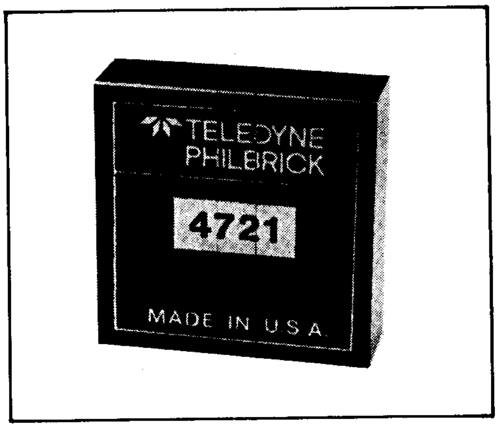
TELEDYNE PHILBRICK

10kHz Precision, Low Drift Voltage to Frequency Converters

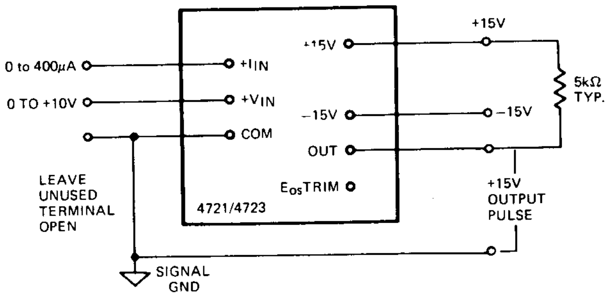
4721 4723



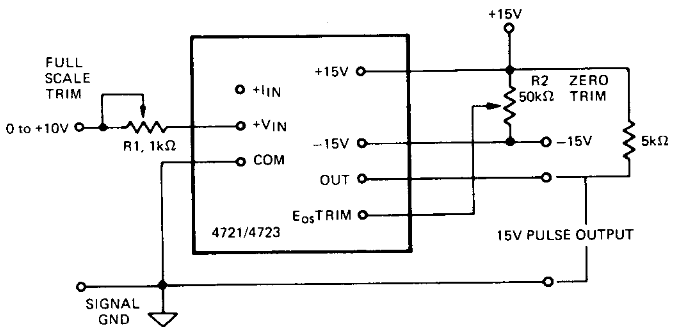
The 4721 and 4723 are precision, low cost voltage to frequency converters that provide a 10Hz to 10kHz output pulse train from a +10mV to +10V input signal. Thirty percent overrange, pre-trimmed drift and accuracy errors and the versatility of both current and voltage inputs make the 4721 and 4723 ideal for most applications requiring no external components. As current to frequency devices, the 4721 and 4723 resolve currents as low as 250pA, allowing operation with full scale voltages from less than 250mV to greater than 100V.

Applications include low cost pulse generators, motor speed controls, A to D converters, DPM's, digital to frequency converters, and infinite hold time integrators. When operating with the TP4722 F/V, the 4723 provides ±0.1% two-wire or fiber optic analog data transmission for less than the cost of a 100mA power supply.

For applications requiring higher linearity and/or better full scale temperature coefficient, you should investigate the advantages of Teledyne Philbrick's Model 4715 V/F series (linearities to ±0.005%FS and full scale TC to ±30ppm of FS/°C).



Input Signals



Zero & Full Scale Trim for Positive Input Voltages

FEATURES

- ±0.005%FS Nonlinearity
- Pre-trimmed Zero & Full Scale
- ±50ppm of FS/°C Max Full Scale Drift
- Current & Voltage Inputs
- No External Components Required
- Low Cost

APPLICATIONS

- No Drift Integrate/Hold
- High Common Mode Voltage Isolation
- Digital Transmission
- Synchronous Speed Control
- Wide Range Phase Locked Loops

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SPECIFICATIONS At 25°C, $\pm V_{CC}$ = ±15 V, unless otherwise indicated

	TYPICAL	GUARANTEED
FULL SCALE (FS)		
Ideal Transfer Function	---	$f_{out} = \frac{(V_{in})(10\,kHz)}{10\,V} = \frac{(I_{in})(10\,kHz)}{(+400\,\mu A)}$
Full Scale Factor (Input for 10 kHz Out)		
$+V_{in}$ (factory trimmed)	---	9.9 V ±0.5% trimmable to 10.00 V
$+I_{in}$	---	400 μA ± 100 μA
Range (for specified nonlinearity) ①		
$+V_{in}$ Terminal	---	+10 mV to +11 V
$+I_{in}$ Terminal	---	+400 nA to +400 μA (± 25%)
Overrange, max., $+V_{in}$	$+V_{in}$ = 13 V, f_{out} = 13 kHz	$+V_{in}$ = +12 V, f_{out} = 12 kHz
Dynamic Range ②	80 dB	---
NONLINEARITY ±% FS ①		
$+V_{in}$ (+10 mV to +11 V) @ 25°C		
4721	0.005	0.2
4723	0.005	0.015
$+V_{in}$ (+10 mV to +11 V) 0 to 70°C)	0.015	---
$+V_{in}$ (+10 mV to +12 V) 0 to +70°C	1% FS	---
INPUT		
Zero Offset Voltage, Initial Untrimmed	±5 mV	±15 mV
Impedance @ $+V_{in}$	---	26K ± 25%
Impedance @ $+I_{in}$ (op amp summing point)	Virtual Ground	<0.1 Ω
STABILITY OF FULL SCALE FACTOR		
Temperature Coefficient ($+V_{in}$) ± PPM/°C		
4721	30	300
4723	30	100
Temperature Coefficient ($+I_{in}$) PPM/°C	30	---
Power Supply Sensitivity ± PPM/% ΔV_{CC} ③	400	800
Drift: Per Day/Per Month ± PPM	100/100	---
Warm Up Time	<2 min. to 0.02%	---
STABILITY OF ZERO OFFSET VOLTAGE		
Temperature Coefficient μV/°C		
4721	25	100
4723	25	50
Power Supply Sensitivity ±μV/% ΔV_{CC} ③	50	100
Drift: Per Day/Per Month μV	100/100	---
RESPONSE		
Settling Time to 0.01% for Step Input	1 to 2 cycles of new frequency plus 20 μsec	---
Overload Recovery	1 sec.	2 sec.
Allowable Capacitive Load	Depends on external pull-up resistor	---
OUTPUT WAVEFORM (See Timing Diagram)		
Pulse Characteristics: '1' (HIGH)	---	Output leakage, 1 μA @ 14 V max.
'0' (LOW)	---	+0.20 V ± 0.20 V @ −16 mA sink current
WIDTH	---	20 μsec min., 60 μsec max., 30 μsec typ.
Output Impedance (In High State)	---	Open collector (see Block Diagram)
POWER REQUIREMENT		
Voltage Range ($\pm V_{CC}$)	±12 V to ±18 V	±15 V ±5%
Current ($\pm I_{CC}$) @ V_{CC} = ±15 V	±14 mA	±18 mA
ENVIRONMENT/RELIABILITY		
Operating Temperature	---	0 °C to +70 °C
Storage Temperature, Absolute Max.	---	−55 °C to +85 °C

Input Protection: All inputs may be shorted to $\pm V_{CC}$ indefinitely without damage.
Output Protection: May be shorted to ground indefinitely; to $+V_{CC}$ for 5 seconds.

DO NOT short OUTPUT to $-V_{CC}$ or the units will fail.

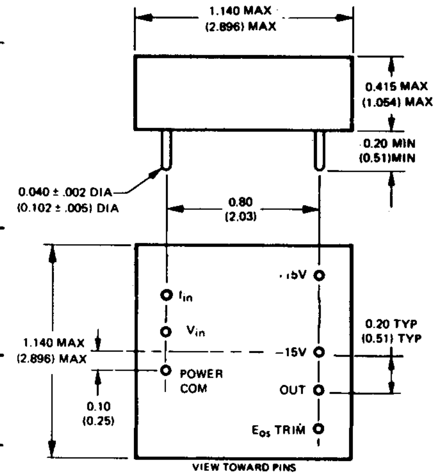
NOTES:

① Nonlinearity is deviation from ideal transfer function when Full Scale Factor has been trimmed to +10,000 V and Input Offset Voltage to 0.10 V.

② With external resistor and capacitor, the 4721 and 4723 will operate linearly from V_{in} = 1 mV to +11 V, with f_{out} from 1 Hz to 11 kHz. See Figure 7.

③ Constant voltage at Zero trim pin.

For V/F application notes, request AN-1, 2, 6, 9, 20, 22, 32



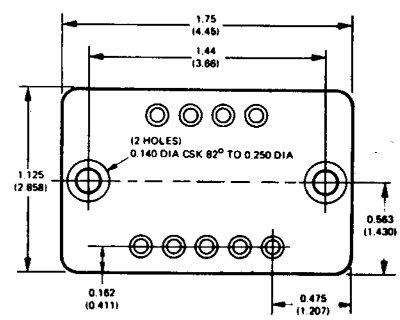
±0.01 Non-cumulative tolerance between pins
±0.02 Tolerance from case edge to center of pins

DIMENSIONS IN PARENTHESES ARE EXPRESSED IN CENTIMETERS

SOCKET: NSK–20

SOCKET MATERIAL:
0.90" (0.23 cm)
THICK EPOXY

OVERALL HEIGHT:
0.68" (1.73 cm)



MATING SOCKET NSK-20
(Order Separately)

DIMENSIONS IN PARENTHESES ARE EXPRESSED IN CENTIMETERS

To take maximum advantage of the 4721/4723's versatility, a functional block diagram and theory of operation is provided. With this information, input and output circuitry are easily modified to handle virtually any signal or load.

These V/F's are free running (astable) voltage controlled multivibrators (see Figure 4). The effective currents from the two inputs (A & B) are summed at the minus input of op amp A1. A1 and transistor Q1 form a precision current pump, producing current I from the collector of Q1, which is a linear function of the A1 input currents. Current I charges capacitor C at a rate which is a precise linear function of the input signal.

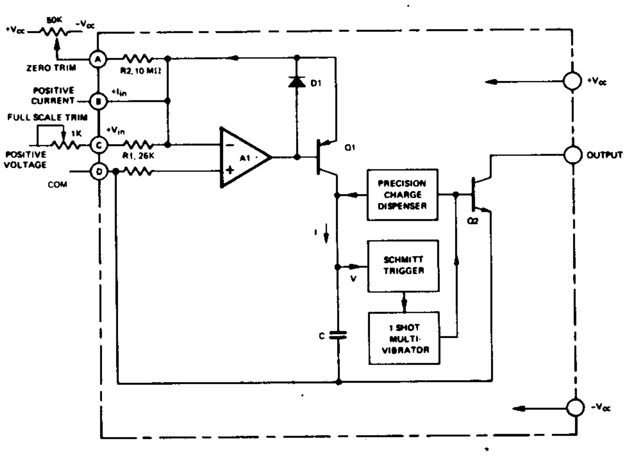


Figure 4. Models 4721/4723 Simplified Block Diagram

When the voltage impressed on C (due to I) reaches a fixed precision threshold, the Schmitt-Trigger output changes state and triggers the one-shot (monostable) multivibrator, which in turn produces a constant width output pulse. This pulse performs two functions. Amplified by Q2, it is the output and functionally activates the Precision Charge Dispenser (PCD). The PCD discharges C to the same "zero" level every time an output pulse is produced. Thus capacitor C is repeatedly charged between two precise voltages at a rate which is a linear function of the input signal, producing the waveforms shown in the timing diagram. That is, the rate of charging C (the repetition rate of charging C and thus the output frequency) is a function of the 4721/4723 voltage and or current inputs.

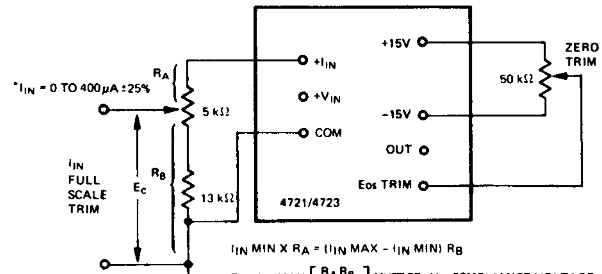
TRIM THEORY

The input circuit Zero and Full Scale trim techniques are based on the input circuit amp (A1, Figure 4) and the user may treat the input as such within certain limits. No combination of signals may be applied to these inputs which will drive the A1 output positive. That is, a frequency output will not result if the total current into the inputs (A1, summing point) becomes negative with respect to Pin D. If this occurs, D1 will become forward biased, Q1 cut off, I becomes zero, and f_{out} becomes zero. The inherent current Full Scale Factor is 400 μA, ± 25% to give 10 kHz out. All current trimming must take this ± 25% tolerance into account. Factory trims the full scale $\pm V_{in}$ to within ±0.5%.

TRIM PROCEDURE

1. Apply 100 mV between the + voltage input terminal and ground; then adjust R2 for f_{out} = 100 Hz.
2. Apply +10 V between the + voltage input terminal ($+V_{in}$) and ground. Adjust R1 for f_{out} = 10 kHz.
3. Repeat (1) and (2) for precise Zero and Full Scale set. Note: "Zero" is set at 100 Hz out for 100 mV in, because it is very difficult to measure zero Hz out for zero volts in.

Full Scale accuracy for the + current input is ±25%. Greater accuracy is obtained by using the Full Scale and Zero trim circuits shown in Figure 3.



I_{IN} MIN X R_A = (I_{IN} MAX − I_{IN} MIN) R_B

$E_C = I_{IN}\,MAX \left[\frac{R_A R_B}{R_A + R_B}\right]$ MUST BE < I_{IN} COMPLIANCE VOLTAGE

USE THESE EQUATIONS IF FULL SCALE POSITIVE CURRENT (I_{IN}) IS GREATER THAN OR LESS THAN 400 µA ± 25%

*COMPLIANCE VOLTAGE > +1.5 V.

Figure 3. Zero & Full Scale Trim for Positive Input Currents

OUTPUT CONSIDERATIONS

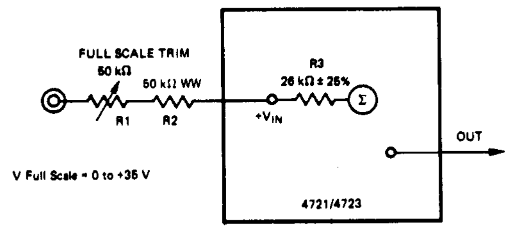
The output circuit of the 4721/4723 is an open collector (see block diagram). The OUTPUT pin should be connected through a resistor to a positive supply voltage. The value of the resistor should not be so low as to permit more than 16 mA of current to flow (950 Ω min. for +15 V), nor so large as to load down the output. In many TTL applications the logic may be driven directly without a pull-up resistor. To drive CMOS, a resistor is normally used.

FULL SCALE FACTOR CHANGE

The specified Full Scale Factor for these units is 9.9 V ± 0.05 V (or +400 μV, ± 25%) to produce 10.00 kHz out. Many applications require 10 kHz for other (larger or smaller) Full Scale input signals and polarities. Figures 5A and 5B illustrate how to operate with such signal levels.

Magnitude of $V_{in} > 10$ Volts

They can be operated with input voltages greater than +10 V by connecting a fixed resistor and trim potentiometer in series with the + voltage input (see Figure 5A). Zero Trim and other adjustments remain the same as in Figure 2.



$R1 + R2 = \frac{V\ Full\ Scale}{10}$ (26 kΩ ± 25%) −26 kΩ ± 25%

R1 compensates for ±25% tolerance of R3.

Figure 5A. Full Scale $+V_{in}$ Greater Than +10 V

Full Scale V_{in} < +10 Volts

If the full scale input voltage is between +0.1 V and +10 V, the full scale output is set at 10 kHz by using the + current input terminal with a series resistor as shown in Figure 5B. The only effect will be to reduce dynamic range since the minimum input voltage does not change.

Full Scale Input Current Greater Than +400 μA

If the full scale input current is greater than +400 μA, the "current splitter" circuit of Figure 3 is used. As noted in Figure 3, the voltage developed at the wiper of the potentiometer must be less than the compliance voltage of the current source.

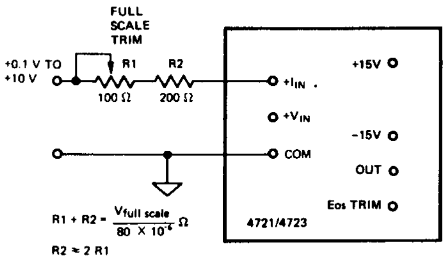


Figure 5B. Full Scale Input Between ≈ +0.1 V and +10 V

BIPOLAR SIGNALS – SCALE EXPANSION – FAST SIGNALS

Operate With Bipolar Input Signals

The 4721/4723 cannot operate with bipolar (e.g., –5 V to +5 V) input signals when connected as shown in Figures 1 and 2. To handle such inputs, it is necessary to offset the zero. That is, produce a pulse train out for "zero" volts in. For example, if +5 V is applied to +I in through a 27K resistor and trimpot, the 4723 has been offset to 5 kHz. If the $+V_{in}$ pin is now connected to –5 V, f_{out} is 0 kHz; if $+V_{in}$ is zero, f_{out} is 5 kHz; if $+V_{in}$ is +5 V, f_{out} is 10 kHz.

Expand a Portion of Scale to Full Scale

An input signal is often a small voltage change impressed on a larger fixed voltage. This situation is handled by nulling (offsetting) the D.C. or unchanging component of the input signal at one input and adjusting the Full Scale Gain Factor at another so the variable portion of the input signal causes the output frequency to cover the full excursion from 0 Hz to 10 kHz. Such a signal is a voltage level which varies between +4 and +6 volts. To implement offsetting, connect $+V_{in}$ to –4 V. Since the actual signal is 2 V (6 V –4 V), connect it to $+I_{in}$ in series with resistor and trimpot to generate 400 μA with 2 V.

Operate With Fast Signals

A basic V/F application requires operation with rapidly changing input signals. For example, the output of a load cell may change from 0 to Full Scale (or Full Scale to 0) in one millisecond. To accurately handle this signal, the output of the V/F must be able to change faster than the input.

The basic response or settling time of the 4721/4723 for any step input is one period of the new frequency plus 20 μsec. That is, if the input is changed one volt from 1.001 volts to 0.001 volts, the new frequency is one Hertz and response time is one second +20 μsec. When the input changes from 11 volts to 10 volts, the new frequency is 10 kHz, one period is 100 μsec, and response time is 120 μsec. Therefore, if the V/F input signal changes between 0 and Full Scale in one millisecond, the output frequency of the V/F for zero volts in must be offset to a new frequency, the period of which is less than the one millisecond required for the input to change. The Full Scale value of the input signal is then adjusted so the V/F will operate between this offset or zero frequency and the maximum Full Scale frequency. In Figure 6 a zero to +1 volt signal is shown providing an output frequency which will vary between 9 kHz and 10 kHz.

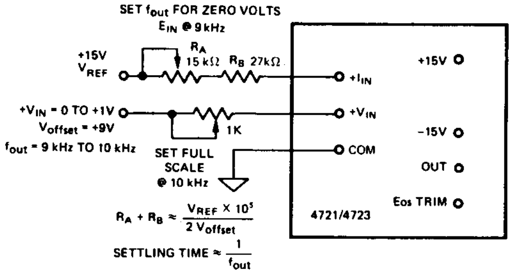


Figure 6. 4721/4723 With Zero Frequency Offset to 9 kHz to Decrease Settling Time

Dynamic Range Expansion

With external resistor and capacitor the 4723 will operate linearly from V_{in} = +1 mV to +11 V, with f_{out} from 1 Hz to 11 kHz. See Figure 7.

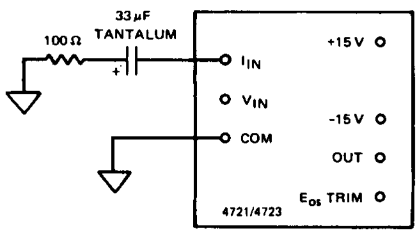


Figure 7. Four Decade Operation

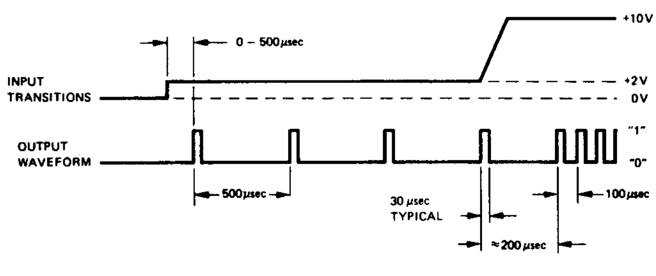


Figure 8. Timing Diagram (Output Waveform)

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