

LM3411

LM3411 Precision Secondary Regulator/Driver



Literature Number: SNVS113D

LM3411

Precision Secondary Regulator/Driver

General 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 guaranteed 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.

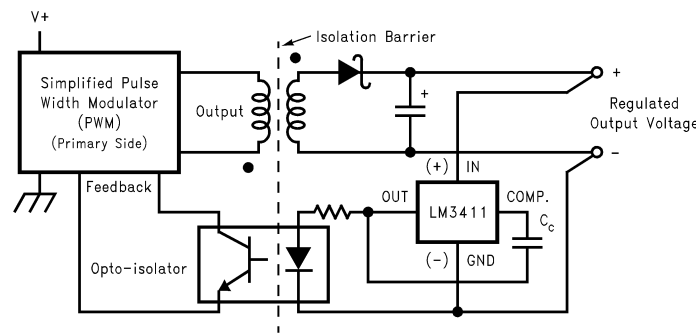
Features

- Fixed voltages of 3.3V and 5.0V with initial tolerance of $\pm 1\%$ for standard grade and $\pm 0.5\%$ 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

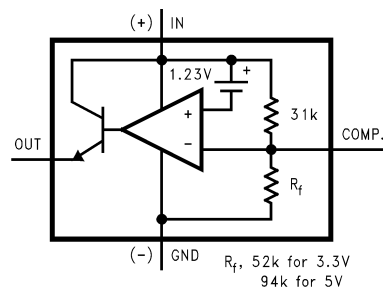
- Secondary controller for isolated DC/DC PWM switching regulators systems
- Use with LDO regulator for high-precision fixed output regulators
- Precision monitoring applications
- Use with many types of regulators to increase precision and improve performance

Typical Application and Functional Diagram



Basic Isolated DC/DC Converter

01198701



LM3411 Functional Diagram

01198702

SIMPLE SWITCHER™ is a trademark of National Semiconductor Corporation.

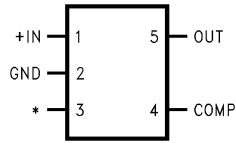
Connection Diagrams and Order Information

Actual Size



01198704

5-Lead Small Outline Package (M5)



01198703

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

Top View

For Ordering Information
See *Figure 1* in this Data Sheet
See NS Package Number MF05A

Five Lead Surface Mount Package Marking and Order Information (SOT23-5)

The small SOT23-5 package allows only 4 alphanumeric characters to identify the product. The table below contains the field information marked on the package.

	Grade	Order Information	Package Marking	Supplied as
3.3V	A (Prime)	LM3411AM5-3.3	D00A	1000 unit increments on tape and reel
3.3V	A (Prime)	LM3411AM5X-3.3	D00A	3000 unit increments on tape and reel
3.3V	B (Standard)	LM3411M5-3.3	D00B	1000 unit increments on tape and reel
3.3V	B (Standard)	LM3411M5X-3.3	D00B	3000 unit increments on tape and reel
5.0V	A (Prime)	LM3411AM5-5.0	D01A	1000 unit increments on tape and reel
5.0V	A (Prime)	LM3411AM5X-5.0	D01A	3000 unit increments on tape and reel
5.0V	B (Standard)	LM3411M5-5.0	D01B	1000 unit increments on tape and reel
5.0V	B (Standard)	LM3411M5X-5.0	D01B	3000 unit increments on tape and reel

FIGURE 1. SOT23-5 Marking and Order Information

The first letter "D" identifies the part as a Driver, the next two numbers indicate the voltage, "00" for 3.3V part and "01" for a 5V part. The fourth letter indicates the grade, "B" for standard grade, "A" for the prime grade.

The SOT23-5 surface mount package is only available on tape in quantities increments of 250 on tape and reel (indi-

cated by the letters "M5" in the part number), or in quantities increments of 3000 on tape and reel (indicated by the letters "M5X" in the part number).

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

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) (Note 2)	300 mW

ESD Susceptibility (Note 3)

Human Body Model 1500V

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

Operating Ratings (Notes 1, 2)

Ambient Temperature Range	-40°C ≤ T _A ≤ +85°C
Junction Temperature Range	-40°C ≤ T _J ≤ +125°C
Output Current	15 mA

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 (Note 4)	LM3411A-3.3 Limit (Note 5)	LM3411-3.3 Limit (Note 5)	Units (Limits)
V _{REG}	Regulation Voltage	I _{OUT} = 5 mA	3.3	3.317/ 3.333 3.284/ 3.267	3.333/ 3.366 3.267/ 3.234	V V(max) V(min)
	Regulation Voltage Tolerance	I _{OUT} = 5 mA		±0.5/ ±1	±1/ ±2	%(max)
I _q	Quiescent Current	I _{OUT} = 5 mA	85	110/ 115	125/ 150	μA μA(max)
G _m	Transconductance ΔI _{OUT} /ΔV _{REG}	20 μA ≤ I _{OUT} ≤ 1 mA	3.3	1.5/ 0.75	1/ 0.50	mA/mV mA/mV(min)
		1 mA ≤ I _{OUT} ≤ 15 mA	6.0	3.3/ 2.0	2.5/ 1.7	mA/mV mA/mV(min)
A _V	Voltage Gain ΔV _{OUT} /ΔV _{REG}	1V ≤ V _{OUT} ≤ V _{REG} - 1.2V (-1.3) R _L = 140Ω (Note 6)	1000	550/ 250	450/ 200	V/V V/V(min)
		1V ≤ V _{OUT} ≤ V _{REG} - 1.2V (-1.3) R _L = 2 kΩ	3500	1500/ 900	1000/ 700	V/V V/V(min)
V _{SAT}	Output Saturation (Note 7)	V(IN) = V _{REG} + 100 mV I _{OUT} = 15 mA	1.0	1.2/ 1.3	1.2/ 1.3	V V(max)
I _L	Output Leakage Current	V(IN) = V _{REG} - 100 mV V _{OUT} = 0V	0.1	0.5/ 1.0	0.5/ 1.0	μA μA(max)
R _f	Internal Feedback Resistor (Note 8)		52	65	65	kΩ kΩ(max)
				39	39	kΩ(min)
E _n	Output Noise Voltage	I _{OUT} = 1 mA, 10 Hz ≤ f ≤ 10 kHz	50			μV _{RMS}

LM3411-5.0 Electrical Characteristics

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

Symbol	Parameter	Conditions	Typical (Note 4)	LM3411A-5.0 Limit (Note 5)	LM3411-5.0 Limit (Note 5)	Units (Limits)
V_{REG}	Regulation Voltage	$I_{\text{OUT}} = 5\text{ mA}$	5	5.025/ 5.050 4.975/ 4.950	5.050/ 5.100 4.950/ 4.900	V V(max) V(min)
	Regulation Voltage Tolerance	$I_{\text{OUT}} = 5\text{ mA}$		$\pm 0.5/\pm 1$	$\pm 1/\pm 2$	%(max)
I_q	Quiescent Current	$I_{\text{OUT}} = 5\text{ mA}$	85	110/ 115	125/ 150	μA $\mu\text{A}(\text{max})$
G_m	Transconductance $\Delta I_{\text{OUT}}/\Delta V_{\text{REG}}$	$20\ \mu\text{A} \leq I_{\text{OUT}} \leq 1\text{ mA}$	3.3	1.5/ 0.75	1.0/ 0.5	mA/mV mA/mV(min)
		$1\text{ mA} \leq I_{\text{OUT}} \leq 15\text{ mA}$	6.0	3.3/ 2.0	2.5/ 1.7	mA/mV mA/mV(min)
A_V	Voltage Gain $\Delta V_{\text{OUT}}/\Delta V_{\text{REG}}$	$1\text{V} \leq V_{\text{OUT}} \leq V_{\text{REG}} - 1.2\text{V}$ (-1.3) $R_L = 250\ \Omega$ (Note 6)	1000	750/ 350	650/ 300	V/V V/V(min)
		$1\text{V} \leq V_{\text{OUT}} \leq V_{\text{REG}} - 1.2\text{V}$ (-1.3) $R_L = 2\text{ k}\Omega$	3500	1500/ 900	1000/ 700	V/V V/V(min)
V_{SAT}	Output Saturation (Note 7)	$V(\text{IN}) = V_{\text{REG}} + 100\text{ mV}$ $I_{\text{OUT}} = 15\text{ mA}$	1.0	1.2/ 1.3	1.2/ 1.3	V V(max)
I_L	Output Leakage Current	$V(\text{IN}) = V_{\text{REG}} - 100\text{ mV}$ $V_{\text{OUT}} = 0\text{V}$	0.1	0.5/ 1.0	0.5/ 1.0	μA $\mu\text{A}(\text{max})$
R_f	Internal Feedback Resistor (Note 8)		94	118 70	118 70	k Ω k Ω (max) k Ω (min)
E_n	Output Noise Voltage	$I_{\text{OUT}} = 1\text{ mA}$, $10\text{ Hz} \leq f \leq 10\text{ kHz}$	80			μV_{RMS}

Note 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 guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Note 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 $(P_{\text{Dmax}} = T_{\text{Jmax}} - T_{\text{A}})/\theta_{\text{JA}}$ 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 M5 package.

Note 3: The human body model is a 100 pF capacitor discharged through a 1.5 k Ω resistor into each pin.

Note 4: Typical numbers are at 25°C and represent the most likely parametric norm.

Note 5: Limits are 100% production tested at 25°C. Limits over the operating temperature range are guaranteed through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate National's Averaging Outgoing Level (AOQL).

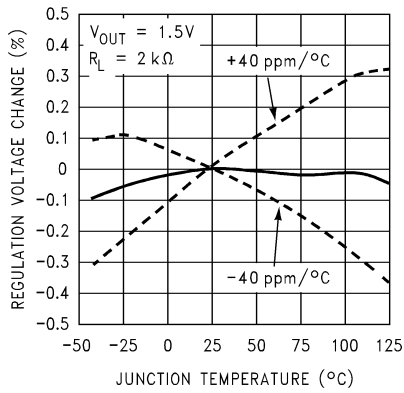
Note 6: Actual test is done using equivalent current sink instead of a resistor load.

Note 7: $V_{\text{SAT}} = V(\text{IN}) - V_{\text{OUT}}$, when the voltage at the IN pin is forced 100 mV above the nominal regulating voltage (V_{REG}).

Note 8: See Applications and Curves sections for information on this resistor.

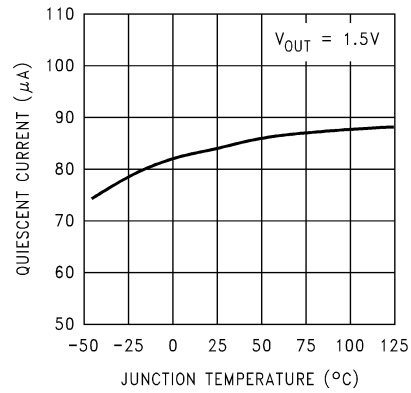
Typical Performance Characteristics

Normalized Temperature Drift



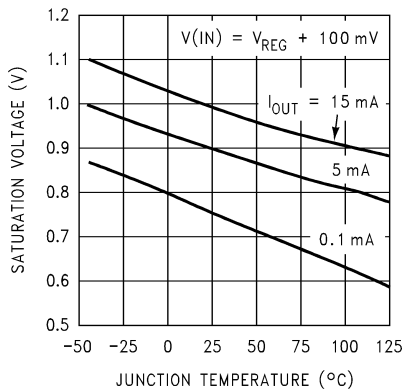
01198730

Quiescent Current



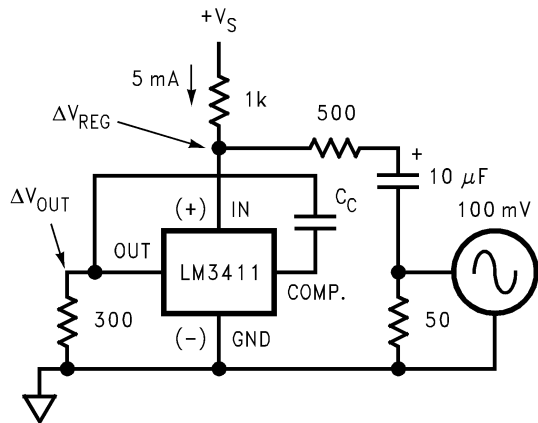
01198731

Output Saturation Voltage (V_{SAT})



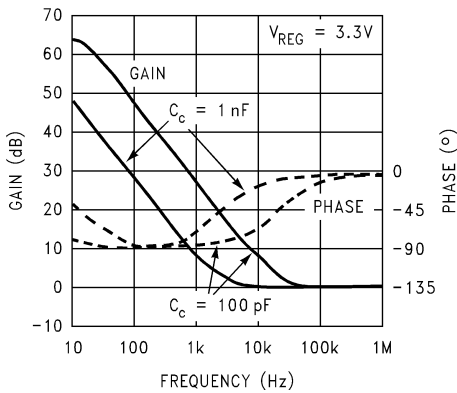
01198732

Circuit Used for Bode Plots



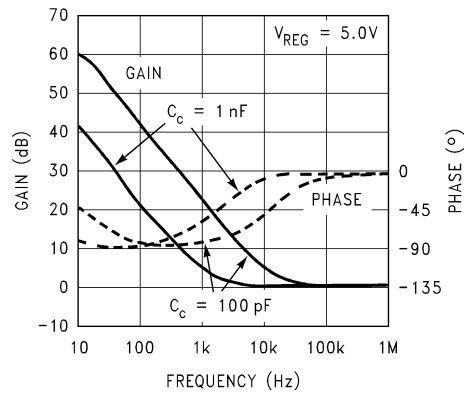
01198708

Bode Plot



01198733

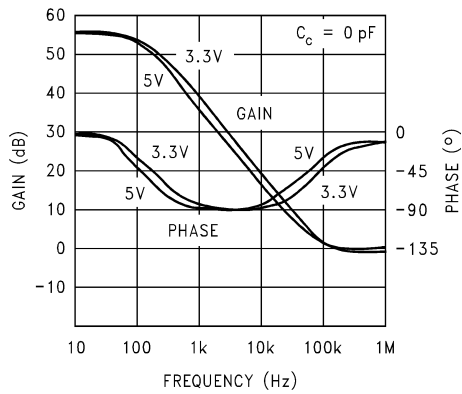
Bode Plot



01198734

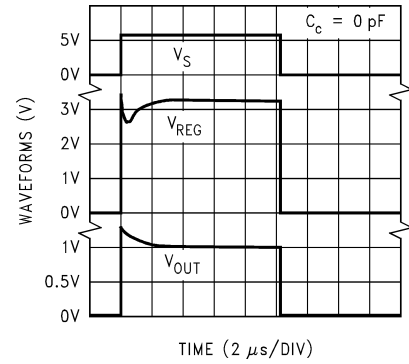
Typical Performance Characteristics (Continued)

Bold Plot



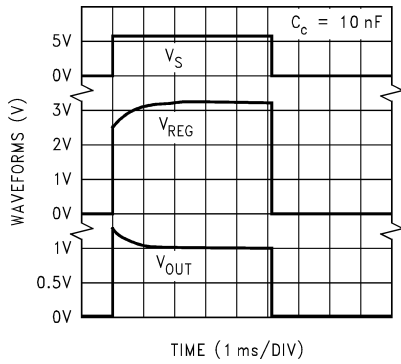
01198744

Response Time for 3.3V Version ($C_c = 0 \text{ pF}$)



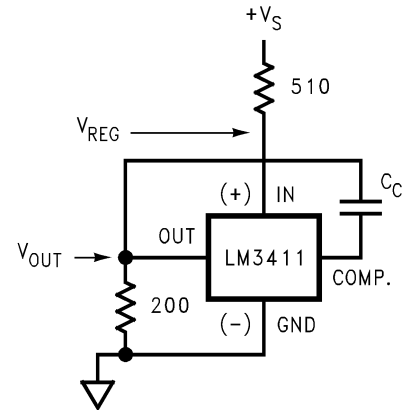
01198735

Response Time for 3.3V Version ($C_c = 10 \text{ nF}$)



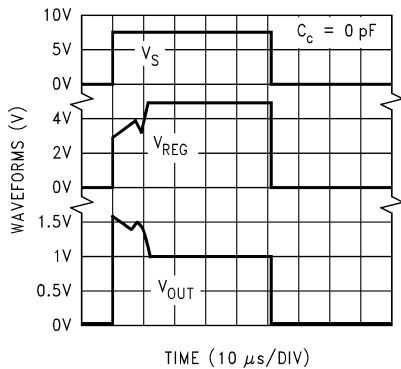
01198736

Circuit Used for Response Time



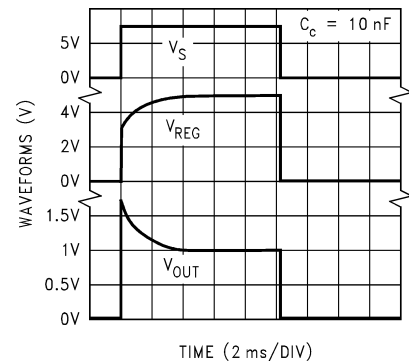
01198711

Response Time for 5V Version ($C_c = 0 \text{ pF}$)



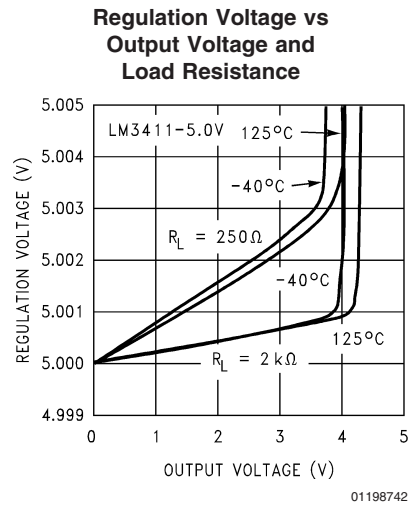
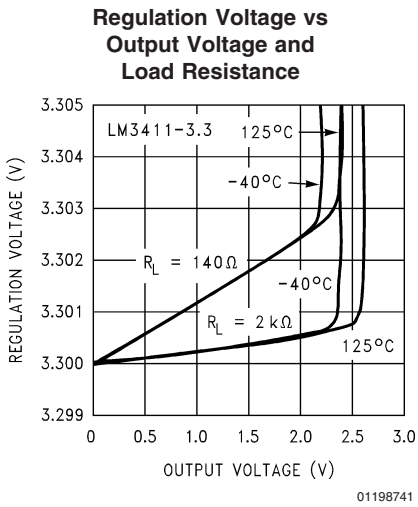
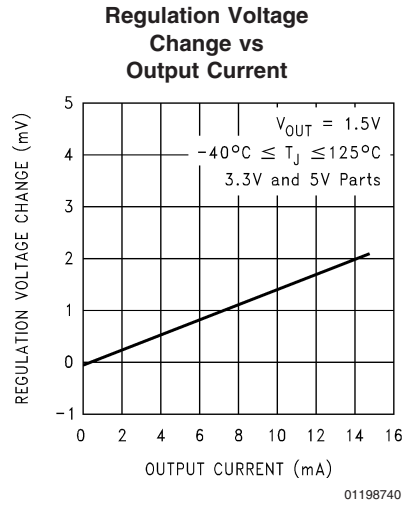
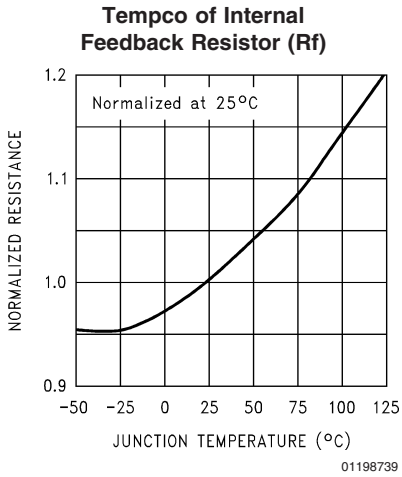
01198737

Response Time for 5V Version ($C_c = 10 \text{ nF}$)



01198738

Typical Performance Characteristics (Continued)



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 serves 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;

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

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

where $R_f \approx 52 \text{ k}\Omega$ for the 3.3V part, and $R_f \approx 94 \text{ k}\Omega$ for the 5V part.

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 curves 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 2* 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.

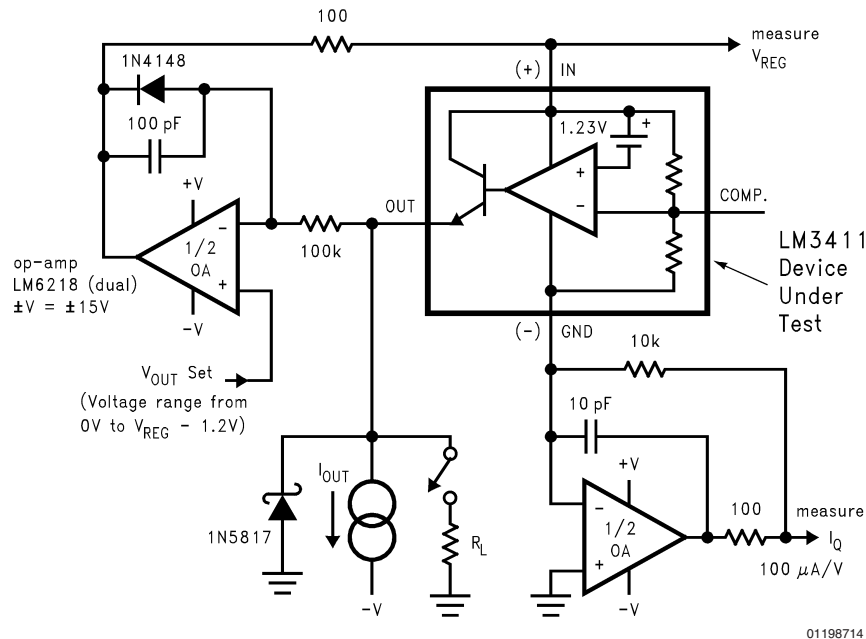
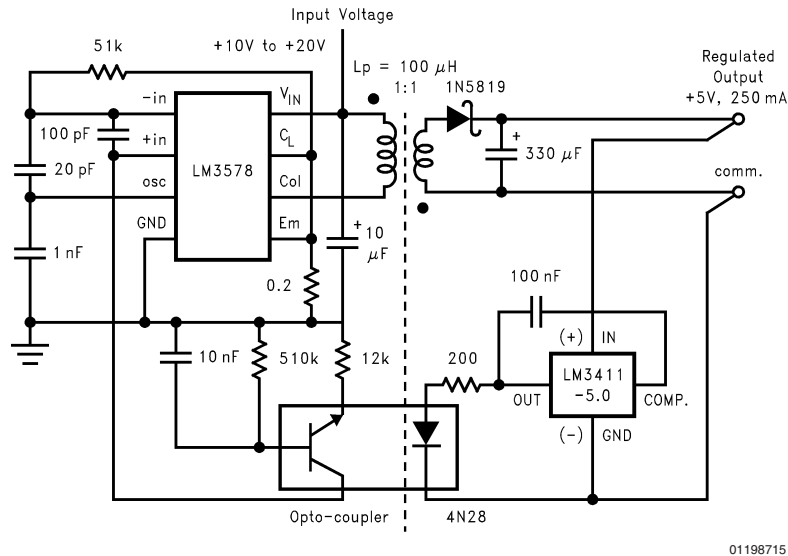


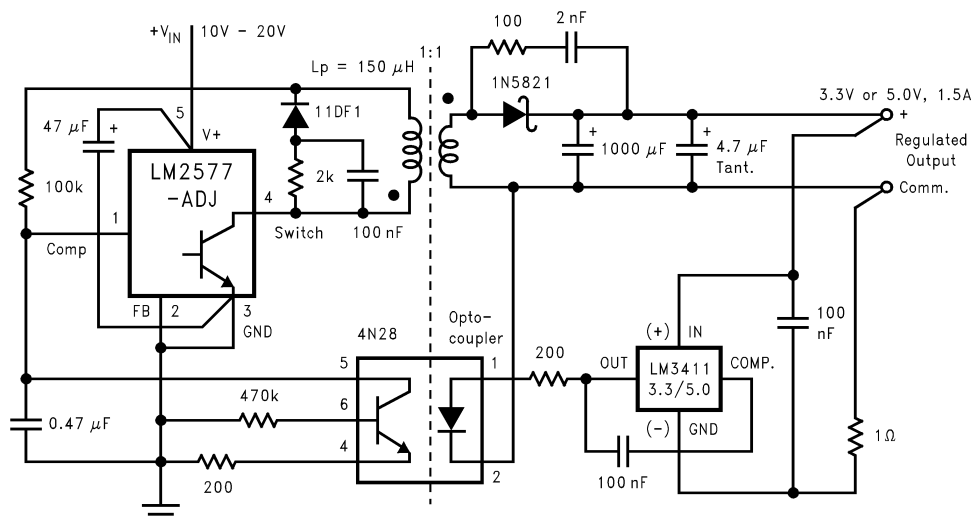
FIGURE 2. LM3411 Test Circuit

Applications Information



01198715

FIGURE 3. Isolated 250 mA Flyback Switching Regulator



01198716

FIGURE 4. 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 3 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 4. 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.

Applications Information (Continued)

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.

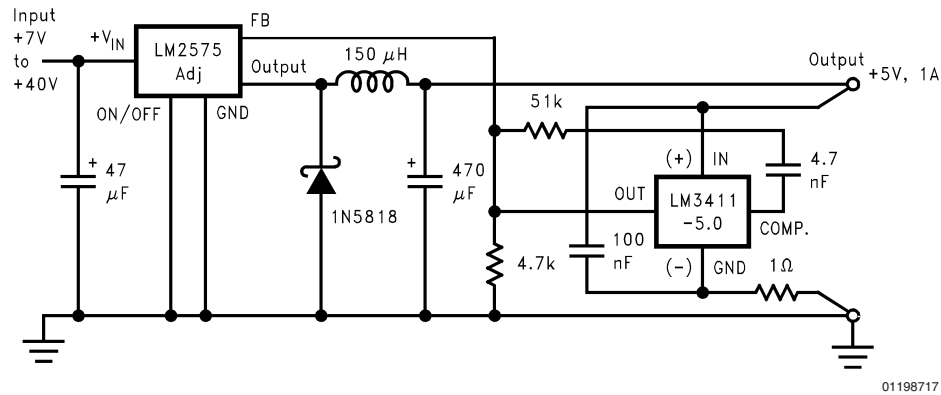


FIGURE 5. Precision 1A Buck Regulator

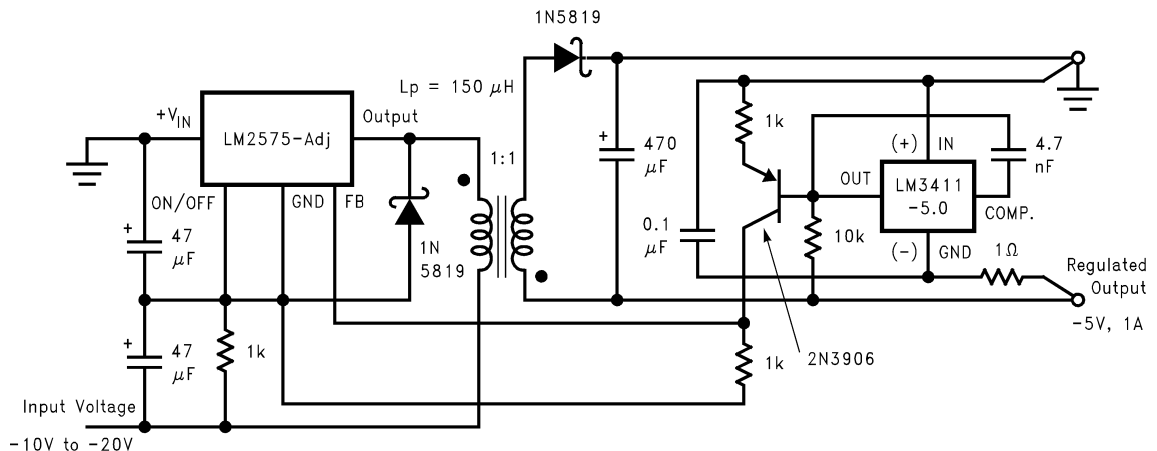


FIGURE 6. Negative Input, Negative or Positive Output Flyback Regulator

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 5* can provide a 5V , $\pm 0.5\%$ 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 – 1 A .

A DC-DC flyback converter that accepts a negative input voltage, and delivers either a positive or negative output is shown in *Figure 6*. 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 1 A low dropout linear regulator results in a 5V $\pm 0.5\%$ (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 , 1 A regulator circuit featuring low dropout, very good regulation specifications, self protection features and allows output voltage sensing is shown in *Figure 7*. The regulator used is a LM2941 adjustable low dropout positive regulator, which also features an ON/OFF pin to provide a shutdown feature.

Applications Information (Continued)

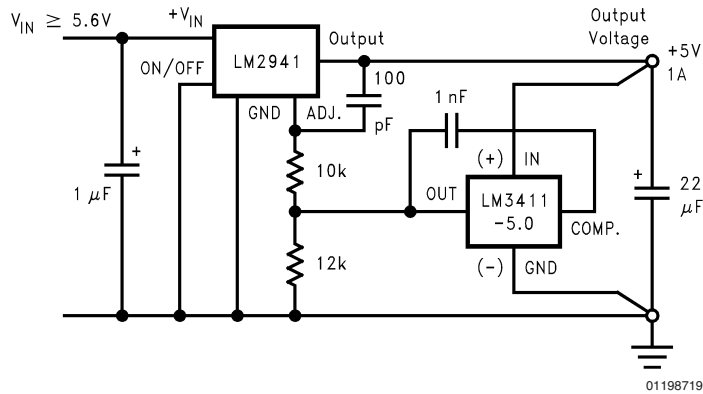


FIGURE 7. Precision 5V 1A Low Dropout Regulator

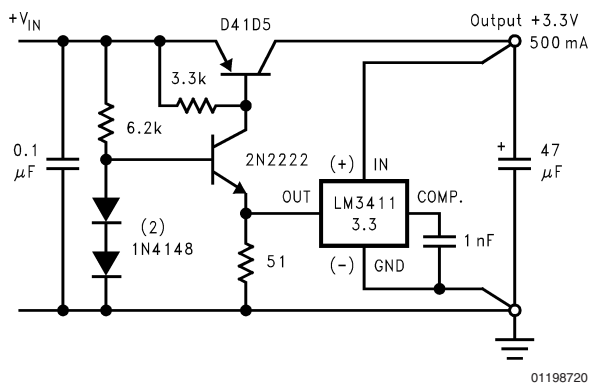


FIGURE 8. 3.3V 0.5A Low Dropout Regulator

The circuit in *Figure 8* 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 9* 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 $\pm 10\%$ 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 9* can provide a current limit accuracy that is better than $\pm 4\%$, over all possible variations, in addition to having excellent line, load and temperature specifications.

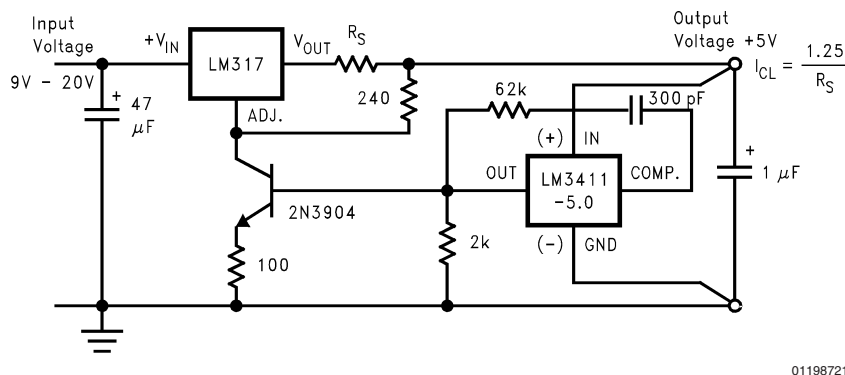
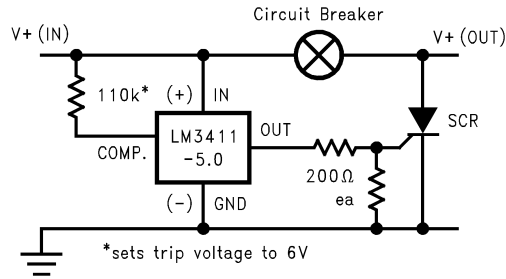


FIGURE 9. Precision Positive Voltage Regulator with Accurate Current Limit

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 10* adds the precision current

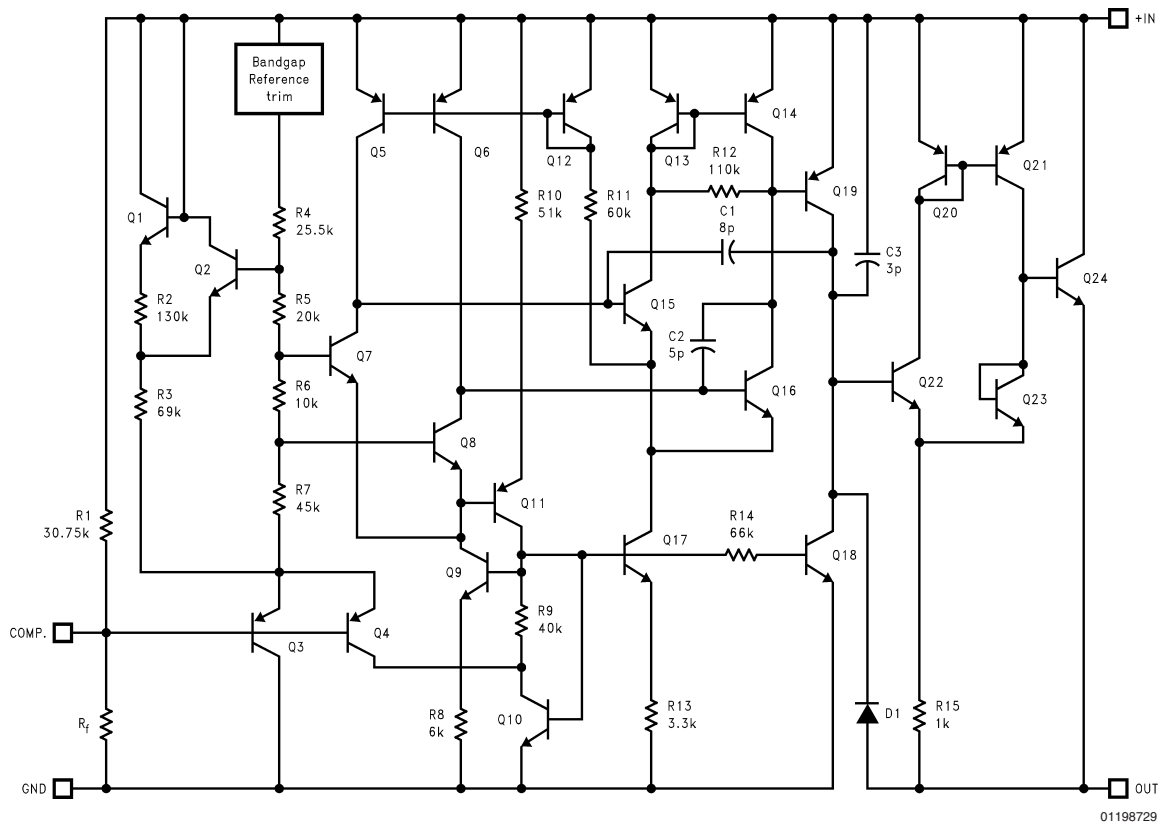
Applications Information (Continued)



01198728

FIGURE 16. Overtoltage Crowbar

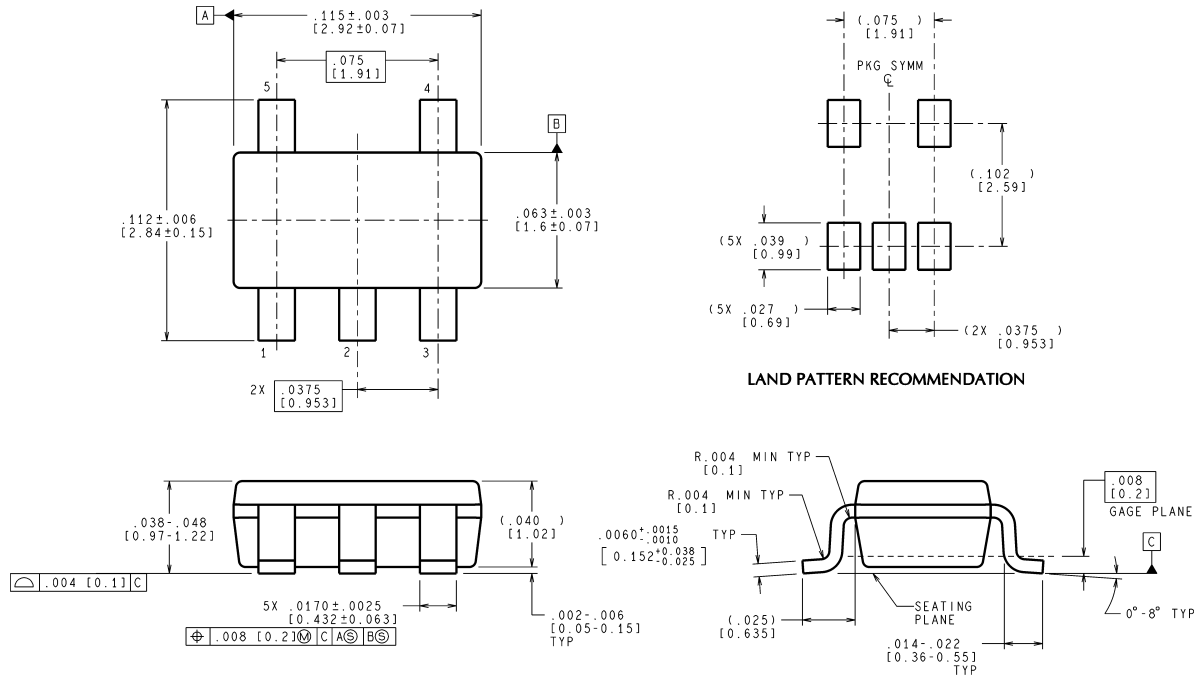
Schematic Diagram



01198729

Physical Dimensions inches (millimeters)

unless otherwise noted



CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS

MF05A (Rev B)

5-Lead Small Outline Package (M5)
Order Number LM3411M5-3.3, LM3411AM5-3.3,
LM3411M5-5.0 or LM3411AM5-5.0
NS Package Number MF05A

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

For the most current product information visit us at www.national.com.


LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

BANNED SUBSTANCE COMPLIANCE

National Semiconductor manufactures products and uses packing materials that meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.

 **National Semiconductor**
Americas Customer Support Center
 Email: new.feedback@nsc.com
 Tel: 1-800-272-9959

National Semiconductor
Europe Customer Support Center
 Fax: +49 (0) 180-530 85 86
 Email: europe.support@nsc.com
 Deutsch Tel: +49 (0) 69 9508 6208
 English Tel: +44 (0) 870 24 0 2171
 Français Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer Support Center
 Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
 Fax: 81-3-5639-7507
 Email: jpn.feedback@nsc.com
 Tel: 81-3-5639-7560

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

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

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

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

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

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Mobile Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Transportation and Automotive	www.ti.com/automotive
Video and Imaging	www.ti.com/video

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated