**XTR105**

**4-20mA CURRENT TRANSMITTER**
with Sensor Excitation and Linearization

**FEATURES**
- LOW UNADJUSTED ERROR
- TWO PRECISION CURRENT SOURCES 800μA EACH
- RTD OR BRIDGE EXCITATION
- LINEARIZATION
- TWO OR THREE-WIRE RTD OPERATION
- LOW OFFSET DRIFT: 0.4μV/°C
- LOW OUTPUT CURRENT NOISE: 30nA
- HIGH PSR: 110dB min
- HIGH CMR: 86dB min
- WIDE SUPPLY RANGE: 7.5V TO 36V
- 14-PIN DIP AND SO-14 SOIC PACKAGES

**APPLICATIONS**
- INDUSTRIAL PROCESS CONTROL
- FACTORY AUTOMATION
- SCADA REMOTE DATA ACQUISITION
- REMOTE TEMPERATURE AND PRESSURE TRANSDUCERS

**DESCRIPTION**

The XTR105 is a monolithic 4-20mA, two-wire current transmitter with two precision current sources. It provides complete current excitation for Platinum RTD temperature sensors and bridges, instrumentation amplifier, and current output circuitry on a single integrated circuit.

Versatile linearization circuitry provides a 2nd-order correction to the RTD, typically achieving a 40:1 improvement in linearity.

Instrumentation amplifier gain can be configured for a wide range of temperature or pressure measurements. Total unadjusted error of the complete current transmitter is low enough to permit use without adjustment in many applications. This includes zero output current drift, span drift and nonlinearity. The XTR105 operates on loop power supply voltages down to 7.5V.

The XTR105 is available in 14-pin plastic DIP and SO-14 surface-mount packages and is specified for the –40°C to +85°C industrial temperature range.

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### SPECIFICATIONS

At $T_A = +25^\circ\text{C}$, $V_+ = 24\text{V}$, and TIP29C external transistor, unless otherwise noted.

#### OUTPUT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>XTR105P, U</th>
<th>XTR105PA, UA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN</td>
<td>TYP</td>
<td>MAX</td>
</tr>
<tr>
<td>Output Current Equation</td>
<td>$I_\text{OUT} = V_+ \cdot \left(\frac{40}{R_G}\right) + 4\text{mA}$, $V_+$ in Volts, $R_G$ in $\Omega$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Current, Specified Range</td>
<td>4</td>
<td>20</td>
<td>*</td>
</tr>
<tr>
<td>Over-Scale Limit</td>
<td>24</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>Under-Scale Limit</td>
<td>1.8</td>
<td>2.2</td>
<td>2.6</td>
</tr>
</tbody>
</table>

#### ZERO OUTPUT

- $V_{\text{IN}} = 0\text{V}, R_G = \infty$ | 4 | * | mA |
- **Initial Error**
  - vs Temperature | ±5 | ±25 | ±50 | μA |
  - vs Supply Voltage, $V_+$ | ±0.07 | ±0.5 | ±0.9 | μA/V |
  - vs Common-Mode Voltage | 0.04 | 0.2 | * | μA/V |
  - vs $V_{\text{REG}}$, Output Current | 0.02 | * | μA/mA |
- **Noise:**
  - 0.1 Hz to 10 Hz | 0.03 | * | μA/√Hz |

#### SPAN

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>XTR105P, U</th>
<th>XTR105PA, UA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN</td>
<td>TYP</td>
<td>MAX</td>
</tr>
<tr>
<td>Span Equation (Transconductance)</td>
<td>$S = \frac{40}{R_G}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Error</td>
<td>±0.05</td>
<td>±0.2</td>
<td>±0.4</td>
</tr>
</tbody>
</table>
- vs Temperature | ±3 | ±25 | * | % |
- Nonlinearity: Ideal Input | Full Scale ($V_{\text{IN}}$) = 50mV | | | | | | % |
- vs Temperature | ±3 | ±25 | ±50 | ppm/°C |
- vs Common-Mode Voltage | 0.1 || 1 | * | μA/°C |
- vs Supply Voltage | ±0.2 | ±10 | ±0.3 | μV |
- Common-Mode | 0.1 || 10 | * | μA/°C |
- vs Temperature | 5 | * | μA/°C |
- Noise: 0.1 Hz to 10 Hz | 0.6 | * | μA/√Hz |

#### INPUT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>XTR105P, U</th>
<th>XTR105PA, UA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN</td>
<td>TYP</td>
<td>MAX</td>
</tr>
<tr>
<td>Offset Voltage</td>
<td>$V_{\text{CM}} = 2\text{V}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- vs Temperature | ±0.4 | ±1.5 | ±3 | μA/V |
- vs Supply Voltage, $V_+$ | ±0.3 | ±3 | * | μA/V |
- vs Common-Mode Voltage | ±10 | ±50 | ±100 | μA/V |
- vs Temperature (CMRR) | 1.25 | 3.5 | * | V |
- Input Bias Current | 5 | 25 | * | 50 | nA |
- vs Temperature | 20 | * | μA/C |
- Input Offset Current | ±0.2 | ±3 | ±10 | nA |
- vs Temperature | 5 | * | μA/C |
- Impedance: Differential | 0.1 || 1 | * | GΩ || pF |
- Common-Mode | 0.1 || 10 | * | GΩ || pF |
- vs Temperature | 5 | * | μA/C |
- Noise: 0.1 Hz to 10 Hz | 0.6 | * | μA/√Hz |

#### CURRENT SOURCES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>XTR105P, U</th>
<th>XTR105PA, UA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN</td>
<td>TYP</td>
<td>MAX</td>
</tr>
<tr>
<td>Current</td>
<td>800</td>
<td>*</td>
<td>μA</td>
</tr>
</tbody>
</table>
- vs Temperature | ±0.05 | ±0.2 | ±0.4 | % |
- vs Supply Voltage, $V_+$ | ±15 | ±35 | ±75 | ppm/°C |
- Matching | ±0.02 | ±0.1 | ±0.2 | % |
- vs Temperature | ±3 | ±15 | ±30 | % |
- vs Power Supply, $V_+$ | ±1 | 10 | ±0.3 | ppm/°C |
- Compliance Voltage, Positive | $V_{+} = 7.5\text{V}$ to 36V | | | | | | V |
- vs Supply Voltage, $V_+$ | ±10 | ±25 | ±50 | V |
- vs Temperature (Positive) | ±0.2 | ±3 | ±10 | μA |
- vs Temperature (Negative) | ±0.1 | ±25 | ±50 | μA |
- vs Supply Voltage, $V_+$ | ±1 | ±25 | ±50 | μA |
- vs Temperature (Negative) | ±0.2 | ±3 | ±10 | μA |
| Output Impedance | 0.003 | * | μA/√Hz |

#### TEMPERATURE RANGE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>XTR105P, U</th>
<th>XTR105PA, UA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN</td>
<td>TYP</td>
<td>MAX</td>
</tr>
<tr>
<td>Specified, $T_{\text{MIN}}$ to $T_{\text{MAX}}$</td>
<td>-40</td>
<td>+85</td>
<td>*</td>
</tr>
<tr>
<td>Operating</td>
<td>-55</td>
<td>+125</td>
<td>*</td>
</tr>
<tr>
<td>Storage</td>
<td>-55</td>
<td>+125</td>
<td>*</td>
</tr>
</tbody>
</table>

### NOTES

1. Describes accuracy of the 4mA low-scale offset current. Does not include input amplifier effects. Can be trimmed to zero.
2. Voltage measured with respect to $I_{\text{RET}}$ pin.
3. Does not include initial error or TCR of gain-setting resistor, $R_G$.
4. Increasing the full-scale input range improves nonlinearity.
5. Does not include Zero Output initial error.
6. Current source output voltage with respect to $I_{\text{RET}}$ pin.
PIN CONFIGURATION

Top View DIP and SOIC

N = No Internal Connection.

ABSOLUTE MAXIMUM RATINGS(1)

- Power Supply, V+ (referenced to IO pin) .......................................... 40V
- Input Voltage, V IN, V LIN (referenced to IO pin) ............................ 0V to V+
- Storage Temperature Range ........................................ –55°C to +125°C
- Lead Temperature (soldering, 10s) .............................................. +300°C
- Junction Temperature ................................................................... +165°C

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

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown 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

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>PACKAGE</th>
<th>PACKAGE DRAWING NUMBER(1)</th>
<th>TEMPERATURE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>XTR105PA</td>
<td>14-Pin Plastic DIP</td>
<td>010</td>
<td>–40°C to +85°C</td>
</tr>
<tr>
<td>XTR105P</td>
<td>14-Pin Plastic DIP</td>
<td>010</td>
<td>–40°C to +85°C</td>
</tr>
<tr>
<td>XTR105UA</td>
<td>SO-14 Surface Mount</td>
<td>235</td>
<td>–40°C to +85°C</td>
</tr>
<tr>
<td>XTR105U</td>
<td>SO-14 Surface Mount</td>
<td>235</td>
<td>–40°C to +85°C</td>
</tr>
</tbody>
</table>

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

FUNCTIONAL BLOCK DIAGRAM

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TYPICAL PERFORMANCE CURVES

At $T_A = +25^\circ C, V_+ = 24V$, unless otherwise noted.

**TRANSCONDUCTANCE vs FREQUENCY**

**COMMON-MODE REJECTION vs FREQUENCY**

**OVER-SCALE CURRENT vs TEMPERATURE**

**UNDER-SCALE CURRENT vs TEMPERATURE**

**STEP RESPONSE**

**POWER-SUPPLY REJECTION vs FREQUENCY**

**COMMON-MODE REJECTION vs FREQUENCY**

**TRANSCONDUCTANCE vs FREQUENCY**

**OVER-SCALE CURRENT vs TEMPERATURE**

**UNDER-SCALE CURRENT vs TEMPERATURE**
TYPICAL PERFORMANCE CURVES (CONT)

At $T_A = +25^\circ C$, $V_+ = 24V$, unless otherwise noted.
TYPICAL PERFORMANCE CURVES (CONT)

At $T_A = +25^\circ C$, $V_+ = 24V$, unless otherwise noted.

**CURRENT SOURCE DRIFT PRODUCTION DISTRIBUTION**

Typical Production Distribution of Packaged Units, $I_{R1}$ AND $I_{R2}$ Included.

**CURRENT SOURCE MATCHING DRIFT PRODUCTION DISTRIBUTION**

Typical Production Distribution of Packaged Units.

**$V_{REG}$ OUTPUT VOLTAGE vs $V_{REG}$ OUTPUT CURRENT**

NOTE: Above 1mA, Zero Output Degrades

**REFERENCE CURRENT ERROR vs TEMPERATURE**

Typical Production Distribution of Packaged Units.
APPLICATION INFORMATION

Figure 1 shows the basic connection diagram for the XTR105. The loop power supply, $V_{PS}$, provides power for all circuitry. Output loop current is measured as a voltage across the series load resistor, $R_L$.

Two matched 0.8mA current sources drive the RTD and zero-setting resistor, $R_Z$. The instrumentation amplifier input of the XTR105 measures the voltage difference between the RTD and $R_Z$. The value of $R_Z$ is chosen to be equal to the resistance of the RTD at the low-scale (minimum) measurement temperature. $R_Z$ can be adjusted to achieve 4mA output at the minimum measurement temperature to correct for input offset voltage and reference current mismatch of the XTR105.

$R_{CM}$ provides an additional voltage drop to bias the inputs of the XTR105 within their common-mode input range. $R_{CM}$ should be bypassed with a 0.01μF capacitor to minimize common-mode noise. Resistor $R_G$ sets the gain of the instrumentation amplifier according to the desired temperature range. $R_{LIN1}$ provides second-order linearization correction to the RTD, typically achieving a 40:1 improvement in linearity. An additional resistor is required for three-wire RTD connections, see Figure 3.

The transfer function through the complete instrumentation amplifier and voltage-to-current converter is:

$$I_O = 4mA + V_{IN} \cdot \left(\frac{40}{R_G}\right)$$

where $V_{IN}$ is the differential input voltage. As evident from the transfer function, if no $R_G$ is used the gain is zero and the output is simply the XTR105's zero current. The value of $R_G$ varies slightly for two-wire RTD and three-wire RTD connections with linearization. $R_G$ can be calculated from the equations given in Figure 1 (two-wire RTD connection) and Table I (three-wire RTD connection).

The $I_{RET}$ pin is the return path for all current from the current sources and $V_{REG}$. The $I_{RET}$ pin allows any current used in external circuitry to be sensed by the XTR105 and to be included in the output current without causing an error.

The $V_{REG}$ pin provides an on-chip voltage source of approximately 5.1V and is suitable for powering external input circuitry (refer to Figure 6). It is a moderately accurate voltage reference—it is not the same reference used to set the 800μA current references. $V_{REG}$ is capable of sourcing approximately 1mA of current. Exceeding 1mA may affect the 4mA zero output.

FIGURE 1. Basic Two-Wire RTD Temperature Measurement Circuit with Linearization.
A negative input voltage, $V_{IN}$, will cause the output current to be less than 4mA. Increasingly negative $V_{IN}$ will cause the output current to limit at approximately 2.2mA. Refer to the typical curve “Under-Scale Current vs Temperature.”

Increasingly positive input voltage (greater than the full-scale input) will produce increasing output current according to the transfer function, up to the output current limit of approximately 27mA. Refer to the typical curve “Over-Scale Current vs Temperature.”

**EXTERNAL TRANSISTOR**

Transistor Q1 conducts the majority of the signal-dependent 4-20mA loop current. Using an external transistor isolates the majority of the power dissipation from the precision input and reference circuitry of the XTR105, maintaining excellent accuracy.

Since the external transistor is inside a feedback loop its characteristics are not critical. Requirements are: $V_{CEO} = 45V$ min, $\beta = 40$ min and $P_D = 800mW$. Power dissipation requirements may be lower if the loop power supply voltage is less than 36V. Some possible choices for Q1 are listed in Figure 1.

The XTR105 can be operated without this external transistor, however, accuracy will be somewhat degraded due to the internal power dissipation. Operation without Q1 is not recommended for extended temperature ranges. A resistor ($R = 3.3k\Omega$) connected between the $I_{RET}$ pin and the E (emitter) pin may be needed for operation below $0^\circ C$ without Q1 to guarantee the full 20mA full-scale output, especially with $V+$ near 7.5V.

**LOOP POWER SUPPLY**

The voltage applied to the XTR105, $V+$, is measured with respect to the I0 connection, pin 7. $V+$ can range from 7.5V to 36V. The loop supply voltage, $V_{PS}$, will differ from the voltage applied to the XTR105 according to the voltage drop on the current sensing resistor, $R_L$ (plus any other voltage drop in the line).

If a low loop supply voltage is used, $R_L$ (including the loop wiring resistance) must be made a relatively low value to assure that $V+$ remains 7.5V or greater for the maximum loop current of 20mA:

$$R_{L max} = \left( \frac{(V+) - 7.5V}{20mA}\right) - R_{WIRING}$$

It is recommended to design for $V+$ equal or greater than 7.5V with loop currents up to 30mA to allow for out-of-range input conditions.

The low operating voltage (7.5V) of the XTR105 allows operation directly from personal computer power supplies (12V ±5%). When used with the RCV420 Current Loop Receiver (Figure 7), load resistor voltage drop is limited to 3V.

**ADJUSTING INITIAL ERRORS**

Many applications require adjustment of initial errors. Input offset and reference current mismatch errors can be corrected by adjustment of the zero resistor, $R_Z$. Adjusting the gain-setting resistor, $R_G$, corrects any errors associated with gain.

**TWO-WIRE AND THREE-WIRE RTD CONNECTIONS**

In Figure 1, the RTD can be located remotely simply by extending the two connections to the RTD. With this remote two-wire connection to the RTD, line resistance will introduce error. This error can be partially corrected by adjusting the values of $R_G$, $R_Z$, and $R_{LIN1}$.

A better method for remotely located RTDs is the three-wire RTD connection shown in Figure 3. This circuit offers improved accuracy. $R_Z$’s current is routed through a third wire to the RTD. Assuming line resistance is equal in RTD lines 1 and 2, this produces a small common-mode voltage which is rejected by the XTR105. A second resistor, $R_{LIN2}$, is required for linearization.

Note that although the two-wire and three-wire RTD connection circuits are very similar, the gain-setting resistor, $R_G$, has slightly different equations:

$$R_G = \frac{2R_1(R_2 + R_Z) - 4(R_1R_Z)}{R_2 - R_1}$$

where $R_Z = RTD$ resistance at $T_{MIN}$

$R_1 = RTD$ resistance at $(T_{MIN} + T_{MAX})/2$

$R_2 = RTD$ resistance at $T_{MAX}$
To maintain good accuracy, at least 1% (or better) resistors should be used for $R_G$. Table I provides standard 1% $R_G$ resistor values for a three-wire Pt100 RTD connection with linearization.

LINEARIZATION

RTD temperature sensors are inherently (but predictably) nonlinear. With the addition of one or two external resistors, $R_{LIN1}$ and $R_{LIN2}$, it is possible to compensate for most of this nonlinearity resulting in 40:1 improvement in linearity over the uncompensated output.
A typical two-wire RTD application with linearization is shown in Figure 1. Resistor \( R_{\text{LIN1}} \) provides positive feedback and controls linearity correction. \( R_{\text{LIN1}} \) is chosen according to the desired temperature range. An equation is given in Figure 1.

In three-wire RTD connections, an additional resistor, \( R_{\text{LIN2}} \), is required. As with the two-wire RTD application, \( R_{\text{LIN1}} \) provides positive feedback for linearization. \( R_{\text{LIN2}} \) provides an offset canceling current to compensate for wiring resistance encountered in remotely located RTDs. \( R_{\text{LIN1}} \) and \( R_{\text{LIN2}} \) are chosen such that their currents are equal. This makes the voltage drop in the wiring resistance to the RTD a common-mode signal which is rejected by the XTR105. The nearest standard 1% resistor values for \( R_{\text{LIN1}} \) and \( R_{\text{LIN2}} \) should be adequate for most applications. Table I provides the 1% resistor values for a three-wire Pt100 RTD connection.

If no linearity correction is desired, the \( V_{\text{LIN}} \) pin should be left open. With no linearization, \( R_G = 2500 \times V_{\text{FS}} \), where \( V_{\text{FS}} = \) full-scale input range.

**RTDs**

The text and figures thus far have assumed a Pt100 RTD. With higher resistance RTDs, the temperature range and input voltage variation should be evaluated to ensure proper common-mode biasing of the inputs. As mentioned earlier, \( R_{CM} \) can be adjusted to provide an additional voltage drop to bias the inputs of the XTR105 within their common-mode input range.

**ERROR ANALYSIS**

Table II shows how to calculate the effect various error sources have on circuit accuracy. A sample error calculation for a typical RTD measurement circuit (Pt100 RTD, 200°C measurement span) is provided. The results reveal the XTR105’s excellent accuracy, in this case 1.1% unadjusted. Adjusting resistors \( R_G \) and \( R_Z \) for gain and offset errors improves circuit accuracy to 0.32%. Note that these are worst case errors; guaranteed maximum values were used in the calculations and all errors were assumed to be positive (additive). The XTR105 achieves performance which is difficult to obtain with discrete circuitry and requires less space.

**OPEN-CIRCUIT PROTECTION**

The optional transistor \( Q_2 \) in Figure 3 provides predictable behavior with open-circuit RTD connections. It assures that if any one of the three RTD connections is broken, the XTR105’s output current will go to either its high current limit (~27mA) or low current limit (~2.2mA). This is easily detected as an out-of-range condition.

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**FIGURE 3. Three-Wire Connection for Remotely Located RTDs.**

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**NOTES:** (1) See Table I for resistor equations and 1% values. (2) \( Q_2 \) optional. Provides predictable output current if any one RTD connection is broken.

<table>
<thead>
<tr>
<th>OPEN RTD TERMINAL</th>
<th>( i_b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>~2.2mA</td>
</tr>
<tr>
<td>2</td>
<td>~27mA</td>
</tr>
<tr>
<td>3</td>
<td>~2.2mA</td>
</tr>
</tbody>
</table>

Resistance in this line causes a small common-mode voltage which is rejected by XTR105.

EQUAL line resistances here creates a small common-mode voltage which is rejected by XTR105.
TABLE II. Error Calculation.

<table>
<thead>
<tr>
<th>ERROR SOURCE</th>
<th>ERROR EQUATION</th>
<th>SAMPLE ERROR CALCULATION(1)</th>
<th>ERROR (ppm of Full Scale)</th>
<th>UNADJ.</th>
<th>ADJUST.</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Offset Voltage</td>
<td>$V_{OS}/(V_{IN MAX}) \times 10^6$</td>
<td>1645 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vs Common-Mode</td>
<td>$CMRR \times (V_{IN MAX}) \times 10^6$</td>
<td>50 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Offset Current</td>
<td>$I_{OS}/(V_{RTD MAX}/V_{IN MAX}) \times 10^6$</td>
<td>5 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXCITATION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Reference Accuracy</td>
<td>$I_{REF}$ Accuracy (%) $\times 10^6$</td>
<td>2000 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vs Supply</td>
<td>$V_{IN} = 5V$</td>
<td>125 125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Reference Matching</td>
<td>$I_{REF}$ Matching (%) $\times 800µA$</td>
<td>1316 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vs Supply</td>
<td>$V_{IN} = 5V$</td>
<td>800µA $\times 0.1%/100% \times 10^6$</td>
<td>66 66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GAIN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Span</td>
<td>$\times 0.2%/100% \times 10^6$</td>
<td>2000 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonlinearity</td>
<td>$\times 0.01%/100% \times 10^6$</td>
<td>100 100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OUTPUT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero Output</td>
<td>$(I_{ZERO} - 4mA)/16000µA \times 10^6$</td>
<td>1583 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vs Supply</td>
<td>$V_{IN} = 5V$</td>
<td>1626 63</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRIFT ($\Delta T_a = 20^\circ C$)</td>
<td>$\times 1.5µV/°C \times 20°C$</td>
<td>493 493</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Offset Voltage</td>
<td>$\times 20°C/800µA \times 0.383°C/°C \times 200°C \times 10^6$</td>
<td>493 493</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>$\times 5µA/°C \times 20°C/800µA \times 0.383°C/°C \times 200°C \times 10^6$</td>
<td>0.5 0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Offset Current</td>
<td>$\times 5µA/°C \times 20°C/800µA \times 0.383°C/°C \times 200°C \times 10^6$</td>
<td>0.2 0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Reference Accuracy</td>
<td>$\times 15µpm/°C \times 20°C/800µA \times 0.383°C/°C \times 200°C \times 10^6$</td>
<td>395 395</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Reference Matching</td>
<td>$\times 25µpm/°C \times 20°C$</td>
<td>626 626</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Span</td>
<td>$\times 0.5µA/°C \times 20°C/16000µA \times 10^6$</td>
<td>2715 2715</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOISE (0.1 to 10Hz, typ)</td>
<td>$\times 0.6µV/800µA \times 0.383°C/°C \times 200°C \times 10^6$</td>
<td>10 10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Reference</td>
<td>$\times 3nA/16000µA \times 0.383°C/°C \times 200°C \times 10^6$</td>
<td>5 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero Output</td>
<td>$\times 2nA/16000µA \times 10^6$</td>
<td>2 2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE (1):** All errors are min/max and referred to input unless otherwise stated.

TOTAL ERROR: 11728 3168 (1.17%) (0.32%)
REVERSE-VOLTAGE PROTECTION

The XTR105’s low compliance rating (7.5V) permits the use of various voltage protection methods without compromising operating range. Figure 4 shows a diode bridge circuit which allows normal operation even when the voltage connection lines are reversed. The bridge causes a two diode drop (approximately 1.4V) loss in loop supply voltage. This results in a compliance voltage of approximately 9V—satisfactory for most applications. If 1.4V drop in loop supply is too much, a diode can be inserted in series with the loop supply voltage and the V+ pin. This protects against reverse output connection lines with only a 0.7V loss in loop supply voltage.

SURGE PROTECTION

Remote connections to current transmitters can sometimes be subjected to voltage surges. It is prudent to limit the maximum surge voltage applied to the XTR105 to as low as practical. Various zener diode and surge clamping diodes are specially designed for this purpose. Select a clamp diode with as low a voltage rating as possible for best protection. For example, a 36V protection diode will assure proper transmitter operation at normal loop voltages, yet will provide an appropriate level of protection against voltage surges. Characterization tests on three production lots showed no damage to the XTR105 within loop supply voltages up to 65V.

Most surge protection zener diodes have a diode characteristic in the forward direction that will conduct excessive current, possibly damaging receiving-side circuitry if the loop connections are reversed. If a surge protection diode is used, a series diode or diode bridge should be used for protection against reversed connections.

RADIO FREQUENCY INTERFERENCE

The long wire lengths of current loops invite radio frequency interference. RF can be rectified by the sensitive input circuitry of the XTR105 causing errors. This generally appears as an unstable output current that varies with the position of loop supply or input wiring.

If the RTD sensor is remotely located, the interference may enter at the input terminals. For integrated transmitter assemblies with short connection to the sensor, the interference more likely comes from the current loop connections.

Bypass capacitors on the input reduce or eliminate this input interference. Connect these bypass capacitors to the IRET terminal as shown in Figure 5. Although the dc voltage at the IRET terminal is not equal to 0V (at the loop supply, VPS) this circuit point can be considered the transmitter’s “ground.” The 0.01µF capacitor connected between V+ and IO may help minimize output interference.

![Figure 4. Reverse Voltage Operation and Over-Voltage Surge Protection.](image-url)
FIGURE 5. Input Bypassing Technique with Linearization.

FIGURE 6. Thermocouple Low Offset, Low Drift Loop Measurement with Diode Cold Junction Compensation.
FIGURE 7. ±12V Powered Transmitter/Receiver Loop.

NOTE: A two-wire RTD connection is shown. For remotely located RTDs, a three-wire RTD connection is recommended. R_G becomes 393Ω, R_LIN2 is 8060Ω. See Figure 3 and Table I.

FIGURE 8. Isolated Transmitter/Receiver Loop.

NOTE: A three-wire RTD connection is shown. For a two-wire RTD connection eliminate R_LIN2.

NOTE: (1) Use $R_{CM}$ to adjust the common-mode voltage to within 1.25V to 3.5V.
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