LM231A/LM231/LM331A/LM331 Precision Voltage-to-Frequency Converters

General Description
The LM231/LM331 family of voltage-to-frequency converters are ideally suited for use in simple low-cost circuits for analog-to-digital conversion, precision frequency-to-voltage conversion, long-term integration, linear frequency modulation or demodulation, and many other functions. The output when used as a voltage-to-frequency converter is a pulse train at a frequency precisely proportional to the applied input voltage. Thus, it provides all the inherent advantages of the voltage-to-frequency conversion techniques, and is easy to apply in all standard voltage-to-frequency converter applications. Further, the LM231A/LM331A attain a new high level of accuracy versus temperature which could only be attained with expensive voltage-to-frequency modules. Additionally, the LM231/331 are ideally suited for use in digital systems at low power supply voltages and can provide low-cost analog-to-digital conversion in microprocessor-controlled systems. And, the frequency from a battery powered voltage-to-frequency converter can be easily channeled through a simple photo isolator to provide isolation against high common mode levels.

The LM231/LM331 utilize a new temperature-compensated band-gap reference circuit, to provide excellent accuracy over the full operating temperature range, at power supplies as low as 4.0V. The precision timer circuit has low bias currents without degrading the quick response necessary for 100 kHz voltage-to-frequency conversion. And the output are capable of driving 3 TTL loads, or a high voltage output up to 40V, yet is short-circuit-proof against \( V_{CC} \).

Features
- Guaranteed linearity 0.01% max
- Improved performance in existing voltage-to-frequency conversion applications
- Split or single supply operation
- Operates on single 5V supply
- Pulse output compatible with all logic forms
- Excellent temperature stability: ±50 ppm/°C max
- Low power consumption: 15 mW typical at 5V
- Wide dynamic range, 100 dB min at 10 kHz full scale frequency
- Wide range of full scale frequency: 1 Hz to 100 kHz
- Low cost

Connection Diagram

Ordering Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Temperature Range</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM231N</td>
<td>(-25°C ≤ T_A ≤ +85°C)</td>
<td>N08E (DIP)</td>
</tr>
<tr>
<td>LM231AN</td>
<td>(-25°C ≤ T_A ≤ +85°C)</td>
<td>N08E (DIP)</td>
</tr>
<tr>
<td>LM331N</td>
<td>(0°C ≤ T_A ≤ +70°C)</td>
<td>N08E (DIP)</td>
</tr>
<tr>
<td>LM331AN</td>
<td>(0°C ≤ T_A ≤ +70°C)</td>
<td>N08E (DIP)</td>
</tr>
</tbody>
</table>

Teflon® is a registered trademark of DuPont
Absolute Maximum Ratings
(Notes 1, 2)
If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

- Supply Voltage, $V_S$: 40V
- Output Short Circuit to Ground: Continuous
- Output Short Circuit to $V_{CC}$: Continuous
- Input Voltage: $-0.2V$ to $+V_S$
- Package Dissipation at 25°C: 1.25W (Note 3)
- Lead Temperature (Soldering, 10 sec.): Dual-In-Line Package (Plastic) 260°C
- ESD Susceptibility (Note 5): 500V

Operating Ratings (Note 2)

- Operating Ambient Temperature
  - LM231, LM231A: −25°C to +85°C
  - LM331, LM331A: 0°C to +70°C
- Supply Voltage, $V_S$: +4V to +40V

Package Thermal Resistance

<table>
<thead>
<tr>
<th>Package</th>
<th>$\theta_{JA}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-Lead Plastic DIP</td>
<td>100°C/W</td>
</tr>
</tbody>
</table>

Electrical Characteristics

All specifications apply in the circuit of Figure 4, with $4.0V \leq V_S \leq 40V$, $T_A=25°C$, unless otherwise specified.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>VFC Non-Linearity (Note 4)</td>
<td>$4.5V \leq V_S \leq 20V$</td>
<td>±0.003</td>
<td>±0.01</td>
<td>% Full- Scale</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$T_{MIN} \leq T_A \leq T_{MAX}$</td>
<td>±0.006</td>
<td>±0.02</td>
<td>% Full- Scale</td>
<td></td>
</tr>
<tr>
<td>VFC Non-Linearity in Circuit of Figure 3</td>
<td>$V_S = 15V$, $f = 10$ Hz to 11 kHz</td>
<td>±0.024</td>
<td>±0.14</td>
<td>% Full- Scale</td>
<td></td>
</tr>
<tr>
<td>Conversion Accuracy Scale Factor (Gain)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LM231, LM331A</td>
<td>$V_{IN} = -10V$, $R_S = 14$ kΩ</td>
<td>0.95</td>
<td>1.00</td>
<td>1.05</td>
<td>kHz/V</td>
</tr>
<tr>
<td>LM331, LM331A</td>
<td></td>
<td>0.90</td>
<td>1.00</td>
<td>1.10</td>
<td>kHz/V</td>
</tr>
<tr>
<td>Temperature Stability of Gain</td>
<td>$4.5V \leq V_S \leq 20V$</td>
<td>±30</td>
<td>±150</td>
<td>ppm/°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$T_{MIN} \leq T_A \leq T_{MAX}$</td>
<td>±20</td>
<td>±50</td>
<td>ppm/°C</td>
<td></td>
</tr>
<tr>
<td>Change of Gain with $V_S$</td>
<td>$4.5V \leq V_S \leq 10V$</td>
<td>0.01</td>
<td>0.1</td>
<td>%/V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$10V \leq V_S \leq 40V$</td>
<td>0.006</td>
<td>0.06</td>
<td>%/V</td>
<td></td>
</tr>
<tr>
<td>Rated Full-Scale Frequency</td>
<td>$V_{IN} = -10V$</td>
<td>10.0</td>
<td></td>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td>Gain Stability vs. Time (1000 Hours)</td>
<td>$T_{MIN} \leq T_A \leq T_{MAX}$</td>
<td>±0.02</td>
<td></td>
<td>% Full- Scale</td>
<td></td>
</tr>
<tr>
<td>Over Range (Beyond Full-Scale) Frequency</td>
<td>$V_{IN} = -11V$</td>
<td>10</td>
<td></td>
<td>%</td>
<td></td>
</tr>
</tbody>
</table>

**INPUT COMPARATOR**

| Offset Voltage                                      |                                   | ±3        | ±10       | mV        |
|                                                     | $T_{MIN} \leq T_A \leq T_{MAX}$   | ±4        | ±14       | mV        |
| Bias Current                                        |                                   | ±3        | ±10       | mV        |
| Offset Current                                      |                                   | ±8        | ±100      | nA        |
| Common-Mode Range                                   |                                   | −0.2      | $V_{CC}-2.0$ | V        |

**TIMER**

| Timer Threshold Voltage, Pin 5                      |                                   | 0.63      | 0.667     | 0.70      | $xV_S$ |
| Input Bias Current, Pin 5                           | $V_S = 15V$                       |           |           |           |        |
| All Devices                                         | $0V \leq V_{PIN 5} \leq 9.9V$     | ±10       | ±100      | nA        |
| LM231/LM331                                         | $V_{PIN 5} = 10V$                 | 200       | 1000      | nA        |
| LM231A/LM331A                                       | $V_{PIN 5} = 10V$                 | 200       | 500       | nA        |
| $V_{SAT PIN 5}$ (Reset)                             | $I = 5$ mA                       | 0.22      | 0.5       | V        |

**CURRENT SOURCE (Pin 1)**

| Output Current                                      |                                   | 126       | 135       | 144       | μA     |
| LM231, LM231A                                       | $R_S = 14$ kΩ, $V_{PIN 1} = 0$    | 116       | 136       | 156       | μA     |
| LM331, LM331A                                       |                                   |           |           |           |        |
| Change with Voltage                                 | $0V \leq V_{PIN 1} \leq 10V$      | 0.2       | 1.0       | μA        |
| Current Source OFF Leakage                          |                                   |           |           |           |        |

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## Electrical Characteristics

All specifications apply in the circuit of Figure 4, with $4.0V \leq V_S \leq 40V$, $T_A=25^\circ C$, unless otherwise specified.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CURRENT SOURCE (Pin 1)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LM231, LM231A, LM331, LM331A</td>
<td>$T_A = T_{\text{MAX}}$</td>
<td>0.02</td>
<td>10.0</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>All Devices</td>
<td></td>
<td>2.0</td>
<td>50.0</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td><strong>Operating Range of Current (Typical)</strong></td>
<td>(10 to 500)</td>
<td>µA</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>REFERENCE VOLTAGE (Pin 2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LM231, LM231A</td>
<td></td>
<td>1.76</td>
<td>1.89</td>
<td>2.02</td>
<td>V DC</td>
</tr>
<tr>
<td>LM331, LM331A</td>
<td></td>
<td>1.70</td>
<td>1.89</td>
<td>2.08</td>
<td>V DC</td>
</tr>
<tr>
<td><strong>Stability vs. Temperature</strong></td>
<td></td>
<td>±60</td>
<td>ppm/°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stability vs. Time, 1000 Hours</strong></td>
<td></td>
<td>±0.1</td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td><strong>LOGIC OUTPUT (Pin 3)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{\text{SAT}}$</td>
<td>$I = 5\ mA$</td>
<td>0.15</td>
<td>0.50</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I = 3.2\ mA$ (2 TTL Loads), $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}}$</td>
<td>0.10</td>
<td>0.40</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td><strong>OFF Leakage</strong></td>
<td></td>
<td>±0.05</td>
<td>1.0</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td><strong>SUPPLY CURRENT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LM231, LM231A</td>
<td>$V_S = 5V$</td>
<td>2.0</td>
<td>3.0</td>
<td>4.0</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>$V_S = 40V$</td>
<td>2.5</td>
<td>4.0</td>
<td>6.0</td>
<td>mA</td>
</tr>
<tr>
<td>LM331, LM331A</td>
<td>$V_S = 5V$</td>
<td>1.5</td>
<td>3.0</td>
<td>6.0</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>$V_S = 40V$</td>
<td>2.0</td>
<td>4.0</td>
<td>8.0</td>
<td>mA</td>
</tr>
</tbody>
</table>

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its specified operating conditions.

**Note 2:** All voltages are measured with respect to $GND = 0V$, unless otherwise noted.

**Note 3:** The absolute maximum junction temperature ($T_{\text{max}}$) for this device is 150°C. The maximum allowable power dissipation is dictated by $T_{\text{max}}$, the junction-to-ambient thermal resistance ($\theta_{JA}$), and the ambient temperature $T_A$, and can be calculated using the formula $P_{\text{Dmax}} = (T_{\text{max}} - T_A) / \theta_{JA}$. The values for maximum power dissipation will be reached only when the device is operated in a severe fault condition (e.g., when input or output pins are driven beyond the power supply voltages, or the power supply polarity is reversed). Obviously, such conditions should always be avoided.

**Note 4:** Nonlinearity is defined as the deviation of $f_{\text{OUT}}$ from $V_N \times (10\ kHz/-10\ V_{\text{DC}})$ when the circuit has been trimmed for zero error at 10 Hz and at 10 kHz, over the frequency range 1 Hz to 11 kHz. For the timing capacitor, $C_T$, use NPO ceramic, Teflon®, or polystyrene.

**Note 5:** Human body model, 100 pF discharged through a 1.5 kΩ resistor.
Pin numbers apply to 8-pin packages only.

FIGURE 1.
Typical Performance Characteristics
(All electrical characteristics apply for the circuit of Figure 4, unless otherwise noted.)
Typical Performance Characteristics (Continued)

100 kHz Nonlinearity Error
(Figure 5)

Nonlinearity Error
(Figure 5)

Input Current (Pins 6,7) vs.
Temperature

Power Drain vs. V\textsubscript{SUPPLY}

Output Saturation Voltage vs.
I\textsubscript{OUT} (Pin 3)

Nonlinearity Error, Precision
F-to-V Converter (Figure 7)
Applications Information

PRINCIPLES OF OPERATION

The LM231/331 are monolithic circuits designed for accuracy and versatile operation when applied as voltage-to-frequency (V-to-F) converters or as frequency-to-voltage (F-to-V) converters. A simplified block diagram of the LM231/331 is shown in Figure 2 and consists of a switched current source, input comparator, and 1-shot timer.

Simplified Voltage-to-Frequency Converter

The operation of these blocks is best understood by going through the operating cycle of the basic V-to-F converter, Figure 2, which consists of the simplified block diagram of the LM231/331 and the various resistors and capacitors connected to it.

The voltage comparator compares a positive input voltage, V1, at pin 7 to the voltage, Vs, at pin 6. If V1 is greater, the comparator will trigger the 1-shot timer. The output of the timer will control both the frequency output transistor and the switched current source for a period t = 1.1 RtCt. During this period, the current i will flow out of the switched current source and provide a fixed amount of charge, Q = i x t, into the capacitor, C1. This will normally charge Vs up to a higher level than V1. At the end of the timing period, the current i will turn OFF, and the timer will reset itself.

Now there is no current flowing from pin 1, and the capacitor C1 will be gradually discharged by Rs until Vs falls to the level of V1. Then the comparator will trigger the timer and start another cycle.

The current flowing into C1 is exactly
\[ i_{\text{AVE}} = i \times (1.1 \times R_l C_l) \times f \]
and the current flowing out of C1 is exactly
\[ V_2/V_l = V_{IN}/R_L \]
If V_IN is doubled, the frequency will double to maintain this balance. Even a simple V-to-F converter can provide a frequency precisely proportional to its input voltage over a wide range of frequencies.

Detail of Operation, Functional Block Diagram (Figure 1)

The block diagram shows a band gap reference which provides a stable 1.9 VDC output. This 1.9 VDC is well regulated over a Vs range of 3.9V to 40V. It also has a flat, low temperature coefficient, and typically changes less than 1/2% over a 100°C temperature change.

The current pump circuit forces the voltage at pin 2 to be at 1.9V, and causes a current i = 1.90V/Rs to flow. For Rs = 14k, i = 135 µA. The precision current reflector provides a current equal to i to the current switch. The current switch switches the current to pin 1 or to ground, depending upon the state of the Rsi flip-flop.

The timing function consists of an Rs flip-flop and a timer comparator connected to the external R, C network. When the input comparator detects a voltage at pin 7 higher than pin 6, it sets the Rs flip-flop which turns ON the current switch and the output driver transistor. When the voltage at pin 5 rises to 2/3 Vcc, the timer comparator causes the Rs flip-flop to reset. The reset transistor is then turned ON and the current switch is turned OFF.

However, if the input comparator still detects pin 7 higher than pin 6 when pin 5 crosses 2/3 Vcc, the flip-flop will not reset, and the current at pin 1 will continue to flow, trying to make the voltage at pin 6 higher than pin 7. This condition will usually apply under start-up conditions or in the case of an overload voltage at signal input. During this sort of overload, the output frequency will be 0. As soon as the signal is restored to the working range, the output frequency will be resumed.

The output driver transistor acts to saturate pin 3 with an ON resistance of about 50Ω. In case of over voltage, the output current is actively limited to less than 50 mA.

The voltage at pin 2 is regulated at 1.90 VDC for all values of i between 10 µA to 500 µA. It can be used as a voltage reference for other components, but care must be taken to ensure that current is not taken from it which could reduce the accuracy of the converter.

Basic Voltage-to-Frequency Converter (Figure 3)

The simple stand-alone V-to-F converter shown in Figure 3 includes all the basic circuitry of Figure 2 plus a few components for improved performance.

A resistor, Rs = 100 kΩ ± 10%, has been added in the path to pin 7, so that the bias current at pin 7 (~80 nA typical) will cancel the effect of the bias current at pin 6 and help provide minimum frequency offset.

The resistance Rs at pin 2 is made up of a 12 kΩ fixed resistor plus a 5 kΩ (cermet, preferably) gain adjust rheostat. The function of this adjustment is to trim out the gain tolerance of the LM231/331, and the tolerance of Rs, Rs, and C1.

For best results, all the components should be stable low-temperature-coefficient components, such as metal-film resistors. The capacitor should have low dielectric absorption, depending on the temperature characteristics desired, NPO ceramic, polystyrene, Teflon or polypropylene are best suited.

A capacitor CIN is added from pin 7 to ground to act as a filter for V_IN. A value of 0.01 µF to 0.1 µF will be adequate in most cases; however, in cases where better filtering is required, a 1 µF capacitor can be used. When the RC time constants are matched at pin 6 and pin 7, a voltage step at V_IN will cause a step change in f_OUT. If C_IN is much less than C_L, a step at V_IN may cause f_OUT to stop momentarily.
Applications Information (Continued)

A 47Ω resistor, in series with the 1 µF C_L, provides hysteresis, which helps the input comparator provide the excellent linearity.

Details of Operation: Precision V-To-F Converter (Figure 4)

In this circuit, integration is performed by using a conventional operational amplifier and feedback capacitor, C_F. When the integrator's output crosses the nominal threshold level at pin 6 of the LM231/331, the timing cycle is initiated. The average current fed into the op-amp's summing point (pin 2) is \( i \times (1.1 \frac{R_T}{C_T}) \times f \) which is perfectly balanced with \( -\frac{V_{IN}}{R_{IN}} \). In this circuit, the voltage offset of the LM231/331 input comparator does not affect the offset or accuracy of the V-to-F converter as it does in the stand-alone V-to-F converter; nor does the LM231/331 bias current or offset current. Instead, the offset voltage and offset current of the operational amplifier are the only limits on how small the signal can be accurately converted. Since op-amps with voltage offset well below 1 mV and offset currents well below 2 nA are available at low cost, this circuit is recommended for best accuracy for small signals. This circuit also responds immediately to any change of input signal (which a stand-alone circuit does not) so that the output frequency will be an accurate representation of \( V_{IN} \), as quickly as 2 output pulses' spacing can be measured.

In the precision mode, excellent linearity is obtained because the current source (pin 1) is always at ground potential and that voltage does not vary with \( V_{IN} \) or \( f_{OUT} \). (In the stand-alone V-to-F converter, a major cause of non-linearity is the output impedance at pin 1 which causes \( I \) to change as a function of \( V_{IN} \)).

The circuit of Figure 5 operates in the same way as Figure 4, but with the necessary changes for high speed operation.

*Use stable components with low temperature coefficients. See Typical Applications section.

**0.1µF or 1µF, See “Principles of Operation.”

**0.01µF or 1µF, See “Principles of Operation.”

***Use low offset voltage and low offset current op-amps for A1: recommended type LF411A

FIGURE 3. Simple Stand-Alone V-to-F Converter with ±0.03% Typical Linearity (f = 10 Hz to 11 kHz)

FIGURE 4. Standard Test Circuit and Applications Circuit, Precision Voltage-to-Frequency Converter

*Use stable components with low temperature coefficients. See Typical Applications section.

**This resistor can be 5 kΩ or 10 kΩ for \( V_S=8V \) to 22V, but must be 10 kΩ for \( V_S=4.5V \) to 8V.

***Use low offset voltage and low offset current op-amps for A1: recommended type LF411A
DETAILS OF OPERATION: F-to-V CONVERTERS
(Figure 6 and Figure 7)

In these applications, a pulse input at fIN is differentiated by a C-R network and the negative-going edge at pin 6 causes the input comparator to trigger the timer circuit. Just as with a V-to-F converter, the average current flowing out of pin 1 is

\[ I_{\text{AVERAGE}} = i \times (1.1 \times R_t C_t) \times f. \]

In the simple circuit of Figure 6, this current is filtered in the network \( R_L = 100 \, \text{k}\Omega \) and 1 \( \mu \text{F} \). The ripple will be less than 10 mV peak, but the response will be slow, with a 0.1 second time constant, and settling of 0.7 second to 0.1% accuracy.

In the precision circuit, an operational amplifier provides a buffered output and also acts as a 2-pole filter. The ripple will be less than 5 mV peak for all frequencies above 1 kHz, and the response time will be much quicker than in Figure 6. However, for input frequencies below 200 Hz, this circuit will have worse ripple than Figure 6. The engineering of the filter time-constants to get adequate response and small enough ripple simply requires a study of the compromises to be made. Inherently, V-to-F converter response can be fast, but F-to-V response can not.

*Use stable components with low temperature coefficients.
See Typical Applications section.

**This resistor can be 5 kΩ or 10 kΩ for \( V_S=8\,\text{V} \) to \( 22\,\text{V} \), but must be 10 kΩ for \( V_S=4.5\,\text{V} \) to \( 8\,\text{V} \).

***Use low offset voltage and low offset current op-amps for A1: recommended types LF411A or LF356.

FIGURE 5. Precision Voltage-to-Frequency Converter, 100 kHz Full-Scale, ±0.03% Non-Linearity
Applications Information (Continued)

*Use stable components with low temperature coefficients.

FIGURE 6. Simple Frequency-to-Voltage Converter, 10 kHz Full-Scale, ±0.06% Non-Linearity

\[ V_{OUT} = f_{IN} \times 2.09V \times \frac{R_F}{R_S} \times (R_1C_1) \]

*Use stable components with low temperature coefficients.

FIGURE 7. Precision Frequency-to-Voltage Converter, 10 kHz Full-Scale with 2-Pole Filter, ±0.01% Non-Linearity Maximum

\[ V_{OUT} = -f_{IN} \times 2.09V \times \frac{R_E}{R_S} \times (R_1C_1) \]

SELECT \( R_x = \frac{(V_S - 2V)}{0.2 \text{ mA}} \)

*Use stable components with low temperature coefficients.
Applications Information (Continued)

Light Intensity to Frequency Converter

![Diagram of Light Intensity to Frequency Converter]

*L14F-1, L14G-1 or L14H-1, photo transistor (General Electric Co.) or similar

Temperature to Frequency Converter

![Diagram of Temperature to Frequency Converter]

Long-Term Digital Integrator Using VFC

![Diagram of Long-Term Digital Integrator Using VFC]

Basic Analog-to-Digital Converter Using Voltage-to-Frequency Converter

![Diagram of Basic Analog-to-Digital Converter Using Voltage-to-Frequency Converter]

Analog-to-Digital Converter with Microprocessor

![Diagram of Analog-to-Digital Converter with Microprocessor]
Applications Information (Continued)

Remote Voltage-to-Frequency Converter with 2-Wire Transmitter and Receiver

Voltage-to-Frequency Converter with Square-Wave Output Using ÷2 Flip-Flop

Voltage-to-Frequency Converter with Isolators
Applications Information (Continued)

Voltage-to-Frequency Converter with Isolators

Voltage-to-Frequency Converter with Isolators

TELEMETRY USING RF LINK

Voltage-to-Frequency Converter with Isolators

FIBER-OPTIC LIGHT PIPE

TO COMPUTER OR TO COUNTER OR TO F TO V CONVERTER USING LM331

00568017

00568018

00568019
Physical Dimensions

inches (millimeters) unless otherwise noted

Dual-In-Line Package (N)
Order Number LM231AN, LM231N, LM331AN, or LM331N
NS Package N08E

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LIFE SUPPORT POLICY

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

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.

2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

BANNED SUBSTANCE COMPLIANCE

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

Leadfree products are RoHS compliant.

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