LM2907/LM2917 Frequency to Voltage Converter

General Description
The LM2907, LM2917 series are monolithic frequency to voltage converters with a high gain op amp/comparator designed to operate a relay, lamp, or other load when the input frequency reaches or exceeds a selected rate. The tachometer uses a charge pump technique and offers frequency doubling for low ripple, full input protection in two versions (LM2907-8, LM2917-8) and its output swings to ground for a zero frequency input.

Advantages
- Output swings to ground for zero frequency input
- Easy to use: \( V_{\text{OUT}} = f_N \times V_{\text{CC}} \times R1 \times C1 \)
- Only one RC network provides frequency doubling
- Zener regulator on chip allows accurate and stable frequency to voltage or current conversion (LM2917)

Features
- Ground referenced tachometer input interfaces directly with variable reluctance magnetic pickups
- Op amp/comparator has floating transistor output
- 50 mA sink or source to operate relays, solenoids, meters, or LEDs
- Frequency doubling for low ripple
- Tachometer has built-in hysteresis with either differential input or ground referenced input
- Built-in zener on LM2917
- ±0.3% linearity typical
- Ground referenced tachometer is fully protected from damage due to swings above \( V_{\text{CC}} \) and below ground

Applications
- Over/under speed sensing
- Frequency to voltage conversion (tachometer)
- Speedometers
- Breaker point dwell meters
- Hand-held tachometer
- Speed governors
- Cruise control
- Automotive door lock control
- Clutch control
- Horn control
- Touch or sound switches

Block and Connection Diagrams
Dual-In-Line and Small Outline Packages, Top Views
Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Power Dissipation

<table>
<thead>
<tr>
<th>Device</th>
<th>Power Dissipation</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM2907-8, LM2917-8</td>
<td>1200 mW</td>
</tr>
<tr>
<td>LM2907-14, LM2917-14</td>
<td>1580 mW</td>
</tr>
</tbody>
</table>

(See Note 1)

Supply Voltage 28V

Supply Current (Zener Options) 25 mA

Collector Voltage 28V

Differential Input Voltage

- Tachometer 28V
- Op Amp/Comparator 28V

Input Voltage Range

- Tachometer LM2907-8, LM2917-8 +28V
- LM2907, LM2917 0.0V to +28V
- Op Amp/Comparator 0.0V to +28V

Soldering Information

- Dual-in-Line Package (Soldering (10 seconds) 260°C)
- Small Outline Package (Vapor Phase (60 seconds) 215°C, Infrared (15 seconds) 220°C)

See AN-450 “Surface Mounting Methods and Their Effect on Product Reliability” for other methods of soldering surface mount devices.

Electrical Characteristics \( V_{CC} = 12 \ V, T_{A} = 25^\circ C \), see test circuit

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TACHOMETER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Input Thresholds

- \( V_{IN} \) = 250 mVp-p @ 1 kHz (Note 2)
- Hysteresis
- Offset Voltage
  - LM2907/LM2917 3.5 mV
  - LM2907-8/LM2917-8 5 mV
- Input Bias Current
- \( V_{OH} \) Pin 2
- \( V_{OL} \) Pin 2
- \( I_{O}, I_{I} \) Output Current
  - \( V_{2} = V_{3} = 6.0V \) (Note 4)
  - \( I_{2} = 0, V_{3} = 0 \)
- \( K \) Gain Constant
- Linearity

OP/AMP COMPARATOR

- \( V_{DS} \)
- \( I_{BS} \)
- Input Common-Mode Voltage
- Voltage Gain
- Output Sink Current
- Output Source Current
- Saturation Voltage

- \( I_{SINK} \) = 5 mA
- \( I_{SINK} \) = 20 mA
- \( I_{SINK} \) = 50 mA

- See AN-450 “Surface Mounting Methods and Their Effect on Product Reliability” for other methods of soldering surface mount devices.
## Electrical Characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ZENER REGULATOR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regulator Voltage</td>
<td>R_{DROP} ≈ 470Ω</td>
<td>7.56</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Series Resistance</td>
<td>10.5</td>
<td>15</td>
<td>Ω</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Temperature Stability</td>
<td>+1</td>
<td>mV/°C</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>TOTAL SUPPLY CURRENT</td>
<td>3.8</td>
<td>6</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 1: For operation in ambient temperatures above 25°C, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 101°C/W junction to ambient for LM2907-8 and LM2917-8, and 79°C/W junction to ambient for LM2907-14 and LM2917-14.

Note 2: Hysteresis is the sum +{\text{VTH}} - (-{\text{VTH}}), offset voltage is their difference. See test circuit.

Note 3: \( V_{OH} \) is equal to \( \frac{V_{CC}}{4} \), \( V_{OL} \) is equal to \( \frac{V_{CC}}{4} - 1V_{BE} \), therefore \( V_{OH} - V_{OL} = V_{CC}/2 \). The difference, \( V_{OH} - V_{OL} \), and the mirror gain, \( I_{2}/I_{3} \), are the two factors that cause the tachometer gain constant to vary from 1.0.

Note 4: Be sure when choosing the time constant \( R_1 \times C_1 \) that \( R_1 \) is such that the maximum anticipated output voltage at pin 3 can be reached with \( I_3 \times R_1 \). The maximum value for \( R_1 \) is limited by the output resistance of pin 3 which is greater than 10 MΩ typically.

Note 5: Nonlinearity is defined as the deviation of \( V_{OUT} \) (at pin 3) for \( f_{IN} = 6 \text{ kHz} \) from a straight line defined by the \( V_{OUT} \) @ 1 kHz and \( V_{OUT} \) @ 10 kHz.

### General Description (Continued)

The op amp/comparator is fully compatible with the tachometer and has a floating transistor as its output. This feature allows either a ground or supply referred load of up to 50 mA. The collector may be taken above \( V_{CC} \) up to a maximum \( V_{CE} \) of 28V.

The two basic configurations offered include an 8-pin device with a ground referenced tachometer input and an internal connection between the tachometer output and the op amp non-inverting input. This version is well suited for single speed or frequency switching or fully buffered frequency to voltage conversion applications.

The more versatile configurations provide differential tachometer input and uncommitted op amp inputs. With this version the tachometer input may be floated and the op amp becomes suitable for active filter conditioning of the tachometer output.

Both of these configurations are available with an active shunt regulator connected across the power leads. The regulator clamps the supply such that stable frequency to voltage and frequency to current operations are possible with any supply voltage and a suitable resistor.

### Test Circuit and Waveform

The test circuit and waveform are shown in the figure below.

The tachometer input threshold measurement is depicted in the figure.
Typical Performance Characteristics

- Total Supply Current vs Temperature
- Zener Voltage vs Temperature
- Normalized Tachometer Output vs Temperature
- Normalized Tachometer Output vs Temperature
- Tachometer Currents $I_2$ and $I_3$ vs Supply Voltage
- Tachometer Currents $I_2$ and $I_3$ vs Temperature
- Tachometer Linearity vs Temperature
- Tachometer Linearity vs Temperature
- Tachometer Linearity vs $R_1$
- Tachometer Input Hysteresis vs Temperature
- Op Amp Output Transistor Characteristics
- Op Amp Output Transistor Characteristics

TLH/7042-5
Applications Information

The LM2907 series of tachometer circuits is designed for minimum external part count applications and maximum versatility. In order to fully exploit its features and advantages let’s examine its theory of operation. The first stage of operation is a differential amplifier driving a positive feedback flip-flop circuit. The input threshold voltage is the amount of differential input voltage at which the output of this stage changes state. Two options (LM2907-8, LM2917-8) have one input internally grounded so that an input signal must swing above and below ground and exceed the input thresholds to produce an output. This is offered specifically for magnetic variable reluctance pickups which typically provide a single-ended ac output. This single input is also fully protected against voltage swings to ±28V, which are easily attained with these types of pickups.

The differential input options (LM2907, LM2917) give the user the option of setting his own input switching level and still have the hysteresis around that level for excellent noise rejection in any application. Of course in order to allow the inputs to attain common-mode voltages above ground, input protection is removed and neither input should be taken outside the limits of the supply voltage being used. It is very important that an input not go below ground without some protection is removed and neither input should be taken outside the limits of the supply voltage being used. Of course in order to allow the inputs to attain common-mode voltages above ground, input protection is removed and neither input should be taken outside the limits of the supply voltage being used. It is very important that an input not go below ground without some protection is removed and neither input should be taken outside the limits of the supply voltage being used. Of course in order to allow the inputs to attain common-mode voltages above ground, input protection is removed and neither input should be taken outside the limits of the supply voltage being used. It is very important that an input not go below ground without some protection.

Following the input stage is the charge pump where the epi-substrate diode.

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As a final consideration, the maximum attainable input frequency is determined by \( V_{CC}, C_1 \) and \( I_2 \):

\[
I_{MAX} = \frac{I_2}{C_1 \times V_{CC}}
\]

**Using Zener Regulated Options (LM2917)**

For those applications where an output voltage or current must be obtained independent of supply voltage variations, the LM2917 is offered. The most important consideration in choosing a dropping resistor from the unregulated supply to the device is that the tachometer and op amp circuitry alone require about 3 mA at the voltage level provided by the zener. At low supply voltages there must be some current flowing in the resistor above the 3 mA circuit current to operate the regulator. As an example, if the raw supply varies from 9V to 16V, a resistance of 470 ohms will minimize the zener variation quickly rises above 200 mV for the same input variation.

The size of \( C_2 \) is dependent only on the amount of ripple voltage allowable and the required response time.
Typical Applications (Continued)

"Speed Switch" Load is Energized When $f_{IN} \geq \frac{1}{2RC}$

Zener Regulated Frequency to Voltage Converter

Breaker Point Dwell Meter
**Typical Applications (Continued)**

** Voltage Driven Meter Indicating Engine RPM **

\[ V_D = 6V \text{ @ } 400 \text{ Hz or } 6000 \text{ ERPM (8 Cylinder Engine)} \]

** Current Driven Meter Indicating Engine RPM **

\[ I_D = 10 \text{ mA} \text{ @ } 300 \text{ Hz or } 6000 \text{ ERPM (6 Cylinder Engine)} \]

** Capacitance Meter **

\[ V_{OUT} = 1V \text{–} 10V \text{ for } C_x = 0.01 \text{ to } 0.1 \text{ mFd} \]

\[ (R = 111k) \]
Typical Applications (Continued)

Two-Wire Remote Speed Switch

![Two-Wire Remote Speed Switch Diagram](image1)

V3 steps up in voltage by the amount $V_{CC} \times \frac{C1}{C2}$ for each complete input cycle (2 zero crossings).

Example:
If $C2 = 200 \times C1$ after 100 consecutive input cycles.

$V3 = \frac{1}{2} V_{CC}$

100 Cycle Delay Switch

![100 Cycle Delay Switch Diagram](image2)
Typical Applications (Continued)

Variable Reluctance Magnetic Pickup Buffer Circuits

Precision two-shot output frequency equals twice input frequency.

Pulse width $= \frac{V_{CC} C_1}{2} \frac{1}{f_{IN}}$

Pulse height $= V_{ZENER}$

Finger Touch or Contact Switch

Flashing LED Indicates Overspeed

Flashing begins when $f_{IN} > 100$ Hz.
Flash rate increases with input frequency increase beyond trip point.
Typical Applications (Continued)

Frequency to Voltage Converter with 2 Pole Butterworth Filter to Reduce Ripple

\[ f_{\text{POLE}} = \frac{0.707}{2\pi f_{\text{RC}}} \]
\[ f_{\text{RESPONSE}} = \frac{2.57}{2\pi f_{\text{POLE}}} \]

Overspeed Latch

Output latches when
\[ f_{\text{OUT}} = \frac{R2}{R1 + R2 \cdot RC} \]
Reset by removing VCC.
Some Frequency Switch Applications May Require Hysteresis in the Comparator Function Which can be Implemented in Several Ways:
Typical Applications (Continued)

Changing the Output Voltage for an Input Frequency of Zero

TL/H/7942–29

Changing Tachometer Gain Curve or Clamping the Minimum Output Voltage

TL/H/7942–31
Anti-Skid Circuit Functions

"Select-Low" Circuit

V_OUT is proportional to the lower of the two input wheel speeds.

"Select-High" Circuit

V_OUT is proportional to the higher of the two input wheel speeds.

"Select-Average" Circuit

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Physical Dimensions inches (millimeters)

8-Lead (0.150" Wide) Molded Small Outline Package, JEDEC
Order Number LM2907M-8 or LM2917M-8
NS Package Number M08A
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