All of the feedback has been removed from the fourth two-pole section. This is all that is necessary for optimum transient-free filtering. In some cases, the term (low Q) may be more appropriate.

1.2 SPECIFICATIONS (Specifications in parentheses apply to Models 3341 and 3343)

Frequency Range

High-Pass and Low-Pass cutoff frequencies continuously adjustable from 0.001 Hz (0.01 Hz) to 99.9 kHz in six (five) bands.

		BAND	MULTIPLIER	FREQUENCY (Hz)
		1	0.001	0.001 - .999
		2	0.01	1 - 9.99
3340	3341	3	0.1	10 - 99.9
3342	3343	4	1	100 - 999
		5	10	1,000 - 9,990
		6	100	10,000 - 99,900

Frequency Control (each channel)

Three rotary decade switches for frequency digits and a six (five) position rotary multiplier switch.

Cutoff Frequency Calibration Accuracy

±2% from 0.05 Hz to 9.99 kHz, rising to ±10% at 0.001 Hz (0.01 Hz) (less accurate in High-Pass mode at 0.001 Hz (0.01 Hz)), ±10% from 10.0 kHz to 99.9 kHz (Band 6). Relative to pass-band level, the Filter output is down 3 db at cutoff in the Butterworth (maximally flat) position and approximately 21 db down when operated as a Low-Pass filter in RC (transient-free) position.

Bandwidth

Low-Pass Mode: DC to cutoff frequency setting within the range from 0.001 Hz (0.01 Hz) to 99.9 kHz.

High-Pass Mode: Cutoff frequency setting within the range of 0.001 Hz (0.01 Hz) and 99.9 kHz to the upper 3 db point of approximately 1 MHz.

Band-Pass Operation (Models 3342, 3343): Variable within the cutoff frequency limits of 0.001 Hz (0.01 Hz) to 99.9 kHz. For minimum bandwidth, the High-Pass and Low-Pass cutoff frequencies are set equal. This produces an insertion loss of 6 db, with the minus 3 db points at 0.9 and 1.12 times the midband frequency.

Band-Reject Operation (Models 3342, 3343): Variable within the cutoff frequency limits of 0.001 Hz (0.01 Hz) and 99.9 kHz. The Low-Pass band extends to dc, and the High-Pass band has its upper 3 db point at approximately 1 MHz.

Response Characteristics

Butterworth: Maximally flat, eight pole Butterworth response for optimum performance in frequency domain.

RC: Eight pole damped response for transient-free time-domain performance.

Attenuation Slope

Nominal 48 db per octave per channel in Low-Pass or High-Pass mode.

Maximum Attenuation

Greater than 80 db for input frequencies to 100 kHz, rising to 60 db at 1 MHz.

Pass-Band Gain (selected by front panel control)

0 ±0.5 db or 20 ±0.5 db for bands 1 thru 5, 0 ±1 db or 20 ±1 db for band 6.

Input Characteristics

±7 volts peak in the 0 db gain position, ±0.7 volts peak in the 20 db gain position to 500 kHz, decreasing to ±3 volts peak (±0.3 volts peak in the 20 db gain position) at 1 MHz.

Maximum DC Component Low-Pass Mode: Combined ac plus dc should not exceed ±7 volts peak in the 0 db gain position, ±0.7 volts peak in the 20 db gain position.

Maximum DC Component High-Pass Mode: ±100 volts.

Impedance: 10 megohms in parallel with 100 pF.

Output Characteristics

Maximum Voltage: ±7 volts peak to 500 kHz decreasing to ±3 volts peak at 1 MHz, open circuit.

Maximum Current: ±70 ma peak to 500 kHz decreasing to 30 ma peak at 1 MHz.

Impedance: 50 ohms.

Distortion: Typically less than 0.1% over most of the range.

Hum and Noise (0 db or 20 db gain position)

Less than 0.5 millivolts rms for a detector bandwidth of 100 kHz, rising to 2 millivolts rms for a detector bandwidth of 10 MHz. Band 6, High-Pass mode only, 2 millivolts rms for a detector bandwidth of 100 kHz, rising to 5 millivolts rms for a detector bandwidth of 10 MHz.

Output DC Level Stability

±1 millivolt per hour, ±1 millivolt per degree C.

Operating Temperature Range

$-10^{\circ}C$ to $45^{\circ}C$.

Front Panel Controls

Frequency Hz. Three rotary decade switches and a six (five) position multiplier.

DC Levels: One each screwdriver adjustment control for LP and HP.

Function Switch: LOW-PASS RC, LOW-PASS MAX FLAT, HIGH-PASS.

Gain Switch: 0 db, 20 db.

Power Switch: OFF, LINE OPERATE, BATTERY CHARGE/LINE OPERATE, BATTERY OPERATE.

Floating (ungrounded) Operation

A switch is provided on rear of chassis to disconnect signal ground from chassis.

Terminals

Front panel and rear of chassis, one BNC connector for Input, one for Output, each channel. One multipurpose connector on rear for chassis ground.

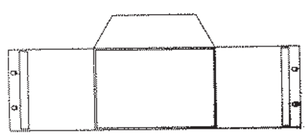
Power Requirements

105-125 or 210-250 volts, single phase, 50-400 Hz, 5 watts for Models 3340, 3341, 10 watts for Models 3342, 3343.

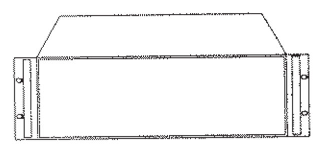
Dimensions and Weights

Model		Cabinet Size H	W	D	Weight Net	Gross
3340/3341	U.S.	5 1/4"	8 5/8"	13 1/2"	12 lbs.	14 lbs.
	Metric	13.3 cm	21.9 cm	34.3 cm	5.5 Kgs.	6.4 Kgs.
3342, 3343	U.S.	5 1/4"	16 5/8"	13 1/2"	24 lbs.	31 lbs.
	Metric	13.3 cm	42.2 cm	34.3 cm	10.9 Kgs.	14.1 Kgs.

Optional Rack-Mounting Kits



RK-58: Models 3340, 3341



RK-519: Models 3342, 3343

Optional Battery Kits

Part No. BK-332, Models 3340, 3341; Part No. BK-334, Models 3342, 3343. Batteries will operate up to 10 hours before recharging is required.

1.3 FILTER CHARACTERISTICS

The flexibility of adjustment of bandwidth is shown in Figure 2. Low-Pass and High-Pass operation is shown in curves (1) and (2). The solid lines show the maximally flat Butterworth operation, while the dotted lines show the simple RC characteristic. Curve (3) shows Band-Pass operation for two different bandwidths, illustrated by curves A and B. Curve B shows the minimum pass-band width obtained by setting the two cutoff frequencies equal. In this condition the insertion loss is 6 db, and the -3 db cutoff frequencies occur at 0.9 and 1.12 times the mid-band frequency. Band-Reject operation for a reject band with a cutoff frequency separation ratio of 10 is shown by curve 4.

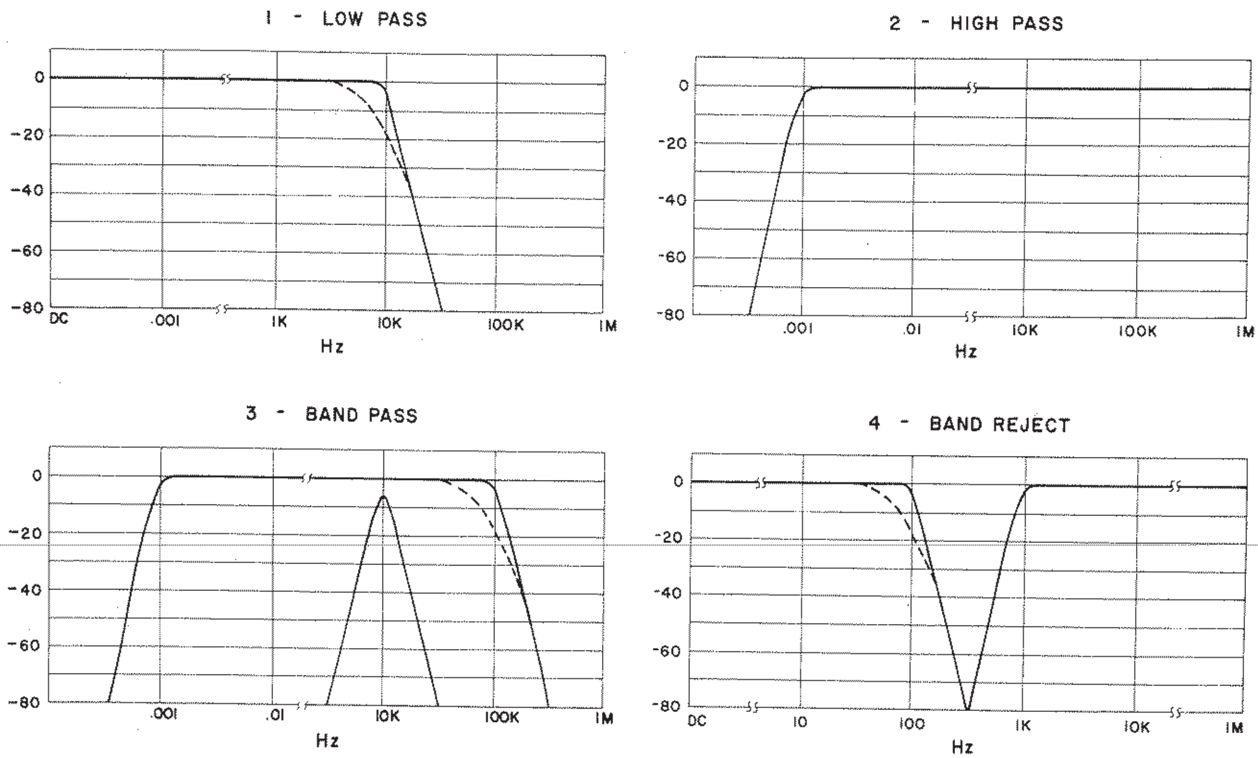
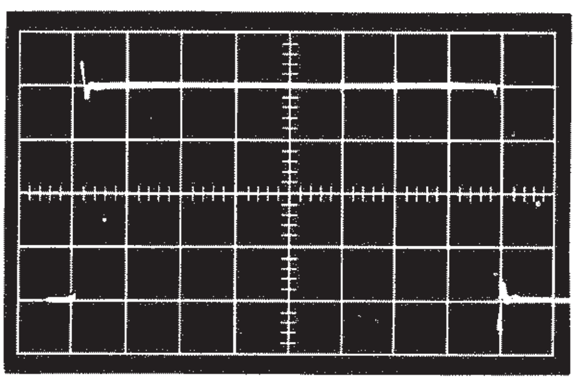
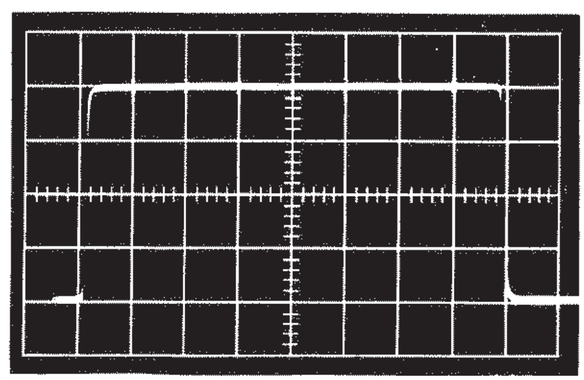


Figure 2. Multifunction Response of Butterworth (solid curves) and Low-Pass RC (dashed curves)



Response (in Low-Pass Mode) to 1 Hz square wave, with cutoff at 1 kHz. Overshoot is approximately 1 db with FUNCTION switch in LOW-PASS MAX FLAT position.



Response to same square wave in LOW-PASS RC position. NOTE complete removal of overshoot.

Figure 3. Filter Response to Square Wave Input

1.3.1 Transient Response

The frequency response characteristics of this Filter closely approximates an eighth-order Butterworth with maximal flatness, ideal for filtering in the frequency domain. For pulse-type signals, the FUNCTION switch is set to Low-Pass RC to change the response characteristic to the RC type, optimum for transient-free filtering. Figure 3 shows a comparison of the Filter output response in these modes to a square wave input signal.

1.3.2 Cutoff Response

The attenuation characteristics of the Filter are shown in Figure 4. With the FUNCTION switch in the LOW-PASS MAX FLAT (Butterworth) mode, the gain, as shown by a solid curve, is virtually flat until the -3 db cutoff frequency. At approximately 1.2X the cutoff frequency, the attenuation rate coincides with the 48 db per octave straight line asymptote.

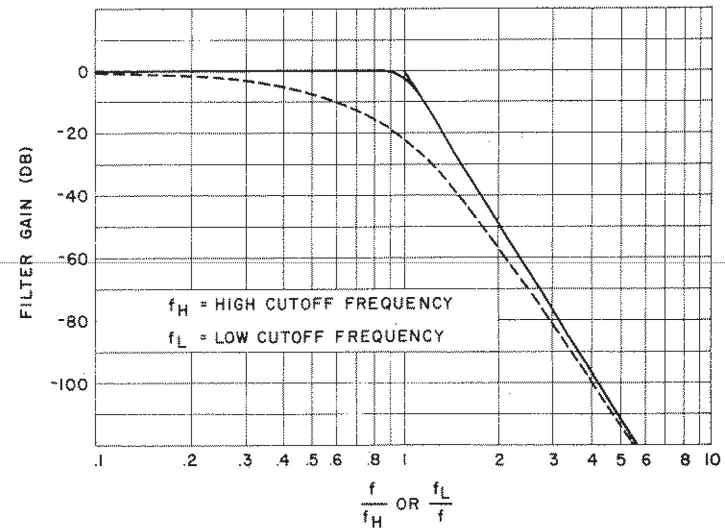


Figure 4. Normalized Attenuation Characteristics

In the LOW-PASS RC mode, optimum for transient-free filtering, the dotted line shows that the gain is down approximately 21 db at cutoff and has approximately a 48 db per octave attenuation rate at five times the cutoff frequency. Beyond this frequency the Filter attenuation rate and maximum attenuation, in either mode, are identical.

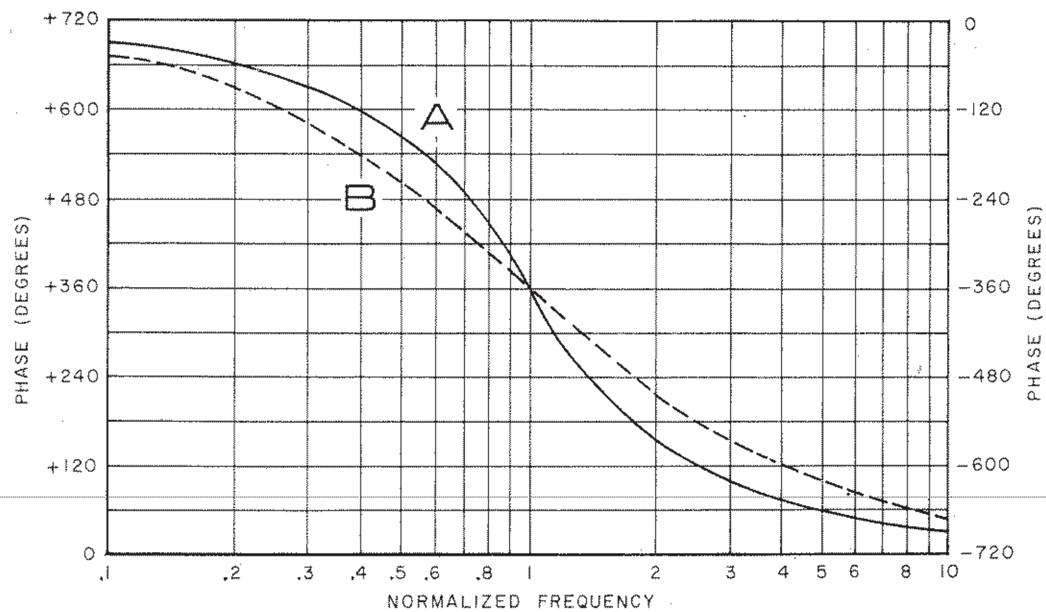
1.3.3 Phase Response

The phase response of the Models 3340, 3341 or each channel of the Models 3342, 3343 can be obtained from Figure 5, which gives the phase characteristic for either mode of operation in degrees lead (+) or lag (-) as a function of ratio of the operating frequency (f) to the low cutoff frequency f_L (HIGH-PASS mode) or high frequency f_H (LOW-PASS mode).* The solid curve is for the MAX FLAT (Butterworth) mode and the dotted curve is for the transient-free (LOW-PASS RC) mode.

1.3.3.1 Example

Determine the phase shift of the Filter in the MAX FLAT or Butterworth mode, with the FUNCTION switch set to the HIGH-PASS mode at the X1 position, the cutoff frequency (f_L) set to 100 Hz and an input frequency (f) of 300 Hz. Since f/f_L = 300/100 = 3, then from Figure 5, 3 = 100 degrees. Hence, the output of the Filter leads the input by 100 degrees. The phase response of the Models 3342 and 3343 could be obtained in the same manner by taking the algebraic sum of the phase response of each channel (Band-Pass operation, only).

*The terms "lead (+)" and "lag (-)" are used only to distinguish between phase shift in the High-Pass mode (lead) vs. phase shift in the Low-Pass mode (lag). The actual phase shift in either mode, of course, will always be lagging, since the output can never occur before the input.



$$\frac{\text{INPUT FREQUENCY } (f)}{\text{LOW-CUTOFF } (f_L) \text{ OR HIGH-CUTOFF } (f_H)}$$

Figure 5. Normalized Phase Characteristics

The phase characteristic of the 3340 and 3341 is related to the setting of the cutoff frequency, and is approximately 5 degrees for a 1% frequency error at the cutoff point. Since the cutoff calibration is ±2%, a maximum phase error of 10 degrees is possible, although a 5 degree phase error is typical.

For some applications the phase difference between channels of the Models 3342 and 3343 can be improved by applying the same signal to both channels simultaneously and tuning one channel to minimize the phase difference. Because the resolution of phase adjustment is limited to that of the frequency digits, the increments of phase adjustment will vary from 0.5 degree to 5.0 degrees.