Burr-Brown Products from Texas Instruments

REG711



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50mA SWITCHED-CAP DC/DC CONVERTER

FEATURES

- WIDE INPUT RANGE: 1.8V TO 5.5V
  5V VERSION: 2.7V TO 5.5V
- AUTOMATIC STEP-UP/STEP-DOWN OPERATION
- LOW INPUT CURRENT RIPPLE
- LOW OUTPUT VOLTAGE RIPPLE
- MINIMUM NUMBER OF EXTERNAL COMPONENTS—NO INDUCTORS
- 1MHz INTERNAL OSCILLATOR ALLOWS SMALL CAPACITORS
- "SHUTDOWN" MODE
- THERMAL AND CURRENT LIMIT PROTECTION
- FIVE OUTPUT VOLTAGES AVAILABLE: 5.0V, 3.3V, 3.0V, 2.7V, 2.5V
- THIN, SMALL PACKAGE: MSOP-8

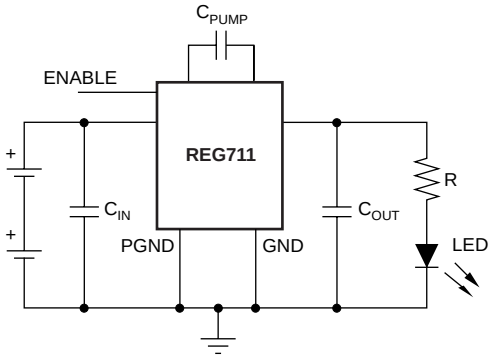
APPLICATIONS

- SMART CARD READERS
- CELLULAR PHONES
- SIM CARD SUPPLIES
- PORTABLE COMMUNICATION DEVICES
- PERSONAL DIGITAL ASSISTANTS
- MODEMS
- NOTEBOOK AND PALM-TOP COMPUTERS
- ELECTRONIC GAMES
- HANDHELD METERS
- PCMCIA CARDS
- CARD BUSES
- LCD DISPLAYS

DESCRIPTION

The REG711 is a switched capacitor voltage converter, which produces a regulated, low ripple output voltage from an unregulated input voltage. A wide input supply voltage of 1.8V to 5.5V makes the REG711 ideal for a variety of battery sources, such as single cell Li-Ion, or two and three cell Nickel or Alkaline based chemistries.

The input voltage may vary above and below the output voltage and the output will remain in regulation. It works equally well for step up or down without the need for an inductor, providing low EMI DC/DC conversion. The high switching frequency allows the use of small surface-mount capacitors, saving board space and reducing cost. The REG711 is thermally protected and current limited, protecting the load and the regulator during fault conditions. Typical ground pin current (quiescent current) is 1mA at full load, 60µA with no load, and less than 1µA in shutdown mode. This regulator comes in a thin MSOP-8 package with a component height of less than 1.1mm.



TEXAS INSTRUMENTS

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SPECIFICATIONS

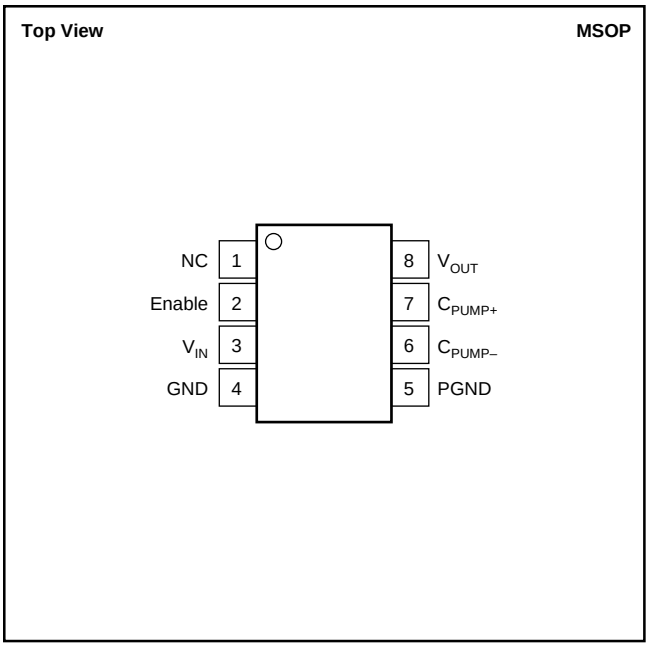
Boldface limits apply over the specified temperature range, **T_A = –40°C to +85°C**

At T_A = +25°C, V_{IN} = V_{OUT}/2 + 0.75V, I_{OUT} = 5mA, C_{IN} = C_{OUT} = 2.2µF, C_{PUMP} = 0.22µF, V_{ENABLE} = 1.3V, unless otherwise noted(1).

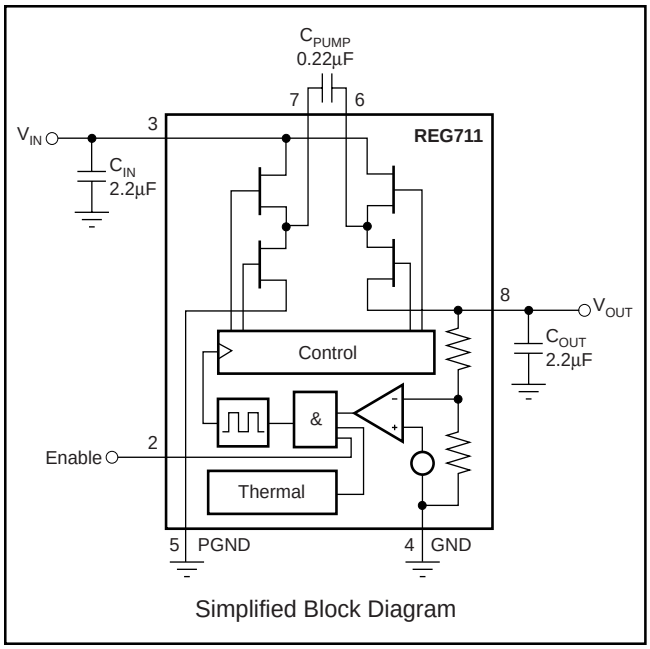
PARAMETER	CONDITIONS	REG711EA MIN	REG711EA TYP	REG711EA MAX	UNITS
INPUT VOLTAGE					
Guaranteed Startup					
REG711-5.0	See conditions under "output voltage" with a	**2.7**		**5.5**	V
All Other Models	resistive load not lower than typical V_{OUT}/I_{OUT}.	**1.8**		**5.5**	V
OUTPUT VOLTAGE					
REG711-5.0	I_{OUT} ≤ 15mA, 2.7V < V_{IN} < 5.5V	**4.75**	5.0	**5.25**	V
	I_{OUT} ≤ 50mA, 3.0V < V_{IN} < 5.5V				
REG711-3.3	I_{OUT} ≤ 15mA, 1.8V < V_{IN} < 5.5V	**3.14**	3.3	**3.46**	V
	I_{OUT} ≤ 50mA, 2.2V < V_{IN} < 5.5V				
REG711-3.0	I_{OUT} ≤ 15mA, 1.8V < V_{IN} < 5.5V	**2.85**	3.0	**3.15**	V
	I_{OUT} ≤ 50mA, 2.2V < V_{IN} < 5.5V				
REG711-2.7	I_{OUT} ≤ 15mA, 1.8V < V_{IN} < 5.5V	**2.57**	2.7	**2.83**	V
	I_{OUT} ≤ 50mA, 2.0V < V_{IN} < 5.5V				
REG711-2.5	I_{OUT} ≤ 15mA, 1.8V < V_{IN} < 5.5V	**2.38**	2.5	**2.62**	V
	I_{OUT} ≤ 50mA, 2.0V < V_{IN} < 5.5V				
OUTPUT CURRENT					
Nominal		50			mA
Short Circuit(2)			80		mA
OSCILLATOR FREQUENCY	NOTE(3)		1.0		MHz
EFFICIENCY(4)	I_{OUT} = 15mA, V_{IN} = 2.7V, REG711-5.0		90		%
RIPPLE VOLTAGE(1)	I_{OUT} = 50mA		40		mVp-p
ENABLE CONTROL	V_{IN} = 1.8 to 5.5V				
Logic High Input Voltage		**1.3**		**V_{IN}**	V
Logic Low Input Voltage		**–0.2**		**0.4**	V
Logic High Input Current				100	nA
Logic Low Input Current				100	nA
THERMAL SHUTDOWN					
Shutdown temperature			160		°C
Shutdown recovery			140		°C
SUPPLY CURRENT					
(quiescent current)	I_{OUT} = 0mA		60	100	µA
In Shutdown Mode	V_{IN} = 1.8 to 5.5V, Enable = 0V		0.01	2	µA
TEMPERATURE RANGE					
Specification T_A		–40		+85	°C
Operating T_A		–55		+125	°C
Storage T_A		–65		+150	°C
Thermal Resistance, θ_{JA}	MSOP-8		150		°C/W

NOTES: (1) Effective series resistance (ESR) of capacitors is < 0.1Ω. (2) The supply circuit is twice the output short-circuit current. (3) The converter regulates by enabling and disabling periods of switching cycles. The switching frequency is the oscillator frequency during an active period. (4) See efficiency curves for other V_{IN}/V_{OUT} configurations.

PIN CONFIGURATION



SIMPLIFIED BLOCK DIAGRAM



Simplified Block Diagram

ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage	–0.3V to +5.5V
Enable Input	–0.3V to V_{IN}
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	–55°C to +125°C
Storage Temperature Range	–65°C to +150°C
Junction Temperature	–55°C to +150°C
Lead Temperature (soldering, 3s)	+240°C

NOTE: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability.

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION

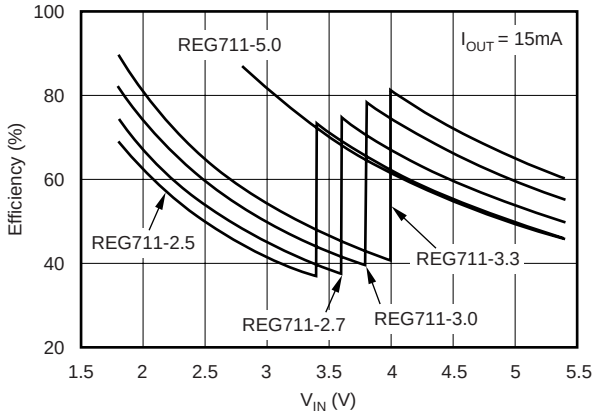
PRODUCT	OUTPUT VOLTAGE	PACKAGE	PACKAGE DRAWING NUMBER	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING[1]	ORDERING NUMBER[2]	TRANSPORT MEDIA
5V Output							
REG711EA-5	5.0V	MSOP-8	337	–40°C to +85°C	C11B	REG711EA-5	Rails
"	"	"	"	"	"	REG711EA-5/250	Tape and Reel
"	"	"	"	"	"	REG711EA-5/2K5	Tape and Reel
3.3V Output							
REG711EA-3.3	3.3V	MSOP-8	337	–40°C to +85°C	C11C	REG711EA-3.3	Rails
"	"	"	"	"	"	REG711EA-3.3/250	Tape and Reel
"	"	"	"	"	"	REG711EA-3.3/2K5	Tape and Reel
3V Output							
REG711EA-3.0	3.0V	MSOP-8	337	–40°C to +85°C	C11D	REG711EA-3	Rails
"	"	"	"	"	"	REG711EA-3/250	Tape and Reel
"	"	"	"	"	"	REG711EA-3/2K5	Tape and Reel
2.7V Output							
REG711EA-2.7	2.7V	MSOP-8	337	–40°C to +85°C	C11F	REG711EA-2.7	Rails
"	"	"	"	"	"	REG711EA-2.7/250	Tape and Reel
"	"	"	"	"	"	REG711EA-2.7/2K5	Tape and Reel
2.5V Output							
REG711EA-2.5	2.5V	MSOP-8	337	–40°C to +85°C	C11G	REG711EA-2.5	Rails
"	"	"	"	"	"	REG711EA-2.5/250	Tape and Reel

NOTE: (1) Voltage will be marked on reel. (2) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /2K5 indicates 2500 devices per reel). Ordering 2500 pieces of "REG711EA-5/2K5" will get a single 2500-piece Tape and Reel.

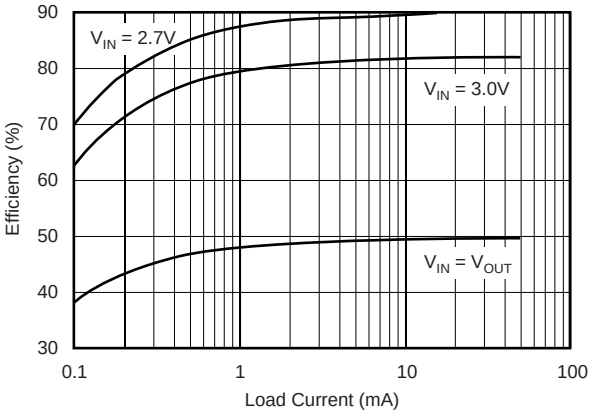
TYPICAL PERFORMANCE CURVES

At T_A = +25°C, V_{IN} = V_{OUT}/2 + 0.75V, I_{OUT} = 5mA, C_{IN} = C_{OUT} = 2.2µF, C_{PUMP} = 0.22µF, unless otherwise noted.

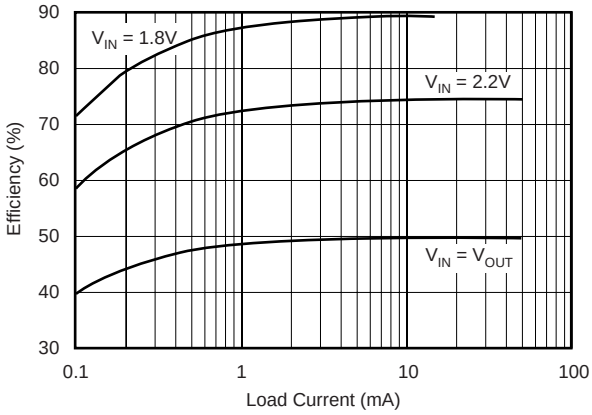
EFFICIENCY vs V_{IN}



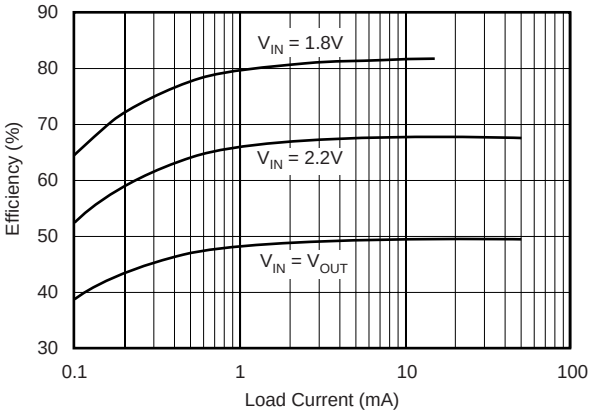
EFFICIENCY vs LOAD CURRENT
REG711 - 5.0V



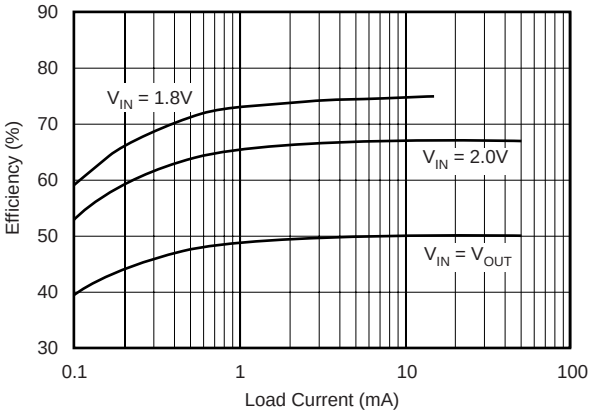
EFFICIENCY vs LOAD CURRENT
REG711 - 3.3V



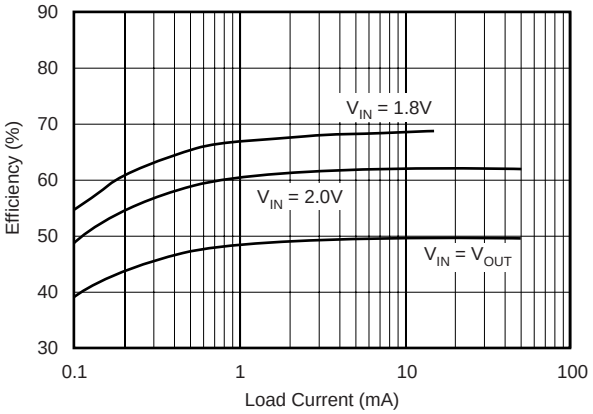
EFFICIENCY vs LOAD CURRENT
REG711 - 3.0V



EFFICIENCY vs LOAD CURRENT
REG711 - 2.7V



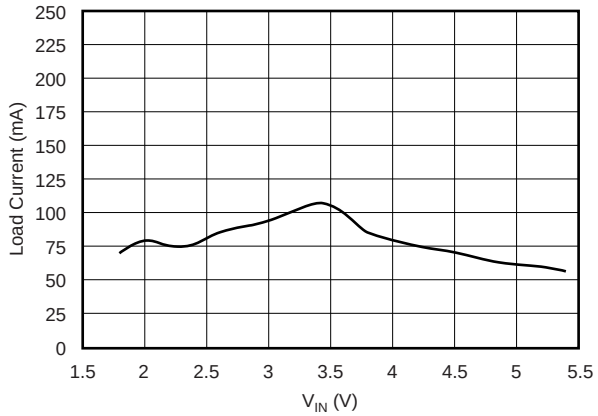
EFFICIENCY vs LOAD CURRENT
REG711 - 2.5V



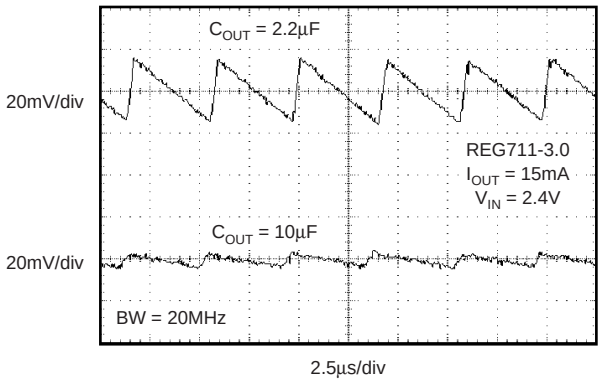
TYPICAL PERFORMANCE CURVES (Cont.)

At T_A = +25°C, V_{IN} = V_{OUT}/2 + 0.75V, I_{OUT} = 5mA, C_{IN} = C_{OUT} = 2.2µF, C_{PUMP} = 0.22µF, unless otherwise noted.

SHORT-CIRCUIT LOAD CURRENT vs V_{IN}

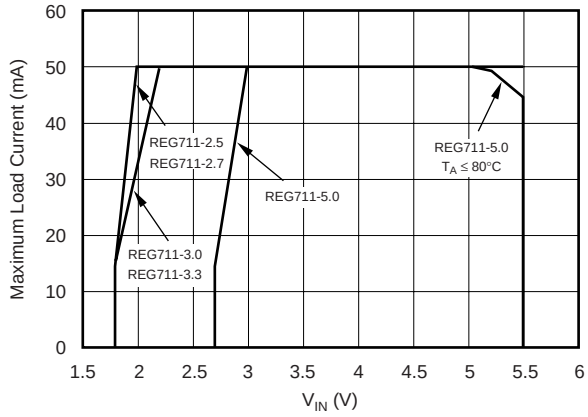


OUTPUT RIPPLE VOLTAGE

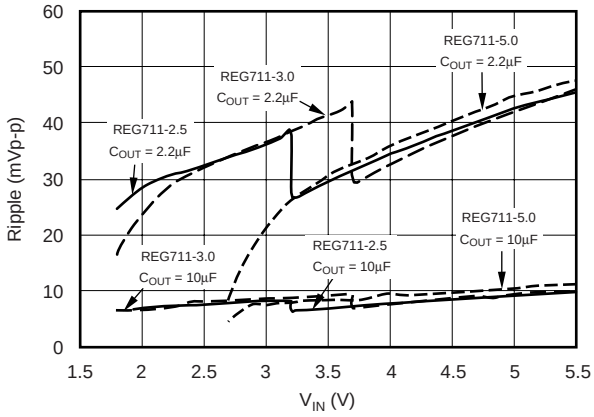


MAXIMUM LOAD CURRENT vs INPUT VOLTAGE

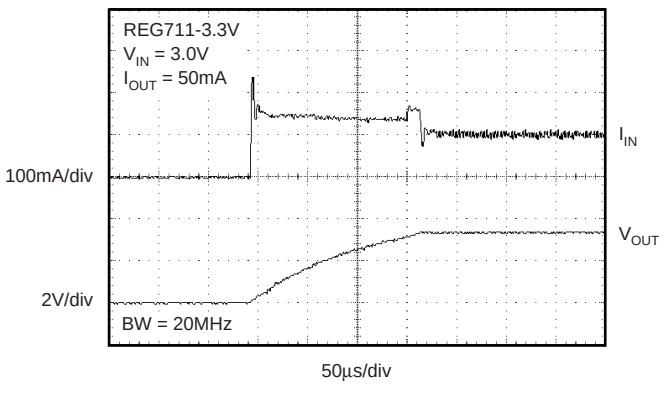
$T_A \leq 85°C$



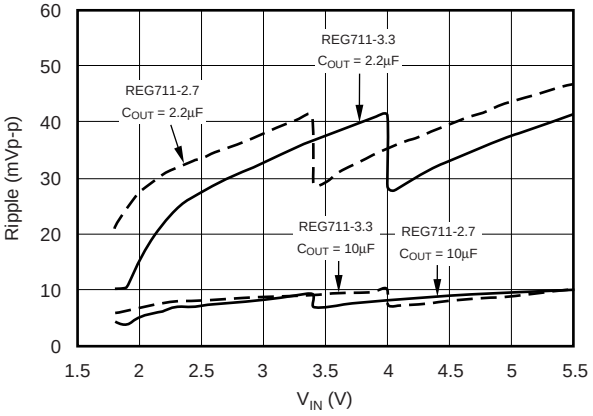
OUTPUT RIPPLE VOLTAGE vs V_{IN}



INPUT CURRENT AT TURN-ON



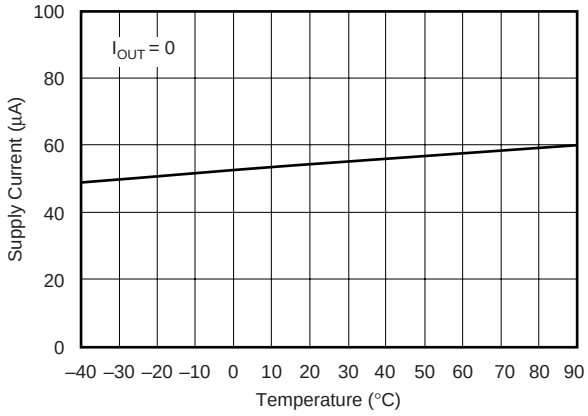
OUTPUT RIPPLE VOLTAGE vs V_{IN}



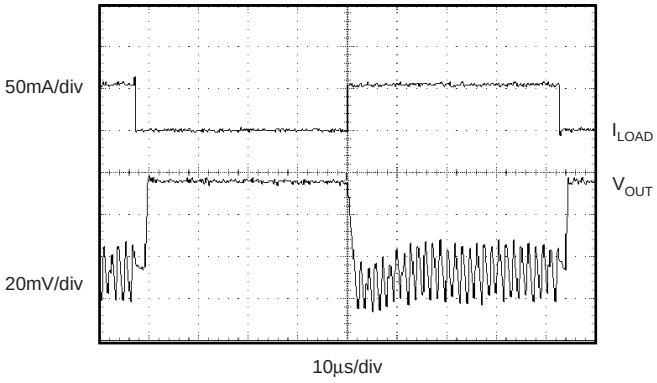
TYPICAL PERFORMANCE CURVES (Cont.)

At T_A = +25°C, V_{IN} = V_{OUT}/2 + 0.75V, I_{OUT} = 5mA, C_{IN} = C_{OUT} = 2.2µF, C_{PUMP} = 0.22µF, unless otherwise noted.

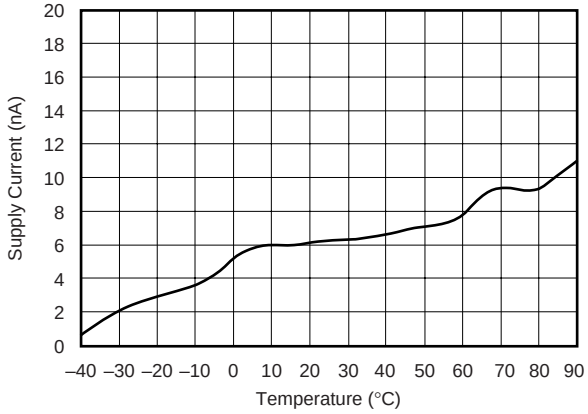
SUPPLY CURRENT vs TEMPERATURE (No Load)



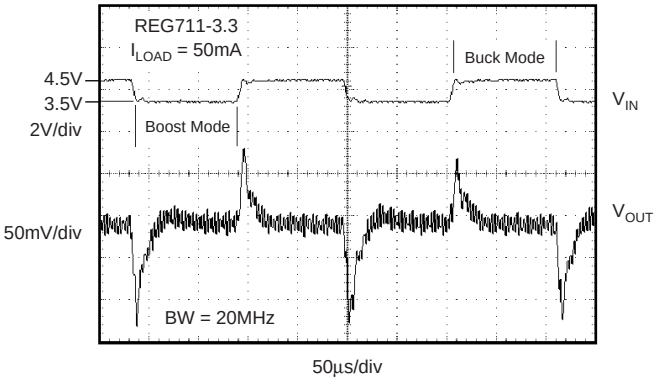
LOAD TRANSIENT RESPONSE



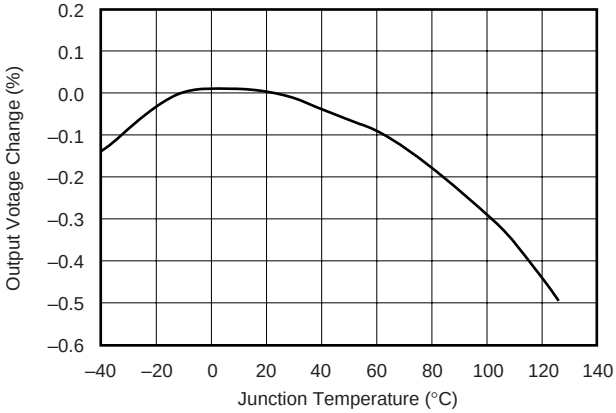
SUPPPLY CURRENT vs TEMPERATURE (Not Enabled)



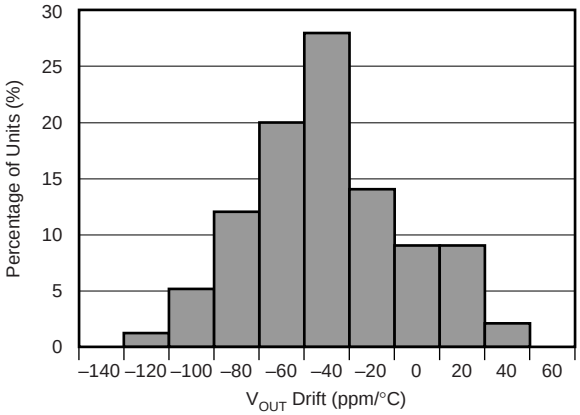
LINE TRANSIENT RESPONSE



OUTPUT VOLTAGE VS TEMPERATURE



OUTPUT VOLTAGE DRIFT HISTOGRAM



THEORY OF OPERATION

The REG711 regulated charge pump provides a regulated output voltage for input voltages ranging from less than the output to greater than the output. This is accomplished by automatic mode switching within the device. When the input voltage is greater than the required output, the unit functions as a variable pulse-width switch-mode regulator. This operation is shown in Figure 1. Transistors Q_1 and Q_3 are held off, Q_4 is on, and Q_2 is switched as needed to maintain a regulated output voltage.

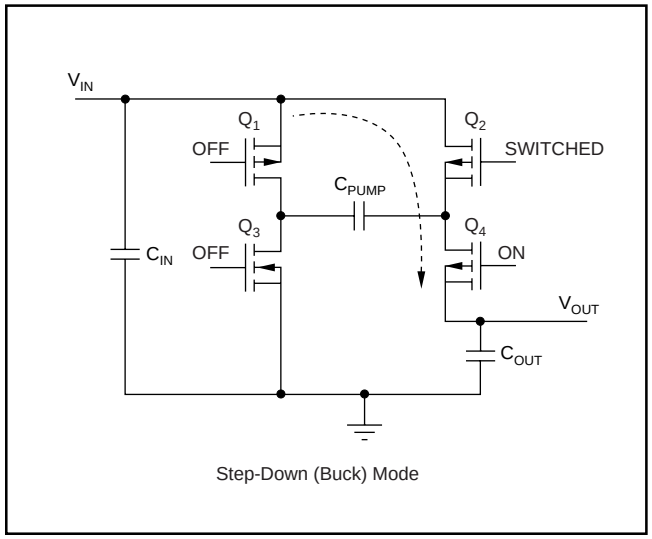


FIGURE 1. Simplified Schematic of the REG711 Operating in the Step-Down Mode.

When the input voltage is less than the required output voltage, the device switched to a step-up or boost mode of operation, as shown in Figure 2.

A conversion clock of 50% duty cycle is generated. During the first half cycle the FET switches are configured as shown in Figure 2A, and C_{PUMP} charges to V_{IN}. During the second half cycle the FET switches are configured as shown in Figure 2B, and the voltage on C_{PUMP} is added to V_{IN}. The output voltage is regulated by skipping clock cycles as necessary.

PEAK CURRENT REDUCTION

In normal operation, the charging of the pump and output capacitors usually leads to relatively high peak input currents which can be much higher than that of the average load current. The regulator incorporates circuitry to limit the input peak current, lowering the total EMI production of the device and lowering output voltage ripple and input current ripple. Input capacitor (C_{IN}) supplies most of the charge required by input current peaks.

PROTECTION

The regulator has thermal shutdown circuitry that protects it from damage caused by overload conditions. The thermal protection circuitry disables the output when the junction temperature reaches approximately 160°C, allowing the device to cool. When the junction temperature cools to approximately 140°C, the output circuitry is automatically reenabled. Continuously running the regulator into thermal shutdown can degrade reliability. The regulator also provides current limit to protect itself and the load.

SHUTDOWN MODE

A control pin on the regulator can be used to place the device into an energy-saving shutdown mode. In this mode, the output is disconnected from the input as long as V_{IN} is greater than or equal to minimum V_{IN} and the input quiescent current is reduced to 2µA maximum.

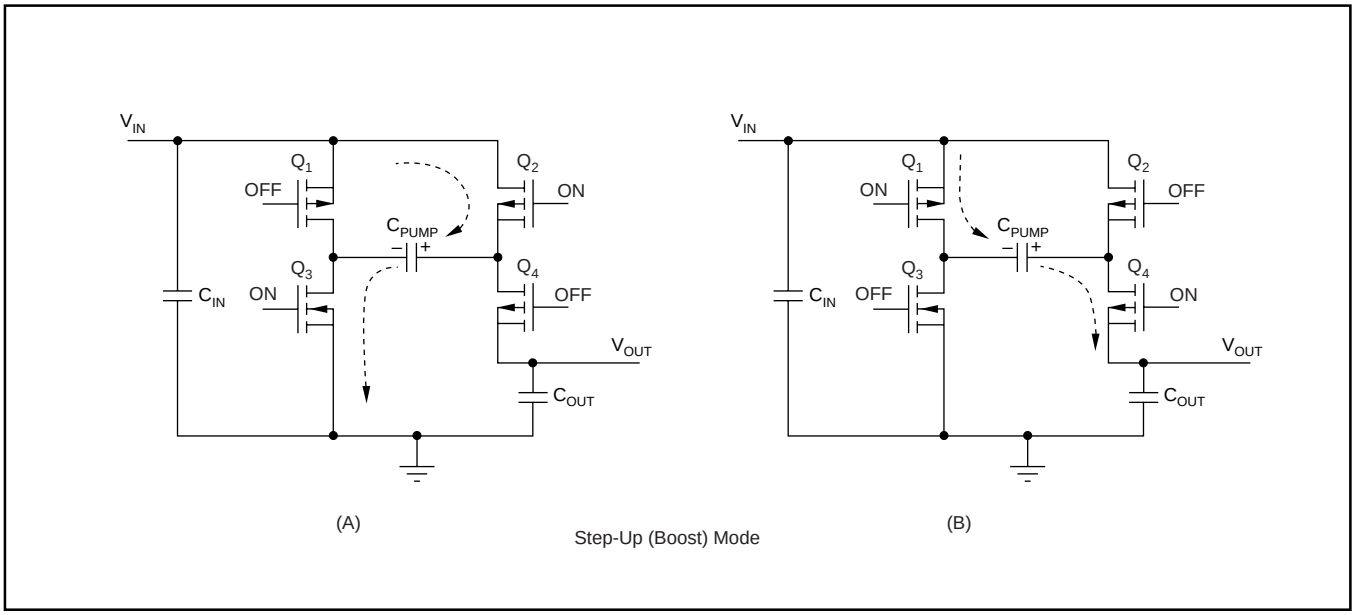


FIGURE 2. Simplified Schematic of the REG711 Operating in the Step-Up or Boost Mode.

CAPACITOR SELECTION

For minimum output voltage ripple, the output capacitor C_{OUT} should be a ceramic, surface-mount type. Tantalum capacitors generally have a higher Effective Series Resistance (ESR) and may contribute to higher output voltage ripple. Leaded capacitors also increase ripple due to the higher inductance of the package itself. To achieve best operation with low input voltage and high load current, the input and pump capacitors (C_{IN}, C_{PUMP} respectively) should also be surface-mount ceramic types. In all cases, X7R or X5R dielectric are recommended. See the Typical Operating Circuit shown in Figure 3 for component values.

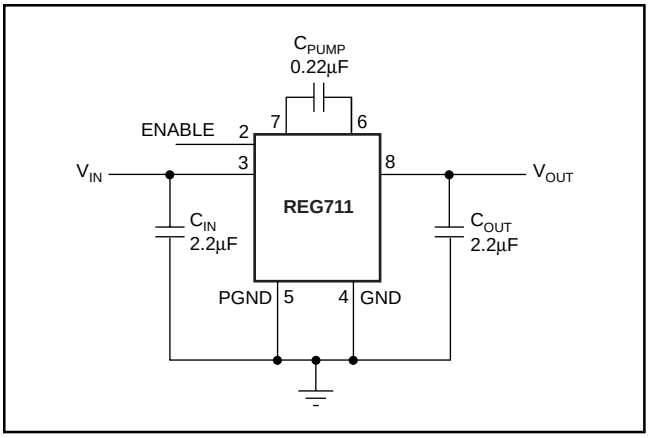


FIGURE 3. Typical Operating Circuit.

With light loads or higher input voltage, a smaller 0.1µF pump capacitor (C_{PUMP}) and smaller 1µF input and output capacitors (C_{IN} and C_{OUT}, respectively) can be used. To minimize output voltage ripple, increase the output capacitor, C_{OUT}, to 10µF or larger.

The capacitors listed in Table I have been used with the REG711. This is only a representative list of those parts that are compatible, and not the results of a complete survey of an industry-wide offering.

EFFICIENCY

The efficiency of the charge pump regulator varies with the output voltage version, the applied input voltage, the load current, and the internal operation mode of the device.

The approximate efficiency is given by:

$$\text{Efficiency (\%)} = V_{OUT}/(2 \cdot V_{IN}) \cdot 100 \text{ (step-up operating mode)}$$

or

$$V_{OUT} \cdot 100/V_{IN} \text{ (step-down operating mode)}$$

Table II lists the approximate values of the input voltage at which the device changes internal operating mode.

PRODUCT	OPERATING MODE CHANGES AT V_{IN} OF
REG711-2.5	> 3.2V
REG711-2.7	> 3.4V
REG711-3.0	> 3.7V
REG711-3.3	> 4.0V
REG711-5.0	Step-up only

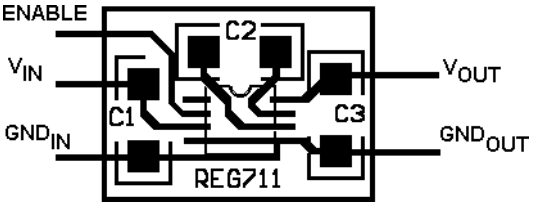
TABLE II.

See efficiency curves in the Typical Performance Curves section for various loads and input voltages.

LAYOUT

Large ripple currents flow in the V_{IN}, PGND and V_{OUT} traces. To minimize both input and output ripple, keep the capacitors as close as possible to the regulator using short, direct circuit traces.

A suggested PCB routing is shown in Figure 4. The trace lengths from the input and output capacitors have been kept as short as possible. A star ground system has been implemented, with pin 5 as the center of the star. No ground plane is provided in other layers, as this will provide capacitive coupling for noise spikes.



NOTE: All Capacitors 1206 Size

FIGURE 4. Suggested PCB Design for Minimum Ripple.

MANUFACTURER	PART NUMBER	VALUE	TOLERANCE	DIELECTRIC MATERIAL	PACKAGE SIZE	RATED WORKING VOLTAGE
Kemet	C1206C255K8RAC	2.2µF	±10%	X7R	1206	10V
	C1206C224K8RAC	0.22µF	±10%	X7R	1206	10V
Panasonic	ECJ3YB1A225K	2.2µF	±10%	X7R	1206	10V
	ECJ3VB1C224K	0.22µF	±10%	X7R	1206	16V
Taiyo Yuden	LMK325BJ106KN	10µF	±10%	X5R	1210	10V
	EMK316BJ225KL	2.2µF	±10%	X7R	1206	16V
	TKM316BJ224KF	0.22µF	±10%	X7R	1206	25V

TABLE I. Capacitors That Have Been Successfully Used With The REG711.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
REG711EA-2.5/250	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C11G	Samples
REG711EA-2.5/2K5	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C11G	Samples
REG711EA-3.3/250	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C11C	Samples
REG711EA-3.3/250G4	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C11C	Samples
REG711EA-3/250	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C11D	Samples
REG711EA-3/250G4	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C11D	Samples
REG711EA-3/2K5	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C11D	Samples
REG711EA-5/250	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C11B	Samples
REG711EA-5/250G4	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C11B	Samples
REG711EA-5/2K5	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C11B	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) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

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

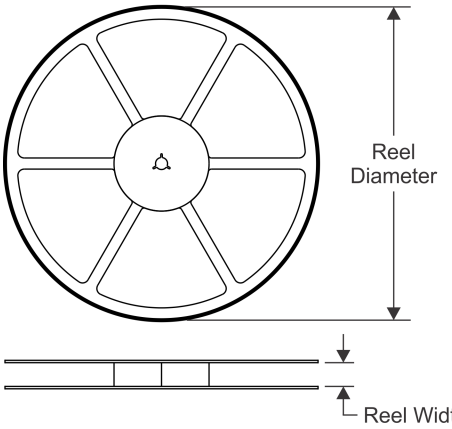
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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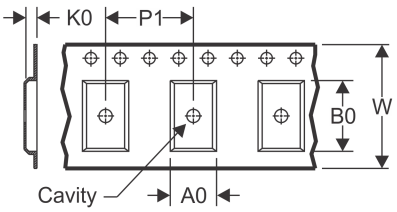
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TAPE AND REEL INFORMATION

REEL DIMENSIONS

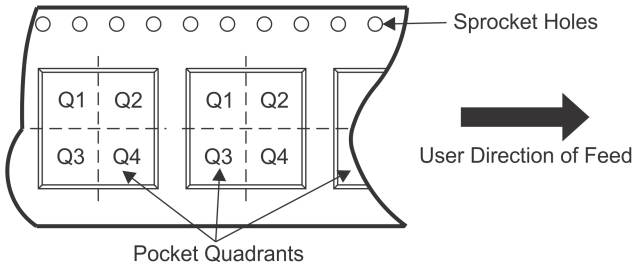


TAPE DIMENSIONS



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

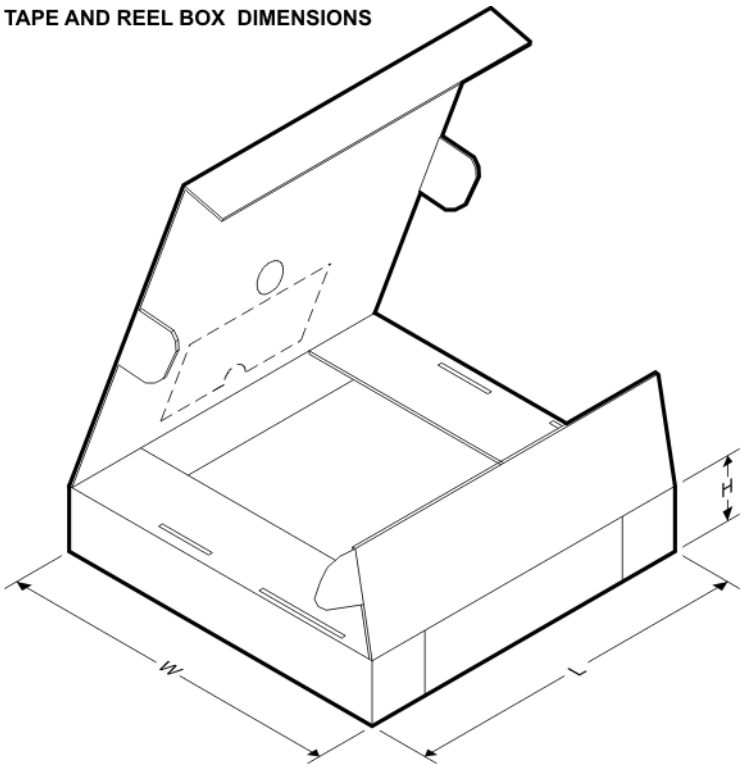
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
REG711EA-2.5/250	VSSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REG711EA-2.5/2K5	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REG711EA-3.3/250	VSSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REG711EA-3/250	VSSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REG711EA-3/2K5	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REG711EA-5/250	VSSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REG711EA-5/2K5	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
REG711EA-2.5/250	VSSOP	DGK	8	250	210.0	185.0	35.0
REG711EA-2.5/2K5	VSSOP	DGK	8	2500	367.0	367.0	35.0
REG711EA-3.3/250	VSSOP	DGK	8	250	210.0	185.0	35.0
REG711EA-3/250	VSSOP	DGK	8	250	210.0	185.0	35.0
REG711EA-3/2K5	VSSOP	DGK	8	2500	367.0	367.0	35.0
REG711EA-5/250	VSSOP	DGK	8	250	210.0	185.0	35.0
REG711EA-5/2K5	VSSOP	DGK	8	2500	367.0	367.0	35.0

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