



MEMS Tiltmeter Instruction Manual

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MEMS Tiltmeter Instruction Manual

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1 GENERAL DESCRIPTION

RST Instruments MEMS Sensor Tilt meters are mounted on vertical or horizontal surfaces and can measure differential angles in the X or Y directions. The Vertical MEMS Tiltmeter system consists of an angle mounting bracket, a cast aluminum water resistant NEMA 4 box, and a uniaxial or biaxial MEMS sensor. The Horizontal MEMS Tiltmeter system consists of a horizontal mounting plate, a cast aluminum water resistant NEMA 4 box, and a uniaxial or biaxial MEMS sensor. Because of the excellent zero and range stability, no sensor leveling is required- i.e. the enclosure should be mounted as close to level as possible, but no secondary level adjustment is required.



Figure 1 - MEMS Tiltmeter

2 INSTALLATION

2.1 REQUIRED TOOLS/COMPONENTS

Before beginning the installation of the MEMS Tilt meter/beam, ensure that all of the components and tools required for installation are present. See the list below for tools and equipment required for a typical installation:

- MEMS Tilt meter/beam
- CR1000/CR8X0Datalogger
- Current meter with 9-24V supply (For 4-20mA Tiltmeter)
- Level
- Phillips screw driver
- Anchor kit (consisting of (2) anchors, (4) washers, (4) 10mm SS nuts
- 16mm wrench

2.2 MEMS TILT METER/BEAM INSTALLATION

Determine the MEMS Tilt meter/beam installation location. The location must allow for access inside the enclosure to connect the sensors after the unit has been mounted. The mounting plate should be securely attached with the supplied hardware to a rigid structure that is free of vibration. Care should be taken to avoid areas of rapid or extreme changes in temperature such as direct sunlight or near heating or cooling equipment. For exposed units, a sun shade and or external insulation is recommended. Install Anchors at a distance equal to the Tiltmeter bolt pattern (using a level, ensure the anchors are installed inline vertically).

The outputs of the sensors are in Volts or milliamps, which can be read with RST Portable Readout Unit, a CR1000/CR8X0Datalogger, or Current meter (For 4-20mA Tiltmeter). The MEMS sensors have excellent zero and full scale stability. As a result, precision sensor zeroing is not necessary. This is in contrast to electrolytic sensors which have high coefficients of thermal sensitivity, necessitating precise leveling on the structure.

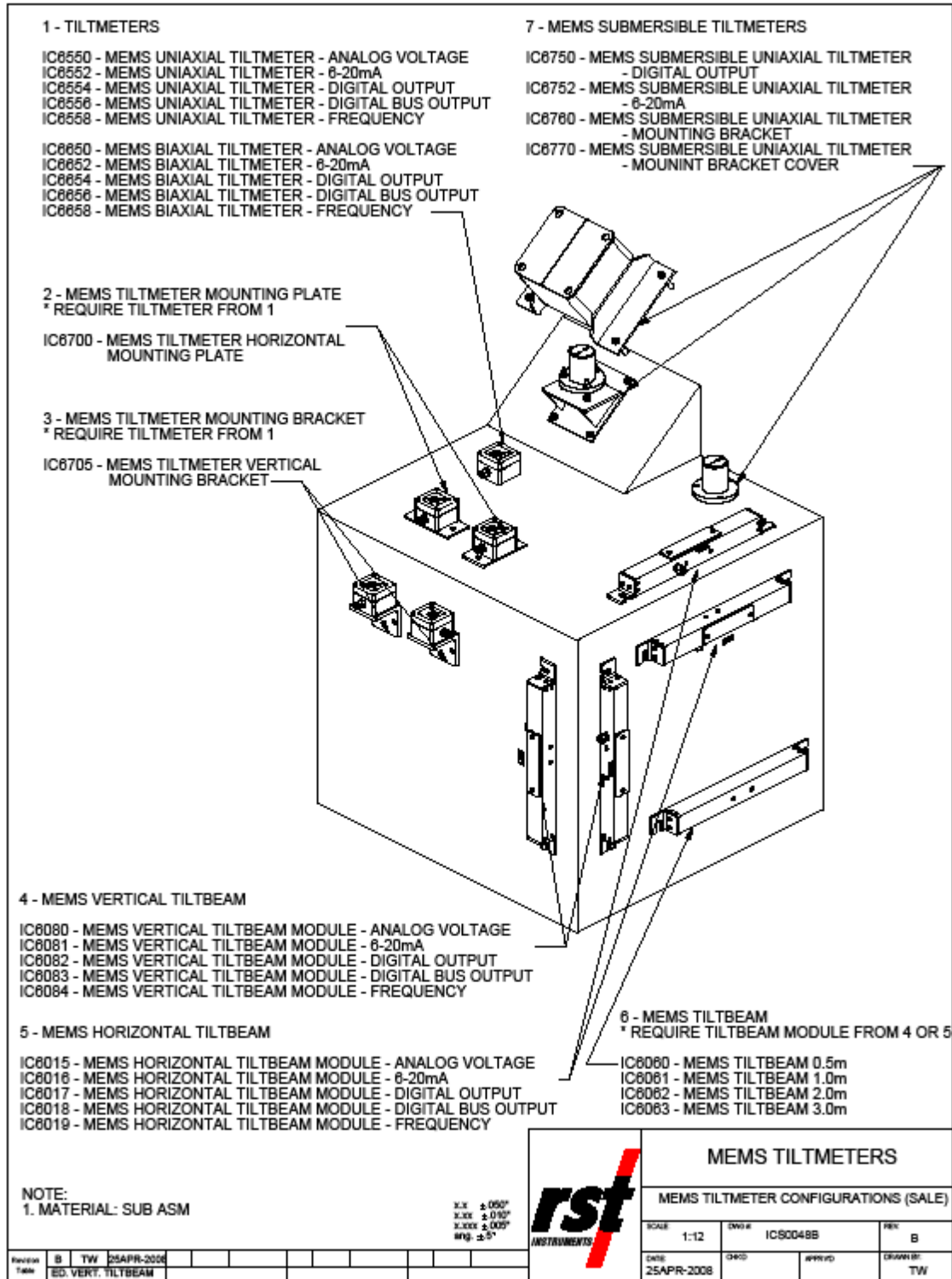


Figure 2 - Tilt Beam/Meter General Arrangement

2.3 ELECTRICAL CONNECTIONS

1. Under the Colour Code Table, look up the lead designations for the type of cable being used.
2. Under the Electrical Connections Table, make the appropriate lead connections, according to the type of system being used.

Information regarding your sensor configuration and cable type is listed on your sensor calibration sheets.

2.3.1 Analog Tiltmeter Electrical Connection

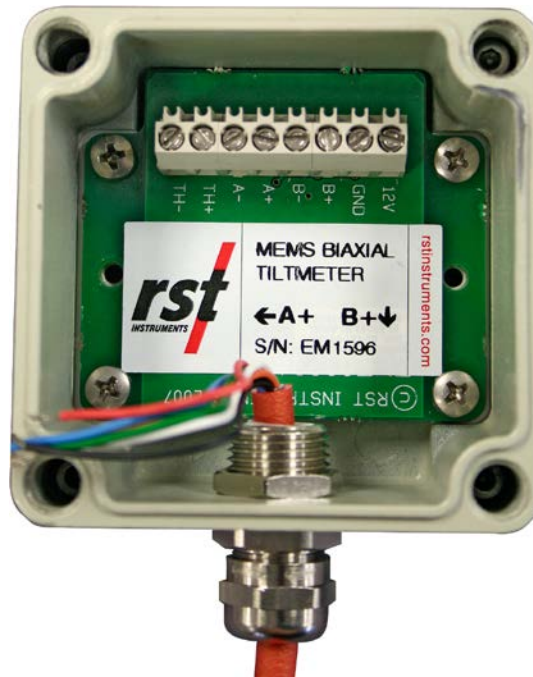


Figure 3 - Analog Tiltmeter Electrical Connections

Tiltmeter	Wire Color	Datalogger
12V	Red	12V
Gnd	Black	Gnd
A+	Green	xH
A-	White	xL
B+	Orange	yH
B-	Blue	yL

2.3.2 Loop Powered 4-20mA Tiltmeter Electrical Connection



Figure 4 - 4-20mA Tiltmeter Electrical Connections

Tiltmeter	Voltage	Wire Color	Datalogger
Supply 1 A+	9-24V	Red	SW12V
Current 1 A-	4-20mA	Black	SE1
Supply 2 B+	9-24V	Green	SW12V
Current 2 B-	4-20mA	White	SE2

Note: Supply Minimum is 9 Volt dc + burden resistor drop ($9V + 125\text{ohm} \times 20\text{mA} = 11.5V$)

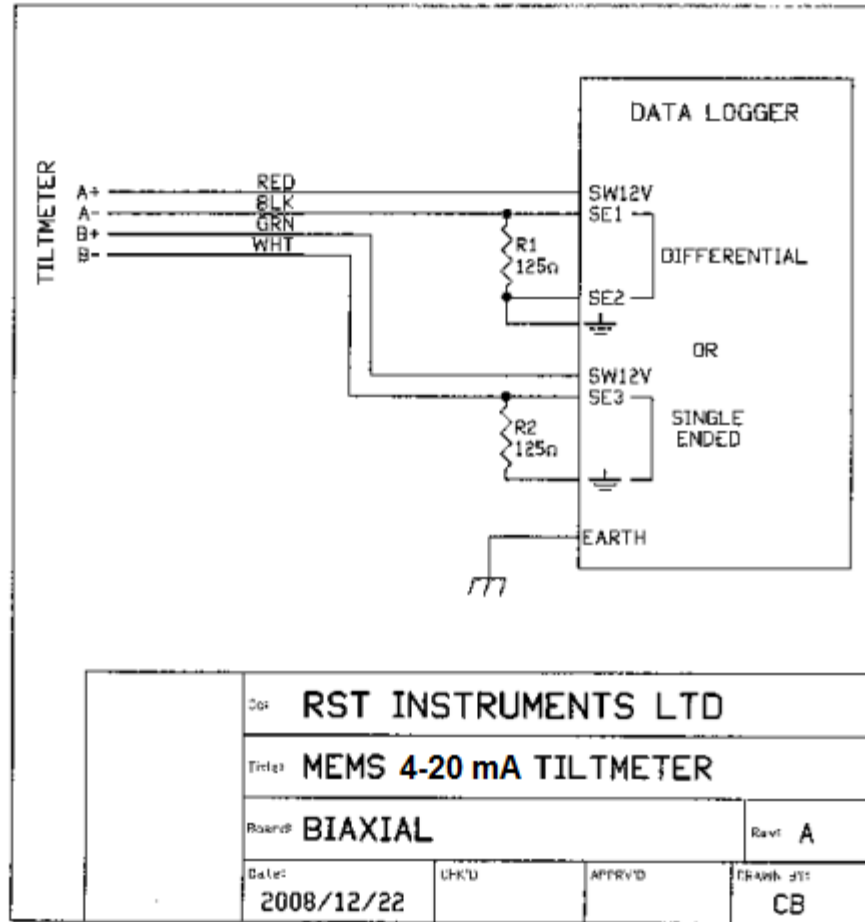


Figure 5 - 4-20mA Tiltmeter Electrical Schematic

2.3.3 Digital Bus Tiltmeter Electrical Connection



Figure 6 - Digital Bus Tiltmeter Electrical Connections

Tiltmeter	Wire Color
V+	Red
Gnd	Black
A+	Green
B-	White

2.4 ANALYZING THE DATA

Each tilt meter is identified by a Serial Number, and has a corresponding Calibration Certificate. See Figure 5 for a sample calibration certificate. The sensing principle of the MEMS tiltmeter is that of an accelerometer with the sensitive axis is oriented horizontally. The measured phenomenon is then the component of gravity transverse to the sensitive axis, i.e.

$$a = g \sin(\alpha)$$

Commonly, tiltmeter data are interpreted as linear motion – i.e. rotation about a presumed radius gives an equivalent motion. In many cases, where the ultimate variable of interest is lateral displacement at some presumed radius due to rotation, the accelerometer result can be simply rescaled, i.e.

$$x = r \sin(\alpha)$$

$$= \frac{r a}{g}$$

In the case of a uniaxial MEMS tilt beam, r is the beam length. For tiltmeter on rigid bodies, the radius must be chosen with some care.

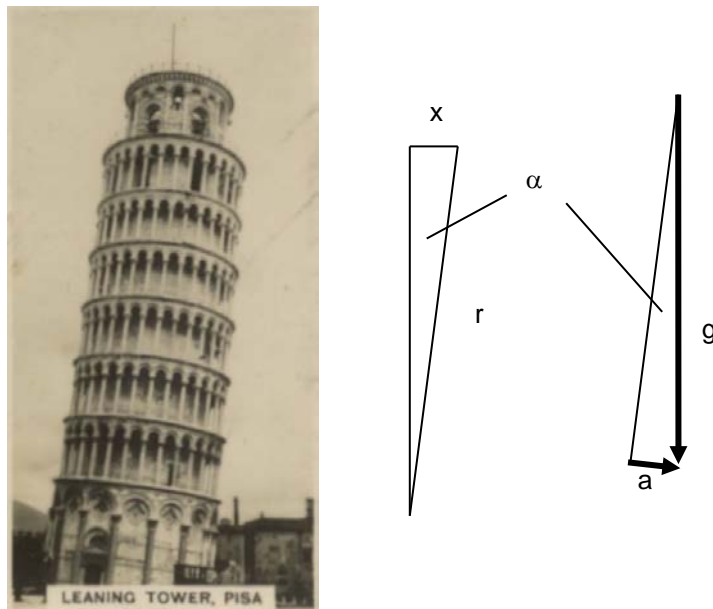


Figure 7 - Tilt Data Interpretation

In cases where the actual angle is sought, the arcsine function or a polynomial equivalent may be used:

$$\alpha = \arcsin(a/g)$$

It should be noted that measuring “dynamic tilt” may be a concept error: the lateral dynamic accelerations may exceed the tilt accelerations

3 Specifications

3.1 ENVIRONMENTAL	
Operating temperature	-20°C to +50°C
3.2 ELECTRICAL	
Sensor	One/Two MEMS Tilt Sensor
Range	+/- 15 ARC Deg Standard
Resolution	1 ARC Second
Null Repeatability	±10 ARC Seconds
Signal Cable	22 Gauge Shielded Twisted
Datalogger	Campbell CR-1000/CR8X0
Portable Readout Unit	IC6800S or Current meter with 9-24V supply

MEMS Biaxial Tiltmeter

Customer: RST Instruments Ltd.
 Order Number: Q012345
 Model Number: IC6080
 Serial Number: **EM1234**
 Calibration Date: 14-Apr-10
 Cable Length: 1 m
 Cable Type: EL380006

Wiring:	Colour	Function
	Red	Voltage+
	Black	Ground
	Green	A Axis +
	White	A Axis -
	Orange	B Axis +
	Blue	B Axis -

References: Inclinator Frame RST-06
 Digital Multimeter HP34401A s/n: US36053118
 Referenced Annually To National Standards.

A-Axis

Applied Degrees θ	Applied Sin θ	Tiltmeter Output (Volts)	Calculated Sin θ
15	0.2588	4.302	0.2587
10	0.1736	2.944	0.1736
5	0.0872	1.566	0.0872
0	0.0000	0.177	0.0001
-5	-0.0872	-1.211	-0.0869
-10	-0.1736	-2.592	-0.1735
-15	-0.2588	-3.957	-0.2591

$$\text{Sin } \theta = m(V-b)$$

$$m = 0.062697$$

$$b = 0.17555$$

B-Axis

Applied Degrees θ	Applied Sin θ	Tiltmeter Output (Volts)	Calculated Sin θ
15	0.2588	3.933	0.2591
10	0.1736	2.569	0.1736
5	0.0872	1.185	0.0869
0	0.0000	-0.205	-0.0002
-5	-0.0872	-1.594	-0.0872
-10	-0.1736	-2.972	-0.1736
-15	-0.2588	-4.330	-0.2587

$$\text{Sin } \theta = m(V-b)$$

$$m = 0.062658$$

$$b = -0.20218$$

Calibrated By: C. Guilbeault

Figure 8 - Analog Tiltmeter Calibration Certificate Sample

MEMS Biaxial Tiltmeter - 4-20mA Output

Customer: RST Instruments Ltd.
 Order Number: 200123
 Model Number: IC6652
 Serial Number: **EM1234**
 Calibration Date: 8-Oct-15
 Cable Length: 1m
 Cable Type: EL380004

Wiring:	Colour	Function	
	Red	Supply A+	(9-24 V Input)
	Black	Current A-	(4-20 mA Output)
	Green	Supply B+	(9-24 V Input)
	White	Current B-	(4-20 mA Output)

References: Inclinometer Frame RST-07
 BK Multimeter SN# 124A15161
 Referenced Annually To National Standards.

A-Axis

Applied Degrees Θ	Applied Sin Θ	Tiltmeter Output (mA)	Calculated Sin Θ
15	0.2588	20.005	0.2589
10	0.1736	17.367	0.1735
5	0.0872	14.695	0.0871
0	0.0000	11.999	-0.0001
-5	-0.0872	9.309	-0.0870
-10	-0.1736	6.638	-0.1734
-15	-0.2588	3.991	-0.2590

$$\text{Sin } \Theta = m(l-b)$$

$$m = 0.032341$$

$$b = 12.001$$

B-Axis

Applied Degrees α	Applied Sin α	Tiltmeter Output (mA)	Calculated Sin α
15	0.2588	20.003	0.2587
10	0.1736	17.379	0.1738
5	0.0872	14.697	0.0872
0	0.0000	12.004	0.0001
-5	-0.0872	9.296	-0.0874
-10	-0.1736	6.630	-0.1736
-15	-0.2588	3.991	-0.2588

$$\text{sin } \alpha = m(l-b)$$

$$m = 0.032318$$

$$b = 12.000$$

Calibrated By: W. Mok

Figure 9 - 4-20mA Tiltmeter Calibration Certificate Sample

MEMS Uniaxial Tiltmeter - Digital Bus Output

Customer: RST Instruments Ltd
 Order Number: Q012345
 Model Number: **IC6554**
 Serial Number: **E M548**
 Calibration Date: 10-Feb-11
 Cable Length: 1m
 Cable Type: M12

Wiring:	Colour	Function	Pin	Colour	Function
	Brown	Voltage +	1	Red	Voltage +
	White	Ground	2	Black	Ground
	Blue	RS485 A +	3	Green	RS485 A +
	Black	RS485 B -	4	White	RS485 B -

References: Inclinator Frame RST-06
 Referenced to National Standards Annually

Applied Degrees θ	Applied Sin θ	Swing Right Sin θ	Swing Left Sin θ	Mean Sin θ	Error Sin θ
15	0.25882	0.25881	0.25882	0.25882	0.00000
10	0.17365	0.17364	0.17366	0.17365	0.00000
5	0.08716	0.08713	0.08715	0.08714	0.00002
0	0.00000	0.00001	0.00001	0.00001	-0.00001
-5	-0.08716	-0.08717	-0.08715	-0.08716	0.00000
-10	-0.17365	-0.17365	-0.17364	-0.17364	0.00000
-15	-0.25882	-0.25882	-0.25879	-0.25881	-0.00001

Calibrated By: _____

Figure 10 - Digital Bus Tiltmeter Calibration Certificate Sample

4 Contact Us

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