CHANNEL CALIBRATION PROCEDURE

FOR SFSI TEST STRUCTURE SYSTEM

AND GVDA SURFACE ARRAY

MODEL RTMS-2001RN

CUSTOMER	University Of California Santa Barbara Crustal Studies Department
SYSTEM LOCATION	GVDA
SYSTEM S/N	207
DATE OF TEST	July 15, 2011
PERFORMED BY (Print)	Dan Radulescu and Robin Gee
SIGNATURE	Robin Gee

CHANNEL CALIBRATION PROCEDURE
FOR SFSI TEST STRUCTURE SYSTEM
AND GVDA SURFACE ARRAY

MODEL RTMS-2001RN

1.0 PURPOSE

The purpose of this procedure is the determination of the calibration factors for the entire system as described in the proposal No: DCR2006-001. The main components of the system will be checked for functionality and when needed a calibration factor will be determined. The sensors and the entire system shall be tested such that they respond within a specified range and accuracy to an input traceable to the National Bureau of Standards or an acceptable physical constant, (e.g., tilt testing of an accelerometer within the earth's gravitational field). This calibration will require temporary removal of the sensors from their normal location.

2.0 DESCRIPTION

The RTMS-2001RN system is a multi-channels Data Acquisition system which is capable of locally recording events and continuously streaming data to multiple remote clients using TCP/IP protocol. The system has a total of 32 channels with a 24-bit resolution for each channel. A total of 28 different sensors are connected to the system. First 24 channels are connected directly to the A/D input and the last 8 channels are connected to the output of an Signal conditioning module Model 163 MK manufactured by CALEX. Table A1 in Appendix A shows the correspondence between the channel number and the sensor type, Model, and Manufacturer.

3.0 REFERENCES

- Digitexx SFSI Monitoring System – System Manual
- Applied Mems Calibration Data Card
- ATA Sensors Calibration Data Card
- Entran Calibration Data Card
- Scientific Technologies Inc. Calibration Data Card
- Calex Operating Manual for 163mk Signal Conditioning

It is recommended that this calibration be performed every 12 months

4.0 SYSTEM PERFORMANCE NOTES

- Because this procedure is intended to be used by a qualified person, step-by-step instructions are not given
- Test sequence may be changed as needed for safety and /or efficiency.
- Items for which quantitative measurements cannot or need not to be made shall be reported in a qualitative mode (e.g. Yes/No).
- Any activities performed outside the normal scope of this procedure shall be documented.
- When a deficiency is observed, the technician may undertake additional testing and install factory authorized and/or factory calibrated replacement parts to restore the proper operation of the instrument.
- Calibration readings are equally valid using either the internal batteries (>11.5 VDC under load) or using an external power supply (between 12.0 and 13.0 VDC.

5.0 TEST EQUIPMENT

Instrument Type	Manufacturer	Model	Range
Digital Voltmeter			
Bubble Level			
Tilt Table			

6.0 PRE-TEST CONDITIONS

- Notify the End user that the system will be taken out of normal operation conditions

(Initials)_____

- Check the overall system functionality and appearance. Document any observed anomaly. If a subassembly is not functional, document the findings, perform the repair first (if possible), and continue with the calibration

(Initials)_____

NOTES:_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

(Initials)_____

7.0 SYSTEM TEST

7.1 UNINTERRUPTIBLE POWER SUPPLY

a) Check the battery charging Indicator.
Mark FULL or indicate in % _____ (Initials)_____

b) Disconnect the AC power cord and wait 10 minutes.
The intermittent Battery operation sound should be present.
The battery charging indicator shall stay on the same range.

(Initials)_____

c) Reconnect the AC (Initials)_____

d) Document when the battery has been installed (dd/mm/yy) _____

NOTES:_____
_____
_____
_____
_____

7.2 SENSOR POWER SUPPLY

a) Check the front LEDs to be ON (Y/N)_____

b) Check the battery voltage with AC connected (>12.5V) _____(V)

c) Measure the output voltage on +12V side (+12V +/- 0.1) _____(V)

d) Measure the output voltage on -12V side (-12V +/-0.1) _____(V)

e) Disconnect the AC and check the battery voltage (>12.3) _____(V)

f) Reconnect the AC (Initials)_____

NOTES:_____

7.3 PC INDUSTRIAL COMPUTER

a) Check the overall functionality (Initials)_____

b) Check the Server software for proper functionality (Initials)_____

c) Check the Hard Disk Space _____(MB)

d) Download all recorded events on a memory stick (Initials)_____

e) Check for OS updates and perform the OS update (Initials)_____

f) Simulate AC power Loss and observe that the System comes UP and is operational (Initials)_____

NOTES:_____

7.4 A/D CALIBRATION CHECK

Using a voltage reference source, check the A/D reading connecting the source to each channel. Record in the table bellow the value read by each channel

CHANNEL #	VOLTAGE REFERENCE [v]	A/D READING [V]	COMMENTS
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			

NOTES:_____

7.5 SENSOR CALIBRATION

ACCELEROMETERS (SURFACE ARRAY)

LOCATION CODE #	SENSOR MODEL	SENSOR S/N	CALIBRATION [V/g]	
			AS FOUND	AS LEFT
00	Triaxial Accelerometer X-axis	205	9.945	"
00	Triaxial Accelerometer Y-axis	205	9.970	"
00	Triaxial Accelerometer Z-axis	205	10.086	"
00-MEMS	Triaxial Accelerometer X-axis	440	1.251	"
00-MEMS	Triaxial Accelerometer Y-axis	440	1.250	"
00-MEMS	Triaxial Accelerometer Z-axis	440	1.195	"
07	Triaxial Accelerometer X-axis	2854	9.965	"
07	Triaxial Accelerometer Y-axis	2854	9.980	"
07	Triaxial Accelerometer Z-axis	2854	10.016	"
08	Triaxial Accelerometer X-axis	2491*		
08	Triaxial Accelerometer Y-axis	2491*		
08	Triaxial Accelerometer Z-axis	2491*		
09	Triaxial Accelerometer X-axis	732	9.965	"
09	Triaxial Accelerometer Y-axis	732	9.980	"
09	Triaxial Accelerometer Z-axis	732	9.958	"
10	Triaxial Accelerometer X-axis	3322	9.865	"
10	Triaxial Accelerometer Y-axis	3322	9.955	"
10	Triaxial Accelerometer Z-axis	3322	9.989	"

NOTES:

* Not Calibrated (could not remove from S. Steel box)

ACCELEROMETERS ON SFSI STUCTURE

CHANNEL #	SENSOR MODEL	SENSOR S/N	CALIBRATION [V/g]	
			AS FOUND	AS LEFT
1	Triaxial Accelerometer X-axis	907	1.292	"
2	Triaxial Accelerometer Y-axis	907	1.276	"
3	Triaxial Accelerometer Z-axis	907	1.272	"
4	Triaxial Accelerometer X-axis	255	1.202	"
5	Triaxial Accelerometer Y-axis	255	1.259	"
6	Triaxial Accelerometer Z-axis	255	1.175	"
7	Uniaxial Accelerometer Z-axis	317	1.226	"
8	Uniaxial Accelerometer Z-axis	316	1.235	"
9	Uniaxial Accelerometer X-axis	319	1.210	"
10	Uniaxial Accelerometer Z-axis	312	1.223	"
11	Uniaxial Accelerometer Z-axis	318	1.212	"
12	Uniaxial Accelerometer X-axis	320 *		
13	Uniaxial Accelerometer X-axis (Shaker)	321 *		
14	Triaxial Downhole Accelerometer X-axis	312 **		
15	Triaxial Downhole Accelerometer Y-axis	312 **		
16	Triaxial Downhole Accelerometer Z-axis	312 **		

NOTES:

* Not Calibrated (could not remove from top Slab)

** Not Calibrated (downhole)

Sensors channel 09, 12, 13 have been changed since last report

ROTATION

CHANNEL #	SENSOR MODEL	SENSOR S/N	CALIBRATION [DEGREE/SEC]	
			AS FOUND	AS LEFT
17	ARS-09			
18	ARS-09			
19	ARS-09			

NOTES: Not Calibrated
Passes functional test

PORE PRESURE

CHANNEL #	SENSOR MODEL	SENSOR S/N	CALIBRATION [ ]	
			AS FOUND	AS LEFT
20				

NOTES: Not Calibrated

SOIL PRESURE

CHANNEL #	SENSOR MODEL	SENSOR S/N	CALIBRATION [mV/PSI]	
			AS FOUND	AS LEFT
25	EPX-V01-100P	04E04EM-D28	1.2393	"
26	EPX-V01-100P	04A03F05-K10	1.5969	"
27	EPX-V01-100P	04A03F05-K08	1.3403	"
28	EPX-V01-100P	D4E04E71-D27	1.1244	"

NOTES: Not Calibrated. Values taken from Factory Cal sheet

RELATIVE DISPLACEMENT

CHANNEL #	SENSOR MODEL	SENSOR S/N	CALIBRATION [V/inch]	
			AS FOUND	AS LEFT
29	DT-30-B	03-2823	0.0664	"
30	DT-30-B	03-2826	0.0730	"
31	DT-30-B	03-2824	0.0651	"
32	DT-30-B	03-2825	0.0663	"

NOTES:

8.0 FINAL STEPS

- Change the batteries from the UPS and SENSOR POWER SUPPLY if they are three (3) years old or more. If the batteries are not purchased, make a note and change them at the first maintenance visit.

(Initials)_____

- Return the system to functional state (Initials)_____
- Attach Final record to this document (Initials)_____
- List all test equipment (Initials)_____
- Inform the end user that the system is functional (Initials)_____
- Prepare the site (close the hat and the equipment) (Initials)_____

NOTES:_____

9.0 SUMMARY (Comments, Parts replaced, Deficiencies, etc.)

10.0 CERTIFICATION

All items included in this procedure have been performed unless noted above and were found or have been adjusted to be within the range required by this procedure.

(yes/no)_____

_____
(Signature)

_____
(Print)

11.0 ACTION REQUIRED (IF ANY)

_____
_____
_____
_____
_____
_____

APPENDIX A

Correspondence between the channel number and sensor type

Table A1: SURFACE ARRAY INSTRUMENTS

Location Code #	Sensor Type	Model / Manufacturer
00	Triaxial Accelerometer X,Y,Z-axis	Kinemetrics FBA ES-T
00-MEMS	Triaxial Accelerometer X,Y,Z-axis	SF3000L / AppliedMems
07	Triaxial Accelerometer X,Y,Z-axis	Kinemetrics FBA ES-T
08	Triaxial Accelerometer X,Y,Z-axis*	Kinemetrics FBA ES-T
09	Triaxial Accelerometer X,Y,Z-axis	Kinemetrics FBA ES-T
10	Triaxial Accelerometer X,Y,Z-axis	Kinemetrics FBA ES-T

Table A2: SFSI INSTRUMENTS

Channel #	Sensor Type	Model / Manufacturer
1	Triaxial Accelerometer X-axis	SF3000 / AppliedMems
2	Triaxial Accelerometer Y-axis	SF3000 / AppliedMems
3	Triaxial Accelerometer Z-axis	SF3000 / AppliedMems
4	Triaxial Accelerometer X-axis	SF3000 / AppliedMems
5	Triaxial Accelerometer Y-axis	SF3000 / AppliedMems
6	Triaxial Accelerometer Z-axis	SF3000 / AppliedMems
7	Uniaxial Accelerometer Z-axis	SF3000 / AppliedMems
8	Uniaxial Accelerometer Z-axis	SF3000 / AppliedMems
9	Uniaxial Accelerometer X-axis	SF3000 / AppliedMems
10	Uniaxial Accelerometer Z-axis	SF3000 / AppliedMems
11	Uniaxial Accelerometer Z-axis	SF3000 / AppliedMems
12	Uniaxial Accelerometer X-axis*	SF3000 / AppliedMems
13	Uniaxial Accelerometer X-axis (Shaker)	SF3000 / AppliedMems
14	Triaxial Downhole Accelerometer X-axis*	Kinemetrics Shallow Borehole Epi-T
15	Triaxial Downhole Accelerometer Y-axis*	Kinemetrics Shallow Borehole Epi-T
16	Triaxial Downhole Accelerometer Z-axis*	Kinemetrics Shallow Borehole Epi-T
17	Rotation Sensor X-X*	ARS-09 / ATA Sensors
18	Rotation Sensor Y-Y*	ARS-09 / ATA Sensors
19	Rotation Sensor Z-Z*	ARS-09 / ATA Sensors
20	Pore Pressure*	
21	Spare channel*	
22	Spare channel*	
23	Spare channel*	
24	Spare channel*	
25	Soil Pressure Z-axis*	EPX-V01-100P / ENTRAN
26	Soil Pressure Z-axis*	EPX-V01-100P / ENTRAN
27	Soil Pressure Z-axis*	EPX-V01-100P / ENTRAN
28	Soil Pressure Z-axis*	EPX-V01-100P / ENTRAN
29	Relative Displacement Transducer Z-axis	DT-30-B / STI
30	Relative Displacement Transducer Z-axis	DT-30-B / STI
31	Relative Displacement Transducer Z-axis	DT-30-B / STI
32	Relative Displacement Transducer Z-axis	DT-30-B / STI

*** Not calibrated**

APPENDIX B

Recommended Calibration Methods

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 205 X-Axis
Location Code 00

The following readings shall be taken in the indicated order:

1. Horizontal -0.421 [V]
2. tilt to +30 degrees -5.39 [V]
3. tilt to +90 degrees -10.28 [V]
4. tilt back to horizontal -0.423 [V]
5. tilt to -30 degrees 4.58 [V]
6. tilt to -90 degrees 9.61 [V]
7. tilt back to horizontal -0.423 [V]

CALIBRATION FACTOR 9.945 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 205 Z-Axis
Location Code 00

The following readings shall be taken in the indicated order:

1. Horizontal -0.014 [V]
2. tilt to +60 degrees -5.08 [V]
3. tilt to +90 degrees -10.10 [V]
4. Continue to Horizontal -20.02 [V]

CALIBRATION FACTOR 10.006 [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 205 Y-Axis

The following readings shall be taken in the indicated order: Location Code 00

1. Horizontal -0.346 [V]
2. tilt to +30 degrees 4.63 [V]
3. tilt to +90 degrees 9.65 [V]
4. tilt back to horizontal -0.348 [V]
5. tilt to -30 degrees -5.33 [V]
6. tilt to -90 degrees -10.29 [V]
7. tilt back to horizontal -0.349 [V]

CALIBRATION FACTOR 9.979 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER MEMS 440 X-Axis
Location Code 00

The following readings shall be taken in the indicated order:

1. Horizontal -0.048 [V]
2. tilt to +30 degrees -0.672 [V]
3. tilt to +90 degrees -1.303 [V]
4. tilt back to horizontal -0.047 [V]
5. tilt to -30 degrees 0.576 [V]
6. tilt to -90 degrees 1.198 [V]
7. tilt back to horizontal -0.048 [V]

CALIBRATION FACTOR 1.251 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER MEMS 440 Z-Axis

The following readings shall be taken in the indicated order:

1. Horizontal 1.109 [V]
2. tilt to +60 degrees 0.516 [V]
3. tilt to +90 degrees -0.086 [V]
4. Continue to Horizontal -1.306 [V]

CALIBRATION FACTOR 1.195 [V/g]
Read 3 – Read 1

v *ACCELEROMETERS*

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER MEMS 440 Y-Axis

The following readings shall be taken in the indicated order: Location Code 00

1. Horizontal -0.075 [V]
2. tilt to +30 degrees -0.699 [V]
3. tilt to +90 degrees -1.323 [V]
4. tilt back to horizontal -0.075 [V]
5. tilt to -30 degrees 0.549 [V]
6. tilt to -90 degrees 1.177 [V]
7. tilt back to horizontal 0.075 [V]

CALIBRATION FACTOR 1.250 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 2854 X-Axis Location Code 07

The following readings shall be taken in the indicated order:

1. Horizontal -0.10 [V]
2. tilt to +30 degrees -5.08 [V]
3. tilt to +90 degrees -10.07 [V]
4. tilt back to horizontal -0.092 [V]
5. tilt to -30 degrees 4.89 [V]
6. tilt to -90 degrees 9.86 [V]
7. tilt back to horizontal -0.093 [V]

CALIBRATION FACTOR 9.965 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 2854 Z-Axis Location Code 07

The following readings shall be taken in the indicated order:

1. Horizontal 0.066 [V]
2. tilt to +60 degrees -4.94 [V]
3. tilt to +90 degrees -9.95 [V]
4. Continue to Horizontal -19.92 [V]

CALIBRATION FACTOR (0.016 [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 2854 Y-Axis

The following readings shall be taken in the indicated order: Location Code 07

1. Horizontal -0.123 [V]
2. tilt to +30 degrees -5.11 [V]
3. tilt to +90 degrees -10.04 [V]
4. tilt back to horizontal -0.128 [V]
5. tilt to -30 degrees 4.87 [V]
6. tilt to -90 degrees 9.92 [V]
7. tilt back to horizontal -0.128 [V]

CALIBRATION FACTOR 9.980 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 732 X-Axis Location Code 09

The following readings shall be taken in the indicated order:

1. Horizontal -0.125 [V]
2. tilt to +30 degrees -5.12 [V]
3. tilt to +90 degrees -10.15 [V]
4. tilt back to horizontal -0.122 [V]
5. tilt to -30 degrees 4.86 [V]
6. tilt to -90 degrees 9.78 [V]
7. tilt back to horizontal -0.121 [V]

CALIBRATION FACTOR 9.965 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 732 Z-Axis Location Code 09

The following readings shall be taken in the indicated order:

1. Horizontal -0.322 [V]
2. tilt to +60 degrees -5.29 [V]
3. tilt to +90 degrees -10.28 [V]
4. Continue to Horizontal -20.3 [V]

CALIBRATION FACTOR 9.958 [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 732 Y-Axis
Location Code 09

The following readings shall be taken in the indicated order:

1. Horizontal -0.312 [V]
2. tilt to +30 degrees 4.68 [V]
3. tilt to +90 degrees 9.70 [V]
4. tilt back to horizontal -0.317 [V]
5. tilt to -30 degrees -5.29 [V]
6. tilt to -90 degrees -10.26 [V]
7. tilt back to horizontal -0.320 [V]

CALIBRATION FACTOR 9.980 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 3322 X-Axis Location Code 10

The following readings shall be taken in the indicated order:

1. Horizontal -0.333 [V]
2. tilt to +30 degrees 4.63 [V]
3. tilt to +90 degrees 9.45 [V]
4. tilt back to horizontal -0.340 [V]
5. tilt to -30 degrees -5.31 [V]
6. tilt to -90 degrees -10.28 [V]
7. tilt back to horizontal -0.336 [V]

CALIBRATION FACTOR 9.865 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 3322 Z-Axis Location Code 10

The following readings shall be taken in the indicated order:

1. Horizontal -0.451 [V]
2. tilt to +60 degrees -5.43 [V]
3. tilt to +90 degrees -10.44 [V]
4. Continue to Horizontal -10.46 [V]

CALIBRATION FACTOR 9.989 [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER 3322 Y-Axis

Location Code 10

The following readings shall be taken in the indicated order:

1. Horizontal -0.151 [V]
2. tilt to +30 degrees -5.12 [V]
3. tilt to +90 degrees -10.01 [V]
4. tilt back to horizontal -0.145 [V]
5. tilt to -30 degrees 4.82 [V]
6. tilt to -90 degrees 9.90 [V]
7. tilt back to horizontal -0.146 [V]

CALIBRATION FACTOR 9.955 [V/g]

{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]

Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER TRI MEMS 907 X-Axis channel 1

The following readings shall be taken in the indicated order:

1. Horizontal - 0.215 [V]
2. tilt to +30 degrees - 0.863 [V]
3. tilt to +90 degrees -1.518 [V]
4. tilt back to horizontal - 0.215 [V]
5. tilt to -30 degrees 0.428 [V]
6. tilt to -90 degrees 1.065 [V]
7. tilt back to horizontal _____ [V]

CALIBRATION FACTOR 1.292 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER TRI MEMS 907 Z-Axis channel 3

The following readings shall be taken in the indicated order:

1. Horizontal 1.113 [V]
2. tilt to +60 degrees 0.489 [V]
3. tilt to +90 degrees - 0.159 [V]
4. Continue to Horizontal 1.460 [V]

CALIBRATION FACTOR 1.272 [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER TRI MEMS 907 Y-AXIS channel 2

The following readings shall be taken in the indicated order:

1. Horizontal -0.207 [V]
2. tilt to +30 degrees -0.843 [V]
3. tilt to +90 degrees -1.475 [V]
4. tilt back to horizontal -0.206 [V]
5. tilt to -30 degrees 0.431 [V]
6. tilt to -90 degrees 1.077 [V]
7. tilt back to horizontal -0.206 [V]

CALIBRATION FACTOR 1.276 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER TRI MEMS 255 X-AXIS channel 4

The following readings shall be taken in the indicated order:

1. Horizontal 0.077 [V]
2. tilt to +30 degrees -0.525 [V]
3. tilt to +90 degrees -1.137 [V]
4. tilt back to horizontal 0.078 [V]
5. tilt to -30 degrees 0.677 [V]
6. tilt to -90 degrees 1.267 [V]
7. tilt back to horizontal 0.078 [V]

CALIBRATION FACTOR 1.202 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER TRI MEMS 255 Z-Axis channel 6

The following readings shall be taken in the indicated order:

1. Horizontal 1.172 [V]
2. tilt to +60 degrees 0.591 [V]
3. tilt to +90 degrees 0.003 [V]
4. Continue to Horizontal -1.211 [V]

CALIBRATION FACTOR 1.175 [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER TRI MEMS 255 Y-Axis channel 5

The following readings shall be taken in the indicated order:

1. Horizontal 0.035 [V]
2. tilt to +30 degrees -0.595 [V]
3. tilt to +90 degrees -1.230 [V]
4. tilt back to horizontal 0.035 [V]
5. tilt to -30 degrees 0.664 [V]
6. tilt to -90 degrees 1.288 [V]
7. tilt back to horizontal 0.038 [V]

CALIBRATION FACTOR 1.259 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER UNI MEMS 317 channel 7

The following readings shall be taken in the indicated order:

1. Horizontal 0.105 [V]
2. tilt to +30 degrees -0.508 [V]
3. tilt to +90 degrees -1.132 [V]
4. tilt back to horizontal 0.106 [V]
5. tilt to -30 degrees 0.718 [V]
6. tilt to -90 degrees 1.319 [V]
7. tilt back to horizontal 1.107 [V]

CALIBRATION FACTOR 1.226 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER UNI MEMS 316

The following readings shall be taken in the indicated order: Channel 8

1. Horizontal 0.109 [V]
2. tilt to +30 degrees -0.507 [V]
3. tilt to +90 degrees -1.13 [V]
4. tilt back to horizontal 0.112 [V]
5. tilt to -30 degrees 0.729 [V]
6. tilt to -90 degrees 1.340 [V]
7. tilt back to horizontal 0.112 [V]

CALIBRATION FACTOR 1.235 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER UNI MEMS 319 channel 9

The following readings shall be taken in the indicated order:

1. Horizontal 0.116 [V]
2. tilt to +30 degrees -0.490 [V]
3. tilt to +90 degrees -1.100 [V]
4. tilt back to horizontal 0.116 [V]
5. tilt to -30 degrees 0.720 [V]
6. tilt to -90 degrees 1.311 [V]
7. tilt back to horizontal 0.117 [V]

CALIBRATION FACTOR 1.210 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER UNI MEMS 312 channel 10

The following readings shall be taken in the indicated order:

1. Horizontal -0.049 [V]
2. tilt to +30 degrees -0.663 [V]
3. tilt to +90 degrees -1.292 [V]
4. tilt back to horizontal -0.049 [V]
5. tilt to -30 degrees 0.558 [V]
6. tilt to -90 degrees 1.153 [V]
7. tilt back to horizontal 0.048 [V]

CALIBRATION FACTOR 1.223 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER UNI MEMS 318 Channel 11

The following readings shall be taken in the indicated order:

1. Horizontal -0.001 [V]
2. tilt to +30 degrees -0.610 [V]
3. tilt to +90 degrees -1.236 [V]
4. tilt back to horizontal -0.001 [V]
5. tilt to -30 degrees 0.602 [V]
6. tilt to -90 degrees 1.188 [V]
7. tilt back to horizontal -0.001 [V]

CALIBRATION FACTOR 1.212 [V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____ [V]
2. tilt to +60 degrees _____ [V]
3. tilt to +90 degrees _____ [V]
4. Continue to Horizontal _____ [V]

CALIBRATION FACTOR _____ [V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER UNI MEMS 320

The following readings shall be taken in the indicated order: channel 12

1. Horizontal _____[V]
2. tilt to +30 degrees _____[V]
3. tilt to +90 degrees _____[V]
4. tilt back to horizontal _____[V]
5. tilt to -30 degrees _____[V]
6. tilt to -90 degrees _____[V]
7. tilt back to horizontal _____[V]

CALIBRATION FACTOR _____[V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____[V]
2. tilt to +60 degrees _____[V]
3. tilt to +90 degrees _____[V]
4. Continue to Horizontal _____[V]

CALIBRATION FACTOR _____[V/g]
Read 3 – Read 1

ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER UNI MEMS 321 Channel 13

The following readings shall be taken in the indicated order:

1. Horizontal _____[V]
2. tilt to +30 degrees _____[V]
3. tilt to +90 degrees _____[V]
4. tilt back to horizontal _____[V]
5. tilt to -30 degrees _____[V]
6. tilt to -90 degrees _____[V]
7. tilt back to horizontal _____[V]

CALIBRATION FACTOR _____[V/g]
{(Read3 – Read1) + (Read6 – Read4)} / 2

For the vertical axis:

The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER _____

The following readings shall be taken in the indicated order:

1. Horizontal _____[V]
2. tilt to +60 degrees _____[V]
3. tilt to +90 degrees _____[V]
4. Continue to Horizontal _____[V]

CALIBRATION FACTOR _____[V/g]
Read 3 – Read 1

RELATIVE DISPLACEMENT

MODEL / SERIAL NUMBER DT-30-B /03-2823
HBZ-16

Take a metallic pin with the Diameter = 0.316"

Measure the exact diameter of the pin
using the caliper **[D1]** 0.344 [in]

Start the system to take a record
Filename of the record _____

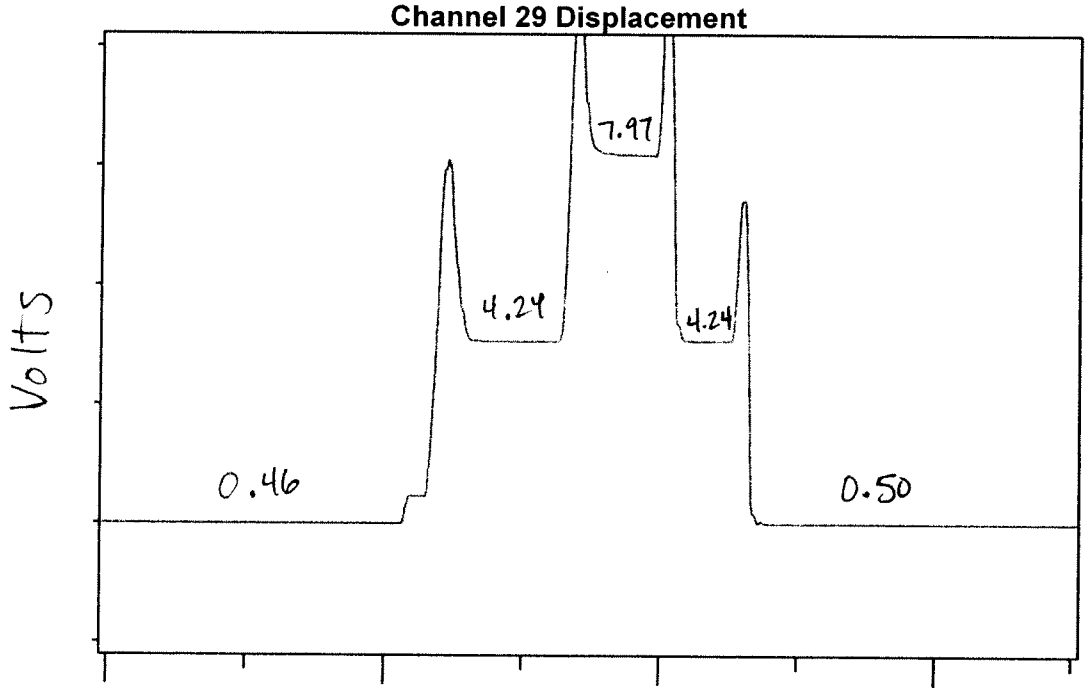
Turn the string (wire) of the sensor once
Around the metal pin and wait 10 seconds (Initials) RG

Turn the string (wire) of the sensor one more turn
Around the metal pin and wait 10 seconds (Initials) RG

Un-wind one turn of the wire from the metal pin
and wait 10 seconds (Initials) RG

Un-wind the last turn of the wire from the metal pin
Wait 10 seconds and stop the recording (Initials) RG

Typical record should look like this:



Starting from the left we have five readings (READ1, READ2, READ3, READ4, READ5.

RECORD The overall Channel amplification factor **AF =** 50

COMPUTE: **OUT [V] = ((READ2 – READ1) + (READ3 – READ1)/2) / (2 * AF)** 0.0749

COMPUTE THE CIRCLE LENGTH OF THE PIN

L [IN] = PI * (D1 + D2) (where D2 is the diameter of the wire) 1.128

CAL FACTOR [V/inch] = OUT[V] / L[in])

Print a separate page for each sensor 0.0664 $\frac{V}{in}$

RELATIVE DISPLACEMENT

MODEL / SERIAL NUMBER DT-30-B / 03-2826
HBZ-17

Take a metallic pin with the Diameter = 0.316"

Measure the exact diameter of the pin
using the caliper **[D1]** 0.344 [in]

Start the system to take a record
Filename of the record _____

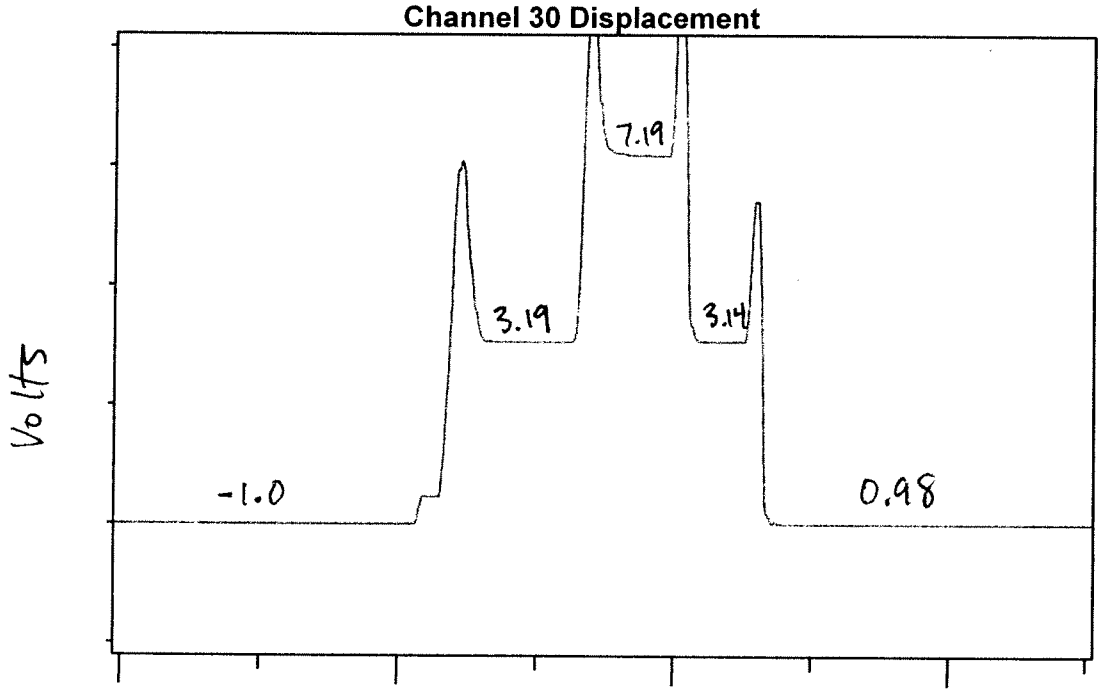
Turn the string (wire) of the sensor once
Around the metal pin and wait 10 seconds (Initials) RG

Turn the string (wire) of the sensor one more turn
Around the metal pin and wait 10 seconds (Initials) RG

Un-wind one turn of the wire from the metal pin
and wait 10 seconds (Initials) RG

Un-wind the last turn of the wire from the metal pin
Wait 10 seconds and stop the recording (Initials) RG

Typical record should look like this:



Starting from the left we have five readings (READ1, READ2, READ3, READ4, READ5.

RECORD The overall Channel amplification factor **AF =** 50

COMPUTE: **OUT [V] = ((READ2 – READ1) + (READ3 – READ1)/2) / (2 * AF)** 0.0823

COMPUTE THE CIRCLE LENGTH OF THE PIN

L [IN] = PI * (D1 + D2) (where D2 is the diameter of the wire) 1.128

CAL FACTOR [V/inch] = OUT[V] / L[in])

Print a separate page for each sensor

0.0730 $\frac{V}{IN}$

RELATIVE DISPLACEMENT

MODEL / SERIAL NUMBER DT-30-B / 03-2824
HBZ-18

Take a metallic pin with the Diameter = 0.316"

Measure the exact diameter of the pin
using the caliper **[D1]** 0.344 [in]

Start the system to take a record
Filename of the record _____

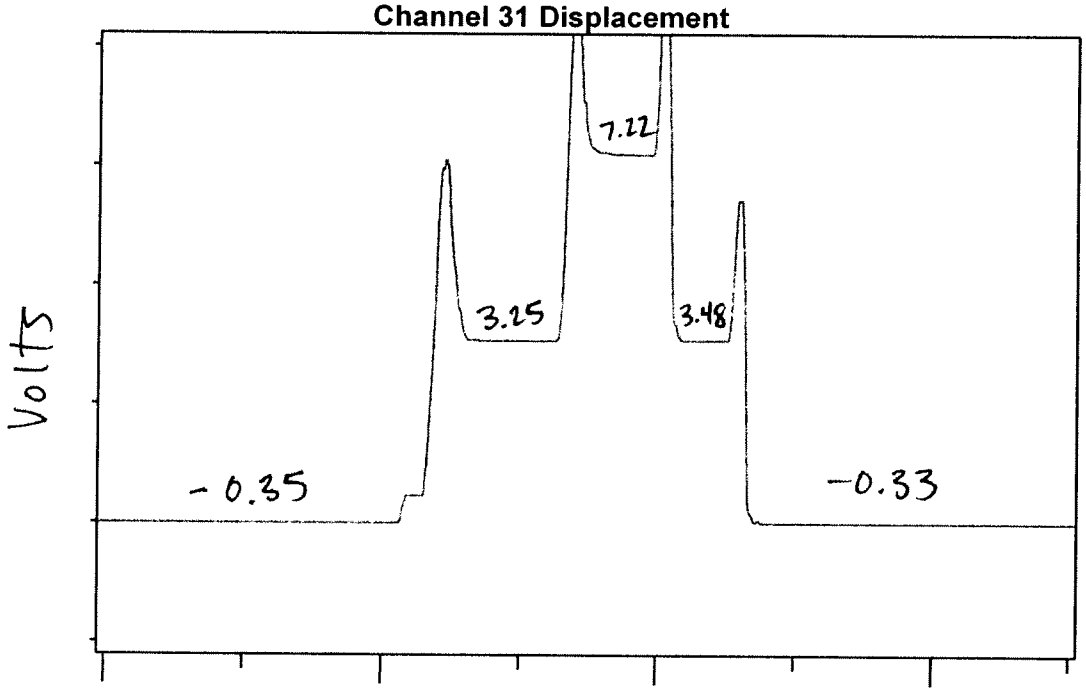
Turn the string (wire) of the sensor once
Around the metal pin and wait 10 seconds (Initials) RG

Turn the string (wire) of the sensor one more turn
Around the metal pin and wait 10 seconds (Initials) RG

Un-wind one turn of the wire from the metal pin
and wait 10 seconds (Initials) RG

Un-wind the last turn of the wire from the metal pin
Wait 10 seconds and stop the recording (Initials) RG

Typical record should look like this:



Starting from the left we have five readings (READ1, READ2, READ3, READ4, READ5.

RECORD The overall Channel amplification factor **AF =** 50

COMPUTE: **OUT [V] = ((READ2 – READ1) + (READ3 – READ1)/2) / (2 * AF)** 0.0735

COMPUTE THE CIRCLE LENGTH OF THE PIN

L [IN] = PI * (D1 + D2) (where D2 is the diameter of the wire) 1.128

CAL FACTOR [V/inch] = OUT[V] / L[in]) 0.0651 $\frac{V}{in}$

Print a separate page for each sensor

RELATIVE DISPLACEMENT

MODEL / SERIAL NUMBER DT-30-B/03-2825
H67-19

Take a metallic pin with the Diameter = 0.316"

Measure the exact diameter of the pin
using the caliper **[D1]** 0.344 [in]

Start the system to take a record
Filename of the record _____

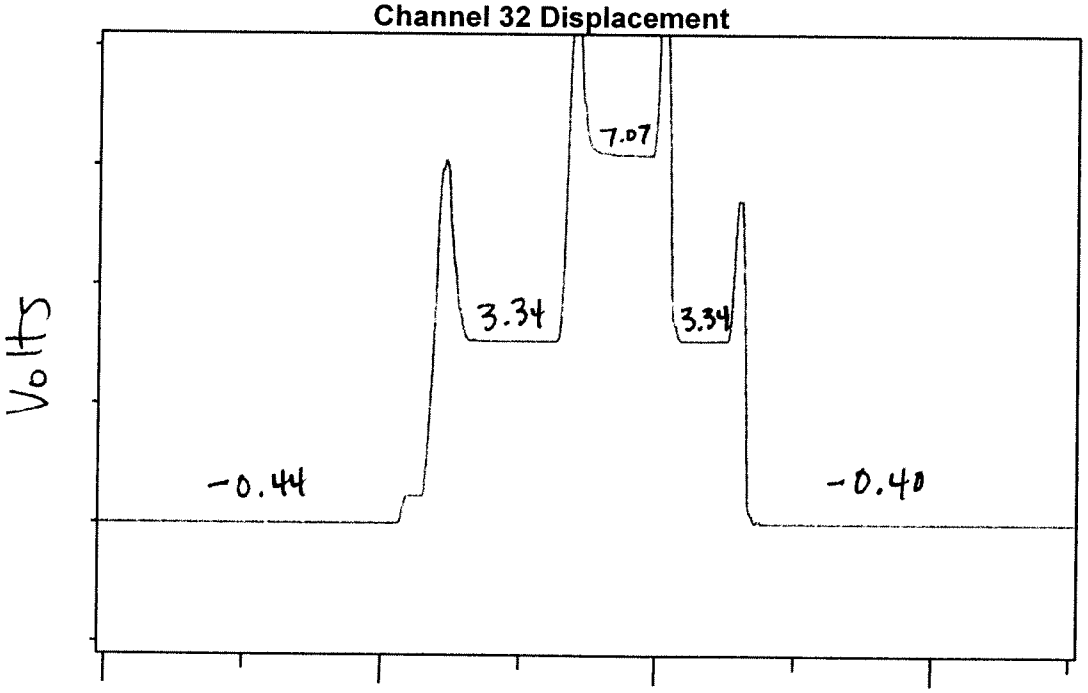
Turn the string (wire) of the sensor once
Around the metal pin and wait 10 seconds (Initials) RG

Turn the string (wire) of the sensor one more turn
Around the metal pin and wait 10 seconds (Initials) RG

Un-wind one turn of the wire from the metal pin
and wait 10 seconds (Initials) RG

Un-wind the last turn of the wire from the metal pin
Wait 10 seconds and stop the recording (Initials) RG

Typical record should look like this:



Starting from the left we have five readings (READ1, READ2, READ3, READ4, READ5.

RECORD The overall Channel amplification factor **AF =** 50

COMPUTE: **OUT [V] = ((READ2 – READ1) + (READ3 – READ1)/2) / (2 * AF)** 0.0748

COMPUTE THE CIRCLE LENGTH OF THE PIN
L [IN] = PI * (D1 + D2) (where D2 is the diameter of the wire) 1.128

CAL FACTOR [V/inch] = OUT[V] / L[in])

Print a separate page for each sensor 0.0663 $\frac{V}{in}$

A/D CHANNEL CALIBRATION

Use one calibrated digital voltmeter and a reference voltage source. Remember that the A/D is set for +/-10V full-scale and it is a 24-bit resolution. This calibration is relative since the calibrated source must be one order of magnitude higher than the device to be calibrated. In our case we check each channel for correct functionality. The reading taken with a regular Digital Voltmeter will have the mV precision and the A/D shall have the same reading up to milivolts. A+/-2mV is acceptable due to possible electrical noise during reading. The unit is calibrated under field conditions not under laboratory conditions.

For first 24 channels of the system, disconnect the existing sensor cable from the connector panel and connect the voltage source between PIN A and PIN B. Take a reading with the Digital Voltmeter and with the A/D Server software (set the calibration factor temporarily to 981. so the reading will be in volts. Record both readings in the table below:

Channel #	Zero Reading	1V IN ±10mV		5V IN ±10mV		9V IN ±10mV		Comments
		REF	A/D	REF	A/D	REF	A/D	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

Initials_____

A/D CHANNEL CALIBRATION

For channels 25 through 32, connect the reference voltage source to the second Connector Panel at the BNC connector for each channel located at the top of the panels. Record the readings in the table bellow
For this channels check the amplification factor of the 163MK Signal conditioning

Channel #	Zero Reading	1V IN ±10mV		5V IN ±10mV		9V IN ±10mV		Comments
		REF	A/D	REF	A/D	REF	A/D	
25								
26								
27								
28								
29								
30								
31								
32								

Initials_____

163MK Amplification Factor

Channel #	INPUT VOLTAGE [mV]	OUTPUT VOLTAGE [mV]	GAIN	COMMENTS
25				
26				
27				
28				
29				
30				
31				
32				

Initials_____