FREQUENCY DEVICES™, INC.

# PGAB5 & PGAL5 Series

## for FDI VME Boards

## Fixed Frequency Filters with Programmable Amplifiers

### Description

The PGAB5 and PGAL5 Series of fixed frequency filters with programmable gain amplifiers utilize digitally controlled gain modules that were designed for Frequency Devices' multi-channel VME board products to condition DC-coupled wide-band signals. Amplifiers are programmed by an 8-bit serial data stream for gain selection using clock, data and strobe inputs.

Other standard performance features include differential input, single ended output, 5V interface logic and low noise/distortion. Available options include AC coupled input (all models) and/or differential output (VM32PAFF only).

### Features/Benefits:

- Offers a low cost, versatile and convenient way to provide up to 32 channels of precision filtering and amplification in a single width B-size (6U) VME form factor.
- Phase match down to 1.0° with gain accuracy of 0.1 dB provides precision performance solutions to design engineers, system integrators and OEM's.
- Butterworth or Bessel transfer functions with a broad range of corner frequencies are offered to meet a wide range of applications.

### Filter/Amplifier Options:

**VM32PAFF-PGAB5-100**
3-pole Butterworth, 100 Hz to 100 kHz
-12 dB to +60 dB gain in 6 dB steps

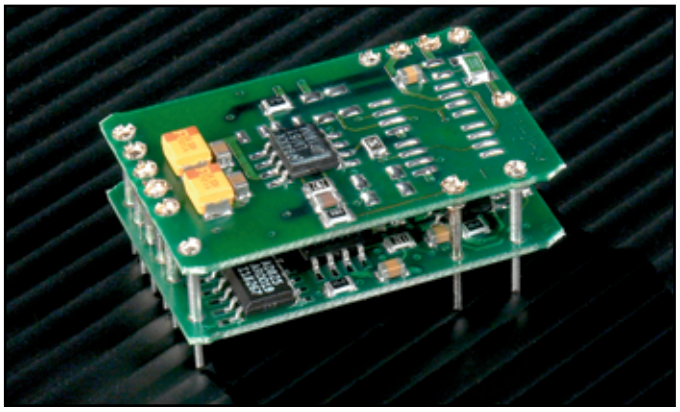
**VM32PAFF-PGAB5-300**
3-pole Butterworth, 100 Hz to 300 kHz
-12 dB to +42 dB gain in 6 dB steps

**VM2.0PAFF-PGAB5-2.0**
4-pole Butterworth, >100 kHz to 2.0 MHz
-12 dB to +36 dB gain in 6 dB steps

**VM32PAFF-PGAL5-100**
3-pole Bessel, 100 Hz to 100 kHz
-12 dB to +60 dB gain in 6 dB steps

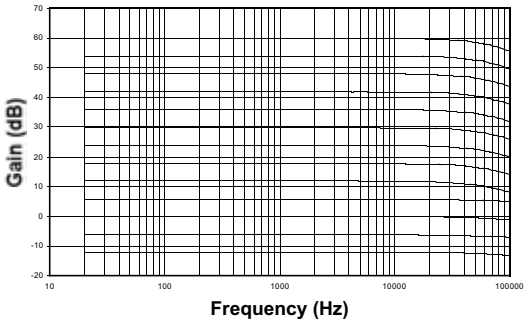
**VM32PAFF-PGAL5-300**
3-pole Bessel, 100 Hz to 300 kHz
-12 dB to +42 dB gain in 6 dB steps

**VM2.0PAFF-PGAL5-2.0**
4-pole Bessel, >100 kHz to 2.0 MHz
-12 dB to +36 dB gain in 6 dB steps

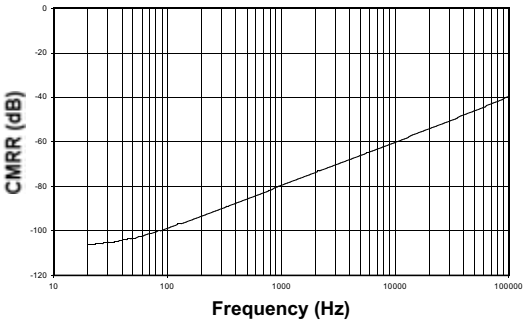


**PGAB5-100 & PGAL5-100**

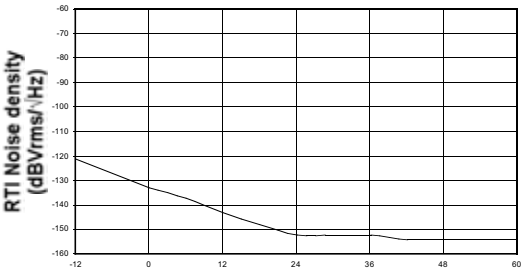
**Frequency Response**




**Common Mode Rejection Ratio**




**Noise**

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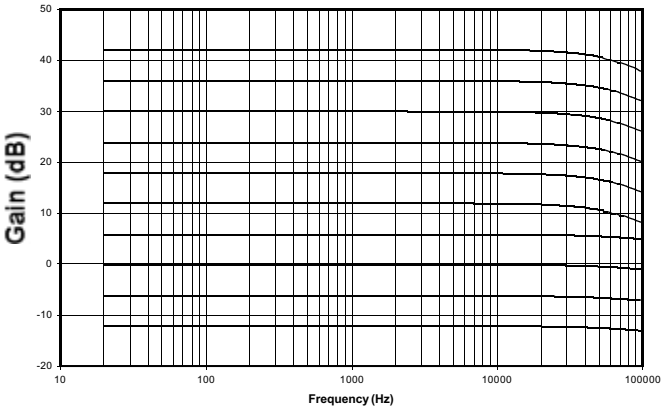
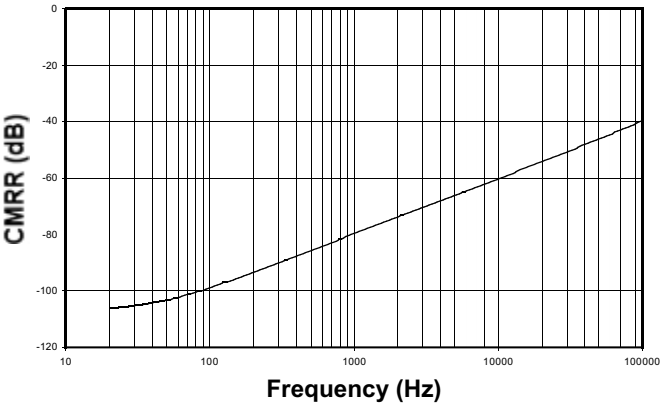
## PGAB5-300 & PGAL5-300

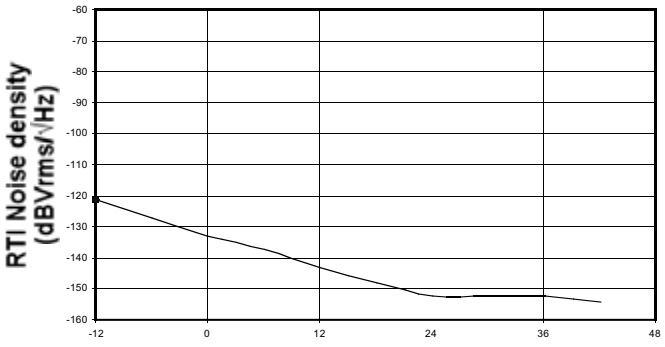
### Frequency Response




### Common Mode Rejection Ratio

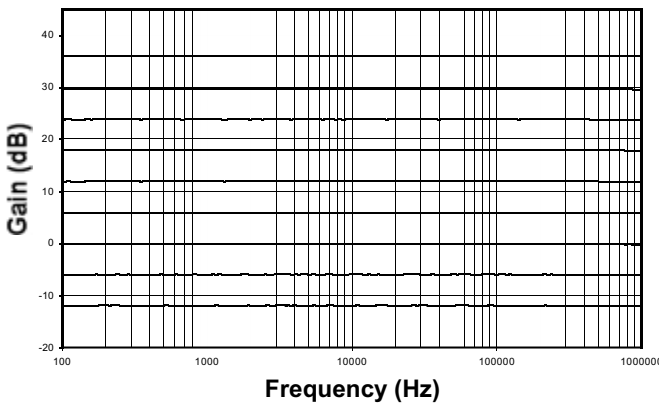



### Noise

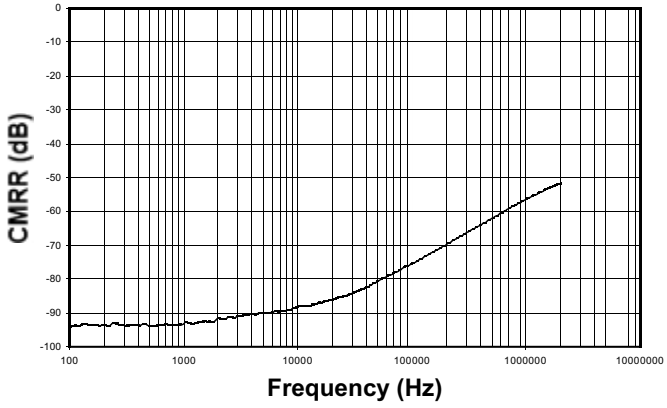



## PGAB5-2.0 & PGAL5-2.0

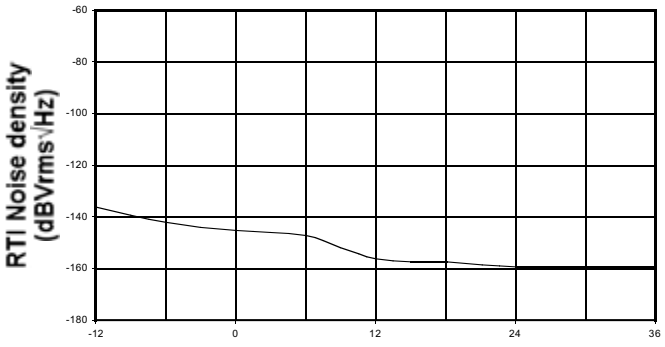
### Frequency Response




### Common Mode Rejection Ratio




### Noise



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## Specification

(25°C and rated power input)

# Butterworth Fixed Frequency Filters with Programmable Amplifiers

| VME Board | VM32PAFF<br>PGAB5-100 | VM32PAFF<br>PGAB5-300 | VM2.0PAFF<br>PGAB5-2.0 |
|---|---|---|---|
| **Analog Input** | | | |
| Impedance | 1 MΩ/22pF | 1 MΩ/22pF | 1 MΩ/22pF |
| Linear Input Range | ±8V pk | ±8V pk | ±8V pk |
| CMRR | 80 dB @ 1kHz typ.<br>60 dB min. | 80 dB @ 1kHz typ.<br>60 dB min. | ≥ 50 dB, DC to 100 kHz<br>≥40dB,100kHz to 2MHz |
| Maximum Input Range | ±15V | ±15V | 20 V pk-pk, each leg |
| AC Couple (Optional Fixed Freq.) | 10Hz to 1.0 kHz | 10Hz to 1.0 kHz | 20 Hz to 1.0 kHz |
| **Analog Output** | | | |
| Impedance | 1Ω typ., 10Ω max. | 1Ω typ., 10Ω max. | 1Ω typ., 10Ω max. |
| Linear Operating Range | ±5V, Output clamped to ±9V | ±5V, Output clamped to ±9V | ±4V into 500Ω |
| Chl. to Chl. Crosstalk | <-100dB @ 1 kHz,<br><-90dB @ 20 kHz | <-100dB @ 1 kHz,<br><-90dB @ 20 kHz | <-100dB @ 1 kHz,<br><-90dB @ 20 kHz |
| Maximum Current | 5 mA | 5 mA | 5 mA |
| Offset Voltage | 2mV RTI, NTE 40 mV max. | 2mV RTI, NTE 40 mV max. | 25 mV typ. 50 mV max. |
| Offset Temp. Coeff. | ±(5+ 100/G) µV/ºC max. | ±(5+ 100/G) µV/ºC max. | ±(5+ 100/G) µV/ºC max. |
| **Filter** Characteristics | | | |
| Filter type | Butterworth, 3-pole low-pass | Butterworth, 3-pole low-pass | Butterworth, 4-pole low-pass |
| Cut-off Frequency fc (-3 dB) | 100 Hz to 100 kHz | 100 Hz to 300 kHz | >100 kHz to 2 MHz |
| **Theoretical Transfer Characteristics** | See Appendix A<br>Page 45 | See Appendix A<br>Page 45 | See Appendix A<br>Page 7 |
| Amplitude Match* | ±0.1dB @ DC,<br>linear to ±0.25dB at fc | ±0.1dB @ DC,<br>linear to ±0.25dB at fc | ±0.2dB @ DC |
| Phase Match* | 0.2º typ., 1º max @ fc | 0.5º typ., 2º max @ fc | 2.0º max @ fc |
| Noise Voltage Density, RTI (Fc = 100 kHz) | 20nV/√Hz @1kHz,G=1,024 | 20nV/√Hz @1kHz,G=128 | 16nV/√Hz @ 1 kHz, G=64 |
| Distortion (2 V pk-pk) | NA | NA | ≤-60db to 100 kHz<br>≤-50 dB, 100 kHz to 2 MHz |
| Distortion G=2X at 1VRMS | -83dB, 1 kHz single ended | -83dB, 1 kHz single ended | NA |
| Output, RL-2kΩ, BW=100 kHz | -86dB, 1 kHz differential | -86dB, 1 kHz single ended | NA |
| Gain Programming (G) | 0.25X to 1024X in factors of 2 | 0.25X to 128X in factors of 2 | 0.25X to 64X in factors of 2 |
| Gain Accuracy @ DC | ±0.1 dB | ±0.1 dB | ±0.1 dB max. |
| Differential Output | Optional | Optional | NA |

*Any two channels set to same gain and loading
NA – Not Available



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## Specification

(25°C and rated power input)

## Bessel Fixed Frequency Filters with Programmable Amplifiers

| VME Board | VM32PAFF<br>PGAL5-100 | <br>PGAL5-300 | VM2.0PAFF<br>PGAL5-2.0 |
|---|---|---|---|
| **Analog Input** | | | |
| Impedance | 1 MΩ/22pF | 1 MΩ/22pF | 1 MΩ/22pF |
| Linear Input Range | ±8V pk | ±8V pk | ±8V pk |
| CMRR | 80 dB @ 1kHz typ.<br>60 dB min. | 80 dB @ 1kHz typ.<br>60 dB min. | ≥ 50 dB, DC to 100 kHz<br>≥40dB,100kHz to 2MHz |
| Maximum Input Range | ±15V | ±15V | 20 V pk-pk, each leg |
| AC Couple (Optional Fixed Freq.) | 10Hz to 1.0 kHz | 10Hz to 1.0 kHz | 20 Hz to 1.0 kHz |
| **Analog Output** | | | |
| Impedance | 1Ω typ., 10Ω max. | 1Ω typ., 10Ω max. | 1Ω typ., 10Ω max. |
| Linear Operating Range | ±5V, Output clamped to ±9V | ±5V, Output clamped to ±9V | ±4V into 500Ω |
| Chl. to Chl. Crosstalk | <-100dB @ 1 kHz,<br><-90dB @ 20 kHz | <-100dB @ 1 kHz,<br><-90dB @ 20 kHz | <-100dB @ 1 kHz,<br><-90dB @ 20 kHz |
| Maximum Current | 5 mA | 5 mA | 5 mA |
| Offset Voltage | 2mV RTI, NTE 40 mV max. | 2mV RTI, NTE 40 mV max. | 25 mV typ. 50 mV max. |
| Offset Temp. Coeff. | ±(5+ 100/G) µV/ºC max. | ±(5+ 100/G) µV/ºC max. | ±(5+ 100/G) µV/ºC max. |
| **Filter Characteristics** | | | |
| Filter type | Bessel, 3-pole low-pass | Bessel, 3-pole low-pass | Bessel, 4-pole low-pass |
| Cut-off Frequency fc (-3 dB) | 100 Hz to 100 kHz | 100 Hz to 300 kHz | >100 kHz to 2 MHz |
| **Theoretical Transfer Characteristics** | See Appendix A<br>Page 44 | See Appendix A<br>Page 44 | See Appendix A<br>Page 2 |
| Amplitude Match* | ±0.1dB @ DC,<br>linear to ±0.25dB at fc | ±0.1dB @ DC,<br>linear to ±0.25dB at fc | ±0.2dB @ DC |
| Phase Match* | 0.2º typ., 1º max @ fc | 0.5º typ., 2º max @ fc | 2.0º max @ fc |
| Noise Voltage Density, RTI (Fc = 100 kHz) | 20nV/√Hz @1kHz,G=1,024 | 20nV/√Hz @1kHz,G=128 | 16nV/√Hz @ 1 kHz, G=64 |
| Distortion (2 V pk-pk) | NA | NA | ≤-60db to 100 kHz<br>≤-50 dB, 100 kHz to 2 MHz |
| Distortion G=2X at 1VRMS | -83dB, 1 kHz single ended | -83dB, 1 kHz single ended | NA |
| Output, RL-2kΩ, BW=100 kHz | -86dB, 1 kHz differential | -86dB, 1 kHz single ended | NA |
| Gain Programming (G) | 0.25X to 1024X in factors of 2 | 0.25X to 128X in factors of 2 | 0.25X to 64X in factors of 2 |
| Gain Accuracy @ DC | ±0.1 dB | ±0.1 dB | ±0.1 dB max. |
| Differential Output | Optional | Optional | NA |

*Any two channels set to same gain and loading
NA – Not Available

We hope the information given here will be helpful. The information is based on data and our best knowledge, and we consider the information to be true and accurate. Please read all statements, recommendations or suggestions herein in conjunction with our conditions of sale which apply to all goods supplied by us. We assume no responsibility for the use of these statements, recommendations or suggestions, nor do we intend them as a recommendation for any use which would infringe any patent or copyright.



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# Low-Pass

**4-Pole**

**Bessel**

**Appendix A**

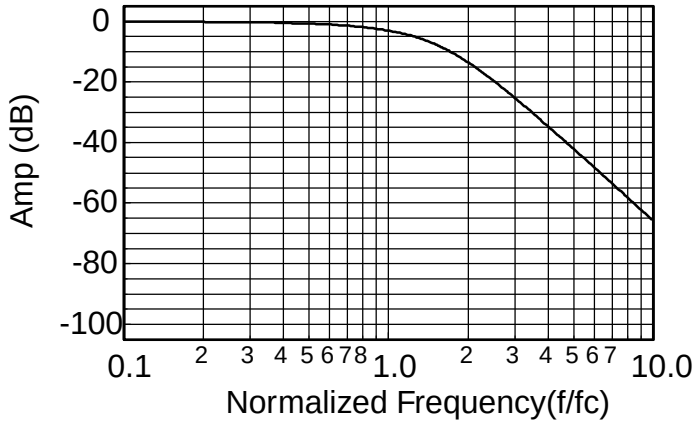
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | .336 |
| 0.10 | -0.028 | -12.1 | .336 |
| 0.20 | -0.111 | -24.2 | .336 |
| 0.30 | -0.251 | -36.3 | .336 |
| 0.40 | -0.448 | -48.4 | .336 |
| 0.50 | -0.705 | -60.6 | .336 |
| 0.60 | -1.02 | -72.7 | .336 |
| 0.70 | -1.41 | -84.8 | .336 |
| 0.80 | -1.86 | -96.8 | .335 |
| 0.85 | -2.11 | -103 | .334 |
| 0.90 | -2.40 | -109 | .333 |
| 0.95 | -2.69 | -115 | .332 |
| 1.00 | -3.01 | -121 | .330 |
| 1.10 | -3.71 | -133 | .325 |
| 1.20 | -4.51 | -144 | .318 |
| 1.30 | -5.39 | -156 | .308 |
| 1.40 | -6.37 | -166 | .295 |
| 1.50 | -7.42 | -177 | .280 |
| 1.60 | -8.54 | -187 | .263 |
| 1.70 | -9.71 | -195 | .246 |
| 1.80 | -10.9 | -204 | .228 |
| 1.90 | -12.2 | -212 | .211 |
| 2.00 | -13.4 | -219 | .194 |
| 2.25 | -16.5 | -235 | .158 |
| 2.50 | -19.5 | -248 | .129 |
| 2.75 | -22.4 | -259 | .107 |
| 3.00 | -25.1 | -267 | .089 |
| 3.25 | -27.6 | -275 | .076 |
| 3.50 | -30.0 | -281 | .065 |
| 4.00 | -34.4 | -291 | .049 |
| 5.00 | -41.9 | -305 | .031 |
| 6.00 | -48.1 | -315 | .021 |
| 7.00 | -53.4 | -321 | .016 |
| 8.00 | -58.0 | -326 | .012 |
| 9.00 | -62.0 | -330 | .009 |
| 10.0 | -65.7 | -333 | .008 |

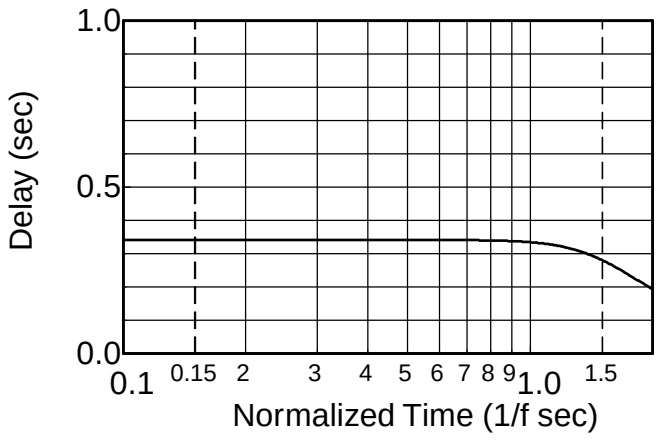
1.**Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

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

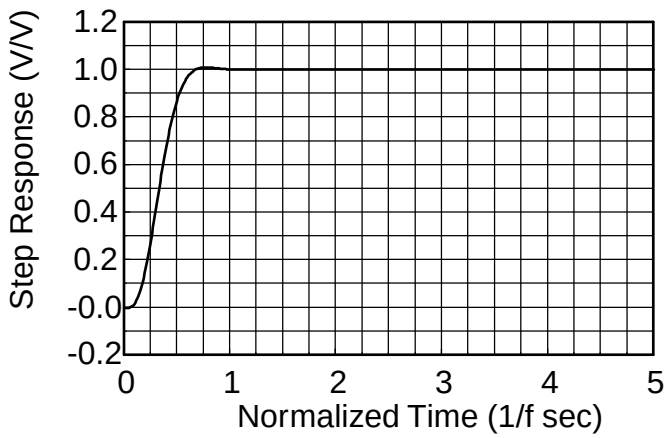
### Frequency Response




### **Delay** (Normalized)




### Step Response



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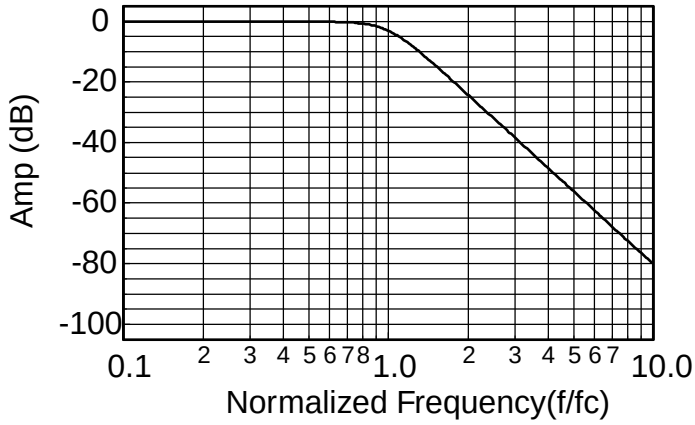
## Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | .416 |
| 0.10 | 0.00 | -15.0 | .418 |
| 0.20 | 0.00 | -30.1 | .423 |
| 0.30 | -0.00 | -45.5 | .433 |
| 0.40 | -0.003 | -61.4 | .449 |
| 0.50 | -0.017 | -78.0 | .474 |
| 0.60 | -0.072 | -95.7 | .511 |
| 0.70 | -0.243 | -115 | .558 |
| 0.80 | -0.674 | -136 | .604 |
| 0.85 | -1.047 | -147 | .619 |
| 0.90 | -1.555 | -158 | .622 |
| 0.95 | -2.21 | -169 | .612 |
| 1.00 | -3.01 | -180 | .588 |
| 1.10 | -4.97 | -200 | .513 |
| 1.20 | -7.24 | -217 | .427 |
| 1.30 | -9.62 | -231 | .350 |
| 1.40 | -12.0 | -242 | .289 |
| 1.50 | -14.3 | -252 | .241 |
| 1.60 | -16.4 | -260 | .204 |
| 1.70 | -18.5 | -266 | .175 |
| 1.80 | -20.5 | -272 | .152 |
| 1.90 | -22.3 | -277 | .134 |
| 2.00 | -24.1 | -282 | .119 |
| 2.25 | -28.2 | -291 | .091 |
| 2.50 | -31.8 | -299 | .072 |
| 2.75 | -35.1 | -304 | .059 |
| 3.00 | -38.2 | -309 | .049 |
| 3.25 | -41.0 | -313 | .041 |
| 3.50 | -43.5 | -317 | .035 |
| 4.00 | -48.2 | -322 | .027 |
| 5.00 | -55.9 | -330 | .017 |
| 6.00 | -62.3 | -335 | .012 |
| 7.00 | -67.6 | -339 | .009 |
| 8.00 | -72.2 | -341 | .007 |
| 9.00 | -76.3 | -343 | .005 |
| 10.0 | -80.0 | -345 | .004 |

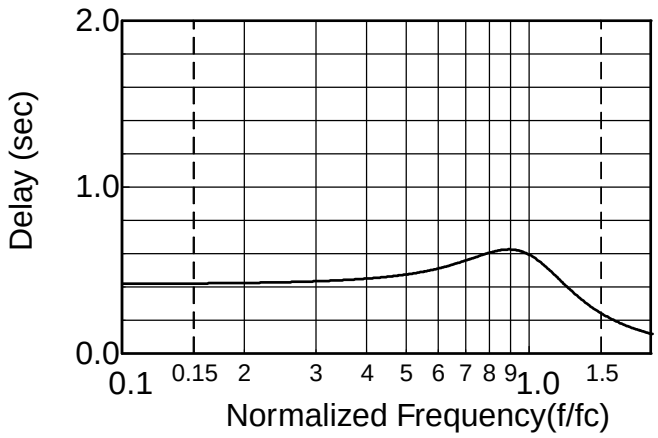
1. **Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

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

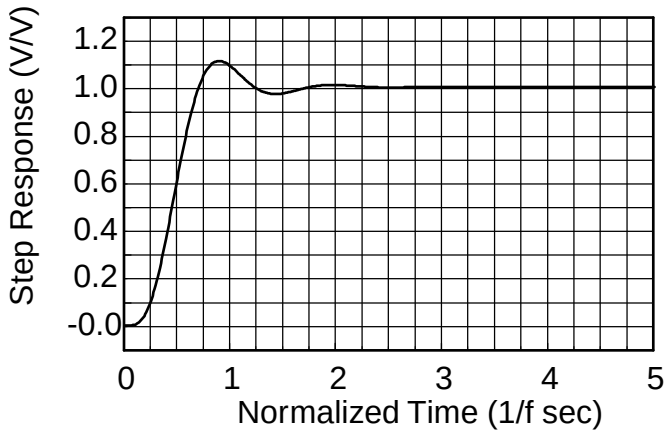
### Frequency Response




### **Delay** (Normalized)




### Step Response



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FREQUENCY DEVICES™, INC.

# Low-Pass

# 3-Pole Bessel

## Appendix A

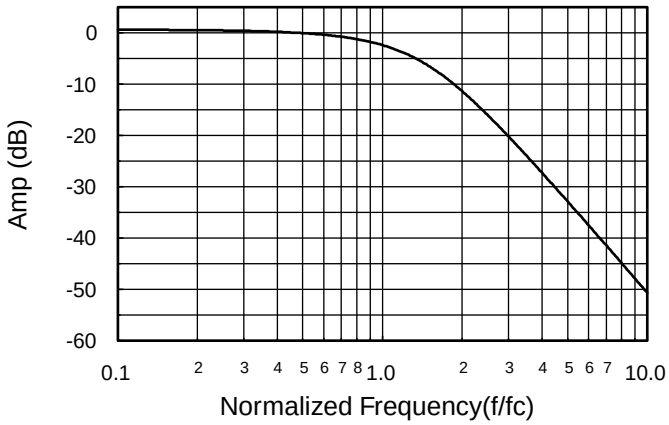
### Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay [1] (sec) |
|---|---|---|---|
| 0.10 | -0.027 | -10.1 | .279 |
| 0.20 | -0.108 | -20.1 | .279 |
| 0.30 | -0.243 | -30.2 | .279 |
| 0.40 | -0.436 | -40.2 | .279 |
| 0.50 | -0.689 | -50.3 | .279 |
| 0.60 | -1.01 | -60.3 | .278 |
| 0.70 | -1.39 | -70.3 | .276 |
| 0.80 | -1.85 | -80.2 | .273 |
| 0.90 | -2.39 | -89.9 | .268 |
| 1.00 | -3.01 | -99.5 | .261 |
| 1.10 | -3.71 | -109 | .252 |
| 1.20 | -4.47 | -118 | .241 |
| 1.30 | -5.31 | -126 | .228 |
| 1.40 | -6.19 | -134 | .214 |
| 1.50 | -7.12 | -141 | .199 |
| 1.60 | -8.08 | -148 | .184 |
| 1.70 | -9.05 | -155 | .170 |
| 1.80 | -10.0 | -161 | .157 |
| 1.90 | -11.0 | -166 | .144 |
| 2.00 | -12.0 | -171 | .133 |
| 2.50 | -16.7 | -191 | .089 |
| 3.00 | -20.9 | -204 | .062 |
| 3.50 | -24.6 | -213 | .046 |
| 4.00 | -27.8 | -221 | .035 |
| 5.00 | -33.4 | -231 | .022 |
| 6.00 | -38.1 | -237 | .015 |
| 7.00 | -42.0 | -242 | .011 |
| 8.00 | -45.5 | -245 | .009 |
| 9.00 | -48.5 | -248 | .007 |
| 10.0 | -51.2 | -250 | .005 |

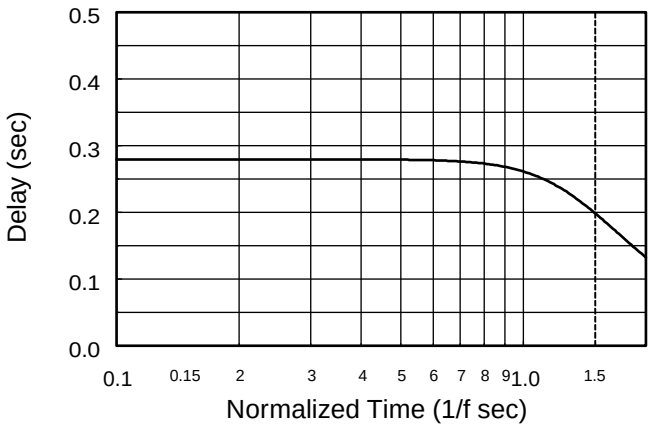
1.**Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

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

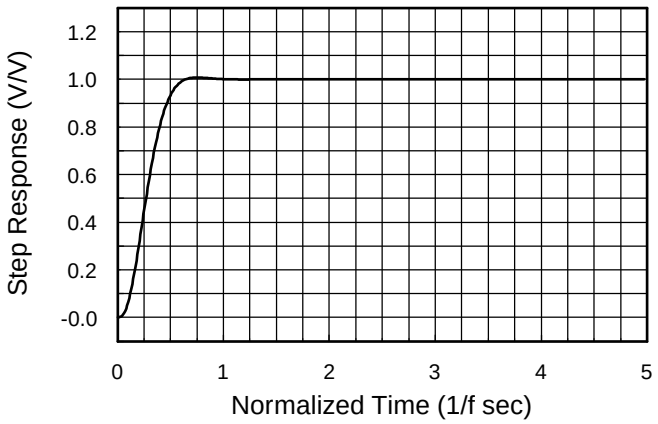
### Frequency Response




### **Delay** (Normalized)




### Step Response



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FREQUENCY DEVICES™, INC.

# Low-Pass

# 3-Pole Butterworth

## Appendix A

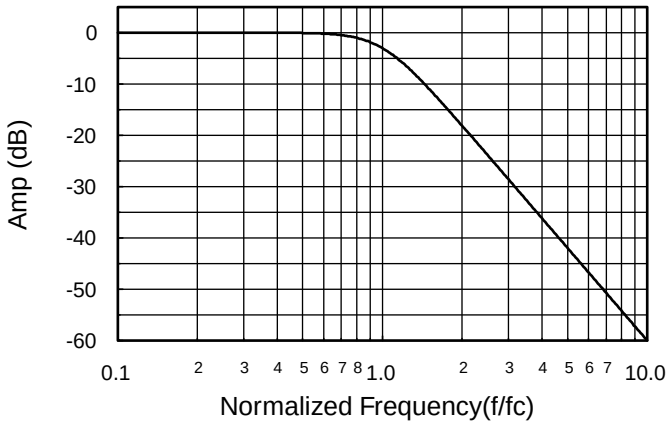
### Theoretical Transfer Characteristics

| f/fc (Hz) | Amp (dB) | Phase (deg) | Delay[1] (sec) |
|---|---|---|---|
| 0.10 | 0.000 | -11.5 | .320 |
| 0.20 | 0.000 | -23.1 | .325 |
| 0.30 | -0.003 | -34.9 | .335 |
| 0.40 | -0.018 | -47.3 | .350 |
| 0.50 | -0.067 | -60.3 | .372 |
| 0.60 | -0.198 | -74.1 | .398 |
| 0.70 | -0.483 | -88.9 | .423 |
| 0.80 | -1.01 | -104 | .436 |
| 0.90 | -1.85 | -120 | .428 |
| 1.00 | -3.01 | -135 | .398 |
| 1.10 | -4.43 | -149 | .352 |
| 1.20 | -6.01 | -160 | .303 |
| 1.30 | -7.65 | -170 | .257 |
| 1.40 | -9.31 | -179 | .217 |
| 1.50 | -10.9 | -186 | .185 |
| 1.60 | -12.5 | -192 | .158 |
| 1.70 | -14.0 | -198 | .137 |
| 1.80 | -15.4 | -202 | .119 |
| 1.90 | -16.8 | -206 | .105 |
| 2.00 | -18.1 | -210 | .093 |
| 2.50 | -23.9 | -223 | .056 |
| 3.00 | -28.6 | -231 | .038 |
| 3.50 | -32.6 | -237 | .027 |
| 4.00 | -36.1 | -241 | .021 |
| 5.00 | -41.9 | -247 | .013 |
| 6.00 | -46.7 | -251 | .009 |
| 7.00 | -50.7 | -254 | .007 |
| 8.00 | -54.2 | -256 | .005 |
| 9.00 | -57.3 | -257 | .004 |
| 10.0 | -60.0 | -259 | .003 |

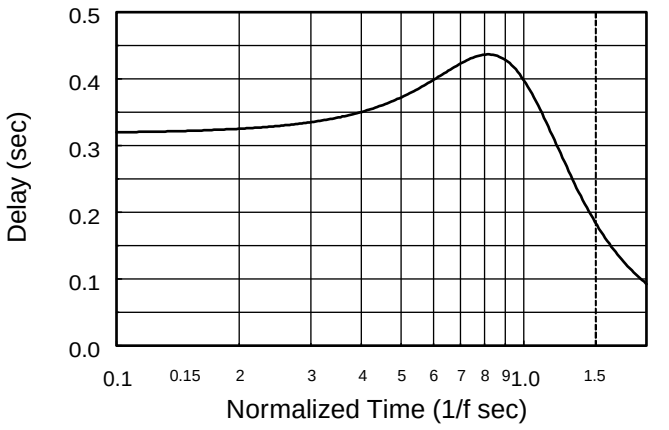
1.**Normalized Group Delay:**
The above delay data is normalized to a corner frequency of 1.0Hz.The actual delay is the normalized delay divided by the actual corner frequency (fc).

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

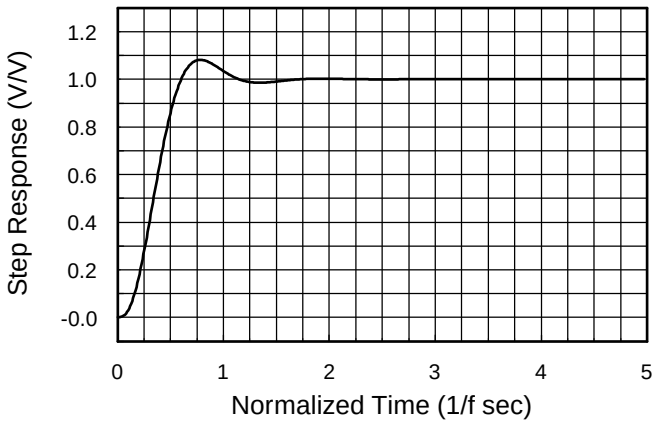
### Frequency Response




### **Delay** (Normalized)




### Step Response



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