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6.5 Continued overview of array and station system responses contributing to NORSAR's Data Center

6.5.1 Introduction

This series of contributions (Pirli and Schweitzer, 2008a; 2008b; 2009; present paper), presenting the system response of seismic stations and arrays contributing to NORSAR's Data Center, is continued with the responses of two seismic arrays situated in neighboring countries, but contributing on a regular basis to NORSAR's database, and two new three-component, broadband seismic stations. The Hagfors array in Sweden and the FINES array in Finland are part of a long collaboration between NORSAR and FOI (the Swedish Defence Research Agency) in Stockholm, and NORSAR and the University of Helsinki, respectively. The two single seismic stations are Åknes (AKN) and Hornsund (HSPB). The latter is also part of a collaborative activity between NORSAR and the Institute of Geophysics of the Polish Academy of Sciences (Schweitzer and The IPY Project Consortium Members, 2008).

6.5.2 Hagfors (HFS) array configurations

The Hagfors array operated initially in 1969 as a sub-station (HFS) of a larger installation known as the Hagfors Observatory (*e.g.*, GSE, 1990; FOI, 2005). This system became modernized in 1989 and later the HFS sub-array became known as Hagfors array instead of the larger deployment. Since June 8, 1994 NORSAR has been collecting data from the Hagfors array and using them in its routine analysis. The Hagfors array was certified as IMS auxiliary station AS101 in December 2002. The initial configuration consisted of 8 sites, distributed over an aperture of about 900 m (see Fig. 6.5.1, left-hand side), all of them equipped with short-period Geotech S-13 or 20171A vertical seismometers and Nanometrics RD-3 digitizers. In addition, site HFSC2 had a three-component long-period and a vertical broadband channel, carrying a 7505A/8700C sensor combination and an STS-1 vertical seismometer respectively.

Poles and zeros for the short-period and long-period sensors are provided by the standard damping seismometer formula (*e.g.*, Geotech Instruments, 1999):

$$p_{1,2} = \lambda_0\omega_0 \pm j\omega_0\sqrt{1-\lambda_0^2}\ , \qquad (6.5.1)$$

where λ_0 is the damping factor and $\omega_0 = 2\pi f_0$. Not much information is available about these sensors and the λ_0 and f_0 values that were used, so for the short-period channels, after several tests we used the same settings as for the NORSAR array (Pirli, 2010; Pirli and Schweitzer, 2008a) and for the long-period channels values of $f_0 = 0.05$ Hz and $\lambda_0 = 0.406$ were the ones reconstructing better the calibration curves provided by FOI in 2005 and shown in Fig. 6.5.2. Channel sensitivity information (see Table 6.5.1) is provided by Lund and Lennartsson (2005), so the system can be tuned accordingly.

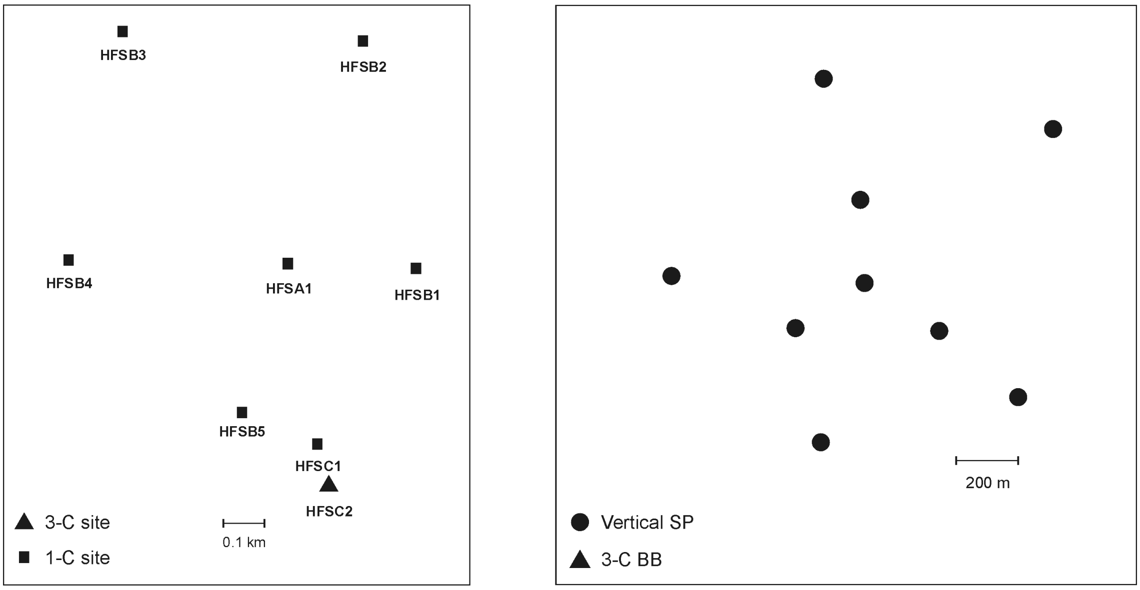

Fig. 6.5.1. Geometry of the initial (left, GSETT3, 1995) and current (right) Hagfors array.

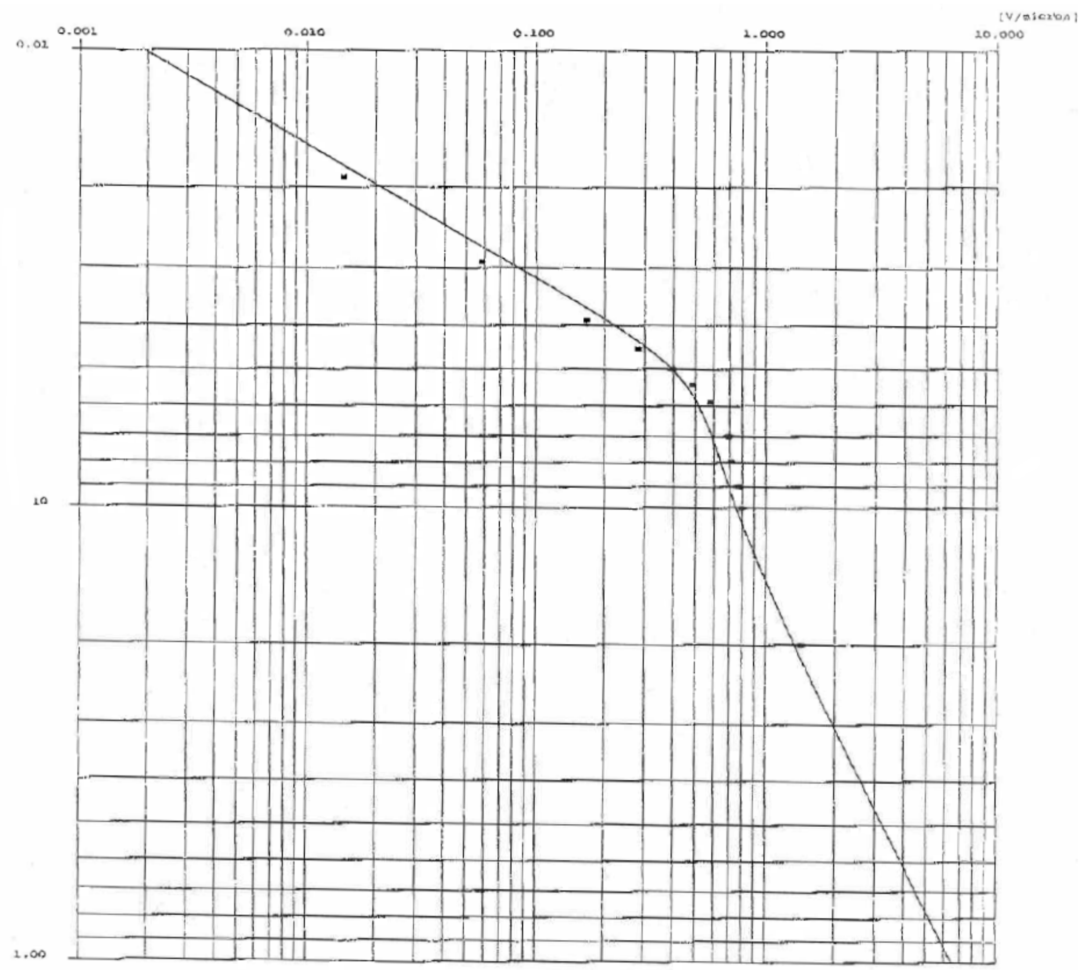

Fig. 6.5.2. Calibration curves for the vertical component (7505A sensor) of the long-period channel displacement amplitude response [V/micron] vs. frequency [Hz]. Information was faxed to J. Schweitzer from FOI SYSTEMTEKNIK in 2005.

The velocity transfer function of the STS-1 seismometer is described by the formula (Streckeisen, 1986):

$$T(\omega) = \frac{-\omega^2 S}{-\omega^2 + 2i\omega\omega_1 h_1 + \omega_1^2} \cdot \frac{\omega_2^2}{-\omega^2 + 2i\omega\omega_2 h_2 + \omega_2^2}, \quad (6.5.2)$$

where $\omega_1 = 2\pi/360$ rad/s, $h_1 = 1/\sqrt{2}$, $\omega_2 = 2\pi/0.1$ rad/s, $h_2 = 0.6235$ and S = 2400 V/m/s.

The RD-3 digitizers employ the following filters:

- Low-pass analog 5th order Butterworth filter (f_{3db} = 20 Hz)
- Low-pass digital FIR filter (symmetric, 150 coefficients, f_{3db} = 17 Hz)
- High-pass digital IIR filter (f_c = 0.008 Hz)

To achieve the overall channel sensitivity values reported by Lund and Lennartsson (2005), a gain factor of 2 is assigned to the low-pass Butterworth filter (Nanometrics, 1992), while an additional gain stage of a factor of 30 is introduced for all channels of this configuration. The displacement amplitude and phase response for all channels of this configuration, as well as the rest of the Hagfors systems described later in this section, are shown in Fig. 6.5.3.

In August 2001 and while the initial HFS was in operation, a new configuration was tested. The new array comprised 10 sites, nine of which carried only vertical short-period GS-13 sensors, the tenth having been equipped with a three-component, broadband STS-2 seismometer. Digitizers were Nanometrics Europa T, including an HRD-24 A/D unit and authentication for CTBTO compatibility. The two systems, which were stored under separate database entries at NORSAR, were kept operating in parallel because of the rather small amplitudes achieved by the new system, due to the needed pre-amplifiers not having been delivered (Bergkvist and Lennartsson, 2004). The pre-amplifiers with a gain factor of 30.23 were installed in late autumn 2003, while the final HFS configuration was shaped in 2004 when the IIR filter of the digitizer for the broadband channel was switched from 10 mHz to 1 mHz. The present day geometry of HFS is shown on the right-hand side of Fig. 6.5.1.

The poles and zeros of the GS-13 seismometers are also computed by formula (6.5.1), while the sensitivity is 2000 V/m/s. Regarding the poles and zeros of the STS-2 seismometer, information on how to calculate their values, as well as the sensitivity for each component can be found in our description of the response of the JMIC station (Pirli, 2010; Pirli and Schweitzer, 2009) and from Streckeisen (2003; 2006) and Wielandt (2002). The Europa T unit contains an HRD-24 digitizer which employs the following filter cascade:

- Low-pass analog 3rd order Bessel filter (f_{3db} = 1500 Hz)
- Digital FIR 1, decimating by factor 5, 34 coefficients
- Digital FIR 2, decimating by factor 3, 30 coefficients
- Digital FIR 7, decimating by factor 5, 36 coefficients
- Digital FIR 10, decimating by factor 5, 256 coefficients
- High-pass IIR digital filter (f_c = 10 mHz)

Overall channel sensitivity for the current system is in the order of 23 count/nm/s (Bergkvist and Lennartsson, 2004). The displacement amplitude and phase responses for all different configurations are shown in Fig. 6.5.3, while a summary of all these systems and corresponding

Respid flags given in parentheses (Pirli, 2010; Pirli and Schweitzer, 2008a) are listed in Table 6.5.1.

Table 6.5.1. The different instrument configurations of the Hagfors array

Time	Installation Name	Components	Calib [nm/count]	Calper [s]
1992-2003	Initial SP (HFSSP1, HFSSP2, HFSSP3)	S-13 RD-3 digitizer LP Butterworth, analog LP FIR, digital HP IIR, digital	0.0265500*	1.00
1992-2003	Initial SP (HFSSP4)	20171A RD-3 digitizer LP Butterworth, analog LP FIR, digital HP IIR, digital	0.0262300*	1.00
2001-2003	New SP, Non amplified (HFSSP5)	GS-13 Europa T digitizer LP Bessel, analog LP FIR, digital HP IIR, digital	0.2019800*	1.00
2003-…	Current SP amplified (HFSSP6)	GS-13 Pre-amplifier, 30.23x Europa T digitizer LP Bessel, analog LP FIR, digital HP IIR, digital	0.0066814*	1.00
1992-2003	LP channel (HFSLP1, HFSLP2, HFSLP3)	7505A & 8700C RD-3 digitizer LP Butterworth, analog LP FIR, digital HP IIR, digital	0.3454400*	20.00
1992-2003	Initial BB (HFSBB1)	STS-1 RD-3 digitizer LP Butterworth, analog LP FIR, digital HP IIR, digital	0.0060000	1.00
2003-2004	New BB, 10 mHz (HFSBB2, HFSBB3, HFSBB4)	STS-2 Europa T digitizer LP Bessel, analog LP FIR, digital HP IIR, digital, 10 mHz	0.0069643*	1.00
2004-…	Current BB, 1 mHz (HFSBB5, HFSBB6, HFSBB7)	STS-2 Europa T digitizer LP Bessel, analog LP FIR, digital HP IIR, digital, 1 mHz	0.0069639*	1.00

* Indicative value

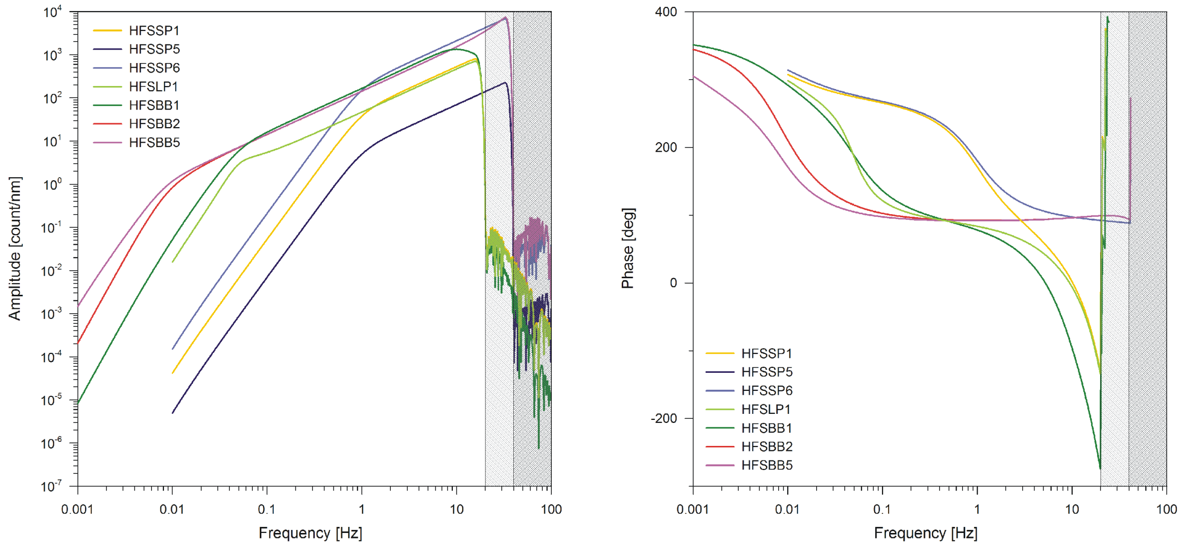

Fig. 6.5.3. Displacement amplitude and phase responses for the short-period (HFSSP1, HFSSP5, HFSSP6), long-period (HFSLP1) and broadband (HFSBB1, HFSBB2, HFSBB5) configurations of the Hagfors array. The shaded areas represent the range beyond the Nyquist frequency (20 Hz for the RD-3 and 40 Hz for the Europa T configurations).

6.5.3 FINES array configurations

The FINES array was installed in November 1985 at Sysmä, about 100 km NE of Helsinki, in cooperation between the Institute of Seismology of the University of Helsinki and NORSAR (*e.g.*, Ringdal *et al.*, 1987; Uski, 1990). The array, which was named FINESA at that time, comprised 10 short-period elements with a maximum intersensor separation of about 1.5 km (see Fig. 6.5.4). All sites were equipped with vertical S-13 seismometers, except for site FIA1 that also carried two horizontal sensors. The instrumentation included also RA-5 and LTA amplifiers and 12-bit DDS-1105 A/D converters by Kinemetrics (Korhonen *et al.*, 1987). Five additional elements were installed in autumn 1987, without modifying the instrumentation, except for the removal of the horizontal sensors (*e.g.*, Uski, 1990). Regarding the response of this configuration, S-13 poles and zeros are calculated by Equation 6.5.1 and the data coil generator constant is equal to 629 V/m/s. The settings of the amplifiers and digitizer, so that the latter has a scaling of 0.181 nm/count at 1 Hz, is shown in the calibration flowchart of Fig. 6.5.5 (Korhonen *et al.*, 1987).

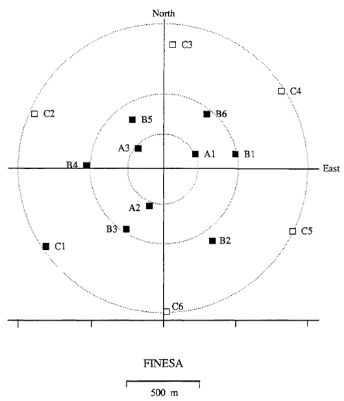

Fig. 6.5.4. Geometry of the FINESA array. Open squares denote elements added in autumn 1987, while the central recording unit is located at site A1 (from Uski, 1990).

We know from the NORSAR array (Pirli, 2010; Pirli and Schweitzer, 2008a) that the amplifiers contained several filters, however the only information we have from Korhonen *et al.* (1987) is about an analog anti-alias filter, directly before the digitizer, with 3db points at 0.7 and 14.5 Hz and slopes of 6 and 30 db/octave respectively. The filter was reconstructed and the resulting displacement response curves (see Fig. 6.5.7) fit the calibration curves of Korhonen *et al.* (1987) (not shown here). For this, the amplifiers were treated as simple gain stages.

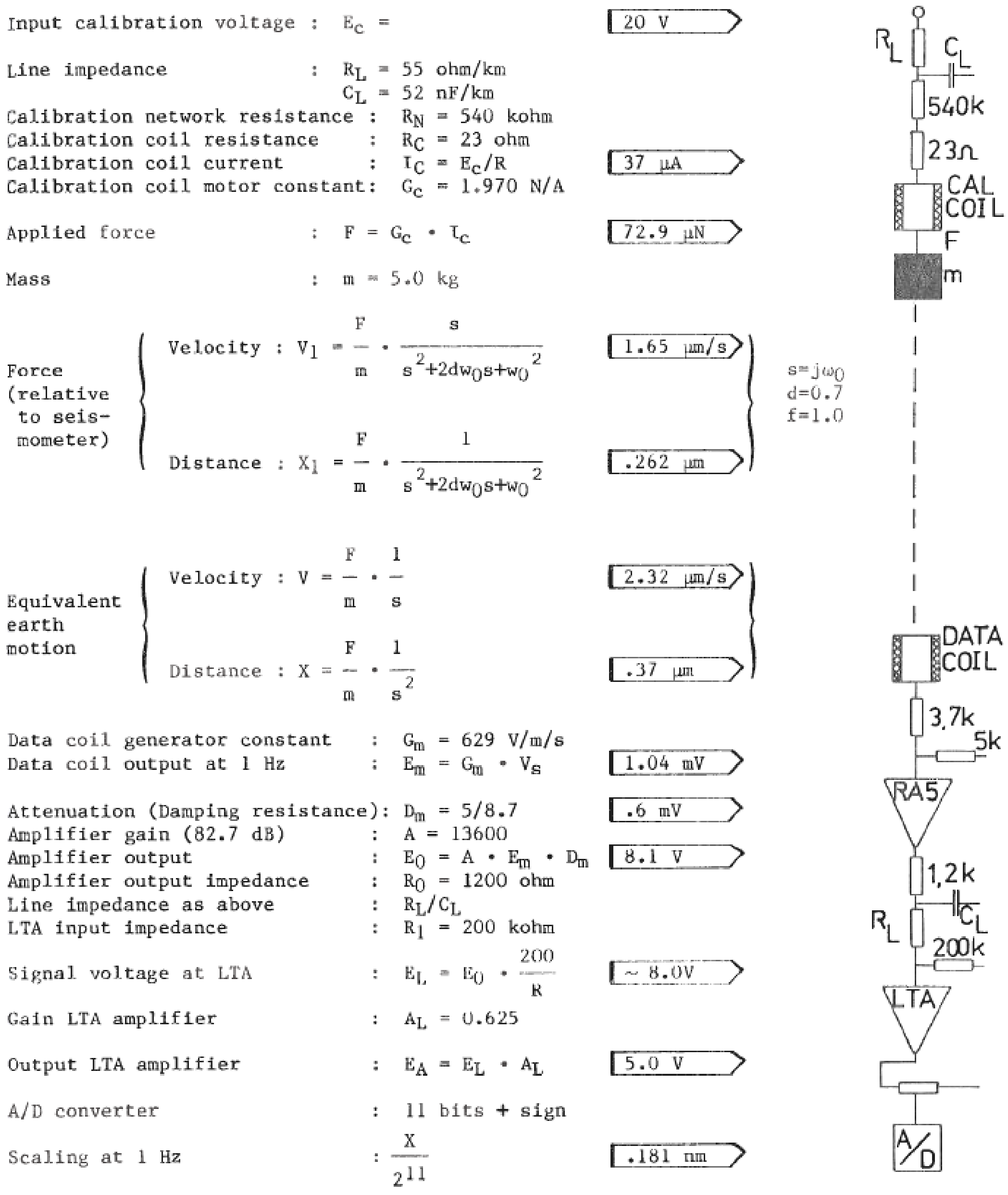

Fig. 6.5.5. FINESA array calibration flowchart (from Korhonen et al., 1987). The entire instrumentation chain, including the A/D converter, is presented.

In 1989, the LTA amplifiers were removed and the Kinemetrics digitizers were exchanged with 16-bit Motorola based (Force Computers) Data Translation A/D converters (DT1405/5716A cards). The response of this configuration was calculated based on the poles and zeros and sensitivity information contained in Teikari and Suvilinna (1994). A channel attenuated by 30 db operated at site FIA0, which was installed in August 1990 (see left in Fig. 6.5.6) in addition to the standard short-period channels, while site FIA1 was once more equipped with horizontal sensors. The displacement response is shown in Fig. 6.5.7.

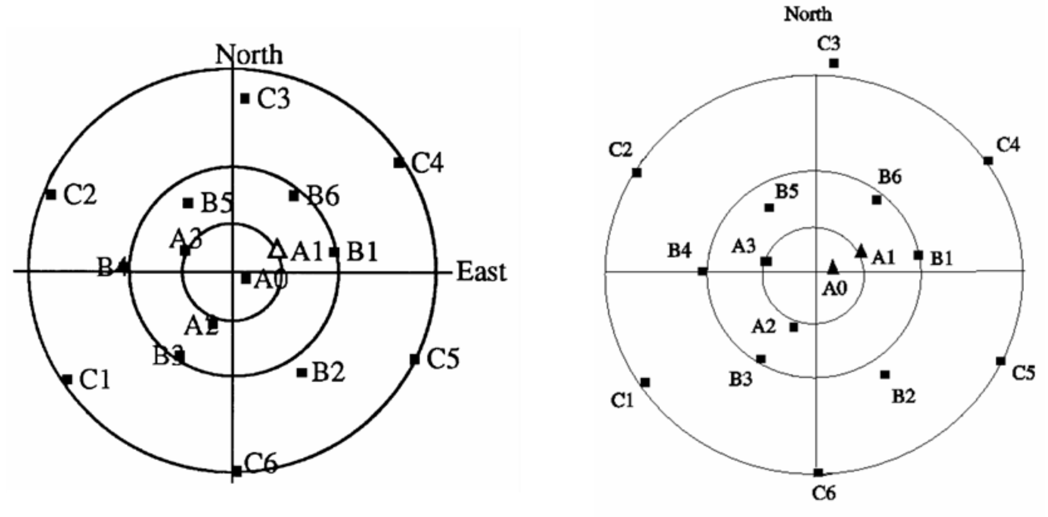

Fig. 6.5.6. (Left) Geometry of the upgraded FINESA array (from Tarvainen, 1994). The 3-component element is noted with an open triangle. (Right) Geometry of the FINES array (from Heikkinen, 2003). Triangles denote 3-component elements. Site FIA1 carries a broadband seismometer.

An extensive upgrade of the array took place in the early 1990s. It was completed in 1993 and the system was then renamed to FINES (Tarvainen, 1994; Tiira *et al.*, 1995). Horizontal channels were moved to site FIA0 from FIA1 and the equipment was modernized, exchanging the old 16-bit digitizers with 24-bit AIM24 units (Tiira *et al.*, 1995). Response information is again reconstructed by using the report of Teikari and Suvilinna (1994). No mention of an amplifier is made, but based on our knowledge of the AIM24 digitizer from the NORSAR array (Pirli 2010; Pirli and Schweitzer, 2008a) an additional gain factor of about 10.5 is needed to achieve the reported channel sensitivity. Thus, a gain-only amplifier stage is assumed. In 2000, a three-component broadband CMG-3T seismometer was added to site FIA1, completing the geometry of the FINES array, which is shown in Fig. 6.5.6 (right). No amplifier was used for the broadband channel, while sensor response information was provided by Güralp Systems Ltd. These responses are also plotted in Fig. 6.5.7.

The current instrumentation of the FINES array was shaped in 2007, when the AIM24 digitizers were exchanged with Nanometrics Europa T models. Initially, this took place for sites FIA0 through FIB4, while the change to the remaining sites was made in the spring of 2009. In the case of the short-period channels, the S-13 sensors and the Europa T digitizers are used together with a preamplifier from Nanometrics, with a gain factor of 51.236. The preamplifiers include an external damping resistor to be used with the damping circuit of the S-13s (Laporte, 2006; J. Kortström, pers. comm.). At FINES, the Europa T includes a Trident A/D converter, with a sensitivity of 1.0078 count/μV for the short-period channels and 4.8 count/μV for the broadband channels (J. Kortström, pers. comm.). No preamplifier is used for the broadband channels. The filter cascade employed by the digitizer to decimate from the input frequency of 30 kHz down to the desired sampling rate of 40 sps is the following:

- Digital FIR 1, decimating by 15, symmetric, 177 coefficients
- Digital FIR 2, decimating by 5, symmetric, 71 coefficients

- Digital FIR 3, decimating by 5, symmetric, 113 coefficients
- Digital FIR 4, decimating by 2, symmetric, 223 coefficients

The different configurations of the FINES array are listed in Table 6.5.2, together with their corresponding Respid flags.

Table 6.5.2. The different instrument configurations of the FINES array

Time	Installation Name	Components	Calib [nm/count]	Calper [s]
1985-1989	Initial SP (FINSP1, FINSP2, FINSP3)	S-13 RA-5 amplifier LTA amplifier anti-alias BB analog filter DDS-1105 digitizer	0.1810000	1.00
1989-1993	Second SP (FINSP4, FINSP5, FINSP6)	S-13 RA-5 amplifier anti-alias BB analog filter Motorola based digitizer	0.0245580	1.00
1990-1993	Attenuated SP (FINSL1)	S-13 RA-5 amplifier, -30 dB anti-alias BB analog filter Motorola based digitizer	0.7760200	1.00
1993-2007	Upgraded SP (FINSP7, FINSP8, FINSP9)	S-13 amplifier AIM24 digitizer LP FIR cascade, digital	0.0100370	1.00
2007-…	Current SP (FINSP10, FINSP11, FINSP12)	S-13 Nanometrics preamplifier Europa T digitizer LP FIR cascade, digital	0.0025756*	0.333
2000-2007	First BB (FINBB1, FINBB2, FINBB3)	CMG-3T AIM24 digitizer LP FIR cascade, digital	0.0250230*	1.00
2007-…	Current BB (FINBB4, FINBB5, FINBB6)	CMG-3T Europa T digitizer LP FIR cascade, digital	0.0273370*	1.00

* Indicative value

The displacement amplitude (in count/nm) and phase (in degrees) responses for the FINES array configurations listed in Table 6.5.2 are depicted in Fig. 6.5.7. Once again, only the vertical channels are pictured and shaded areas represent the range beyond the Nyquist frequency, which is 20 Hz for all channels.

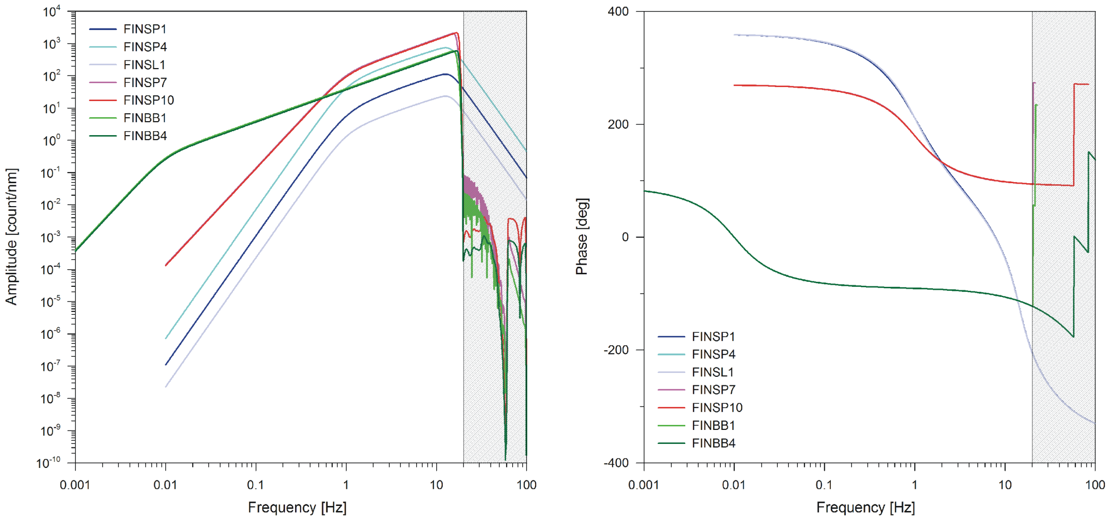

Fig. 6.5.7. Displacement amplitude (left) and phase (right) response for the FINES array configurations. Respids are used to link each curve to the corresponding configuration listed in Table 6.5.2. Shaded areas represent the range beyond the Nyquist frequency (20 Hz for all channels).

6.5.4 Åknes (AKN) station configurations

The AKN broadband, three-component station was installed on the rockslope at Åknes, close to Stranda, Møre og Romsdal, in the end of October 2009, to complement the rockslide monitoring network operating there. The station is equipped with a Güralp Systems CMG-3ESP seismometer and a CMG-DM24S6DCM unit, which combines a DM24 digitizer and EAM data communications module (Güralp Systems, 2009a). The response information of the instrumentation is provided by the manufacturer in the form of poles and zeros and sensitivity values. In the case of AKN, where the output sampling rate is 200 sps, the DM24 digitizer employs the following cascade of FIR filters to decimate down from the input rate of 512 kHz (Güralp Systems, 2006):

- FIR filter SINC-1, decimating by 8, asymmetric, 18 coefficients
- FIR filter SINC-2-stage-3, decimating by 2, asymmetric, 3 coefficients
- FIR filter SINC-2-stage-4, decimating by 2, symmetric, 7 coefficients
- filter FIR-1-set0, decimating by 4, asymmetric, 24 coefficients
- filter FIR-2-set0, decimating by 2, asymmetric, 63 coefficients
- filter DM24-tap0, decimating by 2, symmetric, 501 coefficients
- filter DM24-tap1, decimating by 5, symmetric, 501 coefficients

The AKN station configuration described above and the corresponding Respid flags are listed in Table 6.5.3. The displacement amplitude and phase response curves are shown in Fig. 6.5.8 for the AKN vertical channel. The response is plotted only up to the Nyquist frequency.

Table 6.5.3. The instrument configuration of the Åknes station

Time	Installation Name	Components	Calib [nm/count]	Calper [s]
2009-…	Current BB (AKNBH1, AKNBH2, AKNBH3)	CMG-3ESP CMG-DM24 digitizer LP FIR cascade, digital	0.26421*	1.00

* Indicative value

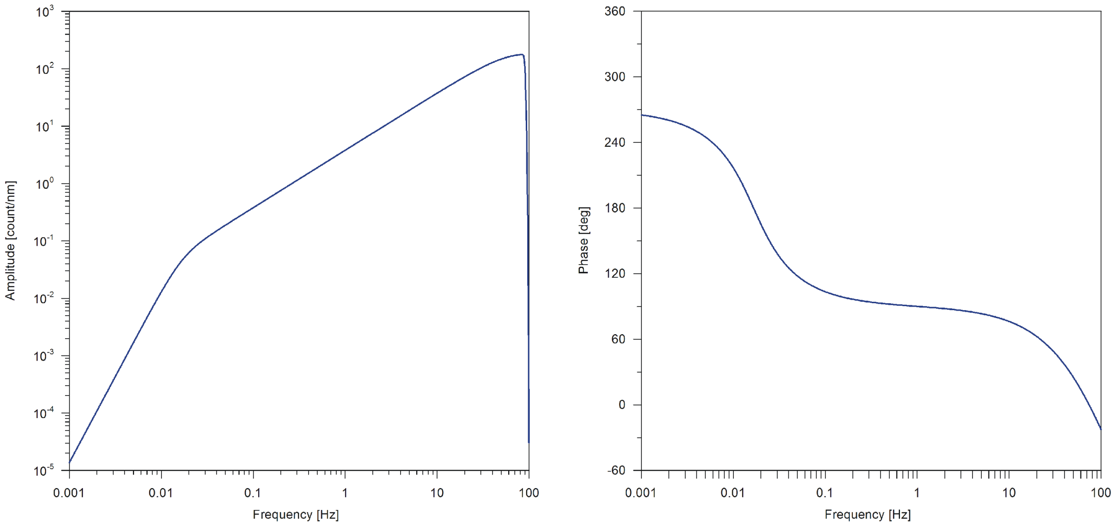

Fig. 6.5.8. Displacement amplitude (left) and phase (right) response for the vertical channel of the AKN broadband, three-component station. The response is plotted only up to the Nyquist frequency.

6.5.5 Hornsund (HSPB) station configurations

A new broadband, three-component seismic station (HSPBB) was installed close to the Polish Polar Station Hornsund, in September 2007, within the frame of the IPY project “The Dynamic Continental Margin Between the Mid-Atlantic-Ridge System (Mohns Ridge, Knipovich Ridge) and the Bear Island Region”, in a collaborative effort between the Institute of Geophysics of the Polish Academy of Sciences (IGF-PAS) and NORSAR (Schweitzer and The IPY Project Consortium Members, 2008). The original instrumentation of the station involved an STS-2 seismometer by Streckeisen and a Güralp Systems DM24 digitizer. The station outputted three different data streams, with sampling rates of 100, 10 and 1 sps.

A detailed description about the way to obtain response information for an STS-2 sensor has already been provided in our reports about the Jan Mayen station (Pirli, 2010; Pirli and Schweitzer, 2009). In the case of the HSPBB station, which is equipped with sensor # 60702, the sensitivity and pole and zero values are provided below.

Generator constant values for X, Y and Z: 1500 ± 15 V/m/s. The generator constant values and orientations of the three different sensors are:

- Sensor U: G/G0 = 1.0486 theta = 54.544° phi = 179.79°
- Sensor V: G/G0 = 1.0525 theta = 54.458° phi = 59.844°
- Sensor W: G/G0 = 1.0516 theta = 53.311° phi = 299.73°

where G/G0 is the normalized generator constant, which is equal to the actual constant divided by 1500 V/m/s. The poles and zeros (Hz) for the vertical component are the following:

Poles (11):	Zeros (4):
-4.55×10^2	$-461.8 \pm j\, 429.1$
$-1.024 \times 10^4 \pm j\, 2.725 \times 10^3$	-191.1
-424.5	-15.15
$-99.7 \pm j\, 391.5$	
$-9.513 \times 10^3 \pm j\, 1.147 \times 10^4$	
-15.46	
$-0.037 \pm j\, 0.037$	

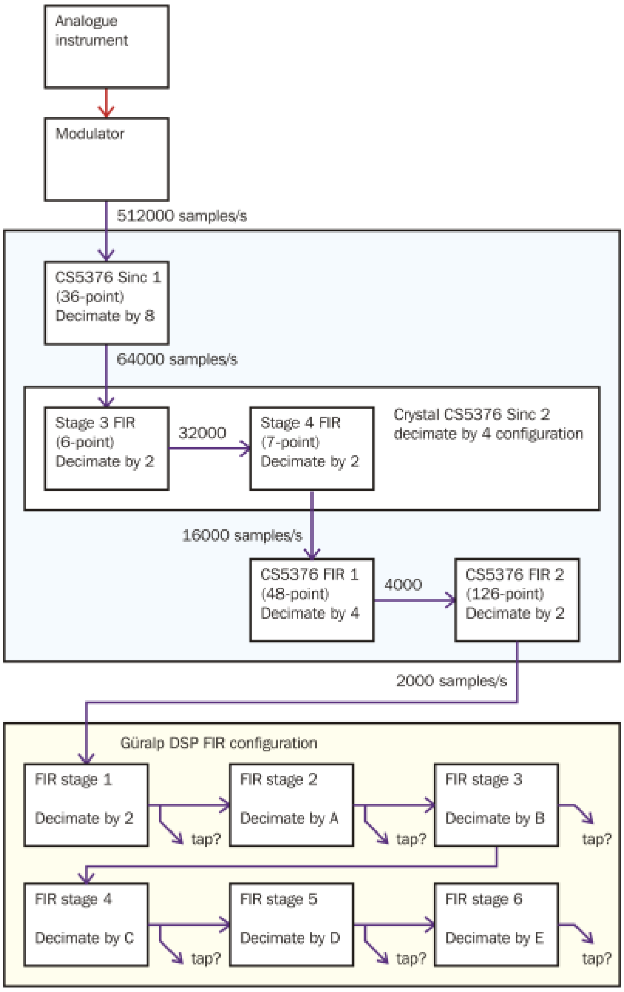

Fig. 6.5.9. The digital filter cascade employed by the Güralp DM24 mk3 digitizer to decimate from the 512 kHz input clock of the CS5375 chipset to the desired data sampling rate(s) (from Güralp Systems, 2009b). In the case of HSPBB a decimation of 5 from the sampling rate of 2 kHz (FIR stage 1) occurs, omitting the decimation by 2 stage shown in the figure.

The DM24 digitizer, with serial number # B794 (mk3), has the following sensitivity for the velocity channels:

- Z: 3.203 μV/count
- N-S: 3.200 μV/count
- E-W: 3.197 μV/count

To achieve the three different sampling rates mentioned earlier, the digitizer employs a particular cascade of FIR filters that has different taps. The standard and variable parts of the cascade for an mk3 system are shown in Fig. 6.5.9 (Güralp Systems, 2009b).

The TTL (tap table lookup) value contained in the GCF data header provides the needed information for the actual cascade used to output the desired sampling rate(s). This corresponds to FIR stages 1 to 6 in Fig. 6.5.9. Initially, only the 100 and 10 sps channels were outputted at Hornsund, and a TTL value of 76 was used. From 23rd September 2007, the 1 sps tap was also installed, with a TTL value of 77. TTL 77 and 76 differ only in the two last FIR stages, which were not used initially, so cascade 77 can be used for both configurations, and it is the following (Cirrus Logic, 2001; Güralp Systems, 2006):

- FIR filter CS5376 Stage 1, Sinc 1, decimating by 8 from the 512 kHz input clock, asymmetric, 18 coefficients
- FIR filter CS5376 Stage 3, Sinc 2, decimating by 8, asymmetric, 3 coefficients
- FIR filter CS5376 Stage 4, Sinc 2, decimating by 2, asymmetric, 7 coefficients
- FIR filter CS5376 Stage 5, FIR1, decimating by 4, asymmetric, 24 coefficients
- FIR filter CS5376 Stage 5, FIR2, decimating by 2, asymmetric, 63 coefficients
- FIR filter DM24 Stage 1, SWA-D24-3D08, decimating by 5 from 2 kHz, symmetric, 501 coefficients
- FIR filter DM24 Stage 2, SWA-D24-3D07, decimating by 4, symmetric, 501 coefficients, tap for 100 sps
- FIR filter DM24 Stage 3, SWA-D24-3D08, decimating by 5, symmetric, 501 coefficients
- FIR filter DM24 Stage 4, SWA-D24-3D06, decimating by 2, symmetric, 501 coefficients, tap for 10 sps
- FIR filter DM24 Stage 5, SWA-D24-3D08, decimating by 5, symmetric, 501 coefficients
- FIR filter DM24 Stage 6, SWA-D24-3D06, decimating by 2, symmetric, 501 coefficients, tap for 1 sps

In August 2009, the digitizer was changed to an MK-6 A/D converter, designed and manufactured at IGF-PAS. The station name was changed to HSPB, and officially reported to the station registry of the ISC and NEIC. In the current configuration, only the 100 sps data streams are outputted. The MK-6 data acquisition unit (Wiszniowski, 2002) employs a PAC56 digitizer with Motorola DSP56 Sigma-Delta signal processors for filtration. The A/D converter applies oversampling to 12.8 kHz to achieve a resolution of 26 bit. Prior to sampling, the signal is low-pass filtered to avoid aliasing, with the analog filter described by Equation (6.5.3):

$$T_f(s) = \frac{K_f}{\prod_{j=1}^{3}(s-p_j)} , \qquad (6.5.3)$$

where p_1, p_2 and p_3 are the poles and $K_f = |p_1.p_2.p_3|$. According to the response information provided by IGF-PAS, the sensitivity of the digitizer is equal to 298.02 nV/count and it employs the following filter cascade:

- Analog anti-alias filter (pac12anf)
- FIR filter (b2d6n), decimating by 2 from 12.8 kHz, symmetric, 20 coefficients
- FIR filter (b4d6n), decimating by 4, symmetric, 20 coefficients
- FIR filter (b2d8n), decimating by 2, symmetric, 10 coefficients
- FIR filter (b2d12nn), decimating by 2, symmetric, 12 coefficients
- FIR filter (pac56lin), decimating by 4, symmetric, 512 coefficients

The different configurations and corresponding Respids for the HSPBB and HSPB station are listed in Table 6.5.4.

Table 6.5.4. The different instrument configurations of the Hornsund station

Time	Installation Name	Components	Calib [nm/count]	Calper [s]
2007-2009	Initial 100 sps HSPBB (HSPHH1, HSPHH2, HSPHH3)	STS-2 CMG-DM24 digitizer LP FIR cascade, digital	0.322570*	1.00
2009-…	Current 100 sps HSPB (HSPHH4, HSPHH5, HSPHH6)	STS-2 MK-6 digitizer LP anti-alias, analog LP FIR cascade, digital	0.030014*	1.00
2007-2009	HSPBB 10 sps (HSPBB1, HSPBB2, HSPBB3)	STS-2 CMG-DM24 digitizer LP FIR cascade, digital	0.322570*	1.00
2007-2009	HSPBB 1 sps (HSPLP1, HSPLP2, HSPLP3)	STS-2 CMG-DM24 digitizer LP FIR cascade, digital	0.322570*	1.00

* Indicative value

The displacement amplitude and phase response for the configurations of the Hornsund station described in the previous paragraphs is depicted in Fig. 6.5.10. Only the vertical component case is presented, while shaded areas cover the range beyond the Nyquist frequency (50 Hz, 5 Hz and 0.5 Hz for the three different taps).

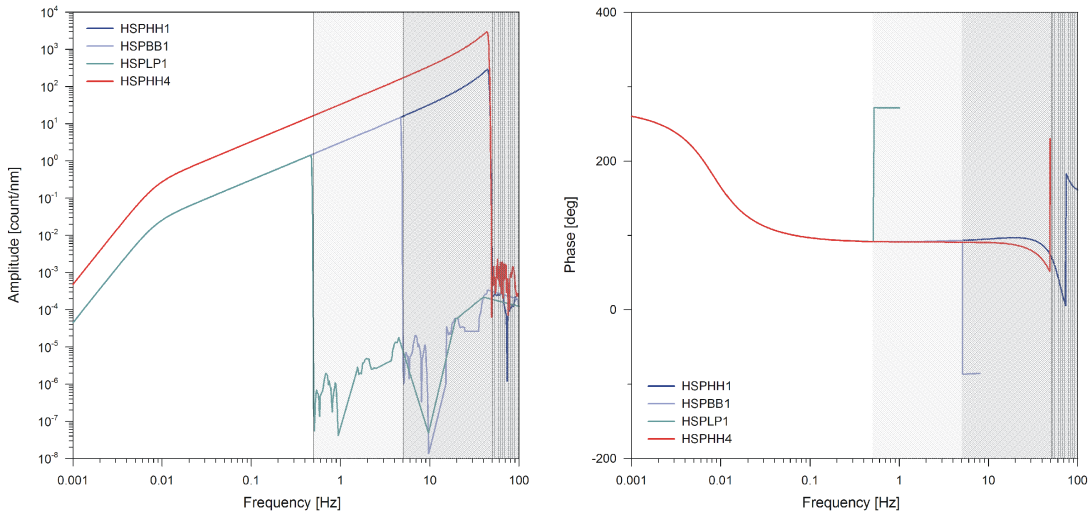

Fig. 6.5.10. Displacement amplitude and phase response curves for the different configurations of the Hornsund broadband station listed in Table 6.5.4. Shaded areas represent the range beyond the Nyquist frequency (50 Hz for the 100 sps channels, 5 Hz for the 10 sps and 0.5 Hz for the 1 sps channels).

6.5.6 Erratum: ARCES response

The response of the ARCES array was presented in Pirli and Schweitzer (2008b). The highly damped version of the new ARCES short-period channel configuration was omitted in that report. For approximately one month in 1999 (14 September – 7 October), the GS-13 seismometers operated with a damping of 1.5 instead of the typical value of 0.75 that was adopted afterwards. Thus, the highly damped version is assigned Respids ARCESSP4,5,6, while the current version is assigned Respids ARCESSP7,8,9.

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