RST INSTRUMENTS LTD.

MEMS Portable Tiltmeter System Instruction Manual

Model ICTS0004, IC6800S Readout

RST Instruments Ltd.
11545 Kingston St.,
Maple Ridge, B.C. Canada V2X 0Z5
Tel: (604) 540-1100
Fax: (604) 540-1005
Email: info@rstinstruments.com
Website: www.rstinstruments.com

MEMS Portable Tiltmeter System Model ICTS0004, IC6800S

Product: MEMS Portable Tiltmeter System Instruction Manual
Model ICTS0004, IC6800S

Document number: ICM0063C
Revision: C
Date: September 11, 2012

Table of Contents

LIST OF FIGURES

1 INTRODUCTION

The Model ICTS0004 Micro-Electro-Mechanical System (MEMS) Portable Tiltmeter System permits the precise measurement of changes in tilt of engineering structures. The system consists of three components, (1) individual Tiltmeter Monuments which are secured to the structure at points of interest, (2) the MEMS Portable Tiltmeter which indexes the Tiltmeter Monuments in a repeatable manner and senses the tilt via MEMS tilt sensor/s (uniaxial/biaxial), and (3) a MEMS Portable Tiltmeter Readout to display the Tiltmeter data.

1.1 TILT MONUMENT

The Tilt Monuments are precision-machined stainless steel or brass plates with 4 indexing studs located 90 degrees apart on a 100 mm diameter circle. Each stud is numbered from 1 to 4 (see figure 2). The Tilt Monuments are fastened to the structure of interest by methods which depend on the material of the structure. Both stainless steel and brass materials are resistant to corrosion in many construction environments.

1.2 MEMS PORTABLE TILTMETER

The MEMS Portable Tiltmeter is a precision stainless steel instrument which can be indexed precisely and in a repeatable manner on the Tiltmeter Monument. It can be fixed in 4 positions which together permit the tilt of the instrument to be sensed along 2 orthogonal axes with normal and reversed readings which permit cancellation of face error. The measurement is made via a MEMS tilt sensor/s, which converts the tilt measurement to a highly precise analog signal.

1.3 MEMS PORTABLE TILTMETER READOUT

The Tiltmeter is typically read via the RST Model IC6800S MEMS Portable Tiltmeter Readout. All Readouts are configured to display the data in engineering units of (sine θ x 10^3).

Figure 1: MEMS Portable Tiltmeter & MEMS Portable Tiltmeter Readout

2 TILTMETER MONUMENT INSTALLATION

In order for the Tiltmeter installation to be successful, the Tiltmeter Monument must be rigidly connected to the structure of interest, free of long-term adverse factors including corrosion, form distortion, and impact damage.

2.1 FRESH CONCRETE HORIZONTAL

In a typical installation on new concrete, the following procedure is suggested:

After the concrete has been placed and leveled in the location of interest, work the Tiltmeter Monument into the concrete until the top surface of the plate is level with the concrete surface, with the diagonal stud pairs aligned with the desired measurement axes, ideally with the orientation of the studs consistent across the entire site.

If desired, increased strength of placement may be achieved by fitting countersunk brass screws through the mounting holes and tightening nuts on the back side, leaving 50 mm of threads exposed below the Tiltmeter Monument.

Ensure that no concrete is permitted to remain on the top of the Tiltmeter Monument, especially on the studs. If necessary, carefully clean the studs with a damp cloth. Ensure that the Tiltmeter Monument is protected from damage during curing, form stripping, and subsequent operations.

2.2 FRESH CONCRETE VERTICAL

In order to avoid damage during form stripping, it is suggested that a separate form segment be built in such a manner that the Tilt Monument is stripped separately. The separate form segment can be drilled to suit the studs and greased to facilitate the stripping of the form and subsequent cleanup of the Tiltmeter Monument. The separate form segment may ideally be recessed slightly below the main vertical surface to give enhanced safety from damage.

The Tiltmeter Monument should be mounted with its face vertical and the axis from stud 1 to stud 3 vertical.

2.3 EXISTING CONCRETE

The Tiltmeter Monument may be attached to existing concrete using mechanical fasteners, using grout, or a combination of methods. Mechanical fasteners require precise concrete drilling and/or a central adapter plate. The effectiveness of grouts, either cement-type or chemical, is highly dependent on the concrete condition, surface preparation, site conditions and other variables.

Figure 2: Tilt Monument Plate

3 READING METHOD (IC6800S)

Tilt data is displayed by pushing the button A (for axis A of uniaxial and biaxial tiltmeter) and button B (for axis B of biaxial tiltmeter) on the front of the readout (IC6800S) (see Figure 3). The Indicator will display the data in engineering units (sine θ x 10^3). The readout has a built-in low pass filter to block vibrations. The reading will take approximately 3 seconds to stabilize. To conserve battery power, the Indicator will turn itself off after approximately 90 seconds.

Figure 3: MEMS Portable Tiltmeter readout & connector

Data should be taken on standard horizontal installations for all 4 axes as follows:

Position the Tiltmeter on the Tiltmeter Monument so that two diagonally opposite studs (ie, stud 1 & stud 3) are in contact with the long alignment bar, and one of the alternate studs (ie, stud 2) is in contact with the short alignment bar (See Figure 4). Each position is named for the visible unused stud (ie, stud 4). Repeat for all 4 positions.

For a Vertical Tiltmeter Monument, only 2 positions can be read on each end of the Tiltmeter, always with the Tiltmeter approximately vertical.

Figure 4: MEMS Portable Tiltmeter alignment bars

4 DATA REDUCTION

The data is reduced by calculating the average change for an opposed pair of positions, i.e.:

$$\Delta \sin \theta_{1,3} \times 10^3 = \frac{(\sin' \theta_1 \times 10^3 - \sin' \theta_3 \times 10^3) - (\sin \theta_1 \times 10^3 - \sin \theta_3 \times 10^3)}{2}$$

and

$$\Delta \sin \theta_{2,4} \times 10^3 = \frac{(\sin' \theta_2 \times 10^3 - \sin' \theta_4 \times 10^3) - (\sin \theta_2 \times 10^3 - \sin \theta_4 \times 10^3)}{2}$$

where:

$\sin \theta_1 \times 10^3$ = the raw initial data with stud 1 visible

$\sin' \theta_1 \times 10^3$ = the raw new data with stud 1 visible

$\sin \theta_2 \times 10^3$ = the raw initial data with stud 2 visible

$\sin' \theta_2 \times 10^3$ = the raw new data with stud 2 visible

$\sin \theta_3 \times 10^3$ = the raw initial data with stud 3 visible

$\sin' \theta_3 \times 10^3$ = the raw new data with stud 3 visible

$\sin \theta_4 \times 10^3$ = the raw initial data with stud 4 visible

$\sin' \theta_4 \times 10^3$ = the raw new data with stud 4 visible

e.g.: A tilt monument plate with raw initial data of:

$\sin \theta_1 \times 10^3 = 15.1$
$\sin \theta_3 \times 10^3 = -14.9$

and new raw data of:

$\sin' \theta_1 \times 10^3 = 17.6$
$\sin' \theta_3 \times 10^3 = -17.4$

$$\Delta \sin\theta_{1,3} \times 10^3 = \frac{(17.6 - [-17.4]) - (15.1 - [-14.9])}{2}$$

$$\Delta \sin\theta_{1,3} \times 10^3 = 2.5$$

$$\Delta \sin\theta_{1,3} = 2.5 \div 1000 = 0.0025$$

$\Delta\theta_{1,3} = \arcsin(0.0025) = 0.14°$ = change in angle θ along studs 1-3 between initial data and new data

The same procedure can be repeated for data along the stud 2,4 axis.

5 CARE AND MAINTENANCE

The Tiltmeter should be treated gently like any precision instrument. In particular, care should be taken to avoid any bumps or impact, both to protect the MEMS tilt sensor and to avoid denting or distorting the machine plates and alignment bars. Any dust or grit on the Tiltmeter Monuments should be carefully wiped off with a damp cloth prior to readings to avoid scratches on the Tiltmeter Monument or base plate.

The connectors should be kept clean and dry to avoid electrical errors.

A reference Tiltmeter Monument should be maintained in a convenient, stable location to permit the instrument to be regularly checked.

The Portable Tiltmeter Readout needs to be replaced with a 9V battery if there is a low or no signal.