LM3411 Precision Secondary Regulator/Driver

Check for Samples: LM3411

FEATURES

- **Fixed Voltages of 3.3V and 5.0V with Initial Tolerance of ±1% for Standard Grade and ±0.5% for A Grade**
- **Custom Voltages Available (3V–17V)**
- **Wide Output Current Range, 20 µA–15 mA**
- **Low Temperature Coefficient**
- **Available in 5-Lead SOT23-5 Surface Mount Package (Tape and Reel)**

APPLICATIONS

- **Secondary Controller for Isolated DC/DC PWM Switching Regulators Systems**
- **Use with LDO Regulator for High-Precision Fixed Output Regulators**
- **Precision Monitoring Applications**
- **Use with many Types of Regulators to Increase Precision and Improve Performance**

DESCRIPTION

The LM3411 is a low power fixed-voltage (3.3V or 5.0V) precision shunt regulator designed specifically for driving an optoisolator to provide feedback isolation in a switching regulator.

The LM3411 circuitry includes an internally compensated op amp, a bandgap reference, NPN output transistor, and voltage setting resistors.

A trimmed precision bandgap reference with temperature drift curvature correction, provides a ensured 1% precision over the operating temperature range (A grade version). The amplifier's inverting input is externally accessible for loop frequency compensation when used as part of a larger servo system. The output is an open-emitter NPN transistor capable of driving up to 15 mA of load current.

Because of its small die size, the LM3411 has been made available in the sub-miniature 5-lead SOT23-5 surface mount package. This package is ideal for use in space critical applications.

Although its main application is to provide a precision output voltage (no trimming required) and maintain very good regulation in isolated DC/DC converters, it can also be used with other types of voltage regulators or power semiconductors to provide a precision output voltage without precision resistors or trimming.

Typical Application and Functional Diagram

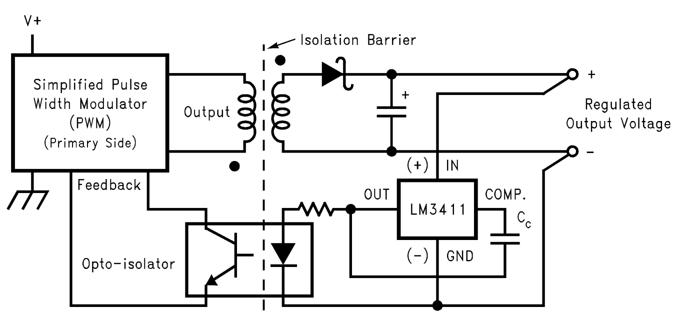


Figure 1. Basic Isolated DC/DC Converter

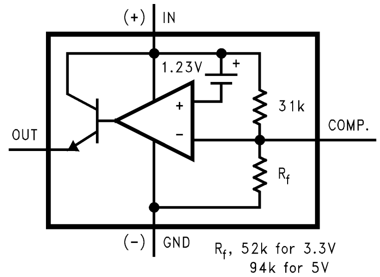
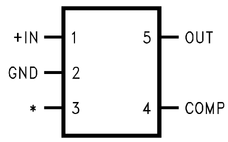


Figure 2. LM3411 Functional Diagram

Connection Diagrams



*No internal connection, but should be soldered to PC board for best heat transfer.

Figure 3. 5-Lead SOT23-5 (DBV) Small Outline Package (M5) Package Number DBV0005A Top View

Figure 4. Actual Size

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.

Absolute Maximum Ratings (1)(2)

Input Voltage V(IN)	20V
Output Current	20 mA
Junction Temperature	150°C
Storage Temperature	−65°C to +150°C
Lead Temperature	
Vapor Phase (60 sec.)	+215°C
Infrared (15 sec.)	+220°C
Power Dissipation (T_A = 25°C) (3)	300 mW
ESD Susceptibility (4)	
Human Body Model	1500V

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
(3) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), $θ_{JA}$ (junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is ($P_{Dmax} = T_{Jmax} − T_A)/θ_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower. The typical thermal resistance ($θ_{JA}$) when soldered to a printed circuit board is approximately 306°C/W for the DBV package.
(4) The human body model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin.

See AN-450 SNOA742 “Surface Mounting Methods and Their Effect on Product Reliability” for methods on soldering surface-mount devices.

Operating Ratings (1)(2)

Ambient Temperature Range	$−40°C ≤ T_A ≤ +85°C$
Junction Temperature Range	$−40°C ≤ T_J ≤ +125°C$
Output Current	15 mA

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
(2) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), $θ_{JA}$ (junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is ($P_{Dmax} = T_{Jmax} − T_A)/θ_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower. The typical thermal resistance ($θ_{JA}$) when soldered to a printed circuit board is approximately 306°C/W for the DBV package.

LM3411-3.3 Electrical Characteristics

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, V(IN) = V_{REG}, V_{OUT} = 1.5V.

Symbol	Parameter	Conditions	Typical (1)	LM3411A-3.3 Limit (2)	LM3411-3.3 Limit (2)	Units (Limits)
V_{REG}	Regulation Voltage	I_{OUT} = 5 mA	3.3			V
				3.317/**3.333**	3.333/**3.366**	V(max)
				3.284/**3.267**	3.267/**3.234**	V(min)
	Regulation Voltage Tolerance	I_{OUT} = 5 mA		±0.5/**±1**	±1/**±2**	%(max)

(1) Typical numbers are at 25°C and represent the most likely parametric norm.
(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate TIs Averaging Outgoing Level (AOQL).

LM3411-3.3 Electrical Characteristics (continued)

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, V(IN) = V_{REG}, V_{OUT} = 1.5V.

Symbol	Parameter	Conditions	Typical (1)	LM3411A-3.3 Limit (2)	LM3411-3.3 Limit (2)	Units (Limits)
I_q	Quiescent Current	I_{OUT} = 5 mA	85			μA
				110/**115**	125/**150**	μA(max)
G_m	Transconductance $\Delta I_{OUT}/\Delta V_{REG}$	20 μA ≤ I_{OUT} ≤ 1 mA	3.3			mA/mV
				1.5/**0.75**	1/**0.50**	mA/mV(min)
		1 mA ≤ I_{OUT} ≤ 15 mA	6.0			mA/mV
				3.3/**2.0**	2.5/**1.7**	mA/mV(min)
A_V	Voltage Gain $\Delta V_{OUT}/\Delta V_{REG}$	1V ≤ V_{OUT} ≤ V_{REG} − 1.2V **(−1.3)**	1000			V/V
		R_L = 140Ω (3)		550/**250**	450/**200**	V/V(min)
		1V ≤ V_{OUT} ≤ V_{REG} − 1.2V **(−1.3)**	3500			V/V
		R_L = 2 kΩ		1500/**900**	1000/**700**	V/V(min)
V_{SAT}	Output Saturation (4)	V(IN) = V_{REG} +100 mV	1.0			V
		I_{OUT} = 15 mA		1.2/**1.3**	1.2/**1.3**	V(max)
I_L	Output Leakage Current	V(IN) = V_{REG} −100 mV	0.1			μA
		V_{OUT} = 0V		0.5/**1.0**	0.5/**1.0**	μA(max)
R_f	Internal Feedback Resistor (5)		52			kΩ
				65	65	kΩ(max)
				39	39	kΩ(min)
E_n	Output Noise Voltage	I_{OUT} = 1 mA, 10 Hz ≤ f ≤ 10 kHz	50			μV_{RMS}

(3) Actual test is done using equivalent current sink instead of a resistor load.
(4) V_{SAT} = V(IN) − V_{OUT}, when the voltage at the IN pin is forced 100 mV above the nominal regulating voltage (V_{REG}).
(5) See Applications Information and Typical Performance Characteristics sections for information on this resistor.

LM3411-5.0 Electrical Characteristics

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, V(IN) = V_{REG}, V_{OUT} = 1.5V.

Symbol	Parameter	Conditions	Typical (1)	LM3411A-5.0 Limit (2)	LM3411-5.0 Limit (2)	Units (Limits)
V_{REG}	Regulation Voltage	I_{OUT} = 5 mA	5			V
				5.025/**5.050**	5.050/**5.100**	V(max)
				4.975/**4.950**	4.950/**4.900**	V(min)
	Regulation Voltage Tolerance	I_{OUT} = 5 mA		±0.5/**±1**	±1/**±2**	%(max)
I_q	Quiescent Current	I_{OUT} = 5 mA	85			μA
				110/**115**	125/**150**	μA(max)
G_m	Transconductance $\Delta I_{OUT}/\Delta V_{REG}$	20 μA ≤ I_{OUT} ≤ 1 mA	3.3			mA/mV
				1.5/**0.75**	1.0/**0.5**	mA/mV(min)
		1 mA ≤ I_{OUT} ≤ 15 mA	6.0			mA/mV
				3.3/**2.0**	2.5/**1.7**	mA/mV(min)

(1) Typical numbers are at 25°C and represent the most likely parametric norm.
(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate TIs Averaging Outgoing Level (AOQL).

LM3411-5.0 Electrical Characteristics (continued)

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, V(IN) = V_{REG}, V_{OUT} = 1.5V.

Symbol	Parameter	Conditions	Typical (1)	LM3411A-5.0 Limit (2)	LM3411-5.0 Limit (2)	Units (Limits)
A_V	Voltage Gain $\Delta V_{OUT}/\Delta V_{REG}$	1V ≤ V_{OUT} ≤ V_{REG} − 1.2V **(−1.3)**	1000			V/V
		R_L = 250Ω (3)		750/**350**	650/**300**	V/V(min)
		1V ≤ V_{OUT} ≤ V_{REG} − 1.2V **(−1.3)**	3500			V/V
		R_L = 2 kΩ		1500/**900**	1000/**700**	V/V(min)
V_{SAT}	Output Saturation (4)	V(IN) = V_{REG} +100 mV	1.0			V
		I_{OUT} = 15 mA		1.2/**1.3**	1.2/**1.3**	V(max)
I_L	Output Leakage Current	V(IN) = V_{REG} −100 mV	0.1			µA
		V_{OUT} = 0V		0.5/**1.0**	0.5/**1.0**	µA(max)
R_f	Internal Feedback Resistor (5)		94			kΩ
				118	118	kΩ(max)
				70	70	kΩ(min)
E_n	Output Noise Voltage	I_{OUT} = 1 mA, 10 Hz ≤ f ≤ 10 kHz	80			μV_{RMS}

(3) Actual test is done using equivalent current sink instead of a resistor load.
(4) V_{SAT} = V(IN) − V_{OUT}, when the voltage at the IN pin is forced 100 mV above the nominal regulating voltage (V_{REG}).
(5) See Applications Information and Typical Performance Characteristics sections for information on this resistor.

Typical Performance Characteristics

Normalized Temperature Drift

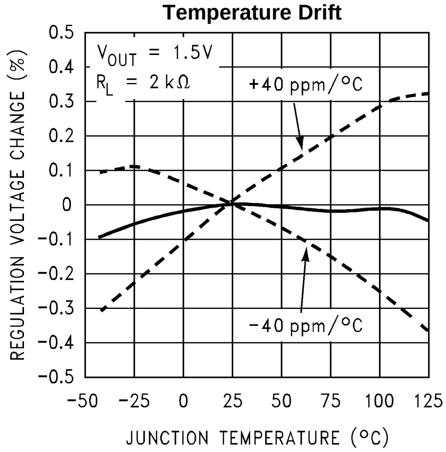


Figure 5.

Quiescent Current

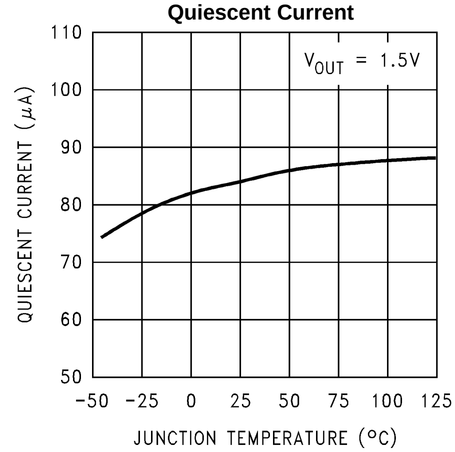


Figure 6.

Output Saturation Voltage (V)$_{SAT}$

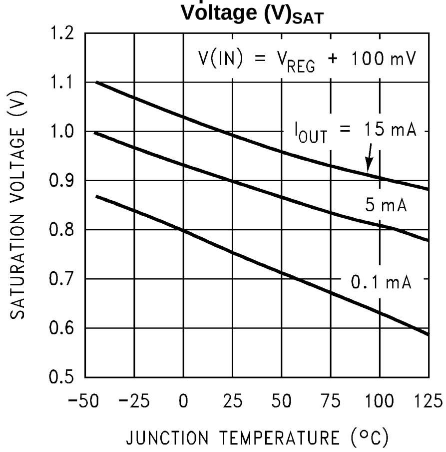


Figure 7.

Circuit Used for Bode Plots

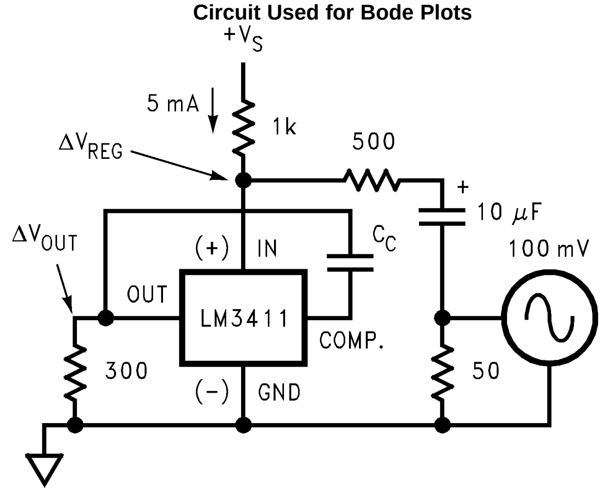


Figure 8.

Bode Plot

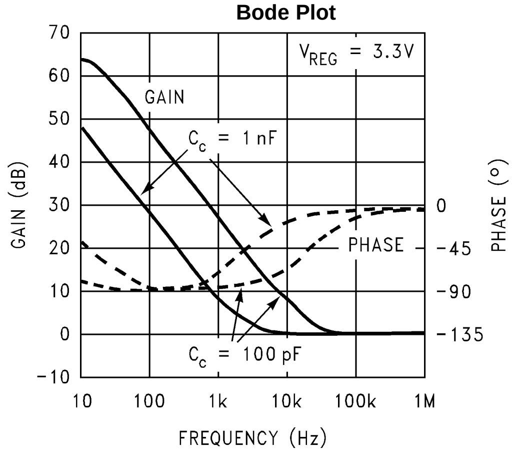


Figure 9.

Bode Plot

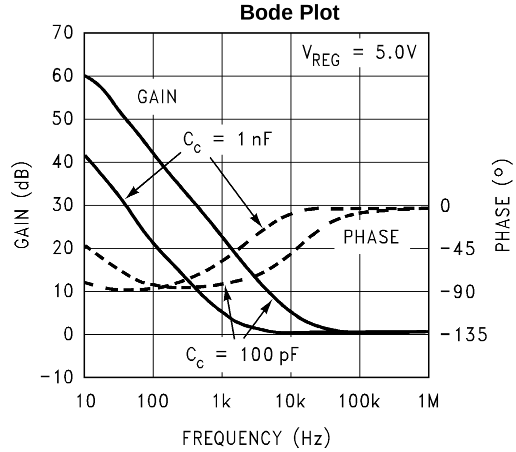


Figure 10.

Typical Performance Characteristics (continued)

Bode Plot

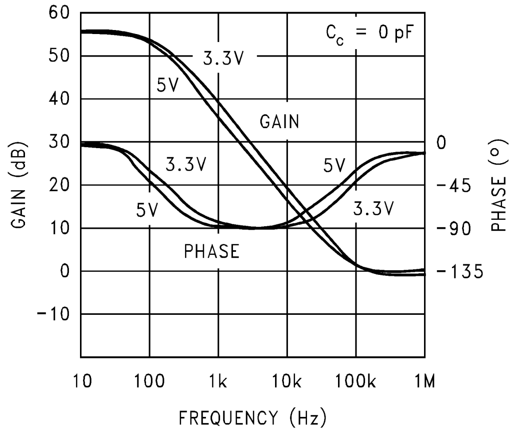


Figure 11.

Response Time for 3.3V Version (C_C = 0 pF)

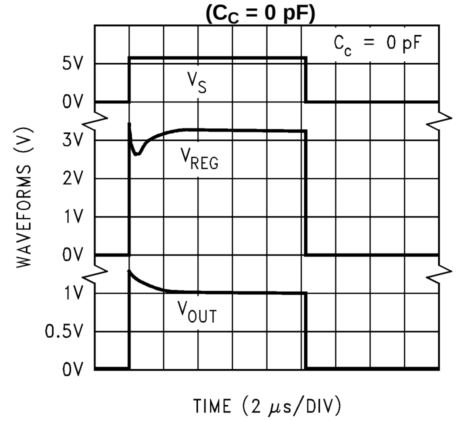


Figure 12.

Response Time for 3.3V Version (C_C = 10 nF)

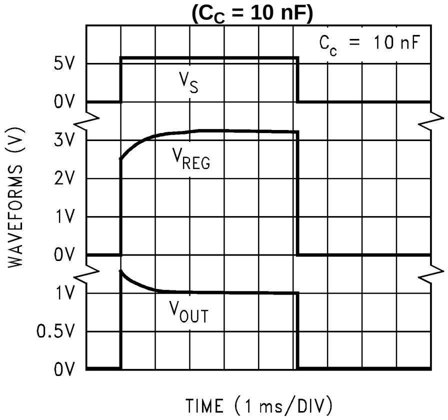


Figure 13.

Circuit Used for Response Time

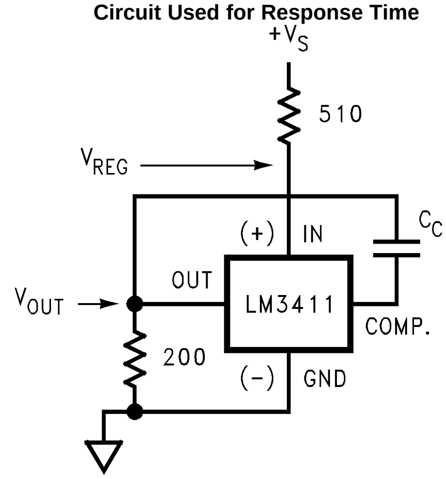


Figure 14.

Response Time for 5V Version (C_C = 0 pF)

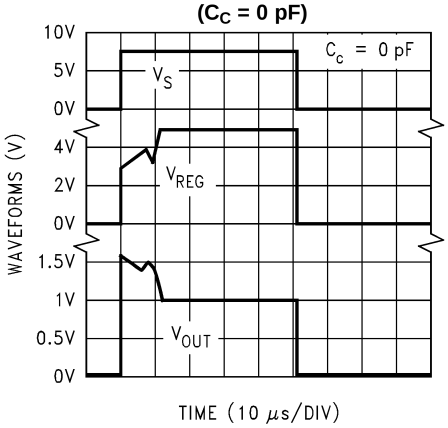


Figure 15.

Response Time for 5V Version (C_C = 10 nF)

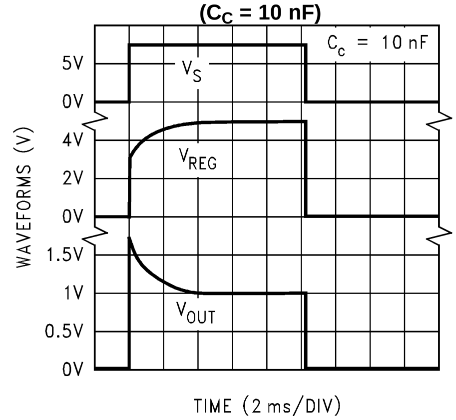


Figure 16.

Typical Performance Characteristics (continued)

Tempco of Internal Feedback Resistor (Rf)

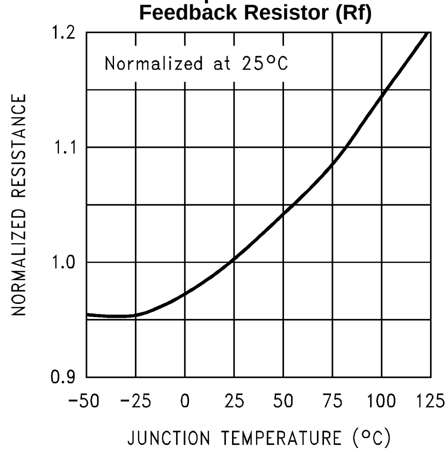


Figure 17.

Regulation Voltage Change vs Output Current

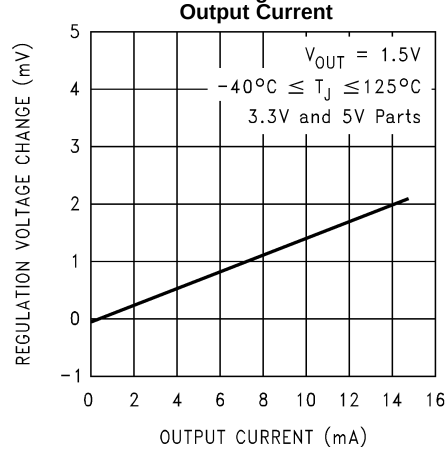


Figure 18.

Regulation Voltage vs Output Voltage and Load Resistance

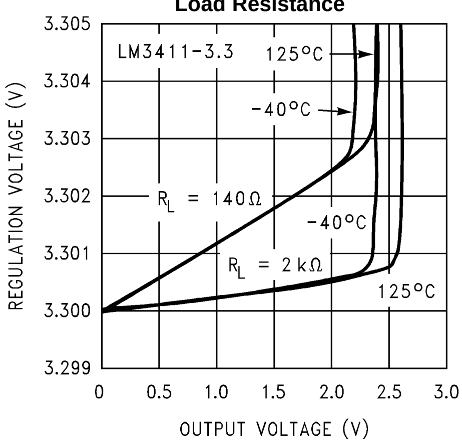


Figure 19.

Regulation Voltage vs Output Voltage and Load Resistance

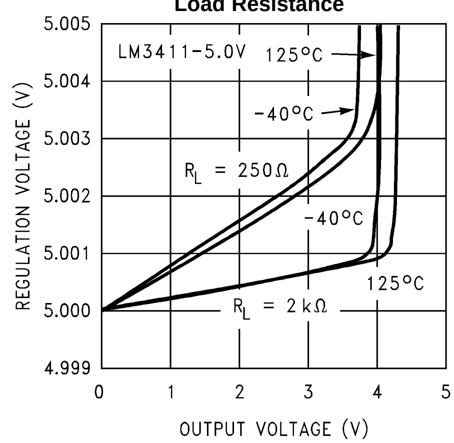


Figure 20.

PRODUCT DESCRIPTION

The LM3411 is a shunt regulator specifically designed to be the reference and control section in an overall feedback loop of a regulated power supply. The regulated output voltage is sensed between the IN pin and GROUND pin of the LM3411. If the voltage at the IN pin is less than the LM3411 regulating voltage (V_{REG}), the OUT pin sources no current. As the voltage at the IN pin approaches the V_{REG} voltage, the OUT pin begins sourcing current. This current is then used to drive a feedback device, (opto-coupler) or a power device, (linear regulator, switching regulator, etc.) which servos the output voltage to be the same value as V_{REG}.

In some applications, (even under normal operating conditions) the voltage on the IN pin can be forced above the V_{REG} voltage. In these instances, the maximum voltage applied to the IN pin should not exceed 20V. In addition, an external resistor may be required on the OUT pin to limit the maximum current to 20 mA.

Compensation

The inverting input of the error amplifier is brought out to allow overall closed-loop compensation. In many of the applications circuits shown here, compensation is provided by a single capacitor connected from the compensation pin to the out pin of the LM3411. The capacitor values shown in the schematics are adequate under most conditions, but they can be increased or decreased depending on the desired loop response. Applying a load pulse to the output of a regulator circuit and observing the resultant output voltage response is a easy method of determining the stability of the control loop. Analyzing more complex feedback loops requires additional information.

The formula for AC gain at a frequency (f) is as follows;

$$\text{Gain (f)} = 1 + \frac{Z_f(f)}{R_f}$$

$$\text{where } Z_f\text{ (f)} = \frac{1}{j \bullet 2\pi \bullet f \bullet C}$$

where

- $R_f \approx 52$ kΩ for the 3.3V part
- $R_f \approx 94$ kΩ for the 5V part (1)

The resistor (R_f) in the formula is an internal resistor located on the die. Since this resistor value will affect the phase margin, the worst case maximum and minimum values are important when analyzing closed loop stability. The minimum and maximum room temperature values of this resistor are specified in the Electrical Characteristics section of this data sheet, and a curve showing the temperature coefficient is shown in the Typical Performance Characteristics section. In the applications shown here, the worst case phase margin occurs with minimum values of R_f.

Test Circuit

The test circuit shown in *Figure 21* can be used to measure and verify various LM3411 parameters. Test conditions are set by forcing the appropriate voltage at the V_{OUT} Set test point and selecting the appropriate R_L or I_{OUT} as specified in the Electrical Characteristics section. Use a DVM at the “measure” test points to read the data.

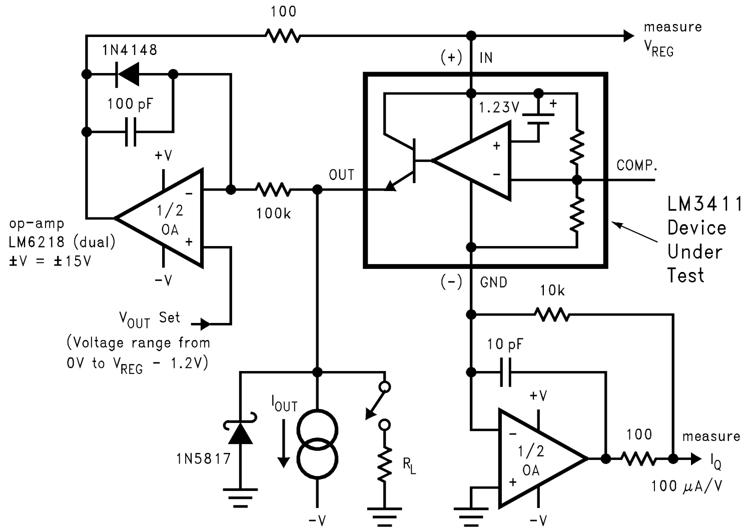


Figure 21. LM3411 Test Circuit

Applications Information

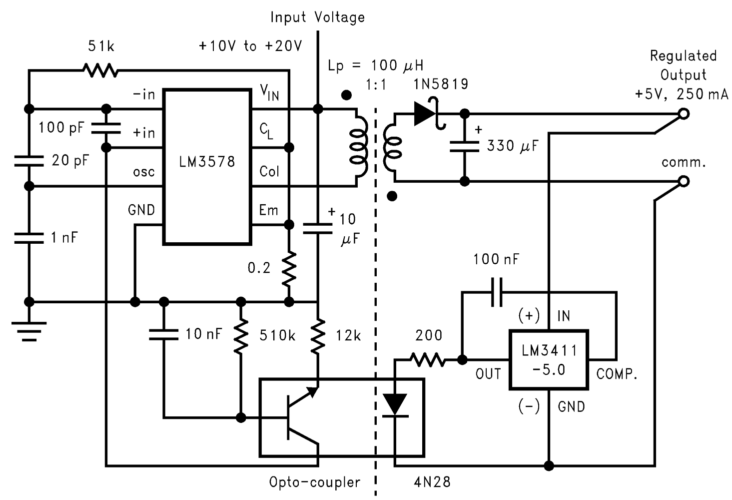


Figure 22. Isolated 250 mA Flyback Switching Regulator

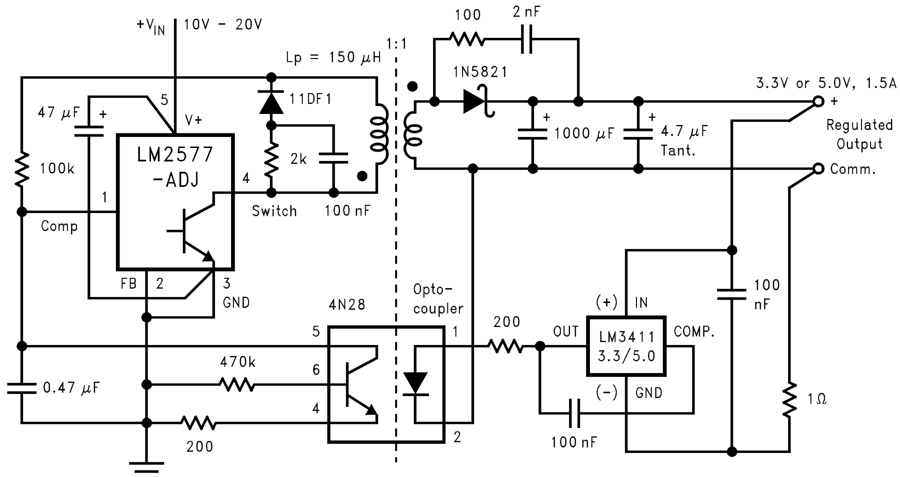


Figure 23. Isolated 1.5A Flyback Switching Regulator Using a LM2577

The LM3411 regulator/driver provides the reference and feedback drive functions in a regulated power supply. It can also be used together with many different types of regulators, (both linear and switching) as well as other power semiconductor devices to add precision and improve regulation specifications. Output voltage tolerances better than 0.5% are possible without using trim pots or precision resistors.

One of the main applications of the LM3411 is to drive an opto-isolator to provide feedback signal isolation in a switching regulator circuit. For low current applications, (up to 250 mA) the circuit shown in *Figure 22* provides good regulation and complete input/output electrical isolation.

For an input voltage of 15V, this circuit can provide an output of either 3.3V or 5V with a load current up to 250 mA with excellent regulation characteristics. With the part values shown, this circuit operates at 80 kHz., and can be synchronized to a clock or an additional LM3578. (See LM1578 data sheet for additional information.)

An isolated DC/DC flyback converter capable of higher output current is shown in *Figure 23*. This circuit utilizes the LM2577 SIMPLE SWITCHER voltage regulator for the Pulse Width Modulation (PWM), power switch and protection functions, while the LM3411 provides the voltage reference, gain and opto coupler drive functions. In this circuit, the reference and error amplifier in the LM2577 are not used (note that the feedback pin is grounded). The gain is provided by the LM3411. Since the voltage reference is located on the secondary side of the transformer, this circuit provides very good regulation specifications.

The output of a switching regulator typically will contain a small ripple voltage at the switching frequency and may also contain voltage transients. These transient voltage spikes can be sensed by the LM3411 and could give an incorrect regulation voltage. An RC filter consisting of a 1Ω resistor and a 100 nF capacitor will filter these transients and minimize this problem. The 1Ω resistor should be located on the ground side of the LM3411, and the capacitor should be physically located near the package.

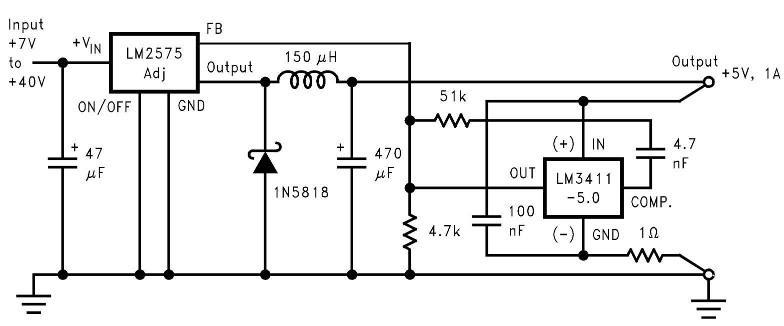


Figure 24. Precision 1A Buck Regulator

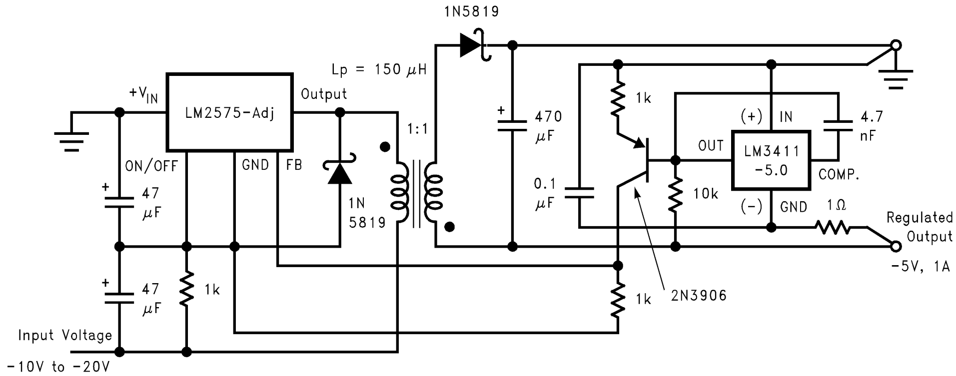


Figure 25. Negative Input, Negative or Positive Output Flyback Regulator

Improved output voltage tolerance and regulation specifications are possible by combining the LM3411A with one of the SIMPLE SWITCHER buck regulator IC's, such as the LM2574, LM2575, or LM2576. The circuit shown in *Figure 24* can provide a 5V, ±0.5% Output (1% over the operating temperature range) without using any trim-pots or precision resistors. Typical line regulation numbers are a 1 mV change on the output for a 8V–18V change on the input, and load regulation of 1 mV with a load change from 100 mA–1A.

A DC-DC flyback converter that accepts a negative input voltage, and delivers either a positive or negative output is shown in *Figure 25*. The circuit utilizes a buck regulator (such as the LM2574, LM2575, or LM2576, depending on how much output current is needed) operating in a flyback configuration. The LM3411 provides the reference and the required level shifting circuitry needed to make the circuit work correctly.

A unique feature of this circuit is the ability to ground either the high or low side of the output, thus generating either a negative or a positive output voltage. Although no isolation is provided, with the addition of an opto-isolator and related components, this circuit could provide input/output isolation.

Combining a LM3411A-5.0 with a 1A low dropout linear regulator results in a 5V ±0.5% (1% over the operating temperature range) regulator with excellent regulation specifications, with no trimming or 1% resistors needed.

An added benefit of this circuit (and also true of many of the other circuits shown here) is the high-side and low-side remote output voltage sensing feature. Sensing the output voltage at the load eliminates the voltage drops associated with wire resistance, thus providing near perfect load regulation.

A 5V, 1A regulator circuit featuring low dropout, very good regulation specifications, self protection features and allows output voltage sensing is shown in *Figure 26*. The regulator used is a LM2941 adjustable low dropout positive regulator, which also features an ON/OFF pin to provide a shutdown feature.

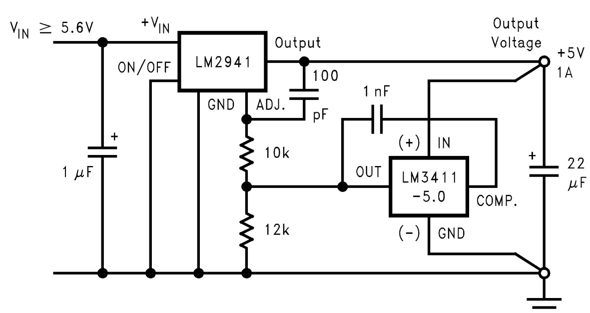


Figure 26. Precision 5V 1A Low Dropout Regulator

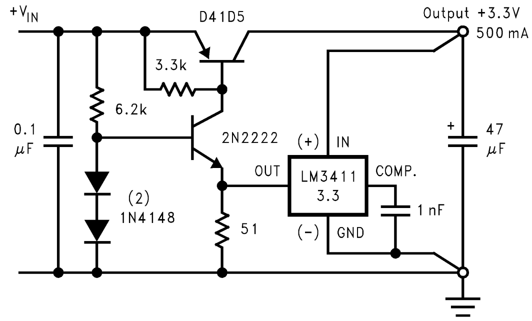


Figure 27. 3.3V 0.5A Low Dropout Regulator

The circuit in *Figure 27* shows a 3.3V low dropout regulator using the LM3411-3.3 and several discrete components. This circuit is capable of excellent performance with both the dropout voltage and the ground pin current specifications improved over the LM2941/LM3411 circuit.

The standard LM317 three terminal adjustable regulator circuit can greatly benefit by adding a LM3411. Performance is increased and features are added. The circuit shown in *Figure 28* provides much improved line and load regulation, lower temperature drift, and full remote output voltage sensing on both the high and low side. In addition, a precise current limit or constant current feature is simple to add.

Current limit protection in most IC regulators is mainly to protect the IC from gross over-current conditions which could otherwise fuse bonding wires or blow IC metalization, therefore not much precision is needed for the actual current limit values. Current limit tolerances can sometimes vary from ±10% to as high as +300% over manufacturing and temperature variations. Often critical circuitry requires a much tighter control over the amount of current the power supply can deliver. For example, a power supply may be needed that can deliver 100% of its design current, but can still limit the maximum current to 110% to protect critical circuitry from high current fault conditions.

The circuit in *Figure 28* can provide a current limit accuracy that is better than ±4%, over all possible variations, in addition to having excellent line, load and temperature specifications.

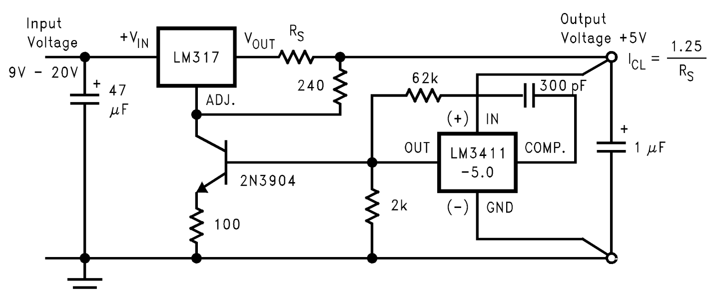


Figure 28. Precision Positive Voltage Regulator with Accurate Current Limit

Like the positive regulators, the performance of negative adjustable regulators can also be improved by adding the LM3411. Output voltages of either 3.3V or 5V at currents up to 1.5A (3A when using a LM333) are possible. Adding two resistors to the circuit in *Figure 29* adds the precision current limit feature as shown in *Figure 30*. Current limit tolerances of ±4% over manufacturing and temperature variations are possible with this circuit.

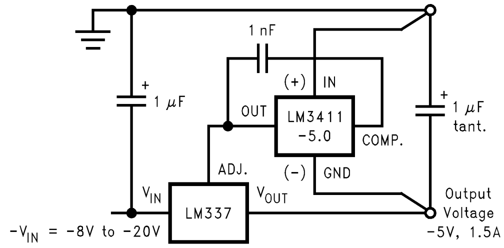


Figure 29. Precision Negative Voltage Regulator

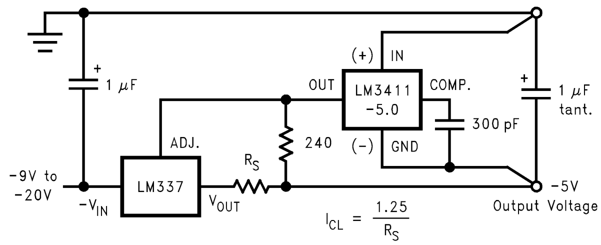


Figure 30. Precision Negative Voltage Regulator with Accurate Current Limit

A simple 5V supply monitor circuit is shown in *Figure 31*. Using the LM3411's voltage reference, op-amp (as a comparator) and output driver, this circuit provides a LED indication of the presence of the 5V supply.

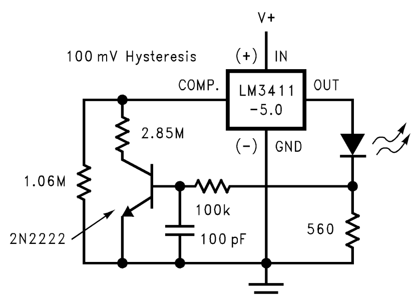


Figure 31. 4.7V Power ON Detector with Hysteresis

The LM3411 initial room temperature tolerance is ±1% and ±0.5% for the "A" grade part. If a tighter tolerance is needed, a trim scheme is shown in *Figure 32* that provides approximately ±1% adjustment range of the regulation voltage (V_{REG}).

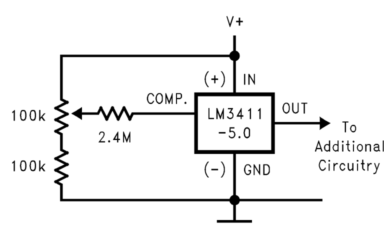


Figure 32. ±50 mV External Trim

The LM3411 is ensured to drive a 15 mA load, but if more current is needed, a NPN boost transistor can be added. The circuit shown in *Figure 33* is a shunt regulator capable of providing excellent regulation over a very wide range of current.

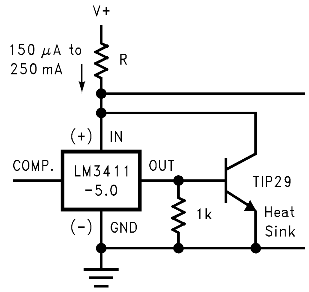


Figure 33. 250 mA Shunt Regulator

Perhaps one of the simplest applications for the LM3411 is the voltage detector circuit shown in *Figure 34* . The OUT pin is low when the input voltage is less than V_{REG}. When the V(IN) pin rises above V_{REG}, the OUT pin is pulled high by the internal NPN output resistor.

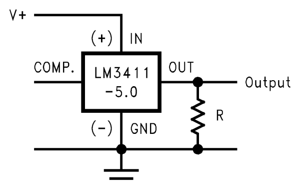


Figure 34. Voltage Detector

Also an overvoltage detector, the crowbar circuit shown in *Figure 35* is normally located at the output of a power supply to protect the load from an overvoltage condition should the power supply fail with an input/output short.

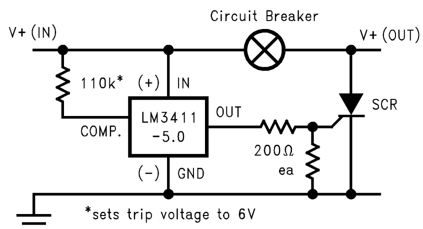
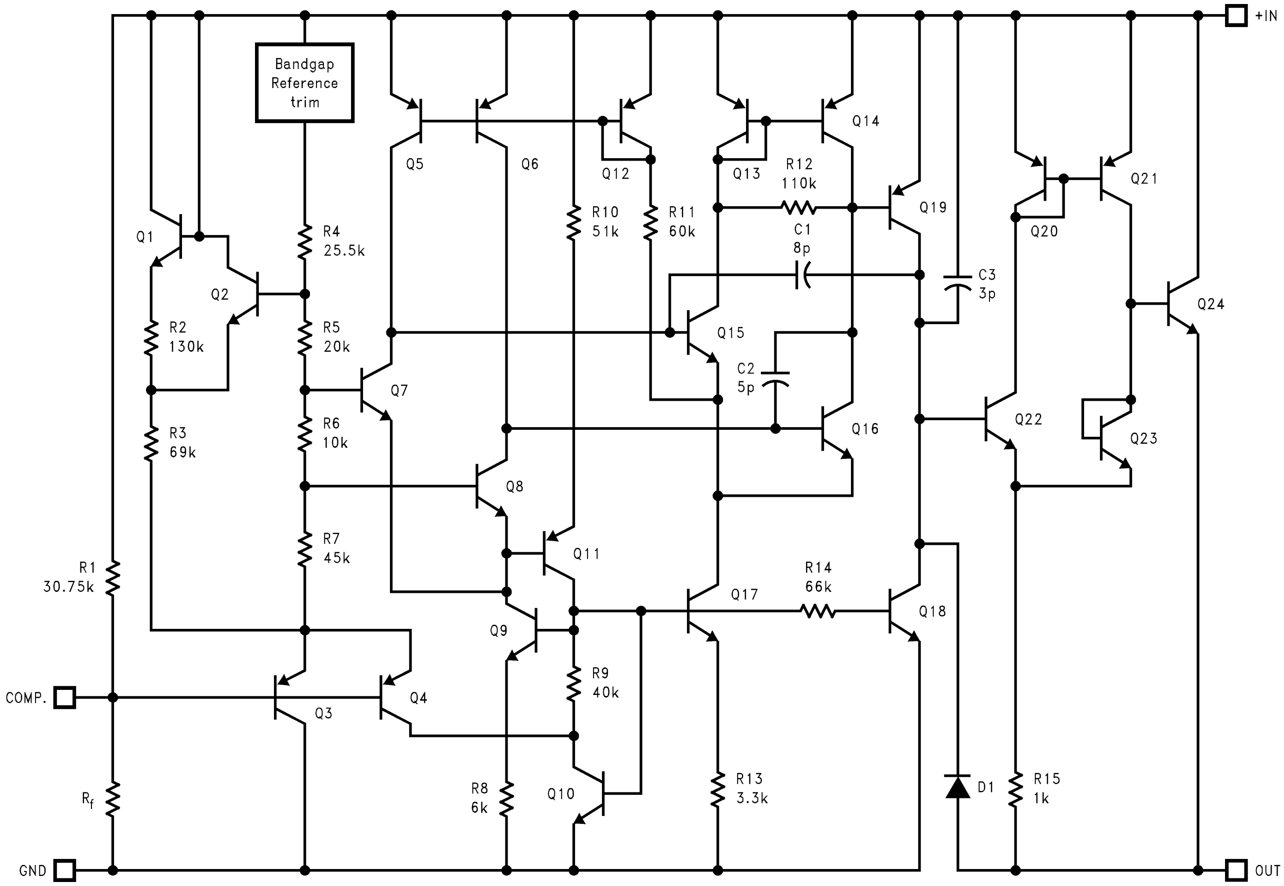


Figure 35. Overvoltage Crowbar

Schematic Diagram



REVISION HISTORY

Changes from Revision D (April 2013) to Revision E	Page
• Changed layout of National Data Sheet to TI format	16

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
LM3411AM5-3.3/NOPB	ACTIVE	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	D00A	Samples
LM3411AM5-5.0	LIFEBUY	SOT-23	DBV	5	1000	TBD	Call TI	Call TI	-40 to 85	D01A	
LM3411AM5-5.0/NOPB	ACTIVE	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	D01A	Samples
LM3411AM5X-3.3/NOPB	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	D00A	Samples
LM3411AM5X-5.0/NOPB	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	D01A	Samples
LM3411M5-3.3/NOPB	ACTIVE	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	D00B	Samples
LM3411M5-5.0	LIFEBUY	SOT-23	DBV	5	1000	TBD	Call TI	Call TI	-40 to 85	D01B	
LM3411M5-5.0/NOPB	ACTIVE	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	D01B	Samples
LM3411M5X-3.3/NOPB	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	D00B	Samples
LM3411M5X-5.0/NOPB	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	D01B	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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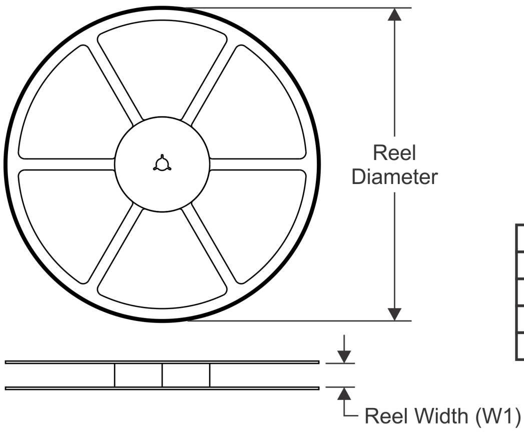
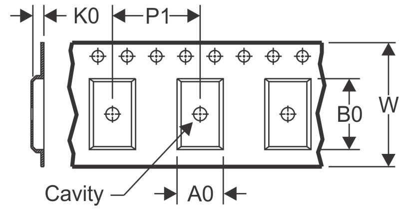
TAPE AND REEL INFORMATION

REEL DIMENSIONS

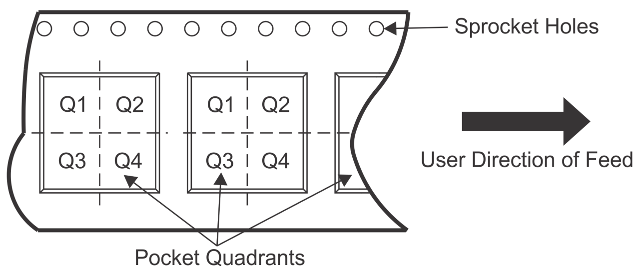


TAPE DIMENSIONS



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

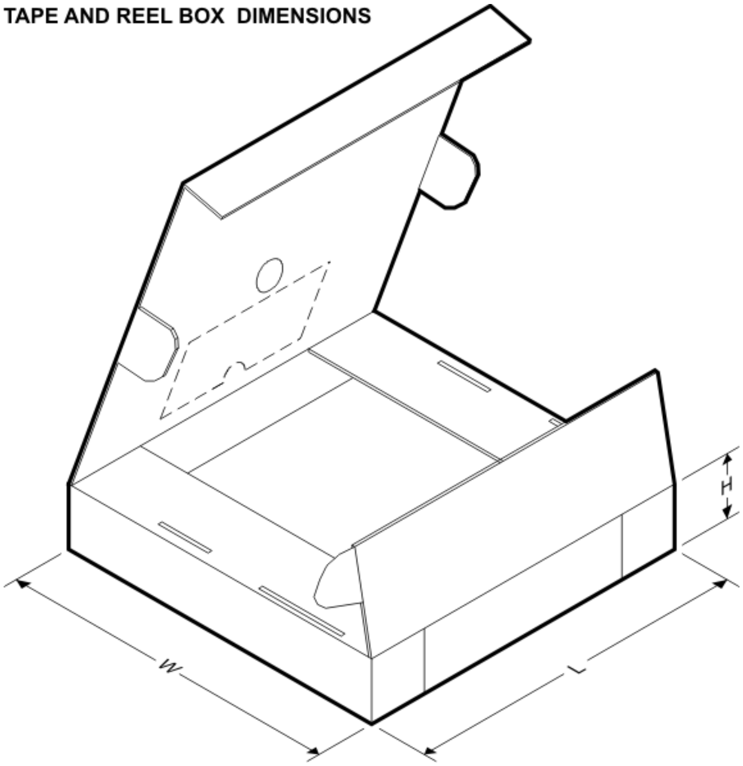
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
LM3411AM5-3.3/NOPB	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM3411AM5-5.0	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM3411AM5-5.0/NOPB	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM3411AM5X-3.3/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM3411AM5X-5.0/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM3411M5-3.3/NOPB	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM3411M5-5.0	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM3411M5-5.0/NOPB	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM3411M5X-3.3/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM3411M5X-5.0/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

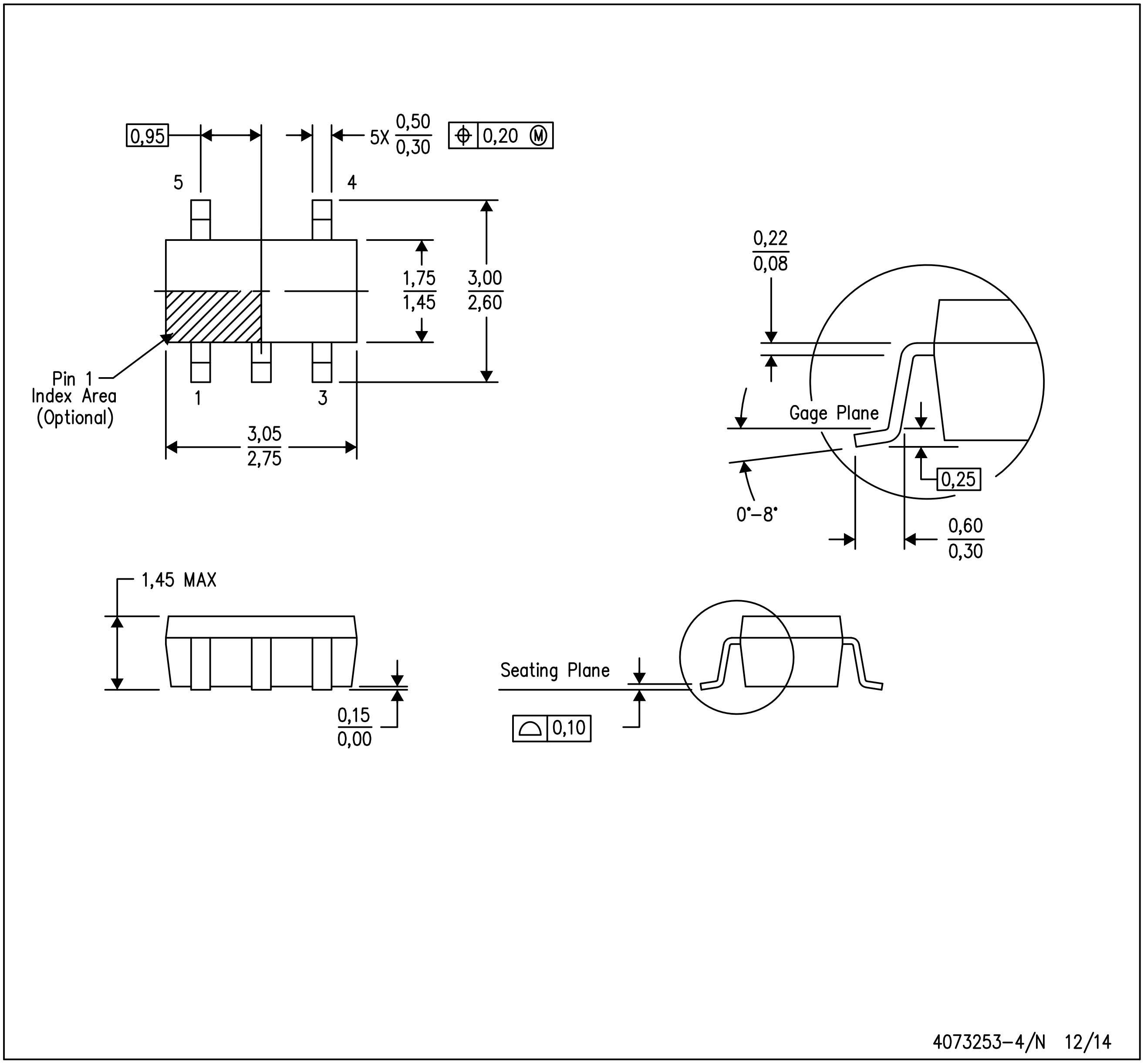
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

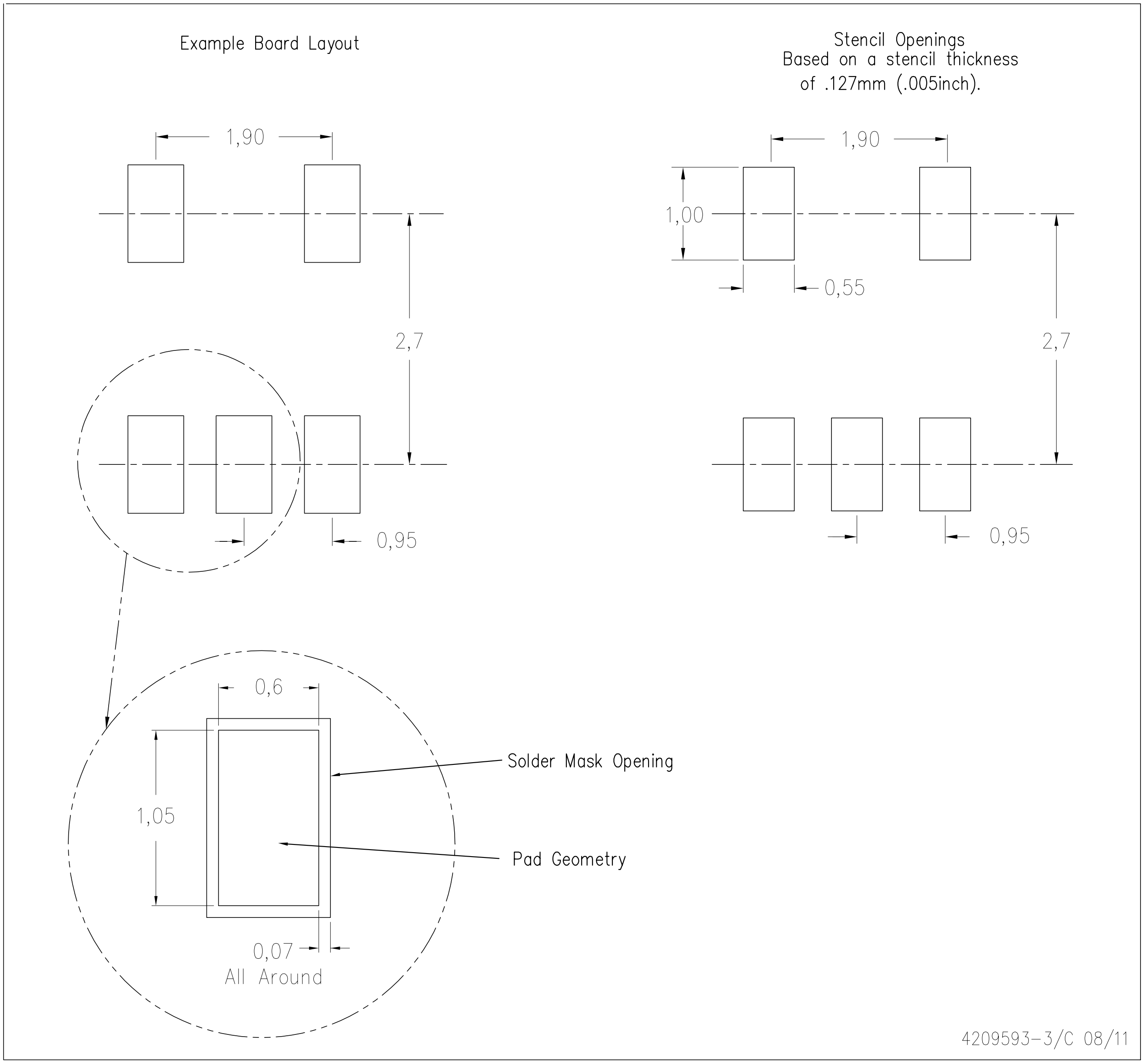
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM3411AM5-3.3/NOPB	SOT-23	DBV	5	1000	210.0	185.0	35.0
LM3411AM5-5.0	SOT-23	DBV	5	1000	210.0	185.0	35.0
LM3411AM5-5.0/NOPB	SOT-23	DBV	5	1000	210.0	185.0	35.0
LM3411AM5X-3.3/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0
LM3411AM5X-5.0/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0
LM3411M5-3.3/NOPB	SOT-23	DBV	5	1000	210.0	185.0	35.0
LM3411M5-5.0	SOT-23	DBV	5	1000	210.0	185.0	35.0
LM3411M5-5.0/NOPB	SOT-23	DBV	5	1000	210.0	185.0	35.0
LM3411M5X-3.3/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0
LM3411M5X-5.0/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0

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.

DBV (R–PDSO–G5) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
D. Publication IPC–7351 is recommended for alternate designs.
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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC–7525 for other stencil recommendations.

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