บทที่ 3

สรุปผลการทดลอง และเสนอแนะ

3.1 สรุปผลการทดลอง

จากการทดลองพบว่าได้ผลเป็นที่น่าพอใจเนื่องจากสามารถส่งข้อมูลผ่านระบบสายไฟได้อย่างมีประสิทธิภาพ โดยมีข้อจำกัดทางด้านอัตราเร็วเนื่องจากมีตัวแปรหลายประการ โดยเฉพาะอย่างยิ่งขีดจำกัดในการแปลงสัญญาณให้มีความผิดพลาดน้อยที่สุด เมื่อใช้ Fregnency to voltage converter และ Voltage-to-freguency converter

ในการทดลองชิ้นนี้ได้ทดสอบเพียงการส่งข้อมูลในลักษณะ Simplex กล่าวคือ ภาคส่งจะส่งสัญญาณออกไปอย่างเดียวในขณะที่ภาครับจะรับและแปลงสัญญาณอย่างเดียว แต่ในงานจริง ๆ แล้ว จำเป็นจะต้องสามารถรับและส่งได้ทั้ง 2 ทาง แม้จะไม่พร้อมกันก็ตาม ซึ่งในทางปฏิบัติแล้วก็น่าจะทำได้ โดยไม่มีปัญหาอะไร แต่เนื่องจากยังไม่ได้ทดสอบในจุดนี้จึงไม่ทราบว่าจะมีผลต่อกันในลักษณะการรบกวนของคลื่นหรือไม่

3.2 ข้อเสนอแนะ

ในงานบางลักษณะที่ไม่จำเป็นที่จะต้องมีการส่งด้วยอัตราเร็วสูง และระบบที่ต้องการเชื่อมต่อไม่ได้อยู่ห่างกันมากนัก การส่งผ่านข้อมูลทางสายไฟนี้น่าจะเป็นประโยชน์ในแง่ความสะดวก และความประหยัด แต่ถ้าจะให้เกิดประโยชน์สูงสุด น่าจะสร้างวงจรในลักษณะ half dupex โดยมีวงจรควบคุมสัญญาณต่าง ๆ ด้วยก็น่าจะได้ประโยชนสูงสุด ซึ่งหากสร้างวงจรรับ/ส่ง และวงจรควบคุมโดยส่งผ่านทาาง RS-232 นี้แบบมาตรฐานแล้ว การเขียนโปรแกรมสั่งงาน อาจไม่จำเป็นเพราะสามารถใช้โปรแกรมมาตรฐาน เช่น Cross talk เพื่อสั่งงานก็ได้ หรือหากต้องการส่งข้อมูลให้ไปพิมพ์ออกทางเครื่องพิมพ์หรือ plotter ก็จะทำได้สะดวก เพราะ baud rate นี้สามารถกำหนดได้อยู่แล้ว อีกทั้งอุปกรณ์บางชนิด เช่น printer และ plotter ก็มี buffer อยู่ในตัวทำให้ปัญหาการล้นของ buffer ไม่น่าจะมี

National Semiconductor

LM131A/LM131, LM231A/LM231, LM331A/LM331 Precision Voltage-to-Frequency Converters

General Description

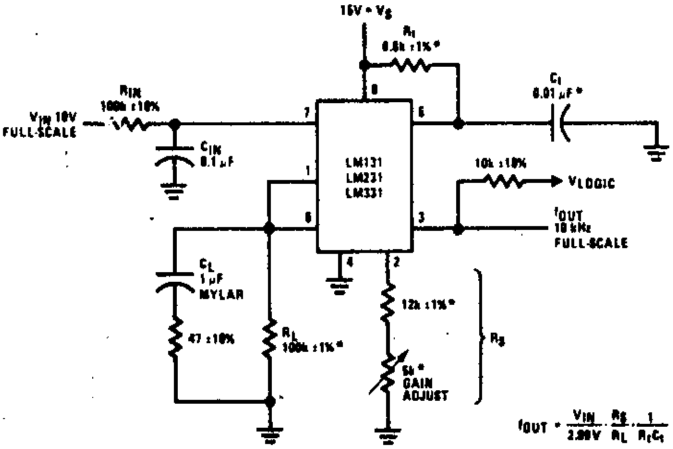
The LM131/LM231/LM331 family of voltage-to-frequency converters are ideally suited for use in simple low-cost circuits for analog-to-digital conversion, precision frequency-to-voltage conversion, long-term integration, linear frequency modulation or demodulation, and many other functions. The output 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 LM131A/LM231A/LM331A attains a new high level of accuracy versus temperature which could only be attained with expensive voltage-to-frequency modules. Additionally the LM131 is 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 photoisolator to provide isolation against high common mode levels.

The LM131/LM231/LM331 utilizes 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 is 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 dissipation, 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

Typical Applications



$$f_{OUT} = \frac{V_{IN}}{2.09V} \cdot \frac{R_S}{R_L} \cdot \frac{1}{R_tC_t}$$

*Use stable components with low temperature coefficients. See applications notes.

FIGURE 1. Simple Stand-Alone Voltage-to-Frequency Converter with ±0.03% Typical Linearity (f = 10 Hz to 11 kHz)

Absolute Maximum Ratings

	LM131A/LM131	LM231A/LM231	LM331A/LM331
Supply Voltage	40V	40V	40V
Output Short Circuit to Ground	Continuous	Continuous	Continuous
Output Short Circuit to V_{CC}	Continuous	Continuous	Continuous
Input Voltage	−0.2V to $+V_S$	−0.2V to $+V_S$	−0.2V to $+V_S$
	T_{MIN} T_{MAX}	T_{MIN} T_{MAX}	T_{MIN} T_{MAX}
Operating Ambient Temperature Range	−55°C to +125°C	−25°C to +85°C	0°C to +70°C
Power Dissipation (P_D at 25°C) and Thermal Resistance (θ_{jA})			
(H Package) P_D	670 mW	570 mW	570 mW
θ_{jA}	150°C/W	150°C/W	150°C/W
(N Package) P_D		500 mW	500 mW
θ_{jA}		155°C/W	155°C/W

Electrical Characteristics $T_A = 25°C$ unless otherwise specified. (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VFC Non-Linearity (Note 2)	$4.5V \le V_S \le 20V$		±0.003	±0.01	% Full Scale
	$T_{MIN} \le T_A \le T_{MAX}$		±0.006	±0.02	% Full Scale
In Circuit of *Figure 1*	$V_S = 15V$, f = 10 Hz to 11 kHz		±0.024	±0.14	% Full Scale
Conversion Accuracy Scale Factor (Gain)	$V_{IN} = -10V$, $R_S = 14\ k\Omega$				
LM131, LM131A, LM231, LM231A		0.95	1.00	1.05	kHz/V
LM331, LM331A		0.90	1.00	1.10	kHz/V
Temperature Stability of Gain	$T_{MIN} \le T_A \le T_{MAX}$, $4.5V \le V_S \le 20V$				
LM131/LM231/LM331			±30	±150	ppm/°C
LM131A/LM231A/LM331A			±20	±50	ppm/°C
Change of Gain with V_S	$4.5V \le V_S \le 10V$		0.01	0.1	%/V
	$10V \le V_S \le 40V$		0.006	0.06	%/V
Rated Full-Scale Frequency	$V_{IN} = -10V$	10.0			kHz
Overrange (Beyond Full-Scale) Frequency	$V_{IN} = -11V$	10			
INPUT COMPARATOR					
Offset Voltage			±3	±10	mV
LM131/LM231/LM331	$T_{MIN} \le T_A \le T_{MAX}$		±4	±14	mV
LM131A/LM231A/LM331A	$T_{MIN} \le T_A \le T_{MAX}$		±3	±10	mV
Bias Current			−80	−300	nA
Offset Current			±8	±100	nA
Common-Mode Range	$T_{MIN} \le T_A \le T_{MAX}$	−0.2		$V_{CC}-2.0$	V
TIMER					
Timer Threshold Voltage, Pin 5		0.63	0.667	0.70	× V_S
Input Bias Current, Pin 5	$V_S = 15V$				
All Devices	$0V \le V_{PIN\ 5} \le 9.9V$		±10	±100	nA
LM131/LM231/LM331	$V_{PIN\ 5} = 10V$		200	1000	nA
LM131A/LM231A/LM331A	$V_{PIN\ 5} = 10V$		200	500	nA
V_{SAT} PIN 5 (Reset)	I = 5 mA		0.22	0.5	V

Electrical Characteristics (Continued) $T_A = 25°C$ unless otherwise specified (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
CURRENT SOURCE (Pin 1)					
Output Current	$R_S = 14\ k\Omega$, $V_{PIN\ 1} = 0$				
LM131, LM131A, LM231, LM231A		126	135	144	μA
LM331, LM331A		116	136	156	μA
Change with Voltage	$0V \le V_{PIN\ 1} \le 10V$		0.2	1.0	μA
Current Source OFF Leakage					
LM131, LM131A			0.01	1.0	nA
LM231, LM231A, LM331, LM331A			0.02	10.0	nA
All Devices	$T_A = T_{MAX}$		2.0	50.0	nA
Operating Range of Current (Typical)			(10 to 500)		μA
REFERENCE VOLTAGE (Pin 2)					
LM131, LM131A, LM231, LM231A		1.76	1.89	2.02	V_{DC}
LM331, LM331A		1.70	1.89	2.08	V_{DC}
Stability vs Temperature			±60		ppm/°C
Stability vs Time, 1000 Hours			±0.1		%
LOGIC OUTPUT (Pin 3)					
V_{SAT}	$I = 5$ mA		0.15	0.50	V
	$I = 3.2$ mA (2 TTL Loads), $T_{MIN} < T_A < T_{MAX}$		0.10	0.40	V
OFF Leakage			±0.05	1.0	μA
SUPPLY CURRENT					
LM131, LM131A, LM231,	$V_S = 5V$	2.0	3.0	4.0	mA
LM231A	$V_S = 40V$	2.5	4.0	6.0	mA
LM331, LM331A	$V_S = 5V$	1.5	3.0	6.0	mA
	$V_S = 40V$	2.0	4.0	8.0	mA

Note 1: All specifications apply in the circuit of *Figure 3*, with $4.0V \le V_S \le 40V$, unless otherwise noted.

Note 2: Nonlinearity is defined as the deviation of f_{OUT} from $V_{IN} \times (10\ kHz/-10\ V_{DC})$ 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.

Functional Block Diagram

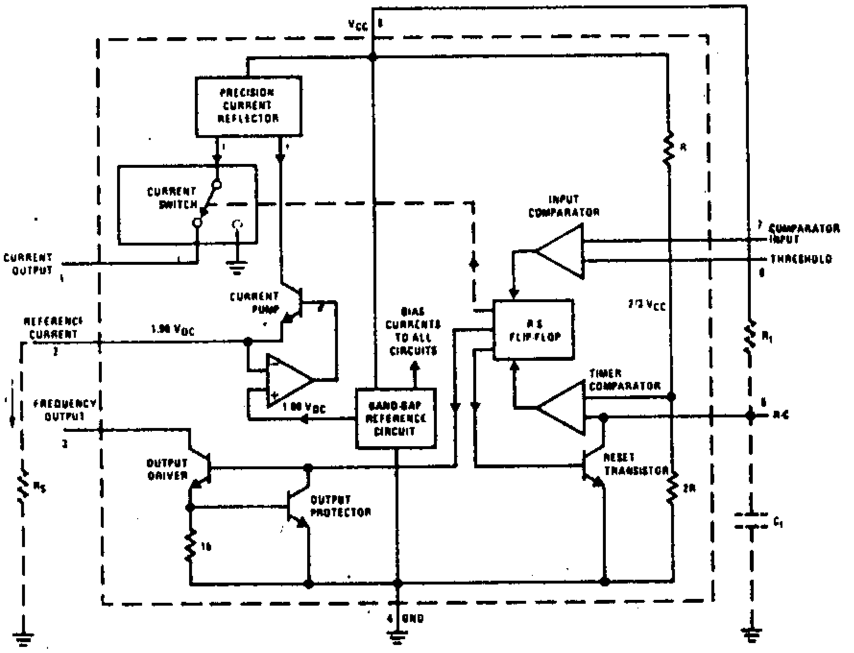
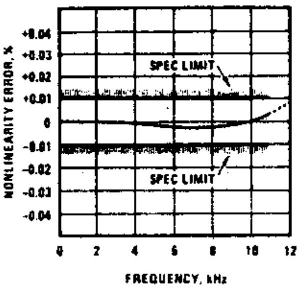


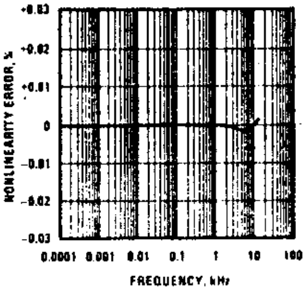
FIGURE 1a

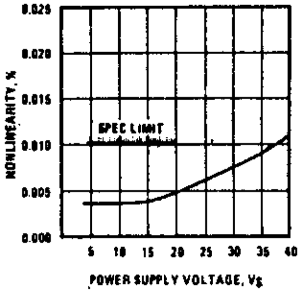
*Registered trademark of DuPont

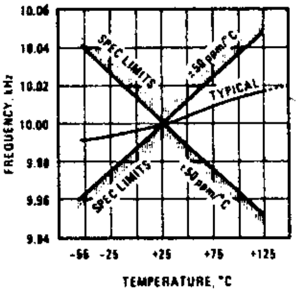
Typical Performance Characteristics

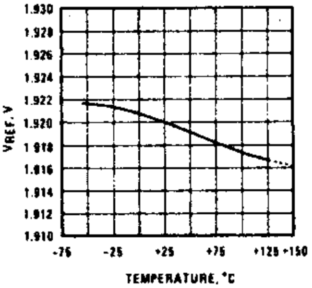
(All electrical characteristics apply for the circuit of *Figure 3*, unless otherwise noted.)

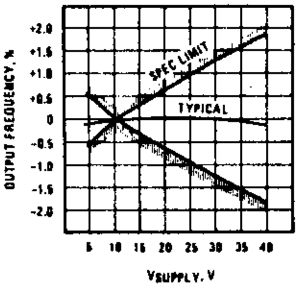

Nonlinearity Error, LM131 Family, as Precision V-to-F Converter *(Figure 3)*

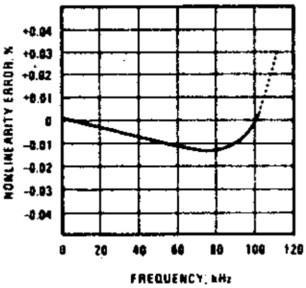

Nonlinearity Error, LM131 Family

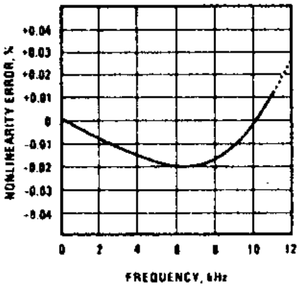

Nonlinearity vs Power Supply Voltage

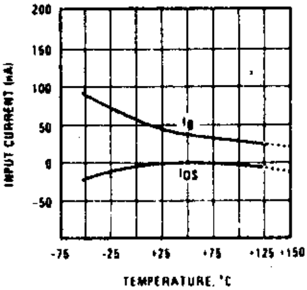

Frequency vs Temperature, LM131A

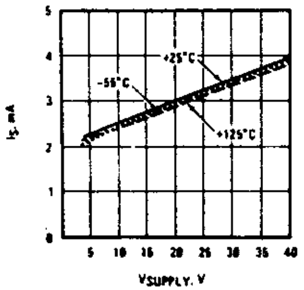

VREF vs Temperature, LM131A

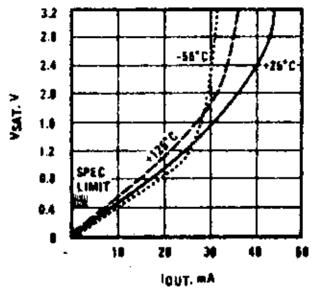

Output Frequency vs VSUPPLY

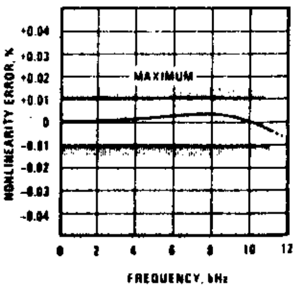

100kHz Nonlinearity Error, LM131 Family *(Figure 4)*


Nonlinearity Error, LM131 *(Figure 1)*


Input Current (Pins 6, 7) vs Temperature


Power Drain vs VSUPPLY


Output Saturation Voltage vs IOUT (Pin 3)


Nonlinearity Error, Precision F-to-V Converter *(Figure 6)*

Typical Applications (Continued)

PRINCIPLES OF OPERATION OF A SIMPLIFIED VOLTAGE-TO-FREQUENCY CONVERTER

The LM131 is a monolithic circuit designed for accuracy and versatile operation when applied as a voltage-to-frequency (V-to-F) converter or as a frequency-to-voltage (F-to-V) converter. A simplified block diagram of the LM131 is shown in *Figure 2* and consists of a switched current source, input comparator, and 1-shot timer.

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 LM131 and the various resistors and capacitors connected to it.

The voltage comparator compares a positive input voltage, V1, at pin 7 to the voltage, V_x, at pin 6. If V1 is greater, the comparator will trigger the 1-shot timer. The output of the timer will turn ON both the frequency output transistor and the switched current source for a period $t \doteq 1.1\ R_tC_t$. During this period, the current i will flow out of the switched current source and provide a fixed amount of charge, $Q = i \times t$, into the capacitor, C_L. This will normally charge V_x 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 C_L will be gradually discharged by R_L until V_x falls to the level of V1. Then the comparator will trigger the timer and start another cycle.

The current flowing into C_L is exactly $I_{AVE} = i \times (1.1 \times R_tC_t) \times f$, and the current flowing out of C_L is exactly $V_x/R_L \cong V_{IN}/R_L$. 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.

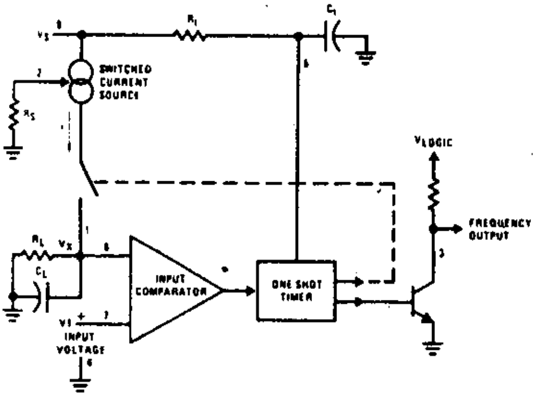


FIGURE 2. Simplified Block Diagram of Stand-Alone Voltage-to-Frequency Converter Showing LM131 and External Components

DETAIL OF OPERATION, FUNCTIONAL BLOCK DIAGRAM *(FIGURE 1a)*

The block diagram shows a band gap reference which provides a stable 1.9 V_{DC} output. This 1.9 V_{DC} is well regulated over a V_s 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 $i = 1.90V/R_s$ to flow. For $R_s = 14k$, $i = 135\ \mu A$. 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 on the state of the R_S flip-flop.

The timing function consists of an R_S flip-flop, and a timer comparator connected to the external R_tC_t network. When the input comparator detects a voltage at pin 7 higher than pin 6, it sets the R_S flip-flop which turns ON the current switch and the output driver transistor. When the voltage at pin 5 rises to 2/3 V_{CC}, the timer comparator causes the R_S 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 V_{CC}, the flip-flop will not be reset, and the current at pin 1 will continue to flow, in its attempt 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. It should be noted that 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 overvoltage, the output current is actively limited to less than 50 mA.

The voltage at pin 2 is regulated at 1.90 V_{DC} 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.

PRINCIPLES OF OPERATION OF BASIC VOLTAGE-TO-FREQUENCY CONVERTER *(FIGURE 1)*

The simple stand-alone V-to-F converter shown in *Figure 1* includes all the basic circuitry of *Figure 2* plus a few components for improved performance.

A resistor, R_{IN} = 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 R_s 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 LM131, and the tolerance of R_t, R_L and C_t. For best results, all the components

Typical Applications (Continued)

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 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.

A 47Ω resistor, in series with the 1 µF C_L, is added to give hysteresis effect which helps the input comparator provide the excellent linearity (0.03% typical).

DETAIL OF OPERATION OF PRECISION V-TO-F CONVERTER *(FIGURE 3)*

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 LM131, the timing cycle is initiated. The average current fed into the op amp's summing point (pin 2) is i × (1.1 R_tC_t) × f which is perfectly balanced with $-V_{IN}/R_{IN}$. In this circuit, the voltage offset of the LM131 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 LM131 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 4* operates in the same way as *Figure 3*, but with the necessary changes for high speed operation.

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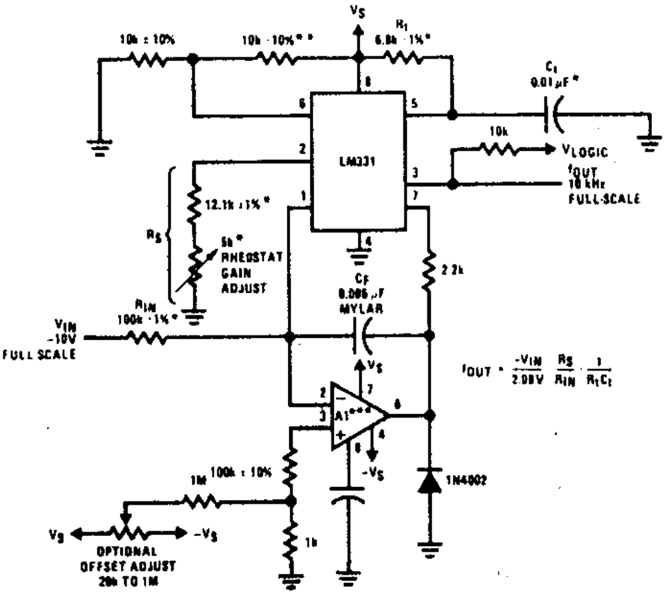
*Registered trademark of DuPont



*Use stable components with low temperature coefficients. See applications notes.

**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 types LM108, LM308A, LF351B

FIGURE 3. Standard Test Circuit and Applications Circuit, Precision Voltage-to-Frequency Converter

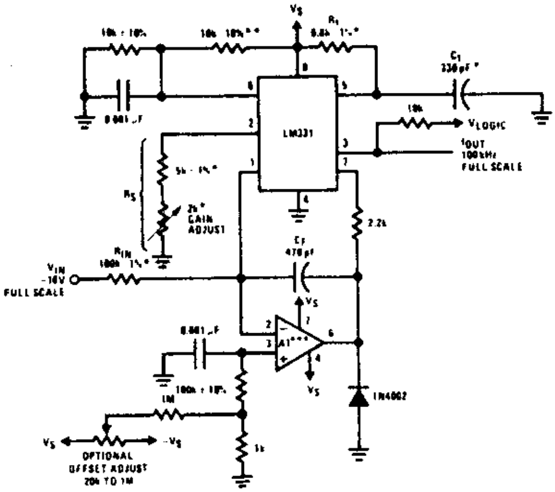
Typical Applications (Continued)

DETAILS OF OPERATION, FREQUENCY-TO-VOLTAGE CONVERTERS *(FIGURES 5 AND 6)*

In these applications, a pulse input at f_{IN} 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 $I_{AVERAGE} = i \times (1.1\ R_tC_t) \times f$.

In the simple circuit of *Figure 5*, this current is filtered in the network R_L = 100 kΩ and 1 µF. 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 5*. However, for input frequencies below 200 Hz, this circuit will have worse ripple than *Figure 5*. 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.

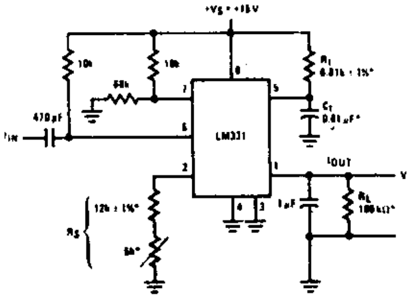


*Use stable components with low temperature coefficients. See applications notes.

**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 types LF351B or LF356.

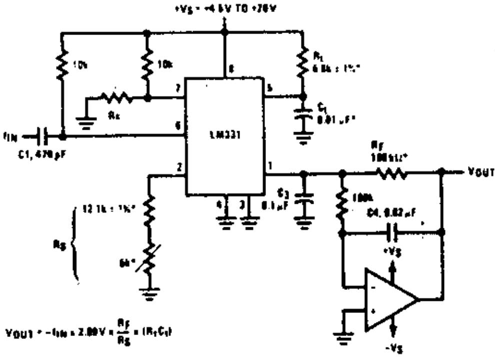
FIGURE 4. Precision Voltage-to-Frequency Converter, 100 kHz Full-Scale, ±0.03% Non-Linearity



$V_{OUT} = f_{IN} \times 2.09V \times \frac{R_L}{R_S} \times (R_tC_t)$

*Use stable components with low temperature coefficients.

FIGURE 5. Simple Frequency-to-Voltage Converter, 10 kHz Full-Scale, ±0.06% Non-Linearity



$V_{OUT} = -f_{IN} \times 2.09V \times \frac{R_F}{R_S} \times (R_tC_t)$

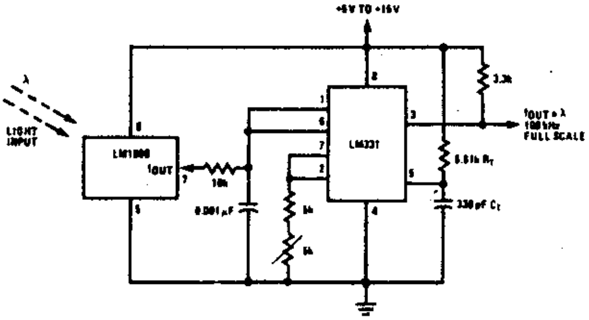
SELECT $R_X = \frac{(V_S - 2V)}{0.2\ mA}$

*Use stable components with low temperature coefficients.

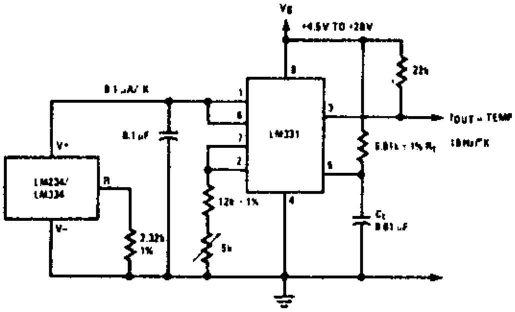
FIGURE 6. Precision Frequency-to-Voltage Converter, 10 kHz Full-Scale with 2-Pole Filter, ±0.01% Non-Linearity Maximum

Typical Applications (Continued)

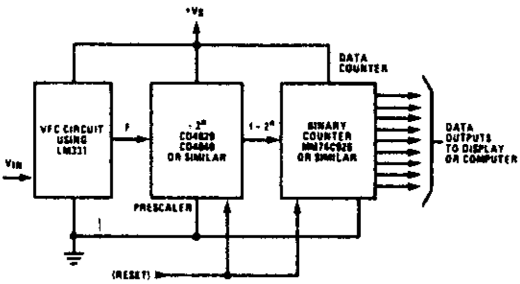
Light Intensity to Frequency Converter



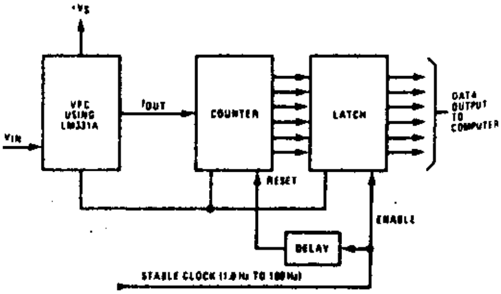
Temperature to Frequency Converter



Long-Term Digital Integrator Using VFC

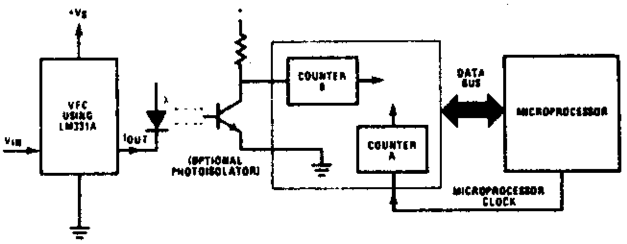


Basic Analog-to-Digital Converter Using Voltage-to-Frequency Converter

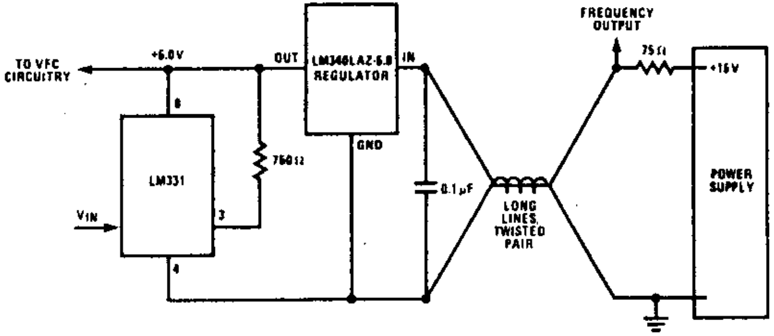


Typical Applications (Continued)

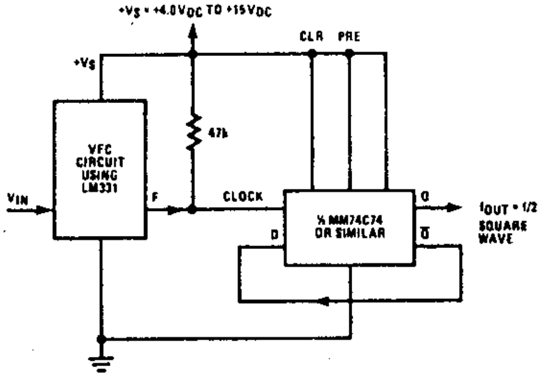
Analog-to-Digital Converter with Microprocessor



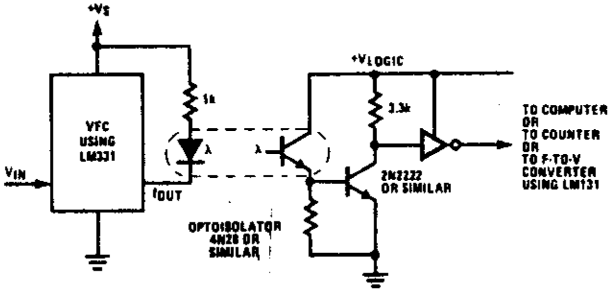
Remote Voltage-to-Frequency Converter with 2-Wire Transmitter and Receiver



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

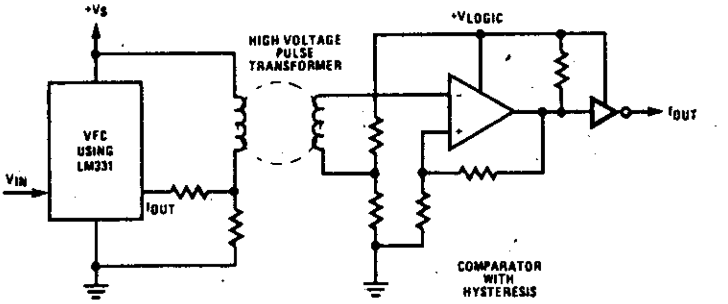


Voltage-to-Frequency Converter with Isolators

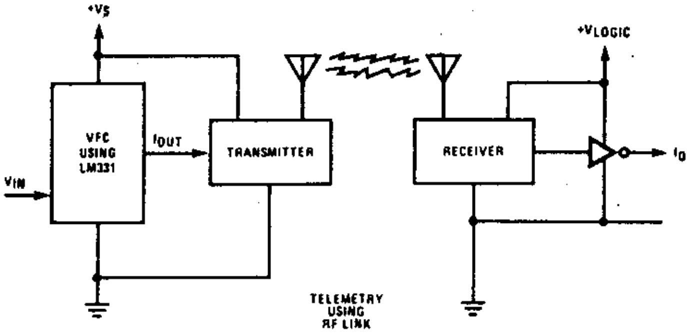


Typical Applications (Continued)

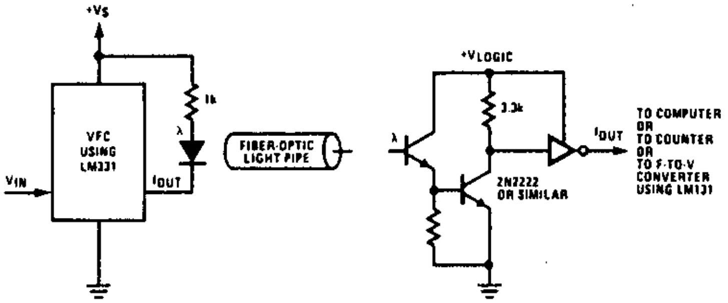
Voltage-to-Frequency Converter with Isolators



Voltage-to-Frequency Converter with Isolators

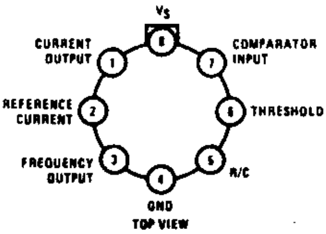


Voltage-to-Frequency Converter with Isolators



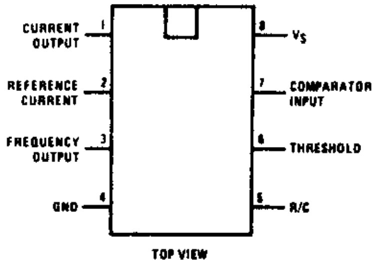
Connection Diagrams

Metal Can Package



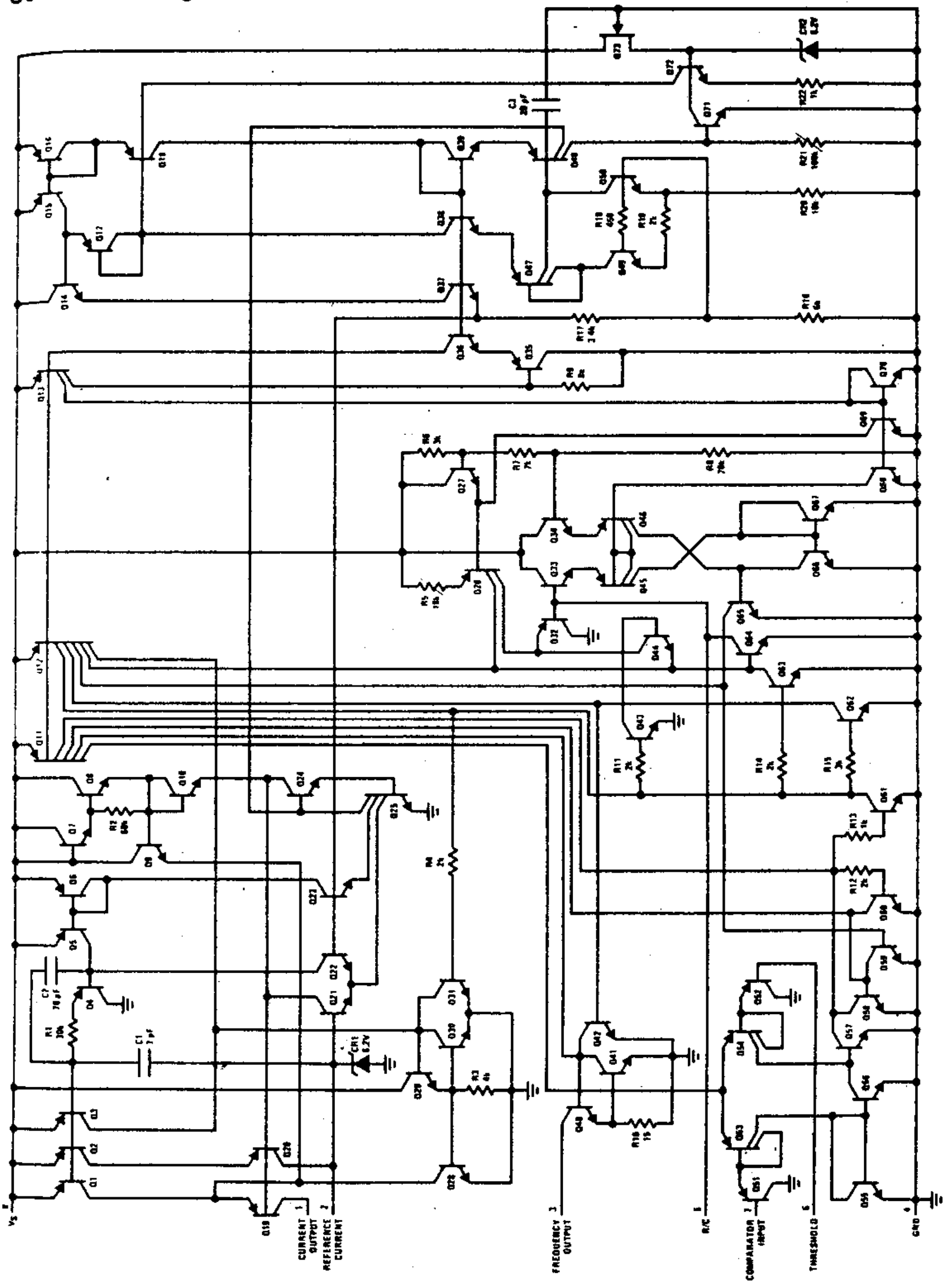
Order Number LM131AH, LM131H, LM231AH, LM231H, LM331AH or LM331H
See NS Package H08C

Dual-In-Line Package



Order Number LM231AN, LM231N, LM331AN, or LM331N
See NS Package N08B

Schematic Diagram



National Semiconductor

Industrial/Automotive/Functional Blocks/ Telecommunications

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.

(continued on page 9-84)

advantages

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

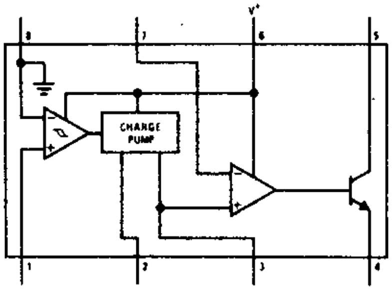
features

- 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_{CC} and below ground

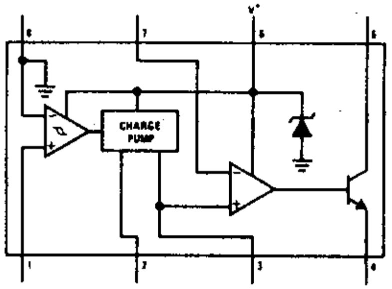
applications

- 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

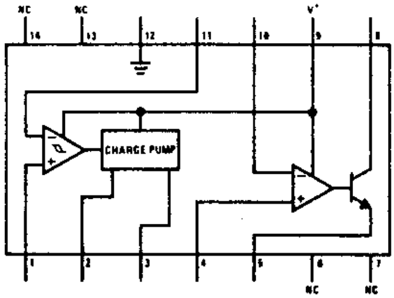
block and connection diagrams Dual-In-Line Packages, Top Views



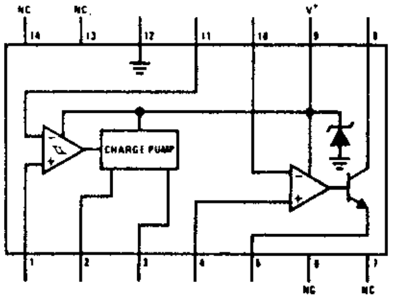
Order Number LM2907N-8
See NS Package N08B



Order Number LM2917N-8
See NS Package N08B



Order Number LM2907J
See NS Package J14A
Order Number LM2907N
See NS Package N14A



Order Number LM2917J
See NS Package J14A
Order Number LM2917N
See NS Package N14A

absolute maximum ratings (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
Power Dissipation	500 mW
Operating Temperature Range	-40°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

electrical characteristics $V_{CC} = 12\ V_{DC}$, $T_A = 25°C$, see test circuit

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
TACHOMETER					
Input Thresholds	V_{IN} = 250 mVp-p @ 1 kHz (Note 2)	±10	±15	±40	mV
Hysteresis	V_{IN} = 250 mVp-p @ 1 kHz (Note 2)		30		mV
Offset Voltage	V_{IN} = 250 mVp-p @ 1 kHz (Note 2)				
LM2907/LM2917			3.5	10	mV
LM2907-8/LM2917-8			5	15	mV
Input Bias Current	V_{IN} = ±50 mV_{DC}		0.1	1	µA
V_{OH} Pin 2	V_{IN} = +125 mV_{DC} (Note 3)		8.3		V
V_{OL} Pin 2	V_{IN} = -125 mV_{DC} (Note 3)		2.3		V
Output Current: I_2, I_3	V2 = V3 = 6.0V (Note 4)	140	180	240	µA
Leakage Current, I_3	I2 = 0, V3 = 0			0.1	µA
Gain Constant, K	(Note 3)	0.9	1.0	1.1	
Linearity	f_{IN} = 1 kHz, 5 kHz, 10 kHz, (Note 5)	-1.0	0.3	+1.0	%
OP/AMP COMPARATOR					
[illegible]	V_{IN} = 6.0V		3	10	mV
[illegible]	V_{IN} = 6.0V		50	500	nA
Input Common Mode Voltage		0		V_{CC}-1.5V	V
Voltage Gain			200		V/mV
Output Sink Current	V_C = 1.0	40	50		mA
Output Source Current	V_E = V_{CC} - 2.0		10		mA
Saturation Voltage	I_{SINK} = 5 mA		0.1	0.5	V
	I_{SINK} = 20 mA			1.0	V
	I_{SINK} = 50 mA		1.0	1.5	V
ZENER REGULATOR					
Regulator Voltage	R_{DROP} = 470Ω		7.56		V
Series Resistance			10.5	15	Ω
Temperature Stability			+1		mV/°C
TOTAL SUPPLY CURRENT			3.8	6	mA

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 175°C/W junction to ambient for package 22 and 16 or a thermal resistance of 187°C/W junction to ambient for package 20.

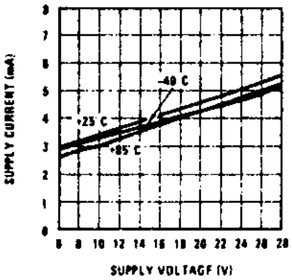
Note 2: Hysteresis is the sum $+V_{TH}-(-V_{TH})$, offset voltage is their difference. See test circuit.

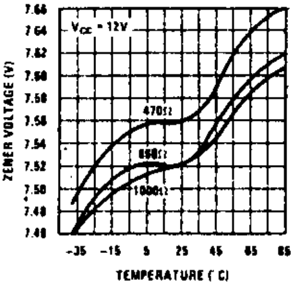
Note 3: V_{OH} is equal to 3/4 x V_{CC} – 1 V_{BE}, V_{OL} is equal to 1/4 x V_{CC} – 1 V_{BE} therefore $V_{OH} - V_{OL} = V_{CC}/2$. The difference, $V_{OH} - V_{OL}$, and the mirror gain, I_2/I_3, are the two factors that cause the tachometer gain constant to vary from 1.0.

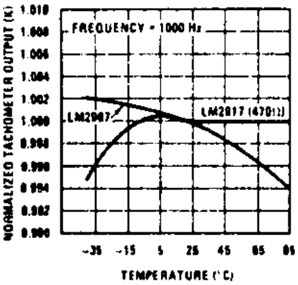
Note 4: Be sure when choosing the time constant R1 x C1 that R1 is such that the maximum anticipated output voltage at pin 3 can be reached with I_3 x R1. The maximum value for R1 is limited by the output resistance of pin 3 which is greater than 10 MΩ typically.

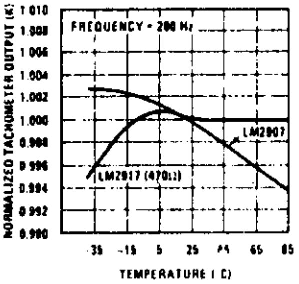
Note 5: Nonlinearity is defined as the deviation of V_{out} (@ pin 3) for f_{IN} = 5 kHz from a straight line defined by the V_{OUT} @ 1 kHz and V_{OUT} @ 10 kHz. C1 = 1000 pF, R1 = 68k and C2 = 0.22 mFd.

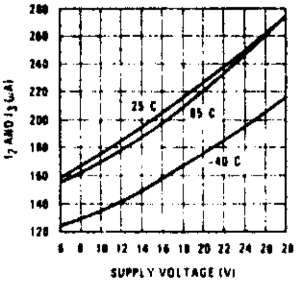
typical performance characteristics

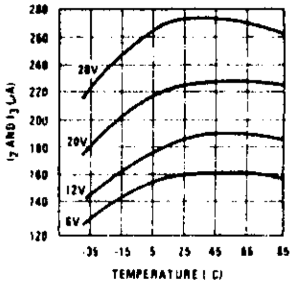

Total Supply Current


Zener Voltage vs Temperature


Normalized Tachometer Output vs Temperature

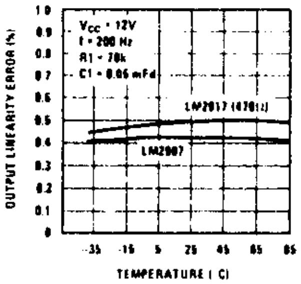

Normalized Tachometer Output vs Temperature


Tachometer Currents I_2 and I_3 vs Supply Voltage

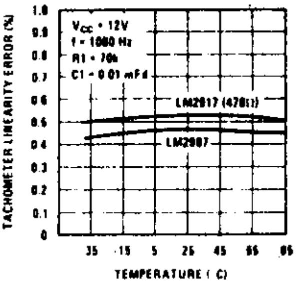

Tachometer Currents I_2 and I_3 vs Temperature

typical performance characteristics (con't)

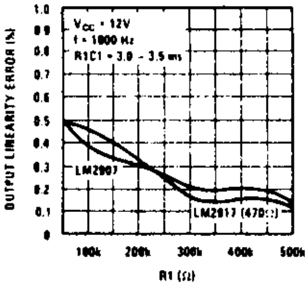
Tachometer Linearity vs Temperature



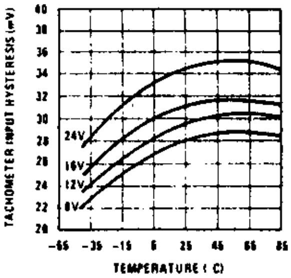
Tachometer Linearity vs Temperature



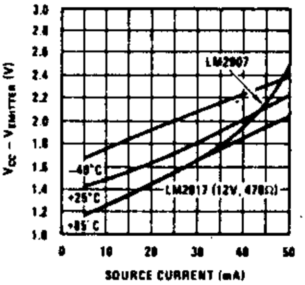
Tachometer Linearity vs R1



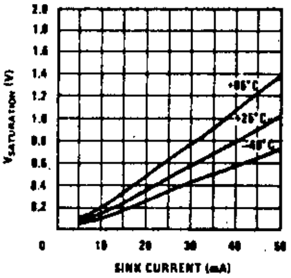
Tachometer Input Hysteresis vs Temperature



Op Amp Output Transistor Characteristics



Op Amp Output Transistor Characteristics



general description (con't)

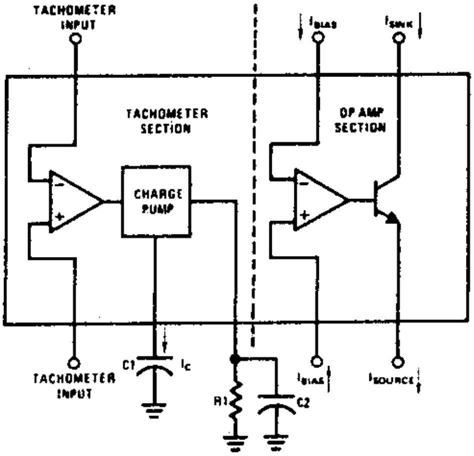
The op amp/comparator is fully compatible with the tachometer and has a floating transistor as its output. This feature allows either a ground or supply referred load of up to 50 mA. The collector may be taken above V_{CC} up to a maximum V_{CE} of 28V.

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.

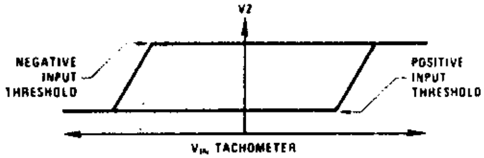
The more versatile configurations provide differential tachometer input and uncommitted op amp inputs. With this version the tachometer input may be floated and the op amp becomes suitable for active filter conditioning of the tachometer output.

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



Tachometer Input Threshold Measurement



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 resistance in its lead to limit the current that will then flow in the epi-substrate diode.

Following the input stage is the charge pump where the input frequency is converted to a dc voltage. To do this requires one timing capacitor, one output resistor, and an integrating or filter capacitor. When the input stage changes state (due to a suitable zero crossing or differential voltage on the input) the timing capacitor is either charged or discharged linearily between two voltages whose difference is $V_{CC}/2$. Then in one half cycle of the input frequency or a time equal to $1/2\ f_{IN}$ the change in charge on the timing capacitor is equal to $V_{CC}/2 \times C1$. The average amount of current pumped into or out of the capacitor then is:

$$\frac{\Delta Q}{T} = i_{c(AVG)} = C1 \times \frac{V_{CC}}{2} \times (2f_{IN}) = V_{CC} \times f_{IN} \times C1$$

The output circuit mirrors this current very accurately into the load resistor R1, connected to ground, such that if the pulses of current are integrated with a filter

applications information (con't)

capacitor, then, $V_o = i_c \times R1$, and the total conversion equation becomes:

$V_O = V_{CC} \times f_{IN} \times C1 \times R1 \times K$

Where K is the gain constant—typically 1.0.

The size of C2 is dependent only on the amount of ripple voltage allowable and the required response time.

CHOOSING R1 AND C1

There are some limitations on the choice of R1 and C1 which should be considered for optimum performance. The timing capacitor also provides internal compensation for the charge pump and should be kept larger than 100 pF for very accurate operation. Smaller values can cause an error current on R1, especially at low temperatures. Several considerations must be met when choosing R1. The output current at pin 3 is internally fixed and therefore $V_O/R1$ must be less than or equal to this value. If R1 is too large, it can become a significant fraction of the output impedance at pin 3 which degrades linearity. Also output ripple voltage must be considered and the size of C2 is affected by R1. An expression that describes the ripple content on pin 3 for a single R1C2 combination is:

$$V_{RIPPLE} = \frac{V_{CC}}{2} \times \frac{C1}{C2} \times \left(1 - \frac{V_{CC} \times f_{IN} \times C1}{I_2}\right) \text{pk-pk}$$

It appears R1 can be chosen independent of ripple, however response time, or the time it takes V_{OUT} to stabilize at a new voltage increases as the size of C2 increases so a compromise between ripple, response time, and linearity must be chosen carefully.

As a final consideration, the maximum attainable input frequency is determined by V_{CC}, C1 and I_2:

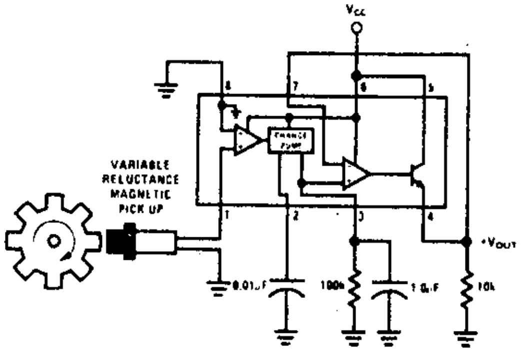
$$f_{MAX} = \frac{I_2}{C1 \times V_{CC}}$$

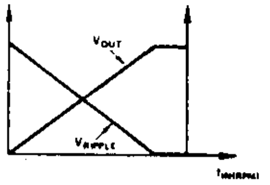
USING ZENER REGULATED OPTIONS (LM2917)

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 9 to 16V, a resistance of 470Ω will minimize the zener voltage variation to 160 mV. If the resistance goes under 400Ω or over 600Ω the zener variation quickly rises above 200 mV for the same input variation.

typical applications

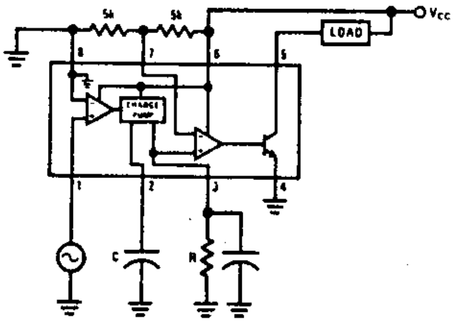
Minimum Component Tachometer

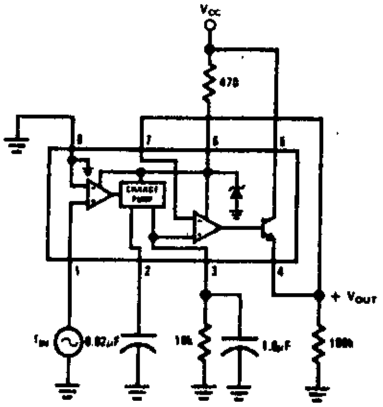




Zener Regulated Frequency to Voltage Converter

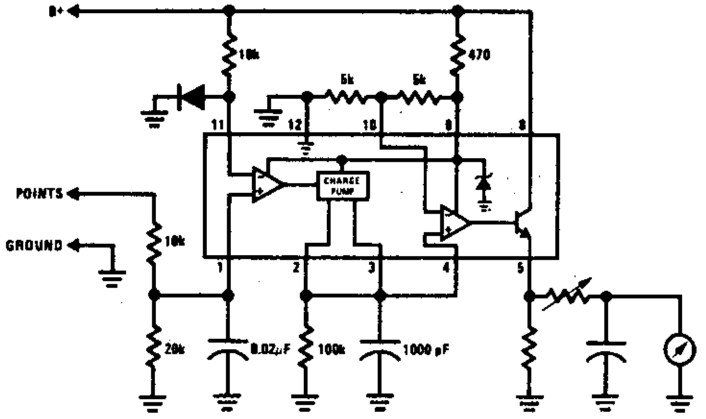
"Speed Switch" Load is Energized When $f_{IN} \geq \frac{1}{2RC}$





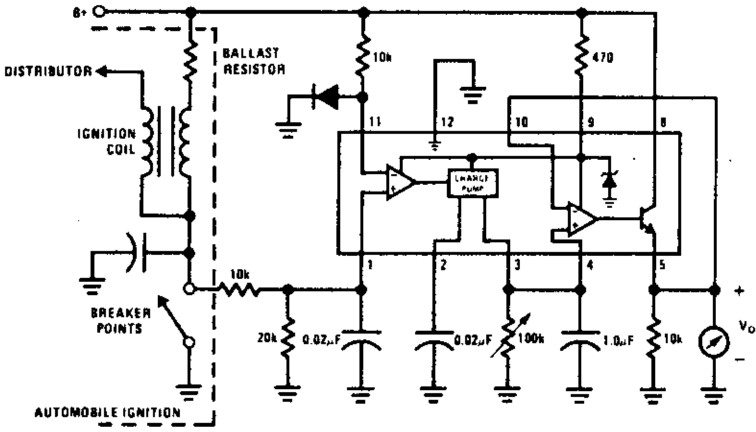
typical applications (con't)

Breaker Point Dwell Meter



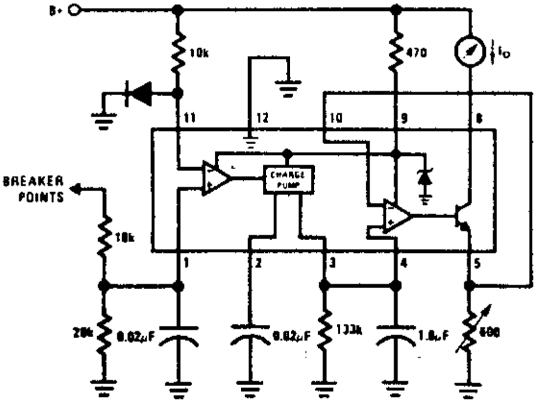
Voltage Driven Meter Indicating Engine RPM

V_O = 6V @ 400 Hz or 6000 ERPM (8 Cylinder Engine)



Current Driven Meter Indicating Engine RPM

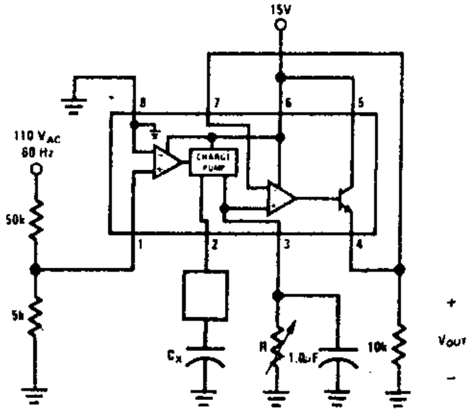
I_o = 10 mA @ 300 Hz or 6000 ERPM (6 Cylinder Engine)



Capacitance Meter

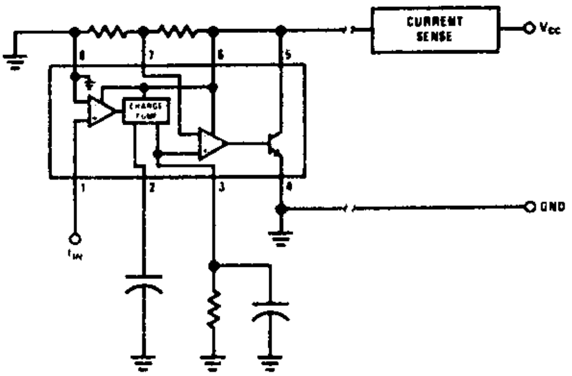
V_{OUT} = 1−10V for C_x = 0.01 to 0.1 mFd

(R = 111k)

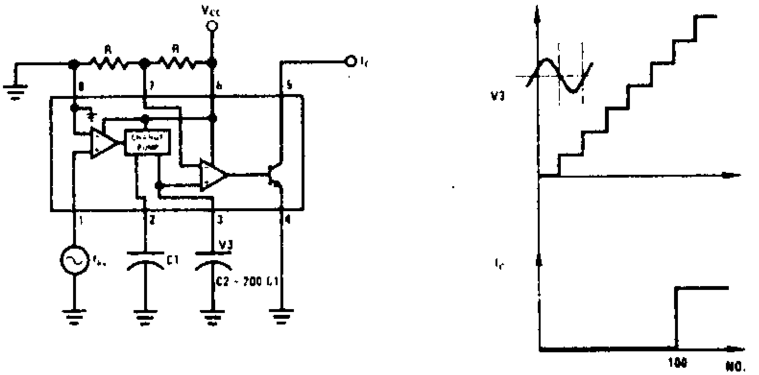


typical applications (con't)

Two-Wire Remote Speed Switch



100 Cycle Delay Switch



V3 steps up in voltage by the amount $\frac{V_{CC} \times C1}{C2}$

for each complete input cycle (2 zero crossings)

Example:

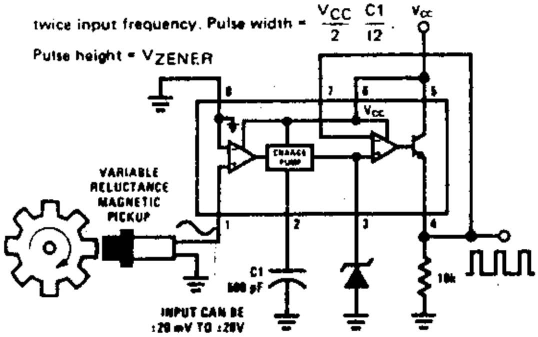
If C2 = 200 C1 after 100 consecutive input cycles

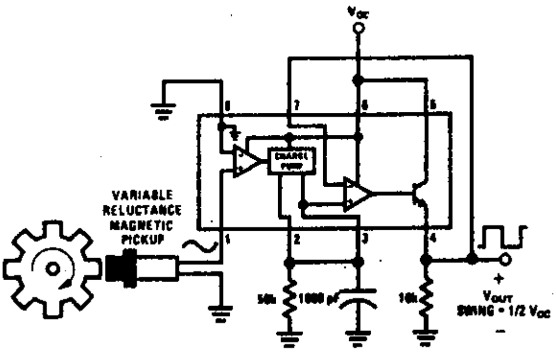
V3 = 1/2 V_{CC}

Variable Reluctance Magnetic Pickup Buffer Circuits

Precision two-shot output frequency equals twice input frequency. Pulse width = $\frac{V_{CC}}{2}\ \frac{C1}{I2}$.

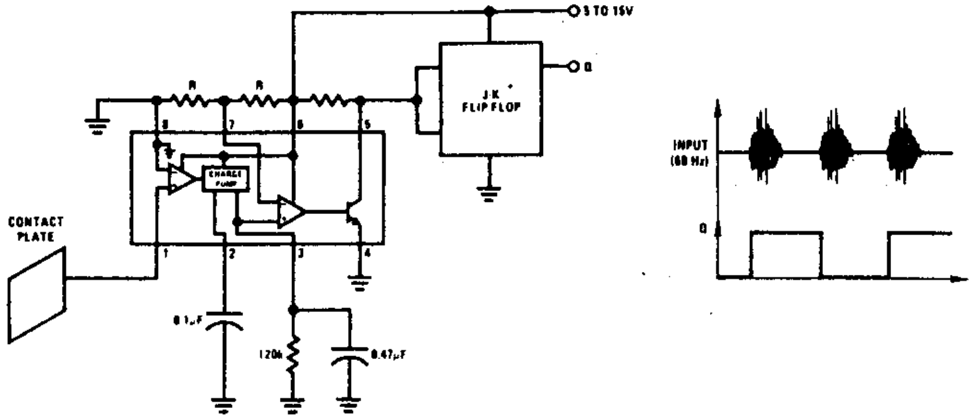
Pulse height = V_{ZENER}



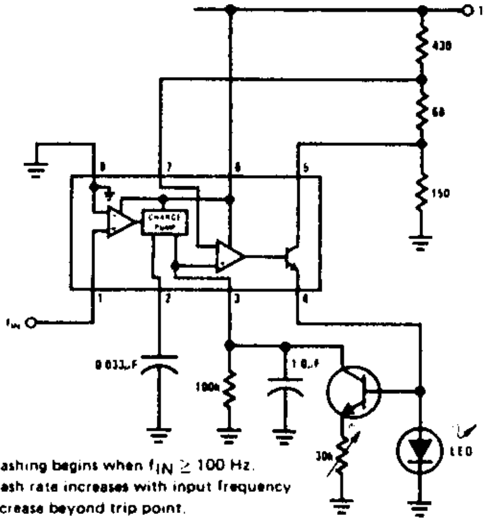


typical applications (con't)

Finger Touch or Contact Switch

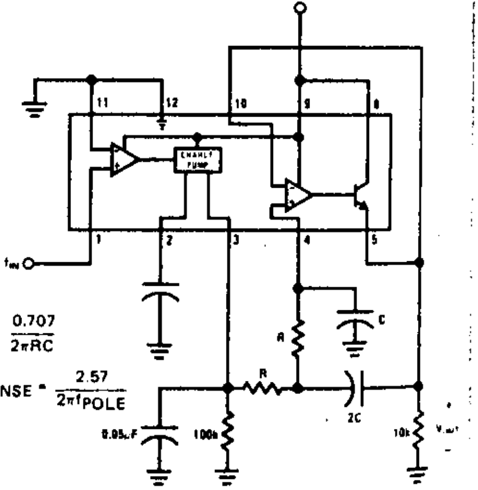


Flashing LED Indicates Overspeed



Flashing begins when $f_{IN} \geq 100$ Hz.
Flash rate increases with input frequency increase beyond trip point.

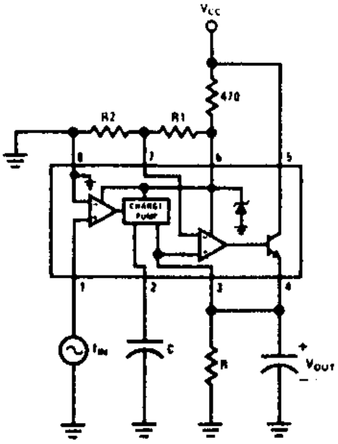
Frequency to Voltage Converter with 2 Pole Butterworth Filter to Reduce Ripple

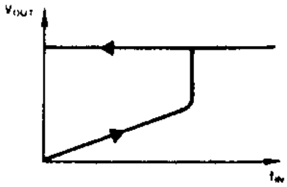


$$f_{POLE} = \frac{0.707}{2\pi RC}$$

$$f_{RESPONSE} = \frac{2.57}{2\pi f_{POLE}}$$

Overspeed Latch





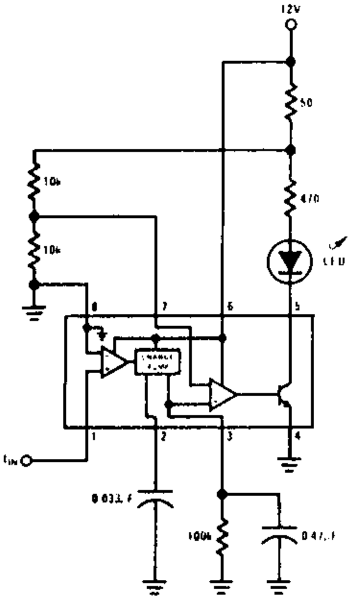
Output latches when

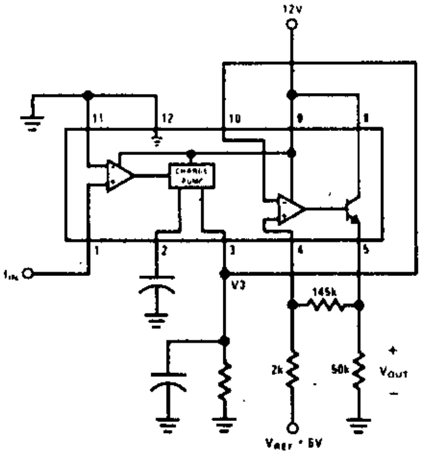
$$f_{IN} = \frac{R2}{R1 + R2} \; \frac{1}{RC}$$

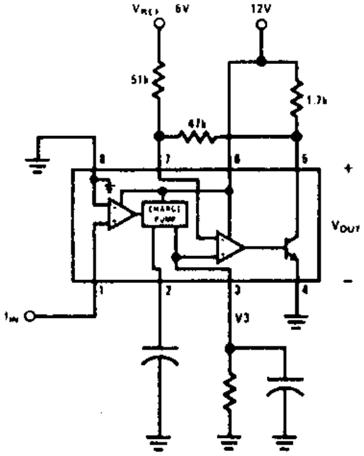
Reset by removing V_{CC}.

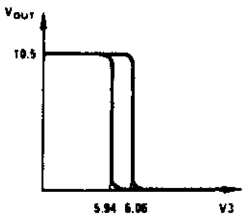
typical applications (con't)

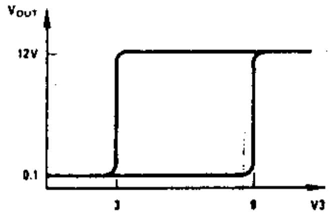
Some Frequency Switch Applications May Require Hysteresis in the Comparator Function Which Can Be Implemented in Several Ways:





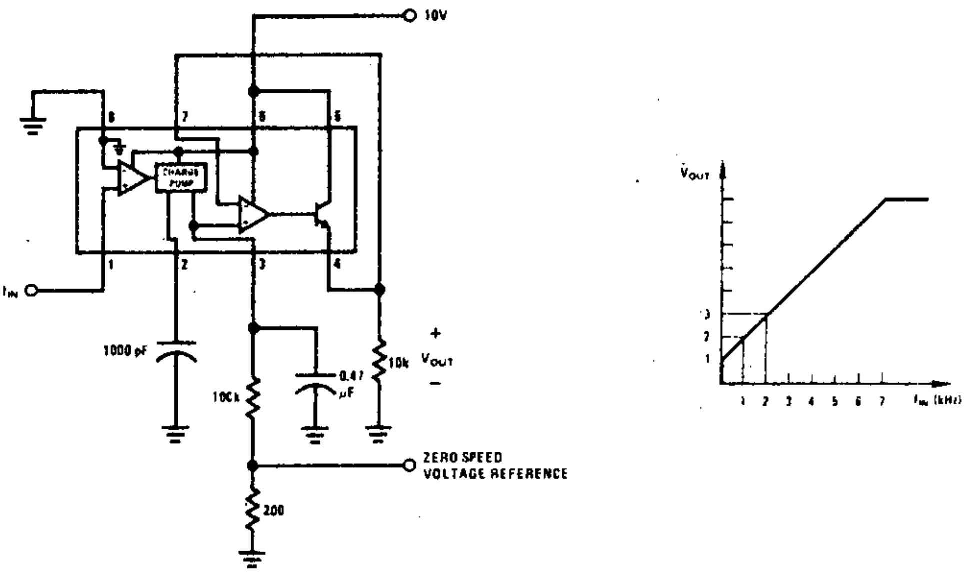




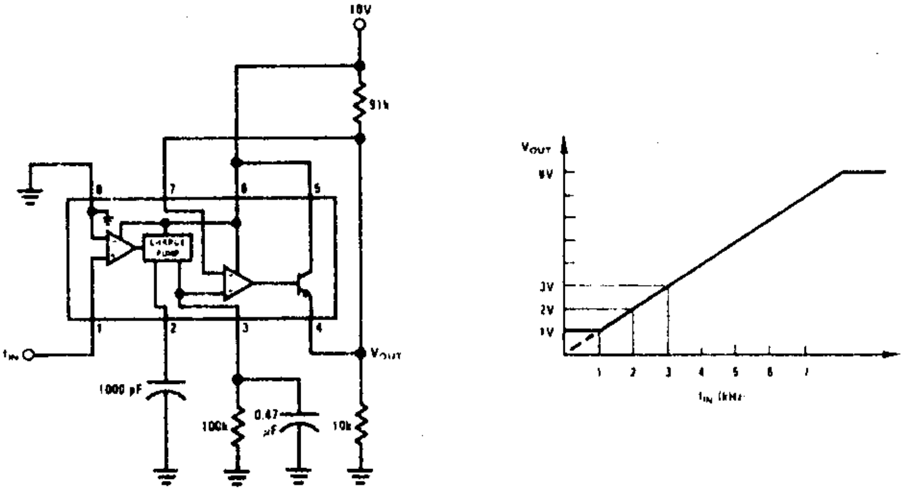


typical applications (con't)

Changing the Output Voltage for an Input Frequency of Zero

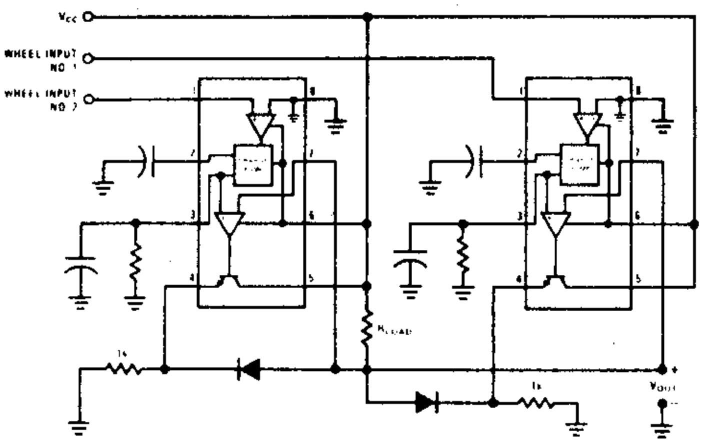


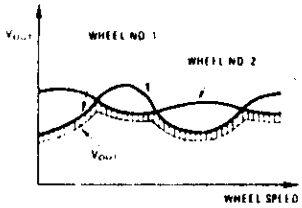
Changing Tachometer Gain Curve or Clamping the Minimum Output Voltage



anti-skid circuit functions

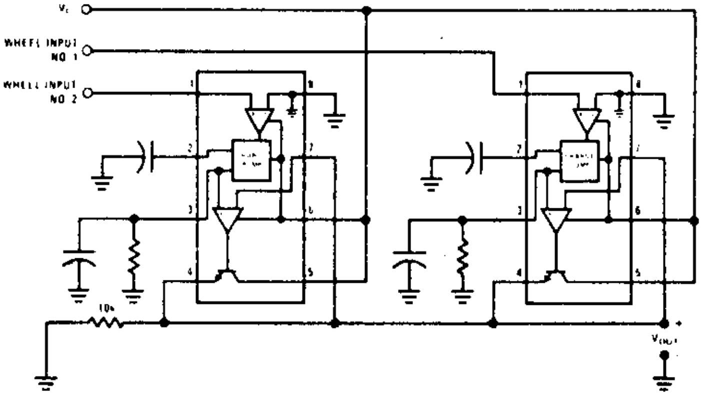
"Select-Low" Circuit

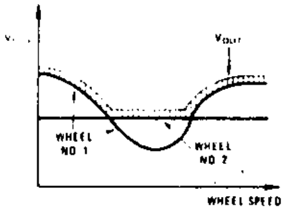




VOUT is proportional to the lower of the two input wheel speeds.

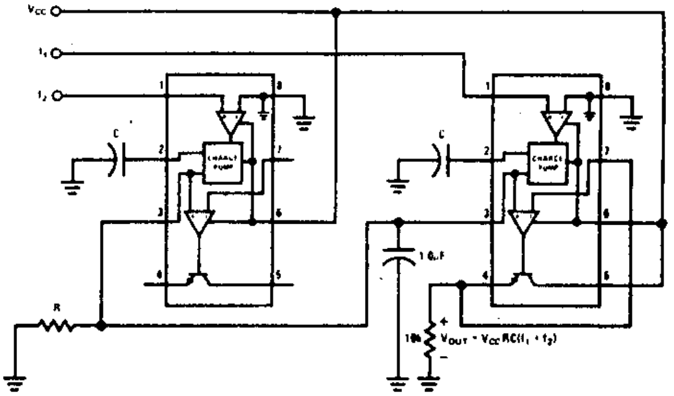
"Select-High" Circuit



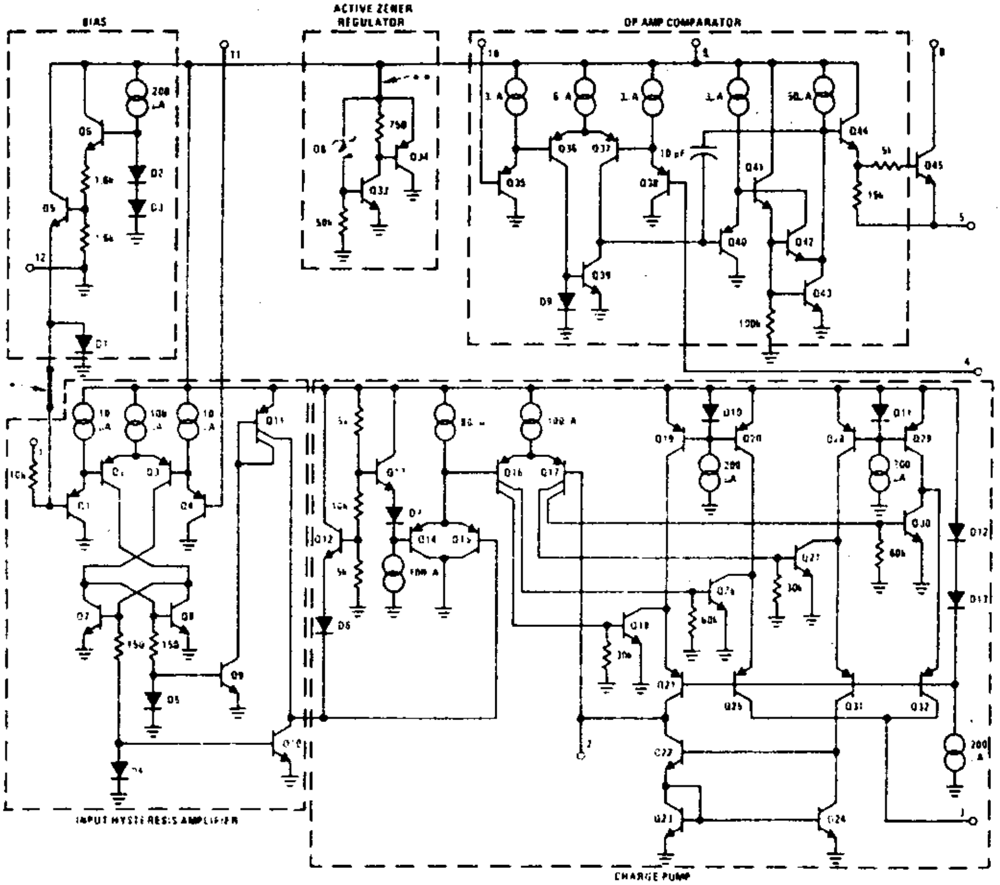


VOUT is proportional to the higher of the two input wheel speeds.

"Select-Average" Circuit



equivalent schematic diagram



* **Note**. This connection made on LM2907-8 and LM2917-8 only

* * **Note**. This connection made on LM2917 and LM2917-8 only