FREQUENCY DEVICES

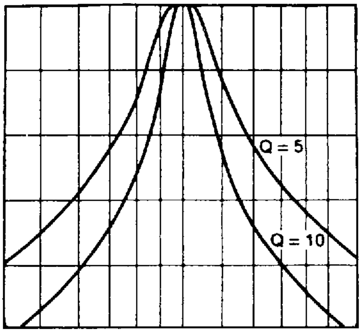
760 SERIES RESISTIVE TUNEABLE 2 POLE-PAIR BANDPASS ACTIVE FILTERS

T-64-05

FREQUENCY DEVICES INC

FEATURES

- Tuneable over 1000:1 Frequency Range
- Filter f_0 from 0.05Hz to 20kHz
- Constant Q over 3-Decade Tuning Range
- 2 Pole-Pair Butterworth Response
- Easy to Use and Available Now
- Stable, Well Defined Performance



APPLICATIONS

- Contiguous Comb Filtering
- Vibration Studies
- RMS Measurements
- Harmonic Analysis
- Noise Reduction

DESCRIPTION

Frequency Devices' 760 Series are resistive tuneable bandpass filters with versatile performance features. These units can be tuned over a 1000:1 frequency range, with each discrete center frequency externally selected by four nominal equal, matched 1% resistors. All models provide a two pole-pair Butterworth bandpass response which is independent of tuning and, therefore, capable of maintaining a constant Q over the three-decade frequency range.

Standard 760 Series models are available with tuning ranges of 0.05 to 50Hz, 0.5 to 500Hz and 20Hz to 20kHz. The filters are factory-calibrated so that, for most applications, the desired center-frequency tuning is the only adjustment needed.

These filters are ideal for the many applications requiring switch-tuneable center frequency selection across a three-decade spectrum. Applications requiring a variety of fixed center frequencies are equally well-served by the 760 Series.

HOW TO ORDER

All 760 Series filters feature a well-defined and stable, two pole-pair **Butterworth** response. To order, simply select the model number tabulated below which provides the desired performance.

AVAILABLE 760 SERIES FILTERS Table 1.1

MODEL NUMBER	f_0 MAX Hz	TUNING RANGE (Hz)	Q	CASE
760BQ5 760BQ10	50	0.05-50	5 ± 10% 10 ± 10%	C-3
762BQ5 762BQ10	500	0.5-500	5 ± 10% 10 ± 10%	C-2
764BQ5 764BQ10	20K	20-20K	5 ± 10% 10 ± 10%	C-2

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760 SERIES SPECIFICATIONS
(Typical @ 25°C; V_S = ± 15Vdc; $f_O \leq f_{max}$ unless otherwise noted)

PASSBAND CHARACTERISTICS	
GAIN @ f_O	
Nominal Value	0 ± 0.3dB, Non-Inverting
Adjustment Range	0 to + 10 (Not in dB)
CENTER FREQUENCY	
Tolerance[1]	± 3%
Stability[1]	± 0.03%/°C
INPUT CHARACTERISTICS	
Input Impedance	100kΩ
Input Voltage Range	± 10V
OUTPUT CHARACTERISTICS	
Linear Output Range @ ± 2mA[2]	± 10V
Output Noise[3]	50μV RMS
Output Offset Voltage[4]	± 2mV ± 20μV/°C
Output Resistance	1Ω
DC POWER SUPPLY (± V_S)	
Nominal Operating Voltage	± 15Vdc
Quiescent Current	± 16mA
Operating Voltage Range	± 5V to ± 18V
TEMPERATURE	
Operating	0°C to 70°C
Storage	− 25°C to + 85°C

NOTES

1) Applicable when using matched 1%, 100ppm/°C tuning resistors.
2) Output short circuit protected to ground.
3) Measured within a 1Hz to 100kHz bandwidth.
4) Offset adjustable to zero using external potentiometer and with R_X installed.

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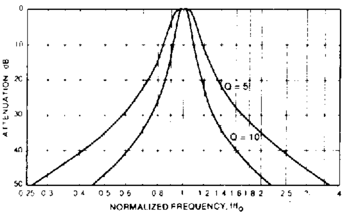
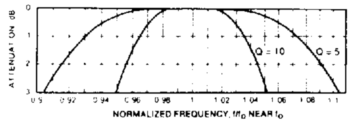
NORMALIZED THEORETICAL RESPONSE





NORMALIZED THEORETICAL RESPONSE VALUES

f_i/f_o	Q = 5		Q = 10	
	A(dB)	ψ(°)	A(dB)	ψ(°)
0.20	−55.21	176.6	−67.25	178.3
0.24	—	—	−63.76	177.9
0.25	−50.92	175.7	—	—
0.30	−47.24	174.7	−59.28	177.3
0.34	—	—	−56.61	176.9
0.35	−43.93	173.5	—	—
0.40	−40.85	172.3	−52.89	176.1
0.44	—	—	−50.52	175.6
0.45	−37.90	170.8	—	—
0.50	−35.00	169.1	−47.04	174.6
0.54	—	—	−44.72	173.8
0.55	−32.09	167.1	—	—
0.60	−29.09	164.6	−41.12	172.4
0.64	—	—	−38.60	171.2
0.65	−25.92	161.5	—	—
0.70	−22.48	157.2	−34.50	168.8
0.74	—	—	−31.46	166.6
0.75	−18.66	151.2	—	—
0.80	−14.25	141.9	−26.14	161.7
0.84	—	—	−21.82	156.3
0.85	− 9.09	125.8	—	—
0.90	− 3.51	94.4	−13.19	139.2
0.94	—	—	− 5.25	106.9
0.95	− 0.29	44.6	—	—
1.00	0.00	− 00.0	0.00	−000.0

USE OF THE NORMALIZED AMPLITUDE AND PHASE DATA is simple. If the center frequency (f_O) exceeds a frequency of interest (f_i), the normalized frequency $f_n = f_i/f_O$ ($f_i < f_O$). Alternatively, $f_n = f_O/f_i$ for $f_i > f_O$. The phase shift (ψ) will be the tabulated value for $f_i < f_O$ and the negative of the tabulated value for $f_i > f_O$. Normalization is relative to the OdB gain point.

A Q of 5 type 760 Series filter with a 50Hz f_O, would have a gain of −36dB at both 25Hz and 100Hz, because the normalized frequency ratios are 0.5 and 2.0, respectively.

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INSTALLATION NOTES

TUNING PROCEDURE

All 760 Series models require a set of four nominally equal tuning resistors for each selected frequency; each resistor within a set tunes one of the four filter poles. A ± 1% match between set-resistors yields tuning accuracy closer than ± 3%.

Equation 4.1 calculates the common, theoretical value of the four equal-valued tuning resistors (R) shown connected in Fig. 4.1. The variables f_o and f_{omax} refer to a desired center frequency and the maximum permissible center frequency, respectively; values of f_{omax} for assorted 760 Series models are tabulated on Table 1.1 on this specification.

$$R(k\Omega) = 2\left[\frac{f_{max}}{f_o} - 1\right] \qquad \text{EQ 1}$$

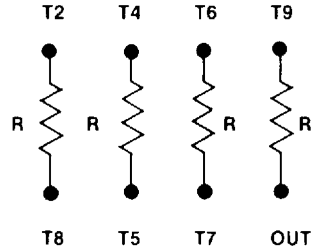

FIGURE 4.1: Connection of Resistive Tuning Components

For user convenience, Table 4.1 (below) lists the standard decade value closest to that calculated by Eq. 1.

The recommended procedure for **TROUBLE FREE START UP REQUIRES USE OF THE *SHORTEST* POSSIBLE CONNECTING LEADS BETWEEN FILTER TERMINALS T5, T7, T8 AND T9 AND THEIR ASSOCIATED TUNING RESISTORS (R's).** Careful circuit layout at this juncture will provide multiple-frequency selection capability for immediate or future applications.

1.00	1.21	1.47	1.78	2.15	2.61	3.16	3.83	4.64	5.62	6.81	8.25
1.02	1.24	1.50	1.82	2.21	2.67	3.24	3.92	4.75	5.76	6.98	8.45
1.05	1.27	1.54	1.87	2.26	2.74	3.32	4.02	4.87	5.90	7.15	8.66
1.07	1.30	1.58	1.91	2.32	2.80	3.40	4.12	4.99	6.04	7.32	8.87
1.10	1.33	1.62	1.96	2.37	2.87	3.48	4.22	5.11	6.19	7.50	9.09
1.13	1.37	1.65	2.00	2.43	2.94	3.57	4.32	5.23	6.34	7.68	9.31
1.15	1.40	1.69	2.05	2.49	3.01	3.65	4.42	5.36	6.49	7.87	9.53
1.18	1.43	1.74	2.10	2.55	3.09	3.74	4.53	5.49	6.65	8.06	9.76

TABLE 4.1: Tabulation of 1% Resistor Standard Decade Values

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INSTALLATION NOTES, Continued

OPTIONAL GAIN ADJUSTMENT

The gain of all 760 Series filters can be adjusted resistively when required by the application. This enables the user to adjust the filter passband gain at the center frequency f_O to a level above or below the non-inverting, factory-preset value of 0 ± 0.3dB.

The 20kΩ cermet potentiometer of Figure 5.1 provides a linear gain ratio range of 0 (zero gain) to ± 10 (20dB). The recommended type of potentiometer provides sufficient resolution and temperature stability for the intended circuit function.

Alternatively, the fixed-resistor approach of Figure 5.2 affords a simple and economical method for incrementally controlling gain. Resistors R1 and R2 form a divider network in which R1 increases gain, R2 decreases gain.. These resistors should be 1%, 100ppm/°C metal film components, the values of which can be determined by the following experimental method:

First, connect a decade box in place of R1 if gain is to be increased or in place of R2 if gain is to be decreased. Next, adjust the resistance until the desired passband gain is obtained. Finally, replace the decade box with the discrete resistor value called for.

When a 760 Series filter is adjusted for a gain of greater than 0dB, the input signal amplitude must be restricted accordingly. The additional gain could cause a ± 10V input signal to drive the filter output stage beyond its linear operating region and produce a clipped output signal. Note that if the factory set gain level is satisfactory, no external gain connections are required.

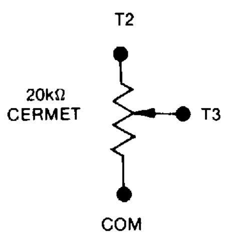

Figure 5.1: Optional Potentiometric Gain Adjustment Circuit

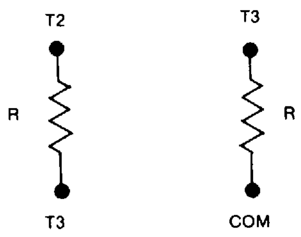

Figure 5.2: Fixed Resistor Gain Adjustment Circuit

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INSTALLATION NOTES, Continued

OPTIONAL DC OFFSET ADJUSTMENT

The filter input bias current flowing through a portion of the external tuning resistor network generates a DC offset voltage. For the typical bandpass filtering application in which DC contains no useful information and the filter output can be AC coupled, this offset presents no problem. The offset can, however, represent a significant amplitude measurement error relative to the rectified and filtered value of an AC input signal. For acceptable system accuracy, the DC offset error voltage should be much less than the DC equivalent value of the AC input signal.

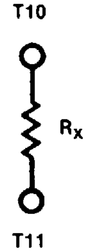

FIGURE 6.1: Connection of Offset Compensation Resistor R_X

Connected as shown in Figure 6.1, resistor R_X can compensate the bias current generated offset voltage as well as its temperature drift. Note that if no compensation is required, $R_X = 0\Omega$ and **FILTER TERMINAL T10 MUST BE CONNECTED TO FILTER TERMINAL T11.**

Figure 6.2 illustrates the typical form and degree of compensation that resistive-balancing can achieve. The graph shows that the compensation resistor R_X equal to tuning resistance R provides an approximate tenfold improvement of output offset and offset drift relative to the uncompensated ($R_X = 0$) case. Here, R refers to the common value of the four nominally equal tuning resistors, which must increase for lower frequencies and decrease for higher selected frequencies. For offset critical multi-frequency applications, a new value of $R_X = R$ should accompany the R for each frequency selected.

Alternatively, the circuit of Figure 6.3 can zero the DC output offset, but only for a single combination of fixed frequency and temperature. In other words, this approach does not compensate, it nulls.

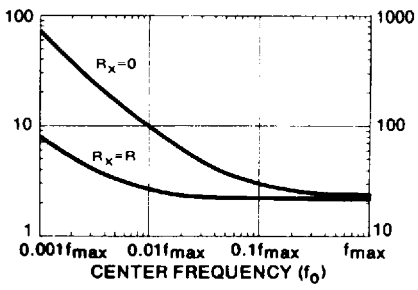

Figure 6.2: Typical Output Offset Voltage and Offset Drift vs. f_0 and R_X

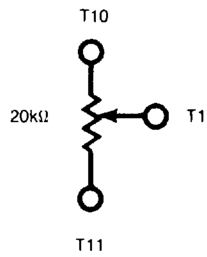

Figure 6.3: Offset Voltage Null Circuit

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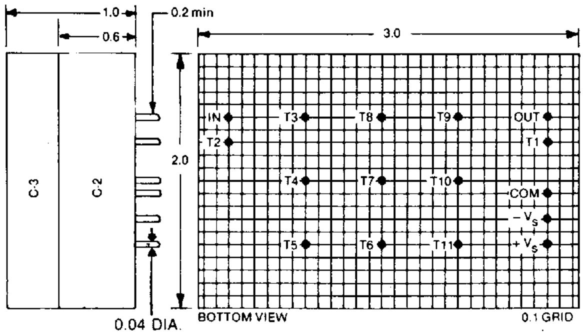
DIMENSIONS AND CONNECTIONS

CASE DIMENSIONS

DIMENSIONS IN INCHES (Use S1002 Socket)



TERMINAL KEY

IN[1]	Signal Input
OUT[1]	Signal Output, Tuning
T1	Offset Adjust
T2[1]	Gain Adjust, Tuning
T3	Gain Adjust
T4 and T5[2]	Frequency Tuning Terminal — Pair No. 1
T6 and T7[2]	Frequency Tuning Terminal — Pair No. 2
T2[1] and T8[2]	Frequency Tuning Terminal — Pair No. 3
OUT[1] and T9[2]	Frequency Tuning Terminal — Pair No. 4
T10 and T11	Offset Compensation Terminal — Pair (for R_X)
$+V_S$	Supply Voltage, Positive
COM	Ground, Supply Common
$-V_S$	Supply Voltage, Negative

NOTES: 1) Serves two simultaneous functions.
2) Requires shortest possible connecting leads for minimum pickup.

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FREQUENCY DEVICES

760 SERIES RESISTIVE TUNEABLE 2 POLE-PAIR BANDPASS ACTIVE FILTERS

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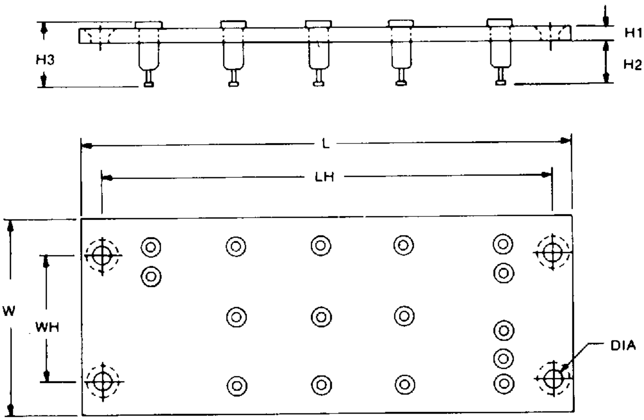
SOCKET DATA/FILTER ORDERING GUIDE

SOCKET DATA

S1002



DIMENSION	MILLIMETERS	INCHES
L	89	3.5
LH	81	3.2
W	36	1.4
WH	23	0.9
H1	2.3	0.09
H2	7.9	0.31
H3	12	0.47
DIA	3.5	0.14

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ORDERING GUIDE

Any of the six standard 760 Series models can be ordered as listed in Table 1.1 on Page 1 of this specification. The S1002 socket can be ordered as a separate line item.

For special OEM requirements please contact FDI directly. Frequency Devices, Inc., can furnish standard and custom design active filters which, in OEM quantities, meet or exceed the price/performance capabilities of many competitive models.

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