SHORT-PERIOD SEISMOMETER
MODEL S-500

OPERATION AND MAINTENANCE MANUAL

STOCK NO. 990-42280-9800

GEOTECH INSTRUMENTS, LLC

OPERATION AND MAINTENANCE MANUAL
SHORT-PERIOD SEISMOMETER, MODEL S-500

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This instrument must be handled with reasonable care. Do not drop on a hard surface even from a few inches height. When transporting over rough terrain, the instrument should be packed in its original shipping container.

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1. GENERAL DESCRIPTION

1.1 PURPOSE OF INSTRUMENT

The Short-Period Seismometer, Model S-500, is a small portable seismometer suitable for use in the 1 Hz to 100 Hz frequency range. The seismometer can be used vertically, horizontally or at any inclination without modifications and/or adjustments.

1.2 DESCRIPTION OF INSTRUMENT

The Short-Period Seismometer, Model S-500 , figure 1-1, is .057 m (2.25 in.) diameter by 0.130 m (5.125 in.) long (excluding connector) and weighs 1.5 kg (3.30 lbs.).Output signals proportional to ground velocity and ground acceleration are available at separate pins of the connector. Outputs are low-impedance single-ended suitable for driving long lines. External damping resistors are not required since the frequency response of the instrument is shaped by internal filter networks.

An electromagnetic calibrator consisting of a coil and magnet is built into each unit. The coil terminals are floating above ground and can be driven from either single-ended or double-ended sources.

Power connections of +12 V, -12 V, and power common are required to power the instruments internal amplifiers. Current required is less than 5 mA maximum from each leg of the power supply.

CAUTION

This instrument must be handled with reasonable care. Do not drop on a hard surface even from a few inches height. When transporting over rough terrain, the instrument should be packed in its original shipping container.

The S-500 seismometer is a rugged instrument that does not require a mass-lock, but reasonable care should be exercised to prevent damage or change in calibration.

1.3 SPECIFICATIONS

1.3.1 Operating Characteristics

Frequency response	1.0 Hz to 100 Hz
Velocity circuit	Low Pass; 100 Hz Knee, 24 dB/octave High Pass; 1.0 Hz Knee, 18 dB/octave
Acceleration circuit	Low Pass; 100 Hz Knee, 12 dB/octave High Pass; 0.9 Hz Knee, 6 dB/octave

Figure 1-1. S-500 Seismometer

Acceleration Knee	150 ±25 Hz, 0.5 nominal damping
Mass	1 kg
Sensitivity	
Velocity (G)	450 ±5% V/(m/s) @25 °C
Acceleration	530 ±10% V/g @25 °C
Linearity	1% of full scale
Dynamic range	100 dB
Calibration	
Type	Electromagnetic
Coil resistance	50 Ω ±10%
Sensitivity (K)	3.0 (m/sec^2)/Amp nominal [1] @ 25 °C
Maximum current	150 mA
Noise level	5 x 10^{-9} m p-p @ 1 Hz with 10 Hz bandwidth .01 x 10^{-6} g O-p @ 1 Hz with 10 Hz bandwidth
Polarity for motion of instrument toward connector end	Velocity channel - positive Acceleration channel - negative
Clipping level	
Velocity channel	8 V p-p min. @ 1 Hz .8 V p-p min. @ 10 Hz .08 V p-p min. @ 100 Hz
Acceleration channel	8 V p-p min., 1 to 100 Hz
Temperature coefficient of sensitivity	.4% / °C @ 10 Hz velocity and acceleration channels
Output offset voltage	
Velocity circuit	2.25 mV typ @ 25 °C, 3 mV max. over full temp range
Acceleration circuit	45 mV typ @ 25 °C, 1.1 V max. over full temp range

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(1) Actual value for each instrument listed on customer data sheet.

Output impedance	
Velocity circuit	Less than 10 ohms
Acceleration circuit	Less than 10 ohms
Cross-axis sensitivity	Less than 2%, 1 to 100 Hz
Spurious resonances	None below 500 Hz
Power Requirement	
Voltage	Positive, +11 to +14 Vdc Negative, -11 to -14 Vdc
	Negative, 5 mA max.
Current	Positive, 5 mA max.
Power	0.12 W max.

1.3.2 Physical Characteristics

Size	.057 m (2.25 in.) diameter
	.165 m (6.5 in.) length including connector
Weight	1.5 kg (3.30 lbs)
Construction	Suitable for direct burial with proper termination of connector
Mating connector (furnished)	Bendix PT06W-12-10S

1.3.3 Environmental Characteristics

Temperature	
Operating	-35 to +60°C (-30 to +140°F)
Storage	-35 to +60°C (-30 to +140°F)
Vibration	20 g 0-p, 1 to 100 Hz sine
Shock	20 g peak, 1 msec, sawtooth

2. INSTALLATION

2.1 UNPACKING

Remove the instrument from the shipping box and check items against the packing list. Contact Teledyne Brown Engineering, Geotech Instruments if there are any discrepancies. Inspect the instrument for any obvious signs of external damage that may have been incurred in shipping.

2.2 SETTING UP AND INSTALLING INSTRUMENT

The instrument may be installed at any angle between vertical and horizontal. When installing unit off vertical orient instrument about its axis until name tag is up. Connector must always be located at the high end. Three 10-32 threaded holes are located in bottom of instrument to permit mounting to brackets, etc. Remove the three protective set screws to use these mounting holes. The holes are equally spaced at 120° on 1.500 in. diameter circle. Oversize or slotted holes should be used if off vertical mounting is required to allow alignment of name tag vertical as described above.

Connect wiring to the mating connector furnished with the unit as indicated in table 2-1 and figure 2-1.

Table 2-1. Connector Pin Assignments

Pin No.	Function
A	Velocity Signal Output
B	Signal Common
C	Shield and Power Common
D	+12 Vdc
E	-12 Vdc
F	Cal Coil
G	Cal Coil
H	Not Used
J	Acceleration Signal Output
K	Not Used

The S-500 does not have a mass lock. No motion can be felt when the instrument is shaken by hand as in a conventional seismometer. The unit is rugged and will withstand normal field handling. However, a drop onto a hard surface can damage the unit and precautions should be taken to prevent extreme shocks

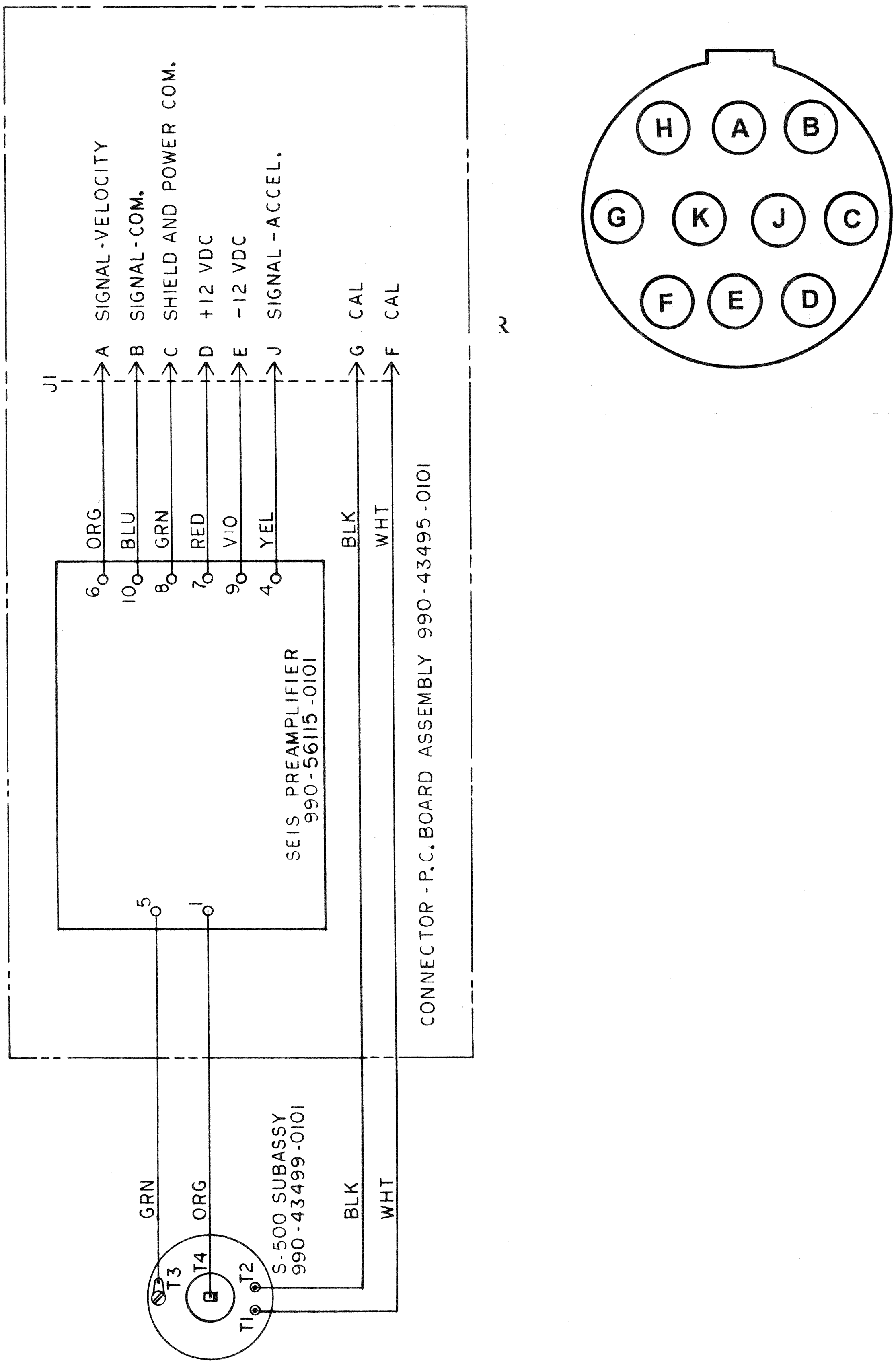

Figure 2-1. Wiring Diagram and Connector Detail

3. OPERATION

3.1 PRINCIPLE OF OPERATION

The basic elements of the seismometer are a spring suspended mass and a sensor to sense motion between this mass and the case or frame of the seismometer. The output of the sensor is amplified and filtered by internal amplifiers to produce the acceleration and velocity signals. The 1 Hz and 100 Hz corner frequencies of the respective responses are produced by electronic circuits, and are quite stable when compared with conventional seismometers. The resonant frequency of the spring and mass is outside of the instrument pass band. However, it does have a minor effect on the instrument response above 50 Hz.

An electromagnetic calibrator is used consisting of a magnet mounted to the frame and a coil mounted to the mass of the instrument. An electric current through the calibration coil will calibrate the entire unit including mechanical components, sensor, and electronics.

3.2 CALIBRATION

The calibration coil constant is listed on the customer data sheet. To calibrate as an accelerometer, connect pin G to the signal generator low and pin F to the signal generator high. The acceleration output (pin J) will be in phase with the calibration signal input for mid-band frequencies. See figures 3-1 and 3-2 for typical amplitude and phase responses.

To calibrate the velocity channel, connect pin G to the signal generator low and pin F to the signal generator high. The velocity output (pin A) will lead the calibration signal by about 90 degrees for mid-band frequencies. See figures 3-3 and 3-4 for typical amplitude and phase responses.

3.2.1 Equivalent Ground Displacement Calibration

To determine the equivalent ground motion amplitude use the following formula:

$$Y = K\, i/(2\, \pi\, f)^2$$

where:

Y = equivalent ground motion in meters

K = calibration factor in $(m/sec^2)/amp$

f = frequency of calibration signal in Hz.

i = current through the calibration coil in amperes. (Maximum current .150 amperes).

If i is measured in amperes peak-to-peak, then Y will be in meters peak-to-peak; and i is measured in amperes rms, then Y will be in meters rms. It should be noted that the calibration coil actually applies a force to the mass of the instrument so that the entire device including the principle sensor, mechanics, and electronics are calibrated.

CAUTION

Maximum current i through calibration coil should not exceed .150 amperes.

3.2.2 Acceleration Calibration

To determine the equivalent ground acceleration use the following formula:

$$a = K\, i/9.8$$

where:

a = equivalent ground acceleration g's where 1 g = 9.8 m/sec^2

i = current through calibration coil-amperes (maximum current .150 amperes)

K = calibration factor - $(m/sec^2)/amp$

If i is measured in amperes zero-to-peak, then acceleration is measured in g zero-to-peak; or if i is measured in amperes rms then acceleration a is measured in g rms.

CAUTION

Maximum current i through calibration coil should not exceed .150 amperes.

3.2.3 Determination of Magnification for Seismic System Using S-500 Seismometer

The magnification of the system is defined as the amount by which the equivalent ground motion is magnified when the system output is measured on a recorder, or by:

Magnification = A/Y

where: A = peak-to-peak trace amplitude, meters

Y = equivalent ground motion, in meters

if: $Y = Ki/(2\pi f)^2$

then: $\text{Magnification} = A(2\pi f)^2/Ki$

where: K = calibrator factor, $(m/sec^2)/amp$

i = p-p sinusoidal current through the calibration coil, amperes

f = frequency of the sinusoidal signal, Hz

Magnification (displacement) = the ratio of recorded amplitude to ground displacement

Example:

$K = 2.866\ (m/sec^2)/amp$

$A = 30 \times 10^{-3}$ meters

F = 1.0 Hz

i = 50 μ A

$$M = \frac{4\pi^2 f^2}{Ki} = \frac{4\pi^2 (1) 30x10^{-3}}{2.866x50x10^{-6}} = 8.26x103$$

Magnification = 8260

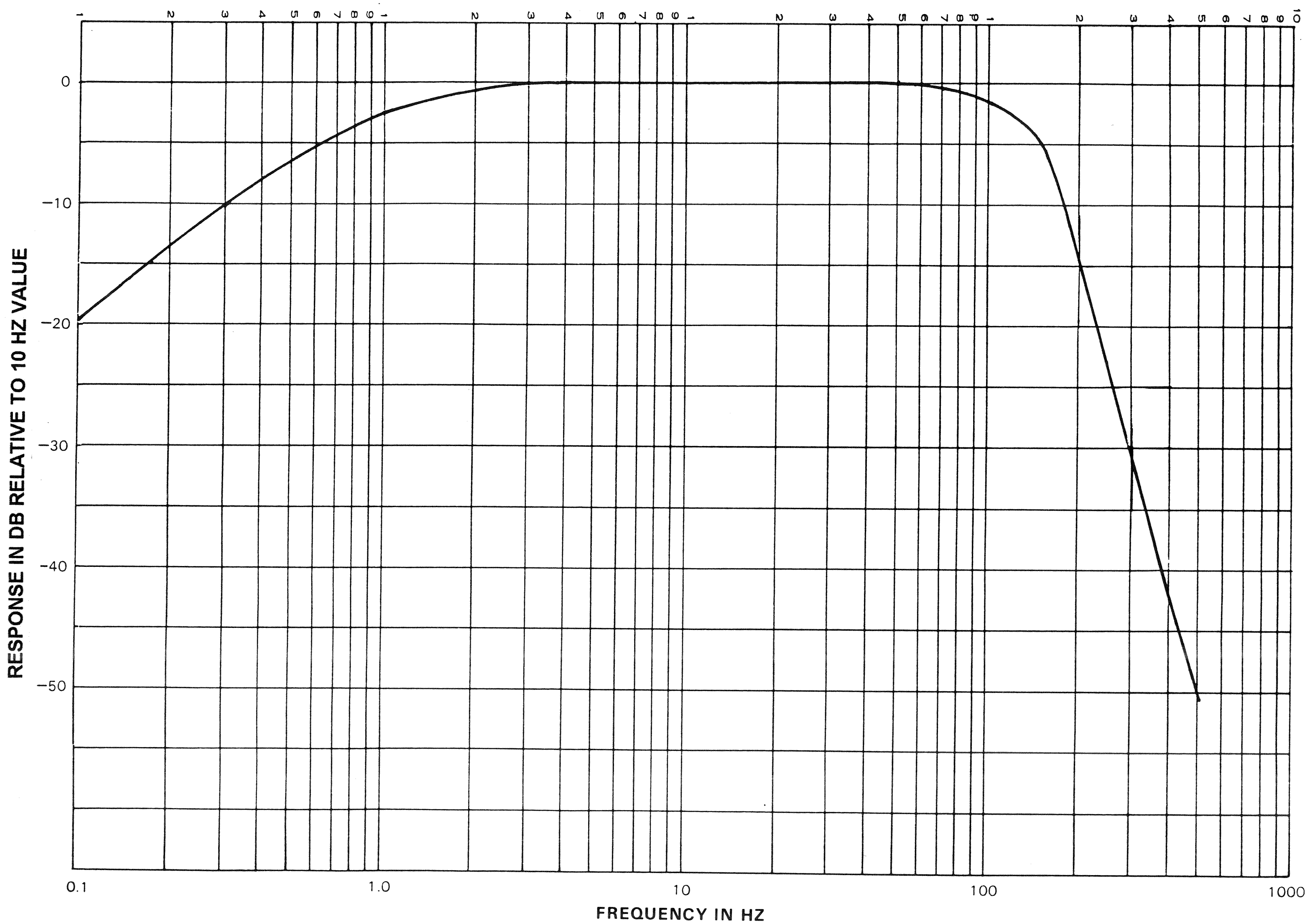

Figure 3-1. Amplitude Response of Acceleration Channel Calibration

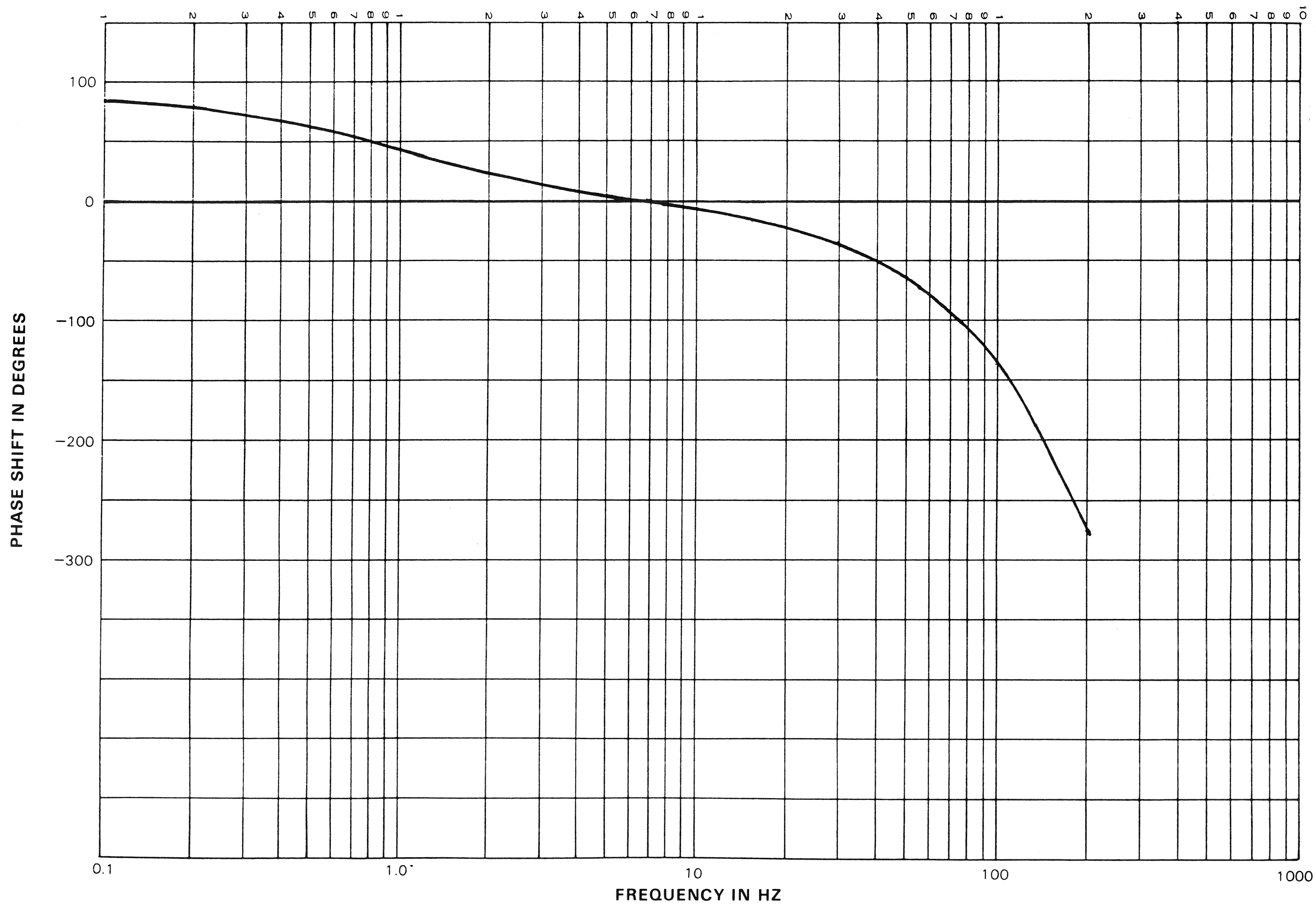

Figure 3-2. Phase Response of Acceleration Channel Calibration

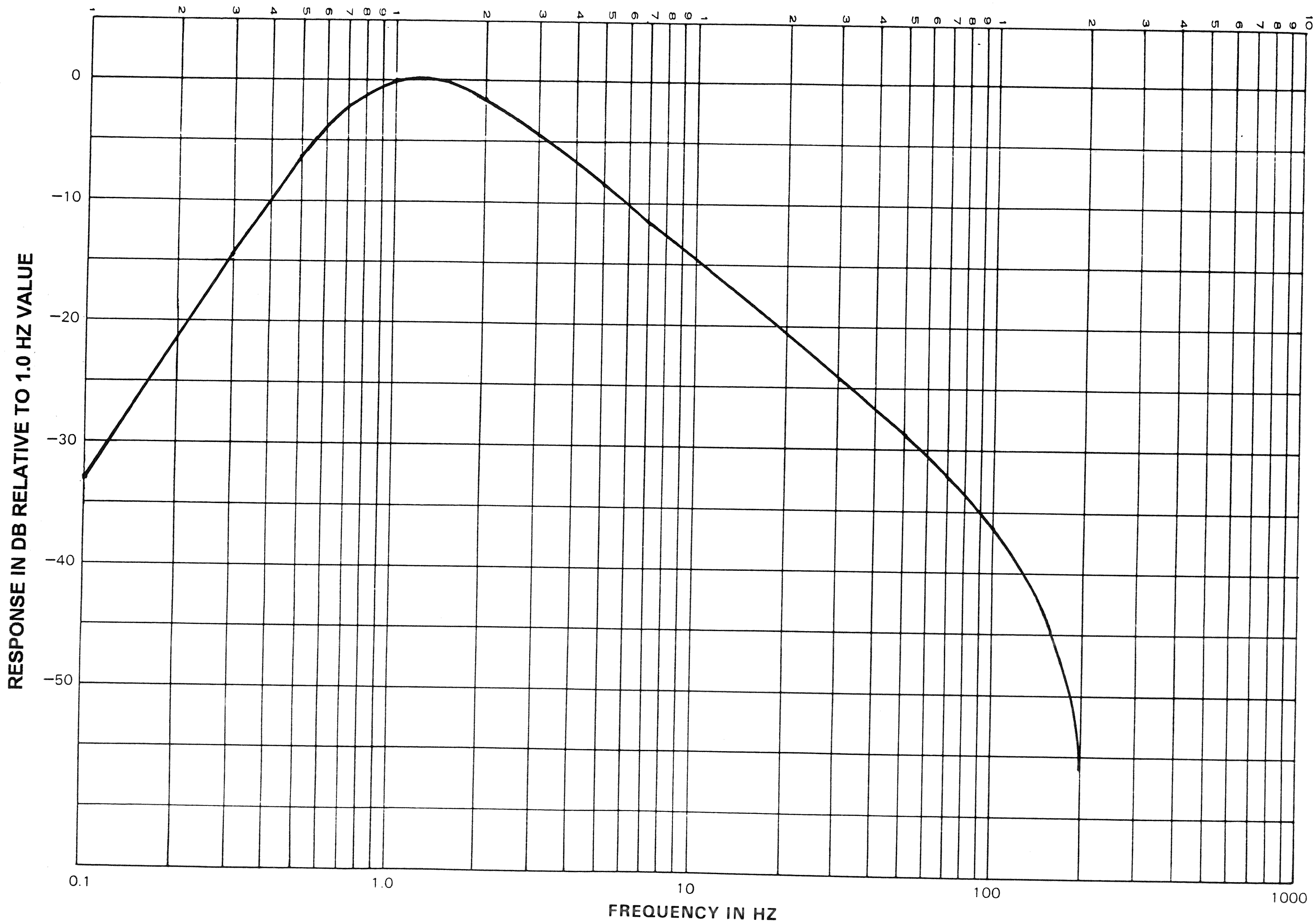

Figure 3-3. Amplitude Response of Velocity Channel Calibration

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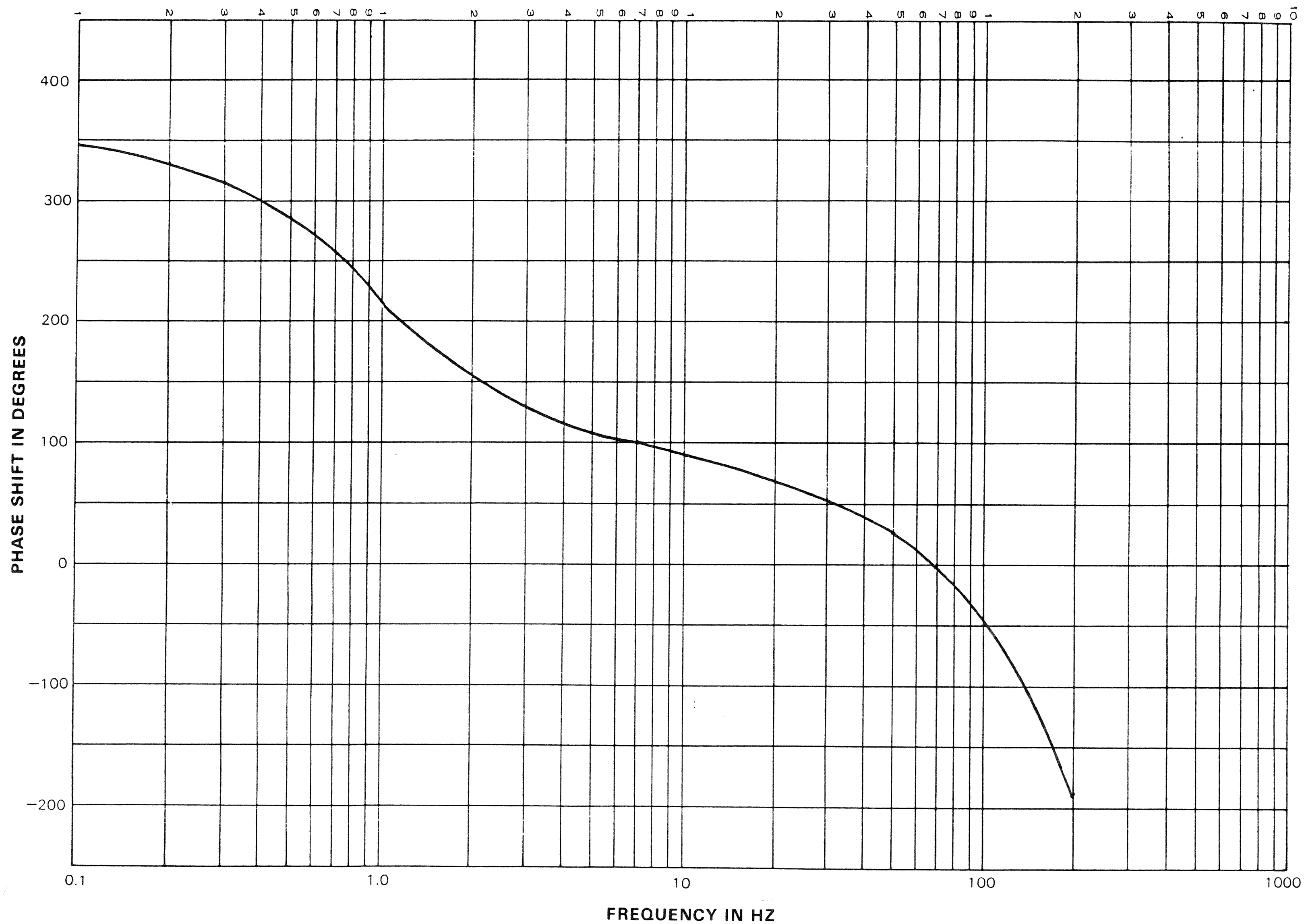

Figure 3-4. Phase Response of Velocity Channel Calibration

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4. MAINTENANCE

The S-500 seismometer does not require any routine maintenance. Should the instrument fail to function properly, it should be returned to Teledyne Brown Engineering, Geotech Instruments for repair.

The S-500 seismometer is a simple instrument requiring no internal or external adjustments or calibrations. To determine if unit is functioning properly, make sure power of proper polarity and voltage is applied to the correct terminals per table 1.1. Connect velocity and/or acceleration channels to appropriate recorders or oscilloscope and adjust sensitivity until background seismic noise can be seen on the record. If unit is located on or near the surface, it should respond to footsteps, lightly tapping instrument, etc.

It should be noted that the acceleration output may have an appreciable dc offset voltage, and this channel could be ac coupled to the recorder through a long-time constant high-pass filter.

In the event that field servicing of the electronics must be performed, the electronics schematic is given in figure 4-1 and the associated parts list in table 4-1.

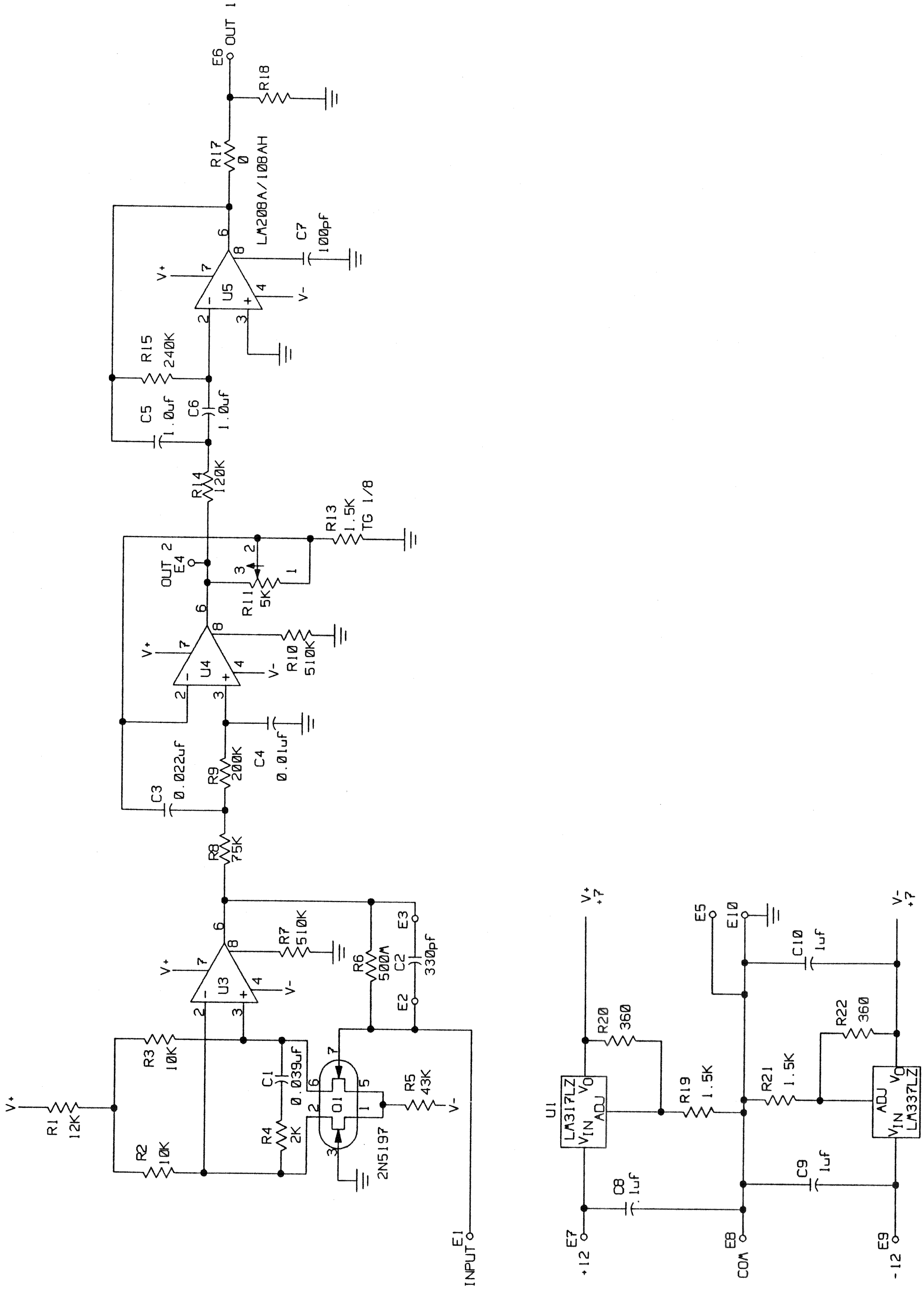

Figure 4-1. Schematic, Seismometer Preamplifier

Table 4-1. Parts Lists, Seismometer Preamplifier

Geotech Part No.	Description	Ref. Des.
302-01000-0128	Capacitor, 0.039 uf	C1
002-23385-2993	Capacitor, 330 pf	C2
302-01000-0125	Capacitor, 0.022 uf	C3
302-01000-0385	Capacitor, 0.010 uf	C4
302-01000-0145	Capacitor, 1.0 uf	C5,6
002-21085-5993	Capacitor, 100 pf	C7
002-51050-0712	Capacitor, 0.10 uf	C8
002-61050-0712	Capacitor, 1.0 uf	C9,10
012-06051-9700	Transistor, Fet	Q1
001-06120-1035	Resistor, 12 K	R1
001-06100-0242	Resistor, 10 K	R2,3
001-05200-1035	Resistor, 2.0 K	R4
001-06430-1035	Resistor, 43 K	R5
001-99500-9720	Resistor, 500 M	R6
001-07510-1035	Resistor, 510 K	R7,10
001-06750-1035	Resistor, 75 K	R8
001-07200-1035	Resistor, 200 K	R9
001-15500-9090	Potentiometer, 5 K	R11
001-35150-9494	Sensistor, 1.5 K	R13
001-07120-1035	Resistor, 120 K	R14
001-07240-1035	Resistor, 240 K	R15
001-05150-1035	Resistor, 1.5 K	R19,21
001-04360-1035	Resistor, 360	R20,22
012-62317-1200	Regulator, LM 317	U1
012-62337-1200	Regulator, LM 337	U2
990-43503-0101	Opamp, 776, selected	U3
990-43503-0102	Opamp, 776, selected	U4
012-62108-1203	Opamp, LM 108	U5

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5. INSTRUMENT CHARACTERISTICS

The following amplitude response graphs have been calculated on the assumption that the electronic circuits contain parts having their specified nominal values, and that the accelerometer's resonant frequency is 150 Hz and the accelerometer's relative damping is 0.3.

The responses represent the variation in output voltage from the specified channel when tested with a constant-amplitude variable-frequency sinusoidal input excitation. The responses plotted are those most often used and are; figure 5-1 Output of the velocity channel for constant velocity input; and figure 5-2 Output of the velocity channel for constant displacement input. The output of the acceleration channel for constant acceleration input is the same as for the acceleration calibration and is shown in figure 3-1.

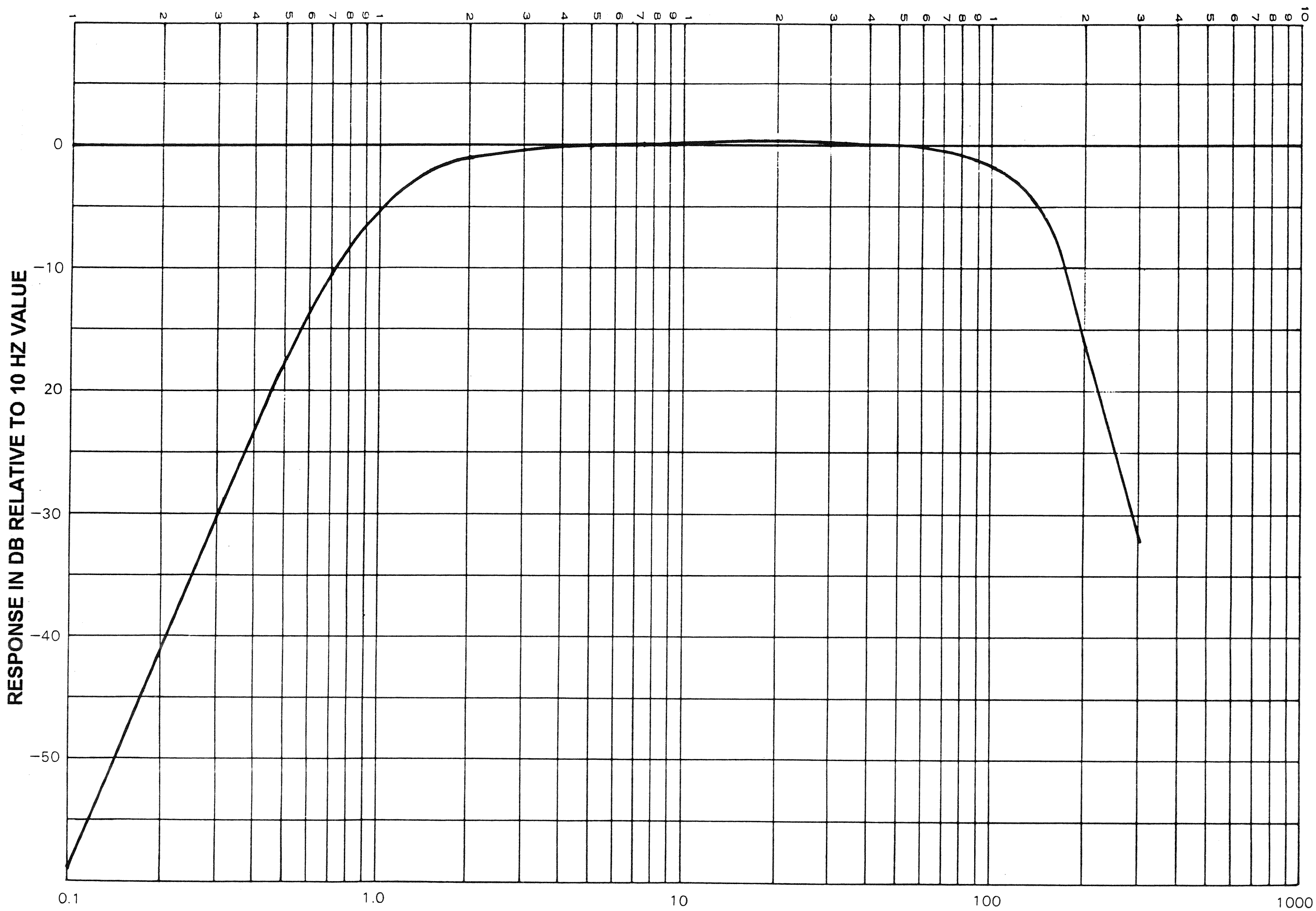

Figure 5-1. Amplitude Response of Velocity Channel to Velocity Input

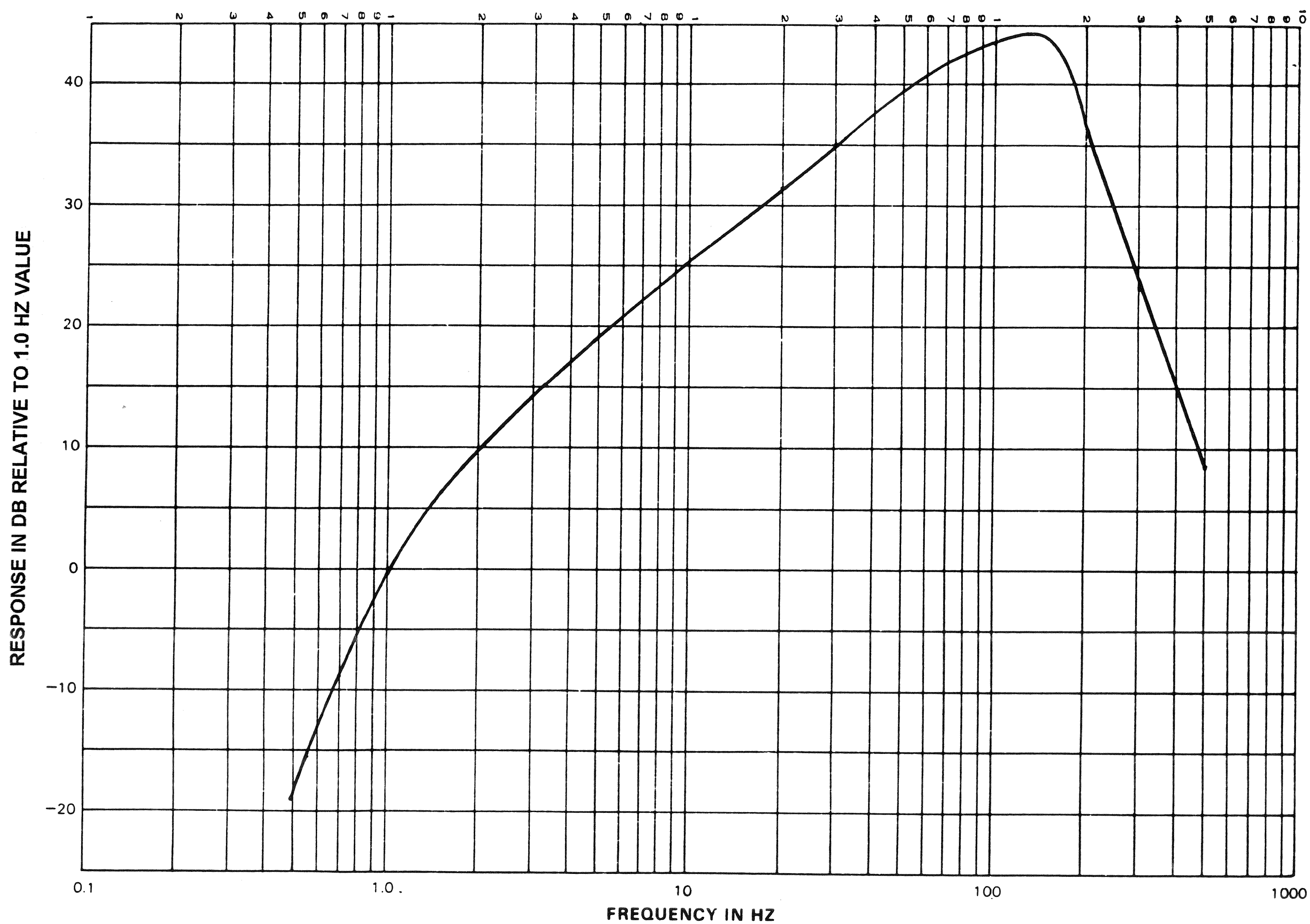

Figure 5-2. Amplitude Response of Velocity Channel to Displacement Input

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