

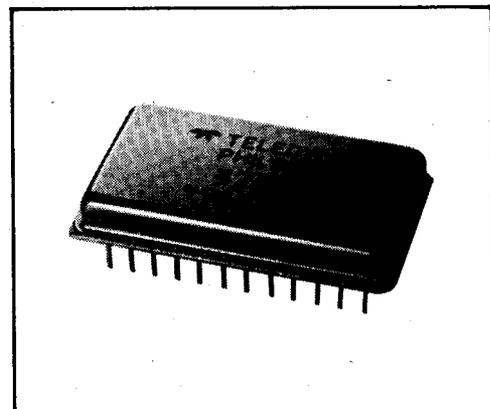
10kHz, 100kHz Precision, High Reliability Frequency to Voltage Converters

The 4732 and 4734 are precision, high reliability frequency to voltage converters that provide an output voltage whose magnitude is linearly proportional to input frequency, regardless of waveshape. Designed for versatility and high performance, these devices guarantee $\pm 0.005\%$ FS nonlinearity, $\pm 0.05\%$ FS initial zero offset, and a specified -25°C to $+85^{\circ}\text{C}$ temperature range. Other features include low full scale and zero offset drifts, thirty percent overrange, and full scale offsetting for bipolar output ranges. Housed in standard 24 pin dual-in-line packages, the 4732 and 4734 are also available with guaranteed performance over the -55°C to $+125^{\circ}\text{C}$ temperature range and fully screened to the high reliability requirements of MIL-STD-883, Method 5008 (add "-83" to part number, Table 2).

Superior specifications, high reliability, and dual-in-line packaging allow the 4732 and 4734 to be used in a wide variety of demanding applications. By monitoring pulsed outputs of motors or flow meters, these devices can be used to measure and adjust motor speed or liquid flow in adverse environments. When used in conjunction with the 4731 and 4733 V/F's, they form the basis of a high performance, low cost fiber optic data link, magnetic tape recording system, or FM telemetry system.

The basic design of the 4732 and 4734 permits the user to select both input and output ranges independently of each other. Input/output signal conditioning of these devices includes adjustment of threshold hysteresis for small peak-to-peak input signals, input signal offsetting for operation with small AC signals impressed on a DC common mode voltage, as well as bipolar output and output scale expansion. These techniques allow the 4732 and 4734 to accept frequencies up to 300kHz while independently adjusting the output for a wide variety of voltage ranges determined by external circuitry.

4732 4734



FEATURES

- $\pm 0.005\%$ FS Max Nonlinearity
- Low Full Scale and Zero Offset Drifts
- High Noise Immunity
- Optional Screening to MIL-STD-883

APPLICATIONS

- RPM, Flow and Frequency Measurements
- FM Demodulation
- FM Telemetry
- Fiber Optic Data Link
- Magnetic Tape Recording
- Multi Decade Range Phase Locked Loops

Each specification is for +25°C, $V_{CC} = \pm 15$ V unless otherwise indicated.

	TYPICAL	GUARANTEED
FULL SCALE (FS)		
Ideal Transfer Function	---	$V_{out} = \frac{10 V \cdot F_{in}}{F_a}$
Full Scale Output, Pin 11 connected to Pin 10 ①	---	$F_a = 10$ kHz (4732)/100 kHz (4734)
Full Scale Adjust Output, Pin 12 connected to Pin 10 ①	---	+10.00 V $\pm 0.1\%$
Full Scale Frequency Range (4732)	0 to 13 kHz	+9.9 $\pm 0.5\%$
Full Scale Frequency Range (4734)	0 to 130 kHz	10 Hz to 11 kHz
		100 Hz to 110 kHz
NONLINEARITY, $\pm\%$FS		
10 Hz to 11 kHz, 4732 ③ ④	.001	.005
100 Hz to 110 kHz, 4734 ③ ④	.002	.005
OUTPUT		
Initial Offset Voltage, $F_{in} = 0$ (trimmable to zero)	1 mV	5 mV
Voltage/Current (volts/mA)	$\pm 12/+20, -2$	$\pm 10/+20, -2$
Ripple at 10 Hz/1 kHz/10 kHz (4732) mVp.p	10/125/140	20/200/200
Ripple at 100 Hz/10 kHz/100 kHz (4734) mVp.p	10/125/75	20/250/100
Offset Scale Factor, $\pm 25\%$	---	10 μ A/V
Impedance (op amp output)	<0.05 Ω	---
Response, internal filler constant (4732/4734)	(560 μ s/56 μ s)	---
Step Response Time to 0.5% FS with 500 Ω load (ms)		
0 Hz to 10 kHz/0 Hz to 100 kHz (4732/4734)	5/0.3	---
10 kHz to 2 kHz/100 kHz to 20 kHz (4732/4734)	5/0.3	---
10 kHz to 0 Hz/100 kHz to 0 Hz (4732/4734)	20/1.4	---
INPUT at F_{in} PIN (See Figure 4).		
Threshold, positive going pulses ③	+1.4 V ± 200 mV	+1.4 V ± 800 mV
Threshold, external set range max	---	+12 V to -12 V
Hysteresis	400 mV	400 mV ± 100 mV
Hysteresis, external set range	0 to 400 mV	---
Levels, TTL compatible (low/high, volts)	---	-12 to +.8/+2 to +12
Waveform	Any	---
Resistance (4732/4734)	4.0/300 M Ω	1.5/40 M Ω
Pulse Width, minimum (4732/4734) μ s (+2.0 V Pulse)	2/0.5	4/1
STABILITY of FULL SCALE FACTOR (FS)		
Temperature Coefficient \pm PPM/ $^{\circ}$ C	Hot Cold	Hot Cold
4732, 4734 ③	15 15	25 25
4732, 4734 ④	25 25	50 50
Warm Up Time to .01% of FS	3 s	---
Power Supply Sensitivity \pm PPM/ $\% \Delta V_{CC}$	4	20
Drift: per day/per week	20 μ V/60 μ V	---
STABILITY of ZERO OFFSET VOLTAGE		
Temperature Coefficient, $\pm \mu$ V/ $^{\circ}$ C ③	Hot Cold	Hot Cold
4732, 4734 ③	5 5	25 25
4732, 4734 ④	50 10	150 50
Power Supply Sensitivity $\pm \mu$ V/ $\% \Delta V_{CC}$	2	10
POWER REQUIREMENT		
Voltage Range ($\pm V_{CC}$)	---	± 12 V to ± 18 V
Current ($\pm I_{CC}$)@ $V_{CC} = \pm 15$ V	± 18 mA	± 25 mA
ENVIRONMENT/RELIABILITY		
Operating Temperature	---	-25 $^{\circ}$ C to +85 $^{\circ}$ C
4732-83/4734-83	---	-55 $^{\circ}$ C to +125 $^{\circ}$ C
Storage Temperature	---	-65 $^{\circ}$ C to +150 $^{\circ}$ C
ABSOLUTE MAX RATINGS		
Frequency Input Voltage (Pin 24) ③	---	± 15 V
Differential Input Voltage (Pin 24 to Pin 23)	---	± 12 V
Ref Input Voltage (Pin 23)	---	± 12 V
Power Supply Voltage	---	± 22 V
Soldering to pins at 1.6 mm (.06 inch) from body	---	260 $^{\circ}$ C for 10 s
WEIGHT	11.2 grams	---

- ① Measurement made without trimming offset error
 ② Over -55 $^{\circ}$ C to +125 $^{\circ}$ C, Hot (+25 $^{\circ}$ C to +125 $^{\circ}$ C) and Cold (-55 $^{\circ}$ C to +25 $^{\circ}$ C)
 ③ Over ± 12 V to ± 18 V power supply range
 ④ The input comparator is preset to operate with TTL pulses
 ⑤ At Full Scale, 10 μ V/ $^{\circ}$ C is an equivalent error of 1 ppm/ $^{\circ}$ C
 ⑥ Over -25 $^{\circ}$ C to +85 $^{\circ}$ C, Hot (+25 $^{\circ}$ C to +85 $^{\circ}$ C) and Cold (-25 $^{\circ}$ C to +25 $^{\circ}$ C)
 ⑦ For supplies less than ± 15 V, the absolute max voltage is equal to the supply voltage

THEORY OF OPERATION

The F to V converter is an example of a sophisticated design concept reduced to a low cost BUT reliable device. The input circuit is a comparator (A₁) whose output switches between +1 V and -14 V each time the polarity of the voltage between the F_{in} pin and the Ref In pin reverses. Two consecutive reversals represent one cycle or pulse of frequency.

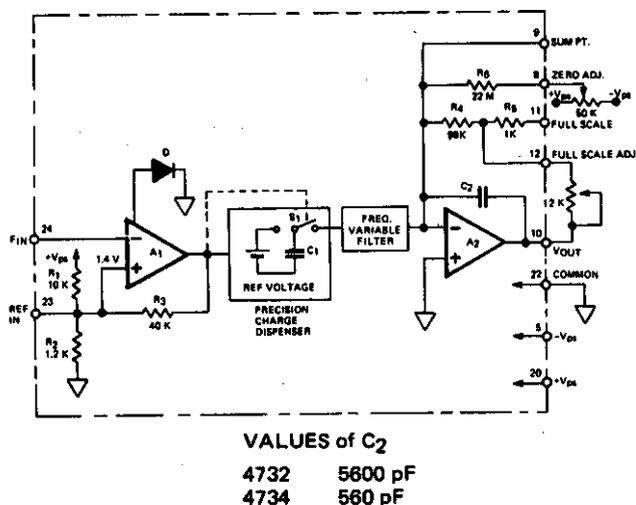


Figure 1. F to V Simplified Block Diagram

Each pair of reversals causes solid state switch S₁, in the Precision Charge Dispenser, to alternately connect C₁ to the precision reference voltage and the summing point of op amp A₂ through a frequency variable filter. See Figure 1. Each time C₁ is connected to the Reference, a fixed amount of charge Q is dumped into C₁ according to the basic equation $Q = CV$.

When connected to the summing point of A₂, C₁ is discharged. The greater the frequency, the greater the average current (I_{in}) is that goes into the summing point of A₂. A₂ is a current to voltage converter, where $V_{out} = -I_{in}R_f$. Thus V_{out} is a function of the discharge current of C₁ and the frequency of discharge. C₂ further filters these current pulses to minimize ripple.

Full Scale Factor is set with R_f, and the output is offset by current into the summing point.

Input Circuit

The threshold level, at which comparator A₁ switches, is set at the Ref In pin by resistors R₁, R₂, and R₃. It is made more positive by shunting R₁ to a positive voltage such as +V_{ps} and more negative by connecting a resistor between Ref In and a negative voltage. The hysteresis is lowered from 400 mV by connecting Ref Input to Common via another resistor.

OPERATION

How to Use the 4732/4734

When used as shown in Figure 2, the factory trimmed 4732/4734 operates as specified without additional components. Pin 12, the Full Scale Adj. and Pin 11, the Full Scale are both outputs.

Pin 11 can be used when accuracy to $\pm 0.1\%$ F.S. is needed with no external components. Pin 12 is usually used when greater accuracy is required using an external trim, see Figure 3. (Note: R₁ and R₂ should have low value temperature coefficients.)

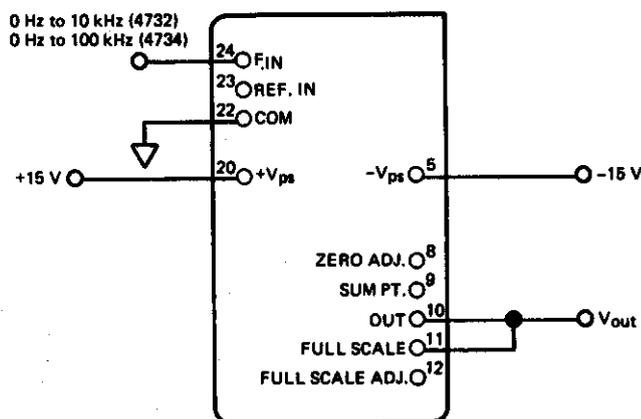


Figure 2. Basic Operational Connections

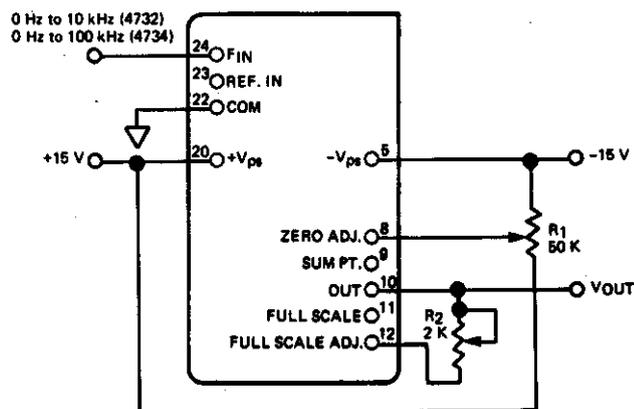


Figure 3. Zero and Full Scale Trim

Trim Procedure, 4732/4734

1. Connect F_{in} pin to Common and adjust R₁ to provide 0.0000 V at V_{out}, see Figure 3.
2. Connect F_{in} to a frequency source set at 10.0000 kHz for 4732 or 100.0000 kHz for 4734. Adjust R₂ to provide 10.0000 at V_{out}.
3. Repeat (1) and (2) precise zero and Full Scale set.

Full Scale Factor Change

The Full Scale Factor of the F to V may be set to provide +10 V_{out} for any F_{in} between 1% and 200% of Full Scale by connecting a resistor, R_f, between the Summing Point pin and V_{out} pin, see Figure 4.

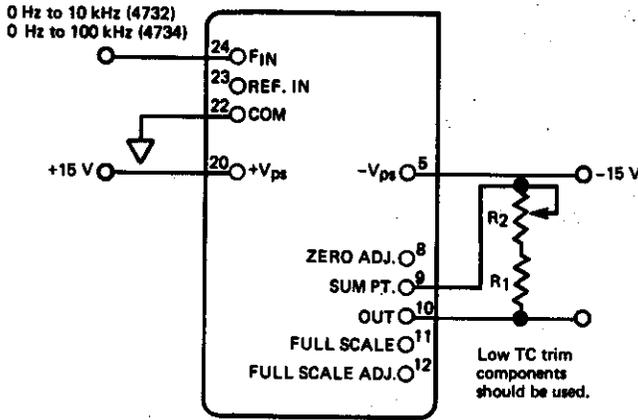


Figure 4. Full Scale Factor Set

$$R_f = R_1 + R_2 = \frac{10^9 \text{ (4732)}}{10^{10} \text{ (4734)}} \times \text{Desired Full Scale } F_{in} \text{ (in Hz)}$$

Input Signal Conditioning

The F to V frequency input circuit is a comparator, the threshold of which is set at +1.4 V (with approximately 400 mV of hysteresis) to provide maximum noise immunity when operating with TTL type levels. It is suitable for operation with signals of any waveshape which pass through this threshold in alternate directions, for example, a 0 to 2 V peak square wave or a ±5 V p-p sine wave. (Each alternate threshold crossing is recognized by the F to V as a cycle or pulse of frequency.) The preset threshold is altered for larger or smaller signals by changing the voltage at the Ref In pin. (See Figure 1.) Ref In should not exceed 12 V, otherwise internal damage will occur.

Operation with CMOS Logic

To obtain the maximum noise immunity of which a particular logic type is capable, the threshold should be set approximately halfway between the upper and lower logic levels. Figure 5 shows a 2.0 kΩ, 5% resistor connected between Ref In and +15 V to provide a threshold of +6 V (a typical CMOS level). Zero and Full Scale trim techniques remain unchanged.

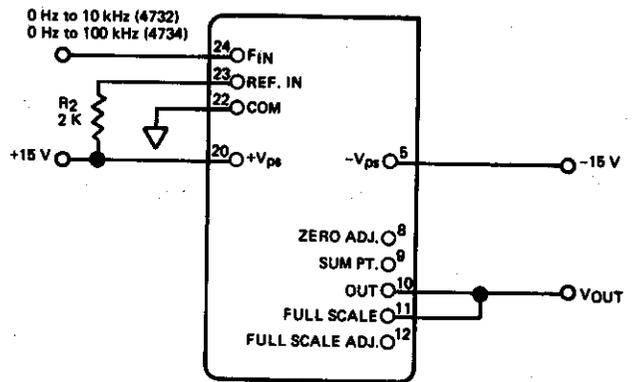


Figure 5. Input Conditioned For Typical CMOS

Operation with Signals Less Than +2 V Peak

Connect a 11 kΩ, 5% resistor between Ref In and -15 V. This will set the threshold at zero Volts with hysteresis of approximately 340 mV. Thus an input signal is any alternate pair of level shifts exceeding 340 mV.

For input signals less than 500 mV, connect a 200 Ω resistor between the Ref In and Common. This will lower the hysteresis (and noise immunity) to 60 mV (see Figure 6).

A 100 Ω resistor will provide 30 mV of hysteresis which is the minimum recommended value. When operating in this mode the F to V input is a zero crossing detector.

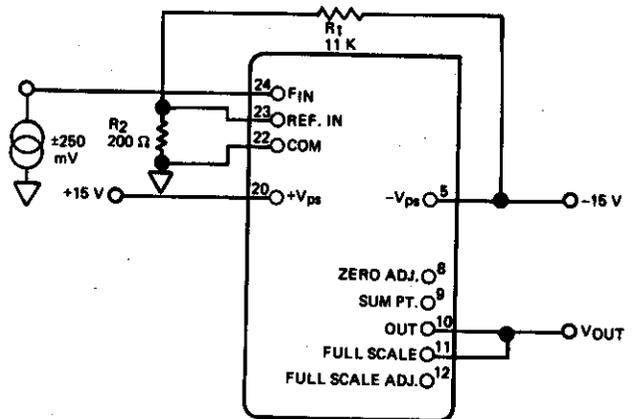


Figure 6. Input Conditioned to Provide Threshold of Zero Volts with 60 mV Hysteresis

Operation with AC Signals with DC Offset

When the F_{in} signal is small and impressed on a DC level of common mode voltage (e.g., +9 V DC ±500 mV AC), it should be capacitively coupled to the F_{in} pin as shown in Figure 7. If the DC voltage is large (100 V DC ±1 V signal), the input should be additionally protected against transients with diodes as in Figure 8.

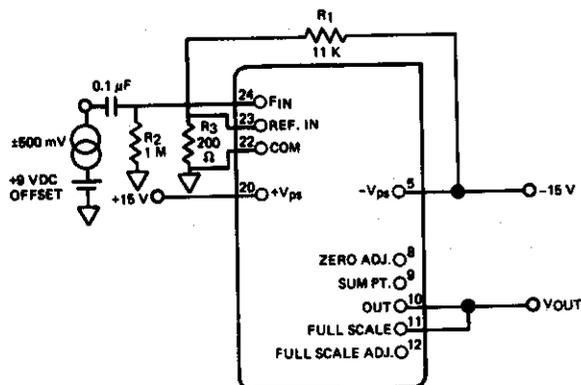


Figure 7. Input Conditioned for Small AC Signal with DC Offset

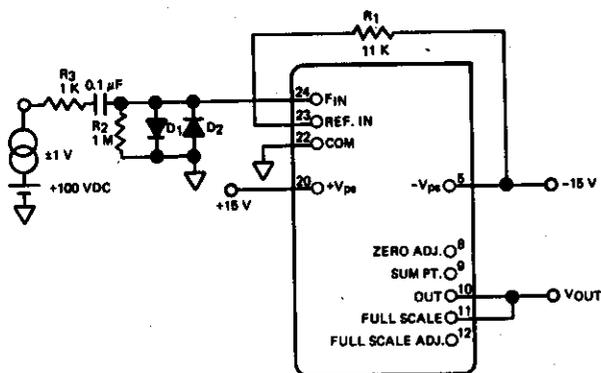


Figure 8. Input Conditioned for Small AC Signal Impressed on Large DC Voltage

Signals greater than $\pm V_{ps}$ peak to peak may be treated in a similar manner or attenuated with a simple resistive divider and the threshold level set by the technique of Figure 5 and 6.

Output Signal Conditioning

The output of the F to V can be conditioned to provide +10 V_{out} for any maximum F_{in} from 1% to 200% of Full Scale (see Figure 4). In addition, V_{out} can be offset (that is, zero volts out for a particular F_{in}) to provide Scale Expansion and/or bipolar output voltages.

Output Offsetting

Many F to V applications measure a range of frequencies that do not include zero, but require zero volts out for a minimum F_{in} . For example, the pulse train from a tachometer in a motor speed control circuit might be 5000 to 10,000 (4732) pulses per second providing +5 V to +10 V from the F to V.

To obtain 0 to +5 V, V_{out} must be Offset 5 V negative by injecting a current of +10 μA into the Summing Point pin for each volt of negative offset required (Figure 9).

10 $\mu A/V$ ($\pm 25\%$) is the Offsetting Scale Factor. It may be developed as shown in Figure 9 by connecting R_{offset} between the Summing Point pin and + V_{ps} per the equation:

$$R_{offset} = \frac{V_{ps}}{(V_{offset}) (Offset Scale Factor)}$$

$$= \frac{15}{5 \times 10 \times 10^{-6}} = 300 \text{ k}\Omega$$

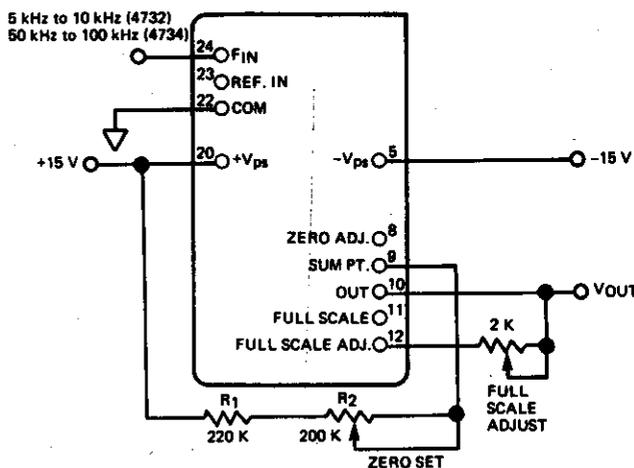


Figure 9. Output Offset of -5 V to Provide 0 to +5 V for 5 kHz to 10 kHz F_{in}

Bipolar Output

If an output voltage of -2.5 V to +2.5 V is required for 5 kHz to 10 kHz (4732) F_{in} , the output may be offset a total of -7.5 V by driving additional + current into the Summing Point pin.

Scale Expansion and Output Offset

If the application required 0 to +10 V_{out} for a reduced range of input frequencies such as 5 kHz to 10 kHz input, the Full Scale Factor must be expanded by adding external resistor R_f between the Summing Point pin and the output.

R_f (in Ohms) = $G \times 100,000$, where G is the Gain of the F to V.

$$G = \frac{\Delta V_{out} \text{ (Volts)}}{\Delta F_{in} \text{ (kHz)}}$$

In the equation $\Delta V_{out} = 10 \text{ V} - 0 \text{ V} = 10 \text{ V}$, and $\Delta F_{in} = 10 \text{ kHz} - 5 \text{ kHz} = 5 \text{ kHz}$; therefore, $G = 10/5 = 2$, and $R_f = 2 \times 100,000 = 200 \text{ k}\Omega$ ($\pm 25\%$).

The transfer function (output voltage for a given input frequency) has also been multiplied by G , and the Offset Scale Factor must be divided by G .

For $G = 2$, a 5 kHz input provides +10 V_{out}, and a 10 kHz input demands +20 V_{out}.

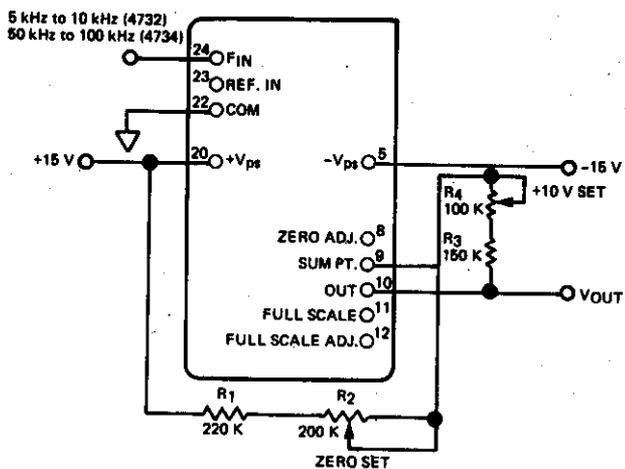


Figure 10. Output Offset and Expansion to Provide 0 to +10 V Output for 5 kHz to 10 kHz F_{in}

The output must now be offset -10 V (from +10 V to 0) by driving +5 $\mu\text{A/V}$ ($1/2$ of 10 $\mu\text{A/V}$) into the Summing Point pin (Figure 10).

$$R_{\text{offset}} = \frac{V_{ps}}{(V_{\text{offset}})(\text{Offset Scale Factor}/G)}$$

$$= \frac{15}{10 \times (10 \times 10^{-6})/2} = 300 \text{ k}\Omega$$

Scale Expansion and Bipolar Output

If an output voltage of -5 V to +5 V is required for 5 kHz to 10 kHz input, the output is offset a total of -15 V (from +10 to -5) with additional current into the Summing Point pin.

A final example, Figure 11, shows the scale expanded and offset to provide an output of -10 V to +10 V for an input of 5 kHz to 10 kHz (4732).

From the equations above:

$$\Delta V_{\text{out}} = 10 \text{ V} - (-10 \text{ V}) = 20 \text{ V}$$

$$\Delta F_{\text{in}} = 10 \text{ kHz} - 5 \text{ kHz} @ 5 \text{ kHz}$$

$$G = \frac{\Delta V_{\text{out}}}{\Delta F_{\text{in}}} = \frac{20}{5} = 4$$

$$R_f = G \times 100,000 = 4 \times 100,000 = 400 \text{ k}\Omega$$

For $G = 4$, a 5 kHz_{in} will demand a 20 V_{out}. Therefore, total offset required is 20 V - (-10 V) = 30 V in the negative direction.

$$R_{\text{offset}} = \frac{V_{ps}}{(V_{\text{offset}})(\text{Offset Scale Factor}/G)}$$

$$= \frac{15 \text{ V}}{30 \text{ V} \times (10 \times 10^{-6})/4} = 200 \text{ k}\Omega$$

Figure 12 compares these three different output voltage ranges for 0 kHz to 10 kHz (4732) and 0 kHz to 100 kHz (4734) F_{in} with the basic connections of Figure 3.

F_{in}		$V_{out}(\text{Volts})$			
4732	4734	Fig. 3	Fig. 9	Fig. 10	Fig. 11
0	0	0	-5	-10	NA
5 kHz	50 kHz	+5	0	0	-10
10 kHz	100 kHz	+10	+5	+10	+10

Figure 12. Output Circuit Conditioning

Output Ripple Filtering and Response Time

By definition, the F to V is converting an AC signal to a DC level. Therefore, there must be ripple on the output. This ripple is filtered by a frequency variable filter and by an internal RC network consisting of R_f and a capacitor (C_2 in Figure 1). Additional filtering is obtained by the addition of an external capacitor between the Summing Point pin and the output. Typical curves of ripple vs. F_{in} capacity are shown in Figure 13.

The Response Time of the F to V (how fast the output voltage changes for a step change in the input frequency) is the RC time constant of the ripple filter. Thus if an external capacitor is used, the response time is increased. If faster response with reduced ripple is required, a higher frequency F to V should be used or a multi-pole sharp cutoff Low Pass Filter should follow the R to V.

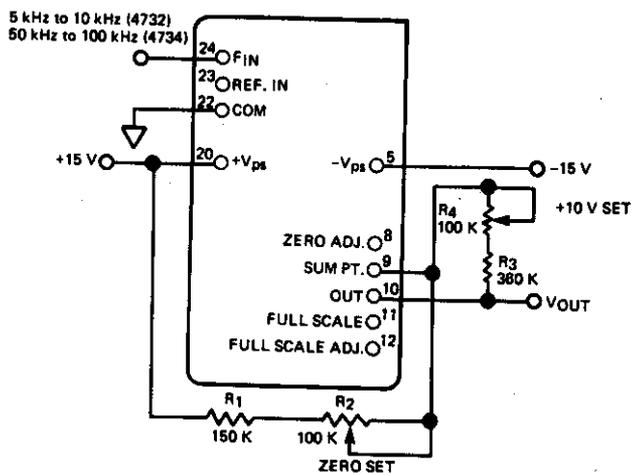


Figure 11. Bipolar Output and Expanded Scale

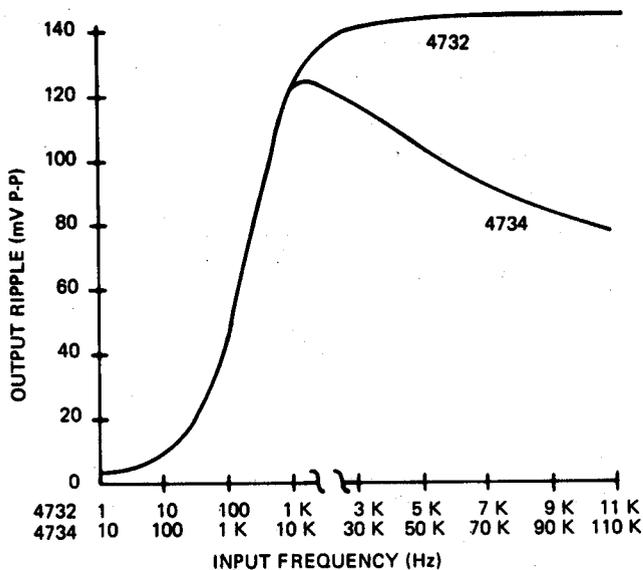
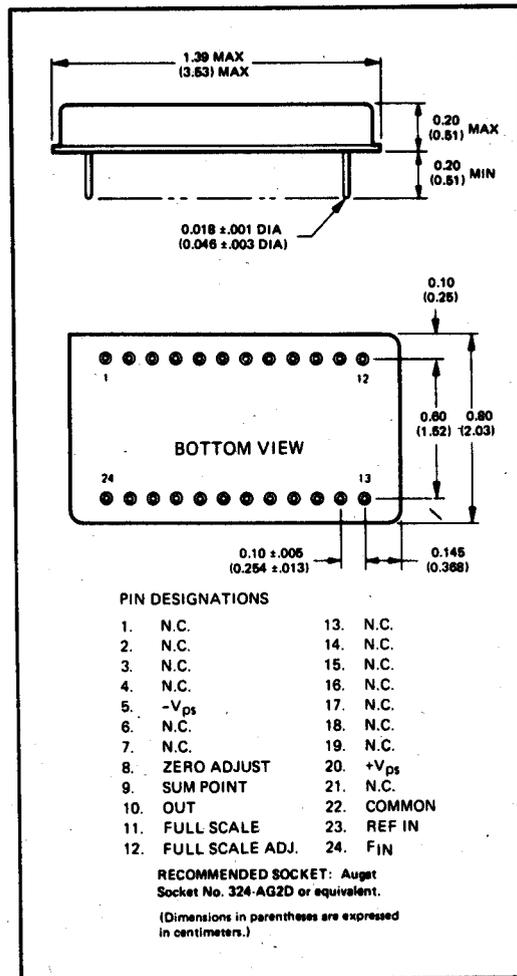


Figure 13. Output Ripple vs. Frequency



SCREENING ACCORDING TO MIL-STD-883 METHOD 5008

TEST	METHODS AND CONDITIONS	PURPOSE
*Internal Visual	Method 2017	Removes potentially defective units with respect to materials, construction, and workmanship
*Stabilization Bake	Method 1008, Condition C 24 hours at 150 °C	Stabilizes circuit components, with a preconditioning treatment, prior to conducting further testing and trimming
*Constant Acceleration	Method 2001, Condition A Y ₁ Axis, 5,000 g	Removes potential failures due to weak wire or chip bonding
*Seal, Fine and Gross	Method 1014, Fine Leak Condition A & C Bomb time 1 hr. at 30 psi; Leak Rate <5 X 10 ⁻⁷ cc/s; Gross Leak, Condition C ₁ , no bubbles	Verifies Integrity of hermetic package
Burn In	Method 1015 Condition B 160 hours at 125 °C	Reduces infant mortality rate
Temperature Cycling	Method 1010, Condition B 10 cycles from -55 °C $\begin{matrix} +0^{\circ}\text{C} \\ -5^{\circ}\text{C} \end{matrix}$ to +125 °C $\begin{matrix} +3^{\circ}\text{C} \\ -0^{\circ}\text{C} \end{matrix}$	Removes potential failures due to weak wire or chip bonding
*External Visual	Method 2009	Removes defective units with respect to materials, construction, and workmanship

*These tests are for both standard and "-83" models 4732 and 4734 Screening Program to MIL-STD-883