

SBOS074C – SEPTEMBER 1997 – REVISED SEPTEMBER 2005

Precision Lowest-Cost ISOLATION AMPLIFIER

FEATURES

- 100% TESTED FOR HIGH-VOLTAGE BREAKDOWN
- RATED 1500Vrms
- HIGH IMR: 140dB at 60Hz
- 0.010% max NONLINEARITY
- BIPOLAR OPERATION: $V_O = \pm 10V$
- DIP-16 AND SO-28
- EASE OF USE: Fixed Unity Gain Configuration
- $\pm 4.5V$ to $\pm 18V$ SUPPLY RANGE

DESCRIPTION

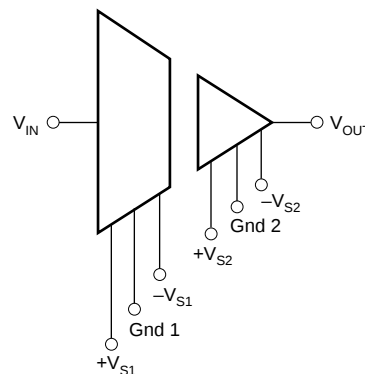
The ISO124 is a precision isolation amplifier incorporating a novel duty cycle modulation-demodulation technique. The signal is transmitted digitally across a 2pF differential capacitive barrier. With digital modulation, the barrier characteristics do not affect signal integrity, resulting in excellent reliability and good high-frequency transient immunity across the barrier. Both barrier capacitors are imbedded in the plastic body of the package.

The ISO124 is easy to use. No external components are required for operation. The key specifications are 0.010% max nonlinearity, 50kHz signal bandwidth, and $200\mu V/^\circ C$ V_{OS} drift. A power supply range of $\pm 4.5V$ to $\pm 18V$ and quiescent currents of $\pm 5.0mA$ on V_{S1} and $\pm 5.5mA$ on V_{S2} make these amplifiers ideal for a wide range of applications.

The ISO124 is available in DIP-16 and SO-28 plastic surface mount packages.

APPLICATIONS

- INDUSTRIAL PROCESS CONTROL:
Transducer Isolator, Isolator for Thermocouples, RTDs, Pressure Bridges, and Flow Meters, 4-20mA Loop Isolation
- GROUND LOOP ELIMINATION
- MOTOR AND SCR CONTROL
- POWER MONITORING
- PC-BASED DATA ACQUISITION
- TEST EQUIPMENT



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.

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

 **TEXAS
INSTRUMENTS**
www.ti.com

Copyright © 1997-2005, Texas Instruments Incorporated

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

Supply Voltage	±18V
V _{IN}	±100V
Continuous Isolation Voltage	1500Vrms
Junction Temperature	+150°C
Storage Temperature	+125°C
Output Short to Common	Continuous

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.

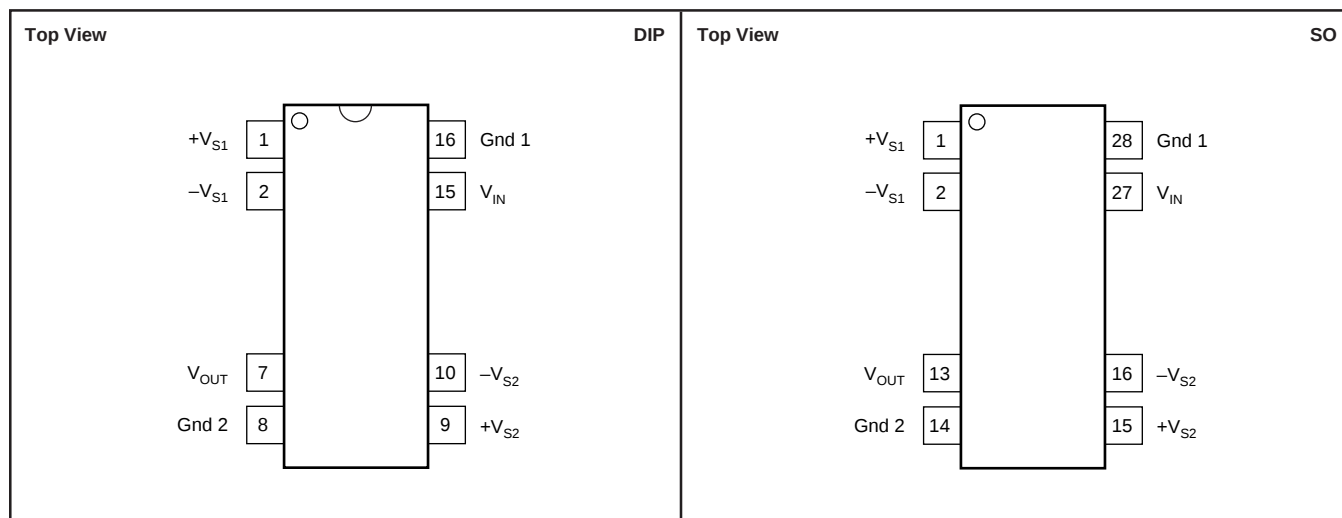
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION⁽¹⁾

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
ISO124P	Plastic DIP-16	NVF	–25°C to +85°C	ISO124P	ISO124P	Rails, 50
ISO124U	Plastic SO-28	DVA	–25°C to +85°C	ISO124U	ISO124U	Rails, 28
"	"	"	"	ISO124U	ISO124U/1K	Tape and Reel, 1000

NOTE: (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

PIN CONFIGURATIONS



ELECTRICAL CHARACTERISTICS

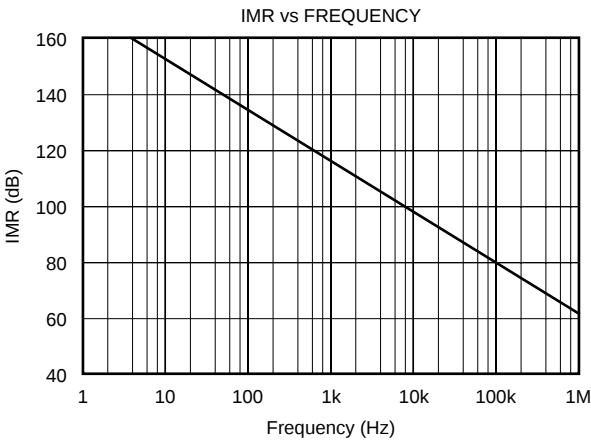
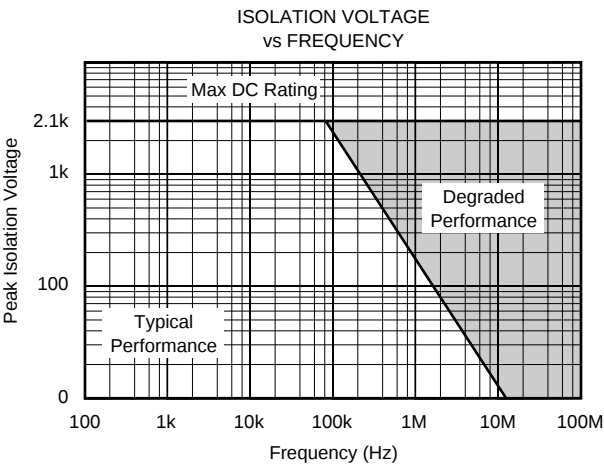
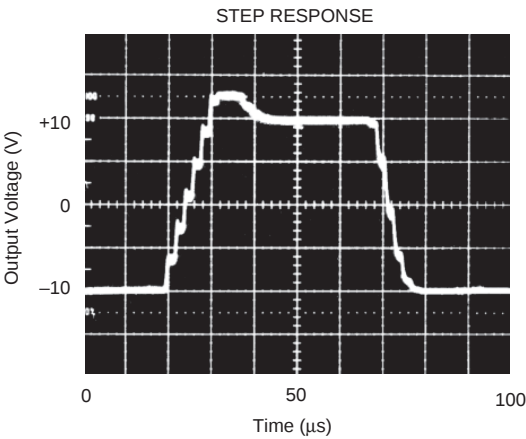
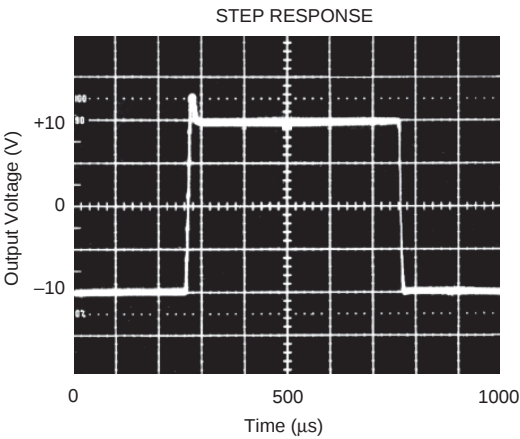
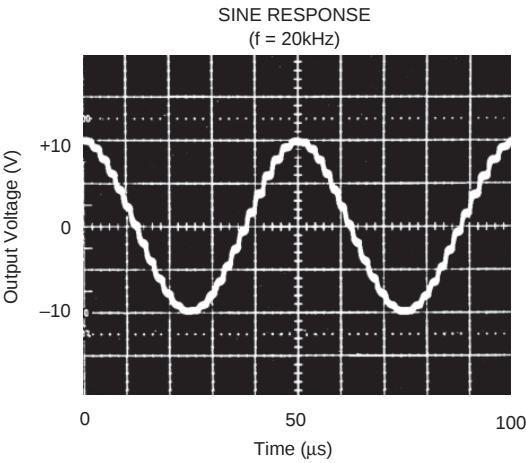
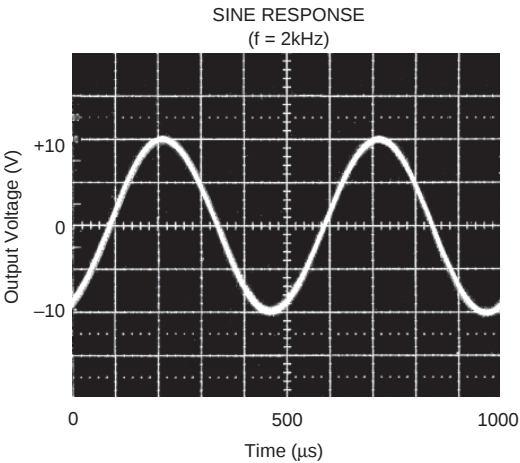
At $T_A = +25^\circ\text{C}$, $V_{S1} = V_{S2} = \pm 15\text{V}$, and $R_L = 2\text{k}\Omega$, unless otherwise noted.

PARAMETER	CONDITIONS	ISO124P, U			UNITS
		MIN	TYP	MAX	
ISOLATION Rated Voltage, continuous ac 60Hz 100% Test ⁽¹⁾ Isolation Mode Rejection Barrier Impedance Leakage Current at 60Hz	1s, 5pc PD 60Hz $V_{ISO} = 240\text{Vrms}$	1500 2400	140 $10^{14} \parallel 2$ 0.18	0.5	Vac Vac dB $\Omega \parallel \text{pF}$ μArms
GAIN Nominal Gain Gain Error Gain vs Temperature Nonlinearity ⁽²⁾	$V_O = \pm 10\text{V}$		1 ± 0.05 ± 10 ± 0.005	± 0.50 ± 0.010	V/V %FSR ppm/ $^\circ\text{C}$ %FSR
INPUT OFFSET VOLTAGE Initial Offset vs Temperature vs Supply Noise			± 20 ± 200 ± 2 4	± 50	mV $\mu\text{V}/^\circ\text{C}$ mV/V $\mu\text{V}/\sqrt{\text{Hz}}$
INPUT Voltage Range Resistance		± 10	± 12.5 200		V k Ω
OUTPUT Voltage Range Current Drive Capacitive Load Drive Ripple Voltage ⁽³⁾		± 10 ± 5	± 12.5 ± 15 0.1 20		V mA μF mVp-p
FREQUENCY RESPONSE Small-Signal Bandwidth Slew Rate Settling Time 0.1% 0.01% Overload Recovery Time	$V_O = \pm 10\text{V}$		50 2 50 350 150		kHz V/ μs μs μs μs
POWER SUPPLIES Rated Voltage Voltage Range Quiescent Current: V_{S1} V_{S2}		± 4.5	± 15 ± 5.0 ± 5.5	± 18 ± 7.0 ± 7.0	V V mA mA
TEMPERATURE RANGE Specification Operating Storage Thermal Resistance, θ_{JA} θ_{JC}		-25 -25 -40	100 65	+85 +85 +125	$^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}/\text{W}$ $^\circ\text{C}/\text{W}$

NOTES: (1) Tested at 1.6 X rated, fail on 5pC partial discharge. (2) Nonlinearity is the peak deviation of the output voltage from the best-fit straight line. It is expressed as the ratio of deviation to FSR. (3) Ripple frequency is at carrier frequency (500kHz).

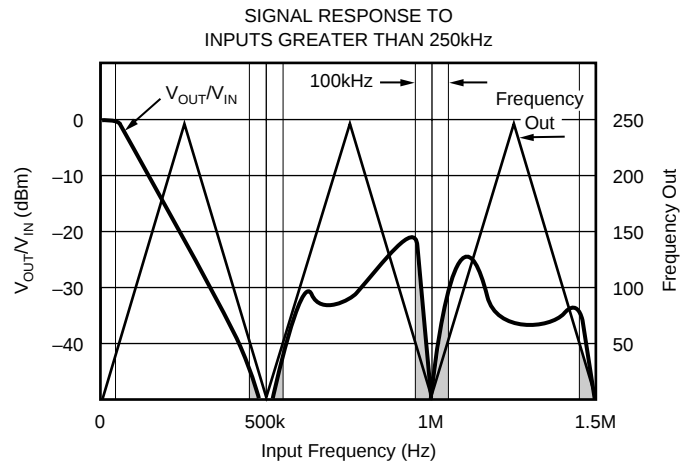
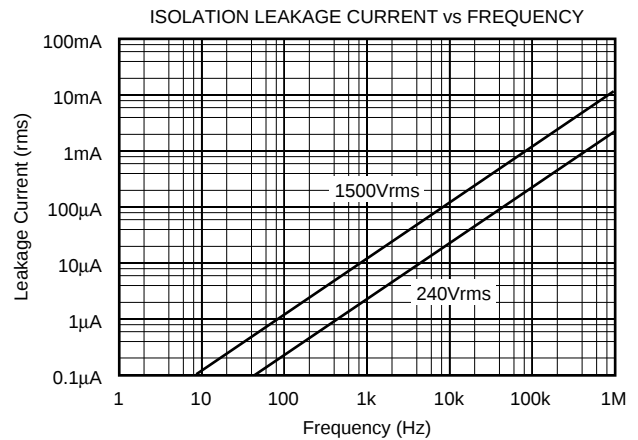
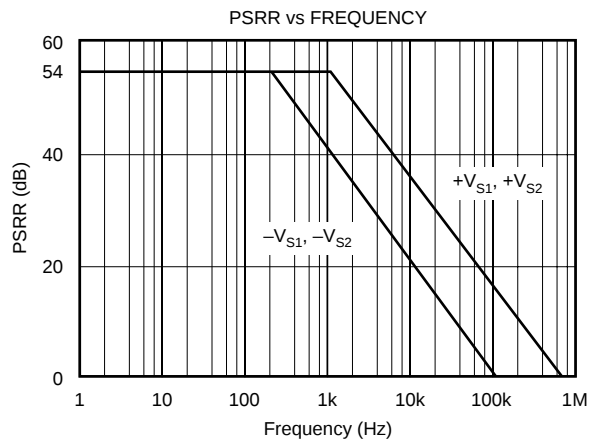
TYPICAL CHARACTERISTICS

At $T_A = +25^{\circ}\text{C}$, and $V_S = \pm 15\text{V}$, unless otherwise noted.



TYPICAL CHARACTERISTICS (Cont.)

At $T_A = +25^\circ\text{C}$, and $V_S = \pm 15\text{V}$, unless otherwise noted.



(NOTE: Shaded area shows aliasing frequencies that cannot be removed by a low-pass filter at the output.)

THEORY OF OPERATION

The ISO124 isolation amplifier uses an input and an output section galvanically isolated by matched 1pF isolating capacitors built into the plastic package. The input is duty-cycle modulated and transmitted digitally across the barrier. The output section receives the modulated signal, converts it back to an analog voltage and removes the ripple component inherent in the demodulation. Input and output sections are fabricated, then laser trimmed for exceptional circuitry matching common to both input and output sections. The sections are then mounted on opposite ends of the package with the isolating capacitors mounted between the two sections. The transistor count of the ISO124 is 250 transistors.

MODULATOR

An input amplifier (A1, as shown in Figure 1) integrates the difference between the input current ($V_{IN}/200k\Omega$) and a switched $\pm 100\mu A$ current source. This current source is implemented by a switchable $200\mu A$ source and a fixed $100\mu A$ current sink. To understand the basic operation of the modulator, assume that $V_{IN} = 0.0V$. The integrator will ramp in one direction until the comparator threshold is exceeded. The comparator and sense amp will force the current source to switch; the resultant signal is a triangular waveform with a 50% duty cycle. The internal oscillator forces the current source to switch at 500kHz. The resultant capacitor drive is a complementary duty-cycle modulation square wave.

DEMODULATOR

The sense amplifier detects the signal transitions across the capacitive barrier and drives a switched current source into integrator A2. The output stage balances the duty-cycle

modulated current against the feedback current through the $200k\Omega$ feedback resistor, resulting in an average value at the V_{OUT} pin equal to V_{IN} . The sample-and-hold amplifiers in the output feedback loop serve to remove undesired ripple voltages inherent in the demodulation process.

BASIC OPERATION

SIGNAL AND SUPPLY CONNECTIONS

Each power-supply pin should be bypassed with $1\mu F$ tantalum capacitors located as close to the amplifier as possible. The internal frequency of the modulator/demodulator is set at 500kHz by an internal oscillator. Therefore, if it is desired to minimize any feedthrough noise (beat frequencies) from a DC/DC converter, use a π filter on the supplies (see Figure 4). The ISO124 output has a 500kHz ripple of 20mV, which can be removed with a simple 2-pole low-pass filter with a 100kHz cutoff using a low-cost op amp (see Figure 4).

The input to the modulator is a current (set by the $200k\Omega$ integrator input resistor) that makes it possible to have an input voltage greater than the input supplies, as long as the output supply is at least $\pm 15V$. It is therefore possible, when using an unregulated DC/DC converter, to minimize PSR related output errors with $\pm 5V$ voltage regulators on the isolated side and still get the full $\pm 10V$ input and output swing. See Figure 9 for an example of this application.

CARRIER FREQUENCY CONSIDERATIONS

The ISO124 amplifier transmits the signal across the isolation barrier by a 500kHz duty-cycle modulation technique. For input signals having frequencies below 250kHz, this system works like any linear amplifier. But for frequencies

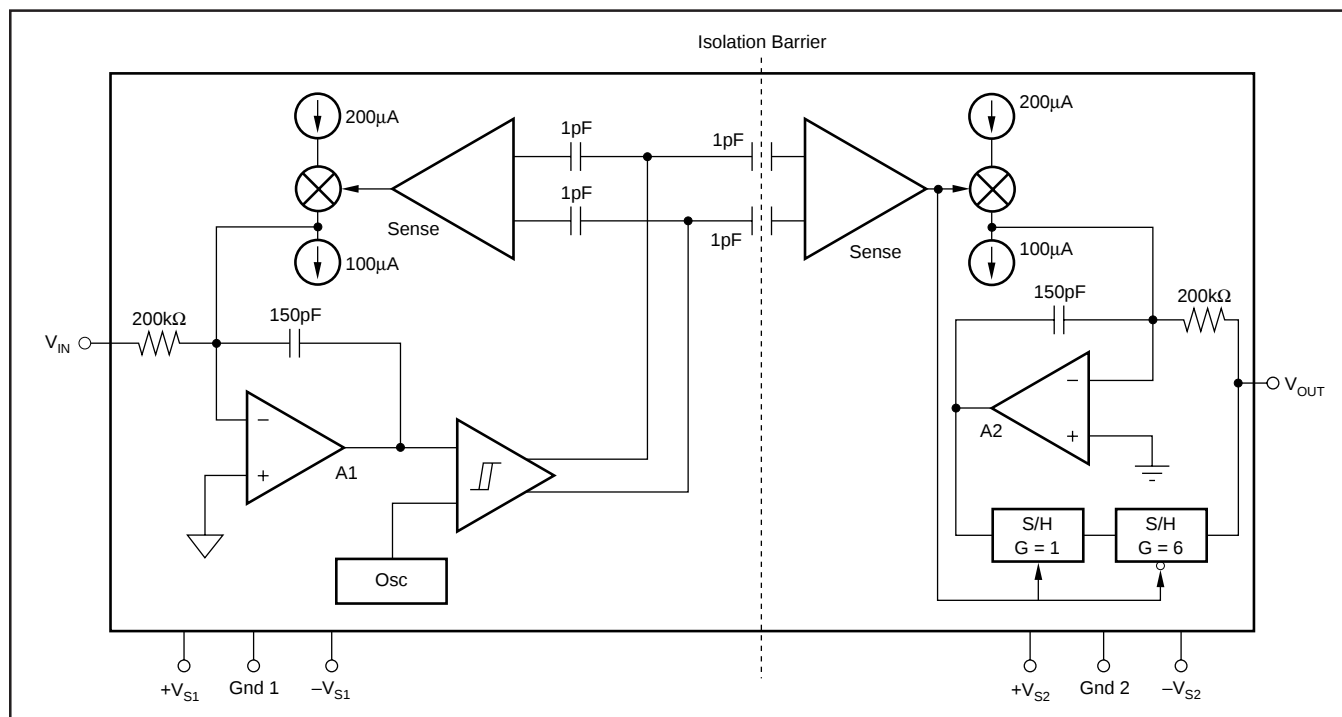


FIGURE 1. Block Diagram.

ISOLATION MODE VOLTAGE INDUCED ERRORS

HIGH IMV dV/dt ERRORS

HIGH VOLTAGE TESTING

This new test method represents the “state-of-the-art” for non-destructive high-voltage reliability testing. It is based on the effects of non-uniform fields that exist in heterogeneous dielectric material during barrier degradation. In the case of void non-uniformities, electric field stress begins to ionize the void region before bridging the entire high-voltage barrier. The transient conduction of charge during and after the ionization can be detected externally as a burst of 0.01-0.1μs current pulses that repeat on each ac voltage cycle. The minimum ac barrier voltage that initiates partial discharge is defined as the “inception voltage.” Decreasing the barrier voltage to a lower level is required before partial discharge ceases and is defined as the “extinction voltage.” We have characterized and developed the package insulation processes to yield an inception voltage in excess of 2400Vrms so that transient overvoltages below this level will not damage the ISO124. The extinction voltage is above 1500Vrms so that even overvoltage induced partial discharge will cease once the barrier voltage is reduced to the 1500Vrms (rated) level. Older high-voltage test methods relied on applying a large enough overvoltage (above rating) to break down marginal parts, but not so high as to damage good ones. Our new partial discharge testing gives us more confidence in barrier reliability than breakdown/no breakdown criteria.

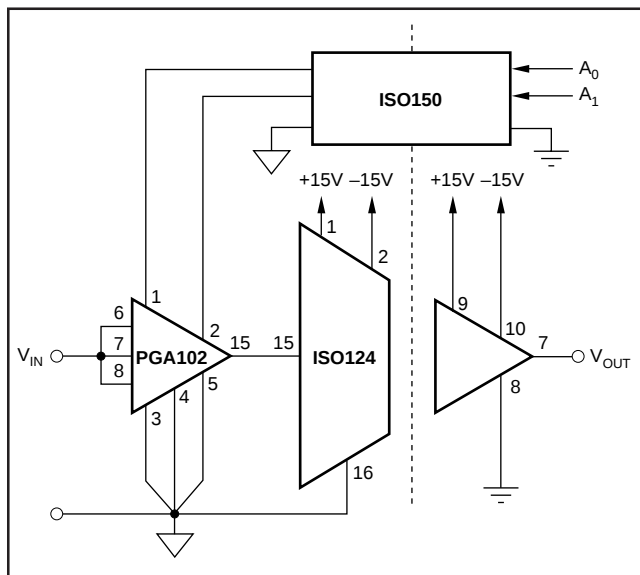


FIGURE 3. Programmable-Gain Isolation Channel with Gains of 1, 10, and 100.

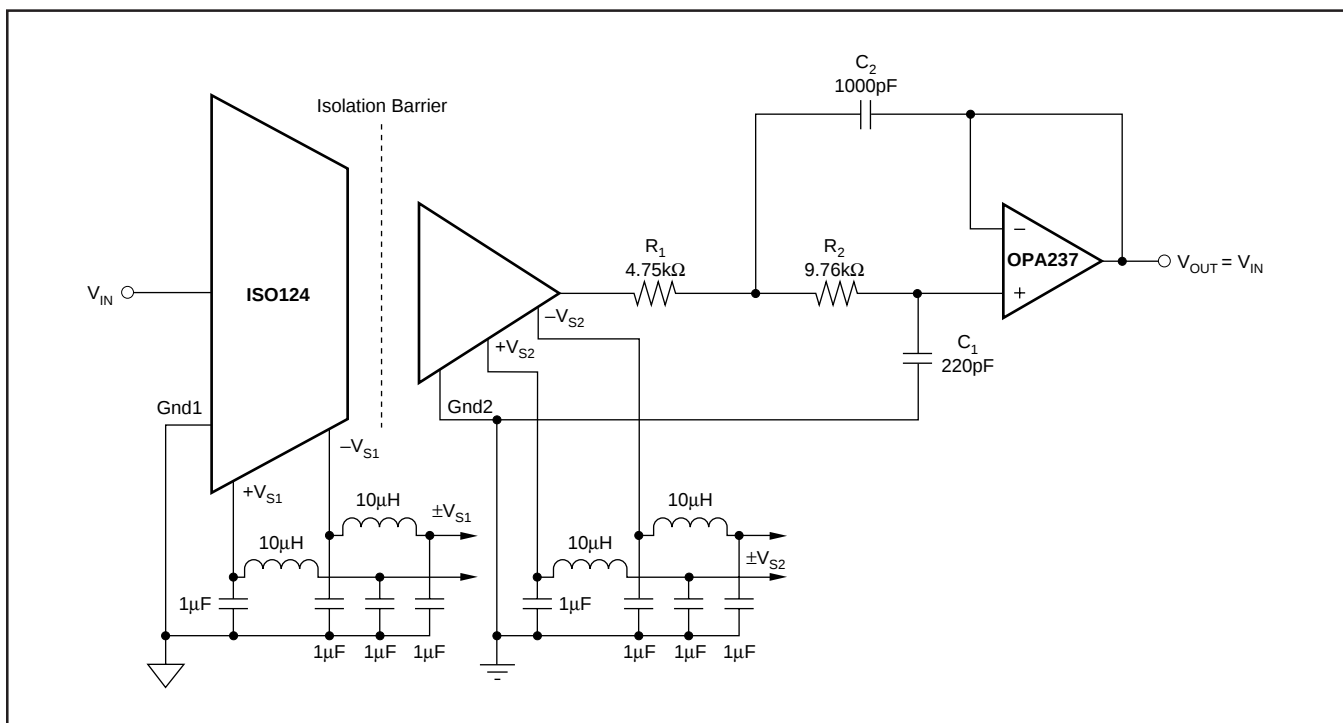


FIGURE 4. Optional π Filter to Minimize Power-Supply Feedthrough Noise; Output Filter to Remove 500kHz Carrier Ripple. For more information concerning output filters refer to Application Notes SBOA012 and SBFA001.

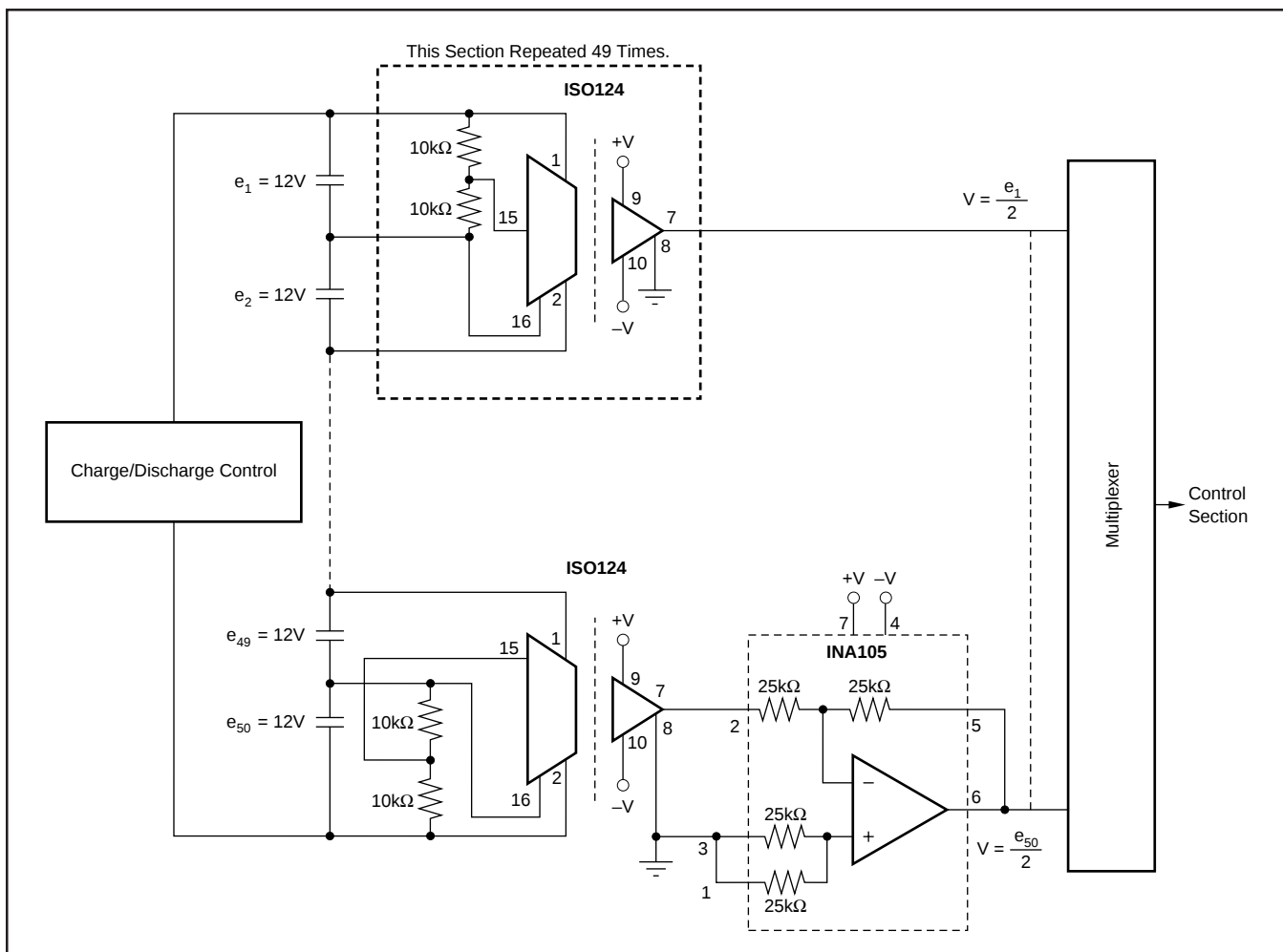


FIGURE 5. Battery Monitor for a 600V Battery Power System. (Derives input power from the battery.)

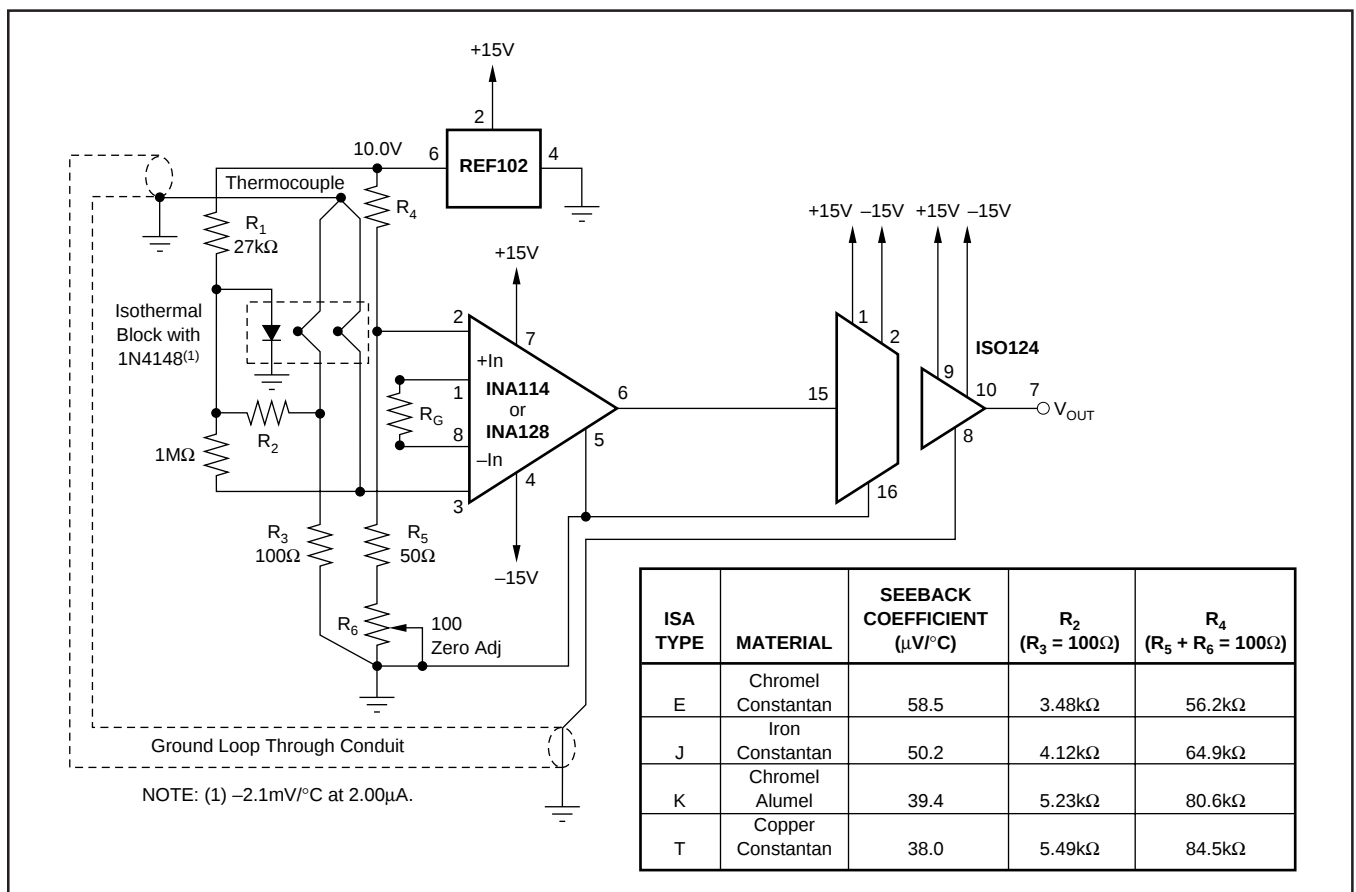


FIGURE 6. Thermocouple Amplifier with Ground Loop Elimination, Cold Junction Compensation, and Up-scale Burn-out.

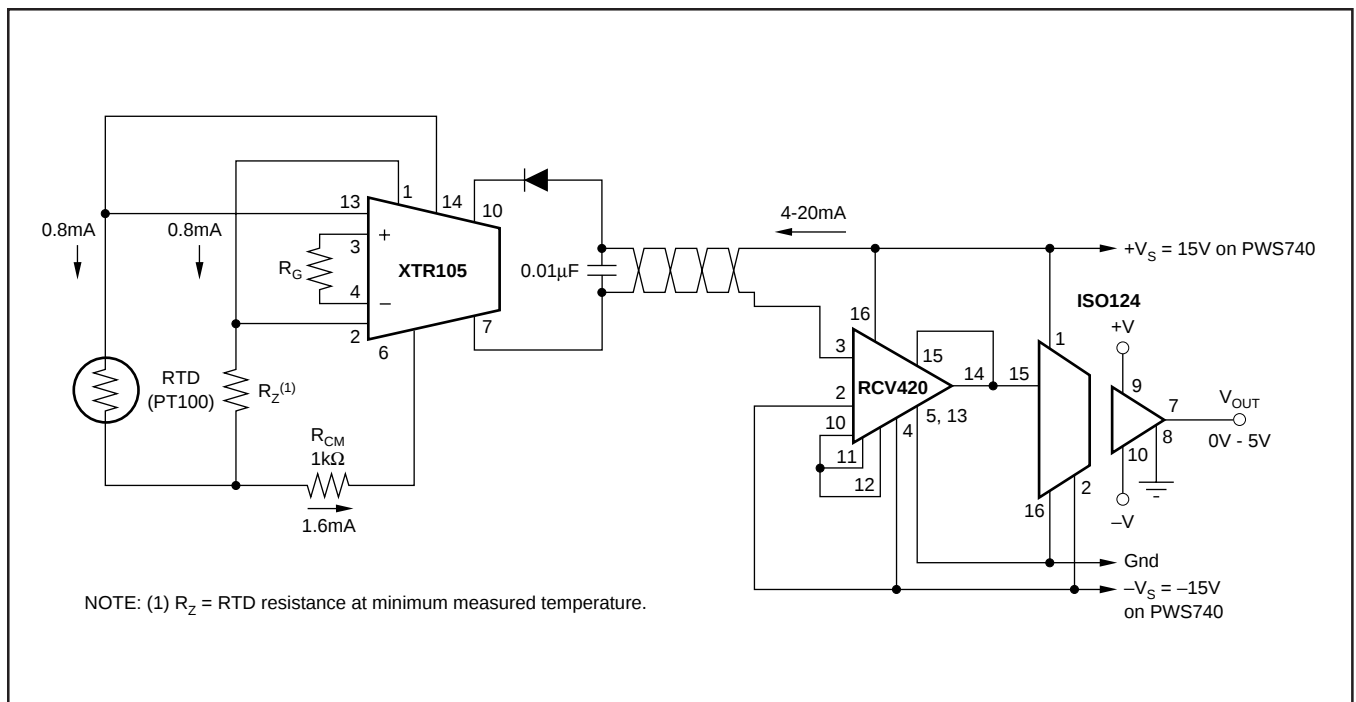


FIGURE 7. Isolated 4-20mA Instrument Loop. (RTD shown.)



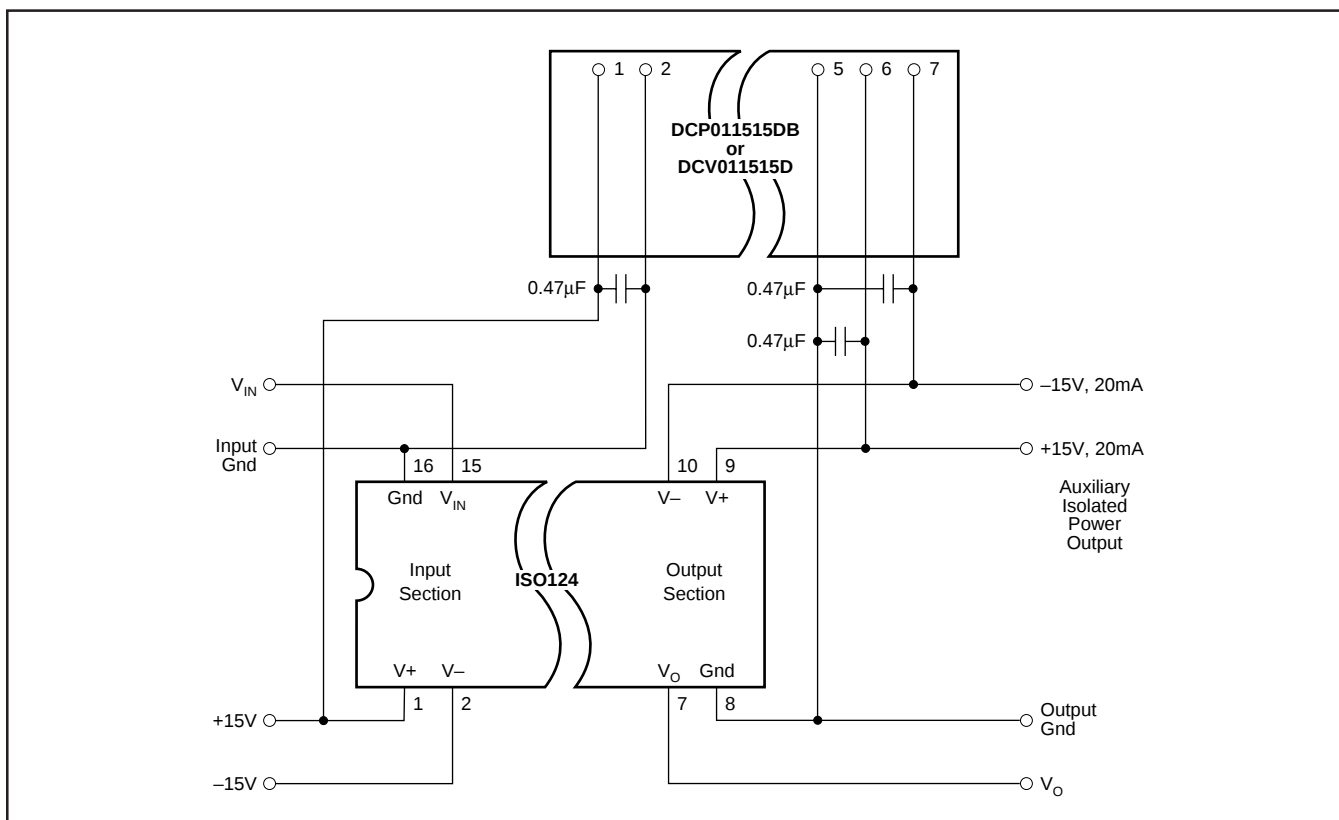


FIGURE 11. Input-Side Powered ISO Amp.

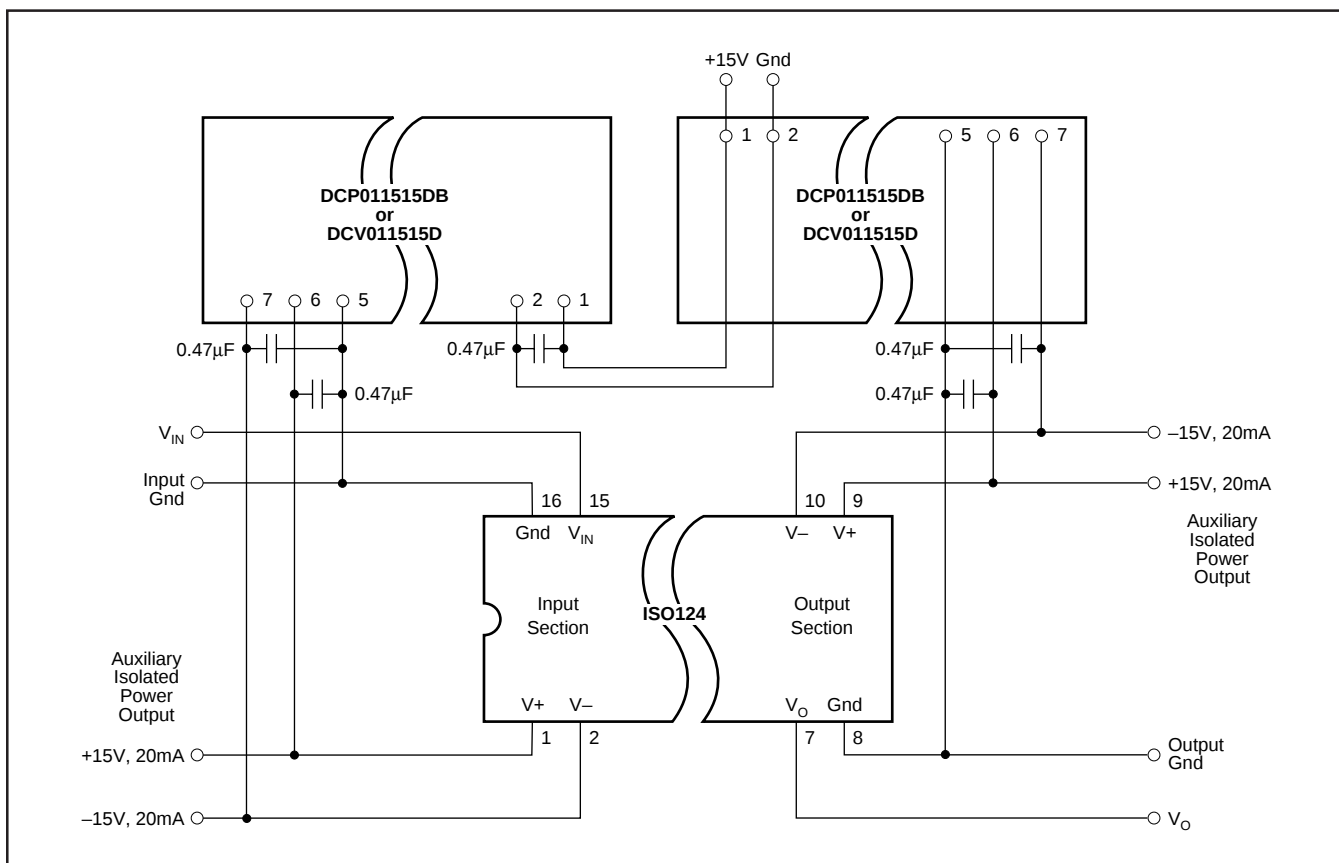


FIGURE 12. Powered ISO Amp with Three-Port Isolation.

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
ISO124P	ACTIVE	PDIP	NVF	8	50	TBD	Call TI	Level-NA-NA-NA
ISO124U	ACTIVE	SO	DVA	8	28	TBD	CU NIPDAU	Level-3-220C-168 HR
ISO124U/1K	ACTIVE	SO	DVA	8	1000	TBD	CU NIPDAU	Level-3-220C-168 HR

⁽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) 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.

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.

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

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

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
ISO124P	ACTIVE	PDIP	NVF	8	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
ISO124U	ACTIVE	SO	DVA	8	28	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
ISO124U/1K	ACTIVE	SO	DVA	8	1000	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
ISO124U/1KE4	ACTIVE	SO	DVA	8	1000	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
ISO124UE4	ACTIVE	SO	DVA	8	28	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR

⁽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.

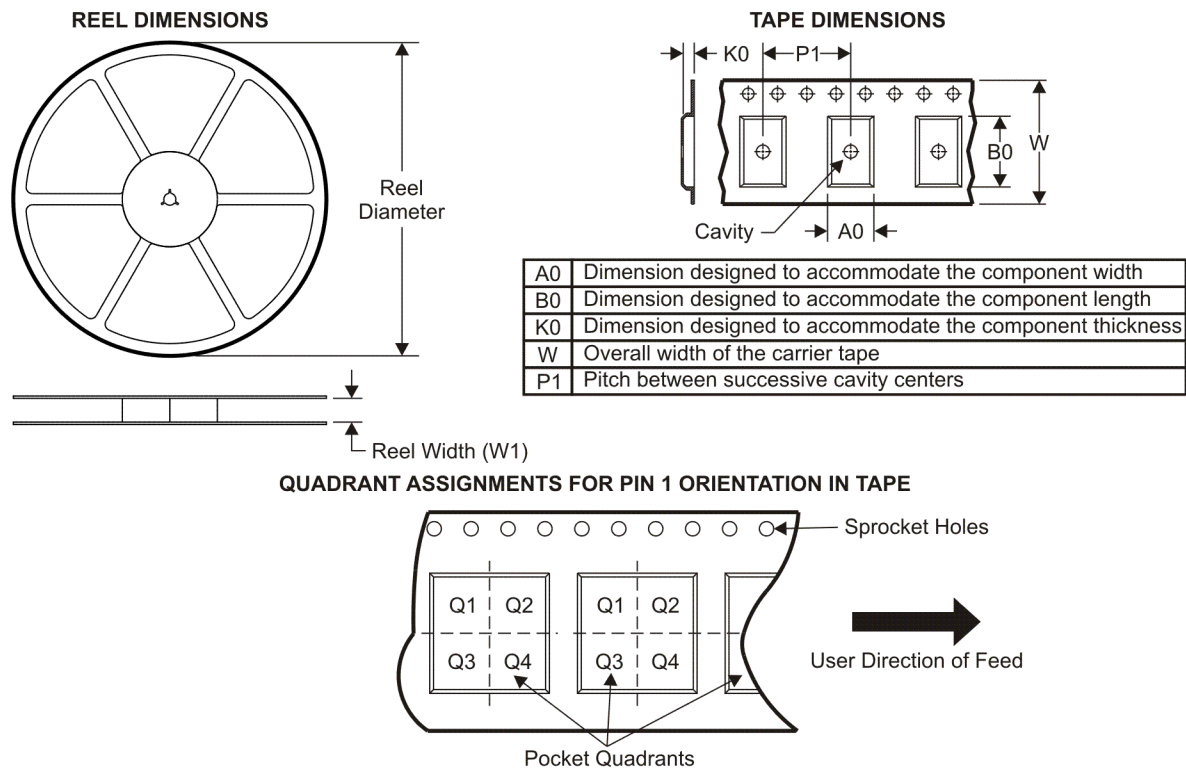
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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

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

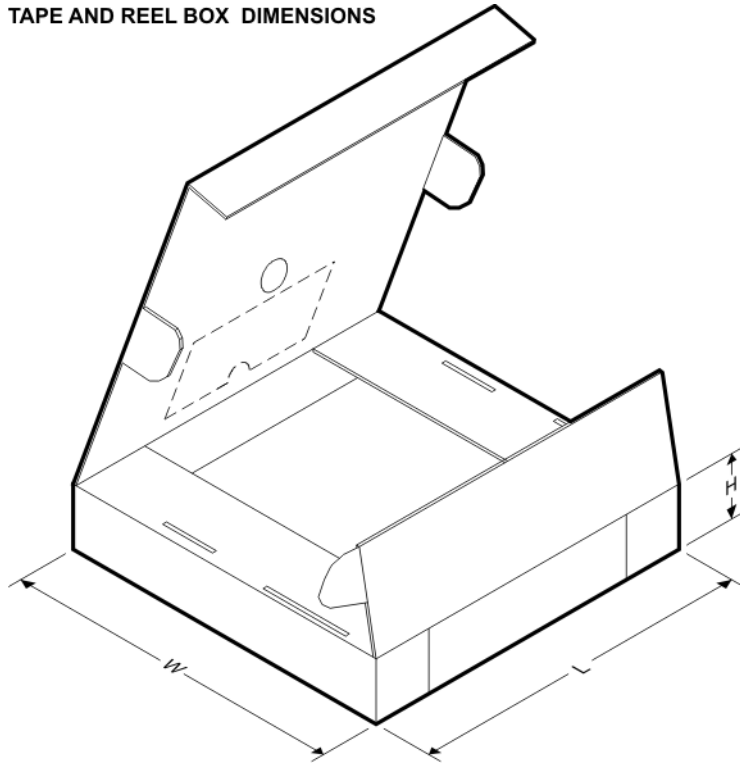
TAPE AND REEL INFORMATION



*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
ISO124U/1K	SO	DVA	8	1000	330.0	24.4	10.9	18.3	3.2	12.0	24.0	Q1

TAPE AND REEL BOX DIMENSIONS

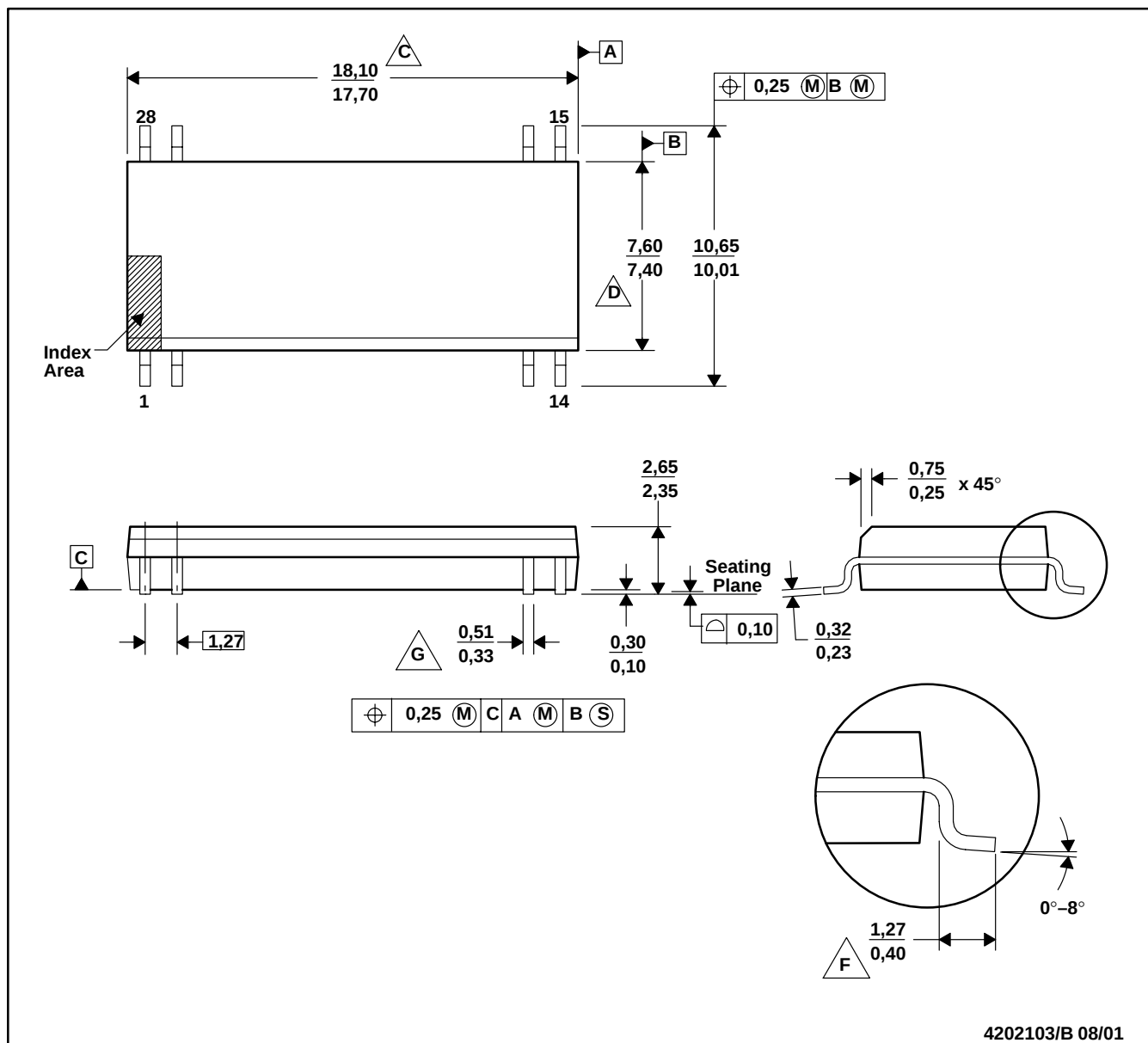


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
ISO124U/1K	SO	DVA	8	1000	346.0	346.0	41.0

DVA (R-PDSO-G8/28)

PLASTIC SMALL-OUTLINE



NOTES: A. All linear dimensions are in millimeters.

B. This drawing is subject to change without notice.

C. Body length dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, and gate burrs shall not exceed 0,15 mm per side.

D. Body width dimension does not include inter-lead flash or protrusions. Inter-lead flash and protrusions shall not exceed 0,25 mm per side.

E. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the cross-hatched area.

F. Lead dimension is the length of terminal for soldering to a substrate.

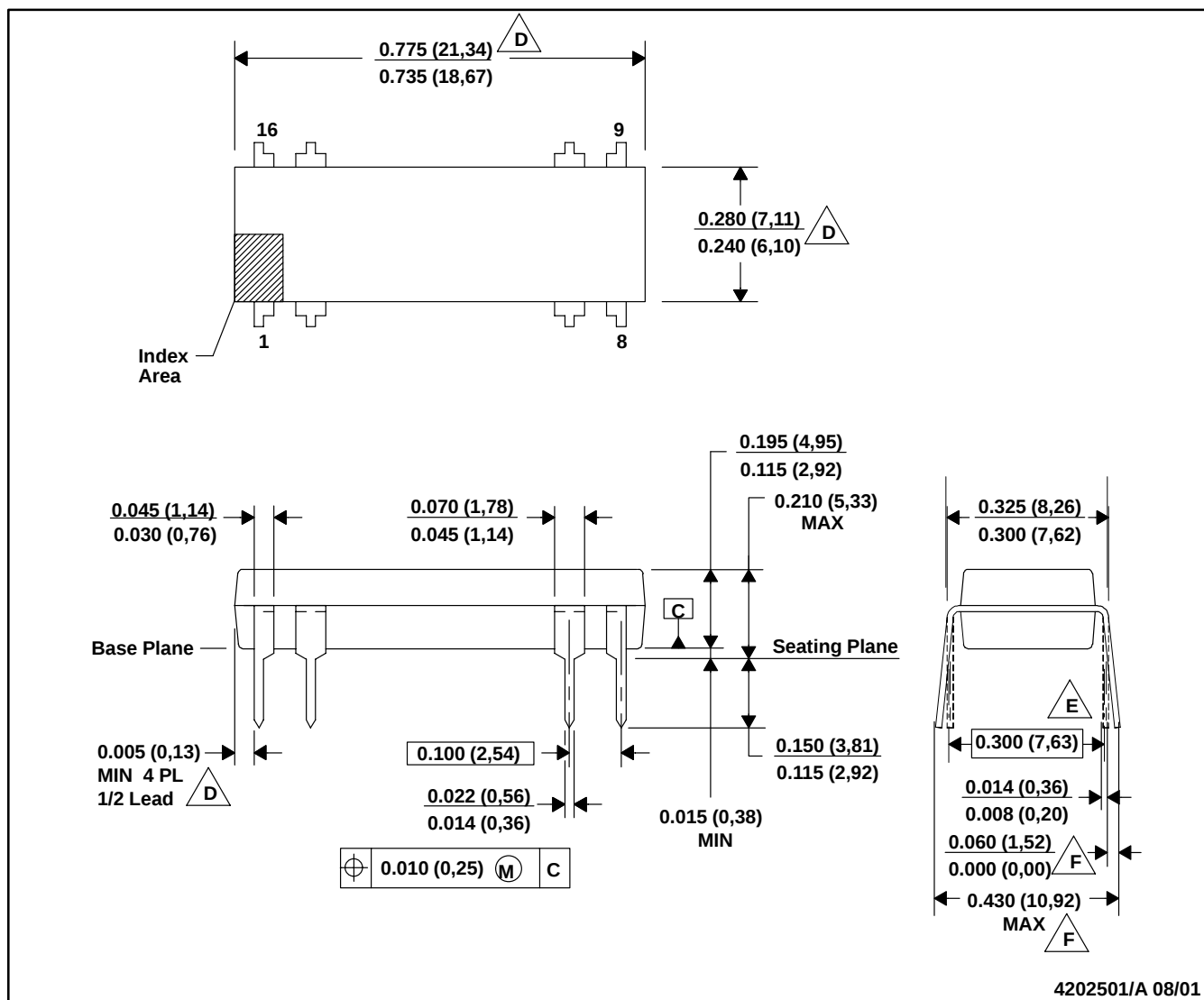
G. Lead width, as measured 0,36 mm or greater above the seating plane, shall not exceed a maximum value of 0,61 mm.

H. Lead-to-lead coplanarity shall be less than 0,10 mm from seating plane.

I. Falls within JEDEC MS-013-AE with the exception of the number of leads.

NVF (R-PDIP-T8/16)

PLASTIC DUAL-IN-LINE



- A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-001-BB with the exception of lead count.

D. Dimensions do not include mold flash or protrusions.
 Mold flash or protrusions shall not exceed 0.010 (0,25).

E. Dimensions measured with the leads constrained to be perpendicular to Datum C.

F. Dimensions are measured at the lead tips with the leads unconstrained.

- G. A visual index feature must be located within the cross-hatched area.

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

Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.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
RF/IF and ZigBee® Solutions	www.ti.com/lprf

Applications

Audio	www.ti.com/audio
Automotive	www.ti.com/automotive
Broadband	www.ti.com/broadband
Digital Control	www.ti.com/digitalcontrol
Medical	www.ti.com/medical
Military	www.ti.com/military
Optical Networking	www.ti.com/opticalnetwork
Security	www.ti.com/security
Telephony	www.ti.com/telephony
Video & Imaging	www.ti.com/video
Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2008, Texas Instruments Incorporated