# FREQUENCY DEVICES™

# 828BP & 828BR Series

## Band Pass and Band Reject

## 8 Bit Programmable 4-Pole Pair Filters

### Description:

The 828BP and 828BR Series are 4-pole-pair digitally programmable band-pass and band-reject (notch) active filters. These new filters take advantage of the company's proprietary designs using surface-mount technology to provide a low profile, compact package in minimal board space. 828BP and 828BR filters are factory tuned to one of three factory set tuning ranges or 8-bit custom ranges from 1 Hz to 25.6 kHz. Each filter type features a near theoretical amplitude/phase response along with low output voltage noise enabling these filters to achieve a 10,000:1 or better dynamic signal range

Pretuned to within ±2% of the center frequency, band-pass 828BP filters pass all frequencies lying between the upper and lower -3 dB points of the amplitude response curve, while 828BR band-reject (notch) filters sharply attenuate those frequencies that are bound and defined by the bottom of the notch. Available Q's for 828 BP models are 1, 2, 5, or 10 and 828BR filters are 3 or 10.

### Features/Benefits:

- Compact 2.0"L x 2.0"W footprint 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 center frequencies to meet a wide range of applications.

### Applications

- Power line interference rejection
- Transducer output filtering:
- Production test instrumentation
- Medical electronics equipment and research
- Comb filtering and equalization
- Noise and harmonic analysis
- RMS measurements
- Frequency spectrum analysis

1

# FREQUENCY DEVICES™

# 828BP & 828BR Series

## 8-Bit Programmable Filters

## Digital Tuning & Control Characteristics

### Digital Tuning Characteristics

The digital tuning interface circuits are a parallel set of eight (8) 4053 CMOS switches which accept CMOS compatible inputs for the eight tuning bits ($D_0$ - $D_7$).

Filter tuning follows the tuning equation given below:

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

where $D_1$ - $D_7$ = "0" or "1", and
$f_{max}$ = Maximum tuning frequency;
$f_c$ = corner frequency;
Minimum tunable frequency = $f_{max}/256$ (D0 thru D7 = 0);
Minimum frequency step (Resolution) = $f_{max}/256$

### Data Input Specifications

**Input Data Levels**       **(CMOS Logic)**

Input Voltage (Vs = 15 Vdc)
    Low Level In       0 Vdc min.       4 Vdc max.
    High Level In      11 Vdc min.      15 Vdc max.

Input Current
    High Level In      - $10^{-5}$ µA typ.      -1 µA max.
    Low Level In       +$10^{-5}$ µA typ.      +1 µA max.

Input Capacitance     5 pF typ       7.5 pF max.

**Input Data Format**       **Frequency Select Bits**

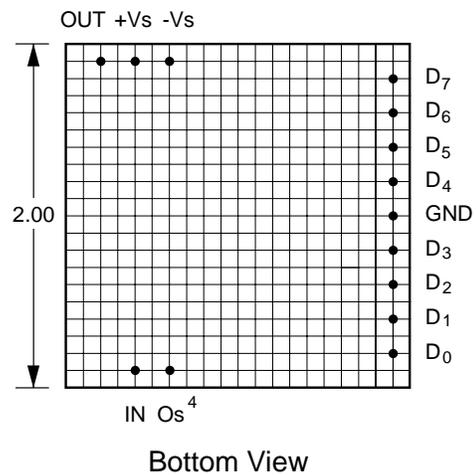Positive Logic       Logic "1" = +Vs
                     Logic "0" = Gnd

Bit Weighting        (Binary-Coded)
    $D_0$            LSB (least significant bit)
    $D_7$            MSB (most significant bit)

Frequency Range      256 : 1, Binary Weighted

### Pin-Out Key

| | |
|---|---|
| IN | Analog Input Signal |
| OUT | Analog Output Signal |
| GND | Power and Signal Return |
| +Vs | Supply Voltage, Positive |
| -Vs | Supply Voltage, Negative |
| Os | Offset Adjustment |

$D_7$ Tuning Bit 7 (MSB)
$D_6$ Tuning Bit 6
$D_5$ Tuning Bit 5
$D_4$ Tuning Bit 4
$D_3$ Tuning Bit 3
$D_2$ Tuning Bit 2
$D_1$ Tuning Bit 1
$D_0$ Tuning Bit 0 (LSB)

OUT  +Vs  -Vs

2.00

$D_7$
$D_6$
$D_5$
$D_4$
GND
$D_3$
$D_2$
$D_1$
$D_0$

IN  Os  4

Bottom View

| MSB | --- | --- | --- | --- | --- | --- | LSB | Bit Weight |
|---|---|---|---|---|---|---|---|---|
| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | $f_c$ Corner Frequency |
| $D_7$ | $D_6$ | $D_5$ | $D_4$ | $D_3$ | $D_2$ | $D_1$ | $D_0$ | |
| 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 | $f_{max}/4$ |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | $f_{max}/2$ |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | $f_{max}$ |

**FREQUENCY DEVICES™**

## 8-Bit Programmable
## 4-Pole Pair Filters

### Band-Pass & Band-Reject

| Model | 828BP4 | Model | 828BR4 |
|---|---|---|---|
| **Product Specifications** | Band-Pass | **Product Specifications** | Band-Reject |
| **Size Model 2**<br>**Model 3 & 4** | 2.0" x 2.0" x 0.6"<br>2.0" x 2.0" x 0.5" | **Size Model 2**<br>**Model 3 & 4** | 2.0" x 2.0" x 0.6"<br>2.0" x 2.0" x 0.5" |
| **Range fo** | 1 Hz to 25.6 kHz | **Range fo** | 1 Hz to 25.6 kHz |
| **Available "Q's"[1]** | 1, 2, 5, 10 | **Available "Q's"[1]** | 3, 10 |
| **Q Accuracy** | ±10% | **Q Accuracy** | ±10% |
| **Theoretical Transfer Characteristics** | Appendix A<br>Pages 41 & 42 | **Theoretical Transfer Characteristics** | Appendix A<br>Pages 43 |
| | | **Notch Attenuation** | 45 db typ. |
| **Pass-Band Gain**<br>(non-inverting) | 0± 0.25 dB typ.<br>0± 0.50 dB max. | **Pass-Band Gain**<br>(non-inverting) | 0± 0.25 dB typ.<br>0± 0.50 dB max. |
| **Attenuation Rate** | 24 dB/octave | **Attenuation Rate** | 24 dB/octave |
| **Center Frequency** | fo ±2% max. | **Center Frequency** | fo ±2% max. |
| **Stability** | ±0.01%/°C | **Stability** | ±0.01%/°C |
| **Filter Mounting Assembly** | FMA-02A | **Filter Mounting Assembly** | FMA-02A |

1. Q – Quality Factor for band-pass and band-reject filters. $Q = f_O/(f_H-f_L)$    $f_O = \sqrt{f_H f_L}$

# FREQUENCY DEVICES™

# 828BP & 828BR Series

## Specification
(25°C and Vs ±15Vdc)

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

**Analog Input Characteristics[1]**

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

**Analog Output Characteristics**

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

**Power Supply (±V)**

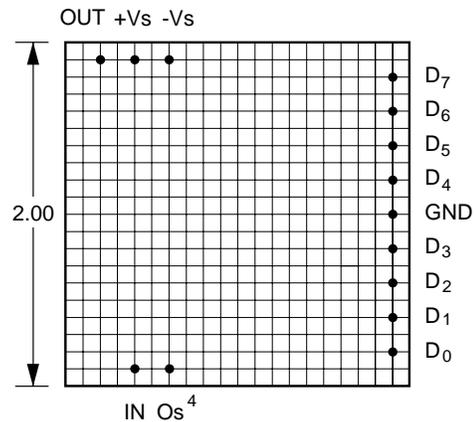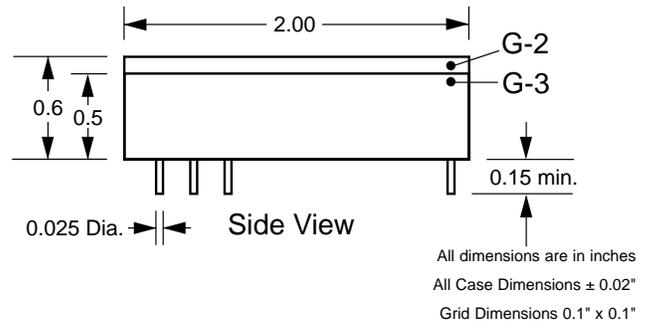| | |
|---|---|
| Rated Voltage | ±15 Vdc |
| Operating Range | ±12 to ±18 Vdc |
| Maximum Safe Voltage | ±18 Vdc |
| Quiescent Current | ±25 mA typ. |
| | ±40 mA max. |

**Temperature**

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

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 without offset pin connected.

### DC Offset Adjustment

+ Vs

Do not connect
if trim is not
required.

20 k Ω
(Cermet)

OS

- Vs

### Pin-Out & Package Data



2.00

G-2
G-3

0.6  0.5

0.15 min.

0.025 Dia.  Side View

All dimensions are in inches
All Case Dimensions ± 0.02"
Grid Dimensions 0.1" x 0.1"

OUT +Vs -Vs

$D_7$
$D_6$
$D_5$
$D_4$
GND
$D_3$
$D_2$
$D_1$
$D_0$

2.00

IN Os[4]
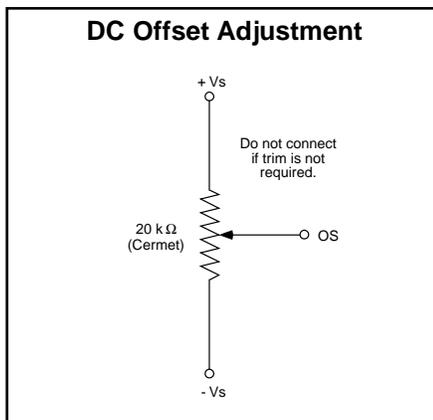
Bottom View

**Filter Mounting Assembly-See FMA-02A**

### Ordering Information

**Filter Type**

**BP** - Band Pass
**BR** - Band Reject

# 828BP4/10-4

**"Q"**
**BP** - 1, 2, 5, 10
**BR** - 3, 10

**Model**

| Model Number | Tuning Range (Hz) | Minimum Step(Hz) | Case |
|---|---|---|---|
| 2 | 1.0 to 256 | 1.0 | G-2 |
| 3 | 10 to 2560 | 10 | G-3 |
| 4 | 100 to 25.6k | 100 | G-3 |

## Amplitude Response Curves



Normalized Frequency (f/fo)



Normalized Frequency (f/fo)
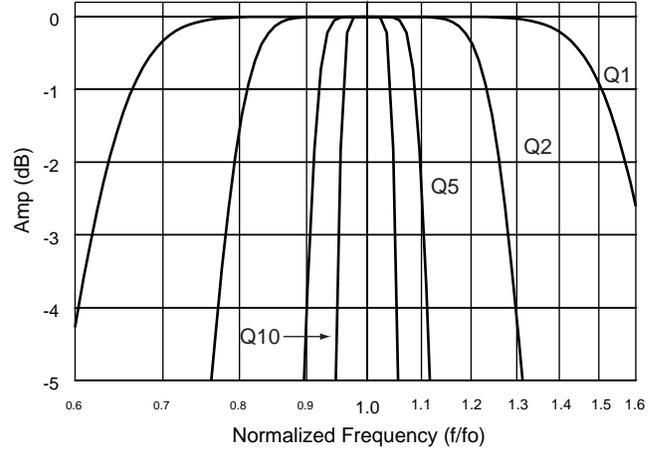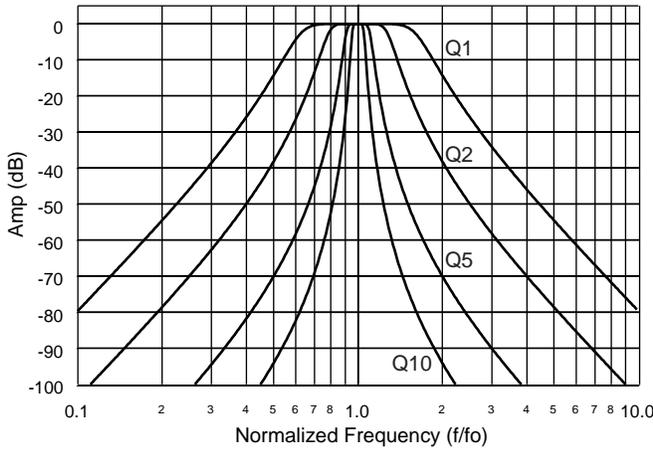
### Normalized Theoretical Amplitude Data

| Amp (dB) | Q = 1 $f_L < f_O < f_H$ | | Q = 2 $f_L < f_O < f_H$ | | Q = 5 $f_L < f_O < f_H$ | | Q = 10 $f_L < f_O < f_H$ | |
|---|---|---|---|---|---|---|---|---|
| | $f/f_o$ | $f/f_o$ | $f/f_o$ | $f/f_o$ | $f/f_o$ | $f/f_o$ | $f/f_o$ | $f/f_o$ |
| -0.10 | 0.735 | 1.360 | 0.856 | 1.168 | 0.939 | 1.064 | 0.969 | 1.032 |
| -0.25 | 0.709 | 1.411 | 0.840 | 1.191 | 0.932 | 1.073 | 0.965 | 1.036 |
| -0.50 | 0.687 | 1.456 | 0.826 | 1.211 | 0.926 | 1.080 | 0.962 | 1.039 |
| -1.00 | 0.663 | 1.508 | 0.811 | 1.233 | 0.919 | 1.088 | 0.959 | 1.043 |
| -1.50 | 0.648 | 1.543 | 0.801 | 1.249 | 0.914 | 1.094 | 0.956 | 1.046 |
| -2.00 | 0.636 | 1.571 | 0.793 | 1.261 | 0.911 | 1.098 | 0.954 | 1.048 |
| -2.50 | 0.627 | 1.596 | 0.787 | 1.271 | 0.908 | 1.102 | 0.953 | 1.050 |
| -3.00 | 0.618 | 1.618 | 0.781 | 1.281 | 0.905 | 1.105 | 0.951 | 1.051 |
| -5.00 | 0.591 | 1.692 | 0.762 | 1.313 | 0.896 | 1.116 | 0.946 | 1.057 |
| -10.00 | 0.539 | 1.855 | 0.724 | 1.382 | 0.877 | 1.140 | 0.936 | 1.068 |
| -15.00 | 0.493 | 2.027 | 0.688 | 1.454 | 0.858 | 1.165 | 0.926 | 1.080 |
| -20.00 | 0.449 | 2.225 | 0.650 | 1.538 | 0.838 | 1.193 | 0.915 | 1.093 |
| -25.00 | 0.407 | 2.459 | 0.611 | 1.637 | 0.816 | 1.226 | 0.903 | 1.108 |
| -30.00 | 0.365 | 2.737 | 0.570 | 1.755 | 0.791 | 1.265 | 0.888 | 1.126 |
| -35.00 | 0.326 | 3.065 | 0.527 | 1.896 | 0.763 | 1.311 | 0.872 | 1.146 |
| -40.00 | 0.290 | 3.452 | 0.484 | 2.065 | 0.733 | 1.365 | 0.854 | 1.171 |
| -45.00 | 0.256 | 3.908 | 0.441 | 2.267 | 0.699 | 1.430 | 0.834 | 1.199 |
| -50.00 | 0.225 | 4.442 | 0.399 | 2.507 | 0.664 | 1.507 | 0.811 | 1.233 |
| -55.00 | 0.197 | 5.067 | 0.358 | 2.793 | 0.625 | 1.599 | 0.786 | 1.273 |
| -60.00 | 0.173 | 5.796 | 0.319 | 3.131 | 0.585 | 1.710 | 0.758 | 1.320 |
| -65.00 | 0.151 | 6.644 | 0.283 | 3.530 | 0.543 | 1.842 | 0.727 | 1.376 |
| -70.00 | 0.131 | 7.630 | 0.250 | 4.000 | 0.500 | 2.000 | 0.693 | 1.443 |
| -75.00 | 0.114 | 8.774 | 0.220 | 4.550 | 0.457 | 2.189 | 0.657 | 1.523 |
| -80.00 | 0.099 | 10.01 | 0.193 | 5.193 | 0.414 | 2.414 | 0.618 | 1.618 |

## Phase Response Curves
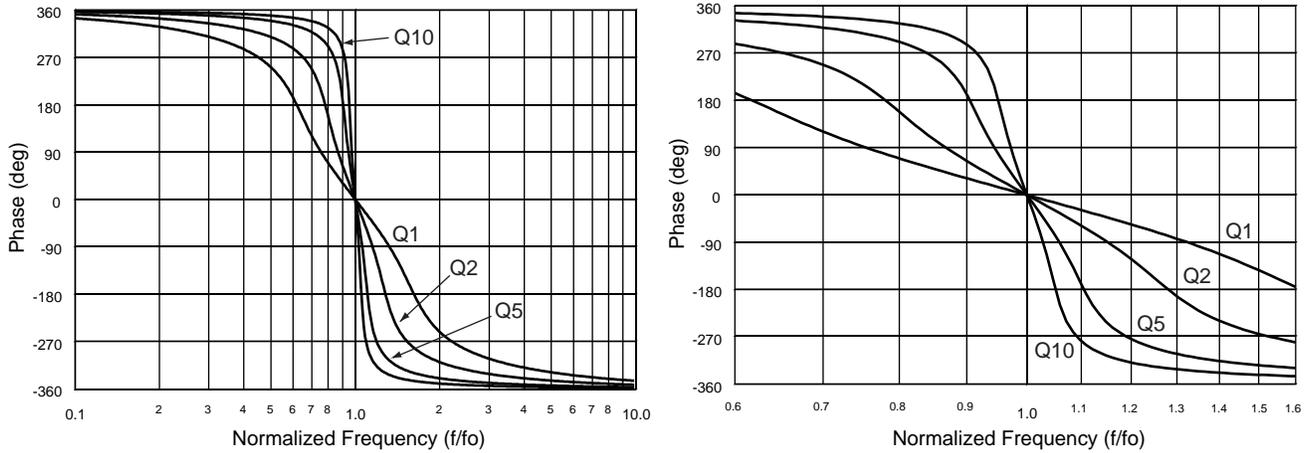


## Normalized Theoretical Phase Data

| Phase Mag (deg) | Q = 1 (+) f/f_o | Q = 1 (-) f/f_o | Q = 2 (+) f/f_o | Q = 2 (-) f/f_o | Q = 5 (+) f/f_o | Q = 5 (-) f/f_o | Q = 10 (+) f/f_o | Q = 10 (-) f/f_o |
|---|---|---|---|---|---|---|---|---|
| 1.0 | 0.997 | 1.003 | 0.998 | 1.002 | 0.999 | 1.001 | 1.000 | 1.000 |
| 2.5 | 0.992 | 1.008 | 0.996 | 1.004 | 0.998 | 1.002 | 0.999 | 1.001 |
| 5.0 | 0.983 | 1.017 | 0.992 | 1.008 | 0.997 | 1.003 | 0.998 | 1.002 |
| 10.0 | 0.967 | 1.034 | 0.983 | 1.017 | 0.993 | 1.007 | 0.997 | 1.003 |
| 15.0 | 0.951 | 1.051 | 0.975 | 1.025 | 0.990 | 1.010 | 0.995 | 1.005 |
| 20.0 | 0.936 | 1.069 | 0.967 | 1.034 | 0.987 | 1.013 | 0.993 | 1.007 |
| 25.0 | 0.920 | 1.087 | 0.959 | 1.042 | 0.984 | 1.017 | 0.992 | 1.008 |
| 30.0 | 0.905 | 1.105 | 0.951 | 1.051 | 0.980 | 1.020 | 0.990 | 1.010 |
| 35.0 | 0.891 | 1.123 | 0.944 | 1.060 | 0.977 | 1.023 | 0.988 | 1.012 |
| 40.0 | 0.876 | 1.141 | 0.936 | 1.068 | 0.974 | 1.027 | 0.987 | 1.013 |
| 45.0 | 0.863 | 1.159 | 0.929 | 1.077 | 0.971 | 1.030 | 0.985 | 1.015 |
| 50.0 | 0.849 | 1.178 | 0.921 | 1.086 | 0.968 | 1.033 | 0.984 | 1.017 |
| 60.0 | 0.823 | 1.215 | 0.907 | 1.103 | 0.962 | 1.040 | 0.981 | 1.020 |
| 70.0 | 0.799 | 1.252 | 0.893 | 1.120 | 0.956 | 1.046 | 0.978 | 1.023 |
| 80.0 | 0.776 | 1.288 | 0.880 | 1.136 | 0.950 | 1.052 | 0.975 | 1.026 |
| 90.0 | 0.755 | 1.324 | 0.868 | 1.152 | 0.945 | 1.058 | 0.972 | 1.029 |
| 120.0 | 0.701 | 1.426 | 0.835 | 1.198 | 0.930 | 1.075 | 0.964 | 1.037 |
| 150.0 | 0.657 | 1.521 | 0.807 | 1.239 | 0.917 | 1.090 | 0.958 | 1.044 |
| 180.0 | 0.618 | 1.618 | 0.781 | 1.281 | 0.905 | 1.105 | 0.951 | 1.051 |
| 210.0 | 0.577 | 1.734 | 0.752 | 1.330 | 0.891 | 1.122 | 0.944 | 1.060 |
| 240.0 | 0.525 | 1.904 | 0.713 | 1.403 | 0.872 | 1.147 | 0.933 | 1.071 |
| 270.0 | 0.452 | 2.210 | 0.653 | 1.532 | 0.840 | 1.191 | 0.916 | 1.092 |
| 300.0 | 0.345 | 2.899 | 0.548 | 1.825 | 0.777 | 1.288 | 0.880 | 1.136 |
| 330.0 | 0.192 | 5.211 | 0.350 | 2.859 | 0.617 | 1.621 | 0.780 | 1.282 |

## Amplitude Response Curves



Normalized Frequency (f/fo)

## Phase Response Curves



Normalized Frequency (f/fo)
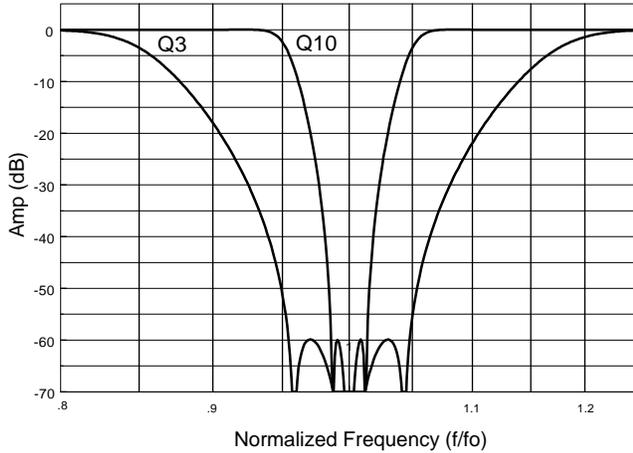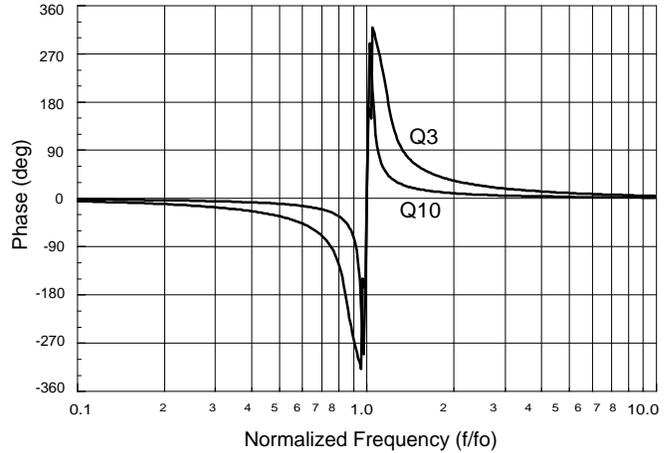
### Normalized Theoretical Amplitude Data

| Amp | Q = 3 | | Q = 10 | |
|---|---|---|---|---|
| | $f_L < f_o < f_H$ | | $f_L < f_o < f_H$ | |
| (dB) | $f / f_o$ | $f / f_o$ | $f / f_o$ | $f / f_o$ |
| -0.10 | 0.799 | 1.251 | 0.935 | 1.069 |
| -0.25 | 0.809 | 1.236 | 0.938 | 1.066 |
| -0.50 | 0.818 | 1.223 | 0.941 | 1.062 |
| -1.00 | 0.828 | 1.208 | 0.945 | 1.059 |
| -1.50 | 0.835 | 1.198 | 0.947 | 1.056 |
| -2.00 | 0.839 | 1.191 | 0.949 | 1.054 |
| -2.50 | 0.844 | 1.185 | 0.95 | 1.053 |
| -3.00 | 0.847 | 1.180 | 0.951 | 1.051 |
| -5.00 | 0.858 | 1.165 | 0.955 | 1.047 |
| -10.00 | 0.877 | 1.140 | 0.961 | 1.040 |
| -15.00 | 0.892 | 1.121 | 0.966 | 1.035 |
| -20.00 | 0.905 | 1.105 | 0.97 | 1.030 |
| -25.00 | 0.916 | 1.092 | 0.974 | 1.027 |
| -30.00 | 0.925 | 1.081 | 0.977 | 1.024 |
| -35.00 | 0.933 | 1.072 | 0.979 | 1.021 |
| -40.00 | 0.939 | 1.065 | 0.982 | 1.019 |
| -45.00 | 0.945 | 1.059 | 0.983 | 1.017 |
| -50.00 | 0.949 | 1.054 | 0.984 | 1.016 |
| -55.00 | 0.952 | 1.050 | 0.985 | 1.015 |
| -60.00 | 0.954 | 1.048 | 0.986 | 1.014 |

### Normalized Theoretical Phase Data

| Phase Mag | Q = 3 | | Q = 10 | |
|---|---|---|---|---|
| | (-) | (+) | (-) | (+) |
| (deg) | $f / f_o$ | $f / f_o$ | $f / f_o$ | $f / f_o$ |
| 1.0 | 0.020 | 49.66 | 0.067 | 14.88 |
| 2.5 | 0.050 | 19.91 | 0.164 | 6.087 |
| 5.0 | 0.100 | 10.03 | 0.306 | 3.268 |
| 10.0 | 0.194 | 5.160 | 0.504 | 1.985 |
| 15.0 | 0.279 | 3.590 | 0.621 | 1.609 |
| 20.0 | 0.352 | 2.838 | 0.696 | 1.437 |
| 25.0 | 0.416 | 2.405 | 0.746 | 1.340 |
| 30.0 | 0.470 | 2.129 | 0.783 | 1.278 |
| 35.0 | 0.515 | 1.940 | 0.810 | 1.235 |
| 40.0 | 0.555 | 1.803 | 0.831 | 1.204 |
| 45.0 | 0.588 | 1.700 | 0.848 | 1.180 |
| 50.0 | 0.617 | 1.620 | 0.861 | 1.161 |
| 60.0 | 0.664 | 1.505 | 0.882 | 1.133 |
| 70.0 | 0.701 | 1.427 | 0.897 | 1.115 |
| 80.0 | 0.729 | 1.372 | 0.909 | 1.101 |
| 90.0 | 0.752 | 1.330 | 0.917 | 1.090 |
| 120.0 | 0.797 | 1.255 | 0.934 | 1.071 |
| 150.0 | 0.824 | 1.214 | 0.943 | 1.060 |
| 180.0 | 0.844 | 1.185 | 0.950 | 1.052 |
| 210.0 | 0.862 | 1.160 | 0.957 | 1.045 |