

A technical review of modern strong motion accelerographs

J.G. Diehl

Kinematics, Inc., Pasadena, Calif., USA

W.D. Iwan

California Institute of Technology, Pasadena, Calif., USA

ABSTRACT: Twenty-five strong motion accelerographs from eight instrument companies are reviewed and the results presented in tabular form.

1 INTRODUCTION

There continues to be a need to record strong-motion earthquake data for regional seismicity research, ground motion studies, and structural response analysis. The International Strong-Motion Array Council (ISMAC) was created by the IAEE to facilitate the deployment and operation of strong-motion instrument arrays worldwide. As part of this charter, ISMAC has undertaken the task of reviewing all known strong-motion earthquake instruments available today, and categorizing their general suitability for applications defined in various workshops (Iwan, Spudich), namely:

- autonomous stations
- regional networks
- structural arrays
- fixed surface arrays
- dense three-dimensional arrays
- mobile arrays

The objective of this paper is to present the results of this review in a form that will facilitate its use by the earthquake engineering community.

2 METHOD

Eighteen seismic instrument manufacturers were provided the opportunity to supply information on the features and capabilities of their strong motion accelerographs. A tabular form was provided with standard definitions for each feature, such as dynamic range, to facilitate comparison. Each feature was corroborated by published data, a catalogue sheet, or a written manual. Manufacturers were allowed to categorize their own instruments according to the guidelines. In addition, each had the opportunity to indicate any special features of their instruments.

In order to qualify for comparison, an accelerograph had to meet the minimum standards for a stand-alone, autonomous station. This meant that a manufacturer combining a recorder with an external sensor package must be willing to sell both units as a system, including all necessary software and cabling. Finally, manufacturers were asked to not provide any information about instruments they did not intend to manufacture for at least the next two years.

3 RESULTS

All data submitted by the manufacturers for accelerographs which meet minimum requirements (see definitions) are presented in the accompanying Table 1.

For the first time, information is presented for comparison regarding services available from manufacturers, including available software, warranty terms, repair facilities, and data processing.

All told, eight manufacturers responded with a total of twenty-five qualified instruments or systems.

4 CONCLUSIONS

The information provided in this paper should be useful to those responsible for the design and operation of strong-motion arrays worldwide.

REFERENCES AND RELATED BIBLIOGRAPHY

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Spudich, P., and Boore, D.M. et al, *National Plan to Record Earthquake Motions on the Ground and in Man-Made Structures*, DRAFT USGS Open File Report, Aug 1985

REVIEW OF STRONG MOTION ACCELEROGRAPHS

MANUFACTURER'S DATA

Address, Tel, and FAX	Warranty Period	Repair Turnarou	Training Availab	Data Processing	Special Notes (see Table)
Kinometrics, Inc. 222 Vista Avenue Pasadena, CA 91107 USA TEL: (818) 795-2220 FAX: (818) 795-0868	365	10 days	YES	YES	* With 300 dpi scanner, SMA-1 equivalent digital performance is: sample rate = 160 sps dynamic range = 55dB resolution = .0035g bandwidth = 1 to 50 Hz
Kinometrics SA Z.I. Le Tresis 3 1028 Preverenges Switzerland TEL: 41-21-8032829 FAX: 41-21-8032895					
Mark Rand Co., LTD 6-1-5 Nogata, Nakano Tokyo 165 Japan Tel. 03-3339-3130 Fax 03-3339-6995	365	10	y	y	*1 mem remaining, ampl gain, trigger level *2 user specify *3 @ 100sps 0-30sec. 1s incr *4 Software used on P/C computer. Serial port is standard at DACS-omega
OFICINA TECNICA DE ESTUDIOS Y CONTROL DE OBRAS (OFITECO) Cardenal Belluga, 21 28028 Madrid Tel 34 1 256 50 06 Fax 34 1 256 97 82	365	10	y	y	
REFRACTION TECHNOLOGIES, INC. 2626 Lombardy Ln. Ste. 105 Dallas, TX 75220 Tel 214-353-0609 Fax 214-353-9659	365	7	y	n	*1 150HZ (2G), 125 (1G) 100 (0.5G), 75 (0.25G) *2 field parameters setup for PC *3 2x10 ⁻⁷ high gain
SYSCOM AG Pfingstweidstr.31A 8037 Zurich Switzerland Tel 41 1 272 3812 Fax 41 1 272 0189	365 parts & labor	10	y	y	*1 0: data transfer/ parameter setup
Teledyne Geotech 3401 Shiloh Road Garland, Texas 75041 PH: (214) 271-2561 FAX: (214) 271-0223	365	14	YES	YES	*Sinewave **Low Battery
Terra Technology Corp 3854 148th Ave N.E. Redmond, WA 98052 USA Tel: (206) 883-7300 Fax: (206) 882-1412 Contact: Greg Hoyle	365	5-10	yes	no yes for DCA	Note1: Bandwidth Selectable in 10 Hz Steps Note2: Digital Filter at 48 dB per octave below 70 Hz Note3: 1000 SPS per channel is digitally filtered/decimated to 250,200,100sps
TOKYO SOKUSHIN CO, LTD 2-22-9 Nishi-Nippori Arakawa-ku Tokyo 116 Japan Tel 03-3806-5911 Fax 03-3806-1340	365	7 14 for SPC	y	y	1 calibration coil 2 Telemetry Interface *Editorial ability; strong 16 data are selected and saved automatically (NOTE: Strong 8 for CV-601)

REVIEW OF STRONG MOTION ACCELEROGRAPHS

DESIGN FEATURE	KINEMATRICS SSA-2	KINEMATRICS SSA-16	KINEMATRICS SSA-3	KINEMATRICS SSR-1 with FBA-23	KINEMATRICS SMA-1	MARK RAND CO. DACS-omega SM16 Sumer
Price	\$3,850	\$7,250	\$19,265	\$12,500	\$3,920	US \$30,000
Suitable Applications	A,N,S	A,N,S,D,3D	A,S	A,D,3D,M	A,N	A,N,D,M,S
No. of Channels std	3	3	6	3	3	3
Optional Sample rate (sps)	200	200	243 200	6 200	*	100,200
Dynamic Range (dB)	66dB	90dB	66	90	45	96 + 18dB (gain range)
Sensor Type	VC, EMF	VC, EMF	VC, EMF	VC, EMF	O	S
Internal/External	1	1	1	1	1	E
Optional	E	E	E	E	E	
Natural Frequency (Hz)	50 Hz	50	50	50	25	
Sensitivity (g)	2	2	2	2	1	2
Optional	1, .5, .25, .1	1, .5, .25, .1	1, .5, .25, .1	1, .5, .25, .1	.5	5, 10
Damping (%critical)	.70	.70	.70	.70	.65	
Resolution	12 bits	12 bits	12 bits	16 bits	0.005	<10-4 g
Bandwidth	DC to 50 Hz	DC to 25	0.08 to 25.50HZ			
Low-pass filter character	2-pole, 50 Hz Butterworth,	2-pole, 50 Hz Butterworth,	2-pole, 50 Hz Butterworth,	2-pole, 50 Hz Butterworth,	-48 Butterworth,	-72
Preamp (dB)					0-60,20	0 to 18dB, 6dB steps
Noise (g)	LSB 0.00098	LSB 0.000061	LSB 0.00098	LSB 0.000061	<0.005	<30 uV
Int.System F.Test	SU	SU	SU	SU	SU	SU
Sensor Interface	SE,100k,+/-12,3	SE,100k,+/-12,3	SE,100k,+/-12,3	D,100k,+/-12,3or6	P,E,T	100K,+/-15 VDC
External Indicators	P,E	P,E	P,E	P,E,T	P,E	P,E,T,H *1)
Interconnect	M,S,C,T,D	M,S,C,T,D	M,S,C,T,D	M,S,C,T,D	M,S,C,T	
Trigger Modes character	threshold	threshold	threshold	threshold, STA/LTA	Threshold	thrsh,ext,STA/LTA rat.
bandwidth range	.1 to 12 Hz .002-.2/.002	1 to 10 Hz 0.005 to 0.025	0.1 TO 5 Hz *2) 1 LSB step 19uV-5v			
Pre-event memory (sec) 3 ch, 200 sps	0,1,25,2.5,5,10,15	0,1,25,2.5,5,10,15	0,1,25,2.5,5,10,15	0,1,25,2.5,5,10,15	0	0-3000 samp, sel. *3
Post-event hold (sec)	10,15,30,60,90	10,15,30,60,90	10,15,30,60,90	10,15,30,60,90	7 to 20 min	1-999, 1 sec incr
Recording medium std	CSRAM	CSRAM	CSRAM	CSRAM	film RAR2494,70mm	memory card
OPTIONAL				Hard Disk		
Mem.Backup Battery (type)	Lithium	Lithium	Lithium	Lithium		dry battery (intrnl)
Recording capacity (min)	9 DC2	18 DC2	25 DC2	14	25min, full	15
OPTIONAL	72,9	108,18	430,18	84,14 RAM, 2800 HD		45,15
Playback hardware Comm Software	IBM Compatible PC QuickTalk(TM)	IBM Compatible PC QuickTalk(TM)	IBM Compatible PC QuickTalk(TM)	IBM Compatible PC QuickTalk(TM)	Dark Room	Display,printer,atthcd
OPTIONAL	any XMODEM	any XMODEM	any XMODEM	any XMODEM		Analog playback
Retrieval Method	T	T	T	T	M	M, T (9600 bps)
OPTIONAL				H		data transmission
Transfer Rate	38400	115200	38400	115200		software (modem dir.) *4
Timing						
Clock stability standard (accuracy, temperature range)	1x10E-4,-20to65C	1x10E-4,-20to65C	1x10E-4,-20to65C	+/-2x10-7,-20-70C aging 5x10-7	+/-2x10-3,-20to55C	5x10-8
OPTIONAL	3x10E-7, 0 to +50C	+/-2x10-7,-20to70C aging 5x10-7	3x10E-7, 0 to +50C		3x10E-7, 0 to +50C	
Synchronization optional	M,A,R	M,A,R	M,A,R	M,A,AS,AR	AS	A
Receivers	M,A,AS G,W,M,D	M,A,AS,AR G,W,M,D	M,A,AS G,W,M,D	G,W,M,D	W,M,D	W,M, J
Power						
Power supply std (#batts,volts,cap)	1,12VDC,6.5Ah	2,12VDC,6.5Ah	2,12VDC,6.5Ah	2,12VDC,6.5Ah	2,2.5Ah,6V	100V AC
external Current Drain (milliamps)	+12 VDC approx 75 ma	+12 VDC approx 140 ma	+12 VDC approx 75 ma	+12 VDC approx 140 ma	+12 VDC 0.15mA	18.4 w
Capacity (days)	4 days	4 days	4 days	4 days	>90	
Physical Size (LxWxH in cm)	27x10x38	40x41x20	19" rack mount depends # ch	23x41x43 + 13x13x6.6	20x35.5x20	30x36.5x27
Weight (Kg)	12	18	sealed aluminum	17 + 2.3	11	9.5
Housing	sealed aluminum	sealed aluminum	sealed aluminum	sealed aluminum	sealed aluminum	glass fiber case
Operating Temp (C)	-20C to +65C	-20C to +65C	-20C to +65C	-20C to +65C	-20C to +55C	-5,-+50
Humidity	100%	100%	100%	100%	100%	95% noncondensing
Data Reduction Software Available	D,P	D,P	D,P	D,P	D,P	D,P, DSP
OPTIONAL	DSP,VOL,I	DSP,VOL,I	DSP,VOL,I	DSP,VOL,I	DSP,VOL	

REVIEW OF STRONG MOTION ACCELEROGRAPHS

DESIGN FEATURE	MARK RAND CO. DACS-omega ME-16	OFITECO ACD-3E	REFRACTION TECH 72A-06/C (Columbia Accel)	REFRACTION TECH 72A-06/G (Guralp Accel)	REFRACTION TECH 72A-06/GDH (Guralp DH Accel)
Price	US \$41,200	US \$9,000	\$11,215	\$12,625	\$18,200
Suitable Applications	A,N,D,M,S	A,N,S	M,D,3D,S,N,A	M,D,3D,S,N,A	3D
No. of Channels std	3	3	3/6	3 (with dual gain)	3 (with dual gain)
Optional				6 (w/o dual gain)	6 (w/o dual gain)
Sample rate (sps)	100,200,500,1000	100,200	500,250,200,125,100	500,250,200,125,100	500,250,200,125,100
Dynamic Range (dB)	96 + 80dB (gain range)	66	50 sps 90 dB	50 sps 90dB(140dB dualgain)	50 sps 90dB(140dB dualgain)
Sensor Type	S	S	S	S	S
Internal/External	E	E	E	E	E
Optional					
Natural Frequency (Hz)		N/A	150	50-100 Hz	50-100 Hz
Sensitivity (g)	2	2g	2	2g	2g
Optional	0.5, 1.5	0.5, 0.25, 1, 5 g	1,0.5,0.25 SEE NOTE 1	1, 0.5, 0.1	1, 0.5, 0.1
Damping (%critical)		0.07	0.8	0.7	0.8
Resolution	<10-6 g	0.001 g	7x10-5G	7x10-5G SEE NOTE 3	7x10-5G SEE NOTE 3
Bandwidth	0.08-25.50,125-250HZ	Dc-30 Hz	DC to 40% of S.R.	DC to 40% of S.R.	DC to 40% of S.R.
Low-pass filter character	-72	Butterworth	-90dB FIR (digital filt)	-90dB FIR (digital filt)	-90dB FIR (digital filt)
Preamp (dB)	0 to 80dB, 10 dB steps	n/a	0dB	0dB and 54dB	0dB and 54dB
Noise (g)	<0.2 uV	0.001			
Int.System F.Test	SU	P	0 (step)	0 (step)	0 (step)
Sensor Interface	100K, +/-15 VDC	SE, +12V, 3	D, 2 Meg, +12V, 3/6	D, 2 Meg, +12V, 3/6	D, 2 Meg, +12V, 3/6
External Indicators	P,E,T,H *1	P,E,T,H, Low Batt			
Interconnect		M,S,C,T	M,S,C,T,D	M,S,C,T,D	M,S,C,T,D
Trigger Modes		LEVEL, STA/LTA	LEVEL, STA/LTA	LEVEL, STA/LTA	LEVEL, STA/LTA
character	thrsh,ext,STA/LTA rat.	External, Time	External, Time	External, Time	External, Time
bandwidth	0.1 TO 20 Hz *2	same as instrument	same as instrument	same as instrument	same as instrument
range	1 LSB step 19uV-5v	Level 1-37,768 cnts (2G to 7x10-5G)	Level 1-37,768 cnts (2G to 7x10-5G)	Level 1-37,768 cnts (2G to 7x10-5G)	Level 1-37,768 cnts (2G to 7x10-5G)
Pre-event memory (sec)		1 to 256 s	0-150s,0.001s incr	0-150s,0.001s incr	0-150s,0.001s incr
3 ch, 200 sps	0-3000 samp, sel. *3		0-99.999s;0.001s incr	0-99.999s;0.001s incr	0-99.999s;0.001s incr
Post-event hold (sec)	1-999, 1 sec incr	1 to 512 s.			
Recording medium		CSRAM	HARD DISK,234 MBYTES FORMATTED	HARD DISK,234 MBYTES FORMATTED	HARD DISK,234 MBYTES FORMATTED
std	memory card				
OPTIONAL					
Mem.Backup Battery/ (typ)	dry battery (intrnl)	Lithium	N/A	N/A	N/A
Recording capacity (min)	15	7 m.	1500 min (25hrs) dual gain	1500 min (25hrs) dual gain	1500 min (25hrs) dual gain
OPTIONAL	45,15		3000 min (50hrs) w/o dual gain	3000 min (50hrs) w/o dual gain	3000 min (50hrs) w/o dual gain
Playback hardware	Display,prnter,atchd	Rampack reader	PC, SUN WORKSTATION	PC, SUN WORKSTATION	PC, SUN WORKSTATION
Comm Software	Analog playback	Accl	PASCAL S/W, FSC *2	PASCAL S/W, FSC *2	PASCAL S/W, FSC *2
OPTIONAL	M, T (9600 bps)	M	Pitsa, DaDisp, Matlab	Pitsa, DaDisp, Matlab	Pitsa, DaDisp, Matlab
Retrieval Method	M, T (9600 bps)		T(SCSI) TO TAPE,DISK	PC OR SUN	* SEE PRIOR
OPTIONAL	data transmission		T (X/MADOM) TO PC	T (X/MADOM) TO PC	T (X/MADOM) TO PC
Transfer Rate	software (modem dir.) *4		58 Kbytes/sec (SCSI)	58 Kbytes/sec (SCSI)	58 Kbytes/sec (SCSI)
Timing					
Clock stability					
standard (accuracy, temperature range)	5x10-8	+- 2x10e-3;0-50C	5X10e-7 (0-50 C)	5X10e-7 (0-50 C)	5X10e-7 (0-50 C)
OPTIONAL		+- 5x10e-6;0-50C	3X10e-7 (0-50 C)	3X10e-7 (0-50 C)	3X10e-7 (0-50 C)
Synchronization	A	AS	A, AS	A, AS	A, AS
optional					
Receivers	W,M, J	W;M;D;MSF	G,M(or any true time receiver with serial output)	G,M(or any true time receiver with serial output)	G,M(or any true time receiver with serial output)
Power					
Power supply					
std (#batts,volts,cap)	100V AC	1.6.8A/h,+12 Vdc	72A-04 aux. pwr sply (EXT), two powerasonic ps-1265, 6.5 AH each	72A-04 aux. pwr sply (EXT), two powerasonic ps-1265, 6.5 AH each	72A-04 aux. pwr sply (EXT), two powerasonic ps-1265, 6.5 AH each
external					
Current Drain (milliamps)	18.4 w	+12 Vdc 150 mA max.	+12Vdc 250ma	+12Vdc 250ma	+12Vdc 250ma
Capacity (days)		2 days	2.0 days	2.0 days	2.0 days
Physical					
Size (LxWxH in cm)	30x36.5x27	36x22x31	32x21x19+32x21x12+senso	32x21x19+32x21x12+senso	32x21x19+32x21x12+senso
Weight (Kg)	9.5	12	11 kg + sensor	11 kg + sensor	11 kg + sensor
Housing	glass fiber case	Aluminum	polyethelene, sealed	polyethelene, sealed	polyethelene, sealed
Operating Temp (C)	-5...+50	-5 to 65 C	-20 to + 60 C	-20 to + 60 C	-20 to + 60 C
Humidity	95% noncondensing	100%	sealed (air 2.5 psi)	sealed (air 2.5 psi)	sealed (air 2.5 psi)
Data Reduction					
Software Available		D, P	D	D	D
OPTIONAL	D,P, DSP		DSP,P,VOL,I,PITSA	DSP,P,VOL,I,PITSA	DSP,P,VOL,I,PITSA

REVIEW OF STRONG MOTION ACCELEROGRAPHS

DESIGN FEATURE	SYSCOM MR 2002	TELEDYNE A-800	TELEDYNE A-900	TERRATECH IDS-3602S	TERRATECH IDS-3602SX	TERRATECH IDS-3602F
Price	\$fr 6,427.00	\$6,960.00	\$9,865	\$9,975	\$7,875.00	\$9,775.00
Suitable Applications	A,N,S	A,N	A,N	A,N,D	A,N,D,3D	M
No. of Channels std	3	3	3	3	3	3
Optional Sample rate (sps)	200 SPS	200	200	1000 NOTE 3	1000 NOTE 3	1000 NOTE 3
Dynamic Range (dB)	72 VC	66 PE, S	90 PE, S	126 NOTE 4 S	126 NOTE 4 S,O Accepts Sensor E	126 NOTE 4 S,O Accepts Sensor E
Sensor Type	E	I	I	Internal	E	E
Internal/External Optional	I	E	E			
Natural Frequency (Hz)	850 Hz	1250 Hz	200 Hz	70Hz	70Hz	70Hz
Sensitivity (g)	2g	+/-2	+/-2	2	2	2
Optional	1,0,5,0.25			1, .5, .25, .1	1, .5, .25, .1	1, .5, .25, .1
Damping (%critical)	0.7	95%	70%	70%	70%	70%
Resolution	1mg	12 bits	16 bits	.95 X 10-6	.95 X 10-6	.95 X 10-6
Bandwidth	DC-50 Hz	0.1 to 50 HZ	DC to 50 HZ	70 Note 1	70 Note 1	70 Note 1
Low-pass filter character	BUTTERWORTH	Butterworth	Butterworth	90 Note 2	90 Note 2	90 Note 2
Preamplifier (dB)	0dB	0.6, 12, 18	0.6, 12, 18	butterworth	Butterworth	Butterworth
Noise (g)	<0.0001	0.0005	0.00044	12,24,36	12,24,36	12,24,36
Int.System F.Test	SU	SU, P, O*	SU, P, O*	.47X 10-6	.47 X 10-6	.47 X 10-6
Sensor Interface		D, >1M, +15.3	D, >1M, +15.3	P	P	P
External Indicators	P,E,H 0:run/mem used	P,E,T, O**	P,E,T, O**	E.T.H	SE,>35K, +/-12.3	SE,>35K, +/-12.3
Interconnect	M,S,C,T,D NOTE 1	M,S,C,T	M,S,C,T	E,T,H	E,T,H	E,T,H
Trigger Modes character	filtered threshold	Threshold, external	Threshold, external	Threshold,STA/LTA	Threshold,STA/LTA	Threshold,STA/LTA
bandwidth	0.5-15Hz	0.1-12	0.1-12	.1-12	.1-12	.1-10
range	0.1-5% full scale	0.002-1.998/O.OO2	0.002-1.998/O.OO2	O.OO2-1.998/O.OO2	O.OO2-1.998/O.OO2	O.OO2-1.998/O.OO2
Pre-event memory (sec)						
3 ch, 200 sps	1-17 sec 1 sec incr	1-40/1	1-40/1	1-99/1	1-99/1	1-99/1
Post-event hold (sec)	1-30 sec 1 sec incr	1-10000/1	1-10000/1	1-99/1	1-99/1	1-99/1
Recording medium std	CS RAM	CSRAM	CSRAM	CRSRAM	CSRAM	CSRAM
OPTIONAL						
Mem.Backup Battery (typ)	MEMORY CARD (JEI)	None	None			
Recording capacity (min)	LITHIUM 15 DC 2.5	Lithium 15.0	Lithium 28.0	Lithium 22 DC 2.5	Lithium 22 DC 2.5	Lithium 22 DC 2.5
OPTIONAL						
Playback hardware	240 IN 4	120,15	112,14	132/22	132/22	132/22
Comm Software	PC, OR MODEM + PC LINK, PREVIEW	IBM Compatible PC	IBM Compatible PC	IBM PC Compatible Terra SDRA	IBM PC Compatible Terra SDRA	IBM PC COMPATIB Terra SDRA
OPTIONAL						
Retrieval Method	VIEW 2002	None	None			
OPTIONAL		ASET, Crosstalk	ASET, Crosstalk			
Transfer Rate	T	T	T	T	T	T
Timing						
Clock stability	M					
standard (accuracy, temperature range)	+/- 2X10-5 FROM -20..65 C	+1 x 10-4 from -20to 70 deg. C	+1 x 10-4 from -20to 70 deg. C	+/-1X10-6, 0to50C 1X10-6 AGING	+/-1X10-6, 0to50C 1X10-6 AGING	+/-1X10-6, 0to50C 1X10-6 AGING
OPTIONAL						
Synchronization optional	+/- 1x10-7, -15to75C 5x10-7 aging	+5 X 10-7 from -20 to 75 deg. C	+5 X 10-7 from -20 to 75 deg. C	+/-3X10-7, -20to70C 1X10-6 AGING	+/-3X10-7, -20to70C 1X10-6 AGING	+/-3X10-7, -20to70C 1X10-6 AGING
Receivers	M, AS, A	M, AR	M, AR	M,A, AS	M,A, AS	M,A, AS
Power	D,M,W	M, A, AR	M, A, AR	W,M,O- Any IRIGE	W,M,O- Any IRIGE	W,M,O- Any IRIGE
Power supply std (#batts,volts,cap)	ONE 12vdc 6.5 Ah	2, +12 Vdc, 5AH	1, +12 Vdc, 17AH	1, +12V, 24 Ah	1, +12V, 24 Ah	3,+/-12&6, 18 Ah tot.
external						
Current Drain (milliamps)	12vdc 125 mA	11-14 Vdc 265 at 12 Vdc	11-14 Vdc 225 at 12 Vdc	125 MA	125 mA	100 mA
Capacity (days)	2.4 days	1.5 days	3.0 days	4.0	4.0	3.5
Physical						
Size (LxWxH in cm)	20x23x11	33x27.9x22.8	33x27.9x22.8	35.6X30.5X20.3	35.6X30.5X20.3	38 X 25 X 18
Weight (Kg)	6.9 kg	20.5	24	21.4	20.2	8.6
Housing	sealed cast aluminum	Base cover of cast aluminum-crushproof	Base cover of cast aluminum-crushproof	Std, Steel IP65	Std, Steel IP65	Formed ABS Plastic
Operating Temp (C)	-20 to 65	-20 to +65 deg. C	-20 to +65 deg. C	OPT.Stainless IP67	OPT.Stainless IP67	W/Remov Battery Pac
Humidity	100%	0-100% non-condensin	0-100% non-condensin	-25 to + 70 C	-25 to + 70 C	-25 to + 70 C
Data Reduction Software Available						
OPTIONAL	D,P,DSP	None D,P	None D,P	D,P, DSP, VOL I	D,P, DSP, VOL I	D,P, DSP, VOL I

REVIEW OF STRONG MOTION ACCELEROGRAPHS

DESIGN FEATURE	TERRATECH IDS-3602D	TERRATECH DCA 333R	TERRATECH DCA 300R	TOKYO SOKUSHIN CV - 601	TOKYO SOKUSHIN CV - 701	TOKYO SOKUSHIN CV - 901
Price	\$11,900.00	\$6,750.00	\$18,900.00	Y 1,400,000.	Y 1,500,000.	Y 2,200,000.
Suitable Applications	S	A,N	S	N, S	N, S	N, S
No. of Channels std	3	3	6	3	3	3
Optional			12/3			8
Sample rate (sps)	1000 NOTE 3	100	100 or 200	100	100	50,100,200
Dynamic Range (dB)	126 NOTE 4	66	66	96	96	96
Sensor Type	S.O Accepts Sensor	S	S	S	S	S
Internal/External	E	I	E	I	I	I
Optional		E		E	E	E
Natural Frequency (Hz)	70Hz	30	30,50	100	100	100
Sensitivity (g)	2	1	1	1.02	1.02	1.02
Optional	1, .5, .25, .1	2, .5, .25	2, .5, .25	0.5, 2	0.5, 2	0.5, 2
Damping (%critical)	70%	70%	70%	64to70	64to70	64to70
Resolution	.95X10-6	.0005	.0005	3X10-5	3X10-5	3X10-5
Bandwidth	70 Note 1	30	30 or 50	DC-47	DC-47	DC-47
Low-pass filter character	90 Note 2 Butterworth	30 Butterworth	30 Butterworth	-12 BUTTERWORTH	-12 BUTTERWORTH	-12 BUTTERWORTH
Preamp (dB)	12,24,36			6	6	6
Noise (g)	.47 X10-6	2.4 x 10-4	2.4 x 10-4	3X10-5	3X10-5	3X10-5
Int.System F.Test	P	P	P	O NOTE 1	O NOTE 1	O NOTE 1
Sensor Interface	SE,>35K, +/-12.3	SE,>10K, +/-12.3	SE, >10K, +/-12.12	SE,100k,+/-15v,3	SE,100k,+/-15v,3	SE,100k,+/-15v,3
External Indicators	E,T,H	E,T,O Led Indicator	E,T,O Led Indicator	P,E,T,O	P,E,T,O	P,E,T,O
Interconnect	M,S,C,T,D	M,S,C,T,D	M,S,C,T,D	M,S,C,T	M,S,C,T	M,S,C,T
Trigger Modes character	Threshold,STA/LTA	Threshold	Threshold	filtered threshold	filtered threshold	filtered threshold
bandwidth	.1 - 10	.1-10	.1-10	0.07-7	0.07-7	0.07-7
range	O.OO2-1.998/O.OO2	.001-.1/.001	.001-.1/.001	0.0002-0.01	0.0002-0.01	0.0005-0.1275
Pre-event memory (sec)						
3 ch, 200 sps	1-99/1	4 @ 100 sps only	.64-3.2/.64	5 (100 sps)	5 (100 sps)	5 - 20
Post-event hold (sec)	1-99/1	15	15	54 sec/event	54 sec/event	0 - 30
Recording medium				IC CARD	IC CARD	IC CARD
std	CSRAM	CSRAM	CSRAM	MAXELL ML-128PC	MAXELL ML-256PC	MAXELL ML-1024P
OPTIONAL		Digital Cassette	Digital Cassette			
Mem.Backup Battery (typ)	Lithium	Dual Lithium	Dual Lithium	Mercury cell	Mercury cell	Mercury cell
Recording capacity (min)	22 DC 2.5	32 DC 1.5 @ 100 SPS	16 DC1.5	128 Kbyte x 2 7.2 (100 sps)	256 Kbytes x 2 14.4 (100 sps) *	1 Mbyte x 4 116 *
OPTIONAL	132/22	96/32	48/16			
Playback hardware	IBM COMPATIBLE	IBM PC Compatible	IBM PC Compatible	DAC-100	DAC-100	DAC-16X
Comm Software	Terra SDRA	Terra TRAP	Terra TRAP			
OPTIONAL						
Retrieval Method	T	T	T	M,O NOTE 2	M,O NOTE 2	M,O NOTE 2
OPTIONAL						
Transfer Rate	115,200	9600	9600			
Timing						
Clock stability				1x10-6, 0-40C	1x10-6, 0-40C	1X10-6, -10-50C
standard (accuracy, temperature range)	+/-1X10-6, 0to50C 1X10-6 AGING	5X10-6, 0 to 50C 5X10-6 Aging	5X10-6, 0 to 50C 5X10-6 Aging			
OPTIONAL	+/-3X10-7, -20to70C 1X10-6 AGING	5x10-7,-25to50C 5X10-7 Aging	5x10-7,-25to50C 5X10-7 Aging	1x10-7, -20-50C	1x10-7, -20-50C	1x10-7, -20-50C
Synchronization optional	M,A, AS	M,AR	M,AR	A	A	A
Receivers	W,M,O- Any IRIGE	W,M	W,M	O, NHK	O, NHK	O, NHK
Power						
Power supply		2,6V,8Ah		one, 12v	one, 12v	one, 12v
std (#batts,volts,cap)						
external	+12V		+/-12V			
Current Drain (milliamps)	125 mA	60	205	100vac, 12vdc 500mA DC	100vac, 12vdc 500mA DC	100vac, 12vdc 700mA DC
Capacity (days)	Supply Dependant	5		1 hours	1 hours	3 hours
Physical						
Size (LxWxH in cm)	45X48X30	30X30X15		24.7x35x31	24.7x35x31	34x42x27
Weight (Kg)	19	10		16	16	24
Housing	Rack Mount, Steel Panel (19")	Std, Steel, IP65 OPT Steel, IP 67	Std, Steel, IP65 OPT Steel, IP 67	cast aluminum case	cast aluminum case	cast aluminum case
Operating Temp (C)	-25 to + 70 C	-23 to +60C	-30 to 65 C	-10-50	-10-50	-10-50
Humidity	100% (Non Condens)	Std. Housing 85% OPT Housing 100%	100%	100%	100%	100%
Data Reduction						
Software Available	D,P, DSP, VOL	D,P DSP, VOL	D,P DSP, VOL	D, P DSP VOL	D, P DSP VOL	D, P DSP VOL
OPTIONAL	I					

REVIEW OF STRONG MOTION ACCELEROGRAPHS

DESIGN FEATURE	TOKYO SOKUSHI SAMTAC-15X	TOKYO SOKUSHIN SPC-35	DEFINITIONS
Price	Y 4,800,000.	Y 2,950,000.	Applications with preferred features: A - Autonomous Stations Minimum accelerograph with: a. triax. orthog accelerometer b. descrim. adjustable trigger c. timing system d. time history recorder e. UPS f. environmental housing
Suitable Applications	3D	M	External Indicators P - AC power applied E - event trigger T - time indicator H - state of health O - other, explain below
No. of Channels std	16	3	Accelerograph Interconnect M - master start S - slave start C - common start, any instrument T - common time shared by all D - common sampling O - other, explain
Optional Sample rate (sps)	50,100,200	6 OR 8 1-1000 (1,2,5 steps)	Retrieval Method M - remove and replace media (card, cassette) H - remove and replace hard disk T - transfer binary data A - transfer ASCII data O - other, explain
Dynamic Range (dB)	120	96	R - Regional Networks bandwidth .1 to 30 Hz pre-event memory trigger range 0.01 to 0.02g dynamic range 60dB high clock stability extended power capacity 2g sensors common time
Sensor Type	S	S	D - Dense Surface Arrays, Fixed bandwidth .1 to 50 Hz dynamic range 120dB common time 45 min storage capacity min preevent memory 2 sec smart trigger adjustable preamp
Internal/External Optional	I E	E	3D - Dense 3D Arrays as in "D" plus downhole sensor borehole package means of orientation means of recovery downhole cabling
Natural Frequency (Hz)	100	100	M - Mobile Arrays as in "D" plus very high recording capacity common time common start low size and weight ruggedness ease of field operation
Sensitivity (g)	1.02	1.02	S - Structural Arrays capability of remote sensors capability of more than 3 channels bandwidth min .1 to 30Hz common start, common time, common sampling
Optional	0.5, 2	2	Dynamic Range = $DR = 20\log_{10}(x_{max}/x_{min})$ where x_{max} is the maximum instantaneous value of the signal that can be transmitted by the system without distortion and x_{min} is the minimum detectable value of the signal generated by the transducer at the output display units are dB
Damping (%critical)	64to70	64to70	Time synchronization M - manual, by depressing key or switch A - completely automatic, simply feed a time code AS - so called "arm and synch" AR - set manually, and then advance and retard to synchronize while watching indicator
Resolution	2X10-6	3x10-5	Receivers G - GPS W - WWVB M - OMEGA E - GOES D - DCF77 J - JJY O - other, explain
Bandwidth	DC-50	DC-1/3 sample Hz	
Low-pass filter character	BUTTERWORTH	Digital filter	
Preamp (dB)	2X10-6	3x10-5	
Noise (g)	N	N	
Int.System F. Test	SE, 100K, +/-15V, 1	SE, 100K, +/-15V, 3	
Sensor Interface	P,E,T,O	P,E,T,O	
External Indicators	M,S,C,T	M,S,C,T	
Interconnect	filtered threshold character bandwidth range	threshold 0.07-7 0.001-0.5	
Trigger Modes	0.07-7 0.0005-0.1275	0.07-7 0.001-0.5	
Pre-event memory (sec) 3 ch, 200 sps	2.5-15	0-25	
Post-event hold (sec)	0-30	0-60	
Recording medium std	IC CARD	FD, HD	
OPTIONAL	MAXELL ML-102		
Mem.Backup Battery (typ)	Mercury cell		
Recording capacity (min)	1 Mbyte x 4 30 *	16 (F.D), 540(H.D)	
OPTIONAL			
Playback hardware	DAC-15X	MS, DOS	
Comm Software			
OPTIONAL			
Retrieval Method	M,O NOTE 2	M,O NOTE 2	
OPTIONAL			
Transfer Rate			
Timing			
Clock stability standard (accuracy, temperature range)	1X10-6, -10-50C	1x10-6, 0-40C	
OPTIONAL	1x10-7, -20-50C		
Synchronization optional	A	A	
Receivers	O, NHK	O, NHK	
Power			
Power supply std (#batts,volts,cap)	one, 12v	one 12v DC	
external	100vac, 12vdc	90-240VDC	
Current Drain (milliamps)	550mA DC	380mA DC	
Capacity (days)		2 hours	
Physical			
Size (LxWxH in cm)	33X47.5X15.2	33x46x17	
Weight (Kg)	8	10	
Housing	cast aluminum case	aluminum attache case	
Operating Temp (C)	-10-50	0-40	
Humidity	100%	80%	
Data Reduction Software Available OPTIONAL	D, P DSP VOL	D, P DSP VOL	NOTE: Generally, feature capacities can be expressed as x,n where x is the maximum value and n is the increment. Example: optional memory expressed as 72,9 means that a maximum capacity of 72 minutes is available in 9 minute steps.

