Frequency-to-Voltage Converter

GENERAL DESCRIPTION

The XR-2917 Frequency-to-Voltage Converter is a high accuracy converter consisting of input comparator with 40 mV hysteresis, charge pump, Zener regulator, and output op amp and transistor. Designed for tachometer and motor control applications, it features excellent linearity and high current output.

Output voltage is a simple function of the Zener regulator voltage (V_Z), a resistor (R_1) and capacitor (C_1) which are connected to the charge pump, and the input frequency (f_{in}). Ripple reduction is implemented by addition of one capacitor (C_2) which is used to achieve frequency doubling. The output transistor can swing to ground, sink a load current of 40 mA, and offers a maximum V_{CE} of 28 V. Stable and accurate frequency to voltage or current conversion is ensured by the on-chip Zener regulator which is connected across the power leads. The Zener may be used with any supply voltage (up to 28 V) when a suitable resistor is connected between the Zener and the supply.

The XR-2917 may be operated with a ground referenced input or differential tachometer input with uncommitted op amp inputs. The ground referenced configuration is most basic, allowing the realization of single speed, frequency switching, and buffered frequency-to-voltage or current conversion applications. Differential input configurations allow the tachometer to be floated, while uncommitted op amp inputs free the op amp for implementation of active filter conditioning of the tachometer output.

The XR-2917, available in a 14 Pin DIP, operates from a single power supply of up to 28 V.

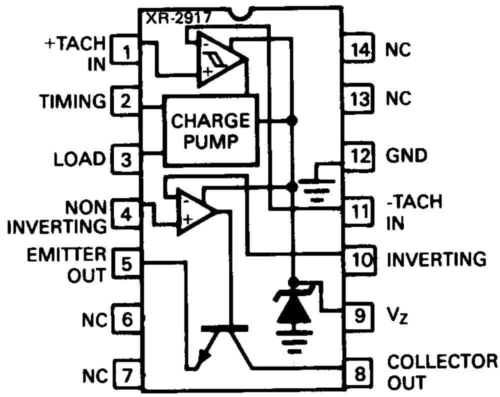
FEATURES

Design Simplicity: $V_{OUT} = f_{in} \times V_Z \times R_1 \times C_1$
Frequency Doubling to Decrease Output Ripple
On-Chip Zener for Functional Stability
Excellent Linearity
Floating Output Drive Transistor Provides
 40 mA Source or Sink
Ground Referenced Tachometer Input Which
 Interfaces Directly with Variable Reluctance
 Magnetic Pickups.

ORDERING INFORMATION

Part Number	Package	Operating Temperature
XR-2917CN	Ceramic	0°C to +70°C
XR-2917CP	Plastic	0°C to +70°C

FUNCTIONAL BLOCK DIAGRAM



SYSTEM DESCRIPTION

The XR-2917 converts an input frequency to a proportional output voltage. Differential inputs provide hysteresis for excellent noise rejection and the capability of setting the comparator's input switching level. Inputs should not be taken below ground without some lead resistance.

The output of the comparator is fed into a charge pump where current is pumped through a timing capacitor (C_1). This same current is mirrored in the load resistor (R_1) where a filter capacitor (C_2) may be used to integrate current pulses and provide a proportional voltage across the load resistor. The result is a voltage across the load resistor which is a function of the supply voltage, input frequency, timing capacitor, and load resistor:

$$V_{R_1} = V_Z \times f_{in} \times C_1 \times R_1$$

The size of the integrating capacitor (C_2) is dependent only on the requirements of response time and output ripple.

The output op amp and transistor are then used to buffer the output drive capability of the part. Thus, the final conversion equation is:

$$V_O = V_Z \times f_{in} \times C_1 \times R_1 \times K$$

where K is the gain provided by the tachometer section, and is typically unity.

ELECTRICAL CHARACTERISTICS

Test Conditions: V_{CC} = +12 V, T_A = 25°C, unless otherwise specified.

SYMBOL	PARAMETERS	MIN.	TYP.	MAX.	UNIT	CONDITIONS
TACHOMETER						
V_T	Threshold Voltage	±10	±15	±40	mV	V_{IN} = 250 mV @ 1 KHz
V_H	Hysteresis Voltage		30		mV	
V_{OS}	Input Offset Voltage		3.5	10	mV	
I_B	Input Bias Current		0.1	1	μA	V_{IN} = ±50 mV_{DC}
V_{OH}	Minimum High Level Output Voltage		5.1		V	V_{IN} = +125 mV_{DC}
V_{OL}	Maximum Low Level Output Voltage		1.2		V	V_{IN} = -125 mV_{DC}
I_T, I_L	Charge Pump Currents (Timing, Load Pins)	140	180	240	μA	V_T = V_L = 6.0 V
I_{OL3}	Output Leakage Current (Pin 3)			0.1	μA	I_T = 0 V, V_T = 0 V
	Linearity		0.3	1.0	%	Note 1
K	Gain Constant	0.9	1.0	1.1		
OP AMP COMPARATOR						
V_{OS}	Input Offset Voltage		3	10	mV	V_{IN} = 6.0 V
I_B	Input Bias Current		50	500	nA	V_{IN} = 6.0 V
V_{CM}	Input Common Mode Voltage	0		V_{CC}-1.5V	V	
A_O	Open Loop Voltage Gain		200		V/mV	
I_{SI}	Output Transistor Sink Current	40	50		mA	V_C = 1.0 V
I_{SO}	Output Transistor Source Current		10		mA	V_E = V_{CC} -2.0 V
V_{SAT}	Transistor Saturation Voltage		0.1	0.5	V	I_{SI} = 5 mA
				1.0	V	I_{SI} = 20 mA
			1.0	1.5	V	I_{SI} = 50 mA
ZENER REGULATOR						
V_Z	Zener Voltage		7.56		V	R_{DROP} = 470Ω
r_Z	Equivalent Zener Reistance		10.5	15	Ω	
	Temperature Stability		+1		mV/°C	
DEVICE CHARACTERISTICS						
I_S	Supply Current		3.8	6	mA	

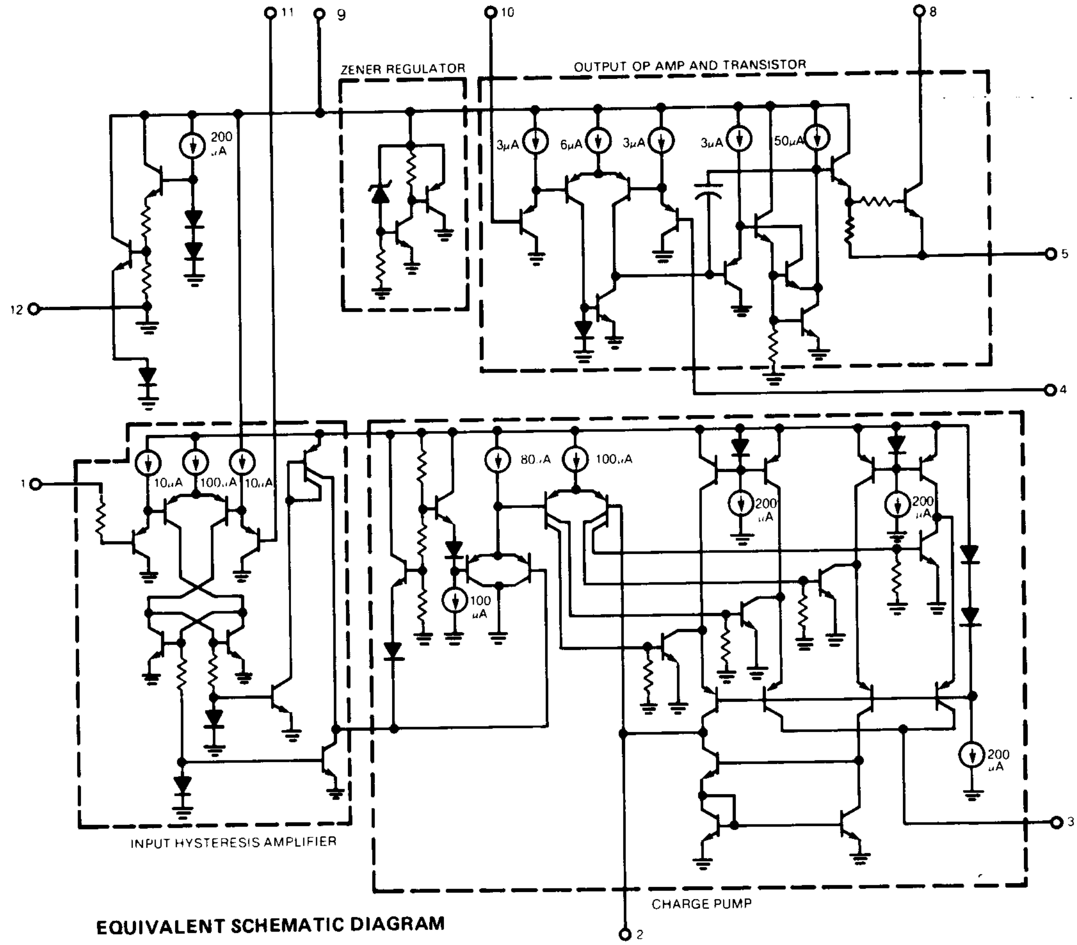
Note 1: Non-linearity is the deviation of V_{OUT} @ f_{in} = 5 KHz from the line defined by V_{OUT} @ f_{in} = 1 KHz and V_{OUT} @ f_{in} = 10 KHz with C_1 = 0.001 μF, R_1 = 68 kΩ, and C_2 = 0.22 μF.

APPLICATIONS

Frequency-to-Voltage Conversion
Speedometers
Breaker Point Dwell Meters
Tachometers
Speed Sensing and Control
Governors
Touch, Contact, or Delay Switching

ABSOLUTE MAXIMUM RATINGS (R_{DROP} = 470 Ω)

Power Supply Voltage (Pin 9)	28 V dc
Input Voltage Range	
Tachometer	0.0 V to +28 V dc
Op Amp and Output Transistor	0.0 V to +28 V dc
Supply Current	25 mA
Storage Temperature Range	-55°C to 150°C
Operating Junction Temperature	150°C
Power Dissipation	500 mW
Derate Above 25°C	5.3 mW/°C



EQUIVALENT SCHEMATIC DIAGRAM

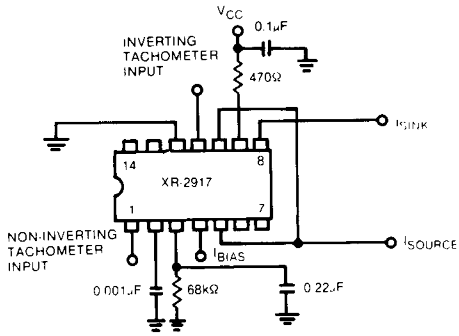
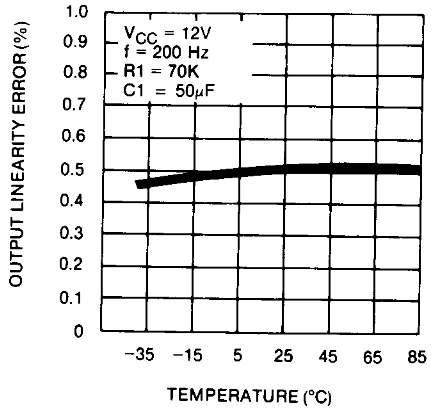


Figure 1. Test Circuit

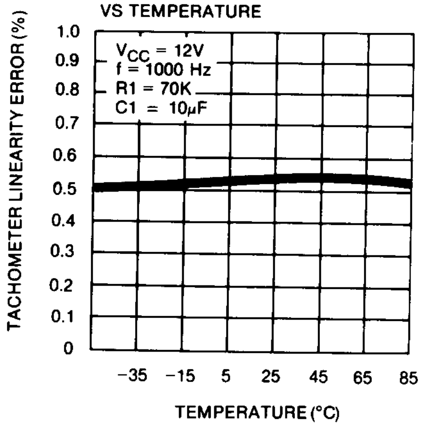
TYPICAL CHARACTERISTICS

R_{DROP} = 470 Ω, V_{CC} = 12 V, unless noted.

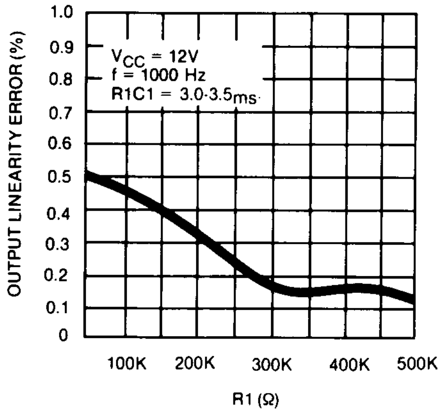
TACHOMETER LINEARITY
VS TEMPERATURE



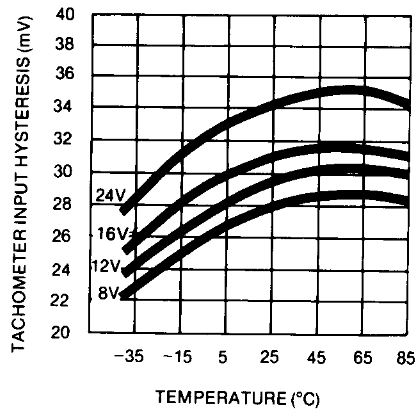
TACHOMETER LINEARITY
VS TEMPERATURE



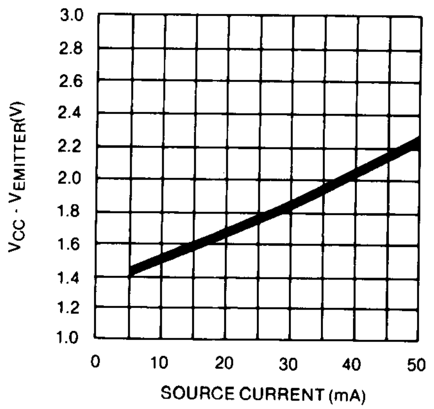
TACHOMETER LINEARITY VS R1



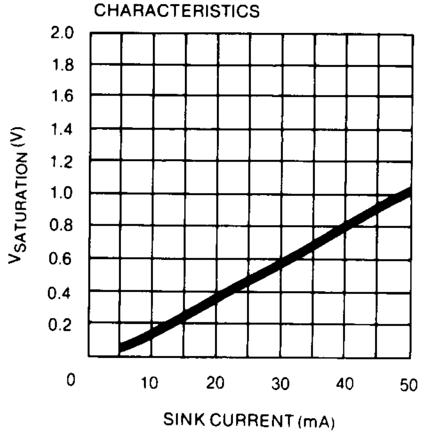
TACHOMETER INPUT HYSTERESIS
VS TEMPERATURE



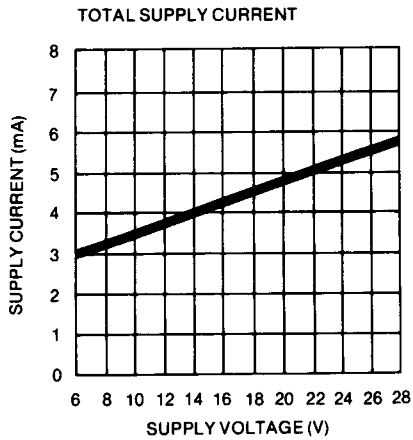
OP AMP OUTPUT TRANSISTOR
CHARACTERISTICS (25°C)

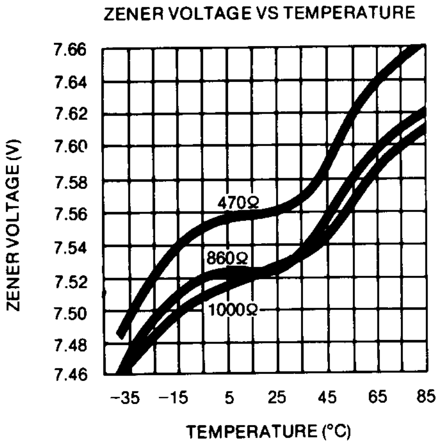


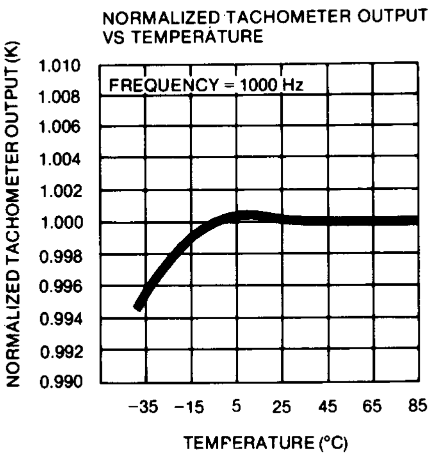
OP AMP OUTPUT TRANSISTOR
CHARACTERISTICS

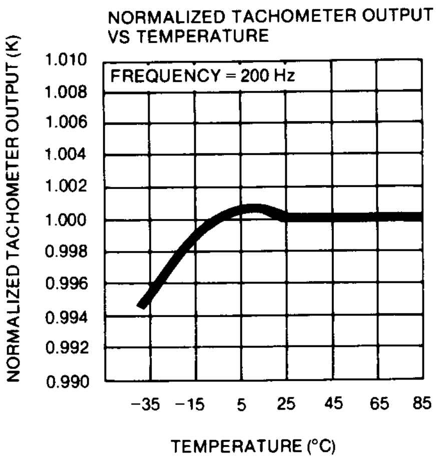


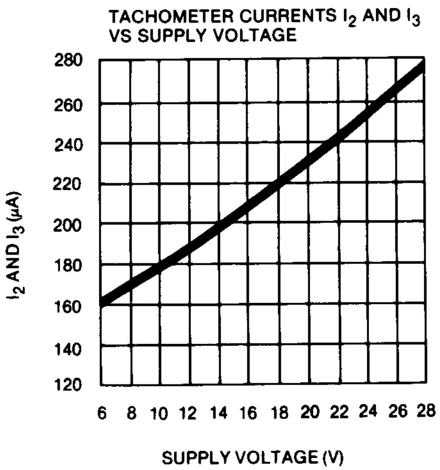
TYPICAL CHARACTERISTICS

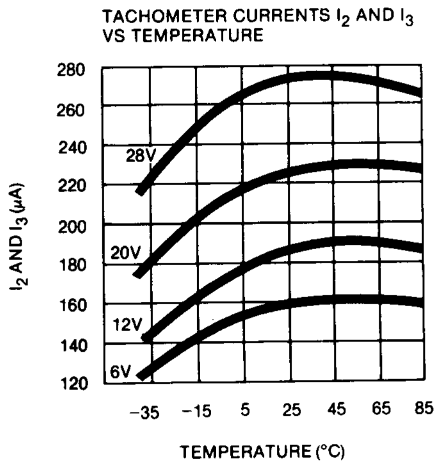












PRINCIPLES OF OPERATION

Figure 1 shows the typical connection for the XR-2917 as a frequency-to-voltage/current converter. The system consists of a tachometer section, Zener regulator, charge pump, and output op amp and transistor. Input may be differential or ground referenced single-ended, and output current may be sourced or sunk through the output transistor.

When using the XR-2917 in the differential mode, inputs to the tachometer front-end should be protected by introducing some current limiting resistance in the input lead.

Timing Capacitor

The timing capacitor, C_1, also provides compensation for the charge pump. As such, it must be larger than 100 pF to ensure accurate operation. Values of C_1 smaller than this can cause an error current through the current mirror of the charge pump and thus through R_1.

Load Resistor

There is an additional constraint placed on the load resistor, R_1. Since the output voltage is determined at Pin 3, then

$$V_{OUT} = R_1 I_3 \qquad (1)$$

I_3 is easily determined from the relationship

$$I_3 = I_2 = VZ \times f_{in} \times C_1$$

Combining these two results gives the simplified design equation

$$V_{OUT} = V_Z \times f_{in} \times R_1 \times C_1 \qquad (2)$$

Thus, R_1 must be chosen to achieve maximum V_{OUT} for f_{in}.

Filter Capacitor

The choice of C_2 is dependent upon the ripple voltage allowable at the output of the transistor emitter, Pin 4. Since C_1 is used to set the current through R_1, and R_1 is chosen to satisfy the equation

$$V_{OUT\,MAX} = R_1 I_3 \qquad (3)$$

and

$$V_{ripple} = \frac{V_Z}{2} \times \frac{C_1}{C_2} \times \left(1 - \frac{V_Z f_{in} C_1}{I_3}\right)_{pp} \qquad (4)$$

Maximum Input Frequency

The maximum input frequency is determined once C_1 has been chosen. It is determined by the relation

$$f_{in\,max} = \frac{I_2}{C_1 \times V_Z} \qquad (5)$$

Response Time

It should be noted that the time necessary for V_{OUT} to stabilize to a new voltage is a function of C_2, thus as C_2 increases, so does the response time of V_{OUT}.

Zener Regulator

The on-board Zener provides a stable source voltage to the XR-2917's internal systems, so that accurate conversion is possible independent of substantial supply voltage variations. A drop resistor should be placed between the raw supply and the Zener such that the current supplied to the part is equal to the current required at the average supply voltage. As an example, with a raw supply which varies from 9 V to 15 V (an average V_{SUPPLY} of 12 V), a current of approximately 3.8 mA is required. This can be accomplished using a drop resistor, R_{DROP} of 470 Ω. Following this procedure will minimize the Zener's voltage variation.

DESCRIPTION OF INPUTS AND OUTPUTS

Pin	Name	Description
1	+TACH IN	The non-inverting input to the tachometer input comparator.
2	TIMING	The timing pin for the charge pump. A timing capacitor is required.
3	LOAD	The load pin where the output voltage is generated. An RC combination is typically required here.
4	NON-INVERTING	The non-inverting input pin of the output op amp.
5	EMITTER OUT	The emitter of the output drive transistor.
6	NC	No connection.
7	NC	No connection.
8	COLLECTOR OUT	The collector of the output drive transistor.
9	V_Z	The Zener regulator voltage, and the pin through which the part is connected to the supply voltage.
10	INVERTING	The inverting input pin of the output op amp.

11	- TACH IN	The inverting input to the tachometer input comparator.
12	GND	Ground
13	NC	No connection.
14	NC	No connection.

APPLICATIONS

Frequency-to-Voltage Convertor

The basic frequency-to-voltage function of the XR-2917 is illustrated in Figure 2. An input frequency is applied to Pin 1.

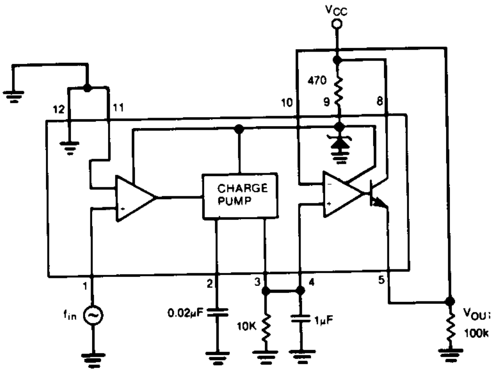


Figure 2. Frequency-to-Voltage Converter

The maximum output voltage is

$$V_{OUT_{MAX}} = R_1 I_3 = (10K)(170\mu A) = 1.7V$$

where $I_3 = 170\,\mu A$ if $V_{CC} = 12$ V, and

$$f_{in_{max}} = \frac{I_2}{C_1 \times V_Z} = \frac{170\mu A}{(0.02\mu F)\times(7.6\ V)} = 1.12\ KHz$$

The ripple voltage is given by

$$V_r = \frac{V_Z}{Z} \times \frac{C_1}{C_2} \times (1 - \frac{V_Z f_{in} C_1}{I_3})pp$$

or

$$V_r = [0.076 \times (1 - f_{in} \times 0.0009)]\,pp$$

Figure 3 shows the relationship of both V_{OUT} and V_r to f_{in}. V_{OUT} and V_r are not of the same scale.

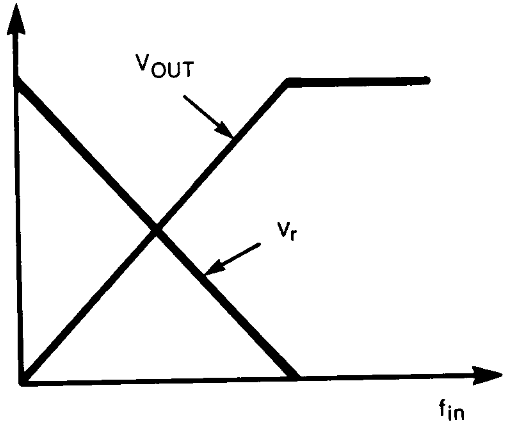


Figure 3. VOUT vs. Vr

A tachometer can be realized by providing the input frequency via a variable reluctance magnetic pick-up. The maximum output voltage and input frequency, and the output ripple voltage may be determined from equations 3 and 5, and equation 4 respectively.

Metering of the output can be performed by sensing current through a current meter in series with the output transistor collector or by taking the voltage off of the emitter.

Separation of the input comparator's inverting input from ground allows the designer to connect a diode to ground to protect the input from transients.

The availability of the output op amp input pins further provides the designer with the opportunity to filter the signal and reduce output ripple.

Speed Switch

Some applications may require a method of determing an overspeed condition for switching purposes. Figure 4 illustrates the basic speed switch configuration. The two 5K ohm resistors from pin 9 to 10 and pin 10 to 11/12 bias the output amplifier a ½ V_Z. When the voltage at pin 4 is greater than ½ V_Z, the output of the amplifier will go high and switch the output transistor into saturation. Once in saturation, current will flow through the load. The output transistor is the "switch."

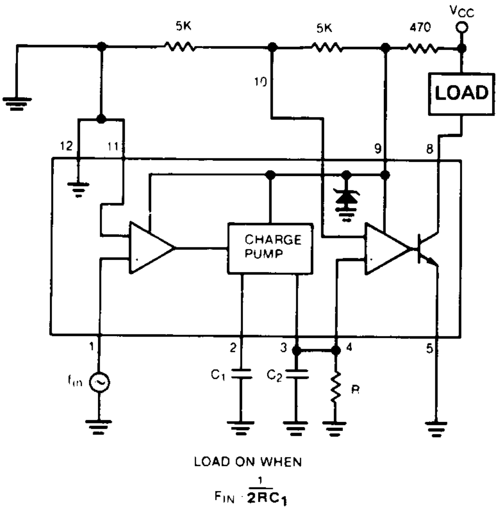


Figure 4. Basic Speed Switch Configuration

From equation 2, it can be shown that the output transistor will switch off when the input frequency (f_{in}) goes below $(2\ RC_2)^{-1}$. This configuration can be adjusted to trip the switch at any fractional frequency of $(RC_2)^{-1}$ by adjusting the voltage divider which is between pins 9 and 10, and pins 10 and 11/12. As an example, to trigger at $(3\ RC_2)^{-1}$, place at 5K ohm resistor between pins 10 and 11/12, and a 10K ohm resistor between pins 9 and 10.

A remote speed switch can be implemented by placing a current sensing resistor between the base and emitter of a transistor. The resistor will be in series with the supply line to the XR-2917, and the load to be switched will be in series with this switch transistor's collector and the supply voltage. When the voltage drop across the resistor equals 700 mV, the transistor will turn on and pull current through the load (see Figure 5).

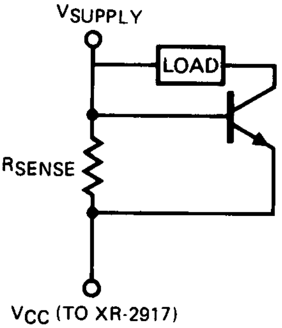


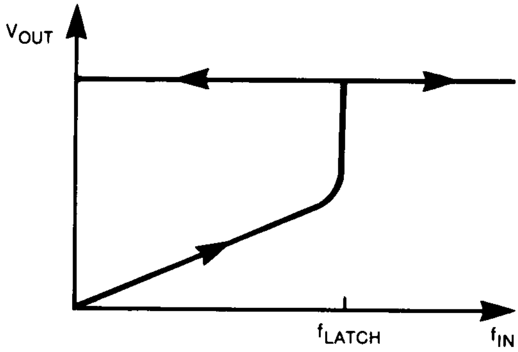
Figure 5. Remote Speed Switch

Since the XR-2917 draws approximately 5 mA as biased with the 470 ohm resistor, and the output transistor can sink about 40 mA, then

$$R_{sense} = \frac{0.7V}{(40+5)mA} = 16\Omega$$

A ¼ watt resistor will suffice, while the transistor should be chosen to pass the required load current. The collector of the output transistor should be connected between the 470 ohm resistor and R_{sense}. The trip voltage is a function of V_Z and is set as before.

An overspeed latch can be realized using a configuration similar to that of Figure 4. The latch requires that the load be voltage controlled, thus be connected between the emitter of the output transistor and ground. Pins 3, 4, and 5 should be tied together thus creating a positive feedback situation which pulls the output, non-inverting input, and load voltages up to the maximum output voltage of the part: this voltage is a function of output transistor current (see Typical Performance Characteristics). The output of the overspeed latch appears in Figure 6.



RESET IS PERFORMED BY REMOVING V_{CC}

Figure 6. V_{OUT} vs. f_{IN}

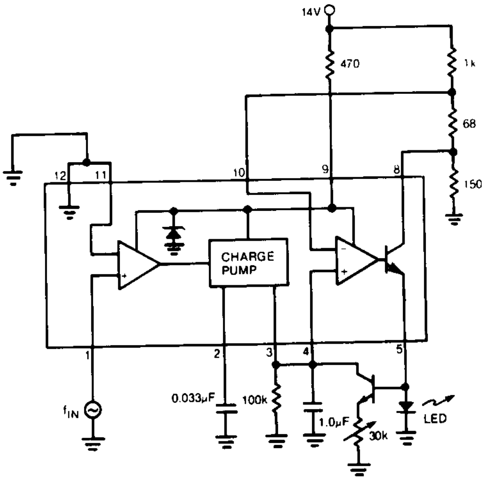
The trip frequency is set as before. If R_1 is the resistor between pins 9 and 10, and R_2 is the resistor between pins 10 and 11/12, then

$$f_{latch} = \left(\frac{R_2}{R_1 + R_2}\right)(RC_1)^{-1}$$

A variation of the overspeed latch is the overspeed indicator of Figure 7. In this case

$$f_{trigger} = \left[\left(\frac{68 + 150}{68 + 150 + IK}\right)(14/7.56)\right]\left[(100K)(.033\mu)\right]^{-1}$$

and the trigger frequency can be adjusted at R and C_2 or by using the voltage divider.



FLASHING BEGINS AT $f_{IN} \geq 100$ Hz AND INCREASES WITH FREQUENCY INCREASES.

Figure 7. Overspeed Indicator

When the voltage at pin 4 exceeds that set by the divider off pin 10, the LED turns on. The transistor whose base is connected to the anode of the LED will turn on and discharge the capacitor at pin 4 and turn off the LED.

A delay switch can be implemented by removing resistor R from pins 3/4 inFigure 4. Choosing C_2 such that

$$C_2 = 2\,n\,C_1$$

Current will not flow through the load until n consecutive input cycles have occured.

Capacitance Meter

Figure 8 is a capacitance meter. The range of the meter can be adjusted by adjusting R_1 in the equation

$$C_X = (2.2 \times 10^{-3})\ (V_{OUT}/R_1)$$

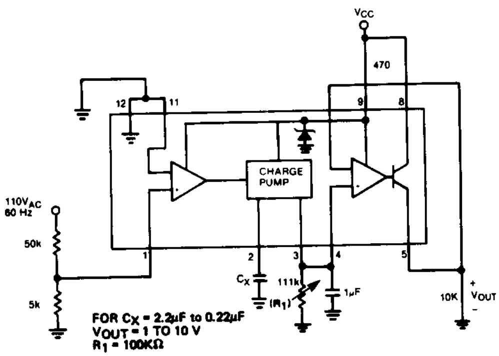


Figure 8. Capacitance Meter

Hysteresis

Figure 9 illustrates one method of providing hysteresis. The magnitude of hysteresis is given by

$$\left(\frac{2K}{2K + 195K}\right) V_{REF}$$

or

$$V_{HYSTERESIS} = 0.01\ V_{REF}$$

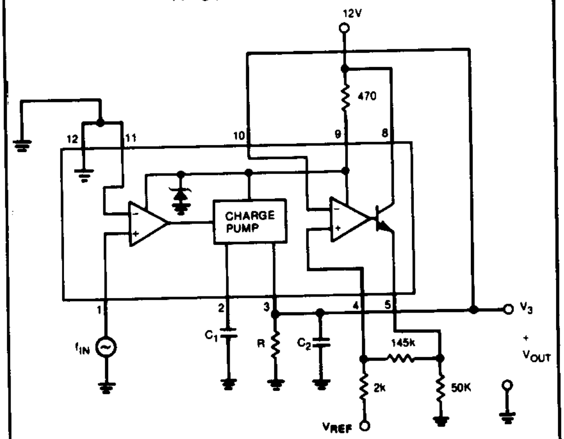


Figure 9. Hysteresis

Shifting Response of Output Voltage

Figure 10 illustrates a simple method of shifting the output voltage up by a constant value, V_{SHIFT}. The output voltage for this circuit is given by

$$V_{OUT} = (V_Z \times f_{in} \times R_1 \times C_1) + V_{SHIFT}$$

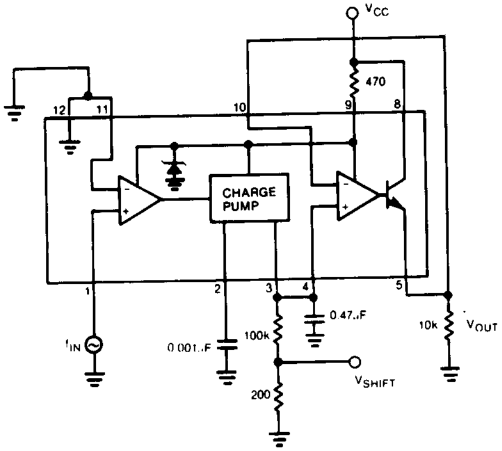


Figure 10. Shifting Output Voltage

A method of delaying the output response to the input frequency is shown in Figure 11. There will be no change in the output voltage until

$$f_{in} = (V_Z \times R_1 \times C_1)^{-1}$$

At this point, equation 2 is valid.. Using the voltage divider between pins 8 and 5, and 5 and ground, one may change the level at which the output voltage will begin to react.

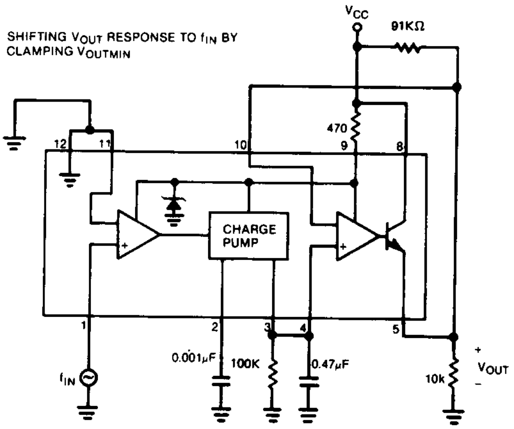


Figure 11. Delaying V_{OUT} Response to f_{in}

This circuit will not react until

$$f_{in} = \left(\frac{V_{CC}}{10}\right)(V_Z \times R_1 \times C_1)^{-1}$$

EXAR

XR-1488/1489A

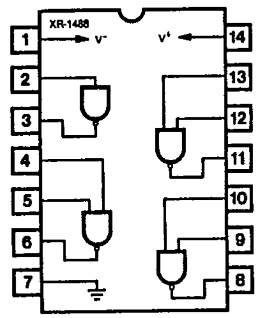
Quad Line Driver/Receiver

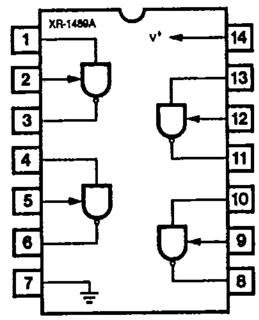
GENERAL DESCRIPTION

The XR-1488 is a monolithic quad line driver designed to interface data terminal equipment with data communications equipment in conformance with the specifications of EIA Standard No. RS232C. This extremely versatile integrated circuit can be used to perform a wide range of applications. Features such as output current limiting, independent positive and negative power supply driving elements, and compatibility with all DTL and TTL logic families greatly enhance the versatility of the circuit.

The XR-1489A is a monolithic quad line receiver designed to interface data terminal equipment with data communications equipment. the XR-1489A quad receiver along with its companion circuit, the XR-1488 quad driver, provide a complete interface system between DTL or TTL logic levels and the RS232C defined voltage and impedance levels.

FUNCTIONAL BLOCK DIAGRAMS





ABSOLUTE MAXIMUM RATINGS

Power Supply	
XR-1488	±15 Vdc
XR-1489A	+10 Vdc
Power Dissipation	
Ceramic Package	1000 mW
Derate above +25°C	6.7 mW/°C
Plastic Package	650 mW/°C
Derate above +25°C	5 mW/°C

ORDERING INFORMATION

Part Number	Package	Operating Temperature
XR-1488N	Ceramic	0°C to +70°C
XR-1488P	Plastic	0°C to +70°C
XR-1489AN	Ceramic	0°C to +70°C
XR-1489AP	Plastic	0°C to +70°C

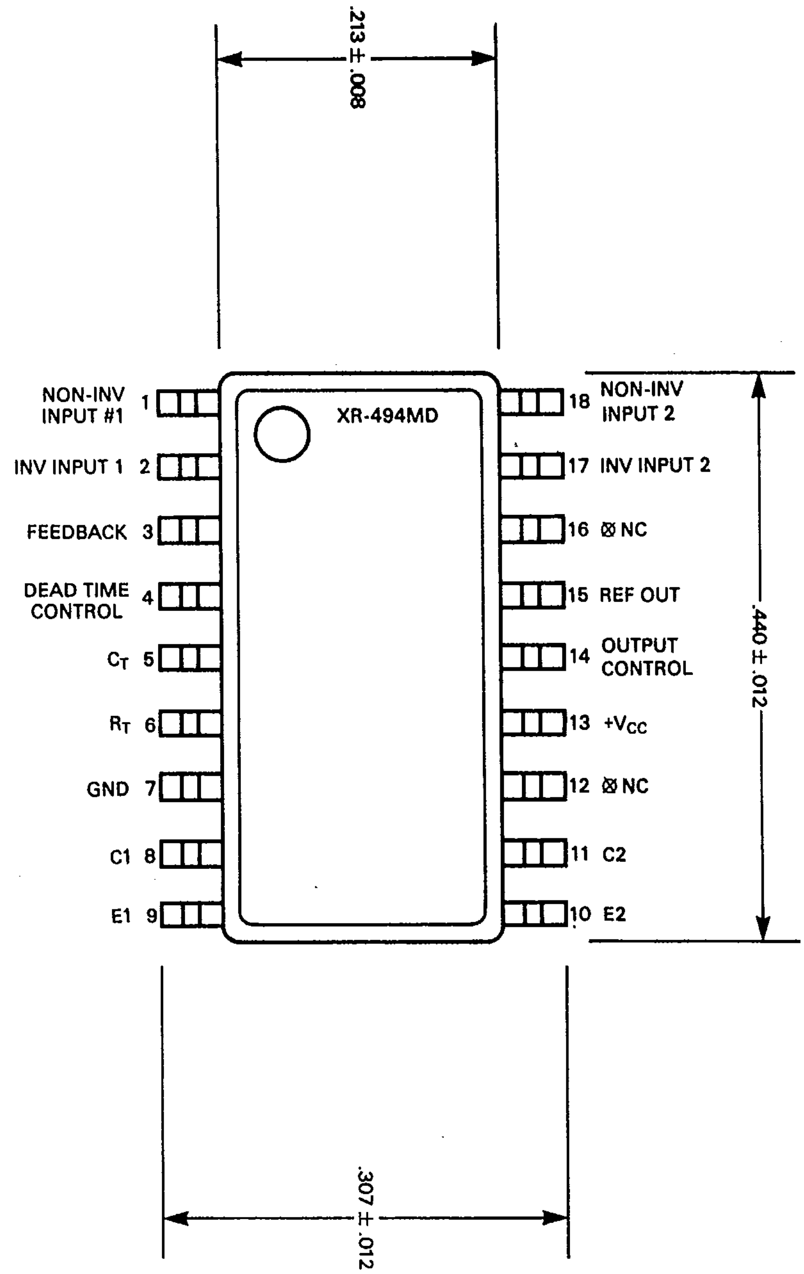
SYSTEM DESCRIPTION

The XR-1488 and XR-1489A are a matched set of quad line drivers and line receivers designed for interfacing between TTL/DTL and RS232C data communication lines.

The XR-1488 contains four independent split supply line drivers, each with a ±10 mA current limited output. For RS232C applications, the slew rate can be reduced to the 30 V/μS limit by shunting the output to ground with a 410 pF capacitor. The XR-1489A contains four independent line receivers, designed for interfacing RS232C to TTL/DTL. Each receiver features independently programmable switching thresholds with hysteresis, and input protection to ±30 V. The output can typically source 3 mA and sink 20 mA.

T-58-11-31

XR-494



EXAR

XR-1468/1568

Dual-Polarity Tracking Voltage Regulator

GENERAL DESCRIPTION

The XR-1468/1568 is a dual polarity tracking voltage regulator, internally trimmed for symmetrical positive and negative 15V outputs. Current output capability is 100 mA, and may be increased by adding external pass transistors. The device is intended for local "on-card" regulation, which eliminates the distribution problems associated with single point regulation.

The XR-1468CN and XR-1568N are guaranteed over the 0°C to 70°C commercial temperature range. The XR-1568M is rated over the full military temperature range of −55°C to +125°C.

FEATURES

Internally Set for ±15V Outputs
±100 mA Peak Output Current
Output Voltages Balanced Within 1% (XR-1568)
0.06% Line and Load Regulation
Low Stand-By Current
Output Externally Adjustable from ±8 to ±20 Volts
Externally Adjustable Current Limiting
Remote Sensing

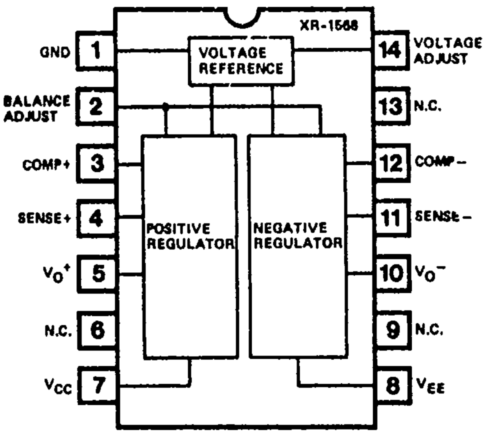
APPLICATIONS

Main Regulation in Small Instruments
On-Card Regulation in Analog and Digital Systems
Point-of-Load Precision Regulation

ABSOLUTE MAXIMUM RATINGS

Power Supply	±30 Volts
Minimum Short-Circuit Resistance	4.0 Ohms
Load Current, Peak	±100 mA
Power Dissipation	
Ceramic (N) Package	1.0 Watt
Derate Above +25°C	6.7 mW/°C
Operating Temperature	
XR-1568M	−55°C to +125°C
XR-1568/XR-1468C	0°C to +70°C
Storage Temperature	−65°C to +150°C

FUNCTIONAL BLOCK DIAGRAM



ORDERING INFORMATION

Part Number	Temperature	Output Offset	Package
XR-1568M	−55°C to +125°C	±150 mV max	Ceramic
XR-1568N	0°C to +70°C	±150 mV max	Ceramic
XR-1468CN	0°C to +70°C	±300 mV max	Ceramic

SYSTEM DESCRIPTION

The XR-1468/1568 is a dual polarity tracking voltage regulator combining two separate regulators with a common reference element in a single monolithic circuit, thus providing a very close balance between the positive and negative output voltages. Outputs are internally set to ±15 Volts but can be externally adjusted between ±8.0 to ±20 Volts with a single control. The circuit features ±100 mA output current, with externally adjustable current limiting, and provision for remote voltage sensing.