LM2907EP /LM2917EP Enhanced Plastic Frequency to Voltage Converter

Check for Samples: LM2907EP, LM2917EP

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 LM2917EP**
- **±0.3% linearity typical**
- **Ground referenced tachometer is fully protected from damage due to swings above V_{CC} and below ground**

APPLICATIONS

- **Selected Military Applications**
- **Selected Avionics Applications**

DESCRIPTION

The LM2907EP, LP2917EP 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 (LM2907-8EP, LM2917-8EP) and its output swings to ground for a zero frequency input.

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.

ENHANCED PLASTIC

- Extended Temperature Performance of −40°C to +85°C
- Baseline Control - Single Fab & Assembly Site
- Process Change Notification (PCN)
- Qualification & Reliability Data
- Solder (PbSn) Lead Finish is standard
- Enhanced Diminishing Manufacturing Sources (DMS) Support

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 (LM2917EP)

Block and Connection Diagrams

Dual-In-Line and Small Outline Packages, Top Views

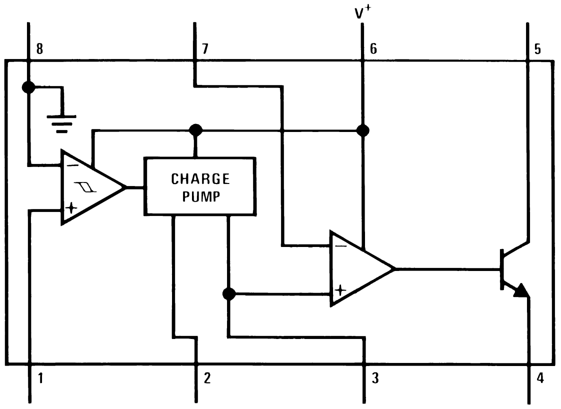


Figure 1. LM2907-8

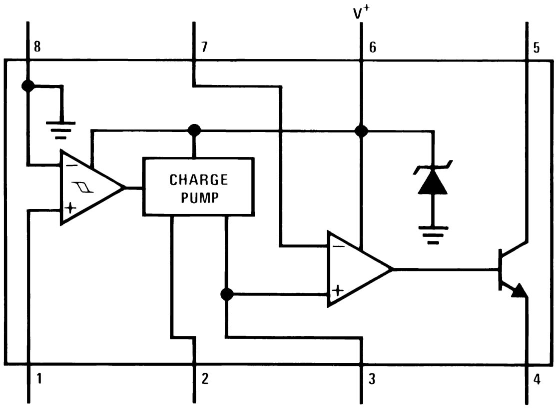


Figure 2. LM2917-8

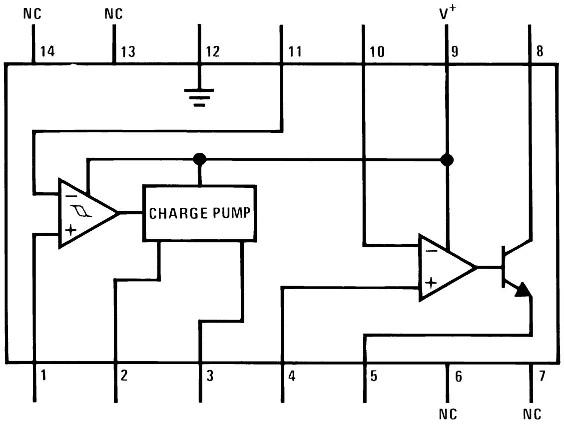


Figure 3. LM2907

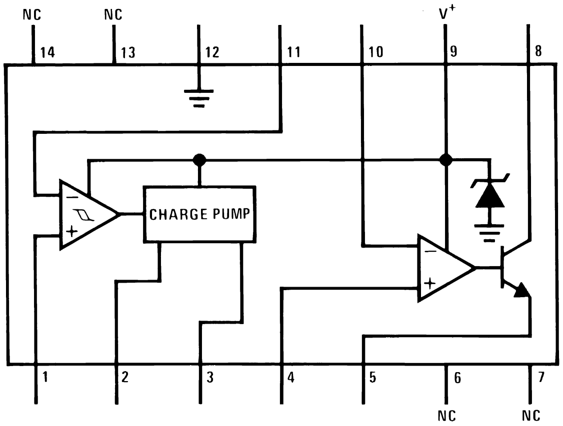


Figure 4. LM2917

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings (1)

Supply Voltage	28V
Collector Voltage	28V
Differential Input Voltage	
Tachometer	28V
Op Amp/Comparator	28V
Input Voltage Range	
Tachometer	
LM2907-8EP, LM2917-8EP	±28V
LM2907EP, LM2917EP	0.0V to +28V
Op Amp/Comparator	0.0V to +28V
Power Dissipation (1)	
LM2907-8EP, LM2917-8EP	1200 mW
LM2907-14EP, LM2917-14EP	1580 mW
Operating Temperature Range	−40°C to +85°C
Storage Temperature Range	−65°C to +150°C
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

(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 LM2907-8EP and LM2917-8EP, and 79°C/W junction to ambient for LM2907-14EP and LM2917-14EP.

Electrical Characteristics

V_{CC} = 12 V_{DC}, T_A = 25°C, see test circuit

Symbol	Parameter	Conditions	Min	Typ	Max	Units
TACHOMETER						
	Input Thresholds	V_{IN} = 250 mVp-p @ 1 kHz (1)	±10	±25	±40	mV
	Hysteresis	V_{IN} = 250 mVp-p @ 1 kHz (1)		30		mV
	Offset Voltage	V_{IN} = 250 mVp-p @ 1 kHz (1)				
	LM2907EP/LM2917EP			3.5	10	mV
	LM2907-8EP/LM2917-8EP			5	15	mV
	Input Bias Current	V_{IN} = ±50 mV_{DC}		0.1	1	μA
V_{OH}	Pin 2	V_{IN} = +125 mV_{DC} (2)		8.3		V
V_{OL}	Pin 2	V_{IN} = −125 mV_{DC} (2)		2.3		V
I_2, I_3	Output Current	V2 = V3 = 6.0V (3)	140	180	240	μA
I_3	Leakage Current	I2 = 0, V3 = 0			0.1	μA
K	Gain Constant	(2)	0.9	1.0	1.1	
	Linearity	f_{IN} = 1 kHz, 5 kHz, 10 kHz (4)	−1.0	0.3	+1.0	%
OP/AMP COMPARATOR						
V_{OS}		V_{IN} = 6.0V		3	10	mV
I_{BIAS}		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

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

(2) V_{OH} is equal to ¾ × V_{CC} − 1 V_{BE}, V_{OL} is equal to ¼ × 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.

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

(4) 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.

Test Circuit and Waveform

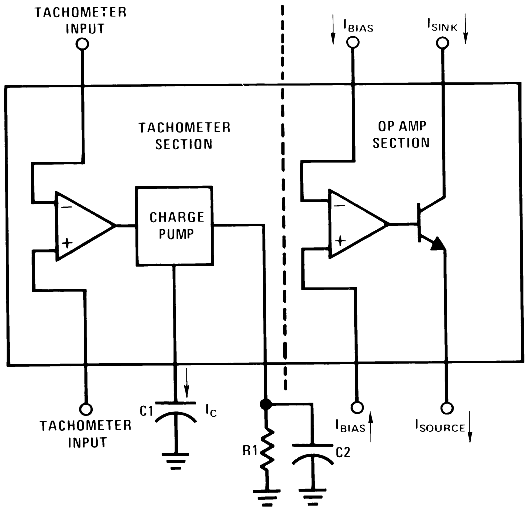
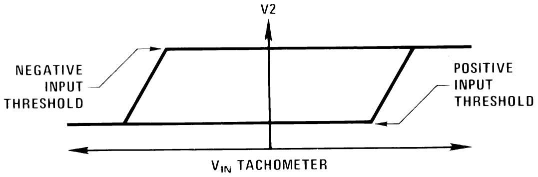
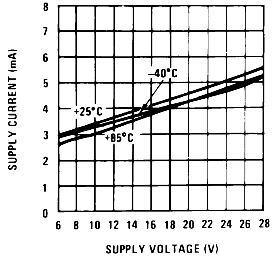


Figure 5. Tachometer Input Threshold Measurement

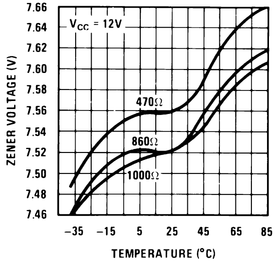


Typical Performance Characteristics

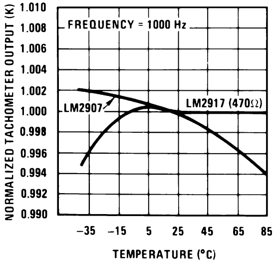
Total Supply Current



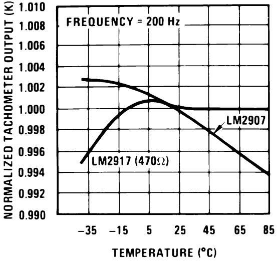
Zener Voltage vs Temperature



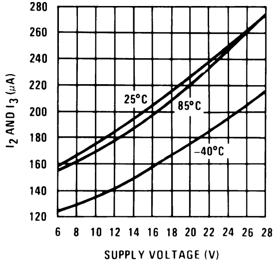
Normalized Tachometer Output vs Temperature



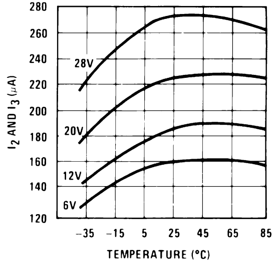
Normalized Tachometer Output vs Temperature



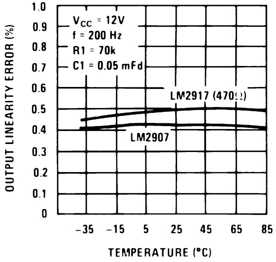
Tachometer Currents I_2 and I_3 vs Supply Voltage



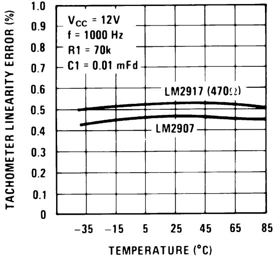
Tachometer Currents I_2 and I_3 vs Temperature



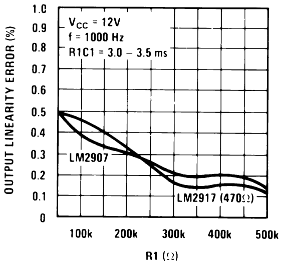
Tachometer Linearity vs Temperature



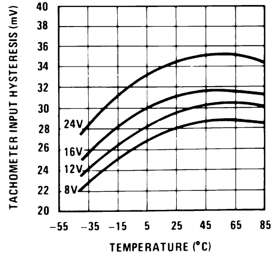
Tachometer Linearity vs Temperature



Tachometer Linearity vs R1

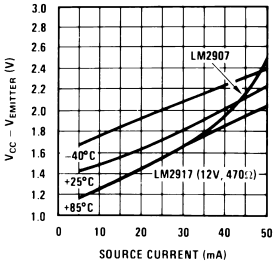


Tachometer Input Hysteresis vs Temperature

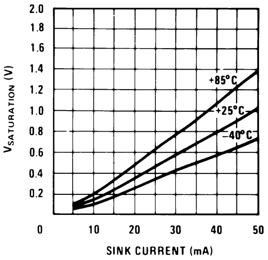


Typical Performance Characteristics (continued)

Op Amp Output Transistor Characteristics



Op Amp Output Transistor Characteristics



Applications Information

The LM2907EP 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 (LM2907-8EP, LM2917-8EP) 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 (LM2907EP, LM2917EP) 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 linearly 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:

$$\frac{\Delta Q}{T} = i_{c(AVG)} = C1 \times \frac{V_{CC}}{2} \times (2f_{IN}) = V_{CC} \times f_{IN} \times C1 \qquad (1)$$

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

$$V_O = V_{CC} \times f_{IN} \times C1 \times R1 \times K \qquad (2)$$

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 500 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:

$$V_{RIPPLE} = \frac{V_{CC}}{2} \times \frac{C1}{C2} \times \left(1 - \frac{V_{CC} \times f_{IN} \times C1}{I_2}\right) \text{pk-pk} \qquad (3)$$

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:

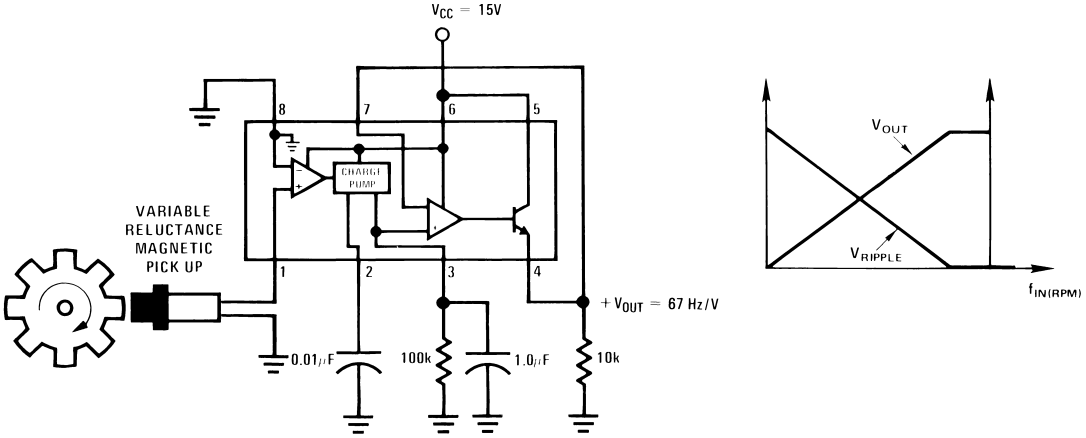
$$f_{MAX} = \frac{I_2}{C1 \times V_{CC}} \tag{4}$$

USING ZENER REGULATED OPTIONS (LM2917EP)

For those applications where an output voltage or current must be obtained independent of supply voltage variations, the LM2917EP 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 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

Figure 6. Minimum Component Tachometer



$$\text{"Speed Switch" Load is Energized When } f_{IN} \geq \frac{1}{2RC} \tag{5}$$

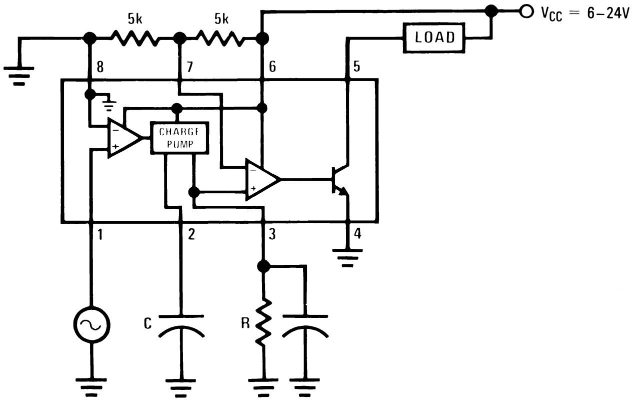


Figure 7. Zener Regulated Frequency to Voltage Converter

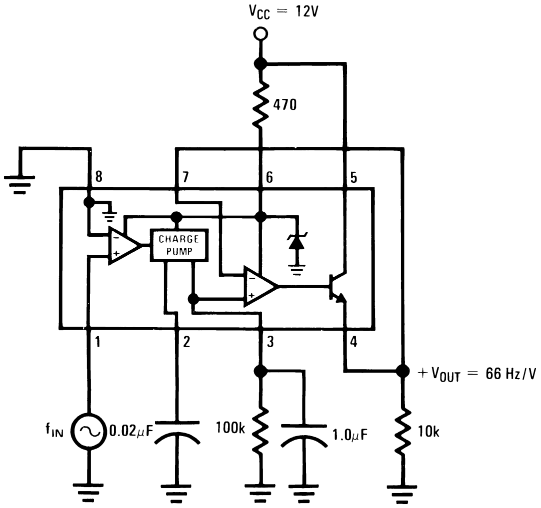


Figure 8. Breaker Point Dwell Meter

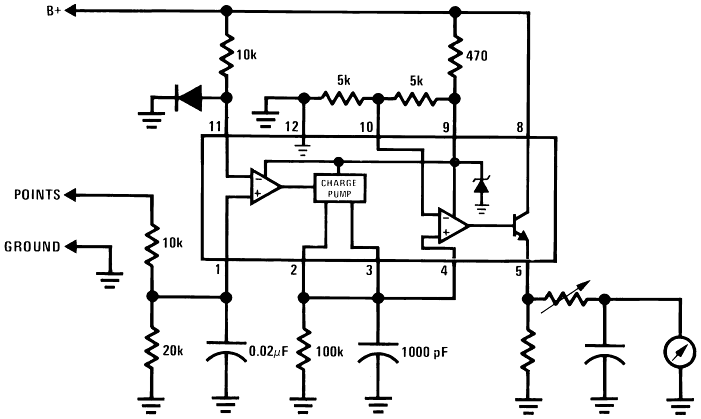


Figure 9. Voltage Driven Meter Indicating Engine RPM
V_O = 6V @ 400 Hz or 6000 ERPM (8 Cylinder Engine)

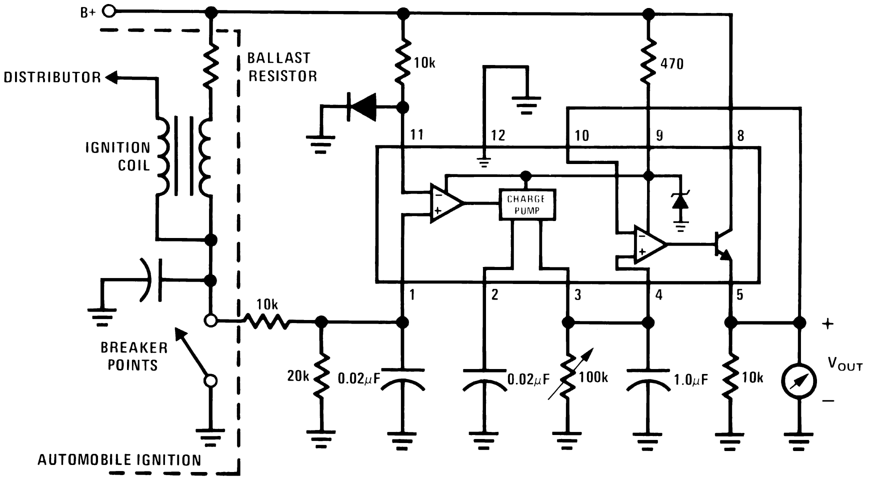


Figure 10. Current Driven Meter Indicating Engine RPM
I_O = 10 mA @ 300 Hz or 6000 ERPM (6 Cylinder Engine)

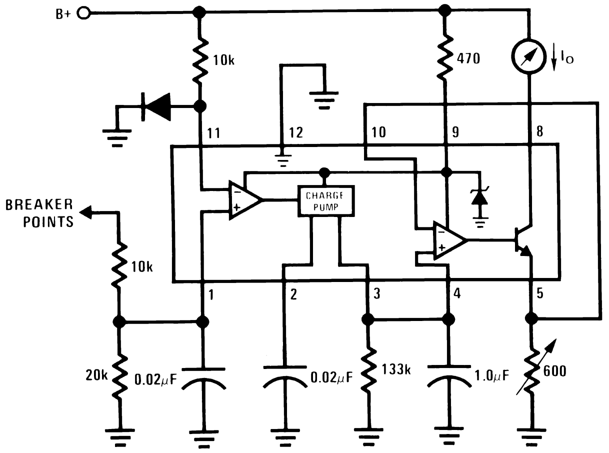


Figure 11. Capacitance Meter
V_{OUT} = 1V–10V for C_X = 0.01 to 0.1 mFd
(R = 111k)

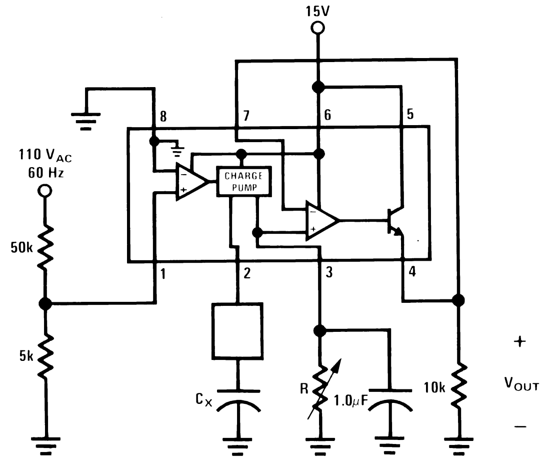


Figure 12. Two-Wire Remote Speed Switch

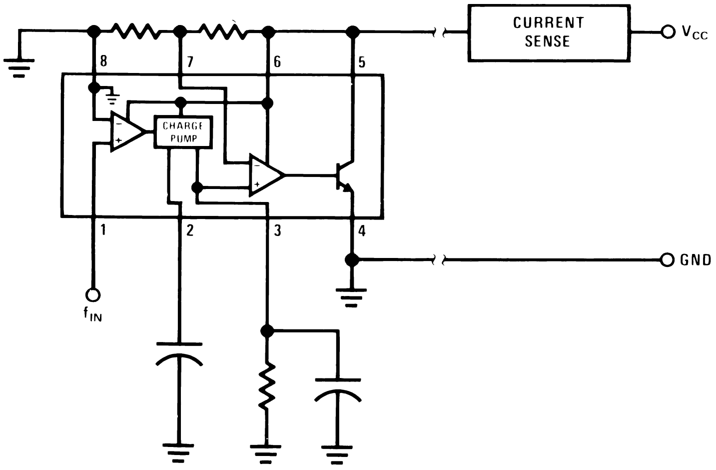
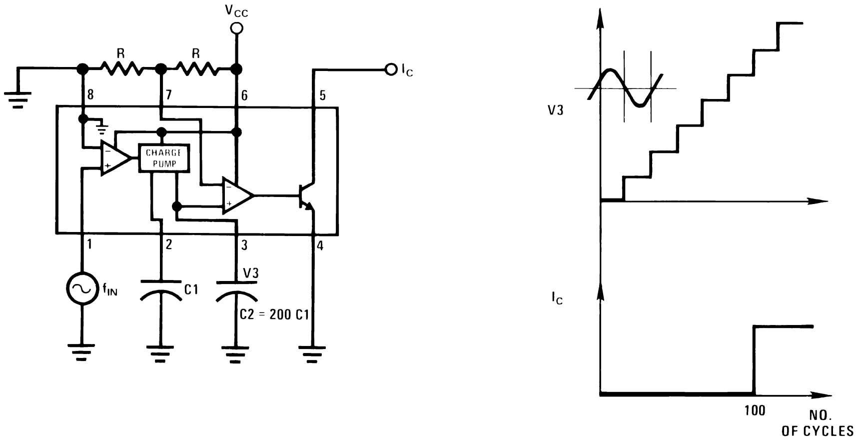


Figure 13. 100 Cycle Delay Switch



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

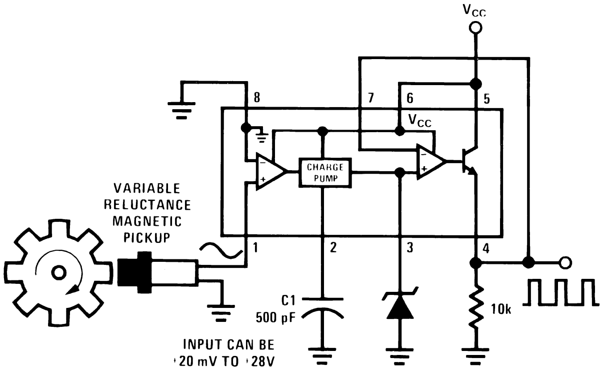
for each complete input cycle (2 zero crossings)

Example:

if C2 = 200 C1 after 100 consecutive input cycles.

V3 = 1/2 V_{CC}

Figure 14. Variable Reluctance Magnetic Pickup Buffer Circuits



Precision two-shot output frequency equals twice input frequency.

$$\text{Pulse width} = \frac{V_{CC}}{2}\,\frac{C1}{I2}$$

Pulse height = V_{ZENER}

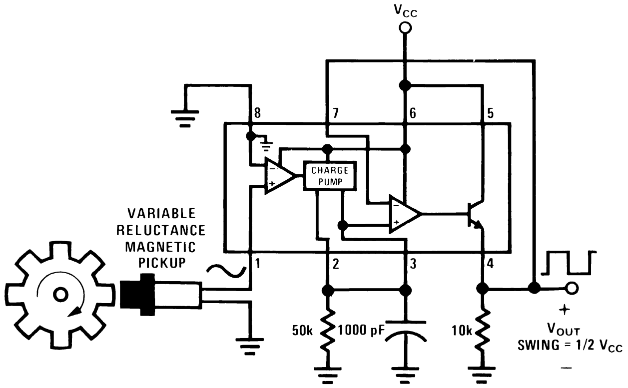


Figure 15. Finger Touch or Contact Switch

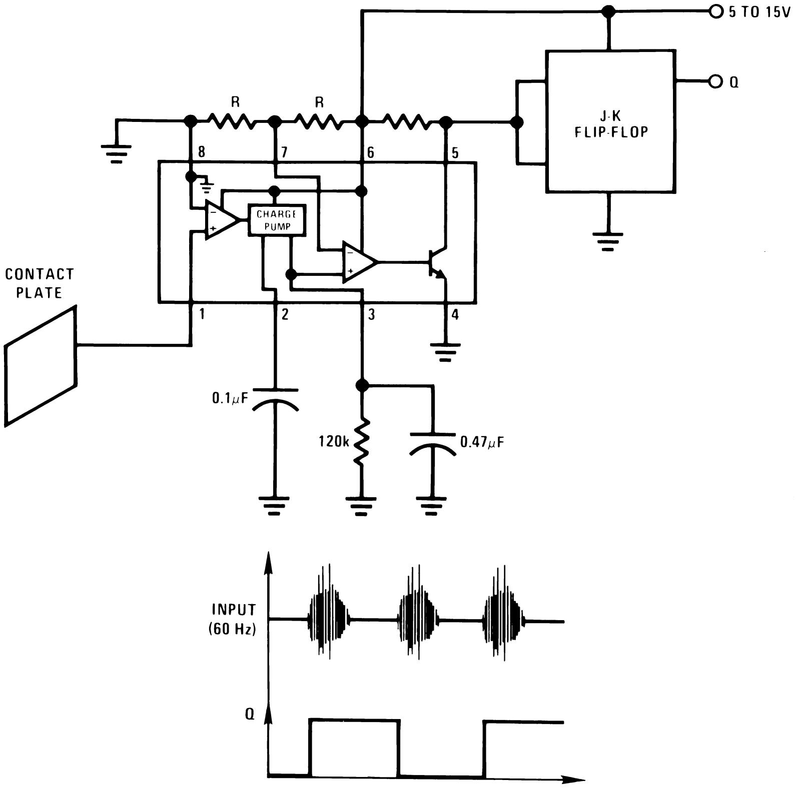
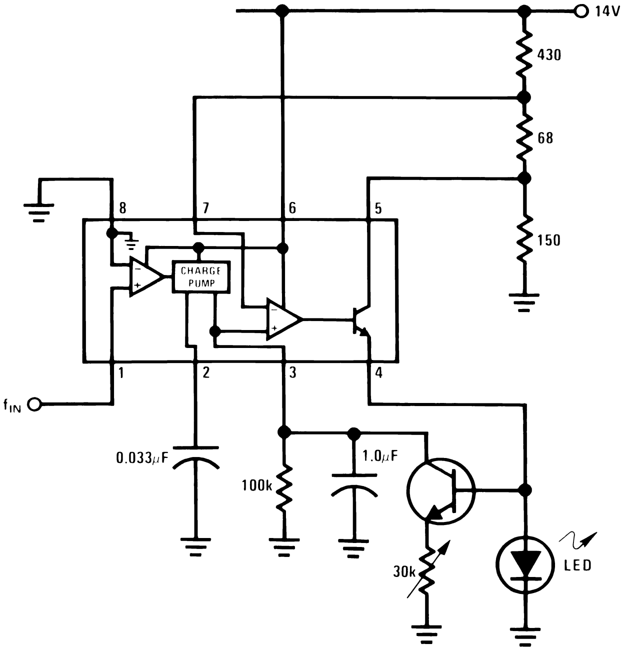
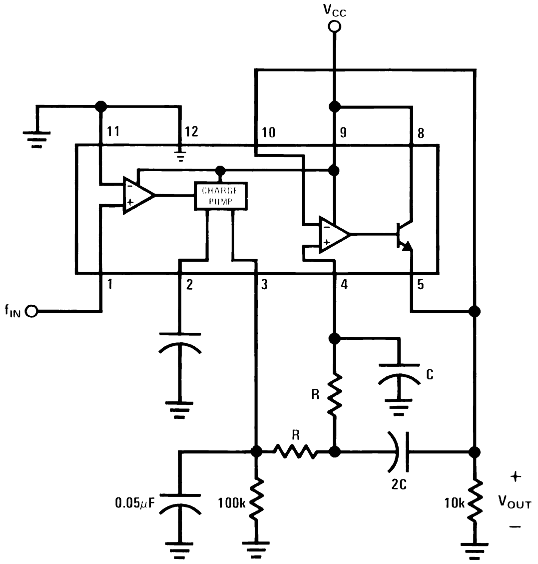


Figure 16. Flashing LED Indicates Overspeed



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

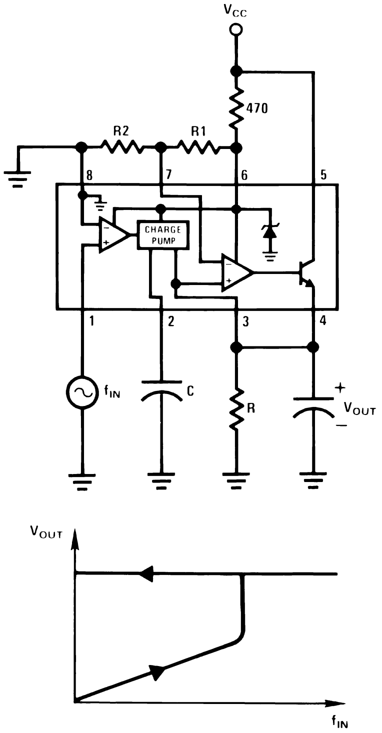
Figure 17. Frequency to Voltage Converter with 2 Pole Butterworth Filter to Reduce Ripple



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

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

Figure 18. Overspeed Latch

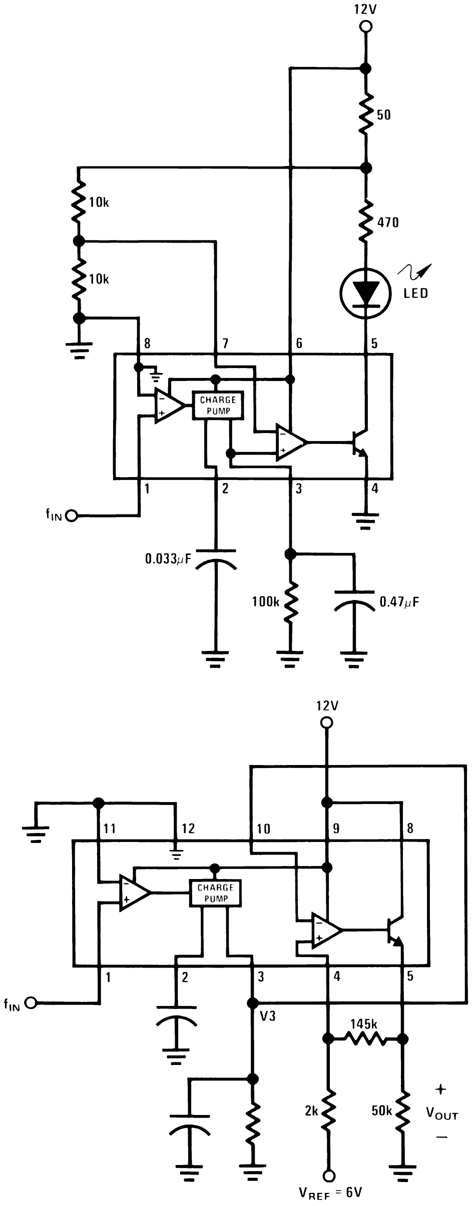


Output latches when

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

Reset by removing V_{CC}.

Figure 19. Some Frequency Switch Applications May Require Hysteresis in the Comparator Function Which can be Implemented in Several Ways:



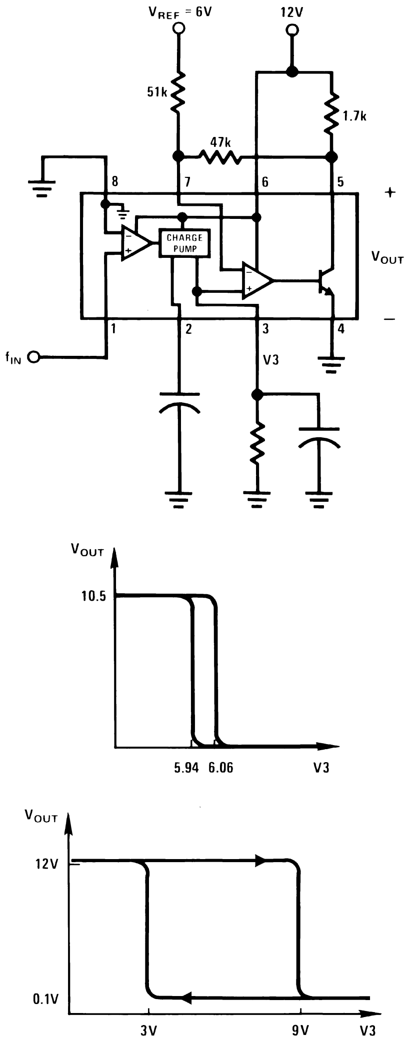
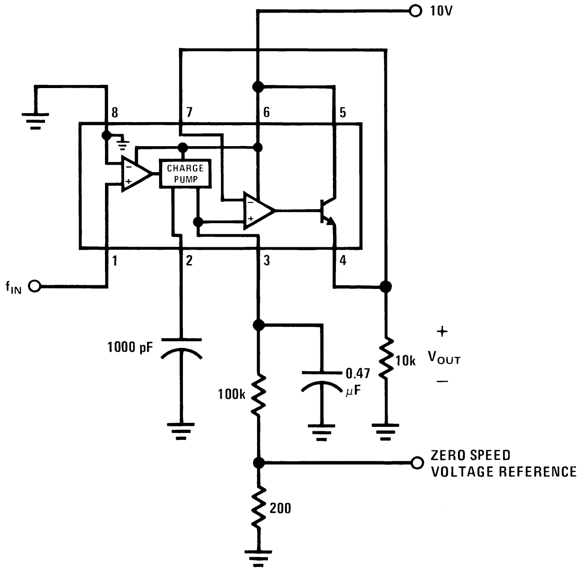


Figure 20. Changing the Output Voltage for an Input Frequency of Zero



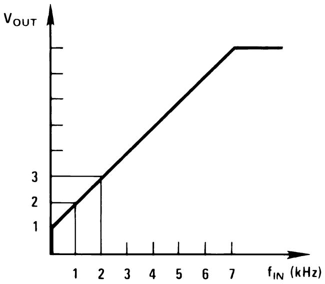
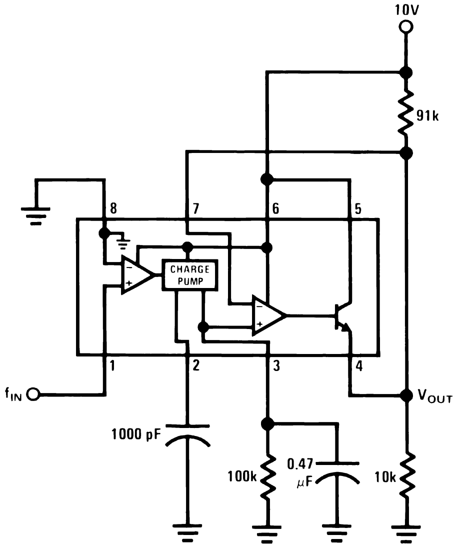
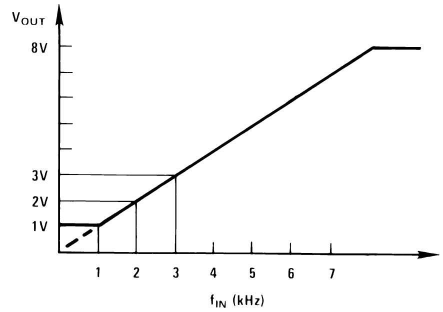


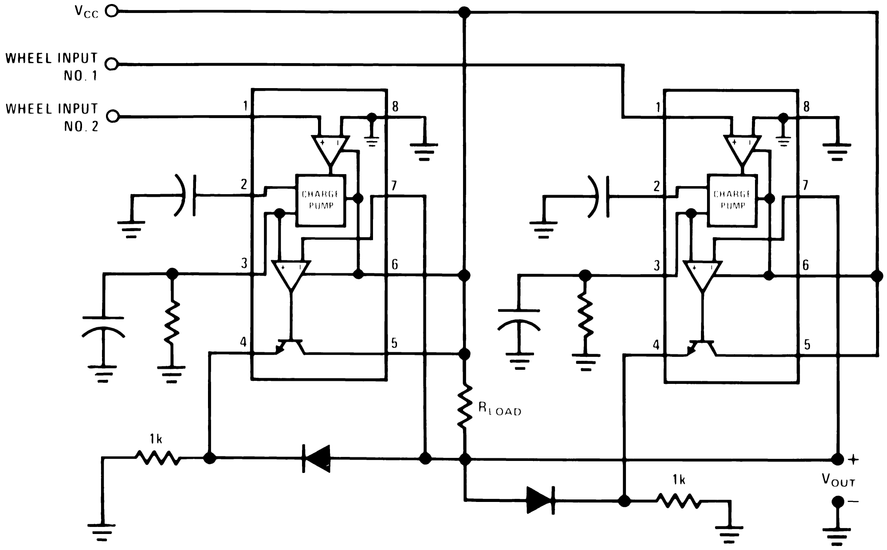
Figure 21. Changing Tachometer Gain Curve or Clamping the Minimum Output Voltage

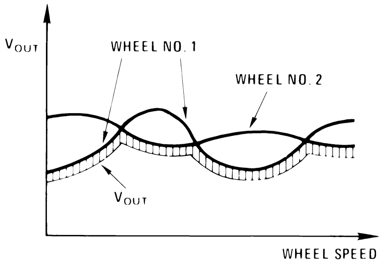




Anti-Skid Circuit Functions

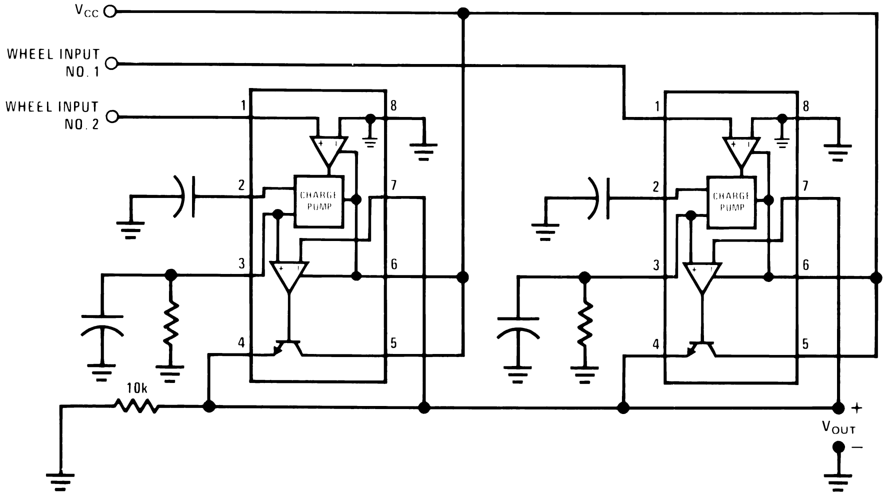
Figure 22. "Select-Low" Circuit

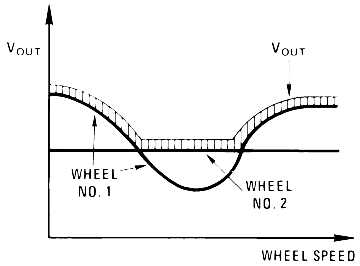




V_{OUT} is proportional to the lower of the two input wheel speeds.

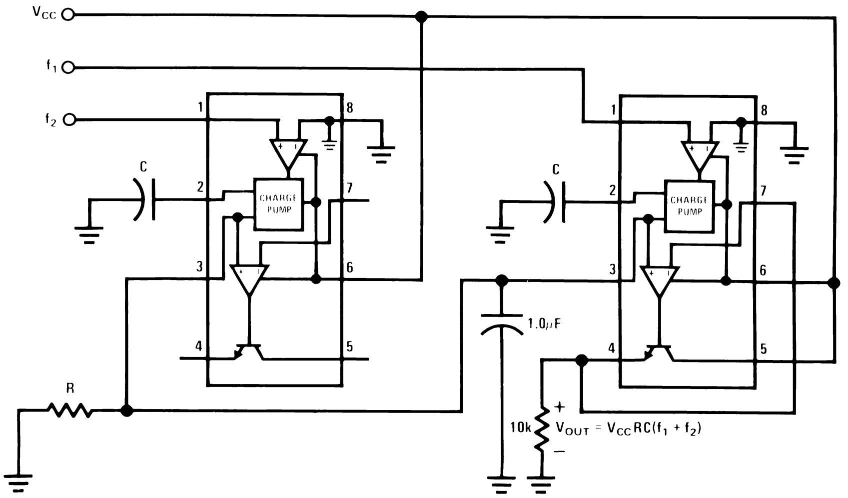
Figure 23. "Select-High" Circuit



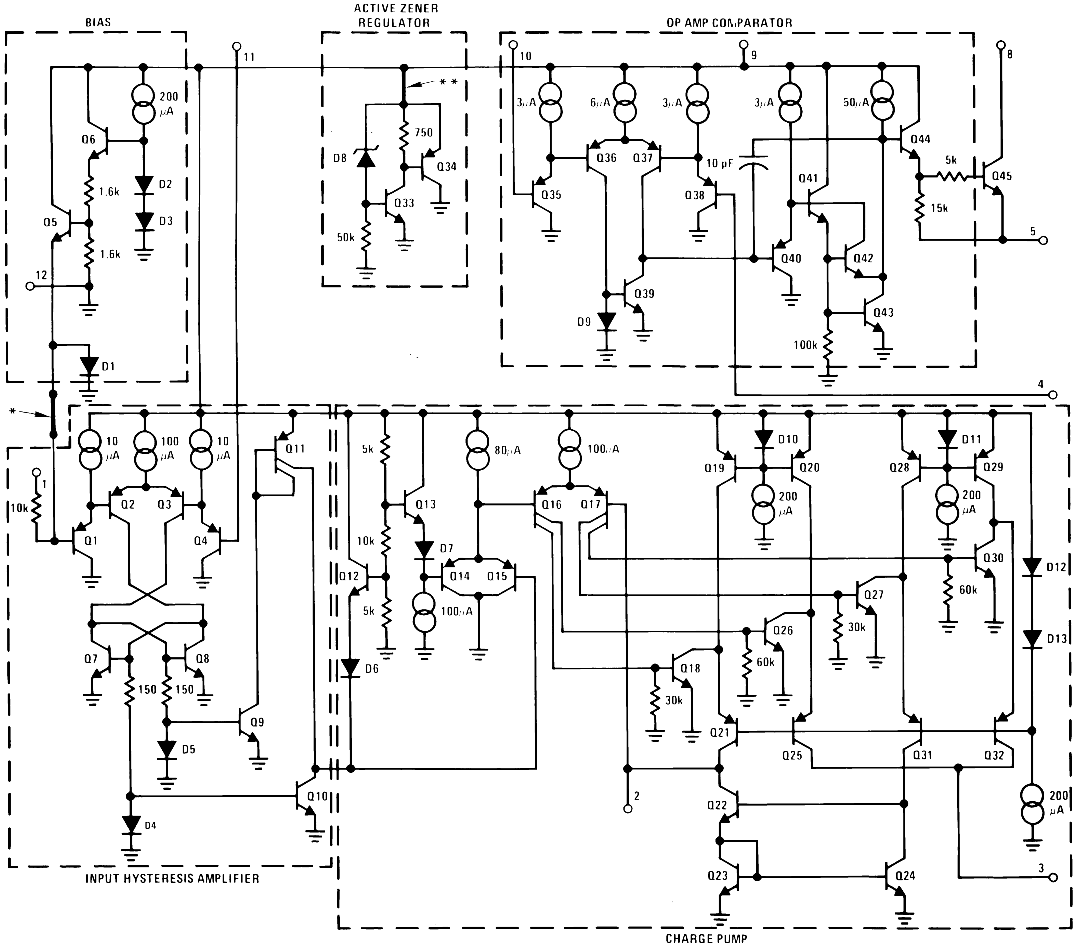


V_{OUT} is proportional to the higher of the two input wheel speeds.

Figure 24. “Select-Average” Circuit



Equivalent Schematic Diagram



*This connection made on LM2907-8EP and LM2917-8EP only.
**This connection made on LM2917EP and LM2917-8EP only.

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