

RCV420

# Precision 4mA to 20mA CURRENT LOOP RECEIVER

## FEATURES

- COMPLETE 4-20mA TO 0-5V CONVERSION
- INTERNAL SENSE RESISTORS
- PRECISION 10V REFERENCE
- BUILT-IN LEVEL-SHIFTING
- ±40V COMMON-MODE INPUT RANGE
- 0.1% OVERALL CONVERSION ACCURACY
- HIGH NOISE IMMUNITY: 86dB CMR

## APPLICATIONS

- PROCESS CONTROL
- INDUSTRIAL CONTROL
- FACTORY AUTOMATION
- DATA ACQUISITION
- SCADA
- RTUs
- ESD
- MACHINE MONITORING

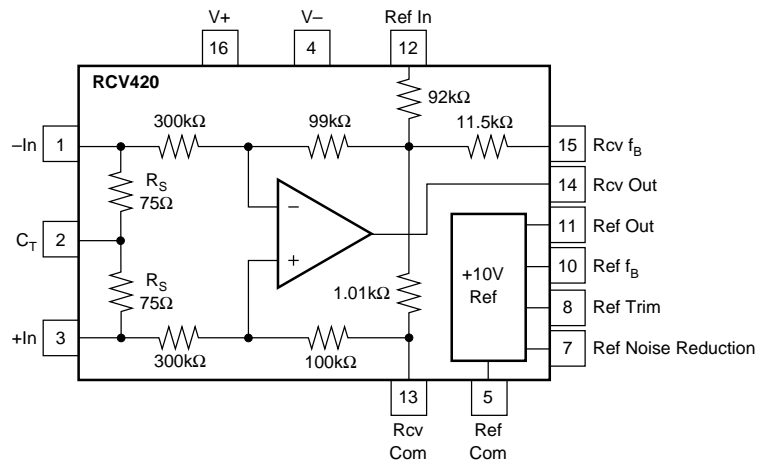
## DESCRIPTION

The RCV420 is a precision current-loop receiver designed to convert a 4–20mA input signal into a 0–5V output signal. As a monolithic circuit, it offers high reliability at low cost. The circuit consists of a premium grade operational amplifier, an on-chip precision resistor network, and a precision 10V reference. The RCV420 features 0.1% overall conversion accuracy, 86dB CMR, and ±40V common-mode input range.

The circuit introduces only a 1.5V drop at full scale, which is useful in loops containing extra instrument burdens or in intrinsically safe applications where

transmitter compliance voltage is at a premium. The 10V reference provides a precise 10V output with a typical drift of 5ppm/°C.

The RCV420 is completely self-contained and offers a highly versatile function. No adjustments are needed for gain, offset, or CMR. This provides three important advantages over discrete, board-level designs: 1) lower initial design cost, 2) lower manufacturing cost, and 3) easy, cost-effective field repair of a precision circuit.



International Airport Industrial Park • Mailing Address: PO Box 11400, Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd., Tucson, AZ 85706 • Tel: (520) 746-1111 • Twx: 910-952-1111  
 Internet: <http://www.burr-brown.com/> • FAXLine: (800) 548-6133 (US/Canada Only) • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

# SPECIFICATIONS

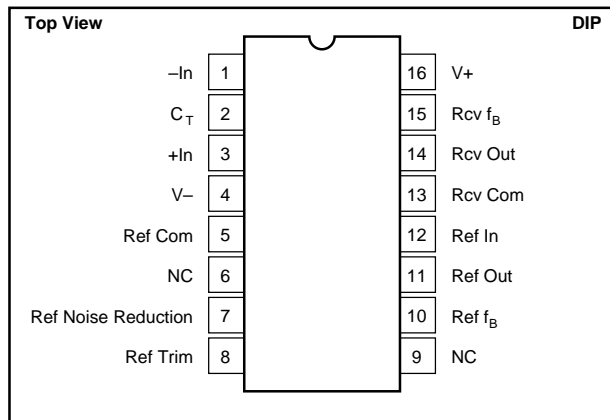
## ELECTRICAL

At T = +25°C and V<sub>S</sub> = ±15V, unless otherwise noted.

CHARACTERISTICS	RCV420KP, JP			UNITS
	MIN	TYP	MAX	
<b>GAIN</b>				
Initial		0.3125		V/mA
Error		0.05	0.15	% of span
Error—JP Grade			0.25	% of span
vs Temp		15		ppm/°C
Nonlinearity <sup>(1)</sup>		0.0002	0.002	% of span
<b>OUTPUT</b>				
Rated Voltage (I <sub>O</sub> = +10mA, -5mA)	10	12		V
Rated Current (E <sub>O</sub> = 10V)	+10, -5			mA
Impedance (Differential)		0.01		Ω
Current Limit (To Common)		+49, -13		mA
Capacitive Load (Stable Operation)		1000		pF
<b>INPUT</b>				
Sense Resistance	74.25	75	75.75	Ω
Input Impedance (Common-Mode)		200		kΩ
Common-Mode Voltage			±40	V
CMR <sup>(2)</sup>	70	80		dB
vs Temp (DC) (T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> )		76		dB
AC 60Hz		80		dB
<b>OFFSET VOLTAGE (RTO)<sup>(3)</sup></b>				
Initial			1	mV
vs Temp		10		μV/°C
vs Supply (±11.4V to ±18V)	74	90		dB
vs Time		200		μV/mo
<b>ZERO ERROR<sup>(4)</sup></b>				
Initial		0.025	0.075	% of span
Initial—JP Grade			0.15	% of span
vs Temp		10		ppm of span/°C
<b>OUTPUT NOISE VOLTAGE</b>				
f <sub>B</sub> = 0.1Hz to 10Hz		50		μVp-p
f <sub>O</sub> = 10kHz		800		nV/√Hz
<b>DYNAMIC RESPONSE</b>				
Gain Bandwidth		150		kHz
Full Power Bandwidth		30		kHz
Slew Rate		1.5		V/μs
Settling Time (0.01%)		10		μs
<b>VOLTAGE REFERENCE</b>				
Initial	9.99		10.01	V
Trim Range <sup>(5)</sup>		±4		%
vs Temp		5		ppm/°C
vs Supply (±11.4V to ±18V)		0.0002		%/V
vs Output Current (I <sub>O</sub> = 0 to +10mA)		0.0002		%/mA
vs Time		15		ppm/kHz
Noise (0.1Hz to 10Hz)		5		μVp-p
Output Current	+10, -2			mA
<b>POWER SUPPLY</b>				
Rated		±15		V
Voltage Range <sup>(6)</sup>	-5, +11.4		±18	V
Quiescent Current (V <sub>O</sub> = 0V)		3	4	mA
<b>TEMPERATURE RANGE</b>				
Specification	0		+70	°C
Operation	-25		+85	°C
Storage	-40		+85	°C
Thermal Resistance, θ <sub>JA</sub>		80		°C/W

NOTES: (1) Nonlinearity is the max peak deviation from best fit straight line. (2) With 0 source impedance on Rcv Com pin. (3) Referred to output with all inputs grounded including Ref In. (4) With 4mA input signal and Voltage Reference connected (includes V<sub>OS</sub>, Gain Error, and Voltage Reference Errors). (5) External trim slightly affects drift. (6) I<sub>O</sub> Ref = 5mA, I<sub>O</sub> Rcv = 2mA.

## PIN CONFIGURATION



## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Supply	±22V
Input Current, Continuous	40mA
Input Current Momentary, 0.1s	250mA, 1% Duty Cycle
Common-Mode Input Voltage, Continuous	±40V
Lead Temperature (soldering, 10s)	+300°C
Output Short Circuit to Common (Rcv and Ref)	Continuous

NOTE: (1) Stresses above these ratings may cause permanent damage.

## PACKAGE INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>
RCV420KP	16-Pin Plastic DIP	180
RCV420JP	16-Pin Plastic DIP	180

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.

## ORDERING INFORMATION

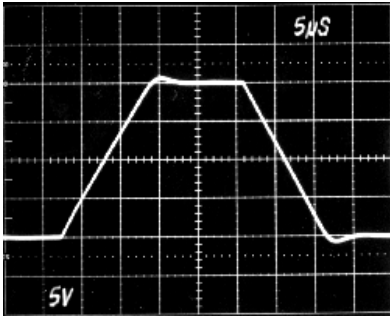
PRODUCT	PERFORMANCE GRADE	PACKAGE
RCV420KP	0°C to +70°C	16-Pin Plastic DIP
RCV420JP	0°C to +70°C	16-Pin Plastic DIP

The information provided herein is believed to be reliable; however, BURR-BROWN assumes no responsibility for inaccuracies or omissions. BURR-BROWN assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. Prices and specifications are subject to change without notice. No patent rights or licenses to any of the circuits described herein are implied or granted to any third party. BURR-BROWN does not authorize or warrant any BURR-BROWN product for use in life support devices and/or systems.

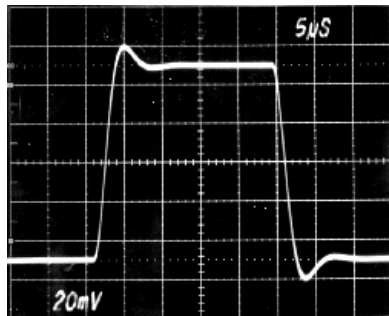
# TYPICAL PERFORMANCE CURVES

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

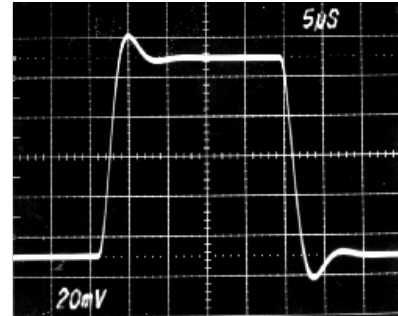
STEP RESPONSE  
NO LOAD



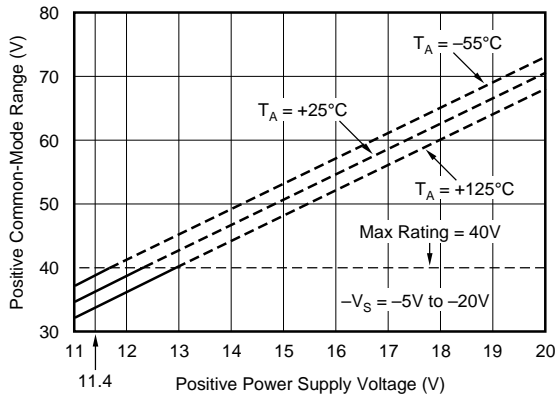
SMALL SIGNAL RESPONSE  
NO LOAD



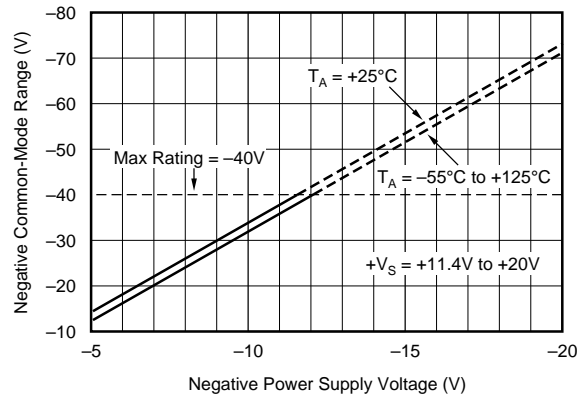
SMALL SIGNAL RESPONSE  
 $R_L = \infty$ ,  $C_L = 1000\text{pF}$



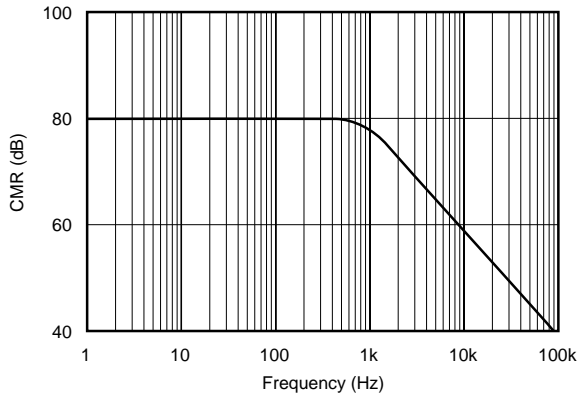
POSITIVE COMMON-MODE VOLTAGE RANGE  
vs POSITIVE POWER SUPPLY VOLTAGE



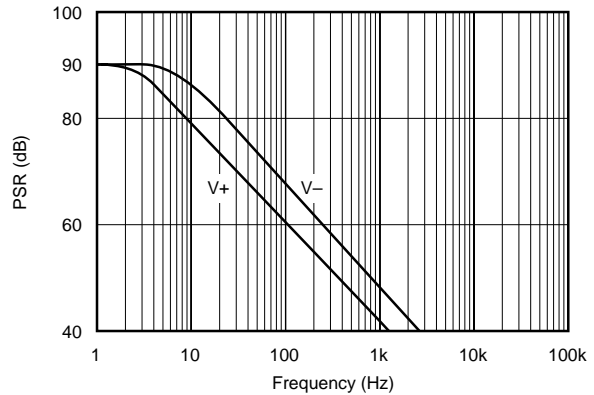
NEGATIVE COMMON-MODE VOLTAGE RANGE  
vs NEGATIVE POWER SUPPLY VOLTAGE



COMMON-MODE REJECTION  
vs FREQUENCY



POWER-SUPPLY REJECTION  
vs FREQUENCY



## THEORY OF OPERATION

Refer to the figure on the first page. For 0 to 5V output with 4–20mA input, the required transimpedance of the circuit is:

$$V_{OUT}/I_{IN} = 5V/16mA = 0.3125V/mA.$$

To achieve the desired output (0V for 4mA and 5V for 20mA), the output of the amplifier must be offset by an amount:

$$V_{OS} = -(4mA)(0.3125V/mA) = -1.25V.$$

The input current signal is connected to either +In or –In, depending on the polarity of the signal, and returned to ground through the center tap,  $C_T$ . The balanced input—two matched  $75\Omega$  sense resistors,  $R_S$ —provides maximum rejection of common-mode voltage signals on  $C_T$  and true differential current-to-voltage conversion. The sense resistors convert the input current signal into a proportional voltage, which is amplified by the differential amplifier. The voltage gain of the amplifier is:

$$A_D = 5V/(16mA)(75\Omega) = 4.1667V/V.$$

The tee network in the feedback path of the amplifier provides a summing junction used to generate the required –1.25V offset voltage. The input resistor network provides high-input impedance and attenuates common-mode input voltages to levels suitable for the operational amplifier’s common-mode signal capabilities.

## BASIC POWER SUPPLY AND SIGNAL CONNECTIONS

Figure 1 shows the proper connections for power supply and signal. Both supplies should be decoupled with  $1\mu F$  tantalum capacitors as close to the amplifier as possible. To avoid gain and CMR errors introduced by the external circuit, connect grounds as indicated, being sure to minimize ground resistance. The input signal should be connected to either +In or –In, depending on its polarity, and returned through the center tap,  $C_T$ . The output of the voltage reference, Ref Out, should be connected to Ref In for the

necessary level shifting. If the Ref In pin is not used for level shifting, then it must be grounded to maintain high CMR.

## GAIN AND OFFSET ADJUSTMENT

Figure 2 shows the circuit for adjusting the RCV420 gain. Increasing the gain of the RCV420 is accomplished by inserting a small resistor in the feedback path of the amplifier. Increasing the gain using this technique results in CMR degradation, and therefore, gain adjustments should be kept as small as possible. For example, a 1% increase in gain is typically realized with a  $125\Omega$  resistor, which degrades CMR by about 6dB.

A decrease in gain can be achieved by placing matched resistors in parallel with the sense resistors, also shown in Figure 2. The adjusted gain is given by the following expression

$$V_{OUT}/I_{IN} = 0.3125 \times R_X/(R_X + R_S).$$

A 1% decrease in gain can be achieved with a  $7.5k\Omega$  resistor. It is important to match the parallel resistance on each sense resistor to maintain high CMR. The TCR mismatch between the two external resistors will effect gain error drift and CMR drift.

There are two methods for nulling the RCV420 output offset voltage. The first method applies to applications using the internal 10V reference for level shifting. For these applica-

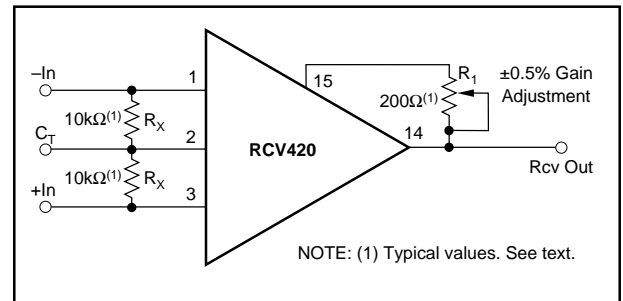


FIGURE 2. Optional Gain Adjustment.

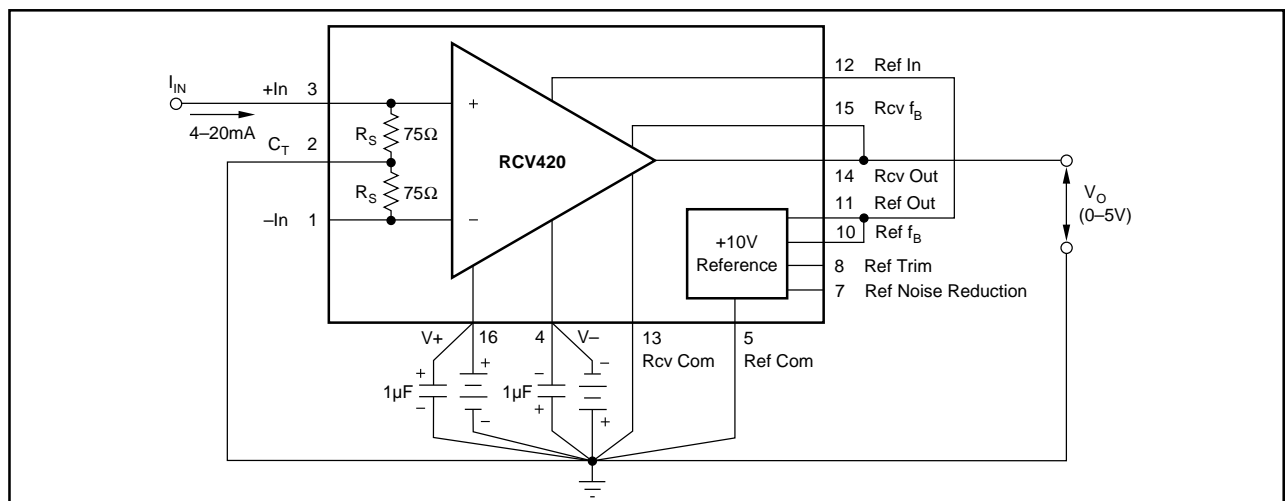


FIGURE 1. Basic Power Supply and Signal Connections.

tions, the voltage reference output trim procedure can be used to null offset errors at the output of the RCV420. The voltage reference trim circuit is discussed under “Voltage Reference.”

When the voltage reference is not used for level shifting or when large offset adjustments are required, the circuit in Figure 3 can be used for offset adjustment. A low impedance on the Rcv Com pin is required to maintain high CMR.

### ZERO ADJUSTMENT

Level shifting the RCV420 output voltage can be achieved using either the Ref In pin or the Rcv Com pin. The disadvantage of using the Ref In pin is that there is an 8:1 voltage attenuation from this pin to the output of the RCV420. Thus, use the Rcv Com pin for large offsets, because the voltage on this pin is seen directly at the output. Figure 4 shows the circuit used to level-shift the output of the RCV420

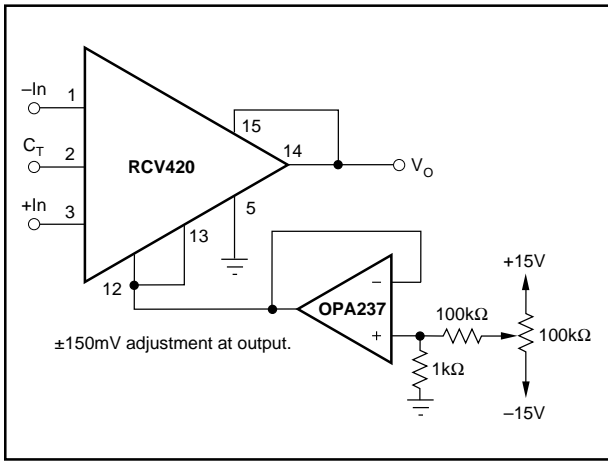


FIGURE 3. Optional Output Offset Nulling Using External Amplifier.

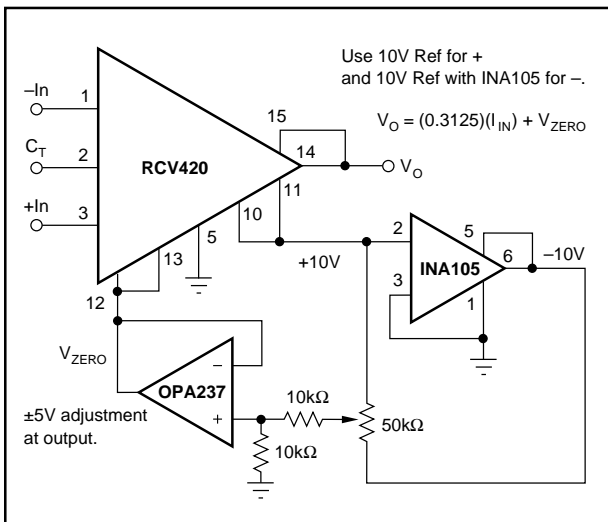


FIGURE 4. Optional Zero Adjust Circuit.

using the Rcv Com pin. It is important to use a low-output impedance amplifier to maintain high CMR. With this method of zero adjustment, the Ref In pin must be connected to the Rcv Com pin.

### MAINTAINING COMMON-MODE REJECTION

Two factors are important in maintaining high CMR: (1) resistor matching and tracking (the internal resistor network does this) and (2) source impedance. CMR depends on the accurate matching of several resistor ratios. The high accuracies needed to maintain the specified CMR and CMR temperature coefficient are difficult and expensive to reliably achieve with discrete components. Any resistance imbalance introduced by external circuitry directly affects CMR. These imbalances can occur by: mismatching sense resistors when gain is decreased, adding resistance in the feedback path when gain is increased, and adding series resistance on the Rcv Com pin.

The two sense resistors are laser-trimmed to typically match within 0.01%; therefore, when adding parallel resistance to decrease gain, take care to match the parallel resistance on each sense resistor. To maintain high CMR when increasing the gain of the RCV420, keep the series resistance added to the feedback network as small as possible. Whether the Rcv Com pin is grounded or connected to a voltage reference for level shifting, keep the series resistance on this pin as low as possible. For example, a resistance of 20Ω on this pin degrades CMR from 86dB to approximately 80dB. For applications requiring better than 86dB CMR, the circuit shown in Figure 5 can be used to adjust CMR.

### PROTECTING THE SENSE RESISTOR

The 75Ω sense resistors are designed for a maximum continuous current of 40mA, but can withstand as much as 250mA for up to 0.1s (see absolute maximum ratings). There are several ways to protect the sense resistor from

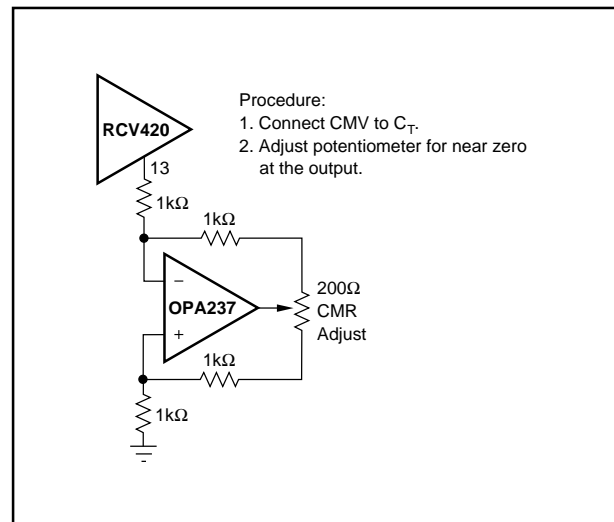


FIGURE 5. Optional Circuit for Externally Trimming CMR.

overcurrent conditions exceeding these specifications. Refer to Figure 6. The simplest and least expensive method is a resistor as shown in Figure 6a. The value of the resistor is determined from the expression

$$R_X = V_{CC}/40\text{mA} - 75\Omega$$

and the full scale voltage drop is

$$V_{RX} = 20\text{mA} \times R_X.$$

For a system operating off of a 32V supply  $R_X = 725\Omega$  and  $V_{RX} = 14.5\text{V}$ . In applications that cannot tolerate such a large voltage drop, use circuits 6b or 6c. In circuit 6b a power JFET and source resistor are used as a current limit. The  $200\Omega$  potentiometer,  $R_X$ , is adjusted to provide a current limit of approximately 30mA. This circuit introduces a 1–4V drop at full scale. If only a very small series voltage drop at full scale can be tolerated, then a 0.032A series 217 fast-acting fuse should be used, as shown in Figure 6c.

For automatic fold-back protection, use the circuit shown in Figure 15.

### VOLTAGE REFERENCE

The RCV420 contains a precision 10V reference. Figure 8 shows the circuit for output voltage adjustment. Trimming the output will change the voltage drift by approximately  $0.007\text{ppm}/^\circ\text{C}$  per mV of trimmed voltage. Any mismatch in TCR between the two sides of the potentiometer will also affect drift, but the effect is divided by approximately 5. The trim range of the voltage reference using this method is typically  $\pm 400\text{mV}$ . The voltage reference trim can be used to trim offset errors at the output of the RCV420. There is an 8:1 voltage attenuation from Ref In to Rcv Out, and thus the trim range at the output of the receiver is typically  $\pm 50\text{mV}$ .

The high-frequency noise (to 1MHz) of the voltage reference is typically  $1\text{mVp-p}$ . When the voltage reference is used for level shifting, its noise contribution at the output of the receiver is typically  $125\mu\text{Vp-p}$  due to the 8:1 attenuation from Ref In to Rcv Out. The reference noise can be reduced by connecting an external capacitor between the Noise Reduction pin and ground. For example,  $0.1\mu\text{F}$  capacitor reduces the high-frequency noise to about  $200\mu\text{Vp-p}$  at the output of the reference and about  $25\mu\text{Vp-p}$  at the output of the receiver.

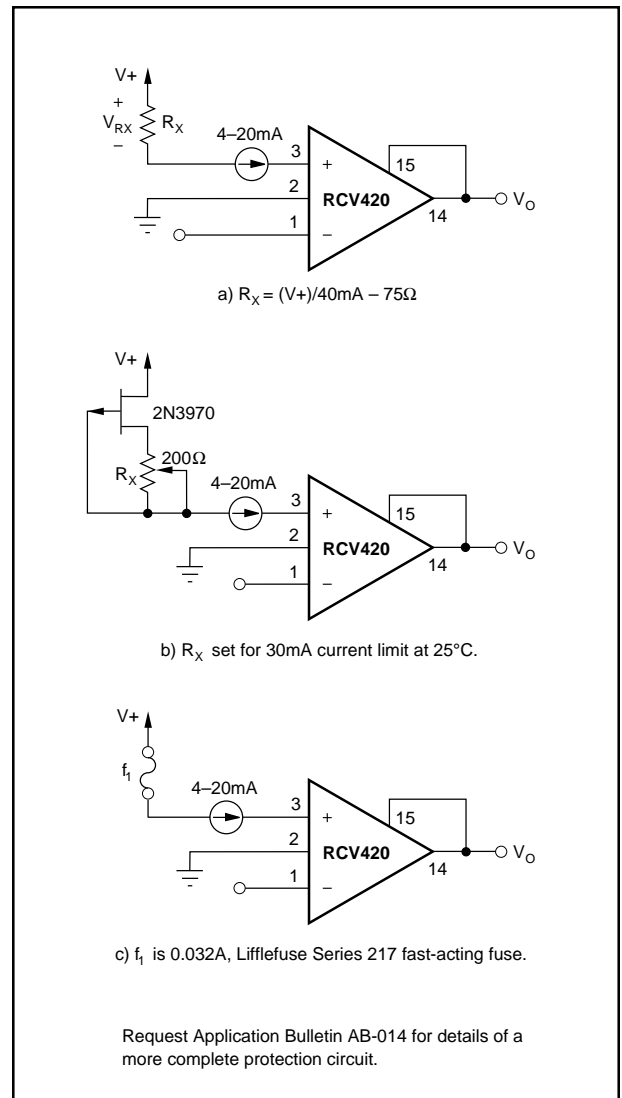


FIGURE 6. Protecting the Sense Resistors.

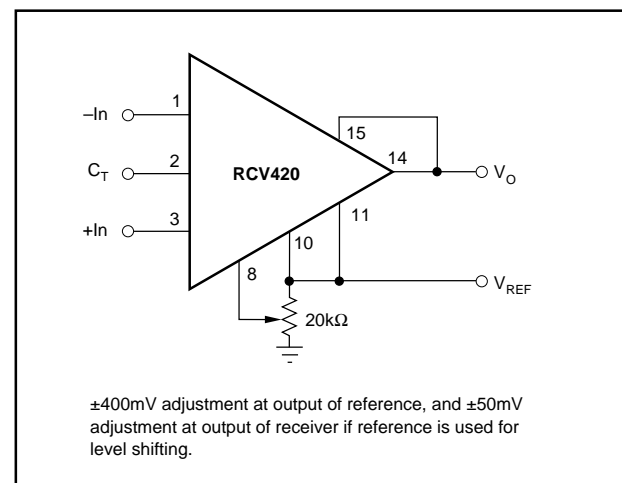


FIGURE 7. Optional Voltage Reference External Trim Circuit.

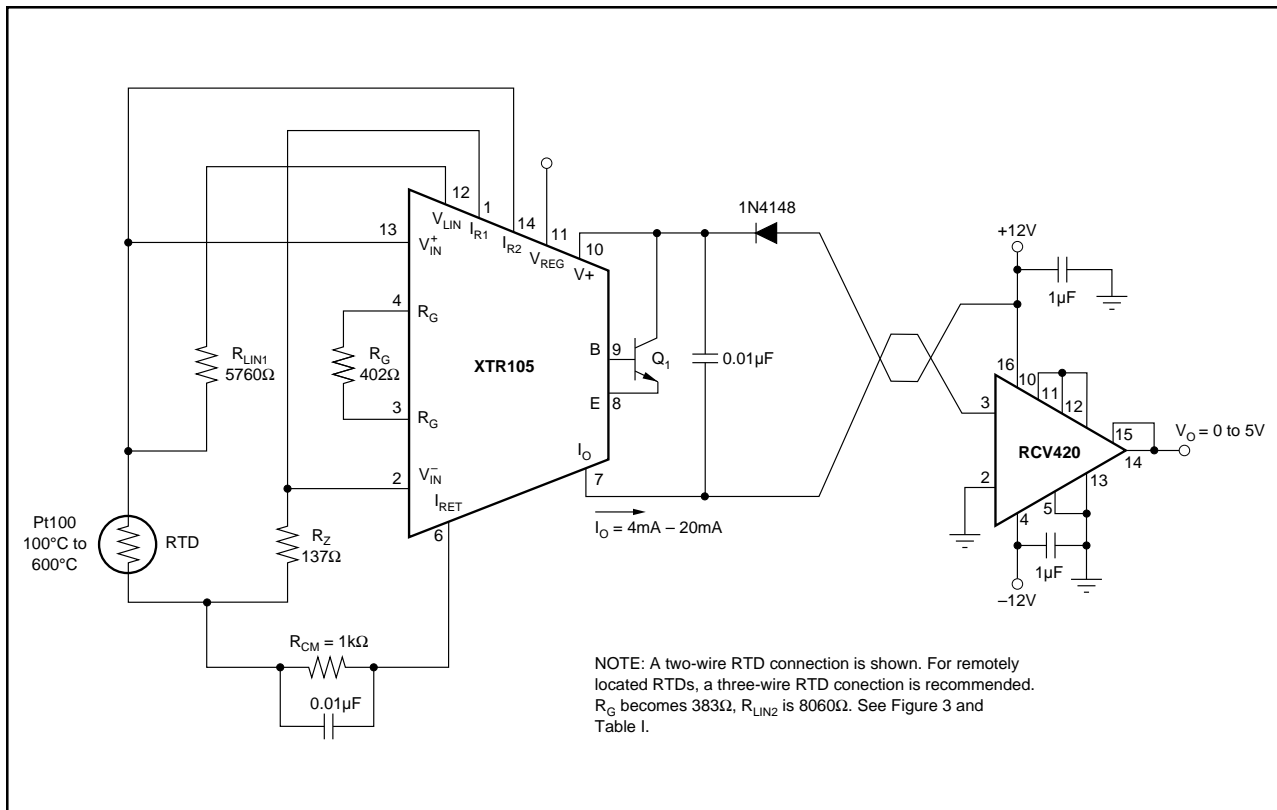


FIGURE 8. RCV420 Used in Conjunction with XTR101 to Form a Complete Solution for 4-20mA Loop.

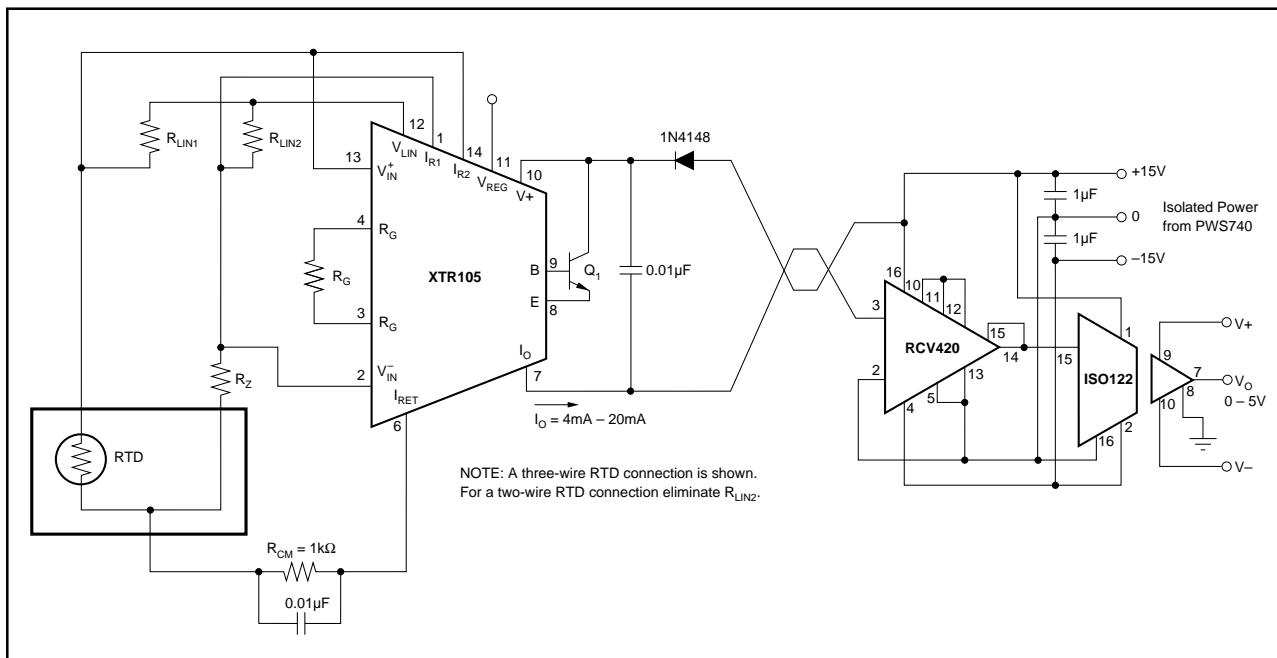
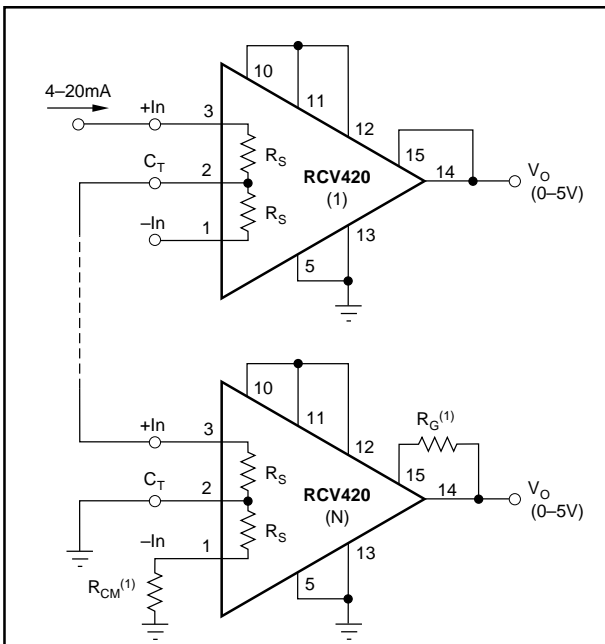


FIGURE 9. Isolated 4-20mA Instrument Loop (RTD shown).



NOTE: (1)  $R_{CM}$  and  $R_G$  are used to provide a first order correction of CMR and Gain Error, respectively. Table 1 gives typical resistor values for  $R_{CM}$  and  $R_G$  when as many as three RCV420s are stacked. Table II gives typical CMR and Gain Error with no correction. Further improvement in CMR and Gain Error can be achieved using a 500k $\Omega$  potentiometer for  $R_{CM}$  and a 100 $\Omega$  potentiometer for  $R_G$ .

RCV420	$R_{CM}$ (k $\Omega$ )	$R_G$ ( $\Omega$ )
1	$\infty$	0
2	200	7
3	67	23

TABLE 1. Typical Values for  $R_{CM}$  and  $R_G$ .

RCV420	CMR (dB)	GAIN ERROR %
1	94	0.025
2	68	0.075
3	62	0.200

TABLE II. Typical CMR and Gain Error Without Correction.

FIGURE 10. Series 4-20mA Receivers.

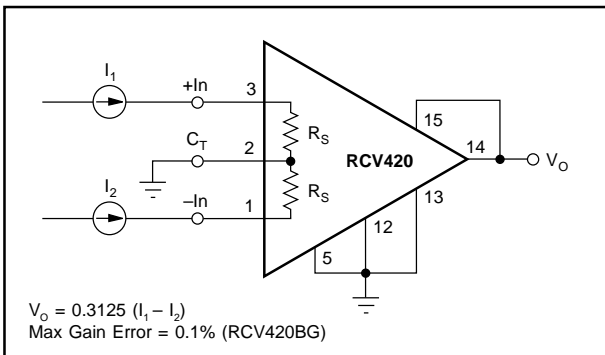


FIGURE 11. Differential Current-to-Voltage Converter.

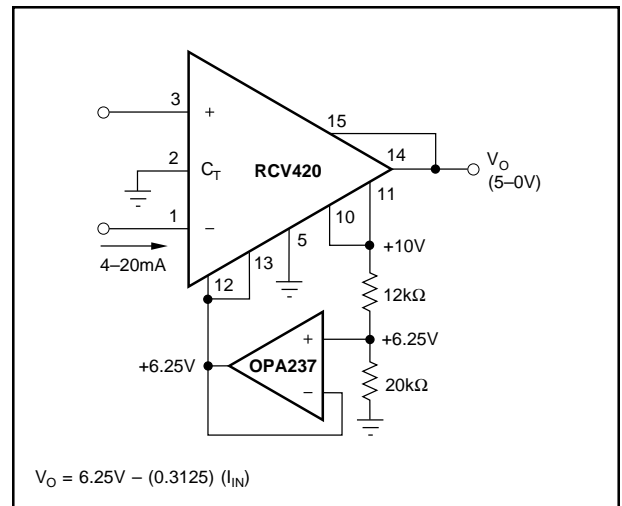


FIGURE 12. 4-20mA to 5-0V Conversion.

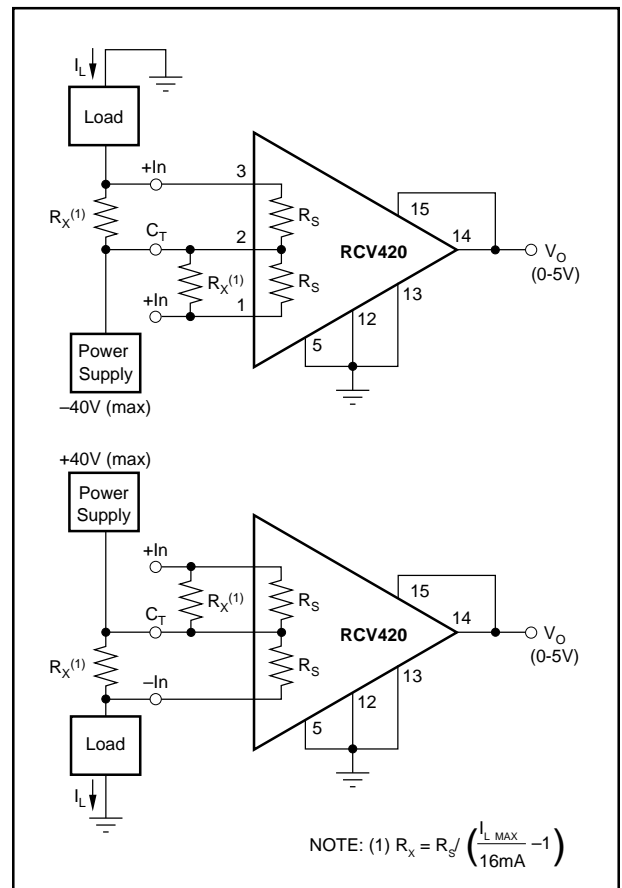


FIGURE 13. Power Supply Current Monitor Circuit.



**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
RCV420JP	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
RCV420JPG4	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
RCV420KP	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
RCV420KPG4	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

<sup>(3)</sup> 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.

## 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	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2009, Texas Instruments Incorporated