



FREQUENCY DEVICES INC.

FEATURES

Fixed Frequency Lowpass Active Filters Featuring:

- **Extremely Steep Rolloff at Stopband Edge to Deep Attenuation Floor**
- **Choice of Attenuation Floors: 54, 66, 78 and 90dB Models**
- **Choice of Phase- & Gain-Matched or General-Purpose, Economy Models**
- **Plug-in Ready-to-Use Fully Finished Filter Component**

APPLICATIONS

Data Conversion and Signal Conditioning Including:

- **Anti-Aliasing 8-, 10-, 12- and 14-Bit A/Ds by Specific 650/670 Series Models**
- **Precision Multi-Channel A/D Prefiltering Using Matched 650/670 Filters**
- **Noise-Critical Applications Including Medical, Scientific & Process Measurement and Control Instrumentation**
- **PCM Transmit & Receive**

GENERAL DESCRIPTION

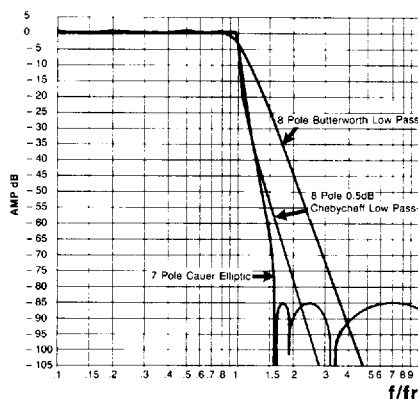
The **650 and 670 Series** are 5th and 7th order Caue elliptic lowpass active filters, respectively, which pass signals between dc and stopband edge frequency f_r . Above f_r , attenuation sharply increases to the "floor" value specified at the somewhat greater f_s .

The Shape Factor $Sf (= f_s/f_r)$ measures steepness of rolloff. Band-edge frequencies of 100Hz to 25kHz may be specified at time of order.

These filters are especially ideal for anti-aliasing 8-, 10-, 12- and 14-bit A/D converters. All models are designed to attenuate stopband frequencies input to an n-bit A/D by a minimum of $-6db(n+1)$ at the attenuation floor.

Frequency Devices ensures the floor depth by specifying the somewhat lower, first frequency (f_a) at which the attenuation is sufficient to reduce signals in the stopband to well below $\frac{1}{2}$ LSB of the n-bit A/D of interest. (See discussion on next page.)

All **650/670 Series** models are fully finished filters which require no external components or adjustments, and operate from non-critical ± 12 to $\pm 18V$ power supplies. A $20K\Omega$ input impedance and a 10Ω (max) output impedance make these small encapsulated plug-in modules easy to interface with A/D converters.



Typical LowPass Filter Transfer Characteristics

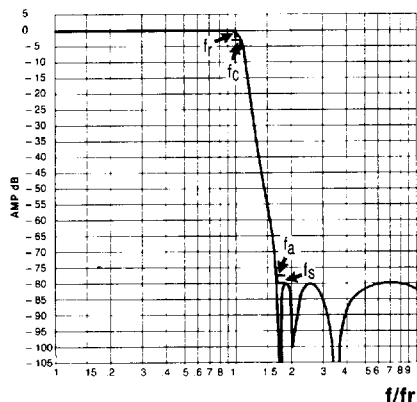
Frequency 25 Haverhill,
 Devices Locust Massachusetts
 Incorporated Street 01832

(508) 374-0761
 FAX
 (508) 521-1839



FREQUENCY DEVICES INC

GENERAL ELLIPTIC FILTER CHARACTERISTICS



The extreme steepness of 5th and 7th order active lowpass elliptic filters is utilized best when both the conversion process the filter characteristics are well understood. The following defines key parameters and their relationship to data conversion.

Basic Definitions: In the **passband**, filter attenuation is least (usually 0 dB), and a characteristic low-level ripple exists.

The passband extends from dc to **stop-band edge** frequency f_r , the highest frequency at which passband ripple occurs. The stopband edge is also the transition point where a small increase in frequency gives a large increase in attenuation.

The next highest frequency defined is **corner frequency** f_c at which attenuation increases to 3 dB. Next defined, is the frequency f_a at which attenuation attains a value of 6dB ($n+1$); n is the resolution (in bits) of the n -bit A/D to be pre-filtered. (More on next page.)

The highest frequency defined, f_s , locates the first frequency at which the specified **attenuation floor** occurs.

The **transition band** is defined as the frequencies bounded by f_r and f_s , the region of greatest attenuation change.

Shape factor $Sf (= f_s/f_r)$ is a useful measure of attenuation steepness. It improves (approaches 1) as the order n increases; a 7th order elliptic rolls off faster than a 5th order elliptic.

Pages 8, 9 and 10 present curves and data of Frequency Devices' 5th and 7th order elliptic designs, and demonstrate the different rolloffs.

FILTER PARAMETERS AT WORK

A nearly flat passband response that rolls sharply down to a well defined, deep stop-band attenuation floor ideally suits Cauer elliptic lowpass active filters for prefiltering analog-to-digital (A/D) converter input signals. The reasons become obvious when the process and effects of A/D conversion are reviewed.



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650/670 SERIES
APPLICATION NOTES
AND USER GUIDELINES

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The A/D is a Signal Sampler

An n-bit A/D converter samples analog signals on a periodic basis. It generates an n-bit digital output code that corresponds to the value of the analog signal at a particular instant in a sampling interval.

A n-bit binary-coded A/D digitizes full scale analog input V_f s into 2^n levels. The least significant bit (LSB) represents an input of $V_f/2^n$, the most significant bit (MSB) $V_f/2^1 = V_f/2$. Each bit represents twice the input of its adjacent less significant neighbor.

The sampling rate, is crucial to the successful recovery of a digitized signal. The Sampling Theorem defines the minimum sampling rate as follows: Complete recovery of a continuous signal $f(x)$ from a sampled signal $f(p)$ requires a sampling repetition frequency f_{sr} high enough to take at least two samples of the highest significant frequency of $f(x)$, including noise.

Sampling generates sideband frequencies that produce the original spectrum, plus shifted original spectra centered about f_{sr} , $2f_{sr}$, $3f_{sr}$, etc. Too low a sampling frequency will cause overlap between the original spectrum and the one centered about f_{sr} . This is called **frequency folding**, and the frequency at which the two spectra intersect is called the **folding frequency**.

Frequency folding produces **aliasing**, the generation of frequencies that do not exist in the original spectrum. The problem can be minimized, but never fully

eliminated, by either sampling at a higher rate or sharply limiting the bandwidth to $f_{sr}/2$.

The **650/670 Series** Causer elliptic lowpass active filters provide near-ideal sharp attenuation, so can perform this function well. Passband gain and ripple are tightly controlled to apply a well defined non-inverting unity gain between dc and f_r .

F_r denotes the end of the passband. It is the frequency at which the passband gain first falls below the passband ripple, and marks the onset of sharp reduction of gain. Set $f_r = f_{sr}/2$ to minimize aliasing.

The gain then falls abruptly, so that at $f_a (> f_r)$, it reduces to $-6(1+n)$ dB, with n the resolution of the n-bit A/D to be prefiltered. This ensures that out-of-band signals will be attenuated to well below the 0.5 LSB threshold of the A/D.

The frequency $f_s (> f_a)$ is the first point at which the attenuation floor is reached. The floor attenuation is greater than at f_a , and **REMAINS SO** over the full specified frequency range.

For ease of selection, Shape Factor ($Sf = fr/fs$) defines the transition band of all **650 and 670 Series** models. These filters provide the flat passband; the well defined, sharp gain reduction in the transition band; and the deep, maintained attenuation floor required to achieve effective A/D prefiltering.

FILTER ATTENUATION RELATIVE TO A/D CONVERTER LSB WEIGHTING

A/D RESOLUTION (In Bits)	A/D CONVERTER CHARACTERISTICS		FILTER RESPONSE	
	LSB WEIGHT $1/2^n$	LSB WEIGHT (APPROX.)	1/2 LSB WEIGHT	GAIN @ F_a^*
8-Bits	1/256	-48 dB	-54 dB	-54 dB
10-Bits	1/1024	-60 dB	-66 dB	-66 dB
12-Bits	1/4096	-72 dB	-78 dB	-78 dB
14-Bits	1/16384	-84 dB	-90 dB	-90 dB

*At f_a , the filter attenuation just equals the A/D's 0.5LSB weighting. The filter design ensures that signals from f_a through f_s and above are attenuated to well below the A/D threshold.

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Frequency 25 Haverhill,
Devices Locust Massachusetts
Incorporated Street 01832

(508) 374-0761
FAX
(508) 521-1839



FREQUENCY DEVICES INC

ANALOG SPECIFICATIONS (Typical @ 25° C & ±15Vdc unless otherwise noted)

RESPONSE CHARACTERISTICS	FOR 8-BIT A/Ds		FOR 10-BIT A/Ds	
	651	652	653	654
Ripple Frequency (fr) (User Specified)	100 Hz-25kHz	*	*	*
Data and Curves Fig. & Table	1 & 1	*	2 & 2	
Pass band Gain (Non-inverting) @ fr	0 ± 0.2dB	0 ± 0.05dB	0 ± 0.2dB	0 ± 0.05dB
Ripple: dc to fr typ/max	± 0.05/0.2dB	*	*	*
Transition Band Gain @ fc (= 1.110 fr)	- 3dB	*	—	—
@ fc (= 1.120 fr)	—	—	- 3dB	*
@ fa (= 1.872 fr)	- 54dB	*	—	—
@ fa (= 2.355 fr)	—	—	- 66dB	*
Shape Factor Sf = fr/fs	1.887	*	2.366	*
Conformance to Theoretical				
Phase: 0 to fr	± 5° max	± 2° max	± 5° max	± 2° max
Gain: 0 to fr	± 0.5dB max	± 0.2db max	± 0.5dB max	± 0.2dB max
DC OFFSET**				
Offset Voltage	± 10mV typ ± 25mV max	± 2mV typ ± 5mV max	± 10mV typ ± 25mV max	± 2mV typ ± 5mV max
Offset Drift: typ max	± 10µV/°C ± 30µV/°C	* *	* *	* *
POWER SUPPLY				
Quiescent Current	± 14mA typ ± 18mA max	± 17mA typ ± 21mA max	± 14mA typ ± 18 mA max	± 17mA typ ± 21mA max
PACKAGING				
Case Style	G-1	H-1	G-1	H-1
Dimensions (inches)	1.5 x 2.0 x 0.4	2.0 x 2.0 x 0.4	1.5 x 2.0 x 0.4	2.0 x 2.0 x 0.4
*Same as specification to left. **Adjustable to zero; see page 7.				



FREQUENCY DEVICES INC

ANALOG SPECIFICATIONS (Typical @ 25° C & ±15Vdc unless otherwise noted)

RESPONSE CHARACTERISTICS	FOR 8-BIT A/Ds		FOR 10-BIT A/Ds	
	671	672	673	674
Ripple Frequency (fr) (User Specified)	100 Hz-25kHz	*	*	*
Data and Curves Fig. & Table	3 & 3	*	4 & 4	
Pass band Gain (Non-inverting) @ fr	0 ± 0.2dB	0 ± 0.05dB	0 ± 0.2dB	0 ± 0.05dB
Ripple: dc to fr typ/max	± 0.05/0.2dB	*	*	*
Transition Band Gain @ fc (= 1.0378 fr)	- 3dB	*	—	—
@ fc (= 1.0459 fr)	—	—	- 3dB	*
@ fa (= 1.2493 fr)	- 54dB	*	—	—
@ fa (= 1.4116 fr)	—	—	- 66dB	*
Shape Factor Sf = fr/fs	1.2521	*	1.414	*
Conformance to Theoretical				
Phase: 0 to fr	± 5° max	± 2° max	± 5° max	± 2° max
Gain: 0 to fr	± 0.5dB max	± 0.2db max	± 0.5 dB max	± 0.2dB max
DC OFFSET**				
Offset Voltage	± 10mV typ ± 25mV max	± 2mV typ ± 5mV max	± 10mV typ ± 25mV max	± 2mV typ ± 5mV max
Offset Drift: typ max	± 15µV/°C ± 45µV/°C	* *	* *	* *
POWER SUPPLY				
Quiescent Current	± 21mA typ ± 27mA max	± 24mA typ ± 30mA max	± 21mA typ ± 27mA max	± 24mA typ ± 30mA max
PACKAGING				
Case Style Dimensions (inches)	H-1 2.0 x 2.0 x 0.4	C-A 2.0 x 3.0 x 0.4	H-1 2.0 x 2.0 x 0.4	C-A 2.0 x 3.0 x 0.4

*Same as specification to left.

**Adjustable to zero; see page 7.


**FREQUENCY
DEVICES™**
**670 SERIES ANALOG
SPECIFICATIONS CONT'D.**
FREQUENCY DEVICES INC
ANALOG SPECIFICATIONS (Typical @ 25° C & ±15Vdc unless otherwise noted)

RESPONSE CHARACTERISTICS	FOR 12-BIT A/Ds		FOR 14-BIT A/Ds	
	675	676	677	678
Ripple Frequency (fr) (User Specified)	100 Hz-25kHz	*	*	*
Data and Curves Fig. & Table	5 & 5	*	6 & 6	
Passband Gain (Non-inverting) @ fr	0 ± 0.2dB	0 ± 0.05dB	0 ± 0.2dB	0 ± 0.05dB
Ripple: dc to fr typ/max	± 0.05/0.2dB	*	*	*
Transition Band Gain @ fc (= 1.0530 fr)	-3dB	*	—	—
@ fc (= 1.0575 fr)	—	—	-3dB	*
@ fa (= 1.6543 fr)	-78dB	*	—	—
@ fa (= 1.9348 fr)	—	—	-90dB	*
Shape Factor Sf = fr/fs	1.6616	*	1.9416	*
Conformance to Theoretical				
Phase: 0 to fr	± 5° max	± 2° max	± 5° max	± 2° max
Gain: 0 to fr	± 0.5dB max	± 0.2db max	± 0.5 dB max	± 0.2dB max
DC OFFSET**				
Offset Voltage	± 10mV typ ± 25mV max	± 2mV typ ± 5mV max	± 10mV typ ± 25mV max	± 2mV typ ± 5mV max
Offset Drift: typ max	± 15μV/°C ± 45μV/°C	* *	* *	* *
POWER SUPPLY				
Quiescent Current	± 21mA typ ± 27mA max	± 24mA typ ± 30mA max	± 21mA typ ± 27mA max	± 24mA typ ± 30mA max
PACKAGING				
Case Style	H-1	C-A	H-1	C-A
Dimensions (inches)	2.0 x 2.0 x 0.4	2.0 x 3.0 x 0.4	2.0 x 2.0x 0.4	2.0 x 3.0 x 0.4

*Same as specification to left.

**Adjustable to zero; see page 7.


FREQUENCY DEVICES INC
SPECIFICATIONS COMMON TO ALL 650 & 670 SERIES MODELS
 (Typical @ 25°C & $\pm 15\text{Vdc}$ unless otherwise noted)

INPUT CHARACTERISTICS (1)

Input Impedance	20 Kilohms min
Input Voltage Range	$\pm 10\text{V}$ min
Maximum Safe Input Voltage	$\pm V_s$ max

OUTPUT CHARACTERISTICS (1)

Output Resistance	10 Ohms max
Linear Voltage Range	$\pm 10\text{V}$ min
Rated Load Current (2)	$\pm 5\text{mA}$ min
Output Noise (3)	50 μV RMS

POWER SUPPLY ($\pm V_s$)

Rated Supply Voltage	$\pm 15\text{Vdc}$
Operating Supply Range	± 5 to $\pm 18\text{Vdc}$ max
Safe Supply Voltage	$\pm 18\text{Vdc}$ max

TEMPERATURE

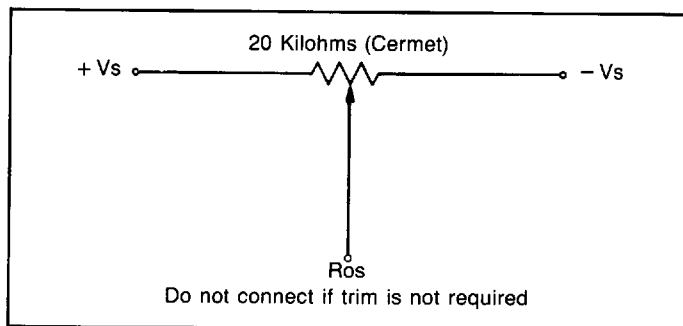
Operating	0°C to +70°C
Storage (non-operating)	-25°C to +85°C

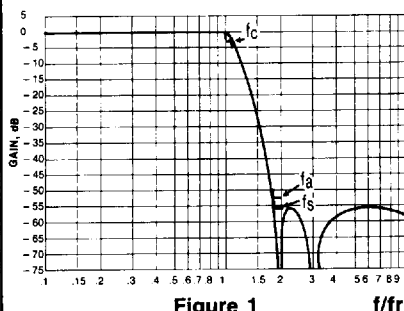
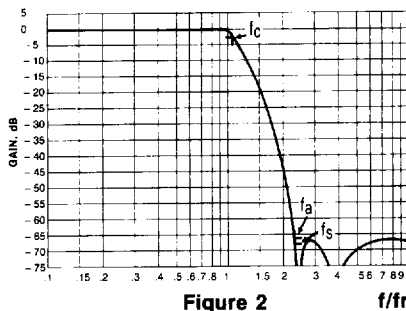
Notes (Common to all models):

- (1) Input and output voltages are referenced to supply common.
- (2) Output short circuit protected to common. DO NOT CONNECT OUTPUT TO $\pm V_s$.
- (3) Measured in 5Hz to 50kHz bandwidth.

650/670 SERIES MATING SOCKETS

MODELS	651/653	652/654	671/3/5/7	672/4/6/8
SOCKETS	S1006	S1006	S1006	S1002


Offset Potentiometer (Optional)


**FREQUENCY
DEVICES™**
**651 - 654 SERIES
THEORETICAL RESPONSE
CHARACTERISTICS**
FREQUENCY DEVICES INC
651, 652

Figure 1
653, 654

Figure 2
NORMALIZED THEORETICAL DATA TABLES
Table 1
651 & 652 Series
Table 2
653 & 654 Series

f/f_c	AMP (dB)	PHASE (deg)	DELAY (sec)	AMP (dB)	PHASE (deg)	DELAY (sec)
0.00	0.00	00.0	0.493	0.00	00.0	0.518
0.10	-0.02	-17.7	0.492	-0.02	-18.7	0.516
0.15	-0.04	-26.6	0.491	-0.04	-27.9	0.515
0.20	-0.06	-35.5	0.491	-0.07	-37.2	0.515
0.25	-0.08	-44.4	0.494	-0.09	-46.5	0.517
0.30	-0.10	-53.2	0.499	-0.10	-55.8	0.521
0.35	-0.10	-62.2	0.507	-0.10	-65.2	0.529
0.45	-0.07	-81.0	0.536	-0.06	-84.7	0.557
0.50	-0.04	-90.8	0.556	-0.03	-94.9	0.576
0.55	-0.02	-101	0.579	-0.01	-105	0.599
0.60	-0.00	-112	0.604	0.00	-116	0.612
0.65	-0.00	-123	0.630	-0.01	-128	0.641
0.70	-0.03	-134	0.656	-0.03	-140	0.662
0.75	-0.06	-146	0.685	-0.07	-152	0.686
0.80	-0.09	-159	0.722	-0.10	-164	0.719
0.85	-0.10	-173	0.780	-0.09	-178	0.772
0.90	-0.06	-187	0.872	-0.05	-192	0.861
0.95	-0.00	-205	1.04	-0.00	-209	1.00
1.00	-0.10	-225	1.27	-0.10	-229	1.20
1.10	-2.50	-277	1.43	-2.16	-277	1.34
1.20	-9.53	-318	0.970	-7.35	-317	0.867
1.30	-15.2	-342	0.509	-13.2	-341	0.520
1.40	-21.4	-357	0.339	-18.6	-356	0.347
1.50	-27.4	-368	0.248	-23.6	-367	0.253
1.60	-33.3	-376	0.193	-28.2	-375	0.197
1.70	-39.6	-382	0.156	-32.6	-381	0.159
1.80	-46.9	-387	0.130	-36.9	-386	0.132
1.90	-57.8	-391	0.111	-41.1	-391	0.112
2.00	-67.9	-215	0.096	-45.5	-395	0.097
2.25	-55.9	-222	0.054	-58.2	-402	0.070
2.50	-57.8	-228	0.070	-83.6	-228	0.054
2.75	-63.4	-232	0.043	-67.7	-232	0.043
3.00	-80.1	-236	0.035	-67.5	-235	0.035
3.25	-63.6	-58.4	0.029	-69.9	-238	0.029
3.50	-62.7	-60.8	0.025	-74.4	-241	0.025
3.75	-59.9	-62.3	0.021	-83.4	-243	0.021
4.00	-58.4	-64.3	0.018	-87.8	-65.5	0.019
4.25	-57.4	-66.2	0.016	-77.6	-66.1	0.016
4.50	-58.8	-67.6	0.014	-73.8	-67.5	0.014
5.00	-56.1	-69.9	0.012	-70.2	-69.8	0.012
6.00	-55.9	-73.3	0.008	—	—	—
7.00	-56.3	-75.7	0.006	—	—	—
9.00	-57.5	-78.9	0.003	—	—	—
10.00	-58.2	-80.1	0.003	—	—	—

Frequency 25 Haverhill,
Devices Locust Massachusetts
Incorporated Street 01832

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FAX
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**FREQUENCY
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**671 - 674 SERIES
THEORETICAL RESPONSE
CHARACTERISTICS**
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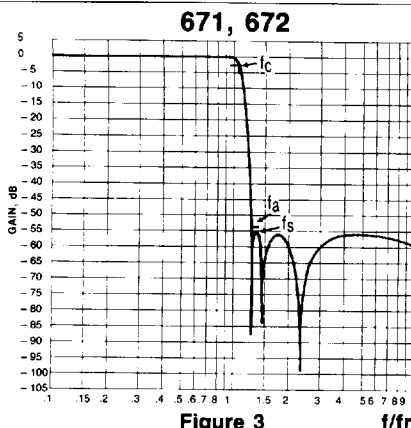


Figure 3

f/fr

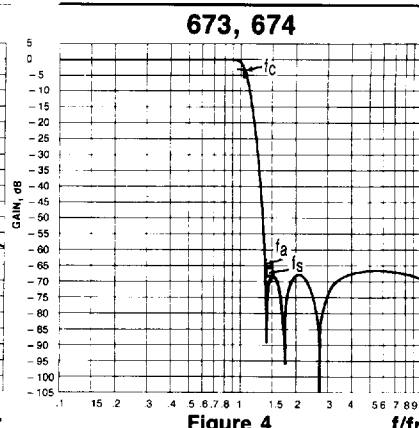


Figure 4

f/fr

NORMALIZED THEORETICAL DATA TABLES

Table 3

671 & 672 Series

Table 4

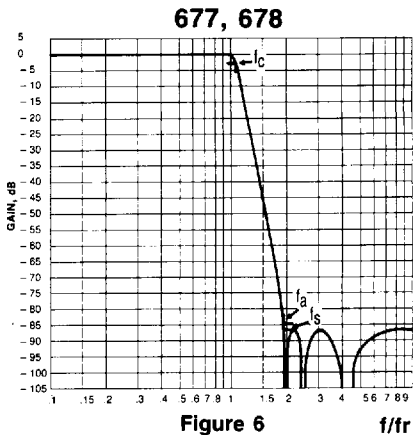
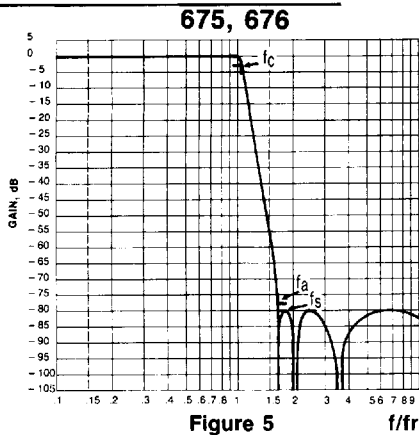
673 & 674 Series

f/f _c	AMP (dB)	PHASE (deg)	DELAY (sec)	AMP (dB)	PHASE (deg)	DELAY (sec)
0.00	0.00	00.0	0.631	0.00	00.0	0.698
0.10	-0.03	-22.7	0.630	-0.03	-25.1	0.696
0.15	-0.05	-34.0	0.630	-0.06	-37.6	0.695
0.20	-0.08	-45.4	0.634	-0.09	-50.2	0.698
0.25	-0.10	-56.9	0.642	-0.10	-62.8	0.706
0.30	-0.10	-68.5	0.656	-0.09	-65.6	0.721
0.35	-0.08	-80.5	0.677	-0.07	-88.8	0.744
0.45	-0.02	-106	0.740	-0.01	-117	0.806
0.50	0.00	-120	0.778	0.00	-132	0.841
0.55	0.00	-134	0.819	-0.02	-147	0.874
0.60	-0.03	-149	0.861	-0.05	-163	0.909
0.65	-0.07	-165	0.910	-0.09	-180	0.954
0.70	-0.10	-182	0.977	-0.10	-197	1.02
0.75	-0.09	-200	1.08	-0.07	-217	1.12
0.80	-0.04	-221	1.23	-0.01	-238	1.25
0.85	0.00	-245	1.43	-0.01	-262	1.42
0.90	-0.05	-273	1.69	-0.07	-299	1.61
0.95	-0.09	-307	2.14	-0.08	-321	1.99
1.00	-0.10	-356	3.64	-0.10	-365	3.08
1.10	-15.6	-475	1.65	-11.5	-472	1.74
1.20	-35.5	-512	0.670	-27.0	-511	0.695
1.30	-57.9	-351	0.409	-41.8	-530	0.418
1.40	-59.6	-363	0.289	-61.9	-543	0.293
1.50	-68.4	-192	0.220	-67.6	-372	0.222
1.60	-57.9	-199	0.175	-70.2	-379	0.177
1.70	-55.8	-205	0.144	-105	-385	0.145
1.80	-55.7	-210	0.121	-72.6	-209	0.122
1.90	-56.8	-214	0.104	-68.5	-213	0.104
2.00	-58.6	-217	0.090	-67.2	-217	0.095
2.25	-68.1	-224	0.066	-68.3	-224	0.067
2.50	-71.4	-49.3	0.510	-73.0	-229	0.051
2.75	-62.4	-53.4	0.041	-84.2	-233	0.041
3.00	-59.2	-56.7	0.033	-82.4	-56.6	0.034
3.25	-57.5	-59.5	0.028	-74.8	-59.3	0.028
3.50	-56.6	-61.8	0.024	-71.6	-61.7	0.024
3.75	-56.0	-63.8	0.020	-69.8	-63.7	0.021
4.00	-55.7	-65.5	0.018	-68.7	-65.4	0.018
4.25	-55.6	-67.0	0.016	-68.0	-66.9	0.016
4.50	-55.6	-68.3	0.014	-67.6	-68.2	0.014
5.00	-55.7	-70.5	0.011	-67.2	-70.5	0.011
6.00	-56.3	-73.9	0.008	-67.2	-73.8	0.008
7.00	-57.1	-76.2	0.006	-67.7	-76.1	0.006
9.00	-58.7	-79.3	0.003	-70.0	-79.3	0.003
10.00	-59.4	-80.4	0.003	-69.6	-80.3	0.003

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 (508) 521-1839

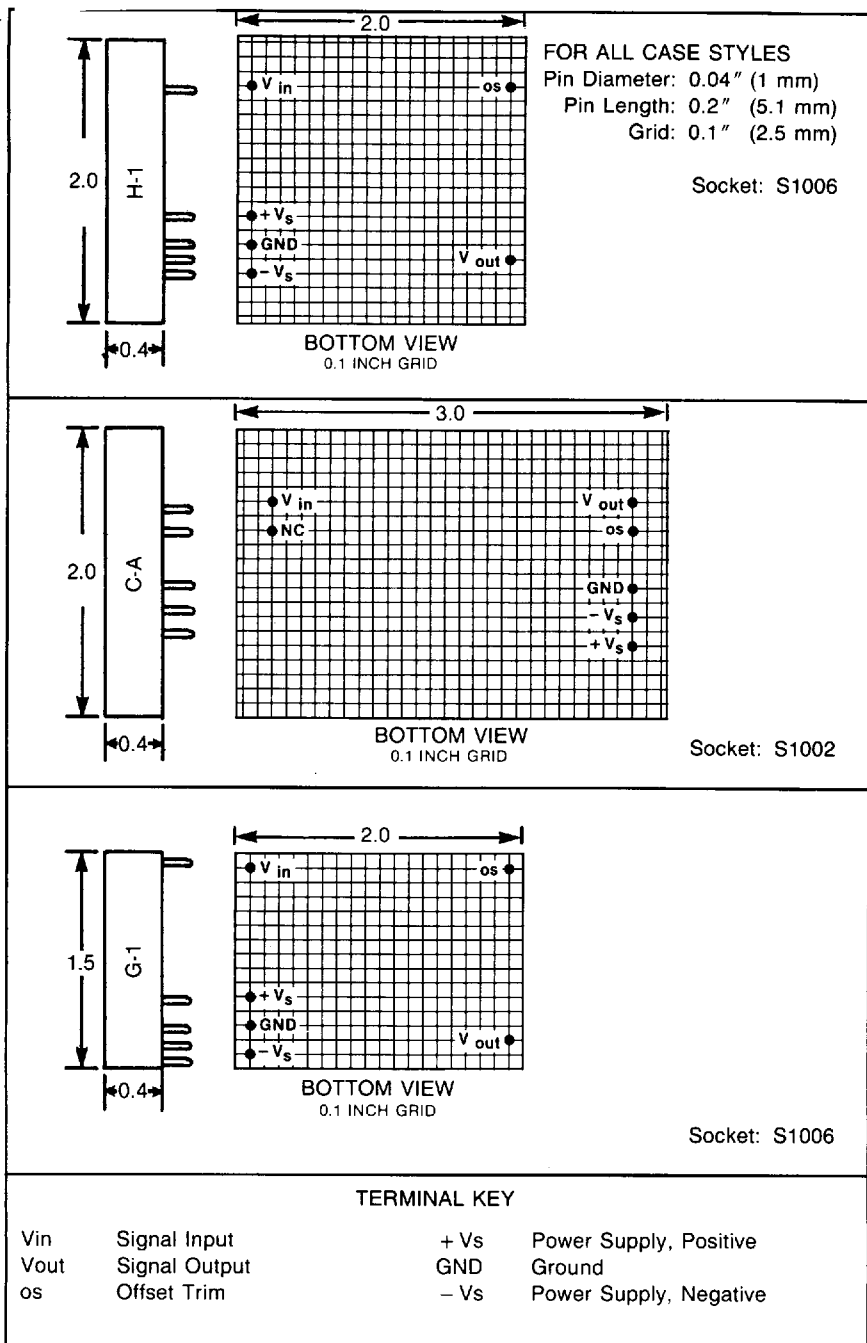

**FREQUENCY
DEVICES**
**675 - 678 SERIES
THEORETICAL RESPONSE
CHARACTERISTICS**
FREQUENCY DEVICES INC

NORMALIZED THEORETICAL DATA TABLES
Table 5 675 & 676 Series
Table 6 677 & 678 Series

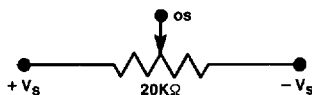
f/f_c	AMP (dB)	PHASE (deg)	DELAY (sec)	AMP (dB)	PHASE (deg)	DELAY (sec)
0.00	0.00	00.0	0.754	0.00	00.0	0.789
0.10	-0.04	-27.1	0.751	-0.04	-28.4	0.785
0.15	-0.07	-40.6	0.749	-0.07	-42.5	0.783
0.20	-0.09	-54.1	0.751	-0.09	-56.6	0.784
0.25	-0.10	-67.7	0.759	-0.10	-70.7	0.792
0.30	-0.09	-81.5	0.775	-0.08	-85.1	0.808
0.35	-0.06	-95.6	0.798	-0.05	-99.9	0.831
0.45	0.00	-125	0.857	0.00	-131	0.860
0.50	0.00	-141	0.886	0.00	-147	0.911
0.55	-0.03	-157	0.913	-0.04	-164	0.933
0.60	-0.07	-174	0.942	-0.08	-181	0.959
0.65	-0.10	-191	0.983	-0.10	-198	0.998
0.70	-0.09	-210	1.05	-0.08	-217	1.06
0.75	-0.05	-229	1.14	-0.03	-237	1.15
0.80	0.00	-251	1.26	0.00	-258	1.25
0.85	-0.02	-274	1.38	-0.03	-282	1.36
0.90	-0.09	-301	1.54	-0.09	-307	1.50
0.95	-0.06	-331	1.87	-0.05	-336	1.80
1.00	-0.10	-371	2.72	-0.10	-375	2.54
1.10	-9.07	-469	1.78	-7.92	-468	1.79
1.20	-22.0	-509	0.718	-19.7	-509	0.733
1.30	-33.1	-529	0.426	-29.5	-529	0.432
1.40	-43.4	-542	0.297	-38.2	-542	0.299
1.50	-54.1	-551	0.225	-46.3	-551	0.226
1.60	-67.1	-558	0.178	-54.2	-558	0.179
1.70	-101	-384	0.146	-62.4	-564	0.147
1.80	-80.2	-389	0.123	-71.5	-569	0.123
1.90	-92.9	-393	0.105	-83.5	-573	0.105
2.00	-94.0	-397	0.091	-104	-397	0.091
2.25	-92.6	-224	0.067	-94.8	-404	0.067
2.50	-80.2	-229	0.052	-102	-229	0.052
2.75	-81.5	-233	0.041	-92.9	-233	0.041
3.00	-84.9	-237	0.034	-91.7	-236	0.038
3.25	-91.2	-239	0.028	-92.7	-239	0.028
3.50	-122	-242	0.024	-95.2	-242	0.024
3.75	-93.2	-63.6	0.021	-99.2	-244	0.021
4.00	-87.9	-65.3	0.018	-106	-245	0.018
4.25	-85.2	-66.8	0.016	-122	-66.8	0.016
4.50	-83.5	-68.2	0.014	-105	-68.1	0.014
5.00	-81.7	-70.4	0.011	-97.5	-70.4	0.011
6.00	-80.4	-73.8	0.008	-93.2	-73.7	0.008
7.00	-80.2	-76.1	0.006	-92.0	-76.1	0.006
9.00	-80.9	-79.2	0.003	-91.8	-79.2	0.003
10.00	-81.4	-80.3	0.003	-92.1	-80.3	0.003

Frequency 25 Haverhill,
 Devices Locust Massachusetts
 Incorporated Street 01832

(508) 374-0761
 FAX
 (508) 521-1839

FREQUENCY DEVICES INC




**FREQUENCY
DEVICES™**
**650/670 SERIES
OPTIONAL ADJUSTMENTS
ORDERING INFORMATION**
FREQUENCY DEVICES INC
OPTIONAL OFFSET ADJUSTMENT

Use cermet potentiometer or fixed resistor
AVAILABLE 650/670 SERIES MODEL

5-Pole Models	For Use with n-Bit A/D's (n)	Voltage Gain @ dc	Attenuation at Floor* @ fa/fr	Conformance to Theoretical (0 to fr)		Offset Voltage (mV)	
				Phase (max)	Gain (max)	(typ)	(max)
651-f	8-Bit	0 ± 0.2dB	54dB @ 1.872	± 5°	± 0.5dB	± 10	± 25
652-f		0 ± 0.05dB		± 2°	± 0.2dB	± 2	± 5
653-f	10-Bit	0 ± 0.2dB	66dB @ 2.355	± 5°	± 0.5dB	± 10	± 25
654-f		0 ± 0.05dB		± 2°	± 0.2dB	± 2	± 5
7-Pole Models							
671-f	8-Bit	0 ± 0.2dB	54dB @ 1.249	± 5°	± 0.5dB	± 10	± 25
672-f		0 ± 0.05dB		± 2°	± 0.2dB	± 2	± 5
673-f	10-Bit	0 ± 0.2dB	66dB @ 1.412	± 5°	± 0.5dB	± 10	± 25
674-f		0 ± 0.05dB		± 2°	± 0.2dB	± 2	± 5
675-f	12-Bit	0 ± 0.2dB	78dB @ 1.654	± 5°	± 0.5dB	± 10	± 25
676-f		0 ± 0.05dB		± 2°	± 0.2dB	± 2	± 5
677-f	14-Bit	0 ± 0.2dB	90dB @ 1.925	± 5°	± 0.5dB	± 10	± 25
678-f		0 ± 0.05dB		± 2°	± 0.2dB	± 2	± 5

Table 1/Figure 1: 651 & 652
Table 2/Figure 2: 653 & 654
Table 3/Figure 3: 671 & 672
Table 4/Figure 4: 673 & 674
Table 5/Figure 5: 675 & 676
Table 6/Figure 6: 677 & 678

TRANSFER CHARACTERISTICS
HOW TO ORDER

The AVAILABLE 650/670 SERIES table lists the key specifications that define each model. Each of the twelve basic models is designed to prefilter an 8-, 10-, 12- or 14-bit A/D, depending on model. A selection of gain, phase, dc offset and attenuation tolerances add further versatility to this family.

Filter selection begins with determining the resolution category, which the user's A/D immediately defines. The required gain, phase and dc offset tolerances eliminate additional models from contention.

The user must now determine whether the 5-pole response of the **650 Series** or the steeper 7-pole response of **670 Series** will best meet system cost/performance requirements. To do this, check that the value of "Attenuation @ fa/fr" in the table provides sufficient bandwidth limiting (See FILTER PARAMETERS AT WORK on page 3.)

Because all **650/670 Series** models achieve an fa/fr of less than two, a filter with $fr = f_{sr}/2$ will strongly

attenuate the overlap frequencies that produce alias signals. However, this approach restricts system bandwidth. The user must therefore define a combination of sampling rate and bandwidth capable of meeting system throughput and accuracy criteria.

To specify the ripple frequency (fr), replace the suffix "f" in the model number with a simple code. The code expresses fr in Hertz (Hz), and substitutes the letter k for the thousands comma. The example below will show the simplicity of this method:

Example: The model number 678-11k2 designates a 7-pole lowpass Causer elliptic filter intended for 14-bit A/D conversion systems. The filter has a non-inverting dc gain of 0 ± 0.05 dB, maximum phase and gain tolerances of ± 2° and ± 0.2dB, respectively, and a maximum ± 5 mV dc offset. The filter has a ripple frequency of 11,200 Hz (11.2kHz).

Mating sockets are described in PACKAGE AND PIN-OUT DATA. To order, list each as a separate purchase order line item.

Frequency 25 Haverhill,
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Incorporated Street 01832

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