PRECISION VOLTAGE-TO-CURRENT CONVERTER/TRANSMITTER

FEATURES
- 4mA TO 20mA TRANSMITTER
- SELECTABLE INPUT/OUTPUT RANGES:
  0V to +5V, 0V to +10V Inputs
  0mA to 20mA, 5mA to 25mA Outputs
  Other Ranges
- 0.005% MAX NONLINEARITY, 14 BIT
- PRECISION +10V REFERENCE OUTPUT
- SINGLE SUPPLY OPERATION
- WIDE SUPPLY RANGE: 13.5V to 40V

APPLICATIONS
- INDUSTRIAL PROCESS CONTROL
- PRESSURE/TEMPERATURE TRANSMITTERS
- CURRENT-MODE BRIDGE EXCITATION
- GROUNDED TRANSDUCER CIRCUITS
- CURRENT SOURCE REFERENCE FOR DATA ACQUISITION
- PROGRAMMABLE CURRENT SOURCE FOR TEST EQUIPMENT
- POWER PLANT/ENERGY SYSTEM MONITORING

DESCRIPTION
The XTR110 is a precision voltage-to-current converter designed for analog signal transmission. It accepts inputs of 0 to 5V or 0 to 10V and can be connected for outputs of 4 to 20mA, 0 to 20mA, 5 to 25mA and many other commonly used ranges.

A precision on-chip metal film resistor network provides input scaling and current offsetting. An internal 10V voltage reference can be used to drive external circuitry.

The XTR110 is available in 16-pin plastic DIP, ceramic DIP and SOL-16 surface-mount packages. Commercial and industrial temperature range models are available.

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.
SPECIFICATIONS

ELECTRICAL

At TA = +25°C and VCC = +24V and RL = 250Ω**, unless otherwise specified.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>XTR110AG, KP, KU</th>
<th>XTR110BG</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSMITTER</td>
<td>Transfer Function</td>
<td>Io = 10 [(Vin1/16) + (Vin2/4) + (Vin2/2)]/RSPAN</td>
<td></td>
</tr>
<tr>
<td>Input Range: Vin1</td>
<td>Specified Performance</td>
<td>0</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>+10</td>
<td>V</td>
</tr>
<tr>
<td>Current, Io</td>
<td>Specified Performance</td>
<td>0</td>
<td>+5</td>
</tr>
<tr>
<td></td>
<td>Derated Performance</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>Nonlinearity</td>
<td>16mA/20mA Span</td>
<td>0.01</td>
<td>0.025</td>
</tr>
<tr>
<td>Offset Current, IoS</td>
<td>Initial</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>vs Temperature</td>
<td>0.0003</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>vs Supply, VCC</td>
<td>0.0005</td>
<td>0.005</td>
</tr>
<tr>
<td>Span Error</td>
<td>Io = 20mA</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>vs Temperature</td>
<td>0.0025</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>vs Supply, VCC</td>
<td>0.0003</td>
<td>0.0005</td>
</tr>
<tr>
<td>Output Resistance</td>
<td>From Drain of FET (QEXT)</td>
<td>10 x 10³</td>
<td>*</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>VIN1</td>
<td>27</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>VIN2</td>
<td>22</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>VREF In</td>
<td>19</td>
<td>*</td>
</tr>
<tr>
<td>Dynamic Response</td>
<td>Setting Time</td>
<td>To 0.1% of Span</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>To 0.01% of Span</td>
<td>20</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Slew Rate</td>
<td>1.3</td>
<td>*</td>
</tr>
<tr>
<td>VOLTaGE REFERENCE</td>
<td>Output Voltage +9.95</td>
<td>+10</td>
<td>+10.05</td>
</tr>
<tr>
<td></td>
<td>vs Temperature</td>
<td>35</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>vs Supply, VCC</td>
<td>0.0002</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>vs Output Current</td>
<td>0.0005</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>vs Time</td>
<td>100</td>
<td>*</td>
</tr>
<tr>
<td>Trim Range</td>
<td>Trim Range</td>
<td>-0.100</td>
<td>+0.25</td>
</tr>
<tr>
<td></td>
<td>Output Current</td>
<td>Specified Performance</td>
<td>10</td>
</tr>
<tr>
<td>POWER SUPPLY</td>
<td>Input Voltage, VCC</td>
<td>+13.5</td>
<td>+40</td>
</tr>
<tr>
<td></td>
<td>Quiescent Current</td>
<td>Excluding Io</td>
<td>3</td>
</tr>
<tr>
<td>TEMPERATURE RANGE</td>
<td>Specification: AG, BG</td>
<td>-40</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>KP, KU</td>
<td>+85</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Operating: AG, BG</td>
<td>-55</td>
<td>+70</td>
</tr>
<tr>
<td></td>
<td>KP, KU</td>
<td>+125</td>
<td>+25</td>
</tr>
<tr>
<td></td>
<td>Output Current Using Internal 50Ω Resistor</td>
<td>40mA</td>
<td></td>
</tr>
</tbody>
</table>

** Specifications same as AG/KP grades. ** Specifications apply to the range of RL shown in Typical Performance Curves.

NOTES: (1) Including internal reference. (2) Span is the change in output current resulting from a full-scale change in input voltage. (3) Within compliance range limited by (+VCC – 2V) +VDS required for linear operation of the FET. (4) For VREF adjustment circuit see Figure 3. (5) For extended IREF drive circuit see Figure 4. (5) Unit may be damaged. See section, “Input Voltage Range”.

ABSOLUTE MAXIMUM RATINGS

- Power Supply, +VCC ................................................................. 40V
- Input Voltage, VIN1, VIN2, VREF In ........................................... +VCC
- Storage Temperature Range: A, B ...................................-55°C to +125°C
- K, U ......................................-40°C to +85°C
- Lead Temperature (soldering, 10s) G, P ....................................300°C
- (wave soldering, 3s) U ..........................................................260°C
- Output Short-Circuit Duration, Gate Drive and VREF Force Continuous to common and +VCC
- Output Current Using Internal 50Ω Resistor ................................. 40mA

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.
ORDERING INFORMATION

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>PACKAGE NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>XTR110AG</td>
<td>109</td>
</tr>
<tr>
<td>XTR110BG</td>
<td>109</td>
</tr>
<tr>
<td>XTR110KP</td>
<td>180</td>
</tr>
<tr>
<td>XTR110KU</td>
<td>211</td>
</tr>
</tbody>
</table>

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

TYPICAL PERFORMANCE CURVES

- **T A  =  +25°C, V CC  =  24VDC, R L  =  250Ω, unless otherwise noted.**

- **V REF  LINE REGULATION vs FREQUENCY**

- **I G  POWER SUPPLY REGULATION vs FREQUENCY**

- **JUNCTION TEMPERATURE RISE vs V REF  OUTPUT CURRENT**

- **TOTAL OUTPUT ERROR vs TEMPERATURE**
TYPICAL PERFORMANCE CURVES (CONT)

At $T_A = +25^\circ C$, $V_{CC} = 24VDC$, $R_L = 250\Omega$, unless otherwise noted.

**ICC vs TEMPERATURE**

<table>
<thead>
<tr>
<th>Temperature ($^\circ C$)</th>
<th>ICC (mA) (excluding $I_O$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40</td>
<td>1</td>
</tr>
<tr>
<td>-20</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>40</td>
<td>5</td>
</tr>
</tbody>
</table>

**MAXIMUM $R_L$ vs $V_{CC}$**

<table>
<thead>
<tr>
<th>$+V_{CC}$ (V)</th>
<th>$R_L$ (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>500</td>
</tr>
<tr>
<td>20</td>
<td>1000</td>
</tr>
<tr>
<td>25</td>
<td>1500</td>
</tr>
<tr>
<td>30</td>
<td>2000</td>
</tr>
<tr>
<td>35</td>
<td>2500</td>
</tr>
<tr>
<td>40</td>
<td>3000</td>
</tr>
</tbody>
</table>

**SETTLING TIME WITH NEG $V_{IN}$ STEP**

- $V_{IN}$: 0V
- $I_O$ Error: 0.01% of Span/Box

**PULSE RESPONSE**

- $V_{IN}$: 0V
- $I_O$ into: 500Ω
- $I_O$ Error: 0.01% of Span/Box

**SETTLING TIME WITH POS $V_{IN}$ STEP**

- $V_{IN}$: 0V
- $I_O$ Error: 0.01% of Span/Box
APPLICATIONS INFORMATION

Figure 1 shows the basic connections required for 0 to 10V input and 4 to 20mA output. Other input voltage and output current ranges require changes in connections of pins 3, 4, 5, 9 and 10 as shown in the table of Figure 1.

The complete transfer function of the XTR110 is:

\[
I_O = \frac{10}{R_{\text{SPAN}}} \left( \frac{V_{\text{REF.IN}}}{16} + \frac{V_{\text{IN1}}}{4} + \frac{V_{\text{IN2}}}{2} \right)
\]

\(R_{\text{SPAN}}\) is the internal 50Ω resistor. \(R_p\) when connected as shown in Figure 1. An external \(R_{\text{SPAN}}\) can be connected for different output current ranges as described later.

EXTERNAL TRANSISTOR

An external pass transistor, \(Q_{\text{EXT}}\), is required as shown in Figure 1. This transistor conducts the output signal current. A P-channel MOSFET transistor is recommended. It must have a voltage rating equal or greater than the maximum power supply voltage. Various recommended types are shown in Table I.

\[
R_5 = 16.25k \Omega
\]

\[
R_6 = 1562.5 \Omega
\]

\[
R_9 = 50 \Omega
\]

\[
R_4 = 10k \Omega
\]

\[
R_3 = 20k \Omega
\]

\[
R_2 = 5k \Omega
\]

\[
R_1 = 15k \Omega
\]

\[
R_7 = 6250 \Omega
\]

\[
R_8 = 1562.5 \Omega
\]

\[
+V_{\text{CC}} = 13.5 \text{ to } 40V
\]

\[
V_{\text{REF}} = 10V
\]

\[
V_{\text{IN}} = 0 \text{ to } 10V
\]

\[
\text{Span Adjust}
\]

\[
\text{Force 15}
\]

\[
\text{Sense 12}
\]

\[
\text{V}_{\text{REF Adj}}
\]

\[
\text{Zero Adjust}
\]

\[
\text{+10V Reference}
\]

\[
\text{Input Range (V)}
\]

\[
\text{Output Range (mA)}
\]

\[
\text{PIN 3}
\]

\[
\text{PIN 4}
\]

\[
\text{PIN 5}
\]

\[
\text{PIN 9}
\]

\[
\text{PIN 10}
\]

\[
\begin{array}{|c|c|c|c|c|c|c|}
\hline
\text{Input Range (V)} & \text{Output Range (mA)} & \text{PIN 3} & \text{PIN 4} & \text{PIN 5} & \text{PIN 9} & \text{PIN 10} \\
\hline
0-10 & 0-20 & \text{Com} & \text{Input} & \text{Com} & \text{Com} & \text{Com} \\
2-10 & 4-20 & \text{Com} & \text{Input} & \text{Com} & \text{Com} & \text{Com} \\
0-10 & 4-20 & +10V Ref & \text{Input} & \text{Com} & \text{Com} & \text{Com} \\
0-10 & 5-25 & +10V Ref & \text{Input} & \text{Com} & \text{Com} & \text{Com} \\
0-5 & 0-20 & \text{Com} & \text{Input} & \text{Com} & \text{Com} & \text{Com} \\
0-5 & 4-20 & +10V Ref & \text{Input} & \text{Com} & \text{Com} & \text{Com} \\
0-5 & 4-20 & +10V Ref & \text{Input} & \text{Com} & \text{Com} & \text{Com} \\
0-5 & 5-25 & +10V Ref & \text{Input} & \text{Com} & \text{Com} & \text{Com} \\
\hline
\end{array}
\]

NOTE: (1) \(BV_{\text{DSS}}\)—Drain-source breakdown voltage. \(BV_{\text{GS}}\)—Gate-source breakdown voltage.

TABLE I. Available P-Channel MOSFETs.

![Figure 1: Basic Circuit Connection.](image-url)
If the supply voltage, \( +V_{CC} \), exceeds the gate-to-source breakdown voltage of \( Q_{EXT} \), and the output connection (drain of \( Q_{EXT} \)) is broken, \( Q_{EXT} \) could fail. If the gate-to-source breakdown voltage is lower than \( +V_{CC} \), \( Q_{EXT} \) can be protected with a 12V zener diode connected from gate to source.

Two PNP discrete transistors (Darlington-connected) can be used for \( Q_{EXT} \)—see Figure 2. Note that an additional capacitor is required for stability. Integrated Darlington transistors are not recommended because their internal base-emitter resistors cause excessive error.

**TRANSISTOR DISSIPATION**

Maximum power dissipation of \( Q_{EXT} \) depends on the power supply voltage and full-scale output current. Assuming that the load resistance is low, the power dissipated by \( Q_{EXT} \) is:

\[
P_{\text{MAX}} = ( +V_{CC} ) I_{FS}
\]

(2)

The transistor type and heat sinking must be chosen according to the maximum power dissipation to prevent overheating. See Table II for general recommendations.

<table>
<thead>
<tr>
<th>PACKAGE TYPE</th>
<th>ALLOWABLE POWER DISSIPATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO-92</td>
<td>Lowest: Use minimum supply and at +25°C.</td>
</tr>
<tr>
<td>TO-237</td>
<td>Acceptable: Trade-off supply and temperature.</td>
</tr>
<tr>
<td>TO-39</td>
<td>Good: Adequate for majority of designs.</td>
</tr>
<tr>
<td>TO-220</td>
<td>Excellent: For prolonged maximum stress.</td>
</tr>
<tr>
<td>TO-3</td>
<td>Use if hermetic package is required.</td>
</tr>
</tbody>
</table>

**INPUT VOLTAGE RANGE**

The internal op amp \( A_1 \) can be damaged if its non-inverting input (an internal node) is pulled more than 0.5V below common (0V). This could occur if input pins 3, 4 or 5 were driven with an op amp whose output could swing negative under abnormal conditions. The voltage at the input of \( A_1 \) is:

\[
V_{A1} = \frac{(V_{\text{REF IN}})}{16} + \frac{(V_{\text{IN1}})}{4} + \frac{(V_{\text{IN2}})}{2}
\]

(3)

This voltage should not be allowed to go more negative than \(-0.5V\). If necessary, a clamp diode can be connected from the negative-going input to common to clamp the input voltage.

**COMMON (Ground)**

Careful attention should be directed toward proper connection of the common (grounds). All commons should be joined at one point as close to pin 2 of the XTR110 as possible. The exception is the \( I_{OUT} \) return. It can be returned to any point where it will not modulate the common at pin 2.

**VOLTAGE REFERENCE**

The reference voltage is accurately regulated at pin 12 (\( V_{\text{REF SENSE}} \)). To preserve accuracy, any load including pin 3 should be connected to this point. The circuit in Figure 3 shows adjustment of the voltage reference.

The current drive capability of the XTR110’s internal reference is 10mA. This can be extended if desired by adding an external NPN transistor shown in Figure 4.

**OFFSET (ZERO) ADJUSTMENT**

The offset current can be adjusted by using the potentiometer, \( R_1 \), shown in Figure 5. Set the input voltage to zero and then adjust \( R_1 \) to give 4mA at the output. For spans starting...
at 0mA, the following special procedure is recommended: set the input to a small nonzero value and then adjust R₁ to the proper output current. When the input is zero the output will be zero. Figures 6 and 7 show graphically how offset is adjusted.

**SPAN ADJUSTMENT**

The span is adjusted at the full-scale output current using the potentiometer, R₂, shown in Figure 5. This adjustment is interactive with the offset adjustment, and a few iterations may be necessary. For the circuit shown, set the input voltage to +10V full scale and adjust R₂ to give 20mA full-scale output. Figures 6 and 7 show graphically how span is adjusted.

The values of R₂, R₃, and R₄ for adjusting the span are determined as follows: choose R₄ in series to slightly decrease the span; then choose R₂ and R₃ to increase the span to be adjustable about the center value.

**LOW TEMPERATURE COEFFICIENT OPERATION**

Although the precision resistors in the XTR110 track within 1ppm/°C, the output current depends upon the absolute temperature coefficient (TC) of any one of the resistors, R₆, R₇, R₈, and R₉. Since the absolute TC of the output current can have 20ppm/°C, maximum, the TC of the output current can have 20ppm/°C drift. For low TC operation, zero TC resistors can be substituted for either the span resistors (R₆ or R₇) or for the source resistor (R₉) but not both.

**EXTENDED SPAN**

For spans beyond 40mA, the internal 50Ω resistor (R₀) may be replaced by an external resistor connected between pins 13 and 16.

Its value can be calculated as follows:

\[ R_{EXT} = R_9 \left( \frac{\text{Span}_{OLD}}{\text{Span}_{NEW}} \right) \]

Since the internal thin-film resistors have a 20% absolute value tolerance, measure R₀ before determining the final value of R_{EXT}. Self-heating of R_{EXT} can cause nonlinearity. Therefore, choose one with a low TC and adequate power rating. See Figure 10 for application.
TYPICAL APPLICATIONS

The XTR110 is ideal for a variety of applications requiring high noise immunity current-mode signal transmission. The precision +10V reference can be used to excite bridges and transducers. Selectable ranges make it very useful as a precision programmable current source. The compact design and low price of the XTR110 allow versatility with a minimum of external components and design engineering expense.

Figures 8 through 10 show typical applications of the XTR110.

**FIGURE 8. ±200mA Current Pump.**

- $V_{IN}$
- $V_{OUT}$
- $A_1$, $A_2$: 1/4 LM324 (powered by ±15V).
- $T_1$: International Rectifier IR9513(1).
- $T_2$: International Rectifier IR513(1).
- $T_3$: International Rectifier IRFF9113(1).

NOTE: (1) Or other adequate power rating MOS transistor.

R1, R2: Low TC resistors to dissipate 0.32W continuous power.
For other current ranges, scale both resistors proportionately.
R6, R10, R11: 10-turn trimpots for greatest sensitivity.
R5, R7, R8: Low TC resistors.
T1: International Rectifier IR9513(1).
T2: International Rectifier IR513(1).
T3: International Rectifier IRFF9113(1).

**Figures 8 through 10 show typical applications of the XTR110.**
FIGURE 9. Isolated 4mA to 20mA Channel.

FIGURE 10. 0A to 10A Output Voltage-to-Current Converter.
### PACKAGE INFORMATION

<table>
<thead>
<tr>
<th>Orderable Device</th>
<th>Status (1)</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>Package Qty</th>
<th>Eco Plan (2)</th>
<th>Lead/Ball Finish</th>
<th>MSL Peak Temp (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XTR110AG</td>
<td>NRND</td>
<td>CDIP SB</td>
<td>JD</td>
<td>16</td>
<td>24</td>
<td>None</td>
<td>Call TI</td>
<td>Level-NA-NA-NA</td>
</tr>
<tr>
<td>XTR110BG</td>
<td>NRND</td>
<td>CDIP SB</td>
<td>JD</td>
<td>16</td>
<td>24</td>
<td>None</td>
<td>Call TI</td>
<td>Level-NA-NA-NA</td>
</tr>
<tr>
<td>XTR110KP</td>
<td>ACTIVE</td>
<td>PDIP</td>
<td>N</td>
<td>16</td>
<td>25</td>
<td>Pb-Free (RoHS)</td>
<td>Call TI</td>
<td>Level-NC-NC-NC</td>
</tr>
<tr>
<td>XTR110KU</td>
<td>ACTIVE</td>
<td>SOIC</td>
<td>DW</td>
<td>16</td>
<td>48</td>
<td>None</td>
<td>CU NIPDAU</td>
<td>Level-2-220C-1 YEAR</td>
</tr>
<tr>
<td>XTR110KU/1K</td>
<td>ACTIVE</td>
<td>SOIC</td>
<td>DW</td>
<td>16</td>
<td>1000</td>
<td>None</td>
<td>CU SNPB</td>
<td>Level-2-220C-1 YEAR</td>
</tr>
</tbody>
</table>

(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 - May not be currently available - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
- **None**: Not yet available Lead (Pb-Free).
- **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” and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

(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.
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package is hermetically sealed with a metal lid.
D. The terminals are gold plated.
E. Falls within MIL STD 1835 C01P2 = T8, T14, T16, T18, T20 and T24 respectively.
N (R—PDIP—T**)  PLASTIC DUAL—IN—LINE PACKAGE

16 PINS SHOWN

<table>
<thead>
<tr>
<th>Pins</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td>0.775 (19.69)</td>
<td>0.775 (19.69)</td>
<td>0.920 (23.37)</td>
<td>1.060 (26.92)</td>
</tr>
<tr>
<td>Min</td>
<td>0.745 (18.92)</td>
<td>0.745 (18.92)</td>
<td>0.850 (21.59)</td>
<td>0.940 (23.88)</td>
</tr>
</tbody>
</table>

** MS—001 Variation AA BB AC AD

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.

⚠️ Falls within JEDEC MS—001, except 18 and 20 pin minimum body length (Dim A).
⚠️ The 20 pin end lead shoulder width is a vendor option, either half or full width.
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0.15).
D. Falls within JEDEC MS-013 variation AA.
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 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.

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.

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

<table>
<thead>
<tr>
<th>Products</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplifiers</td>
<td>Audio</td>
</tr>
<tr>
<td>Data Converters</td>
<td>Automotive</td>
</tr>
<tr>
<td>DSP</td>
<td>Broadband</td>
</tr>
<tr>
<td>Interface</td>
<td>Digital Control</td>
</tr>
<tr>
<td>Logic</td>
<td>Military</td>
</tr>
<tr>
<td>Power Mgmt</td>
<td>Optical Networking</td>
</tr>
<tr>
<td>Microcontrollers</td>
<td>Security</td>
</tr>
<tr>
<td></td>
<td>Telephony</td>
</tr>
<tr>
<td></td>
<td>Video &amp; Imaging</td>
</tr>
<tr>
<td></td>
<td>Wireless</td>
</tr>
</tbody>
</table>

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265

Copyright © 2005, Texas Instruments Incorporated