Bulletin of the Seismographic Stations

Volume 62

January 1, 1992 to December 31, 1992

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BULLETIN OF THE SEISMOGRAPHIC STATIONS

of the

University of California at Berkeley

Volume 62
January 1, 1992 to December 31, 1992

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We would like to thank the following institutions for their assistance in supplying readings for the epicenter locations:

California Division of Mines and Geology
California Department of Water Resources
California Institute of Technology Seismological Laboratory
Lawrence Livermore National Laboratory
Pacific Gas and Electric Company
University of Nevada at Reno Seismological Laboratory
US Geological Survey National Earthquake Information Center
US Geological Survey Northern California Seismic Analysis Group

Distribution

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We strongly encourage you to take advantage of the electronic access and retrieve this and future Bulletins via this mechanism. Interested individuals should contact us at the email address below and we will keep you informed of future developments:

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Introduction

The history of earthquake monitoring at UC Berkeley began with the installation of a seismographic stations at Mount Hamilton and Berkeley, California in 1887. In the intervening 105 years, the UC Berkeley network has evolved with the changing technology and instrumentation. A major upgrade of the Seismographic Station facilities was initiated in January 1991, in conjunction with the arrival of the new Director and the assistance of funding from the University of California. There are three major components to the modernization: 1) upgrade and expansion of the northern and central California regional broadband network; 2) upgrade of the data collection and analysis system; and 3) creation of the Northern California Earthquake Data Center for the archival and electronic distribution of geophysical data, in cooperation with the United States Geological Survey at Menlo Park. This 1992 Bulletin reflects the continuing change at the Seismographic Station in instrumentation and analysis.

The broad scope of changes at the Seismographic Station includes significant modification of the traditional Bulletin. Section I provides a description of the station instrumentation during this period and readers are referred to previous bulletins for a more detailed information about instrumental developments from 1910-1991. A summary of station installations and instrumentation for the period 1910-1972 may be found in Bolt and Miller (1975). Section II describes the analysis procedures at the Seismographic Station. Section III catalogs locations and magnitudes of significant local and regional earthquakes, and begins with a discussion of seismicity rates. Since this event information (location, magnitude, phase and amplitude measurements) is available from the Data Center, we have ceased to provide phase readings in printed form. On the other hand, the expansion of the broadband network allows us to enhance the level of information provided for local and regional earthquakes. Included in Section II is a list of moment magnitude estimates and moment tensor solutions for selected earthquakes. This aspect of the analysis is gradually being introduced into the routine procedures, as the broadband network grows and provides better coverage of northern and central California. Appendix A describes the joint UC Berkeley/USGS Northern California Earthquake Data Center and provides information on access. Appendix B includes detailed descriptions of the broadband stations and instrumentation while Appendix C documents additional aspects of instrument response. The enormous scope of these changes have delayed the publication of this Bulletin. We are working on the 1993 and 1994 Bulletins and hope to complete them shortly.

Recognizing the explosive growth in electronic communciations. the Seismographic Station is making the 1992 Bulletin available over the Internet via WWW browsers at the following address

http://www.seismo.berkeley.edu

with links to the Northern California Earthquake Data Center. We encourage people to access this and future Bulletins over the Internet, as the high cost of printing and mailing will limit future distribution.

Glossary of Abbreviations and Acronyms

Organizations

BDSN:	Berkeley Digital Seismic Network
BARD:	Bay Area Regional Deformation
HFN:	Hayward Fault Network
IRIS:	Incorporated Research Institutions for Seismology
NCSN:	Northern California Seismic Network
NCEDC:	Northern California Earthquake Data Center
SCEC:	Southern California Earthquake Center
SEED:	Standard for the Exchange of Earthquake Data
UC/UCB:	University of California/University of California at Berkeley
USGS:	United States Geological Survey

Instruments and Recording Systems

A/D:	Analog to Digital
BEN:	Benioff
BRB:	BroadBand
DRS:	Digital Recording System
DWWSSN:	Digital World Wide Standard Seismographic Network
EBB:	Extended BroadBand
FBA:	Force-Balance Accelerometer
FIR:	Finite Impulse Response
GPS:	Global Positioning System
LG:	Low Gain
PC:	Personal Computer datalogging system
PE:	Press-Ewing
Q680:	Quanterra, Inc, Q680 datalogging system
Q935:	Quanterra, Inc, Q935 datalogging system
SPR:	Sprengnether
ULP:	Ultra-Long Period
ULPV:	Ultra-Long Period Velocity
UVBB:	Upgraded Very BroadBand
VBB:	Very BroadBand
WA:	Wood-Anderson
WWSSN:	World Wide Standard Seismographic Network

Components

Z:	Vertical
N:	North-South
E:	East-West

Data Streams

HH:	80.00 samples per second from STS-1 or STS-2 seismometer
BH:	20.00 samples per second from STS-1 or STS-2 seismometer
LH:	1.00 samples per second from STS-1 or STS-2 seismometer
VH:	0.10 samples per second from STS-1 or STS-2 seismometer
UH:	0.01 samples per second from STS-1 or STS-2 seismometer
HL:	80.00 samples per second from FBA-23 accelerometer
BL:	20.00 samples per second from FBA-23 accelerometer
LL:	1.00 samples per second from FBA-23 accelerometer

Section I: General Station Information

During 1992, the UC Berkeley Seismographic Station operated a diverse network of instruments in northern and central California and monitored one or more stations from adjoining regional networks. Figure 1 displays the location of the short-period network (black triangles) and the Berkeley Digital Seismic Network (BDSN) stations (black squares) operational during 1992. The grey squares mark the location of BDSN stations upgraded and installed in 1993-1994 while white squares indicate sites of future broadband stations. The inset map indicates the location of the Hayward Fault Network (HFN) - a program to monitor the Hayward fault which began station installation in December 1992 (Details about the HFN will be presented in the 1993 bulletin). In this section, we present tables describing the character of the network along with figures which display the generic transfer functions of some of these instruments. These response diagrams (Figures 2-6) describe the amplitude (solid line) and phase (dashed line) characteristics of the instruments as a function of frequency in Hz.

Table 1 documents all stations operating during this time, with additional information about their location and local geology. Among this heterogeneous collection were several Wood-Anderson seismometers (Table 2 and Figure 2), a network of short-period vertical-component instruments (Table 3 and Figure 3), a collection of miscellaneous instruments located on the UC Berkeley campus and in the Strawberry Canyon vault (Table 4 and Figure 4), several analog strong motion instruments (Table 5 and Figure 5), and the network of digital broadband stations (Table 6 and Figure 6).

Broadband Network Upgrade and Expansion

In 1991 the Seismographic Station began to upgrade and expand the digital broadband instrumentation and telemetry of the BDSN, with the goal of establishing a network of 15-20 regional stations in northern and central California. This process continued in 1992 with the expansion of the broadband network to the sites ARC, ORV, and WDC (previously occupied with short period instruments) and the upgrade of facilities at CMB, MHC, and SAO.

All upgraded stations are equipped with three-component Streckeisen broadband sensors (STS-1 or STS-2) and three-component Kinematrics FBA-23 strong motion accelerometers. With the exception of PKD1, all stations have Quanterra dataloggers for 24-bit A/D conversion at a variety of sampling rates (The 16-bit PC-based datalogging system at PKD1 was replaced with a Quanterra datalogger in 1993). These data are transmitted to UC Berkeley by continuous telemetry by a combination of dedicated phone, microwave, and radio links. Complementary to the new instrumentation and datalogging, a new digital data acquisition system was implemented on a Sun Sparc2 workstation.

This sparse network of broadband instruments is designed to replace the short-period vertical-component seismometers operated by the Seismographic Station over the past 30 years. A number of these older stations are either being replaced by broadband equipment or shut down, as documented in Table 3. Changes in 1993 and 1994 include the upgrade and installation of instrumentation at HOPS, PKD1, and YBH. The instruments at STAN were moved to the site JRSC in 1994 to improve the long-period noise characteristics. The northern Hayward Fault Network (HFN) was installed and data acquisition was begun using the portable 24-bit Reftek digitizers. The Seismographic Station expanded in the Global Positioning System (GPS) analysis with the creation of the joint UCB-USGS Bay Area Regional Deformation (BARD) Network.

Additional details on instrumentation may be found in Appendices B and C.

Data Archival and Distribution: Northern California Earthquake Data Center

In 1991 the joint UCB-USGS Data Center has opened to the entire seismological community, with access provided via the Internet. Over 200 accounts have been established for scientists and researchers around the world. In addition to archiving current digital seismograms and event parameters for northern California earthquakes, the Data Center is continuing to load previously recorded digital waveforms from both the USGS and UCB archives.

The jointly funded facility consists of 2 mass-store devices (SONY jukeboxes with a capacity 330 Gbytes each), accessible on the Internet by means of a Sun Sparc2 workstation. Additional information on the Northern California Earthquake Data Center is presented in Appendix A.

Table 1: STATIONS IN OPERATION: January 1, 1992 to December 31, 1992

Symbol	Station	Latitude	Longitude	Elevation (m)	Foundation Material	Present Auspices and Date Established
ARC	Arcata	40.877°	-124.075°	60	Sandstone (loose)	Humboldt State Univ. 1948
BKS	Berkeley (Byerly)	37.877°	-122.235°	276	Claremont shales and cherts	University of Calif. 1962
BRK	Berkeley	37.873°	-122.260°	81	Franciscan sandstone	University of Calif. 1887
CMB	Columbia College	38.035°	-120.385°	719	Paleozoic marine limestone	Columbia College 1986
EKR	Elk River	40.695°	-124.140°	49	Marine siltstone	Buck Noel Ranch 1986
FHC	Fickle Hill	40.802°	-123.985°	610	Siltstone over graywacke	Humboldt State Univ 1968
FOX	Fox Creek	40.522°	-123.992°	113	Quaternary alluvium	Richard McKenna Ranch 1986
FRI	Friant	36.992°	-119.708°	119	Alluvium over-lying granite	Bureau of Reclamation 1971
GCC	Granite Creek	37.030°	-121.997°	122	Granite	Peter Nash, Santa Cruz 1965
KVN	Kaiserville (Nevada)	39.052°	-118.100°	1829	Limestone shales and cherts	Univ. of Nevada, Reno 1973
LLA	Llanada	36.617°	-120.943°	475	Alluvium overlying sandstone	Charles McCullough Ranch 1961
MHC	Mt. Hamilton	37.342°	-121.642°	1282	Franciscan formation (greenstone)	Lick Observatory 1887
MIN	Mineral	40.345°	-121.605°	1495	Volcanic	National Park Service 1938
ORV	Oroville	39.555°	-121.500°	360	Basalt	Dept. of Water Resources 1969
PCC	Pilarcitos Creek	37.500°	-122.382°	91	Granodiorite (weathered)	Sare Ranch 1965
PKD1	Parkfield	35.873°	-120.425°	466	Quaternary non-marine deposits	US Geological Survey 1991
PRI	Priest	36.142°	-120.665°	1187	Greenstone basic metamorphic	Federal Aviation Agency 1961
PRS	Paraiso	36.332°	-121.370°	363	Granodiorite	Paraiso Hot Springs 1961
SAO	San Andreas Geophysical Observatory	36.765°	-121.445°	350	Granite	University of Calif. 1966
STAN	Stanford	37.404°	-122.174°	158	Miocene volcanic	Stanford University 1991
WDC	Whiskeytown	40.580°	-122.540°	300	Pre-Devonian metavolcanic	National Park Service 1973
ZSP	San Pablo Dam	37.945°	-122.257°	119	Middle Miocene marine	East Bay M.U.D. 1978

Location of Seismographic Stations

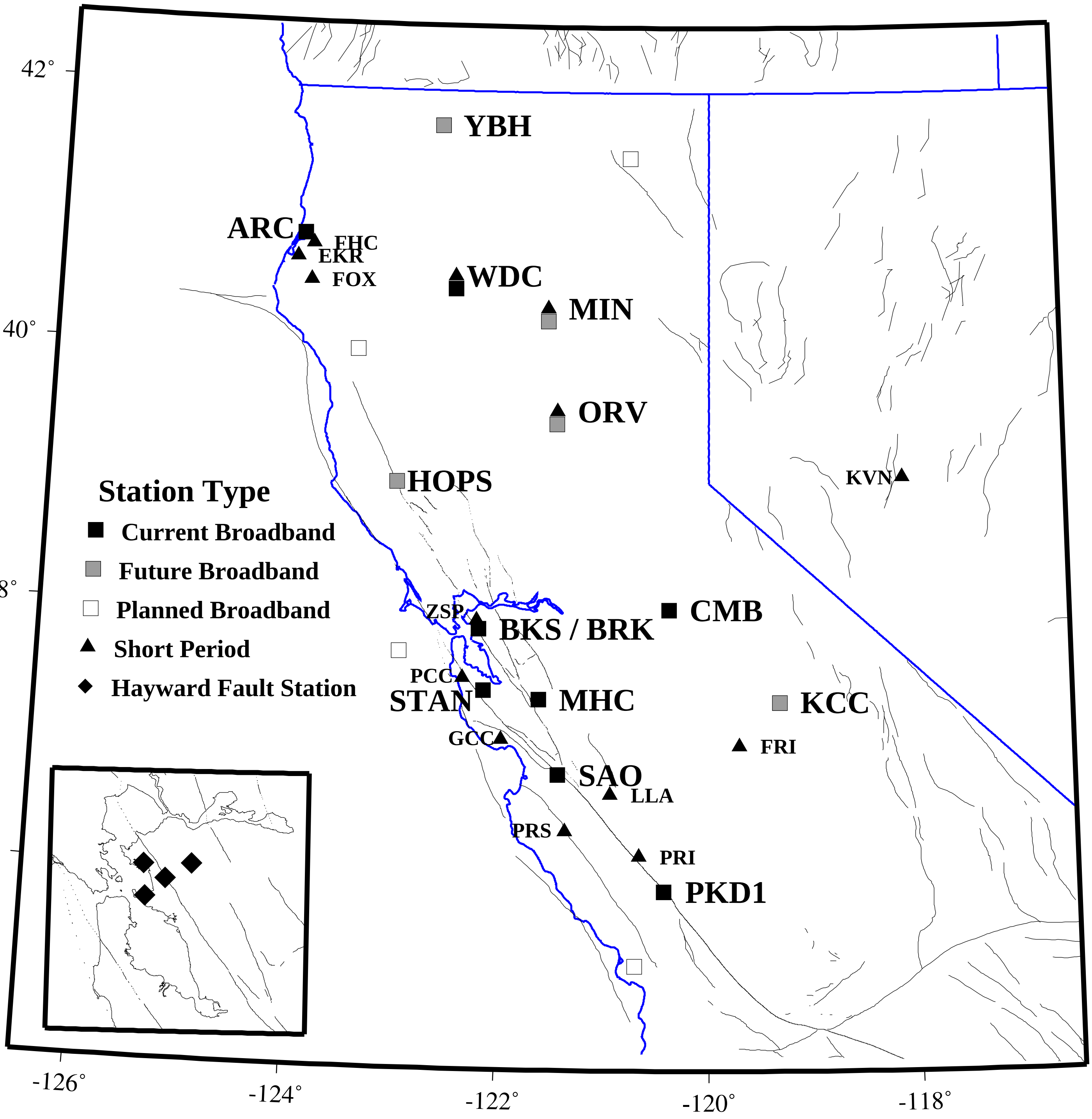

Figure 1: Location of seismographic stations operated/monitored by UC Berkeley

Table 2: WOOD-ANDERSON INSTRUMENTS

Station	Type of Instrument	T_o sec a	Component	Mag at T_o	Installed	Removed
ARC	Wood-Anderson Torsion	0.8	S,W	2,080 max	02/23/1948	01/15/1993
BKS	Wood-Anderson Torsion	0.8	S,W	2,080 max	07/1962	01/15/1993
	High-gain Torsion	0.8	N,E	14,000 max	03/09/1978	Current
	Low-gain Torsion	0.8	N,E	700 max	03/09/1978	Current
BRK	100X Torsion	0.8	N,E	100 max	01/1958	01/15/1993
MHC	Wood-Anderson Torsion	0.8	S,E	2,080 max	04/08/1928	01/15/1993
MIN	Wood-Anderson Torsion	0.8	E	2,080 max	01/02/1939	03/1947
	Wood-Anderson Torsion	0.8	S,E	2,080 max	03/1947	01/16/1994

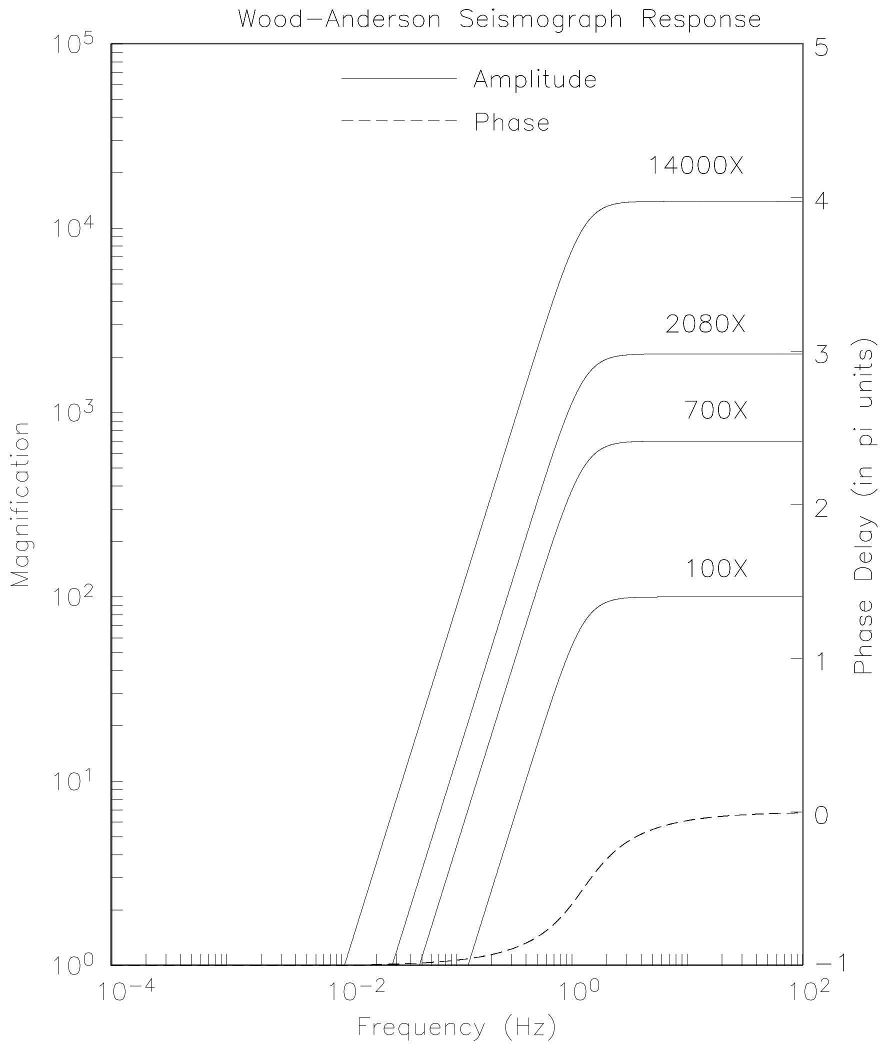

Figure 2: Wood-Anderson Seismograph Responses

Table 3: SHORT PERIOD INSTRUMENTS

Station	Type of Instrument	T_o sec	T_g sec	Component	Mag at T_o	Installed	Removed
BKS	Willmore MK II	1.0	0.04 Filter	Z	Analog Tape	1978	Current
BRK	Benioff 100 kg	1.0	0.2	Z	25,000	05/01/1959	08/23/1991
	Benioff 100 kg	1.0	8.0	Z	Variable	06/21/1947	Current
CMB	Teledyne S-13	1.0	-	Z	Digital Tape	11/06/1986	06/17/1992
EKR	Mark Products L-4C	1.0	-	Z	Analog Tape	08/25/1986	01/01/1994
FHC	Benioff 14 kg	1.0	0.2	Z	50,000	12/10/1968	04/01/1994
FOX	Mark Products L-4C	1.0	-	Z	Analog Tape	08/25/1986	01/01/1994
FRI	Benioff 14 kg	1.0	0.33 Filter	Z	150,000	03/09/1971	Current
GCC	Benioff 14 kg	1.0	0.2	Z	50,000	02/1965	01/12/1967
						01/12/1971	11/15/1993
KVN	Benioff 100 kg	1.0	-	Z	-	06/07/1989	09/14/1990
	Geotech 7507	15	1.0-15 Filter	Z	90,000	09/14/1990	Current
LLA	Benioff 14 kg	1.0	0.2	Z	50,000	09/08/1961	10/15/1993
MIN	Teledyne S-13	1.0	0.2 Filter	Z	150,000	07/12/1974	Current
ORV	Benioff 100 kg	1.0	0.2	Z	220,000	07/22/1970	Current
PCC	Benioff 14 kg	1.0	0.2	Z	50,000	04/02/1968	11/15/1993
PRI	Benioff 14 kg	1.0	0.2	Z	50,000	09/15/1961	06/30/1994
PRS	Benioff 14 kg	1.0	0.2	Z	50,000	07/07/1961	01/12/1967
	Benioff 14 kg	1.0	0.2	Z	50,000	12/03/1970	01/30/1994
SAO	Sprengnether 0.70 kg	0.2	0.05 Filter	Z	1,500,000	09/16/196	06/30/1994
WDC	Sprengnether S-5100	40	-	Z	500,000	03/07/1973	07/15/1992
ZSP	Teledyne S-13	1.0	0.2 Filter	Z	65,000	11/03/1978	03/01/1994

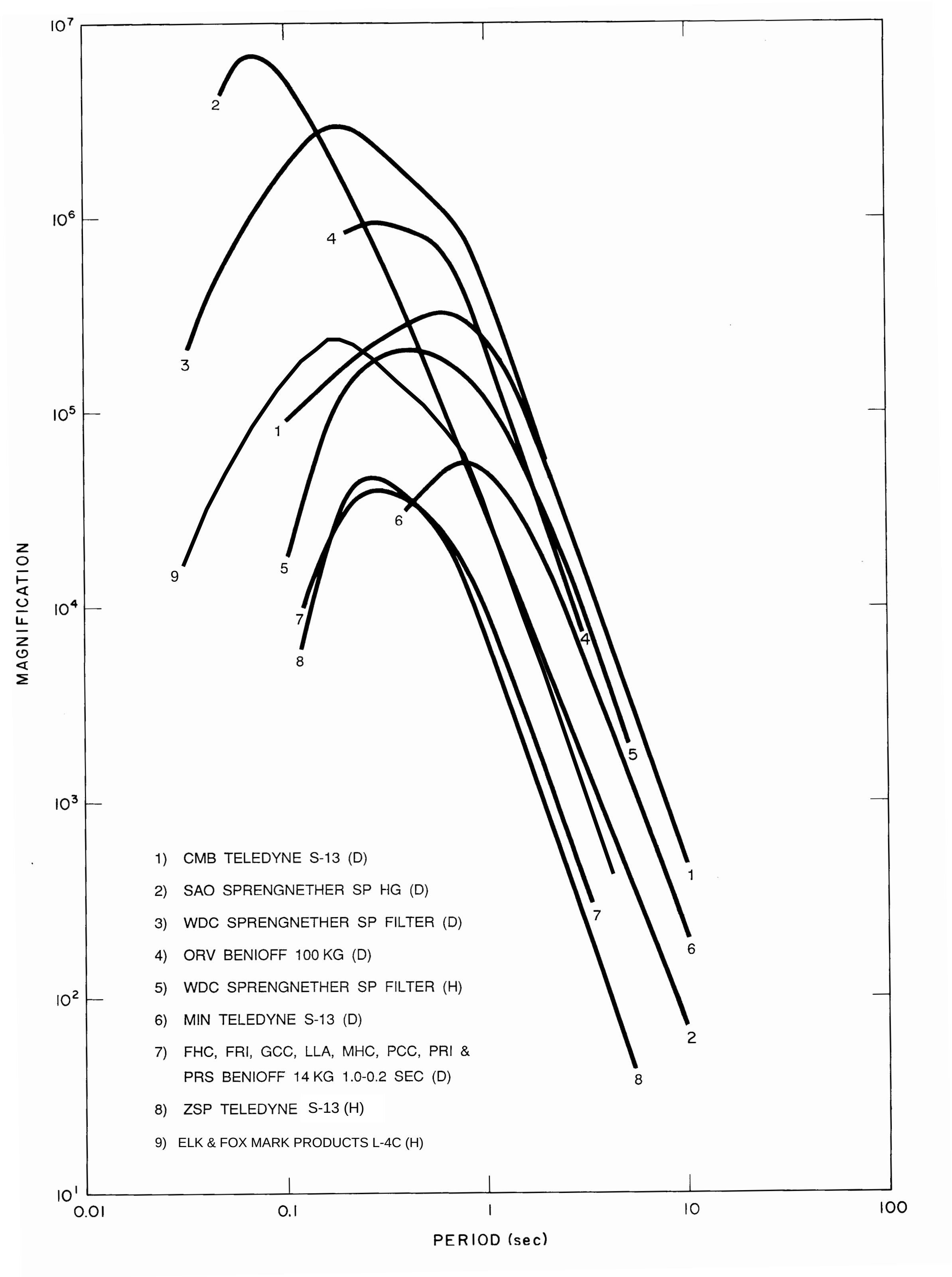

Figure 3: Short Period Instrument Responses

Table 4: BERKELEY MISCELLANEOUS INSTRUMENTS

Station	Type of Instrument	T_o sec	T_g sec	Component	Mag at T_o	Installed	Removed
BKS	Benioff 100 kg	1.0	0.75	Z	25,000	06/08/1962	10/01/1991
	Sprengnether S-5007	15*	100	N,E,Z	3,000	06/08/1962	10/01/1991
	Sprengnether ULP S-5100	100	300 Filter	N45W,N45E,Z**	500	12/09/1969	10/01/1991
	-Filtered Displacement				-		
	-Displacement				-		
BRK	Press-Ewing	15	30	Z	1,000	08/1964	Current

* Natural period was changed from 30 to 15 sec on 05/12/1965.

** N45E installed 12/09/1969; N45W and Z added on 3/30/1971.

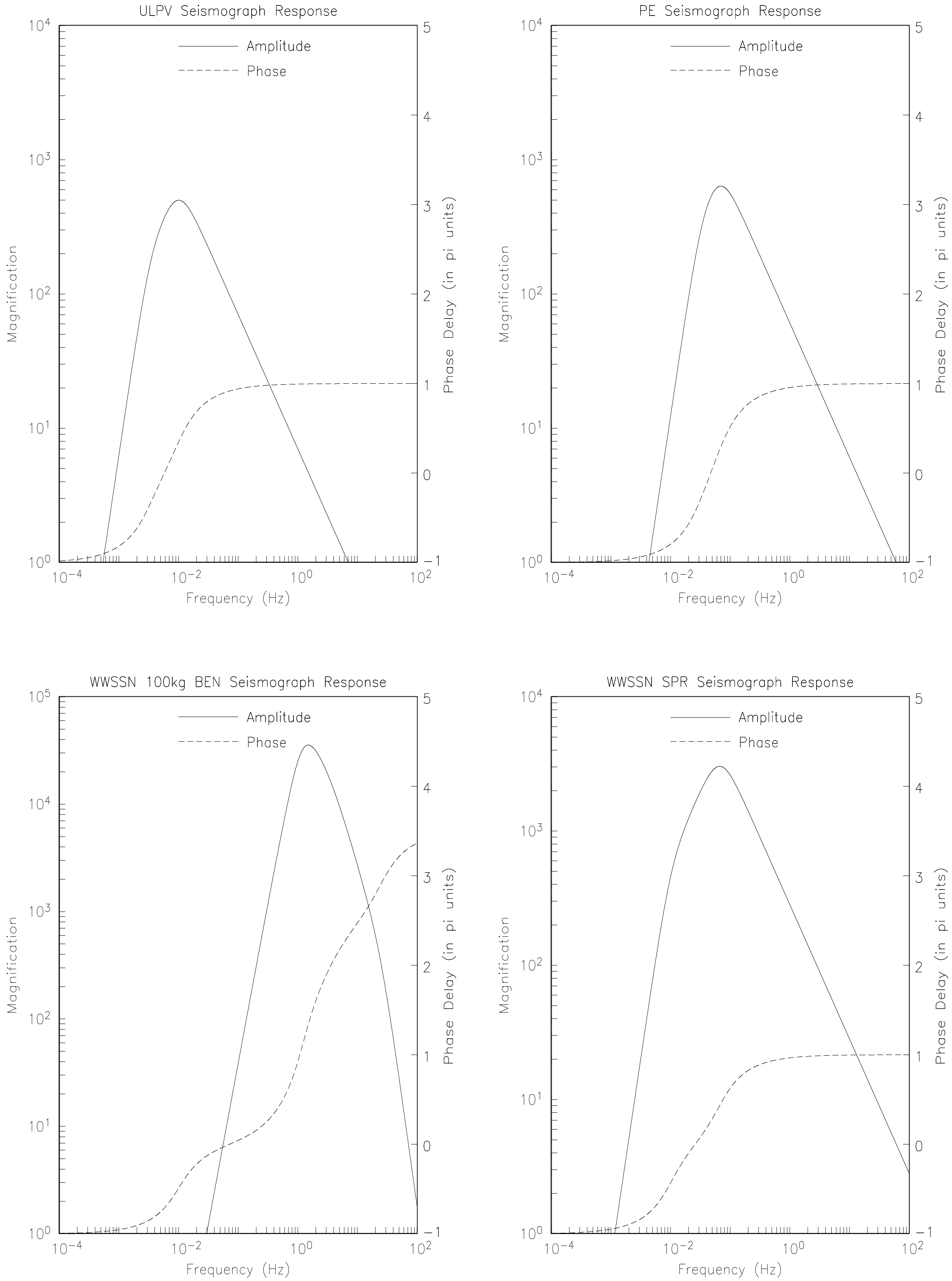

Figure 4: Berkeley Miscellaneous Seismograph Responses

Table 5: ANALOG STRONG MOTION INSTRUMENTS

Station	Coordinates	Installed	Instrument	Component	Sensitivity (cm/g)	Period (sec)	Fraction of Critical Damping	Structure	Location In Structure
Berkeley Memorial Stadium	37.87° -122.25°	08/03/1976	CRA-1 SN-148 (Recorder)	L North V Down T East	1.83 1.90 1.82	0.019 0.020 0.019	0.63 0.60 0.62	Metal Box	Ground Level
Earth Sciences Building	37.87° -122.26°	11/01/1968	Wilmot Seismoscope SR-100	Duplex Horizontal	0.0545 (m/rad)	0.75	≈ 0.10	Six-story Building	Ground Level
SAGO Central USGS No.1032	36.77° -121.45°	04/08/1978	SMA-1 SN-832	L North V Down T West	1.94 1.85 1.81	0.040 0.039 0.038	0.60 0.60 0.60	Concrete Vault	Ground Level
SAGO East USGS No.1657	36.81° -121.41°	09/21/1978	SMA-1 SN-1419	L North V Down T West	1.85 1.80 1.81	0.040 0.037 0.038	0.66 0.63 0.62	One-story Building	Ground Level
Berkeley BRK USGS No.1006	37.87° -122.26°	04/15/1976	SMA-1 SN-2500 with WWVB	L North V Down T West	1.79 1.73 1.71	0.038 0.038 0.039	0.60 0.58 0.57	Concrete Building	Ground Level
Berkeley BKS USGS No.1005	37.87° -122.24°	04/29/1976	SMA-1 SN-2503 with WWVB	L North V Down T West	1.79 1.79 1.73	0.038 0.039 0.039	0.60 0.55 0.57	Concrete Vault	Ground Level
Priest PRI FAA Building	36.14° -120.67°	06/07/1989	SMA-1	L S45E V Down T N45E	1.68 1.52 1.48	0.040 0.035 0.039	0.62 0.63 0.48	One-story Building	Ground Level
					Sensitivity (g/F.S.)	Bandwidth (Hz)			
Richmond Field Station RFS	37.92° -122.33°	05/12/1976	Columbia Research Force Balance Accelerometer	Z,H1*,H2** Z, H1, H2	± 0.010 ± 0.50	0.05-50 0-50		5" I.D. Uncased Backfilled Borehole (43.8m deep)	Downhole (43.7m)
			SA-107 (+2g units) (0-50 Hz)	Z,H1,H2 Z,H1,H2	± 0.010 ± 0.50	0.05-50 0-50			Midhole (15.7m)
			SA-107 (+2g units)	Z,H1,H2 Z,H1,H2	± 0.010 ± 0.50	0.05-50 0-50			Surface Level Metal Box

* Accelerometer aligned S45W.
** Accelerometer aligned S45E.
Up on record corresponds to these directions of ground acceleration.

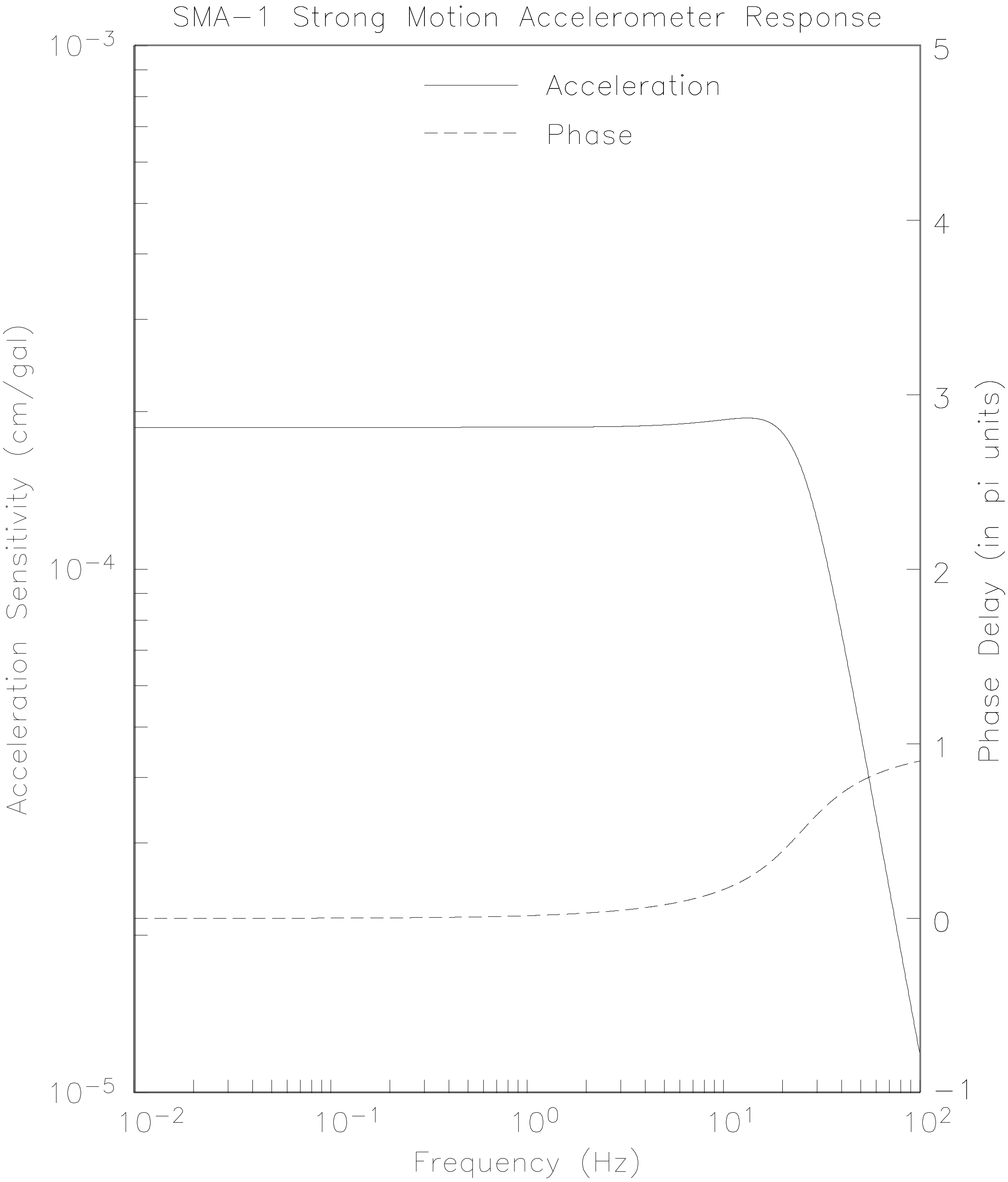

Figure 5: Strong Motion Seismograph Response

Table 6: DIGITAL BROADBAND INSTRUMENTS

Station	Instrument	Channels	Components	Data Logger	Installed	Removed
ARC	STS-2	UH/VH/LH/BH/HH	Z,N,E	Q935	05/26/1992	Current
	FBA-23	LL/BL/HL	Z,N,E	Q935	05/26/1992	Current
BKS	Sprengnether ULPV S-5100	LH/BH	Z,N45W,N45E	PC	01/28/1988	05/09/1991
	STS-1/UVBB	UH/VH/LH/BH/HH	Z,N,E	Q680	05/10/1991	03/12/1993
		UH/VH/LH/BH/HH	Z,N,E	Q935	03/12/1993	Current
	FBA-23	LL/BL/HL	Z,N,E	Q680	05/10/1991	03/12/1993
		LL/BL/HL	Z,N,E	Q935	03/12/1993	Current
CMB	CMG-3	LH/BH	Z,N,E	DRS	03/16/1988	06/17/1992
	STS-1/VBB	UH/VH/LH/BH/HH	Z,N,E	Q935	06/24/1992	Current
	FBA-23	LL/BL/HL	Z,N,E	Q935	06/24/1992	Current
HOPS	STS-1	UH/VH/LH/BH/HH	Z,N,E	Q935	10/20/1994	Current
	FBA-23	LL/BL/HL	Z,N,E	Q935	10/20/1994	Current
JRSC	STS-2	UH/VH/LH/BH/HH	Z,N,E	Q680	07/01/1994	Current
	FBA-23	LL/BL/HL	Z,N,E	Q680	07/30/1994	Current
MHC	STS-1/UVBB	LH/BH	Z,N,E	PC	10/27/1987	04/28/1992
		UH/VH/LH/BH/HH	Z,N,E	Q935	04/28/1992	02/02/1993
	STS-1/VBB	UH/VH/LH/BH/HH	Z,N,E	Q935	02/02/1993	Current
	FBA-23	LL/BL/HL	Z,N,E	Q935	04/28/1992	Current
MIN	STS-1/VBB	UH/VH/LH/BH/HH	Z,N,E	Q935	03/19/1993	Current
	FBA-23	LL/BL/HL	Z,N,E	Q935	03/19/1993	Current
ORV	STS-1	UH/VH/LH/BH/HH	Z,N,E	Q935	07/29/1992	Current
	FBA-23	LL/BL/HL	Z,N,E	Q935	07/29/1992	Current
PKD1	STS-2	LH/BH	Z,N,E	PC	10/21/1991	02/11/1993
		UH/VH/LH/BH/HH	Z,N,E	Q935	02/12/1993	Current
	FBA-23	LL/BL/HL	Z,N,E	Q935	02/12/1993	Current
SAO	STS-1/BRB	LH/BH	Z,N,E	PC	01/28/1988	05/23/1991
		LH/BH	Z,N,E	PC	05/23/1991	06/10/1992
	STS-1/UVBB	UH/VH/LH/BH/HH	Z,N,E	Q935	06/10/1992	Current
	FBA-23	LL/BL/HL	Z,N,E	Q935	06/10/1992	Current
STAN	STS-2	UH/VH/LH/BH/HH	Z,N,E	Q680	04/01/1991	06/30/1994
	FBA-23	LL/BL/HL	Z,N,E	Q680	04/30/1991	06/30/1994
WDC	STS-2	UH/VH/LH/BH/HH	Z,N,E	Q935	07/14/1992	Current
	FBA-23	LL/BL/HL	Z,N,E	Q935	07/14/1992	Current
YBH	STS-1	UH/VH/LH/BH/HH	Z,N,E	Q935	07/24/1993	Current
	FBA-23	LL/BL/HL	Z,N,E	Q935	07/24/1993	Current

PC - PC based 16-bit data logger built in-house at the Berkeley Seismographic Station.
DRS - DWWSSN 16-bit data logger built by USGS/Albuquerque Seismological Laboratory.
Q935/Q680 - 6 channel 24-bit data logger manufactured by Quanterra. Q935 includes 3 additional medium resolution channels.

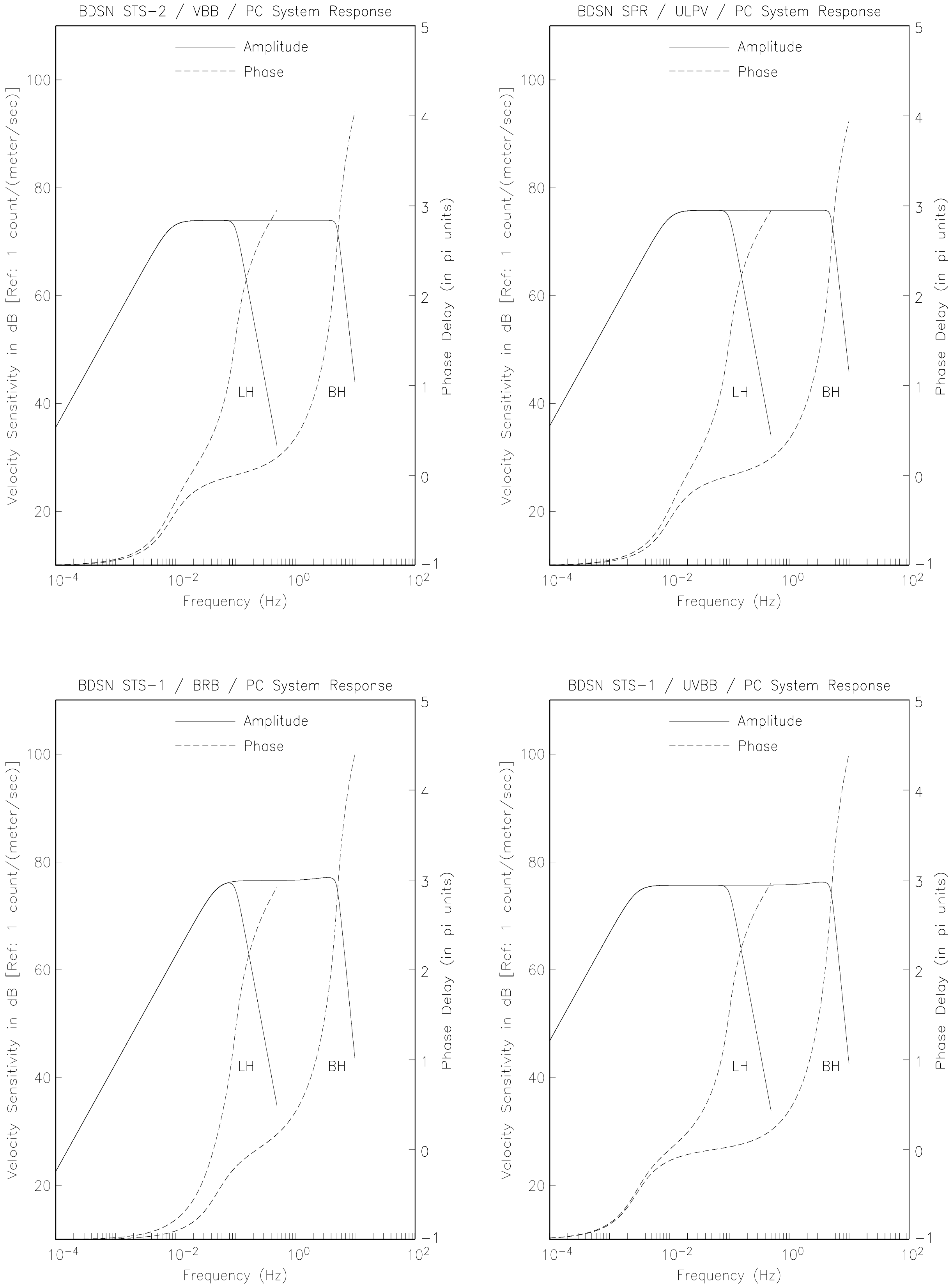

Figure 6: (a) BDSN PC System Seismograph Responses

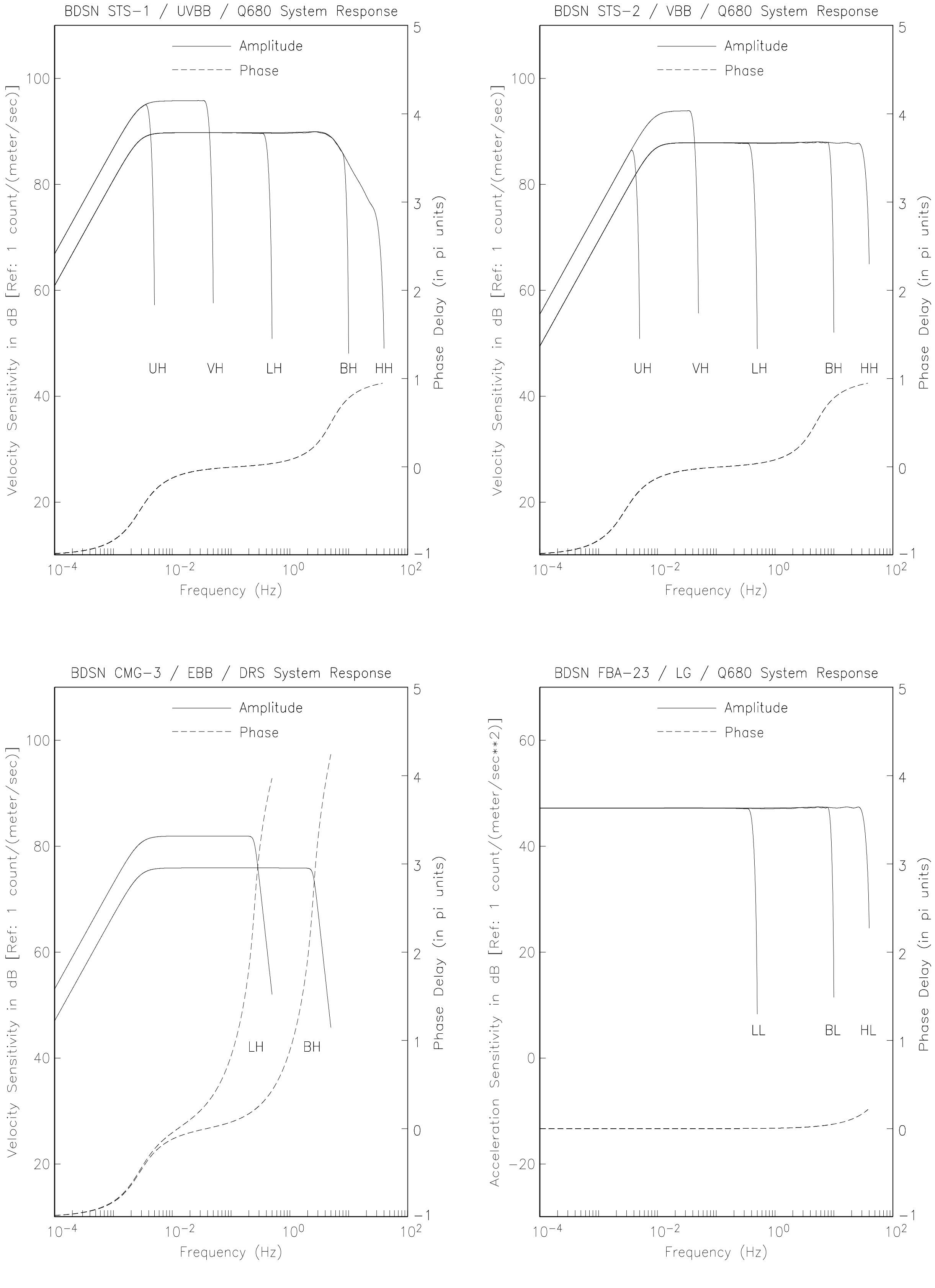

Figure 6: (b) BDSN Quanterra and DRS System Seismograph Responses