottom) thermal resistance is obtained by simulating a cold plate test on the exposed (power) pad. No specific JEDEC standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.

Copyright © 2012, Texas Instruments Incorporated

RECOMMENDED OPERATING CONDITIONS

Over operating free-air temperature range (unless otherwise noted).

		MIN	NOM	MAX	UNIT
Supply voltage	VCC	1.65		5.5	V
Voltage range	U, V, W	–0.7		6.5	V
	FG, CS, FGS, COM	–0.1		5.5	V
	GND	–0.1		0.1	V
	PWM	–0.1		5.5	V
Operating junction temperature, T_J		–40		+125	°C

ELECTRICAL CHARACTERISTICS

Over operating free-air temperature range (unless otherwise noted).

PARAMETER		TEST CONDITIONS	DRV10866			UNIT
			MIN	TYP	MAX	
SUPPLY CURRENT						
I_{Vcc}	Supply current	T_A = +25°C; PWM = V_{CC}; V_{CC} = 5 V		2.5	3.5	mA
$I_{Vcc\text{-}Standby}$	Standby current	T_A = +25°C; PWM = 0 V; V_{CC} = 5 V		5	10	µA
UVLO						
$V_{UVLO\text{-}Th\_r}$	UVLO threshold voltage, rising	Rise threshold, T_A = +25°C		1.80	1.9	V
$V_{UVLO\text{-}Th\_f}$	UVLO threshold voltage, falling	Fall threshold, T_A = +25°C	1.6	1.65		V
$V_{UVLO\text{-}Th\_hys}$	UVLO threshold voltage, hysteresis	T_A = +25°C	75	150	225	mV
INTEGRATED MOSFET						
R_{DSON}	Series resistance (H+L)	T_A = +25°C; V_{CC} = 5 V; I_O = 0.5 A		0.8	1.2	Ω
		T_A = +25°C; V_{CC} = 4 V; I_O = 0.5 A		0.9	1.4	Ω
		T_A = +25°C; V_{CC} = 3 V; I_O = 0.5 A		1.1	1.7	Ω
PWM						
$V_{PWM\text{-}IH}$	High-level input voltage	V_{CC} ≥ 4.5 V	2.3			V
$V_{PWM\text{-}IL}$	Low-level input voltage	V_{CC} ≥ 4.5 V			0.8	V
F_{PWM}	PWM input frequency		15		50	kHz
$I_{PWM\text{-}Source}$		Standby mode, V_{CC} = 5 V		5		µA
		Active mode, V_{CC} = 5 V		100		µA
T_{STBY}		PWM = 0		500		µs
FG AND FGS						
$I_{FG\text{-}Sink}$	FG pin sink current	V_{FG} = 0.3 V	5			mA
$V_{FGS\text{-}Th}$	FG set threshold voltage	FG pin output, full FG signal, V_{CC} ≥ 4.5 V			0.8	V
		FG pin output, one-half FG signal, V_{CC} ≥ 4.5 V	2.3			V
LOCK PROTECTION						
$T_{LOCK\text{-}On}$	Lock detect time	FG = 0	2	3	4	s
$T_{LOCK\text{-}Off}$	Lock release time		2.5	5	7.5	s
CURRENT LIMIT						
	Current limit	CS pin to GND resistor = 3.9 kΩ	680	800	920	mA
THERMAL SHUTDOWN						
T_{SHDN}	Shutdown temperature threshold			+160		°C
		Hysteresis		10		°C

Copyright © 2012, Texas Instruments Incorporated

DETAILED DEVICE DESCRIPTION

DRV10866 is a three phase, sensorless motor driver with integrated power MOSFETs with drive current capability up to 680-mA peak. DRV10866 is specifically designed for low noise, low external component count fan motor drive applications. DRV10866 has built in over current protection with no external current sense resistor needed. The synchronous rectification mode of operation achieves increased efficiency for motor driver applications. DRV10866 can output either FG or ½ FG to indicate motor speed with open drain output through FGS pin selection. A 150° sensorless BEMF control scheme is implemented for a three phase motor. Voltage surge protection scheme prevents input V_{CC} capacitor from over charge during motor acceleration and deceleration modes. DRV10866 has multiple built-in protection blocks including UVLO, over current protection, lock protection and thermal shut down protection.

Speed Control

DRV10866 can control motor speed through either the PWM_{IN} or V_{CC} pin. Motor speed will increase with higher PWM_{IN} duty cycle or V_{CC} input voltage. The curve of motor speed (RPM) vs PWM_{IN} duty cycle or V_{CC} input voltage is close to linear in most cases. However, motor characteristics will affect the linearity of this speed curve. DRV10866 can operate at very low V_{CC} input voltage down to 1.65 V. The PWM_{IN} pin is pulled up to V_{CC} internally and frequency range can vary from 15 kHz to 50 kHz. The motor driver MOSFETs will operate at constant switching frequency 156 kHz. With this high switching frequency, DRV10866 can eliminate audible noise and reduce the ripple of V_{CC} input voltage and current, and thus minimize EMI noise.

Frequency Generator

The FG pin outputs a 50% duty cycle of PWM waveform in the normal operation condition. The frequency of the FG signal represents the motor speed and phase information. The FG pin is an open drain output, so an external pull up resistor is needed when connected to an external system. During the startup, FG output will stay at high impedance until the motor speed reaches a certain level and BEMF is detected. During lock protection condition, FG output will remain high until the motor restarts and startup process is completed. DRV10866 can output either FG or ½ FG to indicate motor status with open drain output through FGS pin selection. When FGS is pulled to V_{CC}, the frequency of FG output is half of that when FGS is pulled to GND. Motor speed can be calculated based on the FG frequency when FGS is pulled to GND, which equals to:

$$RPM = \frac{(FG \times 60)}{\text{pole pairs}} \quad (1)$$

Where FG is in hertz (Hz).

Lock Protection

If the motor is blocked or stopped by an external force, the lock protection is triggered after lock detection time. During lock detection time, the circuit monitors the PWM and FG signals. If PWM has an input signal while the FG output is in high impedance during this period, the lock protection will be enabled and DRV10866 will stop driving the motor. After lock release time, DRV10866 will resume driving the motor again. If the lock condition still exists, DRV10866 will proceed with the next lock protection cycle until the lock condition is removed. With this lock protection, the motor and device will not get over heated or be damaged.

Copyright © 2012, Texas Instruments Incorporated

Voltage Surge Protection

The DRV10866 has a unique feature to clamp the V_{CC} voltage during lock protection and standby mode. If the lock mode condition is caused by an external force that suddenly stops the motor at a high speed, or the device goes into standby mode from a high duty cycle, either situation releases the energy in the motor winding into the input capacitor. When a small input capacitor and anti-reverse diode are used in the system design, the input voltage of the IC could rise above the absolute voltage rate of the chip. This condition either destroys the device or reduces the reliability of the device. For this reason, the DRV10866 has a voltage clamp circuit that clamps the input voltage at 5.95 V, and has a hysteresis of 150 mV. This clamp circuit is only active during the lock protection cycle or when the device enters standby mode. It is disabled during normal operation.

Overcurrent Protection

The DRV10866 can adjust the overcurrent point through an external resistor connected to the CS pin (pin 9) and ground. Without this external current sense resistor, the DRV10866 senses the current through the power MOSFET. Therefore, there is no power loss during the current sensing. The current sense architecture improves the overall system efficiency. Shorting the CS pin to ground disables the overcurrent protection feature. During overcurrent protection, the DRV10866 only limits the current to the motor; it does not shut down the device. The overcurrent limit can be set by the value of current sensing resistor through Equation 2.

$$I\,(A) = \frac{3120}{R_{CS}\,(\Omega)} \tag{2}$$

UVLO (Undervoltage Lockout)

The DRV10866 has a built in UVLO function block. The hysteresis of UVLO threshold is 150 mV. The device will be locked out when V_{CC} reaches 1.65 V and woke up at 1.8 V.

Thermal Shutdown

The DRV10866 has a built in thermal shunt down function, which will shut down the device when the junction temperature is over 160°C and will resume operating when the junction temperature drops back to 150°C.

Copyright © 2012, Texas Instruments Incorporated

APPLICATION INFORMATION

The DRV10866 only requires three external components. A 2.2-µF or higher ceramic capacitor connected to V_{CC} and ground is needed for decoupling purposes. This capacitor must be placed close to the VCC pin (pin 3) and GND pin (pin 5). During normal operation, a sudden drop in motor speed (caused by changing the PWM duty from high to low immediately) causes the V_{CC} voltage to rise to a very high level, especially when an anti-reverse diode is added on the V_{CC} side. In order to avoid this condition, a larger input capacitor between V_{CC} and GND is needed, along with removing the anti-reverse diode. The DRV10866 is simple to design with a single-layer printed circuit board (PCB) layout. During layout, the strategy of ground copper pour is very important to enhance the thermal performance. Refer to Figure 1 for an example of PCB layout.

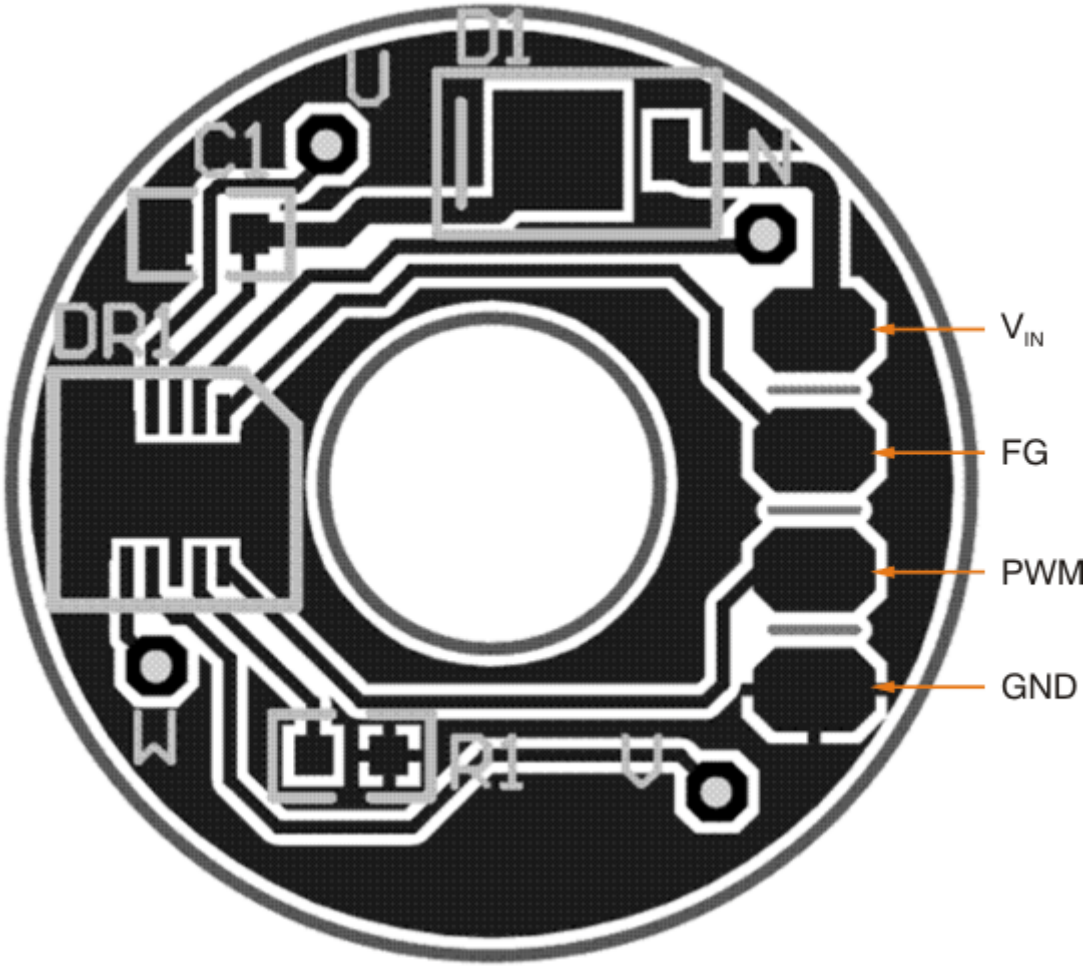


Figure 1. Single-Layer PCB Layout

Copyright © 2012, Texas Instruments Incorporated

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
DRV10866DSCR	ACTIVE	WSON	DSC	10	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	10866	Samples

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

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

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

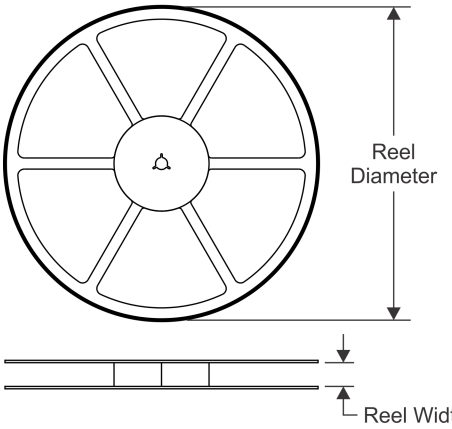
(4) Only one of markings shown within the brackets will appear on the physical device.

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

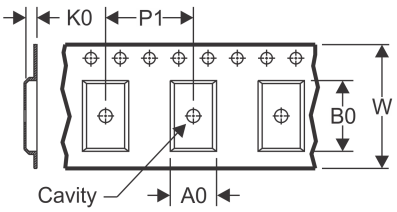
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

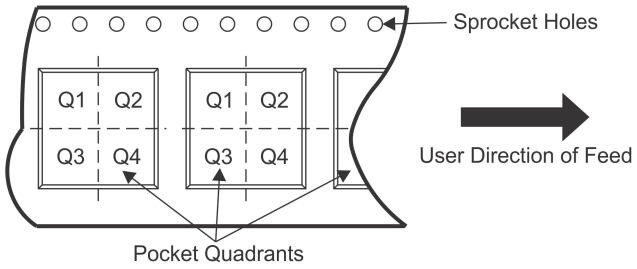


TAPE DIMENSIONS



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

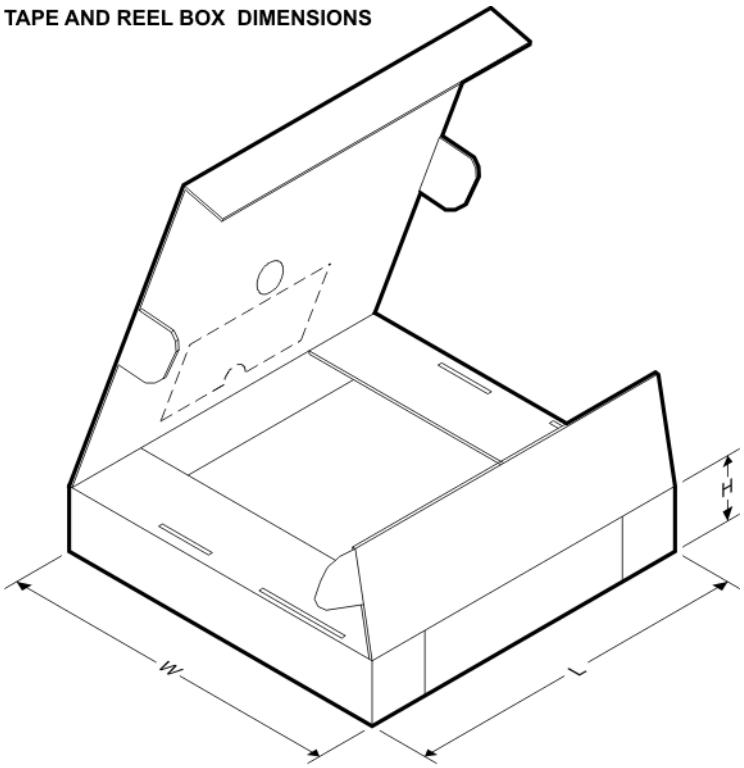
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
DRV10866DSCR	WSON	DSC	10	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2

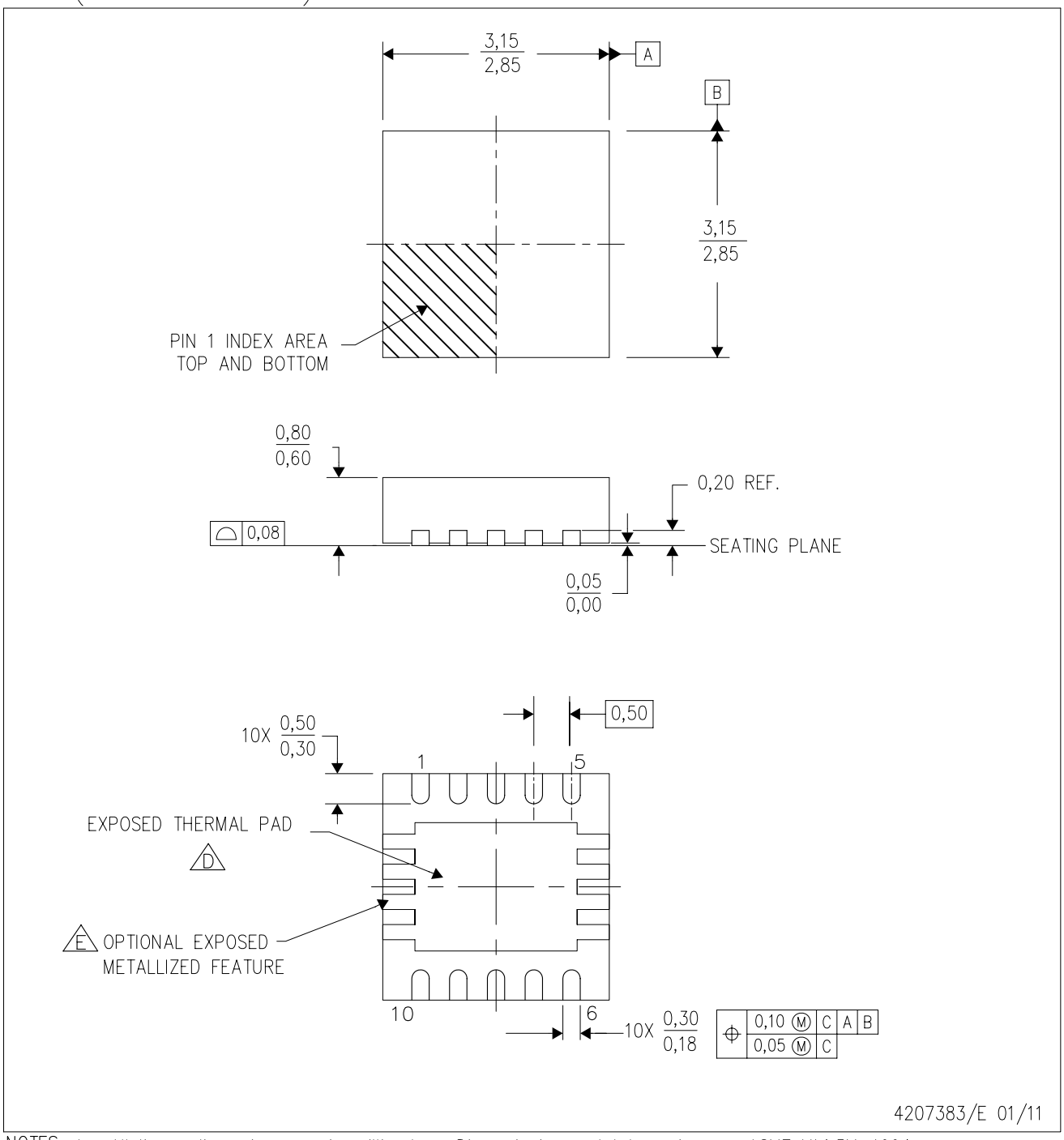
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DRV10866DSCR	WSON	DSC	10	3000	367.0	367.0	35.0

DSC (S–PWSON–N10) PLASTIC SMALL OUTLINE NO–LEAD



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.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
E. See the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.

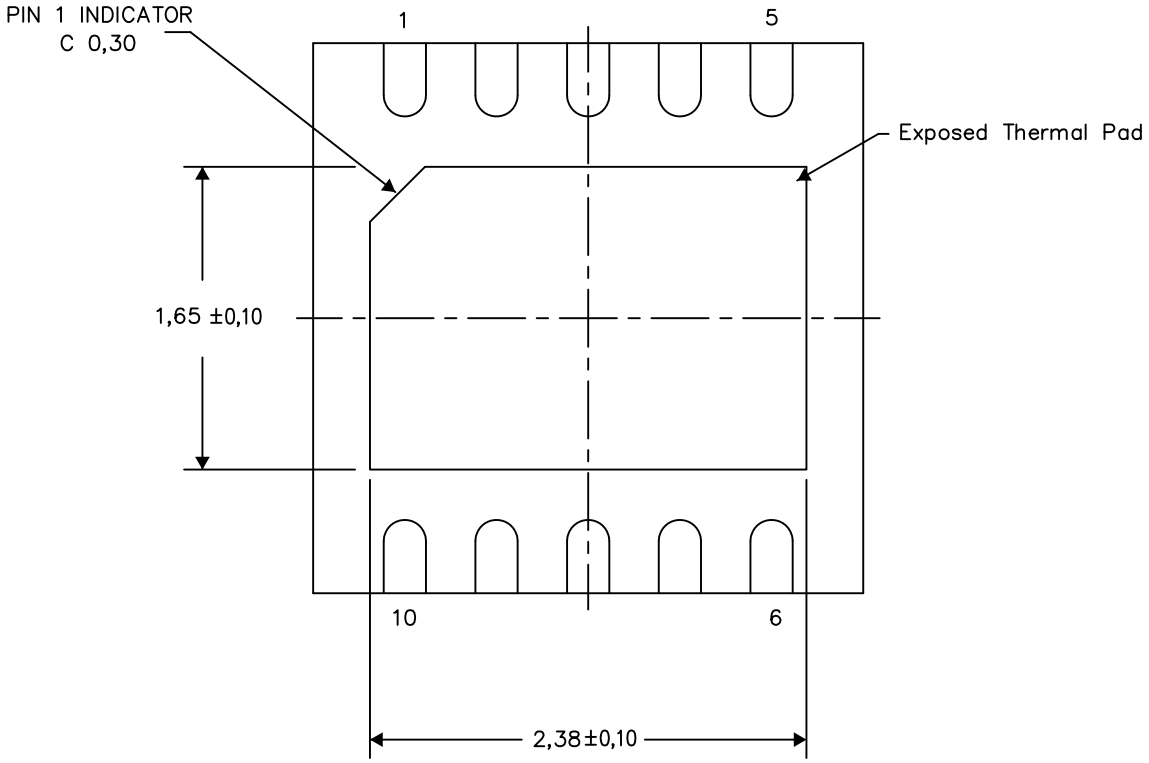
DSC (S–PWSON–N10) PLASTIC SMALL OUTLINE NO–LEAD

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, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

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



Bottom View

Exposed Thermal Pad Dimensions

4210391–6/J 03/13

NOTE: A. All linear dimensions are in millimeters

IMPORTANT NOTICE

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

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

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

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

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

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

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

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

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

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

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

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

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2013, Texas Instruments Incorporated