FREQUENCY DEVICES

770 SERIES RESISTIVE TUNEABLE HIGHPASS ACTIVE FILTERS

FREQUENCY DEVICES INC

T-64.05

FEATURES

- Tuning Range . . . 1000:1
- Available Corner Frequencies . . . Span 0.02Hz to 20kHz
- Full Power Response . . . 100kHz
- Butterworth Response . . . 2- and 4-pole Models

APPLICATIONS

- Biomedical Instrumentation
- Geophysical Instrumentation
- Data Communications
- Broadcast Signal Conditioning
- Production Test Equipment
- Interference Elimination
- Band Limiting

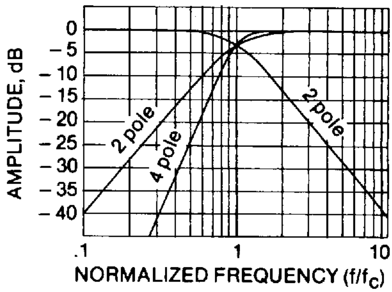


Figure 1.1: Theoretical Response of 770 Series Filters.

GENERAL DESCRIPTION

Frequency Devices' 770 Series are resistive-tuneable active Butterworth highpass filters. Available in 2-pole and 4-pole configurations which feature a 1000:1 tuning range and a selection of corner frequencies spanning 0.02Hz to 20kHz, all models are tuneable using readily-available standard 1% resistor values and simple tuning procedures.

For maximum versatility, all 770 Series models will operate from power supplies ranging between ±5 and ±18Vdc. This enables these filters to serve equally well in battery-powered portable applications and fixed-site applications in which electronically regulated supplies furnish power.

Because a single model can serve in many applications, 770 Series filters should be stocked as standard "building blocks" for both new and existing system designs.

AVAILABLE 770 SERIES FILTERS **TABLE 1.1**

MODEL	f_c TUNING RANGE			CASE SIZE, mm (inches)		
	f_{min} (Hz)	f_{max} (Hz)	TYPE	LENGTH	WIDTH	HEIGHT
2-POLE						
772BT-1	0.02	20	G-2	50.8 (2.0)	38.1 (1.5)	15.2 (0.6)
772BT-2	0.2	200	G-1	50.8 (2.0)	38.1 (1.5)	10.2 (0.4)
772BT-3	2.0	2K	G-1	50.8 (2.0)	38.1 (1.5)	10.2 (0.4)
772BT-4	20.0	20K	G-1	50.8 (2.0)	38.1 (1.5)	10.2 (0.4)
4-POLE						
774BT-1	0.02	20	C-3	76.2 (3.0)	50.8 (2.0)	25.4 (1.0)
774BT-2	0.2	200	C-2	76.2 (3.0)	50.8 (2.0)	15.2 (0.6)
774BT-3	2.0	2K	C-1	76.2 (3.0)	50.8 (2.0)	10.2 (0.4)
774BT-4	20.0	20K	C-1	76.2 (3.0)	50.8 (2.0)	10.2 (0.4)

Frequency Devices Incorporated 25 Locust Street Haverhill, Massachusetts 01832 (508) 374-0761 FAX (508) 521-1839

 FREQUENCY DEVICES

770 SERIES RESISTIVE TUNEABLE HIGHPASS ACTIVE FILTERS

FREQUENCY DEVICES INC

770 SERIES SPECIFICATIONS
(Typical @ 25°C and $\pm V_S$ = ±15Vdc and $f \leq f_{cmax}$ except as noted)

CORNER FREQUENCY (f_C)[1]	
Tolerance	±3%
Tuning Range	1000:1
Stability	
Model 772:	0.01%/°C
Model 774:	0.03%/°C
RESPONSE CHARACTERISTICS	
Passband Gain, Preset	0±0.2dB, Non-inverting
Passband Gain, Adjustable	
Model 772:	Not Adjustable
Model 774:	(V_{out}/V_{in}) = 0 to +10
Passband Frequency Range	
Model 772:	$5f_C < f < 100kHz$
Model 774:	$2.5f_C < f < 100kHz$
Number of Poles	
Model 772:	2-Poles
Model 774:	4-Poles
Response Category	
Model 772:	Butterworth Highpass and Lowpass
Model 774:	Butterworth Highpass Only
INPUT CHARACTERISTICS	
Input Resistance	20kΩ
Input Voltage, Linear	±10V
Input Voltage, Safe	$\pm V_S$
OUTPUT CHARACTERISTICS	
Full Power Response	100kHz
Rated Output @ 5mA[2]	±10V
Output Noise[3]	$50\mu V/\sqrt{Hz}$
Output Offset Voltage[4]	Trimmable to Zero
Output Resistance	1Ω
DC POWER SUPPLY ($\pm V_S$)	
Nominal Operating Voltage	±15Vdc
Quiescent Current	
Model 772:	±8mA
Model 774:	±16mA
Operating Voltage Range	±5V to ±18V
TEMPERATURE RANGE	
Operating	0°C to +70°C
Storage (Non-Operating)	−25°C to +85°C

NOTES

1. Requires 1%, 50ppm/°C tuning resistors.
2. Output protected for short circuit to ground. **DO NOT CONNECT TO $\pm V_S$.**
3. Measured between 1Hz and 100kHz with input grounded.
4. Output drift is 20μV/°C with proper R_X. See OFFSET VOLTAGE ADJUSTMENT.
5. The power supply must provide positive and negative voltages referenced to a common (ground) connection.

Frequency Devices Incorporated 25 Locust Street Haverhill, Massachusetts 01832 (508) 374-0761 FAX (508) 521-1839

FREQUENCY DEVICES

770 SERIES RESISTIVE TUNEABLE HIGHPASS ACTIVE FILTERS

770 SERIES MODELS

INTRODUCTION: The 770 Series filters are available in either 2-pole or 4-pole configurations designated as 772BT-X or 774BT-X, respectively. The subscript (-X) may be -1, -2, -3 or -4, corresponding to tuning ranges of 0.02 to 20Hz, 0.2 to 200Hz, 2.0Hz to 2kHz and 20.0Hz to 20kHz, respectively.

For user convenience, the same resistance value will tune all 2- and 4-pole 770 Series models to the same corner frequency, while compensating the DC offset of all models to the same degree. All tuning resistors are readily-available, standard values that are calculated by a single, simple algebraic equation.

The preceding outlined the performance commonalities that exist between 770 Series filters. The following will detail the differences.

The 772BT- models feature simultaneous highpass and lowpass outputs, each having a 2-pole Butterworth response. Other differences from the 4-pole models include corner frequency stability of 0.01%/°C and a non-adjustable passband gain.

The 774BT- models differ in that they feature resistive passband gain control over a range of 0 to + 10; the gain is expressed as a voltage ratio—NOT a dB value. Also in contrast to the 2-pole companion models, these units have a corner frequency stability of 0.03%/°C and deliver a single output only, having a highpass Butterworth response.

INSTALLATION NOTES—ALL MODELS

External capacitive coupling, wiring inductance and capacitance, and capacitive output loading can seriously degrade filter performance. So, too, can improper power distribution methods. The following easily-implemented techniques can minimize start-up problems by eliminating pitfalls right at the outset.

1. When the desired maximum corner frequency, f_{cmax}, is available from either of two 770 Series models, select the model having the lower f_{cmax}; this model will utilize larger internal tuning capacitors and have proportionally greater immunity to the detuning effects of external stray capacitance.

2. Use non-inductive, non-capacitive external resistive tuning and trim components, locating them as close as possible to the filter to obtain the shortest achievable lead lengths. Metal film fixed resistors and cermet potentiometers are recommended for tuning and trimming, respectively. Avoid the use of shielded cable in connecting these components.

3. Large capacitive loads may cause the filter to oscillate. Connection of a series, isolation resistor of 470 ohms or greater between the filter output and the load can control this de-stabilizing effect for loads in excess of 100pF. Alternately, an external output buffer amplifier can interface the filter to even greater capacitive loads with no loss of stability. Please note that when the filter drives a coaxial cable, the cable shield should be grounded at the common terminal of the filter.

Frequency Devices Incorporated 25 Locust Street Haverhill, Massachusetts 01832 (508) 374-0761 FAX (508) 521-1839

GENERAL TUNING PROCEDURE—ALL MODELS

Each 770 Series filter can be tuned by one set of nominally equal, external matched resistors for each corner frequency required. The value of these resistors is computed by the equation below:

$$R(k\Omega) = R_X(k\Omega) = 2\left[\frac{f_{cmax}}{f_c} - 1\right] \qquad \text{EQ. 4.1}$$

where f_{cmax} is the highest permissible corner frequency for a given 770 Series model as specified in Table 1.1 and in INSTALLATION NOTE No. 1 on the preceding page.

For a given corner frequency, select the standard resistance value from Table 4.1 which most nearly equals the R calculated by Eq. 4.1.

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

Whether used in pairs for tuning 772 Model filters or in quadruples for tuning 774 Model filters, the nominally-equal standard-value tuning components should be 1%, 50ppm/°C, metal film resistors. Under these conditions, any 770 Series model so tuned will meet its published corner frequency specifications. For user convenience, resistor sets as described are directly available from F.D.I. Please see the HOW TO ORDER section, which appears further on.

A compensating resistor, R_X, which minimizes offset error most effectively when equal to the R value of Eq. 4.1, is discussed further on. Connection of the tuning and compensating components is shown in Figure 4.1 below.

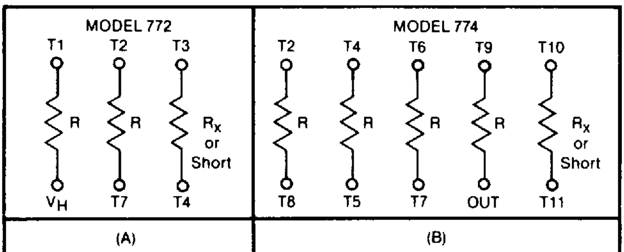


FIGURE 4.1

Tuning and offset compensation connections for 772 models (A) and 774 models (B). Note that either R_X or a short circuit must be connected between terminals T3 and T4 (772) and T10 and T11 (774).

FREQUENCY DEVICES

770 SERIES RESISTIVE TUNEABLE HIGHPASS ACTIVE FILTERS

FREQUENCY DEVICES INC

OPTIONAL FINE TUNING PROCEDURE—ALL MODELS

For applications requiring extremely accurate corner frequency setting, the techniques illustrated in Figures 5.1 and 6.1 enable the user to fine tune the 772 and 774 Model filters, respectively.

The instrumentation shown includes a phase-stable input oscillator tuned to the desired corner frequency, and an x-y plotting oscilloscope with phase-matched x and y channels for observing phase response. Both systems require the connection of DC power ($\pm V_S$) which, for clarity, has not been shown.

The following guidelines will greatly simplify calibration:

1. To generate a straight line display when connected to the same signal source, the x and y oscilloscope channels must be phase matched.
2. The x and y oscilloscope channels must remain phase matched despite adjustment of channel gains.
3. Connect the ground return of the oscillator and the ground return of the oscilloscope to the common terminal of the filter by means of short, individual leads.
4. Though not shown, DC power ($\pm V_S$) is required.

TO FINE TUNE A 772 MODEL FILTER: First, calculate the value of fixed-resistor R, and its equal, R_X, in accordance with Eq. 4.1. Then, using the standard 1% resistor value closest to that computed (see Table 4.1), connect 50ppm/°C metal film resistors for R and R_X as in Figure 5.1. Resistor (A) should be a cermet potentiometer, while the series, fixed segment (0.96R) should be a standard 1% film resistor.

Now, powering-up the system and setting the input oscillator to f_C, adjust resistor (A) for a closed, straight-line display on the oscilloscope. The proportioning of fixed and variable resistance between Pins T2 and T7 provides a smooth ±5% variation. Other proportions may be used. This completes the tuning of the pair of matched poles.

WARNING: IF R_X IS NOT USED, CONNECT A SHORT CIRCUIT BETWEEN FILTER TERMINALS T3 AND T4. LEAVING THESE PINS OPEN WILL CAUSE IMPROPER OPERATION, BUT NO DAMAGE.

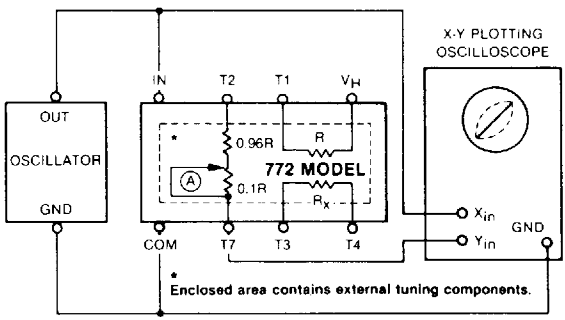


FIGURE 5.1: Recommended Connections for Fine Tuning 772 Model Filters

Frequency Devices Incorporated
25 Locust Street
Haverhill, Massachusetts 01832
(508) 374-0761
FAX (508) 521-1839

OPTIONAL FINE TUNING PROCEDURE, Continued

TO FINE TUNE 774 MODEL FILTERS: First, calculate R (and R_X) by means of Eq. 4.1, which is repeated for user convenience:

$$R(k\Omega) = R_X(k\Omega) = 2\left[\frac{f_{cmax}}{f_c} - 1\right] \quad \text{EQ. 4.1}$$

Next, as in the 772 Model fine tuning procedure, select from Table 4.1 the standard 1% resistor value closest to that computed, and connect the fixed R and R_X resistors as shown in Figure 6.1. Resistors (B) and (C) should be cermet potentiometers, while the series, fixed (0.96R) segments should be the closest standard 1% value metal film resistors.

Now, powering-up the 774 Model filter and setting the input oscillator to the desired f_C, adjust resistor (B) for a closed, straight-line oscilloscope display while monitoring filter terminals IN and T2.

Finally, monitoring filter terminals T3 and T6, adjust resistor (C) for a closed, straight-line oscilloscope display. As before, the proportioning between series, fixed and variable resistor segments can be other than that used in Figures 5.1 and 6.1; this weighting has the advantages of ease of calculation and a smooth ±5% range of tuning adjustment.

This completes the fine tuning of 774 Model filters.

WARNING: IF R_X IS NOT USED, CONNECT A SHORT CIRCUIT BETWEEN FILTER TERMINALS T10 AND T11. LEAVING THESE PINS OPEN WILL CAUSE FAULTY OPERATION, BUT NO DAMAGE.

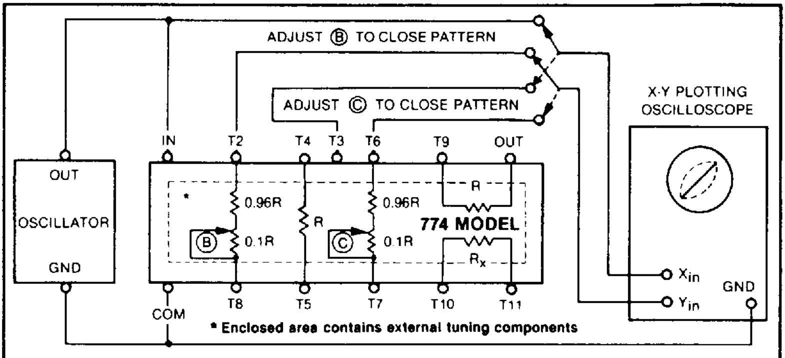


FIGURE 6.1: Recommended Connections for Fine Tuning 774 Model Filters

Frequency Devices Incorporated 25 Locust Street Haverhill, Massachusetts 01832 (508) 374-0761 FAX (508) 521-1839

FREQUENCY DEVICES

770 SERIES RESISTIVE TUNEABLE HIGHPASS ACTIVE FILTERS

FREQUENCY DEVICES INC

OPTIONAL GAIN ADJUSTMENT

All 770 Series models have a factory-calibrated, non-inverting passband gain of 0 ± 0.2dB. In terms of cutoff frequency f_C, the passband region includes all frequencies greater than $5f_C$ but less than 100kHz for 772 Model filters, and frequencies greater than $2.5f_C$ but less than 100kHz for 774 Model filters.

GAIN ADJUSTMENT FOR 772 MODELS: All 772BT- Models contain no provisions for external gain adjustment. These filters deliver simultaneous highpass and lowpass outputs having fixed, nominally-equal gains throughout the appropriate tuning range.

GAIN ADJUSTMENT OF 774 MODELS: All 774BT- Models include terminals for externally adjusting gain. Figure 7.1 illustrates three implementations of resistive gain control techniques. The circuit of Figure 7.1A provides continuous gain adjustment between 0 and + 10. Here, gain is expressed as the ratio of V_{out} to V_{in}, not as a dB value. A cermet-type of 20kΩ gain-set potentiometer is recommended.

The circuit of Figure 7.1B provides a means for incrementally setting fixed gain between + 1 and + 10. Use a resistor decade or rheostat-connected potentiometer to determine RB. This resistor should be a 1% metal film device with a 50ppm/°C tempco.

The circuit of Figure 7.1C enables the user to select incremental values of fixed gain between 0 and + 1. The characteristics and selection methods for resistor RC are identical to those for resistor RB of the preceding step.

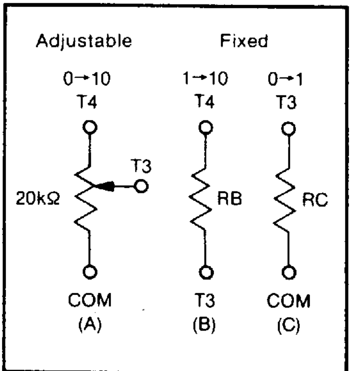


FIGURE 7.1: Gain Set Methods for 774 Model Filters

THEORETICAL TRANSFER FUNCTIONS **TABLE 7.1**

MODEL	772BT-	774BT-
DESIGN	2-Pole Butterworth	4-Pole Butterworth
RESPONSE LOWPASS	$\frac{V_{out}(S)}{V_{in}(S)} = \frac{\omega_0^2}{S^2 + S\frac{\omega_0}{Q} + \omega_0^2}$	No Lowpass Response
HIGHPASS	$\frac{V_{out}(S)}{V_{in}(S)} = \frac{S^2}{S + S^2\frac{\omega_0}{Q} + \omega_0^2}$	$\frac{V_{out}(S)}{V_{in}(S)} = \frac{S^4}{(S^2 + S\frac{\omega_1}{Q_1} + \omega_1^2)(S^2 + S\frac{\omega_2}{Q_2} + \omega_2^2)}$
CONDITIONS	$\omega_0 = 2\pi f_C$ $Q = 0.707$	$\omega_1 = \omega_2 = 2\pi f_C$ $Q_1 = 0.541$ $Q_2 = 1.302$

Frequency Devices Incorporated 25 Locust Street Haverhill, Massachusetts 01832 (508) 374-0761 FAX (508) 521-1839

OPTIONAL DC OFFSET ADJUSTMENT

Filter input bias current flowing through external tuning generates a DC offset voltage. For typical high-pass filtering applications in which DC contains no useful information and the filter output can be AC coupled, the offset presents no problem. However, the offset can become a significant amplitude error in DC coupled systems relative to the rectified and filtered value of an AC input signal. For this case, acceptable system accuracy would require the DC offset error voltage to be significantly less than the equivalent DC value of the AC input signal.

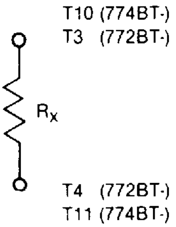


FIGURE 8.1: Connection of R_X for 772 and 774 models

Connected as in Figure 8.1, resistor R_X can compensate the bias-current-generated offset voltage, and its temperature drift.

WARNING: IF NO COMPENSATION IS REQUIRED, R_X MUST BE REPLACED BY A SHORT CIRCUIT. FOR PROPER OPERATION, THE TERMINALS TO WHICH R_X CONNECTS MUST NOT BE LEFT OPEN.

Figure 8.2 shows the typical form and degree of compensation that resistive-balancing can achieve: An R_X value nominally equal to tuning resistor R gives a 10× improvement of offset and offset drift as compared to the uncompensated (R_X = 0Ω) case. Here, R is the common value of tuning resistor found by Eq. 4.1 and Table 4.1, as previously discussed in the OPTIONAL FINE TUNING section.

Alternatively, the circuit of Figure 8.3 can zero the output offset, but only at a single frequency and temperature. Here, R_X must be 0Ω.

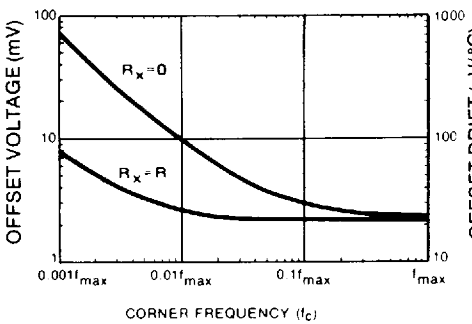


Figure 8.2: Typical Output Offset Voltage and Offset Drift vs. f_c and R_X.

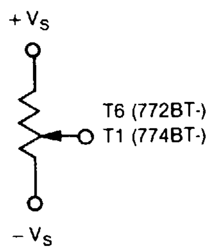


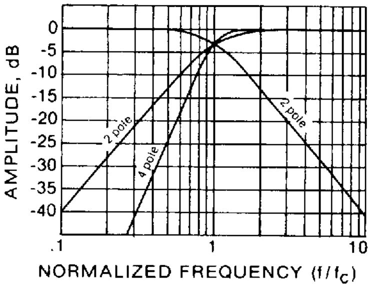
FIGURE 8.3: Offset Voltage null circuit with R_X = 0Ω.

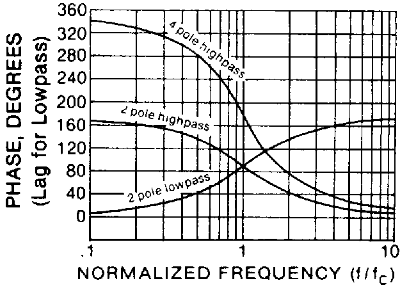
Frequency Devices Incorporated
25 Locust Street
Haverhill, Massachusetts 01832
(508) 374-0761
FAX
(508) 521-1839

FREQUENCY DEVICES

770 SERIES THEORETICAL RESPONSE

THEORETICAL HIGHPASS/LOWPASS BUTTERWORTH RESPONSE





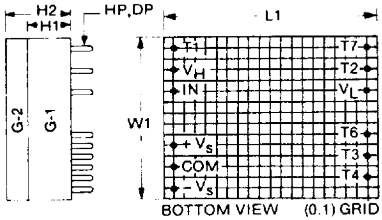
THEORETICAL BUTTERWORTH RESPONSE vs. NORMALIZED FREQUENCY

	MODEL 772				MODEL 774	
	2-Pole Lowpass		2-Pole Highpass		4-Pole Highpass	
f/f_C	A(dB)	Ψ(°)	A(dB)	Ψ(°)	A(dB)	Ψ(°)
0.00	0.0	0.0	−1000.0	180.0	−1000.0	360.0
0.05	−0.0	−4.1	−52.0	175.9	−104.1	352.5
0.10	−0.0	−8.1	−40.0	171.9	−80.0	345.0
0.15	−0.0	−12.2	−33.0	167.8	−65.9	337.5
0.20	−0.0	−16.4	−28.0	163.6	−55.9	329.9
0.25	−0.0	−20.7	−24.1	159.3	−48.2	322.2
0.30	−0.0	−25.0	−21.0	155.0	−41.8	314.5
0.35	−0.1	−29.4	−18.3	150.6	−36.5	306.6
0.40	−0.1	−34.0	−16.0	146.0	−31.8	298.6
0.45	−0.2	−38.6	−14.0	141.4	−27.8	290.4
0.50	−0.3	−43.3	−12.3	136.7	−24.1	282.0
0.55	−0.4	−48.1	−10.8	131.9	−20.8	273.4
0.60	−0.5	−53.0	−9.4	127.0	−17.8	264.3
0.65	−0.7	−57.9	−8.2	122.1	−15.1	254.9
0.70	−0.9	−62.7	−7.1	117.3	−12.6	245.1
0.75	−1.2	−67.6	−6.2	112.4	−10.4	234.8
0.80	−1.5	−72.3	−5.4	107.7	−8.4	224.1
0.85	−1.8	−77.0	−4.6	103.0	−6.7	213.1
0.90	−2.2	−81.5	−4.0	98.5	−5.2	201.9
0.95	−2.6	−85.8	−3.5	94.2	−4.0	190.8
1.00	−3.0	−90.0	−3.0	90.0	−3.0	180.0
1.10	−3.9	−97.7	−2.3	82.3	−1.7	160.1
1.20	−4.9	−104.5	−1.7	75.5	−0.9	143.2
1.30	−5.9	−110.6	−1.3	69.4	−0.5	129.2
1.40	−6.8	−115.9	−1.0	64.1	−0.3	117.8
1.50	−7.8	−120.5	−0.8	59.5	−0.2	108.3
1.60	−8.8	−124.6	−0.6	55.4	−0.1	100.3
1.70	−9.7	−128.2	−0.5	51.8	−0.1	93.5
1.80	−10.6	−131.3	−0.4	48.7	−0.0	87.6
1.90	−11.5	−134.2	−0.3	45.8	−0.0	82.5
2.00	−12.3	−136.7	−0.3	43.3	−0.0	78.0
3.00	−19.1	−152.1	−0.1	27.9	−0.0	50.7
4.00	−24.1	−159.3	−0.0	20.7	−0.0	37.8
5.00	−28.0	−163.6	−0.0	16.4	−0.0	30.1
6.00	−31.1	−166.4	−0.0	13.6	−0.0	25.1
7.00	−33.8	−168.3	−0.0	11.7	−0.0	21.4
8.00	−36.1	−169.8	−0.0	10.2	−0.0	18.8
9.00	−38.2	−171.0	−0.0	9.0	−0.0	16.7
10.00	−40.0	−171.9	−0.0	8.1	−0.0	15.0

Frequency Devices Incorporated
25 Locust Street
Haverhill, Massachusetts 01832
(508) 374-0761
FAX
(508) 521-1839

CASE DIMENSIONS

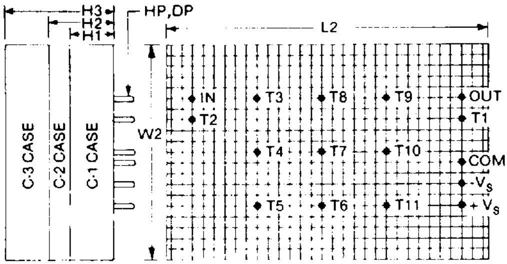
MODEL 772



BOTTOM VIEW (0.1) GRID

USE SOCKET S1006

MODEL 774



BOTTOM VIEW (0.1) GRID

USE SOCKET S1002

DIMENSION	MILLIMETERS	INCHES
L1	50.8	2.0
L2	76.2	3.0
W1	38.1	1.5
W2	50.8	2.0
H1	10.2	0.4
H2	15.2	0.6
H3	25.4	1.0
HP (Pin Height)	5.1 min.	0.2 min.
DP (Pin Diameter)	1.0	0.04

HOW TO ORDER

First, specify the model number from Table 1.1. To order tuning resistor sets, state the filter model number and either the corner frequency in Hz or the closest standard 1% resistor values in Ohms from Table 4.1.

Then, using an A instead of a decimal point and a K instead of a thousands comma, observe the following example:

Tuning Resistor Set for Model 772BT-3:
f = 12A5 (12.5Hz) or R = 318kΩ (316kΩ)*

*the closest standard 1% decade value.

Frequency Devices Incorporated 25 Locust Street Haverhill, Massachusetts 01832 (508) 374-0761 FAX (508) 521-1839

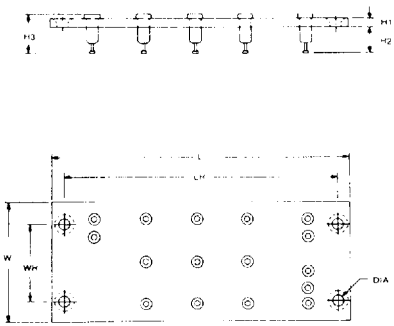
FREQUENCY DEVICES

FREQUENCY DEVICES INC

TERMINAL KEY

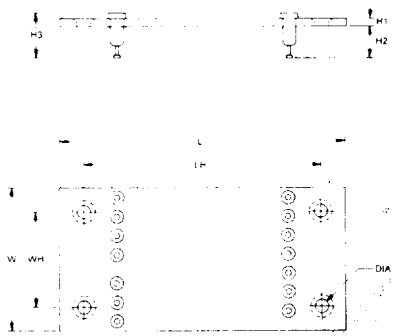
	772 SERIES	774 SERIES
T1	Frequency Tune	Offset Adjust
T2	Frequency Tune	Frequency Tune, Test Out
T3	Offset Compensate	Gain Adjust, Test Out
T4	Offset Compensate	Frequency Tune, Gain Adjust
T5	——	Frequency Tune
T6	Offset Adjust	Frequency Tune, Test Out
T7	Frequency Tune, Test Out	Frequency Tune
T8	——	Frequency Tune
T9	——	Frequency Tune
T10	——	Offset Compensate
T11	——	Offset Compensate
V_H	Highpass Output, Freq Tune	——
V_L	Lowpass Output	——
OUT	——	Output Signal
$+V_S$	Supply Voltage, Positive	Supply Voltage, Positive
COM	Ground, Common	Ground, Common
$-V_S$	Supply Voltage, Negative	Supply Voltage, Negative

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

S1006



DIMENSION	MILLIMETERS	INCHES
L	76.2	3.0
LH	63.5	2.5
W	38.1	1.5
WH	25.4	1.0
H1	2.3	0.09
H2	7.9	0.31
H3	11.9	0.47
DIA	3.5	0.14

Frequency Devices Incorporated 25 Locust Street Haverhill, Massachusetts 01832
(508) 374-0761
FAX
(508) 521-1839