FREQUENCY DEVICES™, INC.

# D68 & DP68 Series

## 1.0 Hz to 100 kHz Fixed Frequency

## 32 Pin DIP 8-Pole Filters

### Description

The D68 and DP68 Series of small 8-pole fixed-frequency, precision active filters provide high performance linear active filtering in a compact 32-pin DIP package, with a broad range of corner frequencies and a choice of transfer functions. Individual D68 filters can serve in low-pass or high-pass applications (DP68, low-pass only) or be combined to create custom band-pass or band-reject filters. These fully self-contained units require no external components or adjustments. Each model comes factory tuned to a user-specified corner frequency between 1 Hz and 100 kHz (DP68, 1 Hz to 5 kHz) and operate with low total harmonic distortion over a wide dynamic input voltage range from non-critical +/-5V to +/-18V power supplies.

### Features/Benefits:

- Low harmonic distortion and wide signal-to-noise ratio to 16 bit resolution.
- Compact 1.8"L x 0.8"W x 0.3"H minimizes board space requirements.
- Plug-in ready-to-use, reducing engineering design and manufacturing cycle time.
- Factory tuned, no external clocks or adjustments needed
- Broad range of transfer characteristics and corner frequencies to meet a wide range of applications.

### Applications

- Anti-alias filtering
- Data acquisition systems
- Communication systems and electronics
- Medical electronics equipment and research
- Aerospace, navigation and sonar applications
- Sound and vibration testing
- Acoustic and vibration analysis and control
- Noise elimination
- Signal reconstruction




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**e-mail: sales@freqdev.com • Web Address: http://www.freqdev.com**

| Model | D68L8B & DP68L8B | D68L8E & DP68L8E | D68L8EX & DP68L8EX | D68L8EY & DP68L8EY |
|---|---|---|---|---|
| **Product Specifications** | | | | |
| **Transfer Function** | 8-Pole, Butterworth | 8-Pole, 6 zero, Elliptic | 8-Pole, 6 zero, Elliptic | 8-Pole, 6 zero, Elliptic |
| **Size** | 1.8" x 0.8" x 0.3" | 1.8" x 0.8" x 0.3" | 1.8" x 0.8" x 0.3" | 1.8" x 0.8" x 0.3" |
| **Range $f_c$, $f_r$**<br>**D68**<br>**DP68** | <br>1 Hz to 100 kHz<br>1 Hz to 5 kHz | <br>1 Hz to 100 kHz<br>1 Hz to 5 kHz | <br>1 Hz to 100 kHz<br>1 Hz to 5 kHz | <br>1 Hz to 100 kHz<br>1 Hz to 5 kHz |
| **Theoretical Transfer Characteristics** | Appendix A<br>Page 9 | Appendix A<br>Page 24 | Appendix A<br>Page 23 | Appendix A<br>Page 25 |
| **Passband Ripple**<br>(theoretical) | 0.0 dB | ± 0.035 dB | -0.05 dB | -0.05 dB |
| **DC Voltage Gain**<br>(non-inverting) | 0 ± 0.1 dB max.<br>0 ± 0.05 dB typ. | 0 ± 0.1 dB max.<br>0 ± 0.05 dB typ. | 0 ± 0.1 dB max.<br>0 ± 0.05 dB typ. | 0 ± 0.1 dB max.<br>0 ± 0.05 dB typ. |
| **Stopband Attenuation Rate** | 48 dB/octave | 80 dB min. | 80 dB min. | 100 dB min. |
| **Cutoff Frequency** | $f_c$ ± 1% max. | $f_r$ ± 1% max. | $f_r$ ± 1% max. | $f_r$ ± 2% max. |
| **Stability** | ± 0.01% /°C | ± 0.01% /°C | ± 0.01% /°C | ± 0.01% /°C |
| **Amplitude** | -3 dB | -0.035 dB | -0.05 dB | -0.05 dB |
| **Phase** | -360° | -323.5° | -414° | -419° |
| **Filter Attenuation**<br>(theoretical) | 0.12 dB 0.80 $f_c$<br>3.01 dB 1.00 $f_c$<br>60.0 dB 2.37 $f_c$<br>80.0 dB 3.16 $f_c$ | 0.035 dB 1.00 $f_r$<br>3.01 dB 1.13 $f_r$<br>60.0 dB 1.67 $f_r$<br>80.0 dB 1.77 $f_r$ | 0.05 dB 1.00 $f_r$<br>3.01 dB 1.05 $f_r$<br>60.0 dB 1.45 $f_r$<br>80.0 dB 1.56 $f_r$ | 0.05 dB 1.00 $f_r$<br>3.01 dB 1.06 $f_r$<br>80.0 dB 1.83 $f_r$<br>100.0 dB 2.00 $f_r$ |
| **Phase Match**[1] | 0 - 0.8 $f_c$ ± 2° max. ± 1° typ.<br>0.8 fc - 1.0 $f_c$ ± 3° max. ± 1.5° typ. | 0 - 0.8 $f_r$ ± 2° max. ± 1° typ.<br>0.8 $f_r$ - 1.0 $f_r$ ± 4° max. ± 2° typ. | 0 - 0.8 $f_r$ ± 3° max. ± 1.5° typ.<br>0.8 $f_r$ - 1.0 $f_r$ ± 4° max. ± 2° typ. | 0 - 0.8 $f_r$ ± 3° max. ± 1.5° typ.<br>0.8 $f_r$ - 1.0 $f_r$ ± 4° max. ± 2° typ. |
| **Amplitude Accuracy**<br>(theoretical) | 0 - 0.8 $f_c$ ± 0.2 dB max. ± 0.1 dB typ.<br>0.8 $f_c$ - 1.0 $f_c$ ± 0.3 dB max. ± 0.15 dB typ. | 0 - 0.8 $f_r$ ± 0.2 dB max. ± 0.1 dB typ.<br>0.8 $f_r$ - 1.0 $f_r$ ± 0.3 dB max. ±0 .15 dB typ. | 0 - 0.8 $f_r$ ± 0.2 dB max. ± 0.1 dB typ.<br>0.8 $f_r$ - 1.0 $f_r$ ± 0.5 dB max. ± 0.25 dB typ. | 0 - 0.8 $f_r$ ± 0.2 dB max. ± 0.1 dB typ.<br>0.8 $f_r$ - 1.0 $f_r$ ± 0.5 dB max. ± 0.25 dB typ. |
| **Total Harmonic Distortion @ 1 kHz**<br>**D68**<br>**DP68** | <br><-100 dB typ.<br><-80 dB typ. | <br><-88 dB typ.<br><-80 dB typ. | <br><-88 dB typ.<br><-80 dB typ. | <br><-88 dB typ.<br><-80 dB typ. |
| **Wide Band Noise**<br>(5 Hz - 2 MHz) | 200 µVrms typ. | 200 µVrms typ. | 250 µVrms typ. | 250 µVrms typ. |
| **Narrow Band Noise**<br>(20 Hz - 100 kHz) | 50 µVrms typ. | 50 µVrms typ. | 75 µVrms typ. | 75 µVrms typ. |
| **Filter Mounting Assembly** | FMA-01A | FMA-01A | FMA-01A | FMA-01A |

1. Unit to unit match for the same transfer function, set to the same frequency and operating configuration, and from the same manufacturing lot.



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## Fixed Frequency

## 8-Pole Low-Pass Filters

| Model | D68L8L & DP68L8L | D68L8D60 & DP68L8D60 | D68L8D & DP68L8D | D68L8D10 & DP68L8D10 |
|---|---|---|---|---|
| **Product Specifications** | | | | |
| **Transfer Function** | 8-Pole, Bessel | 8-Pole, 6 zero, Constant Delay | 8-Pole, 6 zero, Constant Delay | 8-Pole, 6 zero, Constant Delay |
| **Size** | 1.8" x 0.8" x 0.3" | 1.8" x 0.8" x 0.3" | 1.8" x 0.8" x 0.3" | 1.8" x 0.8" x 0.3" |
| **Range $f_c$**<br>**D68**<br>**DP68** | <br>1 Hz to 100 kHz<br>1 Hz to 5 kHz | <br>1 Hz to 100 kHz<br>1 Hz to 5 kHz | <br>1 Hz to 100 kHz<br>1 Hz to 5 kHz | <br>1 Hz to 100 kHz<br>1 Hz to 5 kHz |
| **Theoretical Transfer Characteristics** | Appendix A<br>Page 4 | Appendix A<br>Page 20 | Appendix A<br>Page 21 | Appendix A<br>Page 22 |
| **Passband Ripple**<br>(theoretical) | 0.0 dB | 0.15 dB | 0.15 dB | 0.15 dB |
| **DC Voltage Gain**<br>(non-inverting) | 0 ± 0.1 dB max.<br>0 ± 0.05 dB typ. | 0 ± 0.1 dB max.<br>0 ± 0.05 dB typ. | 0 ± 0.1 dB max.<br>0 ± 0.05 dB typ. | 0 ± 0.1 dB max.<br>0 ± 0.05 dB typ. |
| **Stopband Attenuation Rate** | 48 dB/octave | 60 dB min. | 80 dB min. | 100 dB min. |
| **Cutoff Frequency** | $f_c$ ± 1% max. | $f_c$ ± 1% max. | $f_c$ ± 1% max. | $f_c$ ± 2% max. |
| **Stability** | ± 0.01% /°C | ± 0.01% /°C | ± 0.01% /°C | ± 0.01% /°C |
| **Amplitude** | -3dB | -3dB | -3dB | -3dB |
| **Phase** | -182° | -306° | -306° | -311° |
| **Filter Attenuation**<br>(theoretical) | 1.91 dB 0.80 $f_c$<br>3.01 dB 1.00 $f_c$<br>60.0 dB 4.52 $f_c$<br>80.0 dB 6.07 $f_c$ | 3.01 dB 1.00 $f_c$<br>40.0 dB 2.28 $f_c$<br>60.0 dB 2.64 $f_c$ | 3.01 dB 1.00 $f_c$<br>60.0 dB 3.08 $f_c$<br>80.0 dB 3.57 $f_c$ | 3.01 dB 1.00 $f_c$<br>80.0 dB 4.45 $f_c$<br>100.0 dB 5.20 $f_c$ |
| **Phase Match**[1] | 0 - $f_c$ ± 2° max.<br>± 1° typ. | 0 - $f_c$ ± 2° max.<br>± 1° typ. | 0 - $f_c$ ± 2° max.<br>± 1° typ. | 0 - $f_c$ ± 2° max.<br>± 1° typ. |
| **Amplitude Accuracy**<br>(theoretical) | 0 - $f_c$ ± 0.2 dB max.<br>± 0.1 dB typ. | 0 - 0.8 $f_c$ ± 0.2 dB max.<br>± 0.1 dB typ.<br>0.8 $f_c$ - 1.0 $f_c$ ± 0.3 dB max.<br>±0 .15 dB typ. | 0 - 0.8 $f_c$ ± 0.2 dB max.<br>± 0.1 dB typ.<br>0.8 $f_c$ - 1.0 $f_c$ ± 0.3 dB max.<br>±0 .15 dB typ. | 0 - 0.8 $f_c$ ± 0.2 dB max.<br>± 0.1 dB typ.<br>0.8 $f_c$ - 1.0 $f_c$ ± 0.3 dB max.<br>± 0.15 dB typ. |
| **Total Harmonic Distortion @ 1 kHz**<br>**D68**<br>**DP68** | <br><-100 dB typ.<br><-80 dB typ. | <br><-100 dB typ.<br><-80 dB typ. | <br><-100 dB typ.<br><-80 dB typ. | <br><-100 dB typ.<br><-80 dB typ. |
| **Wide Band Noise**<br>(5 Hz - 2 MHz) | 200 µVrms typ. | 200 µVrms typ. | 200 µVrms typ. | 200 µVrms typ. |
| **Narrow Band Noise**<br>(20 Hz - 100 kHz) | 50 µVrms typ. | 50 µVrms typ. | 50 µVrms typ. | 50 µVrms typ. |
| **Filter Mounting Assembly** | FMA-01A | FMA-01A | FMA-01A | FMA-01A |

1. Unit to unit match for the same transfer function, set to the same frequency and operating configuration, and from the same manufacturing lot.



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| Model | D68H8B | D68H8E | D68H8EX | D68H8EY |
|---|---|---|---|---|
| **Product Specifications** | | | | |
| **Transfer Function** | 8-Pole, Butterworth | 8-Pole, 6 Zero, Elliptic | 8-Pole, 6 Zero, Elliptic | 8-Pole, 6 zero, Elliptic |
| **Size** | 1.8" x 0.8" x 0.3" | 1.8" x 0.8" x 0.3" | 1.8" x 0.8" x 0.3" | 1.8" x 0.8" x 0.3" |
| **Range $f_c$, $f_r$**<br>**D68**<br>**DP68** | <br>1 Hz to 100 kHz<br>Not Available | <br>1 Hz to 100 kHz<br>Not Available | <br>1 Hz to 100 kHz<br>Not Available | <br>1 Hz to 100 kHZ<br>Not Available |
| **Theoretical Transfer Characteristics** | Appendix A<br>Page 29 | Appendix A<br>Page 37 | Appendix A<br>Page 36 | Appendix A<br>Page 38 |
| **Passband Ripple**<br>(theoretical) | 0.0 dB | ± 0.035 dB | -0.05 dB | -0.05 dB |
| **Voltage Gain**<br>(non-inverting) | 0 ± 0.2 dB to 100 kHz<br>0 ± 0.5 dB to 120 kHz | 0 ± 0.2 dB to 100 kHz<br>0 ± 0.5 dB to 120 kHz | 0 ± 0.2 dB to 100 kHz<br>0 ± 0.5 dB to 120 kHz | 0 ± 0.2 dB to 100 kHz<br>0 ± 0.5 dB to 120 kHz |
| **Stopband Attenuation Rate** | 48 dB/octave | 80 dB | 80 dB | 100 dB |
| **Power Bandwidth** | 120 kHz | 120 kHz | 120 kHz | 120 kHz |
| **Small Signal Bandwidth** | (-6dB) 1 MHz | (-6dB) 1 MHz | (-6dB) 1 MHz | (-6dB) 1 MHz |
| **Cutoff Frequency**<br>**Stability**<br>**Amplitude**<br>**Phase** | $f_c$ ± 1% max.<br>± 0.01% /°C<br>-3 dB<br>-360° | $f_r$ ± 1% max.<br>± 0.01% /°C<br>-0.035 dB`<br>-323.5° | $f_r$ ± 1% max.<br>± 0.01% /°C<br>-0.05 dB<br>-414° | $f_r$ ± 2% max.<br>± 0.01% /°C<br>-0.05 dB<br>-419° |
| **Filter Attenuation**<br>(theoretical) | 80.0 dB 0.31 $f_c$<br>60.0 dB 0.42 $f_c$<br>3.01 dB 1.00 $f_c$<br>0.00 dB 2.00 $f_c$ | 80.0 dB 0.56 $f_r$<br>60.0 dB 0.60 $f_r$<br>3.01 dB 0.88 $f_r$<br>0.03 dB 1.00 $f_r$<br>0.00 dB 2.00 $f_r$ | 80.0 dB 0.64 $f_r$<br>60.0 dB 0.69 $f_r$<br>3.01 dB 0.95 $f_r$<br>0.05 dB 1.00 $f_r$<br>0.00 dB 2.00 $f_r$ | 100.0 dB 0.50 $f_r$<br>80.0 dB 0.55 $f_r$<br>3.01 dB 0.94 $f_r$<br>0.03 dB 1.00 $f_r$<br>0.00 dB 2.00 $f_r$ |
| **Phase Match**[1] | $f_c$ - 100 kHz ± 3° max. ± 1.5° typ. | 0 - 1.25 $f_r$ ± 4° max. ± 2° typ.<br>1.25 $f_r$-100 kHz ± 2° max. ± 1° typ. | 0 - 1.25 $f_r$ ± 4° max. ± 2° typ.<br>1.25 $f_r$-100 kHz ± 2° max. ± 1° typ. | 0 - 1.25 $f_r$ ± 4° max. ± 2° typ.<br>1.25 $f_r$-100 kHz ± 3° max. ± 1.5° typ. |
| **Amplitude Accuracy**<br>(theoretical) | 1.0 - 1.25 $f_c$ ± 0.3 dB max. ± 0.15 dB typ.<br>1.25 $f_c$-100 kHz ± 0.2 dB max. ± 0.1 dB typ. | 1.00 - 1.25 $f_r$ ± 0.3 dB max. ± 0.15 dB typ.<br>1.25 $f_r$-100 kHz ± 0.2 dB max. ±0 .1 dB typ. | 1.00 - 1.25 $f_r$ ± 0.5 dB max. ± 0.25 dB typ.<br>1.25 $f_r$-100 kHz ± 0.2 dB max. ±0 .1 dB typ. | 1.00 - 1.25 $f_r$ ± 0.5 dB max ± 0.25 dB typ<br>1.25 $f_r$-100 kHz ± 0.2 dB max. ±0 .1 dB typ. |
| **Total Harmonic Distortion @ 1 kHz**<br>**D68** | <br><-88 dB typ. | <br><-88 dB typ. | <br><-88 dB typ. | <br><-88 dB typ. |
| **Wide Band Noise**<br>(5 Hz - 2 MHz) | 400 µVrms | 400 µVrms typ. | 500 µVrms typ. | 500 µVrms typ. |
| **Narrow Band Noise**<br>(20 Hz - 100 kHz) | 100 µVrms typ. | 100 µVrms typ. | 150 µVrms typ. | 150 µVrms typ. |
| **Filter Mounting Assembly** | FMA-01A | FMA-01A | FMA-01A | FMA-01A |

1. Unit to unit match for the same transfer function, set to the same frequency and operating configuration, and from the same manufacturing lot.



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## Specification

(25°C and Vs ± 15 Vdc)

**Analog Input Characteristics**[1]

| | |
|---|---|
| Impedance | 10 kΩ min. |
| Voltage Range | ± 10 Vpeak |
| Max. Safe Voltage | ± Vs |

**Analog Output Characteristics**

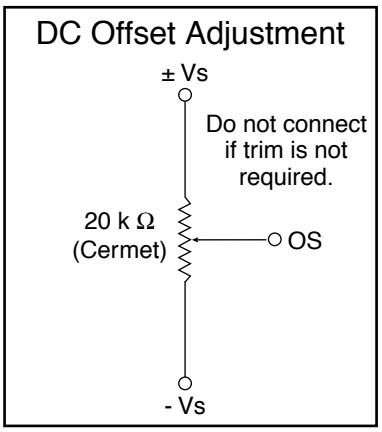
| | |
|---|---|
| Impedance(Closed Loop) | 1 Ω typ.<br>10 Ω max. |
| Linear Operating Range | ± 10 V |
| Maximum Current[2] | ± 2 mA |
| Offset Voltage[3] | 2 mV typ.<br>20 mV max. |
| Offset Temp. Coeff. | 50 µV / °C |

**Power Supply (±V)**

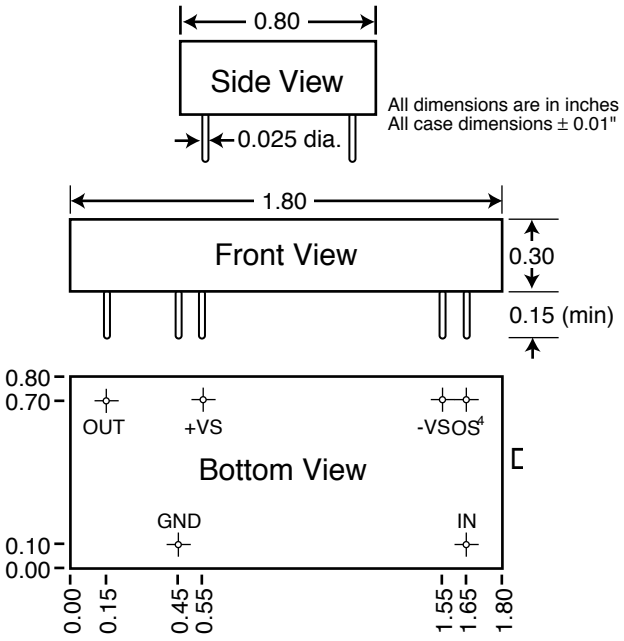
| | |
|---|---|
| Rated Voltage | ± 15 Vdc |
| Operating Range | ± 5 to ± 18 Vdc |
| Maximum Safe Voltage | ± 18 Vdc |
| Quiescent Current D68 | ± 25 mA typ.<br>± 40 mA max. |
| Quiescent Current DP68 | ± 7 mA typ.<br>± 10 mA max. |

**Temperature**

| | |
|---|---|
| Operating | 0 to + 70 °C |
| Storage | - 25 to + 85 °C |




## Pin-Out and Package Data
## Ordering Information




**Filter Mounting Assembly-See FMA-01A**

## Ordering Information

**Filter Type**

**L** - Low Pass
**H** - High Pass

**Transfer Function**

**B** - Butterworth
**L** - Bessel
**D** - constant delay (-80 dB)
**D60** - constant delay (-60 dB)
**D10** - constant delay (-100 dB)
**E** - elliptic 1.77 (-80 dB)
**EX** - elliptic 1.56 (-80 dB)
**EY** - elliptic 2.00 (-100 dB)

**D68L8B-849 Hz**

**Power Level**

**D** – Standard Power

**DP** – Low Power

**- 3 dB Corner Frequency**[5]

e.g., 849 Hz
2.50 kHz
33.3 kHz

Notes:

1. Input and output signal voltage referenced to supply common.
2. Output is short circuit protected to common. DO NOT CONNECT TO ±Vs.
3. Adjustable to zero.
4. Units operate with or with out offset pin connected.
5. How to Specify Corner Frequency:
   Corner frequencies are specified by attaching a three digit frequency designator to the basic model number. Corner frequencies can range from 1.00 Hz to 100 kHz.





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FREQUENCY DEVICES™, INC.

# 8-Pole

**Bessel**

**Low-Pass**

**Appendix A**

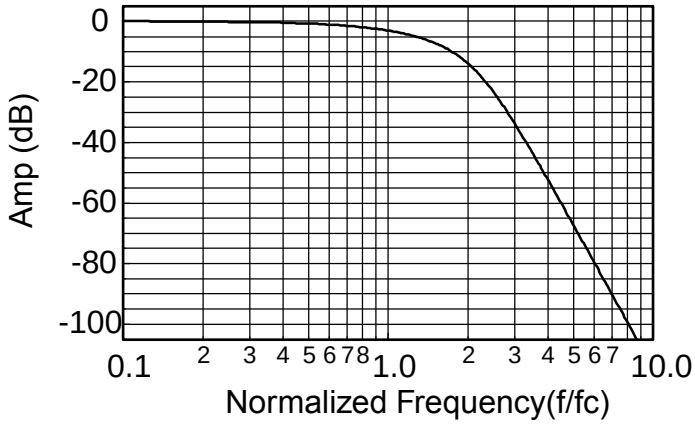
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | .506 |
| 0.10 | -0.029 | -18.2 | .506 |
| 0.20 | -0.117 | -36.4 | .506 |
| 0.30 | -0.264 | -54.7 | .506 |
| 0.40 | -0.470 | -72.9 | .506 |
| 0.50 | -0.737 | -91.1 | .506 |
| 0.60 | -1.06 | -109 | .506 |
| 0.70 | -1.45 | -128 | .506 |
| 0.80 | -1.91 | -146 | .506 |
| 0.85 | -2.16 | -155 | .506 |
| 0.90 | -2.42 | -164 | .506 |
| 0.95 | -2.71 | -173 | .506 |
| 1.00 | -3.01 | -182 | .506 |
| 1.10 | -3.67 | -200 | .506 |
| 1.20 | -4.40 | -219 | .506 |
| 1.30 | -5.20 | -237 | .506 |
| 1.40 | -6.10 | -255 | .505 |
| 1.50 | -7.08 | -273 | .504 |
| 1.60 | -8.16 | -291 | .502 |
| 1.70 | -9.36 | -309 | .498 |
| 1.80 | -10.7 | -327 | .492 |
| 1.90 | -12.1 | -345 | .482 |
| 2.00 | -13.7 | -362 | .468 |
| 2.25 | -18.1 | -402 | .417 |
| 2.50 | -23.1 | -436 | .352 |
| 2.75 | -28.3 | -465 | .291 |
| 3.00 | -33.4 | -489 | .241 |
| 3.25 | -38.3 | -509 | .201 |
| 3.50 | -43.1 | -526 | .170 |
| 4.00 | -51.8 | -552 | .126 |
| 5.00 | -66.8 | -587 | .077 |
| 6.00 | -79.2 | -610 | .052 |
| 7.00 | -89.8 | -626 | .038 |
| 8.00 | -99.0 | -638 | .029 |
| 9.00 | -107 | -647 | .023 |
| 10.0 | -114 | -655 | .018 |

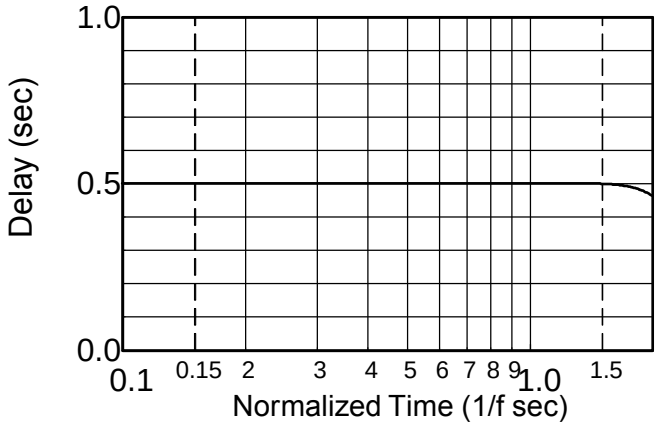
1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$

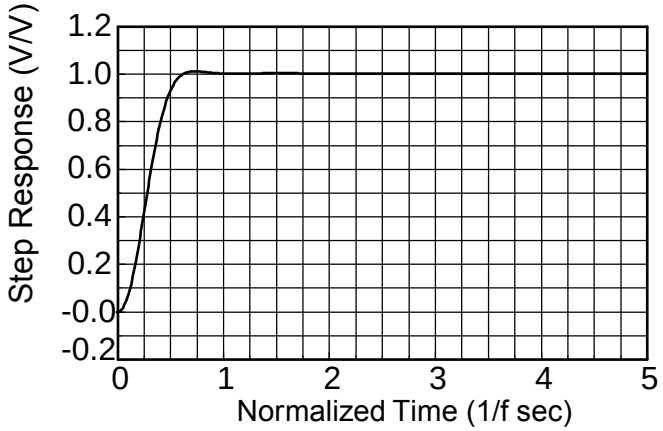
### Frequency Response




### **Delay** (Normalized)




### Step Response



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FREQUENCY DEVICES™, INC.

# Low-Pass

**8-Pole**

**Butterworth**

**Appendix A**

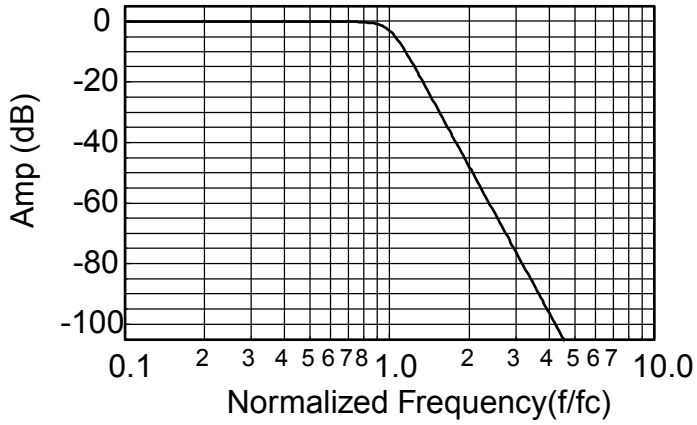
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | .816 |
| 0.10 | 0.00 | -29.4 | .819 |
| 0.20 | 0.00 | -59.0 | .828 |
| 0.30 | 0.00 | -89.1 | .843 |
| 0.40 | 0.00 | -120 | .867 |
| 0.50 | 0.00 | -152 | .903 |
| 0.60 | -0.001 | -185 | .956 |
| 0.70 | -0.014 | -221 | 1.04 |
| 0.80 | -0.121 | -261 | 1.19 |
| 0.85 | -0.311 | -283 | 1.29 |
| 0.90 | -0.738 | -307 | 1.40 |
| 0.95 | -1.58 | -333 | 1.48 |
| 1.00 | -3.01 | -360 | 1.46 |
| 1.10 | -7.48 | -408 | 1.17 |
| 1.20 | -12.9 | -445 | .873 |
| 1.30 | -18.2 | -472 | .672 |
| 1.40 | -23.4 | -494 | .540 |
| 1.50 | -28.2 | -511 | .448 |
| 1.60 | -32.7 | -526 | .380 |
| 1.70 | -36.9 | -539 | .328 |
| 1.80 | -40.8 | -550 | .287 |
| 1.90 | -44.6 | -560 | .253 |
| 2.00 | -48.2 | -568 | .226 |
| 2.25 | -56.3 | -586 | .174 |
| 2.50 | -63.7 | -600 | .139 |
| 2.75 | -70.3 | -611 | .113 |
| 3.00 | -76.3 | -621 | .094 |
| 3.25 | -81.9 | -629 | .080 |
| 3.50 | -87.1 | -635 | .069 |
| 4.00 | -96.3 | -646 | .052 |
| 5.00 | -112 | -661 | .033 |
| 6.00 | -125 | -671 | .023 |
| 7.00 | -135 | -678 | .017 |
| 8.00 | -144 | -683 | .013 |
| 9.00 | -153 | -687 | .010 |
| 10.0 | -160 | -691 | .008 |

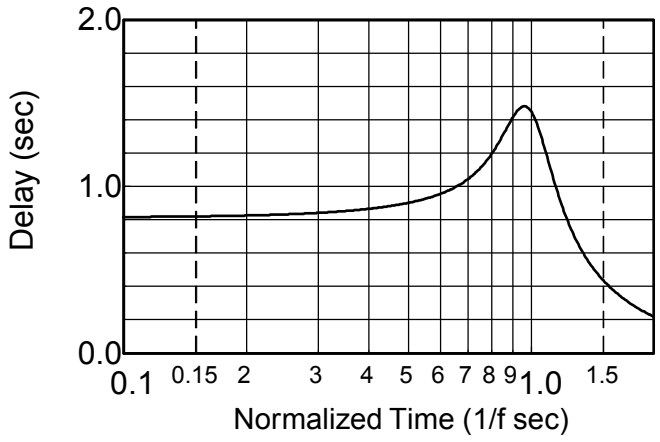
1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$

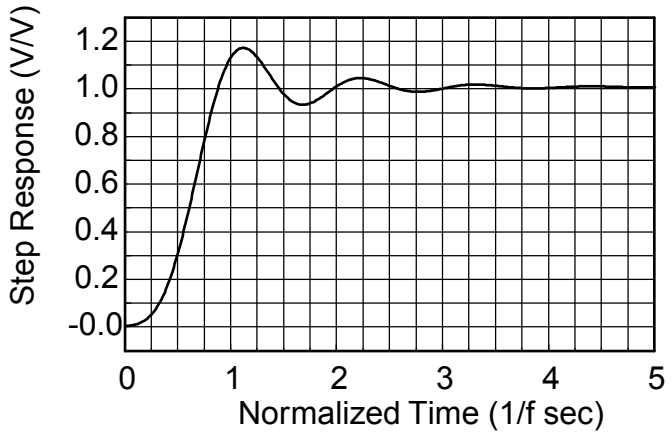
## Frequency Response




## Delay (Normalized)




## Step Response



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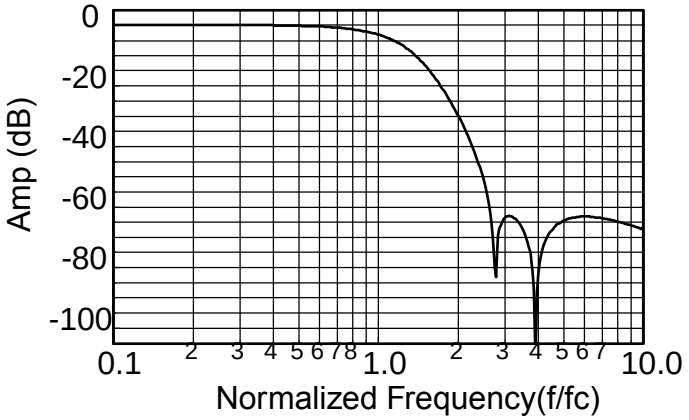
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | .776 |
| 0.10 | 0.005 | -28.0 | .776 |
| 0.20 | 0.012 | -55.9 | .776 |
| 0.30 | 0.005 | -83.9 | .776 |
| 0.40 | -0.042 | -112 | .776 |
| 0.50 | -0.161 | -140 | .776 |
| 0.60 | -0.384 | -168 | .776 |
| 0.70 | -0.745 | -196 | .776 |
| 0.80 | -1.28 | -224 | .776 |
| 0.85 | -1.62 | -238 | .776 |
| 0.90 | -2.02 | -252 | .776 |
| 0.95 | -2.48 | -265 | .775 |
| 1.00 | -3.01 | -279 | .773 |
| 1.10 | -4.29 | -307 | .766 |
| 1.20 | -5.91 | -334 | .749 |
| 1.40 | -10.3 | -386 | .675 |
| 1.60 | -15.9 | -431 | .558 |
| 1.80 | -22.4 | -467 | .443 |
| 2.00 | -29.4 | -495 | .351 |
| 2.25 | -39.0 | -523 | .268 |
| 2.50 | -50.5 | -544 | .212 |
| 2.75 | -78.0 | -561 | .171 |
| 3.00 | -63.7 | -395 | .142 |
| 3.25 | -63.5 | -407 | .119 |
| 3.50 | -66.9 | -417 | .102 |
| 3.75 | -74.7 | -425 | .088 |
| 4.00 | -85.0 | -253 | .077 |
| 4.25 | -72.0 | -259 | .068 |
| 4.50 | -67.9 | -265 | .060 |
| 4.75 | -65.8 | -270 | .054 |
| 5.00 | -64.6 | -275 | .048 |
| 5.25 | -63.9 | -279 | .044 |
| 5.50 | -63.5 | -283 | .040 |
| 5.75 | -63.3 | -286 | .036 |
| 6.00 | -63.2 | -289 | .033 |
| 6.50 | -63.3 | -295 | .028 |
| 7.00 | -63.7 | -299 | .024 |
| 8.00 | -64.7 | -307 | .019 |
| 9.00 | -66.0 | -313 | .015 |
| 10.0 | -67.3 | -318 | .012 |

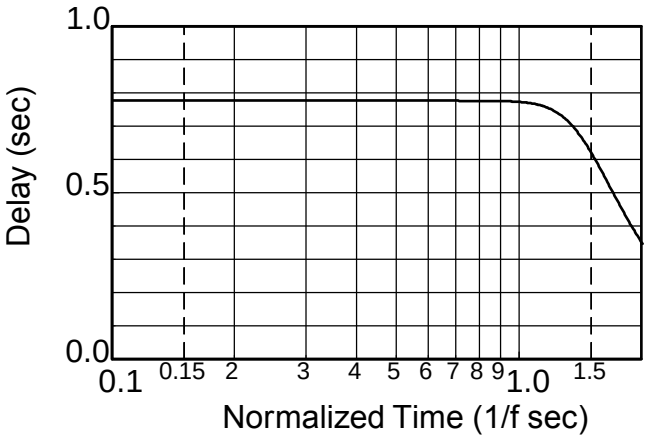
1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$

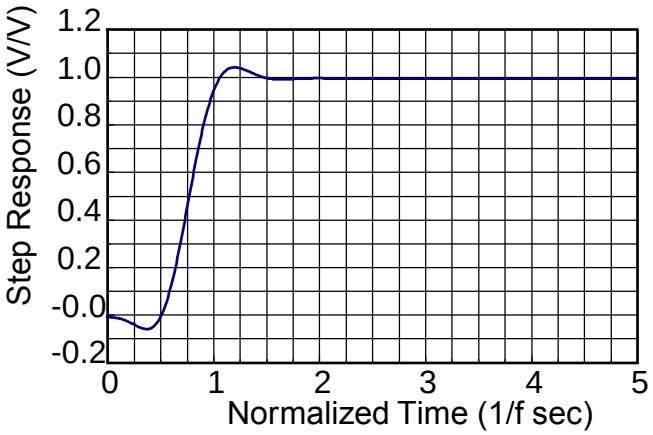
### Frequency Response




### **Delay** (Normalized)




### Step Response



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FREQUENCY DEVICES™, INC.

# 8-Pole, 6-Zero

**Constant Delay**

**Low-Pass (80 dB)**

**Appendix A**

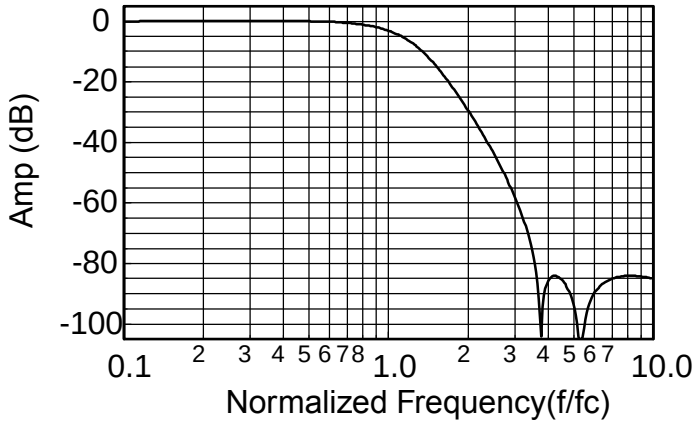
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | .852 |
| 0.10 | 0.017 | -30.7 | .852 |
| 0.20 | 0.058 | -61.3 | .852 |
| 0.30 | 0.099 | -92.0 | .852 |
| 0.40 | 0.105 | -123 | .852 |
| 0.50 | 0.034 | -153 | .852 |
| 0.60 | -0.157 | -184 | .852 |
| 0.70 | -0.510 | -215 | .852 |
| 0.80 | -1.07 | -245 | .851 |
| 0.85 | -1.44 | -261 | .850 |
| 0.90 | -1.89 | -276 | .849 |
| 0.95 | -2.41 | -291 | .846 |
| 1.00 | -3.01 | -306 | .841 |
| 1.10 | -4.50 | -336 | .821 |
| 1.20 | -6.39 | -365 | .783 |
| 1.40 | -11.3 | -417 | .656 |
| 1.60 | -17.1 | -459 | .512 |
| 1.80 | -23.2 | -492 | .396 |
| 2.00 | -29.1 | -517 | .312 |
| 2.25 | -36.3 | -542 | .239 |
| 2.50 | -43.4 | -561 | .189 |
| 2.75 | -50.3 | -576 | .153 |
| 3.00 | -57.6 | -589 | .127 |
| 3.25 | -62.5 | -599 | .107 |
| 3.50 | -75.4 | -608 | .092 |
| 3.75 | -98.3 | -616 | .079 |
| 4.00 | -86.3 | -442 | .069 |
| 4.25 | -84.1 | -448 | .061 |
| 4.50 | -85.1 | -454 | .054 |
| 4.75 | -87.9 | -458 | .049 |
| 5.00 | -92.8 | -462 | .044 |
| 5.25 | -104 | -466 | .040 |
| 5.50 | -101 | -289 | .036 |
| 5.75 | -93.3 | -293 | .033 |
| 6.00 | -89.9 | -295 | .030 |
| 6.50 | -86.6 | -300 | .026 |
| 7.00 | -85.1 | -305 | .022 |
| 8.00 | -84.1 | -312 | .017 |
| 9.00 | -84.3 | -317 | .013 |
| 10.0 | -84.9 | -321 | .011 |

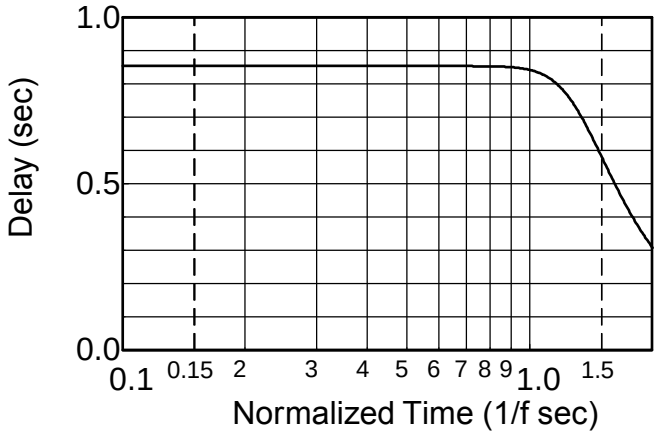
1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$

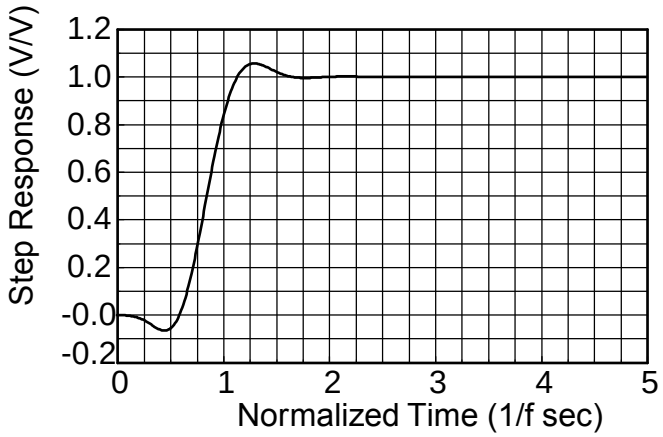
### Frequency Response




### **Delay** (Normalized)




### Step Response



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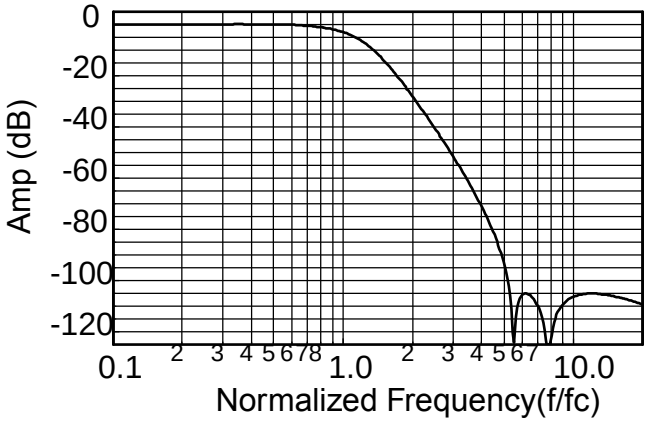
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | .865 |
| 0.10 | 0.015 | -31.1 | .865 |
| 0.20 | 0.051 | -62.3 | .865 |
| 0.30 | 0.085 | -93.4 | .865 |
| 0.40 | 0.085 | -125 | .865 |
| 0.50 | 0.010 | -156 | .865 |
| 0.60 | -0.182 | -187 | .865 |
| 0.70 | -0.532 | -218 | .865 |
| 0.80 | -1.09 | -249 | .864 |
| 0.85 | -1.45 | -265 | .863 |
| 0.90 | -1.89 | -280 | .861 |
| 0.95 | -2.41 | -296 | .857 |
| 1.00 | -3.01 | -311 | .851 |
| 1.10 | -4.50 | -341 | .828 |
| 1.20 | -6.38 | -370 | .785 |
| 1.40 | -11.2 | -422 | .650 |
| 1.60 | -16.8 | -464 | .504 |
| 1.80 | -22.5 | -496 | .389 |
| 2.00 | -28.0 | -520 | .306 |
| 2.25 | -34.5 | -544 | .235 |
| 2.50 | -40.5 | -563 | .186 |
| 2.75 | -46.1 | -578 | .151 |
| 3.00 | -51.4 | -591 | .125 |
| 3.50 | -61.5 | -610 | .090 |
| 4.00 | -71.2 | -624 | .068 |
| 4.50 | -81.3 | -635 | .054 |
| 5.00 | -93.4 | -643 | .043 |
| 5.50 | -142 | -651 | .036 |
| 6.00 | -105 | -476 | .030 |
| 6.20 | -105 | -478 | .028 |
| 6.50 | -106 | -481 | .025 |
| 7.00 | -110 | -486 | .022 |
| 8.00 | -122 | -312 | .017 |
| 9.00 | -109 | -318 | .013 |
| 10.0 | -106 | -322 | .011 |
| 12.0 | -105 | -328 | .007 |
| 14.0 | -106 | -333 | .005 |
| 16.0 | -107 | -336 | .004 |
| 18.0 | -108 | -339 | .003 |
| 20.0 | -109 | -341 | .003 |

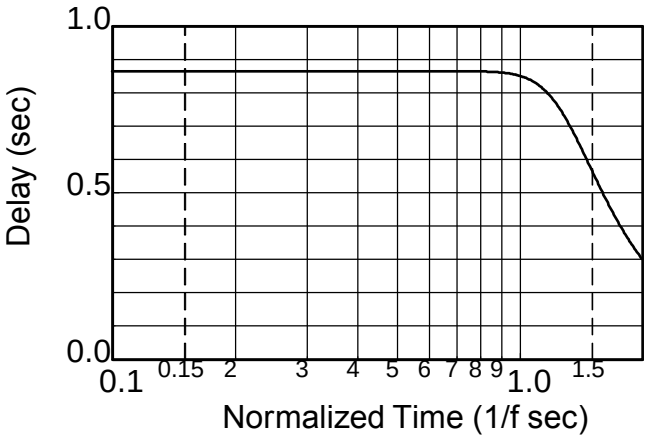
1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$

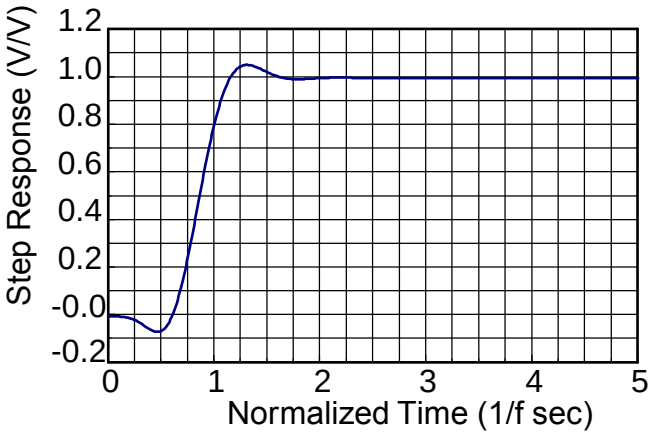
### Frequency Response




### **Delay** (Normalized)




### Step Response



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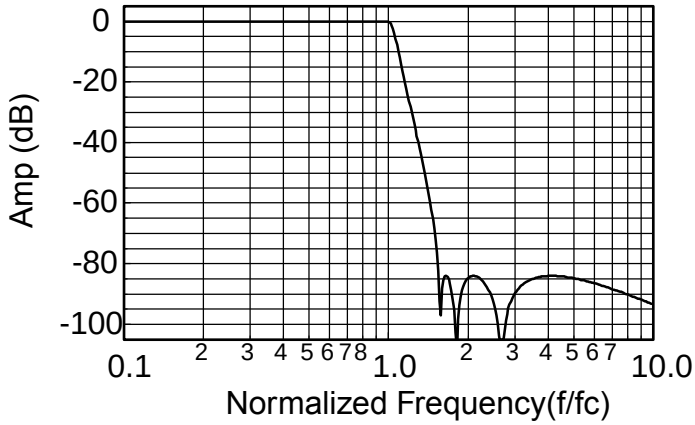
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.823 |
| 0.10 | -0.001 | -29.7 | 0.829 |
| 0.20 | -0.013 | -59.8 | 0.844 |
| 0.30 | -0.040 | -90.5 | 0.865 |
| 0.40 | -0.049 | -122 | 0.904 |
| 0.50 | -0.018 | -156 | 0.972 |
| 0.55 | -0.003 | -174 | 1.016 |
| 0.60 | -0.002 | -192 | 1.064 |
| 0.65 | -0.019 | -212 | 1.116 |
| 0.70 | -0.042 | -233 | 1.178 |
| 0.75 | -0.049 | -255 | 1.264 |
| 0.80 | -0.026 | -279 | 1.388 |
| 0.85 | -0.001 | -305 | 1.557 |
| 0.90 | -0.024 | -335 | 1.767 |
| 0.95 | -0.045 | -369 | 2.111 |
| 1.00 | -0.050 | -414 | 3.062 |
| 1.10 | -10.48 | -531 | 2.043 |
| 1.20 | -25.96 | -576 | 0.814 |
| 1.30 | -39.45 | -598 | 0.493 |
| 1.40 | -52.87 | -614 | 0.348 |
| 1.50 | -69.11 | -624 | 0.265 |
| 1.60 | -89.09 | -453 | 0.211 |
| 1.70 | -85.32 | -459 | 0.174 |
| 1.75 | -89.95 | -463 | 0.156 |
| 1.80 | -103.5 | -465 | 0.147 |
| 1.85 | -95.94 | -288 | 0.158 |
| 1.90 | -89.31 | -290 | 0.126 |
| 1.95 | -86.44 | -292 | 0.117 |
| 2.00 | -84.96 | -295 | 0.110 |
| 2.20 | -84.54 | -302 | 0.087 |
| 2.40 | -88.65 | -307 | 0.069 |
| 2.60 | -99.78 | -311 | 0.057 |
| 2.80 | -99.97 | -135 | 0.048 |
| 3.00 | -90.20 | -139 | 0.041 |
| 3.50 | -85.09 | -145 | 0.029 |
| 4.00 | -84.04 | -150 | 0.022 |
| 5.00 | -84.76 | -156 | 0.014 |
| 6.00 | -86.45 | -160 | 0.009 |
| 7.00 | -88.31 | -163 | 0.007 |
| 8.00 | -90.11 | -165 | 0.005 |
| 9.00 | -91.82 | -167 | 0.004 |
| 10.0 | -93.41 | -168 | 0.003 |

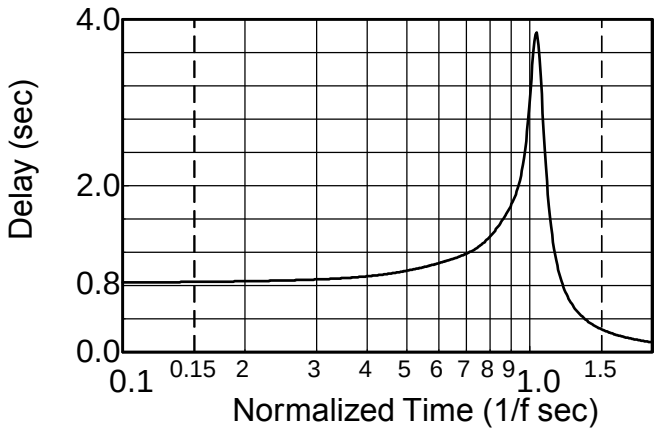
1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$

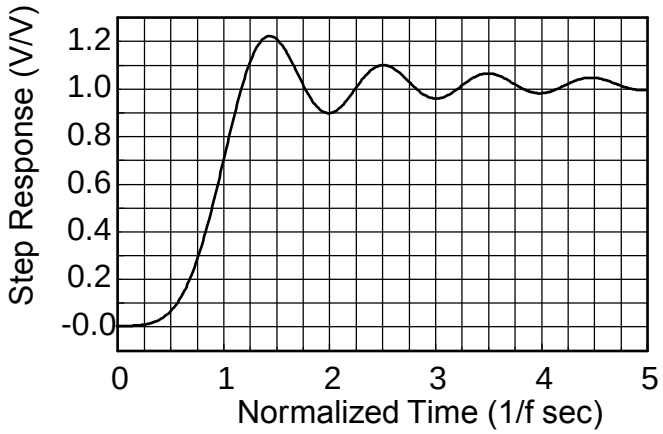
### Frequency Response




### **Delay** (Normalized)




### Step Response



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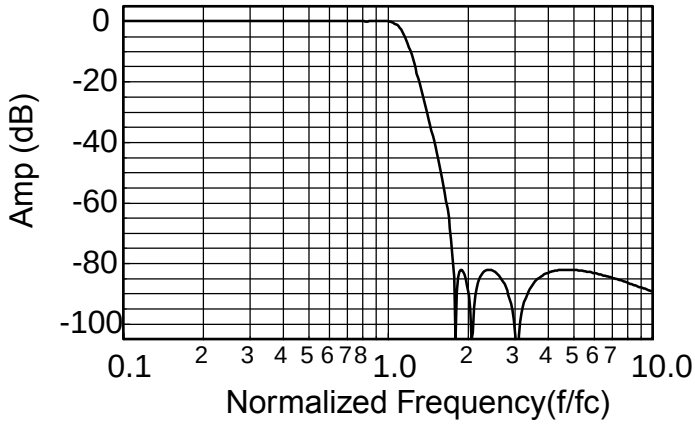
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.713 |
| 0.10 | -0.004 | -25.7 | 0.716 |
| 0.20 | -0.014 | -51.6 | 0.724 |
| 0.30 | -0.024 | -77.9 | 0.740 |
| 0.40 | -0.020 | -105 | 0.767 |
| 0.50 | 0.007 | -133 | 0.811 |
| 0.55 | 0.022 | -148 | 0.840 |
| 0.60 | 0.033 | -163 | 0.872 |
| 0.65 | 0.031 | -179 | 0.908 |
| 0.70 | 0.014 | -196 | 0.946 |
| 0.75 | -0.015 | -213 | 0.989 |
| 0.80 | -0.041 | -232 | 1.04 |
| 0.85 | -0.046 | -251 | 1.12 |
| 0.90 | -0.016 | -272 | 1.23 |
| 0.95 | -0.025 | -296 | 1.40 |
| 1.00 | -0.035 | -323 | 1.65 |
| 1.10 | -1.76 | -392 | 2.14 |
| 1.20 | -8.28 | -467 | 1.86 |
| 1.30 | -18.4 | -522 | 1.19 |
| 1.40 | -29.3 | -558 | 0.753 |
| 1.50 | -40.1 | -578 | 0.517 |
| 1.60 | -51.5 | -594 | 0.381 |
| 1.70 | -65.2 | -606 | 0.296 |
| 1.75 | -75.0 | -611 | 0.265 |
| 1.80 | -113.0 | -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 |
| 2.40 | -82.0 | -289 | 0.099 |
| 2.60 | -83.5 | -295 | 0.081 |
| 2.80 | -88.2 | -301 | 0.067 |
| 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 |

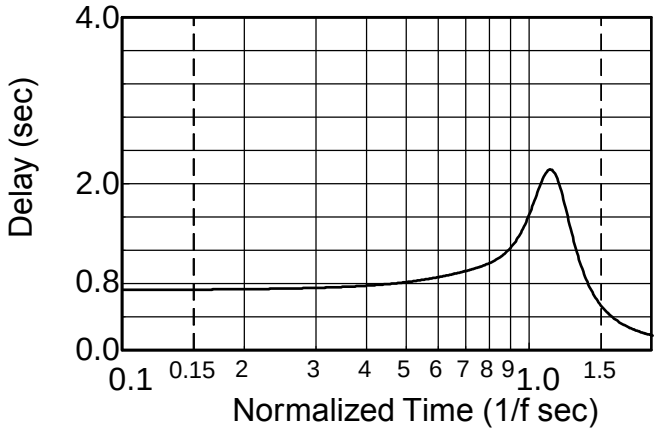
1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$

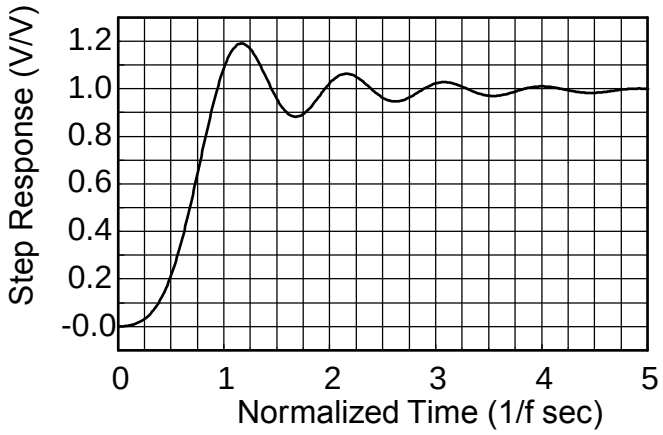
### Frequency Response




### **Delay** (Normalized)




### Step Response



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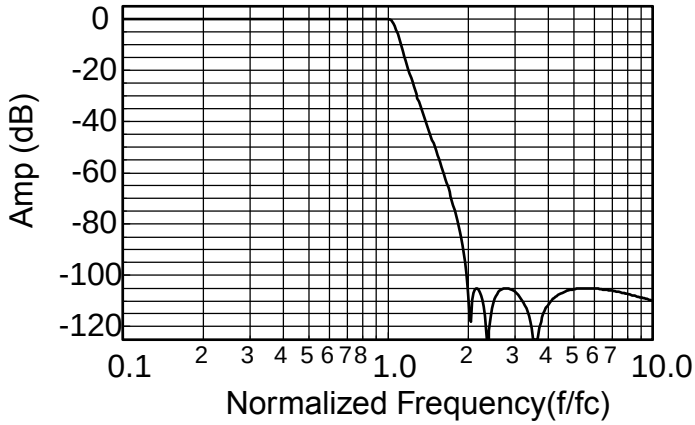
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.885 |
| 0.10 | -0.001 | -31.9 | 0.891 |
| 0.20 | -0.015 | -64.2 | 0.903 |
| 0.30 | -0.040 | -97.0 | 0.922 |
| 0.40 | -0.042 | -131 | 0.958 |
| 0.50 | -0.001 | -166 | 1.020 |
| 0.55 | 0.000 | -185 | 1.057 |
| 0.60 | -0.007 | -204 | 1.099 |
| 0.65 | -0.027 | -225 | 1.140 |
| 0.70 | -0.045 | -245 | 1.193 |
| 0.75 | -0.040 | -268 | 1.269 |
| 0.80 | -0.014 | -291 | 1.377 |
| 0.85 | -0.001 | -317 | 1.513 |
| 0.90 | -0.031 | -346 | 1.677 |
| 0.95 | -0.036 | -378 | 1.960 |
| 1.00 | -0.046 | -419 | 2.681 |
| 1.10 | -7.910 | -525 | 2.127 |
| 1.20 | -21.06 | -573 | 0.856 |
| 1.30 | -31.96 | -597 | 0.509 |
| 1.40 | -41.51 | -612 | 0.357 |
| 1.50 | -50.35 | -623 | 0.271 |
| 1.60 | -58.90 | -632 | 0.216 |
| 1.70 | -67.54 | -639 | 0.177 |
| 1.75 | -72.04 | -642 | 0.162 |
| 1.80 | -76.79 | -645 | 0.149 |
| 1.85 | -81.93 | -647 | 0.138 |
| 1.90 | -87.78 | -650 | 0.128 |
| 1.95 | -95.04 | -652 | 0.119 |
| 2.00 | -106.6 | -654 | 0.111 |
| 2.20 | -106.0 | -481 | 0.087 |
| 2.40 | -121.3 | -307 | 0.070 |
| 2.60 | -106.5 | -311 | 0.058 |
| 2.80 | -105.0 | -315 | 0.049 |
| 3.00 | -106.4 | -318 | 0.042 |
| 3.50 | -123.6 | -325 | 0.030 |
| 4.00 | -111.5 | -149 | 0.022 |
| 5.00 | -105.4 | -156 | 0.014 |
| 6.00 | -105.1 | -160 | 0.010 |
| 7.00 | -106.0 | -163 | 0.007 |
| 8.00 | -107.3 | -165 | 0.005 |
| 9.00 | -108.6 | -167 | 0.004 |
| 10.0 | -110.0 | -168 | 0.003 |

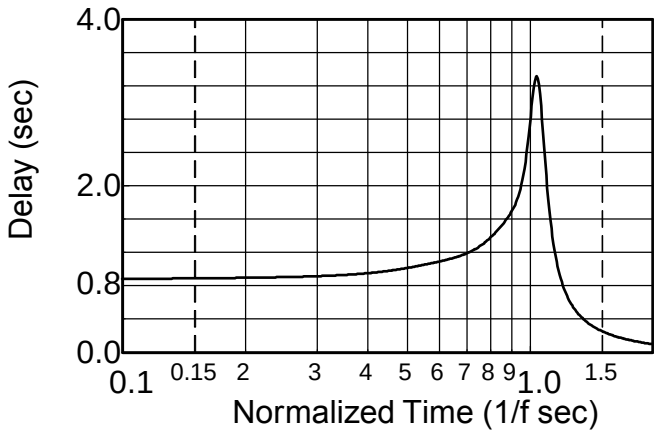
1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$

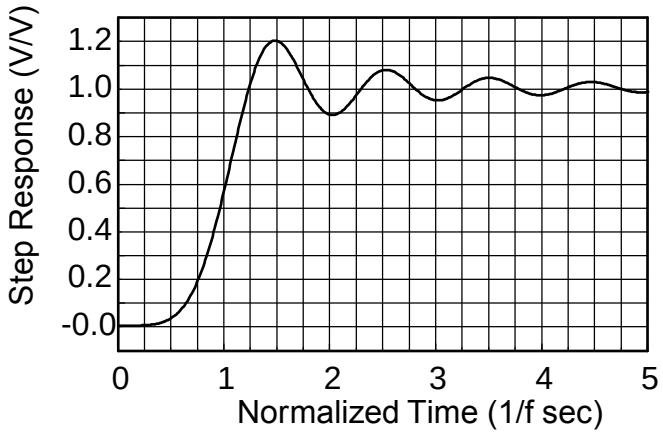
### Frequency Response




### **Delay** (Normalized)




### Step Response



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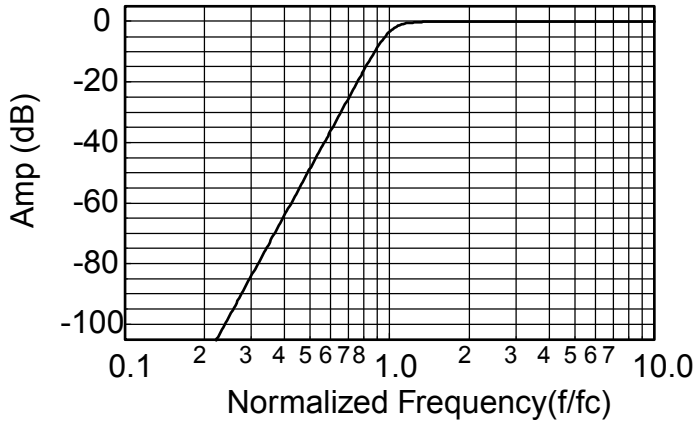
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.10 | -160 | 691 | 0.819 |
| 0.20 | -112 | 661 | 0.828 |
| 0.30 | -83.7 | 631 | 0.843 |
| 0.40 | -63.7 | 600 | 0.867 |
| 0.50 | -48.2 | 568 | 0.903 |
| 0.60 | -35.5 | 535 | .956 |
| 0.70 | -24.8 | 499 | 1.04 |
| 0.80 | -15.6 | 459 | 1.19 |
| 0.85 | -11.6 | 437 | 1.29 |
| 0.90 | -8.06 | 413 | 1.40 |
| 0.95 | -5.15 | 386 | 1.48 |
| 1.00 | -3.01 | 360 | 1.46 |
| 1.20 | -0.229 | 275 | 0.873 |
| 1.40 | -0.020 | 226 | 0.540 |
| 1.60 | -0.002 | 194 | 0.380 |
| 1.80 | 0.00 | 170 | 0.287 |
| 2.00 | 0.00 | 152 | 0.226 |
| 2.50 | 0.00 | 120 | 0.139 |
| 3.00 | 0.00 | 99.2 | 0.094 |
| 4.00 | 0.00 | 74.0 | 0.052 |
| 5.00 | 0.00 | 59.0 | 0.033 |
| 6.00 | 0.00 | 49.0 | 0.023 |
| 7.00 | 0.00 | 42.1 | 0.017 |
| 8.00 | 0.00 | 36.8 | 0.013 |
| 9.00 | 0.00 | 32.7 | 0.010 |
| 10.0 | 0.00 | 29.4 | 0.008 |

## Frequency Response




1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$



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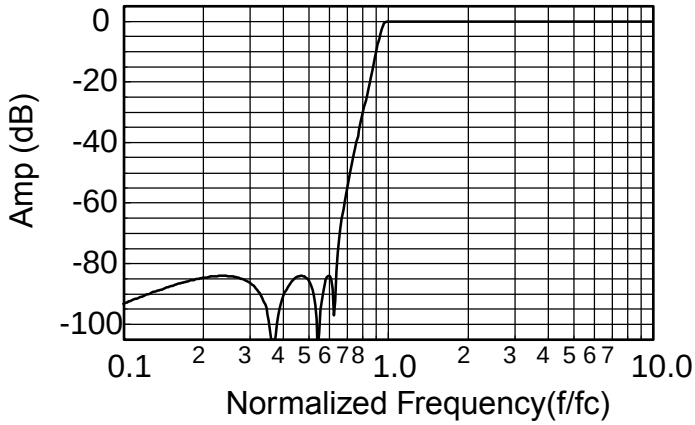
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.10 | -93.4 | 168 | 0.334 |
| 0.20 | -84.8 | 156 | 0.344 |
| 0.30 | -86.0 | 143 | 0.363 |
| 0.40 | -92.6 | 310 | 0.392 |
| 0.50 | -85.0 | 295 | 0.439 |
| 0.55 | -114 | 287 | 0.472 |
| 0.60 | -84.1 | 458 | 0.515 |
| 0.70 | -57.0 | 617 | 0.652 |
| 0.80 | -32.8 | 589 | 0.962 |
| 0.85 | -22.6 | 569 | 1.325 |
| 0.90 | -12.3 | 538 | 2.198 |
| 0.95 | -3.08 | 483 | 3.993 |
| 1.00 | -0.05 | 414 | 3.062 |
| 1.10 | -0.03 | 341 | 1.498 |
| 1.20 | -0.01 | 296 | 1.039 |
| 1.30 | -0.04 | 264 | 0.773 |
| 1.40 | -0.05 | 239 | 0.612 |
| 1.50 | -0.03 | 219 | 0.505 |
| 1.60 | -0.01 | 202 | 0.426 |
| 1.70 | 0.00 | 188 | 0.364 |
| 1.80 | 0.00 | 176 | 0.315 |
| 1.90 | -0.01 | 165 | 0.275 |
| 2.00 | -0.02 | 156 | 0.243 |
| 2.50 | -0.05 | 122 | 0.145 |
| 3.00 | -0.05 | 101 | 0.097 |
| 4.00 | -0.03 | 75.1 | 0.053 |
| 5.00 | -0.01 | 59.8 | 0.034 |
| 6.00 | -0.01 | 49.7 | 0.023 |
| 7.00 | 0.00 | 42.5 | 0.017 |
| 8.00 | 0.00 | 37.2 | 0.013 |
| 9.00 | 0.00 | 33.0 | 0.010 |
| 10.0 | 0.00 | 29.7 | 0.008 |

## Frequency Response




1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$



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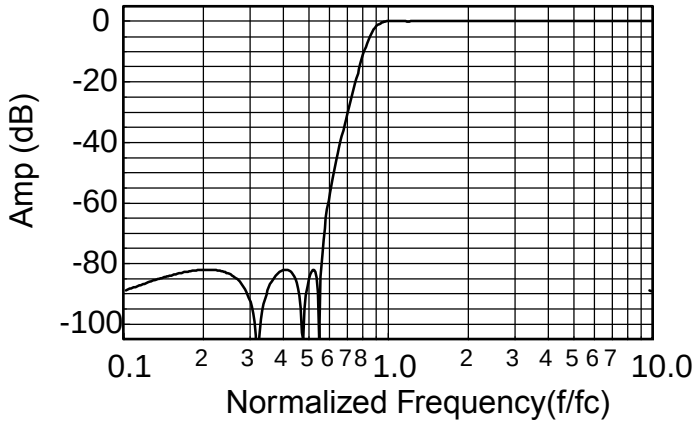
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.10 | -89.3 | 164 | 0.440 |
| 0.20 | -82.1 | 148 | 0.459 |
| 0.30 | -90.6 | 131 | 0.495 |
| 0.40 | -82.4 | 292 | 0.559 |
| 0.50 | -87.8 | 450 | 0.671 |
| 0.55 | -90.0 | 437 | 0.761 |
| 0.60 | -60.2 | 603 | 0.890 |
| 0.70 | -32.4 | 563 | 1.37 |
| 0.80 | -13.1 | 498 | 2.35 |
| 0.85 | -6.28 | 451 | 2.77 |
| 0.90 | -2.21 | 401 | 2.66 |
| 0.95 | -0.51 | 358 | 2.15 |
| 1.00 | -0.03 | 324 | 1.64 |
| 1.10 | -0.01 | 277 | 1.04 |
| 1.20 | -0.05 | 225 | 0.757 |
| 1.30 | -0.03 | 221 | 0.596 |
| 1.40 | 0.01 | 201 | 0.486 |
| 1.50 | 0.03 | 185 | 0.409 |
| 1.60 | 0.03 | 172 | 0.347 |
| 1.70 | 0.03 | 160 | 0.299 |
| 1.80 | 0.02 | 150 | 0.260 |
| 1.90 | 0.01 | 141 | 0.229 |
| 2.00 | 0.01 | 133 | 0.203 |
| 2.50 | -0.02 | 105 | 0.123 |
| 3.00 | -0.02 | 86.9 | 0.083 |
| 4.00 | -0.02 | 64.7 | 0.046 |
| 5.00 | -0.01 | 51.6 | 0.029 |
| 6.00 | -0.01 | 42.9 | 0.020 |
| 7.00 | -0.01 | 36.8 | 0.015 |
| 8.00 | -0.01 | 32.1 | 0.011 |
| 9.00 | -0.01 | 28.6 | 0.009 |
| 10.0 | 0.00 | 25.7 | 0.007 |

## Frequency Response




1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$



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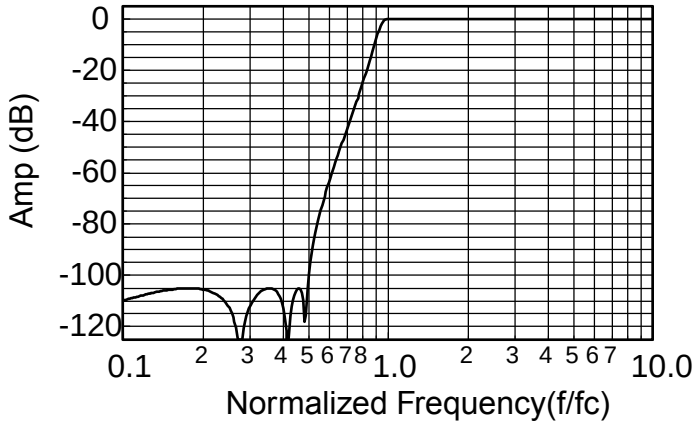
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.10 | -110 | 168 | 0.338 |
| 0.20 | -105 | 156 | 0.348 |
| 0.30 | -114 | 323 | 0.367 |
| 0.40 | -110 | 309 | 0.397 |
| 0.50 | -107 | 654 | 0.445 |
| 0.55 | -78.6 | 646 | 0.480 |
| 0.60 | -64.6 | 637 | 0.524 |
| 0.70 | -44.1 | 615 | 0.669 |
| 0.80 | -26.7 | 586 | 1.001 |
| 0.85 | -18.2 | 565 | 1.401 |
| 0.90 | -9.46 | 533 | 2.315 |
| 0.95 | -2.16 | 478 | 3.604 |
| 1.00 | -0.046 | 419 | 2.681 |
| 1.10 | -0.038 | 352 | 1.416 |
| 1.20 | -0.001 | 308 | 1.018 |
| 1.30 | -0.032 | 277 | 0.773 |
| 1.40 | -0.046 | 252 | 0.618 |
| 1.50 | -0.034 | 231 | 0.514 |
| 1.60 | -0.016 | 214 | 0.436 |
| 1.70 | -0.004 | 200 | 0.376 |
| 1.80 | 0.000 | 187 | 0.328 |
| 1.90 | -0.003 | 176 | 0.288 |
| 2.00 | -0.010 | 166 | 0.255 |
| 2.50 | -0.042 | 131 | 0.153 |
| 3.00 | -0.045 | 108 | 0.103 |
| 4.00 | -0.028 | 80.6 | 0.057 |
| 5.00 | -0.015 | 64.2 | 0.036 |
| 6.00 | -0.008 | 53.4 | 0.025 |
| 7.00 | -0.005 | 45.7 | 0.018 |
| 8.00 | -0.003 | 40.0 | 0.014 |
| 9.00 | -0.002 | 35.5 | 0.011 |
| 10.0 | -0.001 | 31.9 | 0.009 |

## Frequency Response




1. **Normalized Group Delay:**
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$$\text{Actual Delay} = \frac{\text{Normalized Delay}}{\text{Actual Corner Frequency (fc) in Hz}}$$



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