4.5 Frequency response

The frequency response of the Trillium 120P can be measured using the calibration coil. During calibration, the measured response is the product of the calibration system's lowpass response (a single pole at –158 rad/s) and the sensor's own response. Therefore, the seismometer response to ground motion is obtained by dividing the "combined response" obtained during calibration by the calibration input nominal transfer function. These three transfer functions are shown in Figure 4-2.

The nominal poles (p_n), zeroes (z_n), normalization factor (k), and normalization frequency (f_0), and passband sensitivity (S_{sensor}) of the Trillium 120P are listed in Table 4-2. These parameters define the transfer function according to this equation:

$$F(s) = S_{sensor} \cdot k \cdot \frac{\prod_n (s + z_n)}{\prod_n (s + p_n)} \left[\frac{V \cdot s}{m} \right] \qquad \text{(EQ 3)}$$

Where the normalization factor is defined as follows:

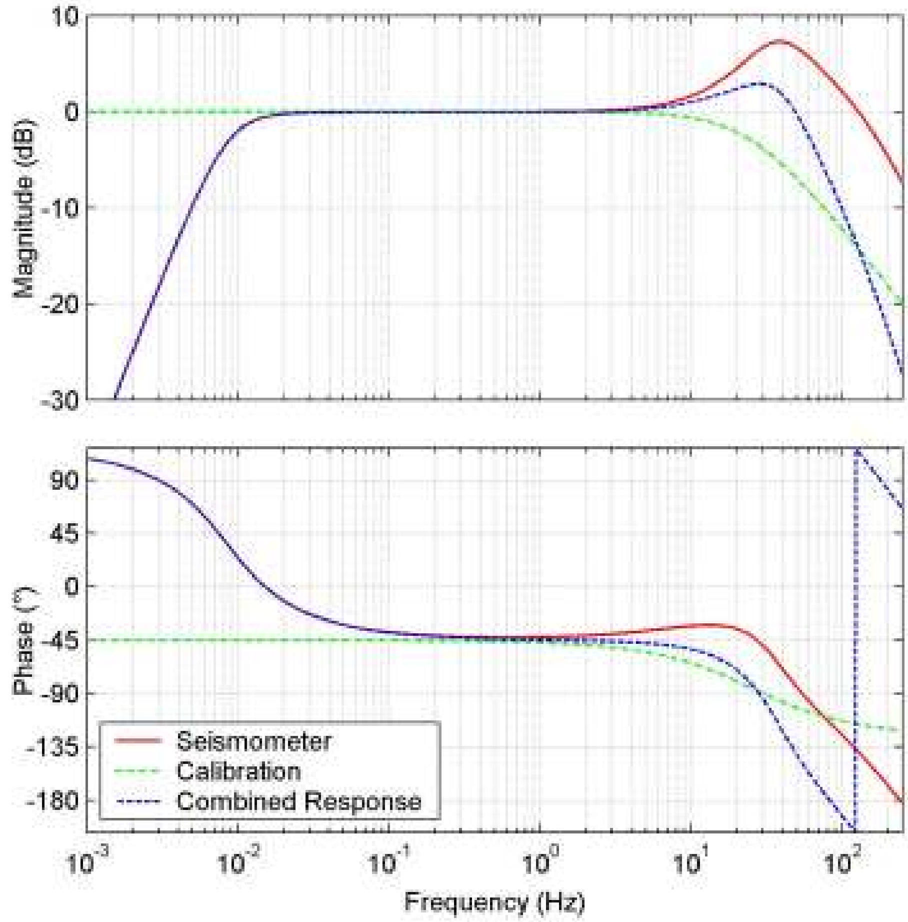
$$k = \frac{1}{\left| \dfrac{\prod_n (i \cdot 2 \cdot \pi \cdot f_0 + z_n)}{\prod_n (i \cdot 2 \cdot \pi \cdot f_0 + p_n)} \right|} \qquad \text{(EQ 4)}$$

Table 4-2 Poles and zeroes

	Parameter	Nominal values	Units
z_n	Zeroes	0 0 –106 –158	rad/s
p_n	Poles	–0.03859 ±0.03649i –190 –158 ±193i –639 ±1418i	rad/s
k	Normalization factor	1.695×10^9	
S_{sensor}	Passband sensitivity at 1 Hz	1201.0	V·s/m
f_0	Normalization frequency	1	Hz

The transfer function is approximately flat from 120 s to 50 Hz and rolls off at 40 dB/decade below the lower corner frequency, as shown in Figure 4-2.

Figure 4-2 Nominal frequency response



4.6 Self-noise

Typical Trillium 120P self-noise is plotted in Figure 4-3. Three curves are included for reference: Peterson's new low-noise model (NLNM) and new high-noise model (NHNM), and McNamara and Buland's PDF Mode Low Noise Model (MLNM).[1] The noise floor specification is valid when the masses are centred within ±0.4 V. The noise floor in the low frequency area will increase if the masses are further decentred. The self-noise at 100 seconds could rise to as high as –168 dB if the masses are off centre by the maximum ±4.5 V. Therefore to obtain the best low noise performance, it is best to ensure the masses are well centred.

1. See also:
Peterson, J. (1993). *Observations and Modeling of Seismic Background Noise.* Open-file report 93-922, U. S. Geological Survey.
McNamara, D.E., and R. P. Buland (1994). Ambient Noise Levels in the Continental United States. *Bull. Seism. Soc. Am.*, **94**, 1517–1527.
Clinton, J. F., and T. H. Heaton (2002). Potential Advantages of a Strong-motion Velocity Meter over a Strong-motion Accelerometer. *Seism. Res. Lett.*, **73**, 332–342.