

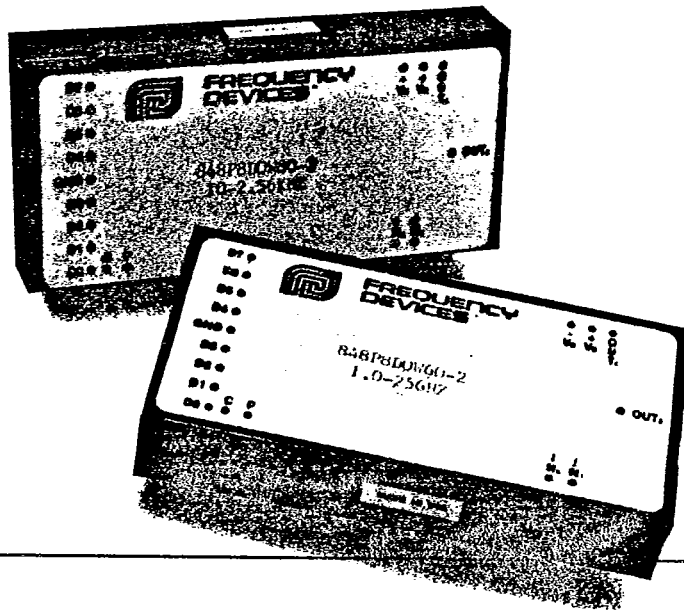


FREQUENCY DEVICES

848/878 Series

T-64-05

Digitally
Programmable
8-Pole
Active
Filters





FREQUENCY DEVICES™

General Description

T-64-05

The 848 and 878 Series are digitally-programmable lowpass and highpass active filters that are tunable over a 256:1 frequency range. These units contain 8 bits CMOS clocked "D" latches which can be digitally configured to operate in any of three modes:

- a.) Transfer frequency control input data into the latches on the STROBE (or CLOCK) rising edge.
- b.) As above, but on the STROBE falling edge.
- c.) Continuously follow the frequency tuning input data, in a non-latching transparent mode.

Each unit is available with any single factory-set tuning range listed below:

- 1 Versions: 0.1 Hz to 25.6 Hz
- 2 Versions: 1.0 Hz to 256 Hz
- 3 Versions: 10 Hz to 2560 Hz
- 4 Versions: 100 Hz to 25.6 kHz
- 5 Versions: 200 Hz to 51.2 kHz

All 848/878 Series models are fully finished filters which require no external components or adjustments, and operate from non-critical ± 12 to ± 18 V power supplies. A 20 k Ω input impedance and a 10 Ω (max.) output impedance make these compact (2.0"W x 4.0"L footprint, by 0.75"H or 1.0"H) encapsulated plug-in modules convenient and easy to use.

Features

- 8 Pole:
 Lowpass Butterworth - 848P8B
 Lowpass Bessel - 848P8L
 Lowpass Linear Phase - 848DOW
 Lowpass Elliptic - 848P8E
 Highpass Butterworth - 878P8B
 Highpass Elliptic - 878P8E
- Digitally Programmable Corner Frequency via CMOS Interface Logic
 - Internally Latched Data Lines to Store Frequency Selection Data
 - Most Widely Used Transfer Characteristics for Broadest Application Scope
 - Plug-in Ready-to-use Fully Finished Filter Component

Applications

- Programmable Automatic Test Equipment (A.T.E.) Systems
- Data Acquisition Systems
- Anti-Alias Prefiltering
- Real and Compressed Time Data Analysis
- Production Test Systems
- Industrial Process Control

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2



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General Analog Specifications

T-64-05

Stability $\pm 0.01\%/^{\circ}\text{C}$

Analog Input Characteristics¹

Impedance 20 k Ω
 Voltage Range $\pm 10\text{ V}$
 Maximum Safe Voltage $\pm V_s$

Analog Output Characteristics¹

Resistance 10 Ω max.
 Linear Operating Range $\pm 10\text{ V}$
 Maximum Current² $\pm 2\text{ mA}$
 Offset Voltage 2 mV typ., 20 mV max.
 Offset vs. Temperature See discussion, next page.

Power Supply (+/-V_s)

Rated Voltage $\pm 15\text{ Vdc}$
 Operating Range ± 12 to $\pm 18\text{ Vdc}$
 Maximum Safe Voltage $\pm 18\text{ Vdc}$
 Quiescent Current 40 mA max.

Temperature

Operating 0°C to $+70^{\circ}\text{C}$
 Storage -25°C to $+85^{\circ}\text{C}$

Deviations from theoretical responses

Characteristic Response	At dc for Lowpass At 100 kHz for H.P. - A -	At f _c , the - 3dB Corner Freq. - B -	At f _{70dB} , Freq. for - 70dB Gain - C -
Lowpass	$\pm 0.2\text{ dB}$	$\pm 0.5\text{ dB}$	$\pm 2\text{ dB}$
Highpass	$\pm 0.5\text{ dB}$	$\pm 0.5\text{ dB}$	$\pm 2\text{ dB}$

The above table defines lowpass responses having a dc (100 kHz for Highpass) gain of 0 dB $\pm A$ (the value in column A), a gain of - 3 dB $\pm B$ at corner frequency f_c, or at the 0.01dB ripple frequency f_r of the elliptic models and a gain of - 70 dB $\pm C$ at f₇₀ dB.

In general, filters programmed at frequencies below 20 kHz fall well within the above deviation boundaries. These error bounds on the filter transfer characteristics are approached only as the programmed frequencies reach 20 kHz and above

Notes:

1. Input and output signal voltages are referenced to supply common.
2. Output is short circuit protected to common. DO NOT CONNECT TO $\pm V_s$.

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FREQUENCY DEVICES™

General Analog

T-64-05

Specifications (cont'd)

-3dB Corner Frequency ±2%

Passband Ripple (theoretical)

Butterworth	0.0 dB
Bessel	0.0 dB
Linear Phase	0.015 dB (60 dB model)
	0.15 dB (80 dB model)
Elliptic	0.035 dB

Typical Noise (Butterworth, Bessel, Linear Phase)

Narrow Band	(5 Hz to 50 kHz) 50 μ V _{rms}
Wide Band	(5 Hz to 2 MHz) 200 μ V _{rms}

Typical Noise (Elliptic)

Narrow Band	(5 Hz to 50 kHz) 75 μ V _{rms}
Wide Band	(5 Hz to 2 MHz) 250 μ V _{rms}

Phase Match (All models)²

@ fc (fr)	Typical ± 1.0°, Maximum ± 2.0°
Passband	Typical ± 0.5°, Maximum ± 1.0°

Gain Match (All models)²

@fc (fr)	Typical ± 0.1 dB, Maximum ± 0.2 dB
Passband	Typical ± 0.05 dB, Maximum ± 0.1 dB

Distortion¹ (For range -1, -2,-3,-4, all lowpass models)

Typical	0.002% (-94 dB)
Maximum	0.004% (-88 dB)

Distortion¹ (For range -5 - all lowpass models)

Typical	0.004% (-88 dB)
Maximum	0.025% (-72 dB)

Note

1. For input signals $\leq 3 V_{rms}$ the total harmonic distortion is $\leq 0.01\%$ (-80 dB) for all five ranges.
2. Unit to unit match for the same transfer function set to the same frequency.

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4



FREQUENCY DEVICES™

**848/878 Series
DC Offset,
Grounding and Control
Characteristics**

T-64-05

DC Offset vs. Temperature

The DC offset voltage of 848/878 Series filters originates at two internal sources that cause it to vary with temperature and selected frequency. Slight mismatches between operational amplifier (op amp) semi-conductor junctions create the first source of DC offset. Switching element leakage currents flowing through switch-selected tuning resistors predominate as the second source of dc offset. Though small at 25°C, the switch leakage currents increase exponentially with absolute temperature to become significantly large at higher temperatures. This becomes a problem when the filter is tuned to low frequencies, which require high-value tuning resistors.

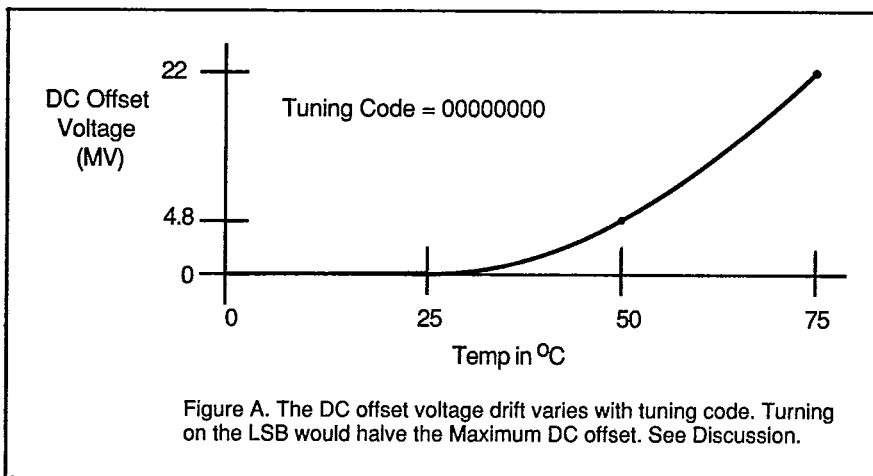
Figure A illustrates the worst case temperature behavior of the offset voltage; this improves with

higher frequency codes. The maximum DC offset voltage will generally occur at the highest temperature and the lowest corner frequency (all "0" input code).

User Notes

Grounding: To achieve specified precision, all analog and digital grounds are connected internal to the filter. Should this cause a problem, all digital inputs (C, P, and D₀ - D₇) can be optically isolated.

Settling Time: When tuned to a different frequency, a filter requires sufficient transient settling time corresponding to several cycles of the new frequency. PLEASE NOTE: DO NOT use these filters in frequency scanning applications without considering settling time.



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**848/878 Series
Data Control
Characteristics**

T-64-05

Data Control Lines

Functions Latch Strobe (C)
 Transition Polarity (P)

Data Control Modes

Mode 1	P = 0; C = 0	frequency follows input codes
	P = 0; C = 0 -->1	frequency latched on rising edge
Mode 2	P = 1; C = 1	frequency follows input codes
	P = 1; C = 1 -->0	frequency latched on falling edge

**Input Data Levels
(CMOS Logic)**

Input Voltage (Vs = 15V)	Min.	Max. Acceptable
Low Level In	0 Volts	4 Volts
High Level In	11 Volts	15 Volts

Input Current	Typ.	Max.
High Level In	- 10 ⁻⁵ μA	- 1 μA
Low Level In	+ 10 ⁻⁵ μA	+ 1 μA

Input Capacitance	5 pF	7.5 pF
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Latch Response

Data Set Up Time ¹	25 ns	---
Data Hold Time ²	50 ns	---
Strobe		
Min Pulse Width	80 ns	---

Notes:

1. The time data must be present before occurrence of strobe edge.
2. The time data must be present after occurrence of strobe edge.

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6



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**848/878 Series
Digital Tuning
Characteristics**

T-64-05

Digital Tuning Characteristics

Filter tuning follows the tuning equation given below:

The digital tuning interface circuits are two 4042 quad CMOS latches which accept the following CMOS-compatible inputs: eight tuning bits ($D_0 - D_7$), a latch strobe bit (C), and a transition polarity bit (P).

$$f_c = (f_{max}/256) [1 + D_7 * 2^7 + D_6 * 2^6 + D_5 * 2^5 + D_4 * 2^4 + D_3 * 2^3 + D_2 * 2^2 + D_1 * 2^1 + D_0 * 2^0]$$

where $D_0 - D_7 = "0" \text{ or } "1"$, and
 $f_{max} = \text{Maximum tunable frequency}$
 $f_c = \text{corner frequency}$
 Minimum tunable frequency = $f_{max}/256$ ($D_0 - D_7 = 0$)
 Minimum frequency step (Resolution) = $f_{max}/256$

Input Data Format

Frequency Select Bits

Positive Logic Logic "1" = +Vs
 Logic "0" = Gnd Logic threshold typ. = 0.45 Vs

Bit Weighting D0 = least significant bit (LSB)
 (Binary-Coded) D7 = most significant bit (MSB)

Frequency Range 256:1, Binary Weighted

MSB	---	---	---	---	---	---	LSB	<- Bit Weight
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	Corner Frequency (f_c)
D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
0	0	0	0	0	0	0	0	$f_{max}/256$
0	0	0	0	0	0	0	1	$f_{max}/128$
0	0	0	0	0	0	1	1	$f_{max}/64$
0	0	0	0	0	1	1	1	$f_{max}/32$
0	0	0	0	1	1	1	1	$f_{max}/16$
0	0	0	1	1	1	1	1	$f_{max}/8$
0	0	1	1	1	1	1	1	$f_{max}/2$
0	1	1	1	1	1	1	1	$f_{max}/4$
1	1	1	1	1	1	1	1	f_{max}

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7

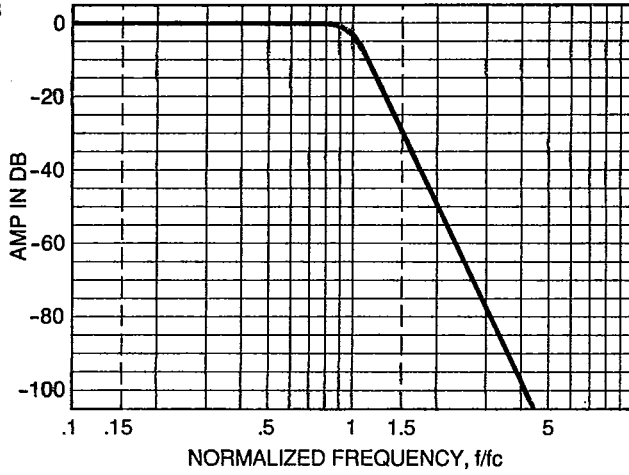


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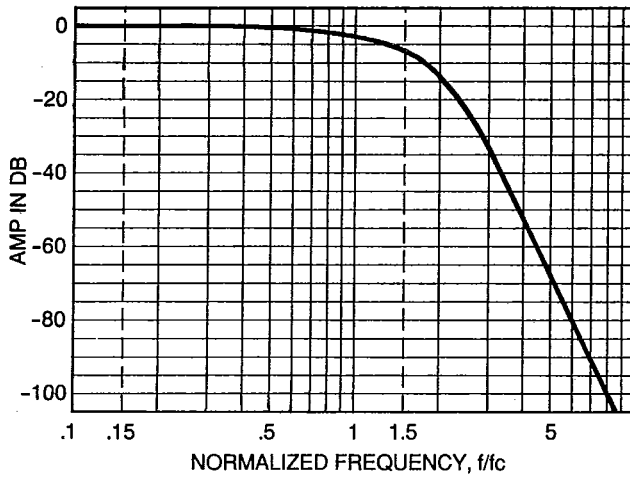
**Lowpass
Theoretical
Frequency Response
Curves**

T-64-05

Butterworth 848P8B



Bessel 848P8L



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8

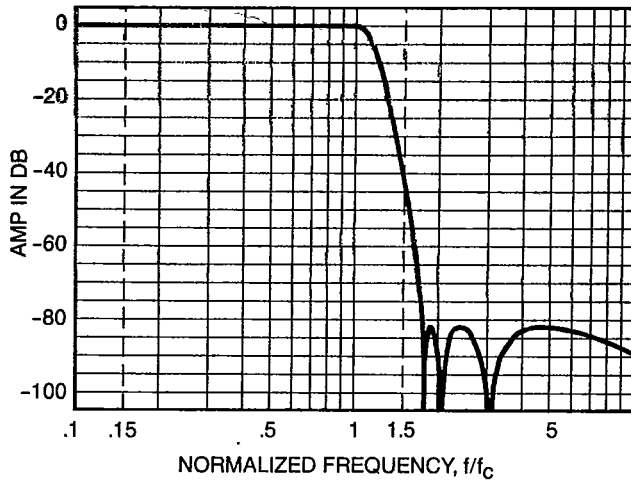


FREQUENCY DEVICES™

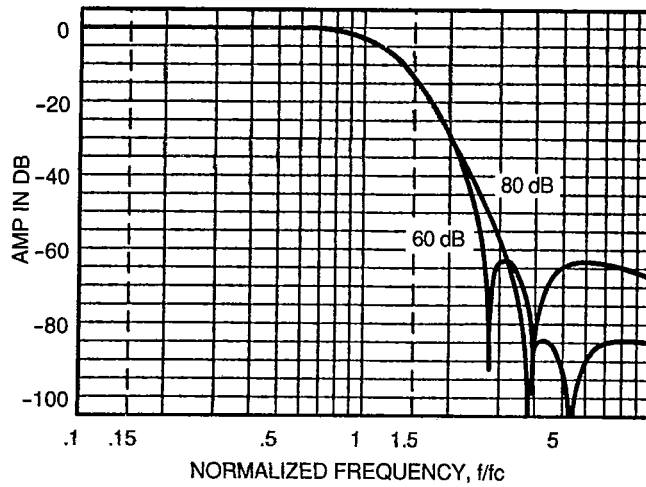
**Lowpass
Theoretical
Frequency Response
Curves**

T-64-05

Elliptic 848PE80



**Linear Phase
848DOW60
848DOW80**



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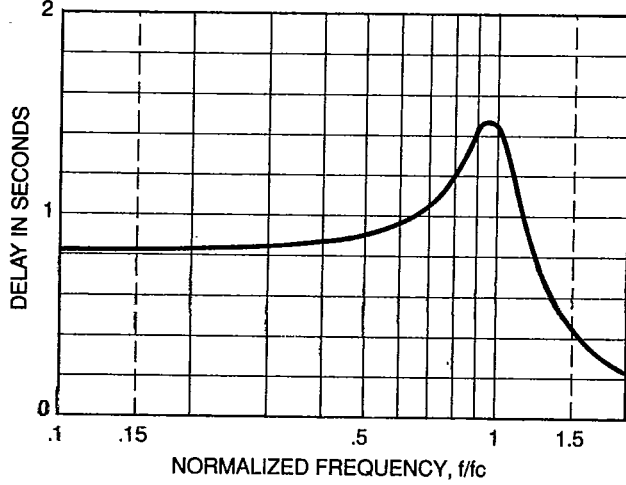


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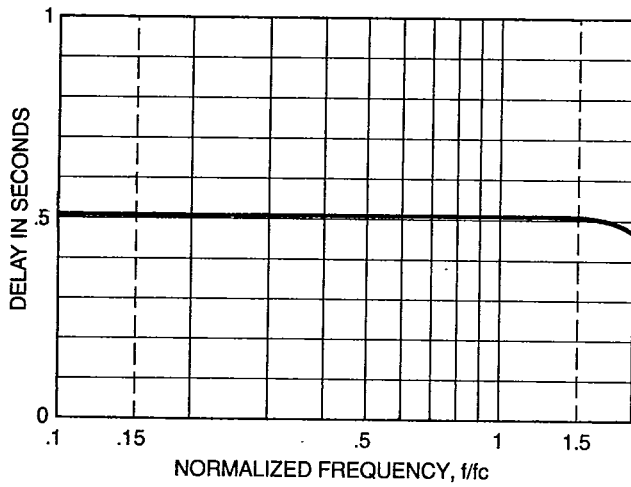
**Lowpass
Theoretical
Delay
Curves**

T-64-05

Butterworth 848P8B



Bessel 848P8L



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10

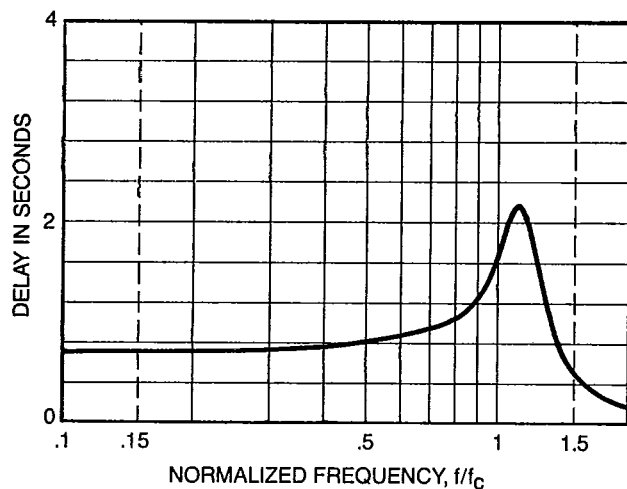


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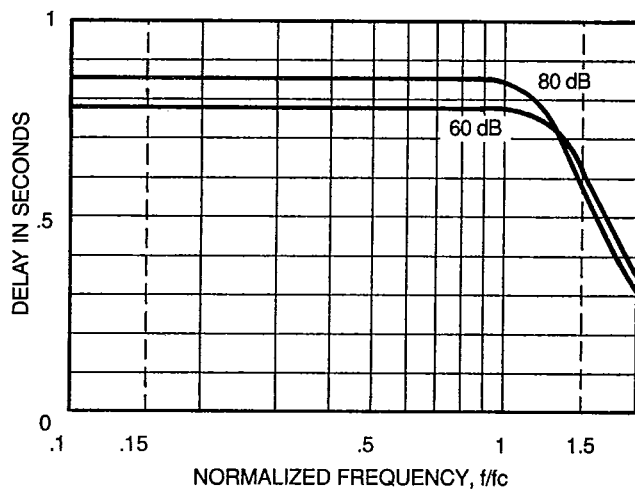
**Lowpass
Theoretical
Delay
Curves**

T-64-05

Elliptic 848P8E80



**Linear Phase
848DOW60
848DOW80**



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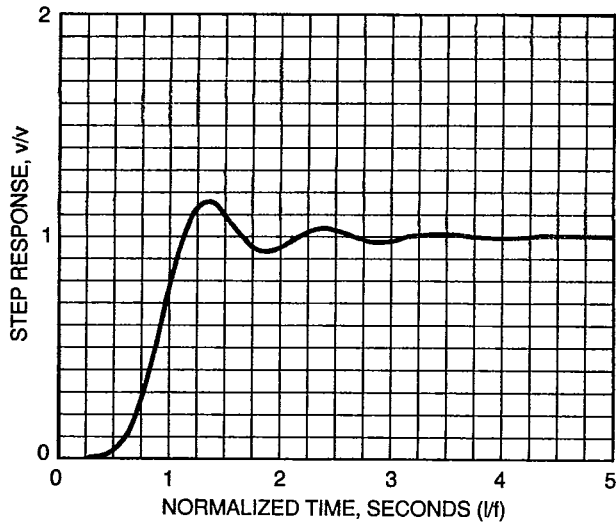


FREQUENCY DEVICES™

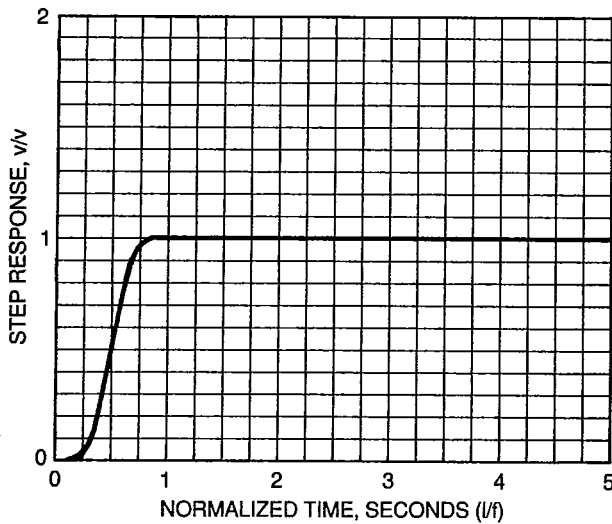
**Lowpass
Theoretical
Step Response
Curves**

T-64-05

Butterworth 848P8B



Bessel 848P8L



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12

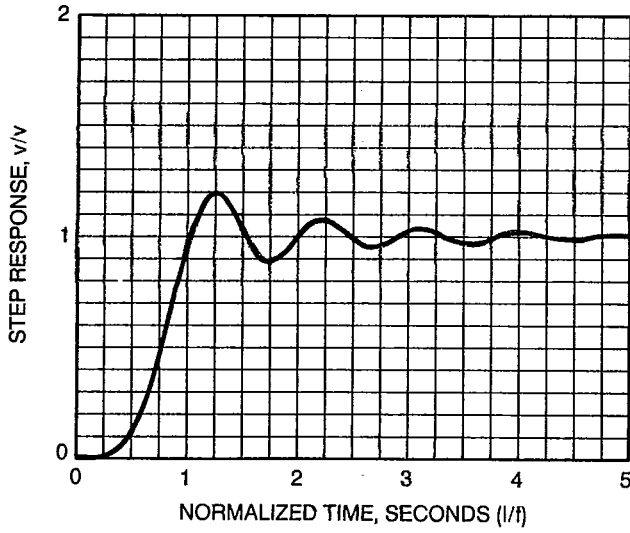


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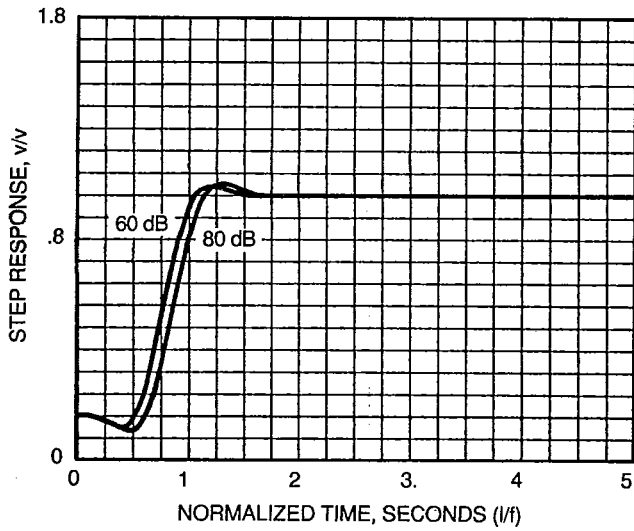
**Lowpass
Theoretical
Step Response
Curves**

T-64-05

Elliptic 848P8E80



**Linear Phase
848DOW60
848DOW80**



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**848P8B Butterworth
(8-Pole)Lowpass
Theoretical Response
Data**

T-64-05

f/fc	Amp (dB)	Phase (deg)	Delay (sec)
0.00	0.000	0.00	0.816
0.10	0.000	-29.4	0.819
0.20	0.000	-59.0	0.828
0.30	0.000	-89.1	0.843
0.40	0.000	-120	0.868
0.50	0.000	-152	0.902
0.60	0.000	-185	0.956
0.70	-0.014	-221	1.04
0.80	-0.121	-261	1.19
0.90	-0.738	-307	1.40
1.00	-3.01	-360	1.46
1.20	-12.9	-445	0.873
1.50	-28.2	-511	0.448
2.00	-48.2	-563	0.226
2.50	-63.7	-600	0.139
3.00	-76.3	-621	0.094
4.00	-96.3	-646	0.052
5.00	-111.8	-661	0.033
6.00	-124.5	-671	0.023
7.00	-132.2	-678	0.017
8.00	-144.5	-683	0.013
9.00	-152.7	-687	0.010
10.0	-160.0	-691	0.008

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14



**FREQUENCY
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**848P8L Bessel
(8-Pole) Lowpass *T-64-05*
Theoretical Response
Data**

f/fc	Amp (dB)	Phase (deg)	Delay (sec)
0.00	0.000	0.00	0.506
0.10	-0.029	-18.2	0.506
0.20	-0.117	-36.4	0.506
0.30	-0.264	-54.7	0.506
0.40	-0.470	-72.9	0.506
0.50	-0.747	-91.1	0.506
0.60	-1.06	-109.3	0.506
0.70	-1.45	-127.5	0.506
0.80	-1.91	-145.7	0.506
0.90	-2.42	-164.0	0.506
1.00	-3.01	-184.2	0.506
1.20	-4.40	-218.6	0.506
1.50	-7.08	-273.2	0.504
2.00	-13.7	-361.9	0.468
2.50	-23.1	-436.4	0.352
3.00	-33.4	-489.2	0.241
4.00	-51.8	-551.8	0.126
5.00	-66.8	-587.3	0.077
6.00	-79.2	-610.2	0.052
7.00	-89.8	-626.3	0.038
8.00	-99.0	-683.2	0.029
9.00	-107.1	-647.4	0.023
10.0	-114.4	-654.3	0.018

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15



**FREQUENCY
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**848P8E80 Elliptic
(8-Pole) Lowpass
Theoretical Response
Data**

T-64-05

Amplitude and Time Response Data

f/f_c	Amp (dB)	Phase (deg)	Delay (sec)
0.00	0.00	0.00	0.713
0.10	-.004	-25.7	0.716
0.20	-.014	-51.6	0.724
0.30	-.024	-77.9	0.740
0.40	-.020	-105	0.767
0.50	.007	-133	0.811
0.60	.033	-163	0.872
0.70	.014	-196	0.946
0.80	-.041	-232	1.04
0.90	-.016	-272	1.23
1.00	-.035	-323	1.65
1.20	-8.28	-467	1.86
1.40	-29.3	-558	0.753
1.60	-51.5	-594	0.381
1.70	-65.2	-606	0.296
1.80	-113	-616	0.239
1.85	-83.6	-440	0.217
1.90	-82.0	-444	0.198
1.95	-83.7	-447	0.182
2.00	-87.8	-450	0.168
2.20	-85.8	-280	0.126
3.00	99.9	-305	0.057
3.50	-87.2	-134	0.040
4.00	-83.1	-140	0.030
5.00	-82.1	-148	0.018
6.00	-83.1	-154	0.013
7.00	-84.6	-157	0.009
8.00	-86.2	-160	0.007
9.00	-87.8	-163	0.005
10.0	-89.3	-164	0.004

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16



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**848DOW Linear Phase
(8-Pole) Lowpass *T-64-05*
Theoretical Response
Data**

Amplitude and Time Response

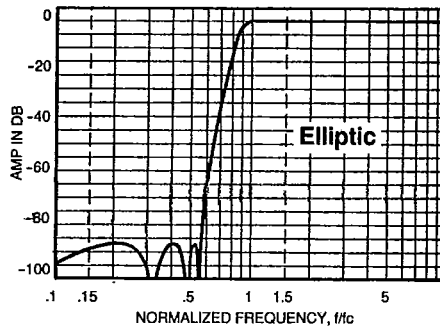
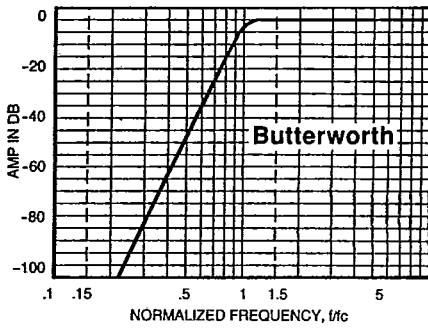
f/f _c	-60 dB Attenuation Floor			-80 dB Attenuation Floor		
	Amp (dB)	Phase (deg)	Delay (sec)	Amp (dB)	Phase (deg)	Delay (sec)
0.00	0.000	-0.00	0.776	0.000	0.00	0.852
0.10	0.005	-27.9	0.776	0.017	-30.7	0.852
0.20	0.012	-55.9	0.776	0.058	-61.4	0.852
0.30	0.005	-83.9	0.776	0.099	-92.0	0.852
0.40	-0.042	-112	0.776	0.105	-123	0.852
0.50	-0.160	-140	0.776	0.034	-153	0.852
0.60	-0.384	-168	0.776	-0.157	-184	0.852
0.70	-0.745	-196	0.776	-0.510	-215	0.852
0.80	-1.28	-224	0.776	-1.07	-245	0.851
0.90	-2.02	-252	0.776	-1.89	-276	0.849
1.00	-3.01	-279	0.773	-3.01	-306	0.841
1.50	-13.0	-409	0.620	-14.1	-440	0.582
2.00	-29.4	-495	0.351	-29.1	-517	0.312
2.50	-50.5	-544	0.212	-43.4	-561	0.189
3.00	-63.7	-395	0.142	-57.6	-589	0.126
10.0	-67.3	-318	0.012	-84.9	-321	0.011

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17



878 Series *T-64-05*
**Theoretical Highpass
 Butterworth and Elliptic
 Response Data**



Normalized Theoretical Data Tables

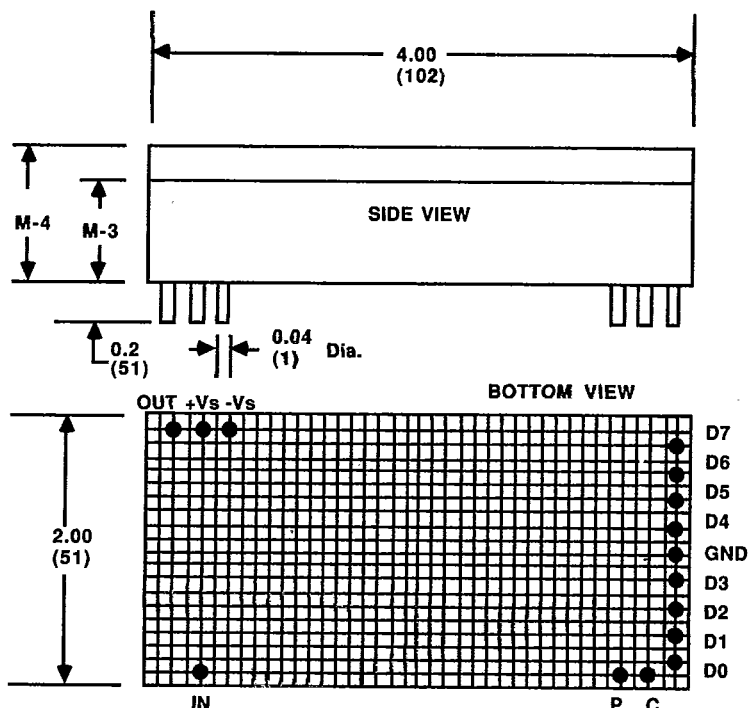
f/fc	Butterworth Response			Elliptic Response		
	Amp (dB)	Phase (deg)	Delay (sec)	Amp (dB)	Phase (deg)	Delay (sec)
0.10	-160	690.6	0.819	-89.3	164.3	0.440
0.20	-112	661.0	0.828	-82.1	140.1	0.459
0.30	-83.7	630.9	0.843	-90.6	131.0	0.495
0.40	-63.7	600.2	0.867	-82.4	292.2	0.559
0.50	-48.2	568.3	0.903	-87.8	450.2	0.671
0.55	-41.5	551.9	0.927	-90.0	437.4	0.761
0.60	-35.5	534.9	0.956	-60.1	602.6	0.890
0.70	-24.8	499.1	1.04	-32.4	563.1	1.37
0.80	-15.6	459.2	1.19	13.1	497.5	2.35
0.90	-8.1	412.6	1.40	-2.2	401.0	2.66
1.00	-3.0	360.0	1.46	-0.04	323.5	1.65
1.20	-0.2	275.5	0.873	-0.05	244.8	0.757
1.50	-0.01	208.6	0.448	-0.03	185.1	0.409
2.00	0.0	151.7	0.226	-0.01	133.4	0.203
2.50	0.0	119.8	0.139	-0.02	105.0	0.123
3.00	0.0	99.2	0.095	-0.03	86.9	0.083
4.00	0.0	74.0	0.052	-0.02	64.7	0.046
5.00	0.0	59.0	0.033	-0.01	51.6	0.029
6.00	0.0	49.1	0.023	-0.01	42.9	0.020
7.00	0.0	42.1	0.017	-0.01	36.8	0.015
8.00	0.0	36.8	0.018	-0.01	32.1	0.011
9.00	0.0	32.7	0.010	-0.01	28.6	0.009
10.0	0.0	29.4	0.008	0.0	25.7	0.007

18
 Frequency Devices Incorporated 25 Locust Street Haverhill, Massachusetts 01830 (508) 374-0761 TWX 710-347-0314 FAX (508) 521-1839



FREQUENCY DEVICES™

**848/878 Series
Package
and
Pin-out Data** *T-64-05*



Package and Pin-out Data - Dimensions in Inches (mm)

Case Dimensions. All 848/878 Series Models

Case	Dimensions in inches and (mm)
M-3	2.0"W x 4.0"L x 0.75"H (51 x 102 x 25 mm)
M-4	2.0"W x 4.0"L x 1.0"H (51 x 102 x 25 mm)

Terminal Key

In	Analog Input Signal	D ₀	Tuning Bit 0 (LSB)
Out	Analog Output Signal	D ₁	Tuning Bit 1
GND	Power and Signal Return	D ₂	Tuning Bit 2
"P"	Transition Polarity Bit	D ₃	Tuning Bit 3
"C"	Tuning Strobe Bit	D ₄	Tuning Bit 4
+Vs	Supply Voltage, Positive	D ₅	Tuning Bit 5
-Vs	Supply Voltage, Negative	D ₆	Tuning Bit 6
		D ₇	Tuning Bit 7 (MSB)

Frequency	25	Haverhill,	(508) 374-0761
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19



**FREQUENCY
DEVICES™**

Ordering Information
848 Series *T-64-05*
Bessel, Butterworth
and Elliptic Models

Butterworth Versions

Model Number	No. Poles	Range	Tuning (Hz)		Case
			Min.	Step	
848P8B-1	8	0.1 to 25.6	0.1		M-4
848P8B-2	8	1.0 to 256	1.0		M-3
848P8B-3	8	10 to 2560	10		M-3
848P8B-4	8	100 to 25.6k	100		M-3
848P8B-5	8	200 to 51.2k	200		M-3

Bessel Version

Model Number	No. Poles	Range	Tuning (Hz)		Case
			Min.	Step	
848P8L-1	8	0.1 to 25.6	0.1		M-4
848P8L-2	8	1.0 to 256	1.0		M-3
848P8L-3	8	10 to 2560	10		M-3
848P8L-4	8	100 to 25.6k	100		M-3
848P8L-5	8	200 to 51.2k	200		M-3

Elliptic Versions

Model Number	No. Poles	Range	Tuning (Hz)		Case
			Min.	Step	
848P8P8E80-1	8	0.1 to 25.6	0.1		M-4
848P8P8E80-2	8	1.0 to 256	1.0		M-3
848P8P8E80-3	8	10 to 2560	10		M-3
848P8P8E80-4	8	100 to 25.6k	100		M-3
848P8P8E80-5	8	200 to 51.2k	200		M-3

Frequency	25	Haverhill,	(508) 374-0761
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20



FREQUENCY DEVICES™

Ordering information
848DOW

T-64-05

Linear Phase
Lowpass Models

-60 dB Attenuation Floor

Model Number	No. Poles	Range	Tuning (Hz)		Case
			Min.	Step	
848P8DOW60-1	8	0.1 to 25.6	0.1		M-4
848P8DOW60-2	8	1.0 to 256	1.0		M-3
848P8DOW60-3	8	10 to 2560	10		M-3
848P8DOW60-4	8	100 to 25.6k	100		M-3
848P8DOW60-5	8	200 to 51.2k	200		M-3

-80 dB Attenuation Floor

Model Number	No. Poles	Range	Tuning (Hz)		Case
			Min.	Step	
848P8DOW80-1	8	0.1 to 25.6	0.1		M-4
848P8DOW80-2	8	1.0 to 256	1.0		M-3
848P8DOW80-3	8	10 to 2560	10		M-3
848P8DOW80-4	8	100 to 25.6k	100		M-3
848P8DOW80-5	8	200 to 51.2k	200		M-3

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21



Ordering Information

878 Series

Highpass Models

T-64-05

Butterworth Versions

Model Number	No. Poles	Range	Tuning (Hz)		Case
			Min.	Step	
878P8B-1	8	0.1 to 25.6	0.1		M-4
878P8B-2	8	1.0 to 256	1.0		M-3
878P8B-3	8	10 to 2560	10		M-3
878P8B-4	8	100 to 25.6k	100		M-3
878P8B-5	8	200 to 51.2k	200		M-3

Elliptic Versions

Model Number	No. Poles	Range	Tuning (Hz)		Case
			Min.	Step	
878P8E-1	8	0.1 to 25.6	0.1		M-4
878P8E-2	8	1.0 to 256	1.0		M-3
878P8E-3	8	10 to 2560	10		M-3
878P8E-4	8	100 to 25.6k	100		M-3
878P8E-5	8	200 to 51.2k	200		M-3

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