OPERATORS MANUAL

DELTA SIGMA Ultrasonic instrument

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Δσ

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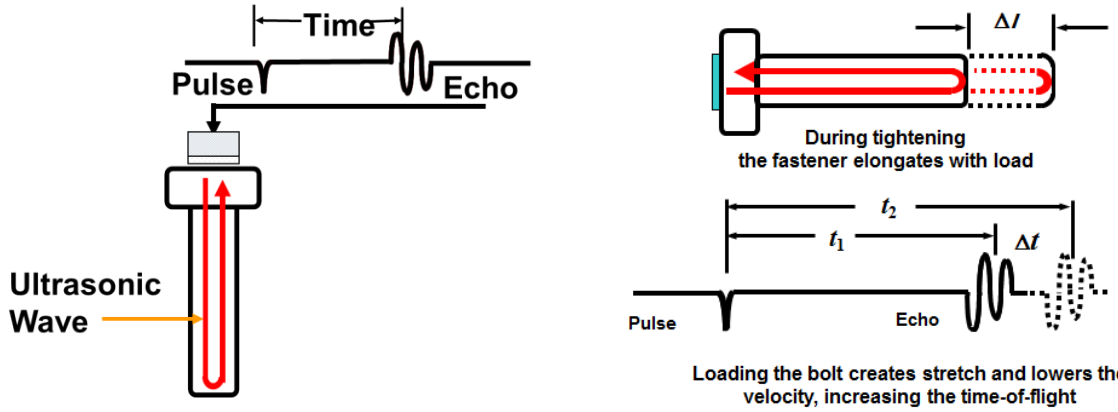
THE RESONIC INSTRUMENTS
Delta Sigma Ultrasonic Bolt Load Measurement Instrument

1. INTRODUCTION

Load in a bolt is determined ultrasonically by measuring the change in the time-of-flight (TOF) of an ultrasonic wave through a bolt as the bolt is loaded (tightened). This technology was developed in the early '70s to keep cryogenic joints together in rocket engines and is still used for that purpose by most of the world's engine and satellite builders.

When a fastener is loaded (tightened) or unloaded (operational loss or disassembly) the ultrasonic TOF will change due to the change in load (tension stress) in the fastener. It is this change in TOF that we use to calculate load, by storing a "Reference" length or time and calculate the difference between that "Reference" time and the "as found" time. This delta time is directly proportional to the load or stretch in the fastener.



The intuitive software was created specifically for the bolting industry, the automatic echo detection algorithm has been developed with input from the most experienced users and electronic developers in the bolt tightening industry! Communicate to any PC with a standard USB connection.

On receipt of your DS the batteries should be charged, plug in the included charger, turn unit on and leave charging for 12hrs. After 5 minutes of inactivity the display will shut off but the charger will stay on, it will shut down when fully charged. The blinking red LED designates charging mode.

The charger/battery system is designed for long, safe battery life, the charger will not over charge and the unit will re-set if a high current operation is call with low batteries.

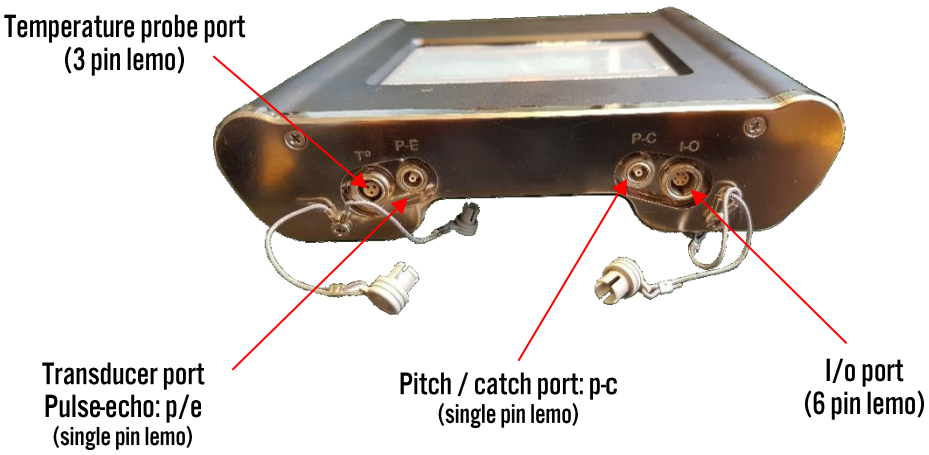
➡ **We highly recommend users to watch instruction videos, visit www.momento.se**

1.1 DS

The Δσ pulse-echo ultrasonic time-of-flight measurement device; measures, displays, stores and transfers bolt load data. The Delta Sigma uses a sealed colour touch screen for all operator I/O. All data is entered and presented on a 4.3” colour, resistive touch screen. Data and digital signal traces are stored for later display and transfer. The unit has automatic temperature compensation from an included magnetic temp probe. For data integrity, the DS memory is divided into a secure sector (A) for all bolt data and a public sector (B) for transfer via USB to a computer. The unit incorporates the latest smart-charge system; it will charge through an external power supply or the waterproof micro USB connector from any standard 5V USB device, battery pack or power supply

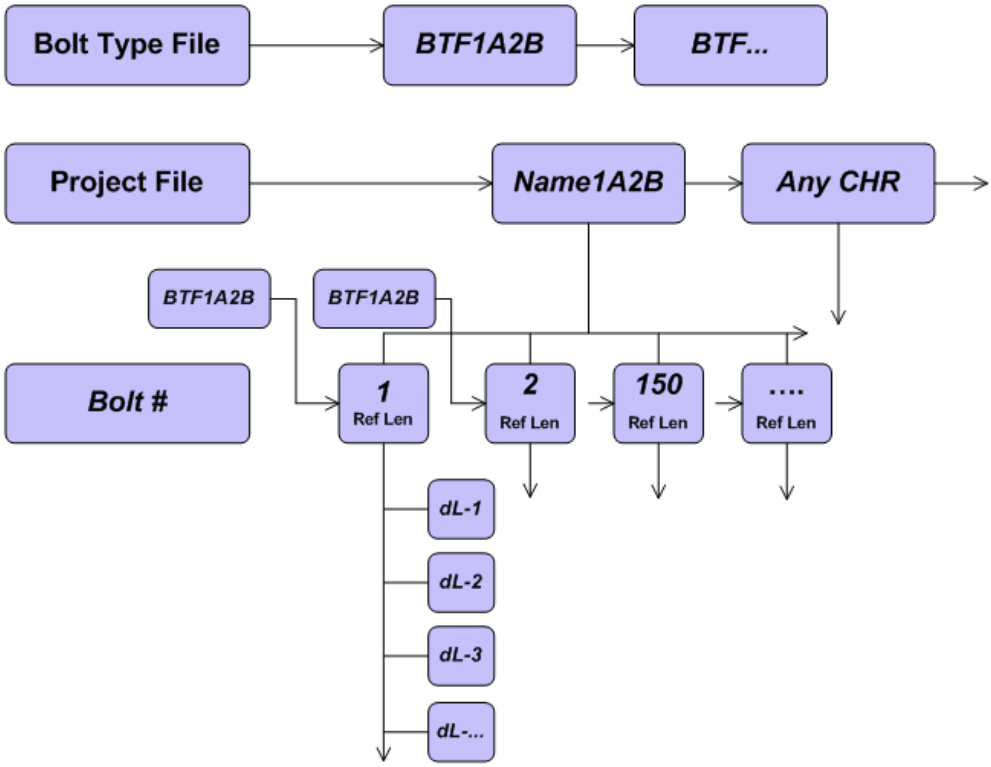
2 OPERATION OF THE DS

2.1 OVERVIEW

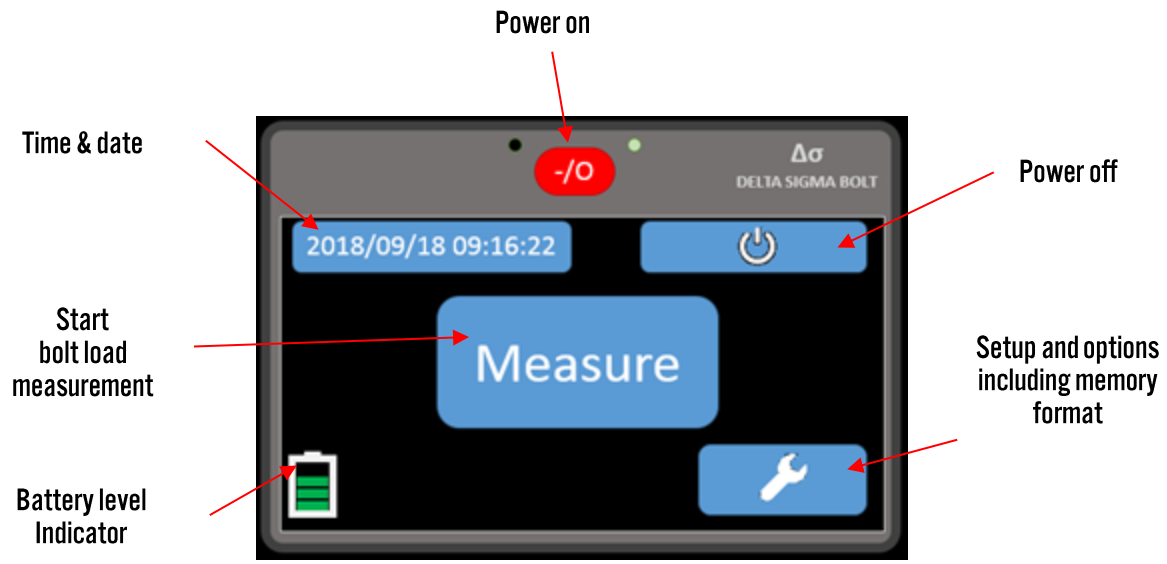


2.2 PROJECT / BOLT DATA FILES

A joint is a structure that contains a collection of bolts whose purpose is to hold the structure together through the combined clamping force of the bolts on the joint. These bolts can all be the same size or may be of different diameters and lengths (types). The data structure used in the DS is setup to accommodate this logical bolted joint structure. The Project file includes the basic joint information and stores the Length, Stretch and Load data.
The DS requires geometric, ultrasonic and material information specific to a type of bolt to determine the load ultrasonically. This information is stored in the Bolt Type File. A bolt type must be named and entered for bolts with different geometries, grip lengths and/or loading requirements.



START UP SCREEN



On receipt of your DS the batteries should be charged, plug in the included charger. A flash symbol will replace the battery status bar showing that the unit is charging. Turn unit on and leave charging for 12hrs. After 5 minutes of inactivity the display will shut off but the charger will stay on, it will shut down when fully charged. The blinking red LED designates charging mode.

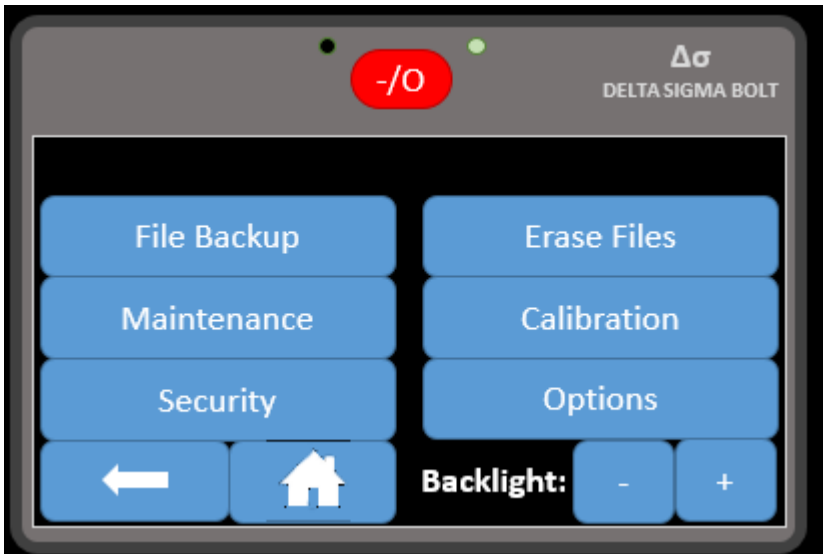
Above is the DS start up screen. The time can easily be set by pressing the active Time & Date button. Here you can easily adjust the time and date if you are in another time zone
The instrument is now ready to use.

In order to start measuring, connect the transducer and the temperature probe into the correct port and press the **MEASURE** button. (See Operations Section)

To shut off the instrument, press the **POWER OFF** button, and then press **YES** in order to power down the instrument. All data is automatically stored, so there is no risk of loosing data by powering down the instrument.

2.3 SETUP SCREEN

On your first screen you have an option to press **SETUP** in order to configure the Delta Sigma.



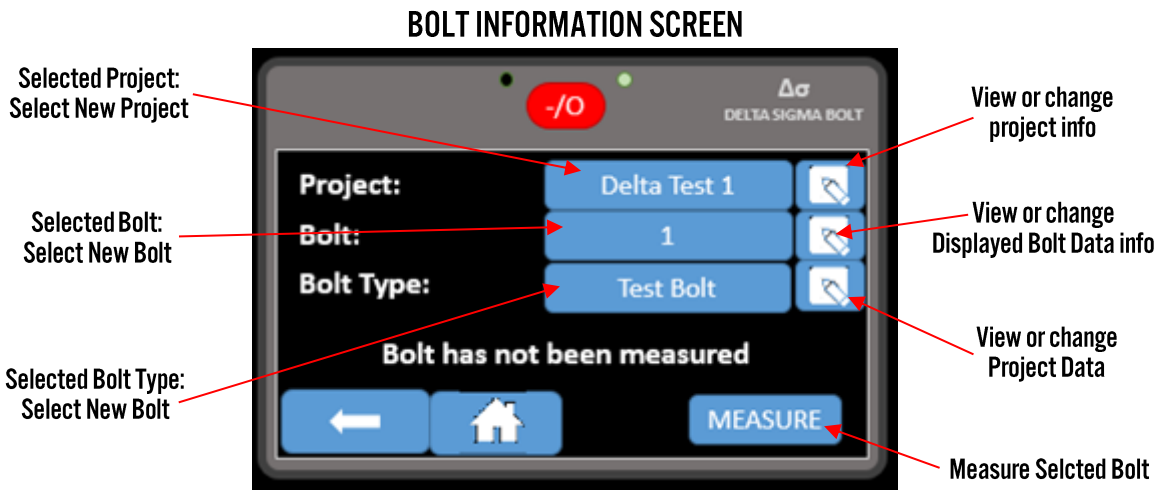
- **FILE BACKUP:** You can backup your files. By entering this option you can select what projects you need to backup to drive B
- **ERASE FILES:** If you need to delete all stored data, Choose the the data you want to delete. If you then press **YES**, the data will be deleted. This operation cannot be reversed.
- **MAINTENANCE:** Factory settings only: password required.
- **CALIBRATION:** Enter this option if you want to calibrate your DS
- **SECURITY:** Lock-Out function for bolt-data settings. Password is: 1 2 3 4.
- **OPTIONS:** In this screen you can chose operational mode.
  Bolt Type Mode: Chose "Expert" mode if you want to work with "Master Bolt" covered in the "Measurement process section".
  Manual Scope Mode: You need to enable this in order to use the ADJ-function covered in the "Measure bolt section"

The DS will not allow dual access to the Public drive memory, so The DS will not read-write to the memory if the USB is connected to a PC.

You can also adjust the backlight brightness of the screen by pressing the plus and minus button.

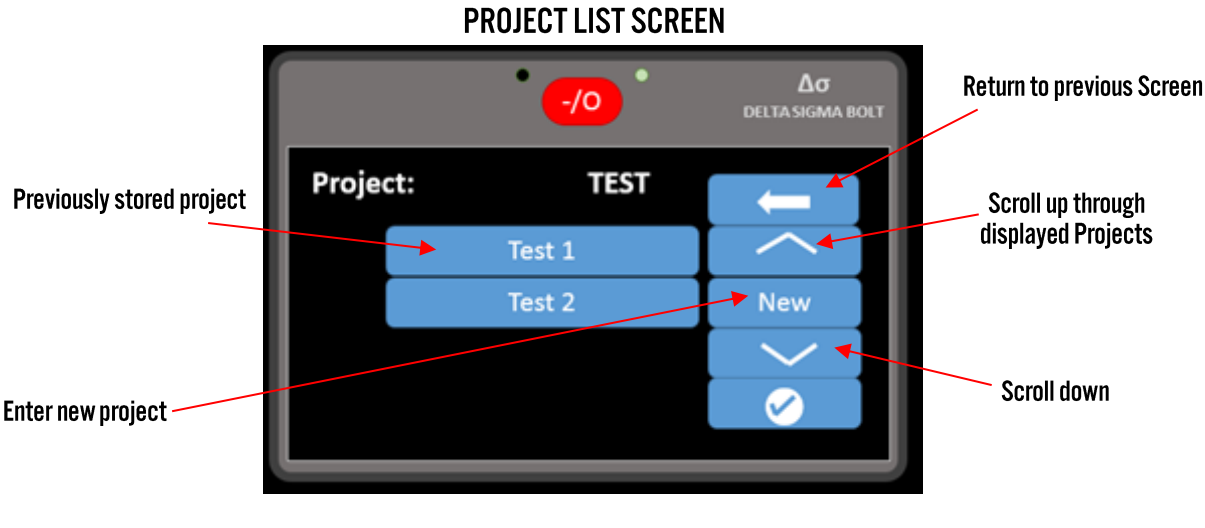
2.4 MEASUREMENT PROCESS

The DS will automatically continue the previously run project. If there are no projects stored in the DS, the screen will show "No projects" before going to the Project List screen as shown on page 8.



If this is your current project, press the **MEASURE** button.

To select a different project or start a new project, press the Selected Project button. You now enter the Project List Screen



Here all previous projects will be listed. If there are no projects stored in the DS, the page will be empty like shown on the picture above, except for the "Operation Subsea" button. Select the project you are working on or to start a new project by pressing the **NEW** button. You will then enter the Project Data Screen as shown on the next page.

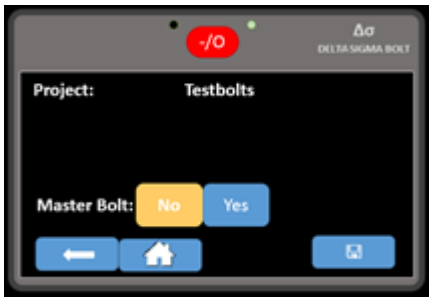
NEW PROJECT SCREEN

Enter Project Name and confirm by pressing **ENTER**.
You then get a question if you really want to create a new project or not. If you do, press **YES**. If you do not, press **NO** and you will return.

Enter Operators name and confirm by pressing **ENTER**.

Choose Units and press **NEXT**.

Enter comments, if any. Once you press **SAVE** button the project is saved.
If you want a short report: Press short
If you want a long report: Press long
All data is stored in the DS so this is changeable. This can be changed at a later stage.



If Expert mode is enabled, the “Master Bolt Option” that can be used to speed up the initial length reading process.
By setting this to YES, if the first bolt you enter is “Bolt 000”, the unit will use this as the “Master Bolt”.
The unit will use the receiver settings for the master bolt for all following bolts. NB: This is only to be used if the bolt group is homogenous.

Choose bolt type or enter a new type by pressing the empty Bolt Type: button, and then **NEW**.

If you assign or create a new bolt type: Name the new type and press **ENTER** to continue. You will then get a question if you want to create a new bolt type. Press **YES**, if you want to stop press **NO**.

Set bolt and measuring properties. 5MHz is standard for most magnetic transducers. 7,5MHz is standard for most glue-on transducers. If the bolt material is listed, select it and you can press **SAVE** or you can press the **NEXT** button for options shown below.

Stress and Temperature Factor and details are default values from material choice. The SF and TF of the selected material in screen 1 will appear. Temperature and Stress Factors are listed in Appendix A for specific materials.

To display load, the calculated or calibrated stiffness of the bolt is entered here. Use the “Calc” button to calculate the “Load Factor”, see Appendix C.
“Load Factor” can also be calculated manually, see Appendix E. Press **NEXT**.

INTCP (Load Intercept) is used if you want to calibrate your bolt in a tensile machine typically starting at 50% of the target load.
DAC 0% & DAC 100%: The DS will output a 0-10V DC analog signal from the I/O port. The value you enter for 100%, for example 0,1mm, means you will have 10V analogue output at 0,1mm elongation Press **NEXT**.

Enter limits to turn on internal buzzer and digital SSR in I-O port.

The velocity factor of the selected material in screen 1 will appear.
The material velocity for different bolt materials is in Appendix A. Press **NEXT**.

Enter the number of pulses and mode and save the bolt type by pressing the **SAVE** button. You will return to the Bolt Information Screen.

The number of pulse cycles used to excite the transducer is a function of transducer frequency and size. For most applications 2 cycles is sufficient. For very long fasteners, large diameter, low frequency transducers and difficult materials, i.e. precipitation hardened alloys; more cycles of excitation may be required.
Do not use the “Pitch/Catch”.

Now, the project is named, the bolt type has been assigned to the bolt, you are now ready to start measuring bolts.
This is the main bolt reading entry screen.
Press the **MEASURE** button to start.

2.5 MEASURE BOLTS

You are now ready to do measurements.
Attach the transducer to the bolt. Make sure to apply a thin layer of ultrasonic couplant between the bolt and transducer and carefully rock the transducer onto the center of the bolt head or end. Then press **MEASURE**.

Please note: There can be no air gap between the transducer and the bolt. Ultrasound do not travel in air.

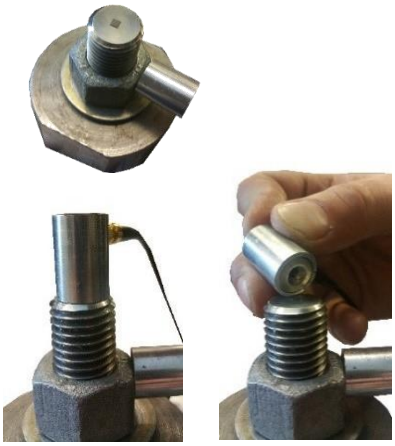
If the bolt surface has protruding marking, this must be grinded down or otherwise removed. Please see YouTube video on bolt ends and surface roughness.

If no temperature probe is attached, press the temperature button and manually enter the temperature. Then press **CONTINUE**.

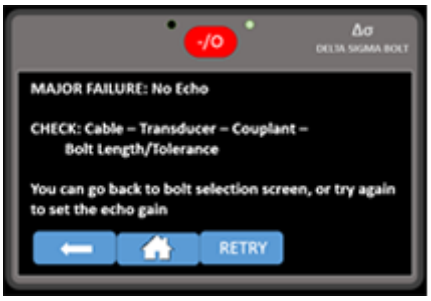
Standard Magnetic Transducer

Let the instrument work for a few seconds while it determines the best echo peak for this bolt. The LED-light will flash red/green while working.

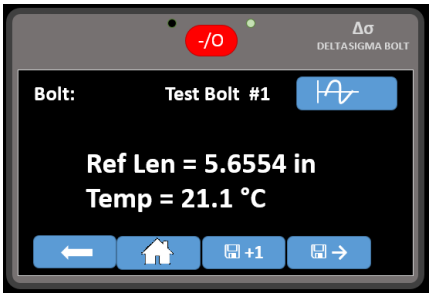
In addition to the standard magnetic transducers, Glue-On transducers are available. The bolt end finish requirements are the same for Glue-Ons as for the standard transducers. Glue the transducer to the center of the bolt according to procedure. Then place the probe so that the connector pin touches the transducer. The rest of the procedure is identical to standard magnetic transducers. See Appendix B for additional finish and gluing information.



If the DS-instrument fails to find a signal from the bolt, this error message will show. Please check if the cable is attached to both the transducer and the instrument. Then check the transducer to see if it is damaged. Apply more couplant and verify the bolt information. Then hit "**RETRY**".

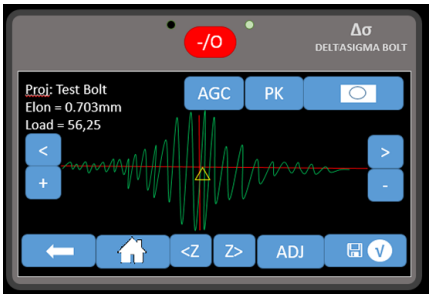


If you are using standard settings and the Ref Len is within ~4-5% of the physical measured length, the signal should be acceptable for you to accept the reading by pressing the **DISK+ARROW** button. Pressing **DISK+1** button, saves the current bolt measurement, and automatically moves the measurement to the next bolt (increment). Aka. "Next bolt" function.



You can also view the actual echo graph by pressing the **SCOPE** button.

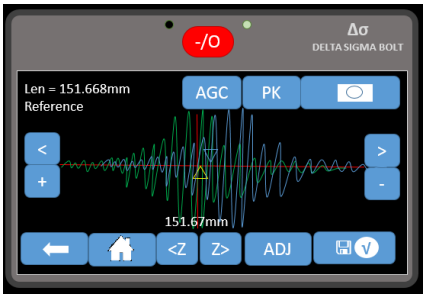
- + - window/signal expansion – compression
- > < Move trace L or R so select different echo packet.
- **AGC** Automatic Gain Adjustment. If this button flashes red, press it.
- **PK** New signal acquisition
- **<Z – Z>** Zero crossing selector (Δ), chose different timing zero crossing
- **STORE** will save the scope trace for later viewing – all Ref Len scope traces are auto stored
- **ADJ** <u>If enabled</u>, this will let you manually set the oscilloscope mode.
- **SAVE AND CHECK** will store time reading and receiver settings.



Your Zero Load (Ref-Len) measurement is now done and you are now ready to do more Ref-Len measurements on other bolts or to start measuring elongation.
The DS automatically goes to ELON screen, **DONE** will store the Elon (tightening performed right after tightening) or **BACK** will not store the first Elon but put you back in the main bolt screen.
When you are about to do the elongation measurement, select the bolt and you will see the Elongation window.

In the Elon screen, the elongation will be displayed in real-time as shown.

You can also view the elongation in scope mode by pressing the **SCOPE** button. You will see the graph move real-time, all with the functionalities as described above. The Zero-measurement scope trace will be displayed as a blue shadow print during the elongation as shown on the picture above.



Once you have reached the required elongation, you press **SAVE AND CHECK** the elongation data is stored in the DS.

Operational Discussion

The DS will search and find the largest amplitude echo packet returning from the end of the fastener in the time window (length) defined in the Bolt Type. Usually, when a bolt is stressed the amplitude of the signal will be lower. In Ref Len and Elon screens, if the signal is lower than amplitude threshold (white horizontal line or the stored Blue (Ref Len) stored reference trace), pushing **AGC** (automatic gain control) will bring the signal behind the reading up to the correct level.
If the fastener has other features in the end; hex wrench recess, lifting hole, long and thin (large L/D), etc., you may see other reflections before or after the true end reflection. Depending on the profile of the end region, you may want to adjust the receiver to read the echo time off the recess feature or go by it to the end reflection. In **SCOPE** mode, the command keys around the base line of the trace, expand and compress the trace to see more of the bolt. If your reading is too long (on mode conversion) or too short (on reflecting surface before the end of bolt), you can expand or contract the window to see more or less of the bolt, move the screen using: < and >. Putting a new wave packet in the screen and pressing **PK** the DS will go through the "select best peak" algorithm on only the packet in the scope screen. When you press **SAVE AND CHECK**, the reading and the new receiver settings are stored in the data file. In most standard bolts, you may never experience these geometry-based issue, the first echo back in a fastener is the end of the bolt.

2.6 MEASURE NEW BOLT

When the **ACCEPT** button is pushed from Bolt Reading or Scope screen, the program returns to the Bolt Info screen.

From here the entered data in each field can be inspected by pushing the Button at the end of each entry button.

The current Bolt can be read again by pushing the **MEASURE** button again, or a new bolt can be read by pushing the displayed number button.
This will bring up the new bolt screen; the next bolt in sequence will be queued, pushing the **OK** button will bring the program back to the Bolt Info Screen.

Pushing the **NEW** button will bring the program to the New Bolt Screen.

You can enter any numeric bolt # here and pushing the **ENTER** button will bring you back to the Bolt Info screen, ready to read the new bolt. From here pushing the Bolt Type: button, you can select or enter a new bolt type.

From the Bolt Info screen push the **MEASURE** Button and read data on the new bolt. Repeat bolt data input process.

2.7 EXPORT EXCEL FORMAT DATA FROM THE DS TO A PC

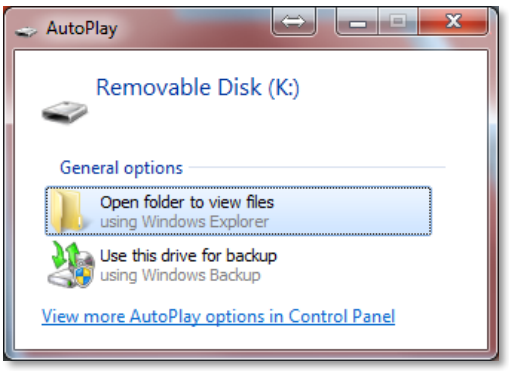
Important notice!

- Once the USB-cable is plugged into the DS, do not enter or change data on the DS.
- The DS will look like a Removable Disk.
- The PC should run on Win7 or later MS Windows version

The DS will write Excel readable files into the public PC formatted USB accessible drive from the system (binary) Project files in the secure drive. Before you connect the DS to your PC, you should make the system bolting data readable. The default setting is **CSV**. Return to the main Bolt menu, choose the project you want to export to your PC and press → button

By pressing the grid button, you create a readable file in the DS public Drive for you to access later. You can generate files from all projects, but you must enter each project to do so.

In the next screen you have the option to choose report type (short/medium/long), pending need for measurement data.

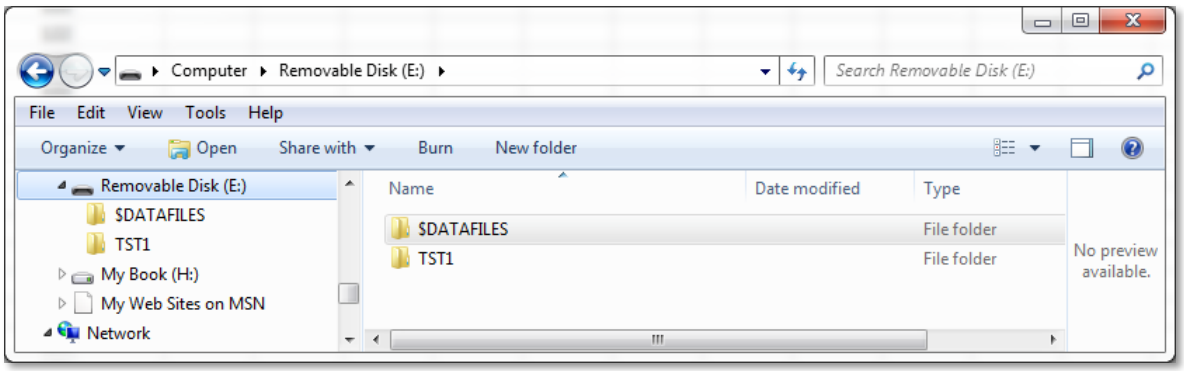


Once you have the Projects in Excel format, plug the provided USB-cable into the DS and your PC. Windows will now recognize the DS as an external hard drive or memory stick. Depending on your PC configuration you should now get a dialogue box like using other external drives (Removable Disk). If not, the DS will show up as an external hard drive in Windows Explorer

NOTE!

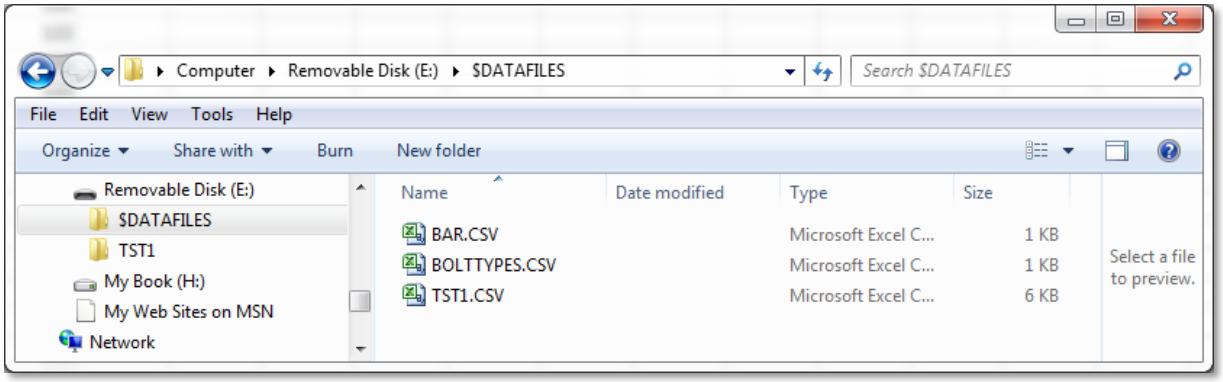
The DS uses 2 – EEPROMs. The second EEPROM is presented to the USB port as a Removable Drive. This visible drive is the 'public' drive, when you plug a USB from a PC into the DS. This public drive appears in Explorer. This drive holds the user data files created by pushing **CSV** in various places of the program and the stored system scope traces for each project in a folder named for that project.

The $DATAFILES folder contains the CSV files for each project and all the Bolt types 'printed' (CSV):



The folder called $DATAFILES contains your generated CSV files information. The other folders are named after your various projects and contain the raw scope data. Do not alter or enter these files, you will lose the stored scope traces, not the bolt data.

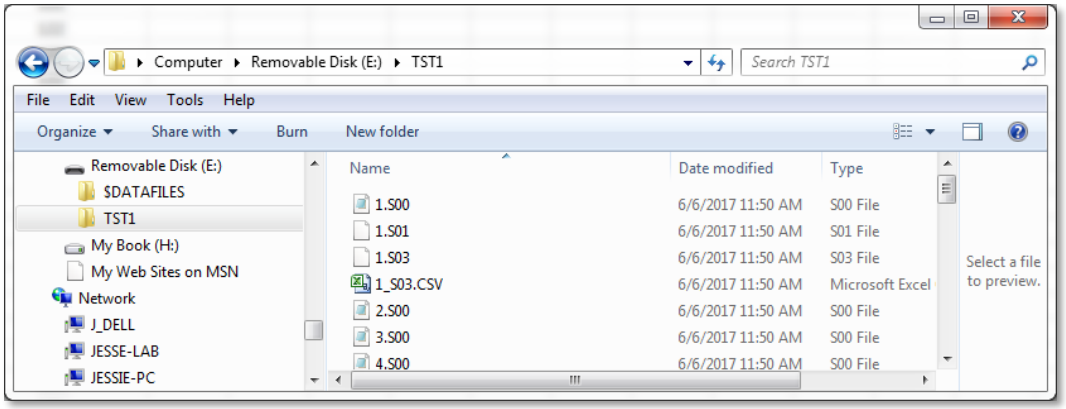
In $DATAFILES:



Copy the $DATAFILES folder from the DS to your local hard drive.

In order to open the files, you need to start MS Excel first and then open document. Then choose "All files" in the document type.
Then go to the file path where you stored the $DATAFILES folder. Find the required document named "project-name".csv. MS Excel will ask you if you want to use "Data using column, tabulators etc.". Press "Next" and then "Complete".

The file will now open as a standard MS Excel file for you to review, print and analyze.
It is not possible to export this excel data back to the DS. That is covered in next section.
Also, in drive B are the system scope traces and the CSV/TSV formatted scope traces:

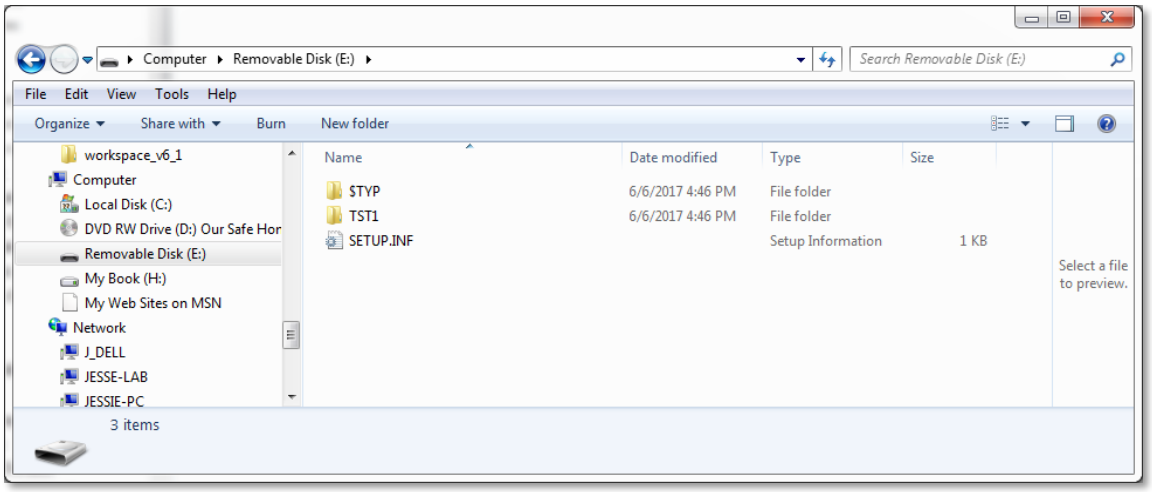


2.8 EXPORT SYSTEM PROJECT DATA FROM THE DS TO A PC FOR DATA BACK UP AND TRANSFER INTO THE SAME OR DIFFERENT DS UNITS

The non-public raw bolt data is stored on drive A, this drive is not user accessible.
In **SETUP** there is a **FILE BACKUP** button. Here you can **BACKUP ALL** Projects and Bolt type files or **SELECT** by touching and highlighting individual Project files from the Project list. The **<MOVE** and **COPY>** button moves the selected Projects to the A or B drive.

To back up the raw project data;

1. Unplug DS from PC
2. Enter **SETUP**.
3. Select **FILE BACKUP**
4. Here you can **SELECT** the individual files or **BACKUP ALL** to write the system data files to the public drive; B.
    a. If you **SELECT** individual project files, be sure to Backup All bolt types!
5. **BACKUP ALL** will also write all system Bolt Type files to B.
6. Return to **MAIN** menu
7. Create back up folder on PC
8. Copy $TYP and all project files from DS to PC folder.
9. Plug USB cable into PC
10. From Computer, Removable Disk (PC generated designator:)



11. From this drive, select all folders and files
    a. The named Project folder now contains all the bolt scope data and the Project data in the PRJ binary file.
    b. The $TYP folder contains all the Bolt Type data.
12. Paste folders to the Back Up folder you have created on your PC
13. Unplug USB cable
14. Go back to **MAIN** and continue.

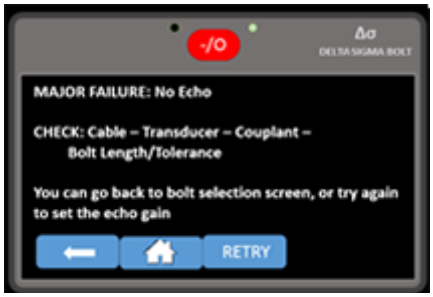
To upload raw data back to DS, reverse procedure.
To **RESTORE** the raw project data;

1. Plug USB cable into PC
2. Bring up DS folders in back up folder on PC
3. From Computer select, Removable Disk (Whatever:): DS drive
4. Copy all files and folders from PC to DS Drive
5. Unplug USB cable
6. From **MAIN** menu select **SETUP**.
7. Select **FILE BACKUP**
8. Here you can **SELECT** the individual files or **RESTORE ALL** to copy the system data files to the secure Drive A.
    a. The DS will overwrite any Project data in secure memory!
9. **RESTORE ALL** bolt Types also.
10. Return to **MAIN** menu

All Project and Bolt type data is ready to call up and re-read.

2.9 IMPORTANT NOTES ON OPERATION OF THE DS SOFTWARE

2.9.1 Receiver is unable to AGC on signal – From the Bolt Info Screen

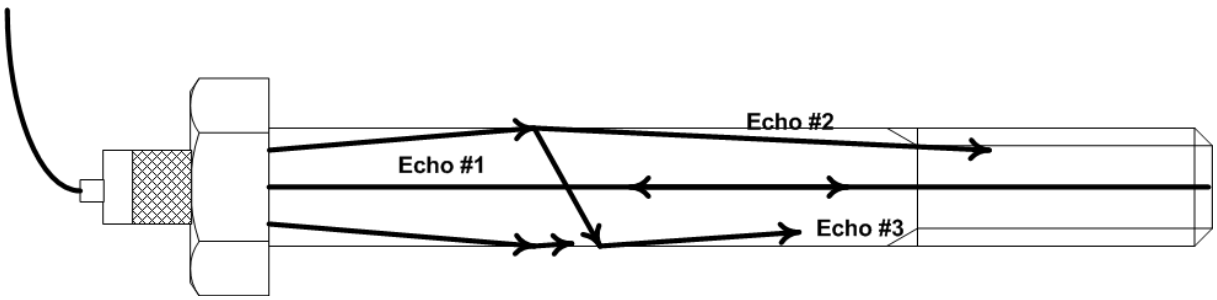


When the **MEASURE** Button is pushed and the receiver setting screen appears, then the program returns to the main menu screen there is something wrong with the ultrasonic connection. Check the Bolt Type File:

- Make sure that the Approximate Length is correct
- Check Cable connection
- Check Bolt/Transducer contact and bolt end finish

2.9.2 Bolt length displayed is <u>not</u> within 2-4% of actual measured length: Mode Conversion

This may be from a property common in long – slender bolts or studs with a solid shank or stud section. The ultrasonic "beam" has a spread angle; this angle is a function of transducer frequency and diameter. The Operational Discussion portion of the Measure Bolts section covers how to move the scope window to re-trigger on the end echo packet that is always in front of the mode conversion packet.



Materials Evaluation/44/April 1986, Glenn M.Light, Narayan R.Joshi, Soung-N.Liuc

3 SPECIFICATIONS & FEATURES:

Intuitive operation

- No buttons, fewer steps, programmable touch pad QWERTY alpha-numeric input
- Creation, storage, retrieval of individual projects (group of fasteners)
- Bolt types for projects (geometry, material, etc.) stored individually for repeated use/retrieval
- Unlimited bolts/readings per project
- Temperature, signal parameters, scope trace and date/time stored with each reading
- Selectable, password protected restricted operating mode; locks selected variables

Data Storage

- Secure data file area – operator controlled public file area
- Pass word protected
- No special PC software required
- Flexible bolt data storage options, no limits on bolts or load data
- Store and display echo traces of every signal for every reading, date/time stored with each reading.

Weight & Dimensions

- Small, lightweight, rugged
- 7x7x1.7 In / 175x175x42 mm
- 3.186 lb / 1445 Grams

Fast digital signal: location, amplitude and threshold detection

- Real time signal tracking: amplitude, peak jumps
- Storage of individual signal parameters for qualitative R&R reading comparison

Connectors

- Lemo 00: ultrasonic and 0B: temperature and I/O communication,
- USB - Rugged, sealed USB micro-B

Display

- 3.8x2.2 in / 97x56 mm
  480x272 - 24bit colour, sunlight readable touch panel display
- -20 to +70°C operating range
- Full touch panel program operation
- Rugged/sealed display module (IP 44)

Temperature transducer

- Class A PT100

Microprocessor

- 32-bit ARM®

A-D

- Single shot
- Time resolution to 0.1ns or better
- 100dB receiver
- Programmable pulser: amplitude, frequency, cycles

Fast A-D and/or dig out control

- Windowing (hi res) analogue output, scaled to SETUP parameters, 0-10V
- Digital, isolated I/O for external control
- SSR switched on programmable limits
- SSR EN50130-4 compliant

Real time oscilloscope trace of echo

- Can be stored with each reading
- Automatic signal acquisition
- Full control of receiver option

Batteries

- 4 sealed 3.4mAH Li Ion 18650 cells, twin smart chargers with SOC monitoring.
- The DS can be sent or carried onboard airplanes as it meets current ITAR/FAA: Lithium Metal Batteries contained in equipment regulations: UN3481, P.I. 967, Section II.
    - Acceptable to all locations.
    - Cells equal to or less than 20Wh; and Batteries
    - equal to or less than 100Wh
    - "…these packages do not require a lithium battery handling label."
- Operating time 20+hrs
- Dual charger inputs
- Fast 9V standard 2.1mm power supply input
- Mini USB charge/operation

Additional Features

- Real time clock – date-time stored with every reading
- Sleep mode and auto shut off
    - Continuous read on bolt
- Power/sleep LED
- Designed and manufactured in the USA

Appendix A

Note: These are approximate average values.

MATERIAL OF BOLT	SONIC STRESS FACTOR	TEMPERATURE FACTOR		SOUND VELOCITY		MODULUS OF ELASTICITY	
		°F	°C	in / sec	mm / sec	psi x 10^6	MPa x 10^3
ISO SPECIFICATIONS R898							
Gr.8.8	0.276	58	104	232000	5892800	29.9	205
Gr.9.8	0.276	58	104	232000	5892800	29.9	205
Gr.10.9	0.274	57	103	232000	5892800	29.9	205
Gr.12.9	0.274	57	103	232000	5892800	29.9	205
MATERIAL SPECIFICATIONS							
4140 STEEL	0.274	56	101	232000	5892800	29.9	205
4340 STEEL	0.285	55	99	232000	5892800	30	207
STS STEEL	0.250	80	144	230000	5840000	29	200
INCONEL	0.296	62	111	225000	5710000	31	214
TITANIUM	0.490	64	115	245000	6220000	16.5	114
ASTM SPECIFICATIONS							
A193 B7	0.280	57	103	232000	5892800	30	207
A193 B16	0.280	57	103	232000	5892800	30	207
A325	0.274	56	101	232000	5892800	29.9	205
A490	0.299	60	108	232000	5892800	29.9	205
A540	0.299	60	108	232000	5892800	30	207
AE SPECIFICATIONS 1038							
Gr.2	0.275	57	103	232000	5892800	29.9	205
Gr.5	0.275	57	103	232000	5892800	29.9	205
Gr.6	0.277	60	108	232000	5892800	29.9	205
Gr.8	0.274	57	103	232000	5892800	29.9	205
Gr.9	0.275	58	104	232000	5892800	29.9	205

Appendix B

Glue-on instructions

1. Bolt end finish for the transducer should be minimum of Ra 0.8 micro-meters.
   Clean the end of the bolt with Loctite cleaner or eq.

2. Place a small amount of glue in the centre at end of the bolt using brush/cocktail sticks or similar device. For normal bolts use Loctite 620 or equivalent. For bolts to be used in high temperatures, use Loctite 638 or equivalent.

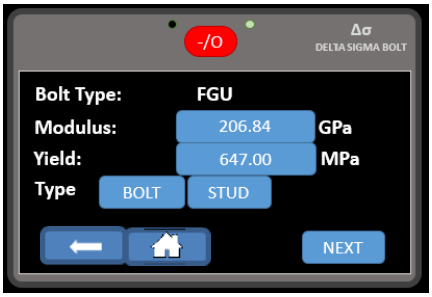
3. Place the transducer on the glue, align the transducer at the centre. Use a pin or a pair of tweezers. Then press the transducer down towards the bolt. Alternatively, one can use scotch tape and place transducer on the glue-side of the tape for easier application of glue and later placing onto bolt.

4. Place a cover of plastic over the newly glued transducer, place a magnet or weight on top of it to let it harden. Leave for 5-10 minutes and remove plastic.

5. The bolt is now ready.

Appendix C - CALC SETUP

Enter the Material Modulus if it is difffernet from the selected Material in Bolt screen. Enter the Yield value of the material. E.g: 8.8 = 640 MPa ; 10.9 = 900 MPa B7 = 724 Mpa (check the material constants with appenidx). NB: It is not necessary to enter Yield value unless %- yield is to be displayed. Choose bolt or stud pending on application.



Enter the geometric values for the bolt or stud.
See Appendix D for geometric terms.
Enter thread pitch or threads per inch.

The Engagement Factor is the percentage of the diameter at the thread or head section that carries/sees the stress from the structure. The default values for a steel-steel standard bolt connection is 0,4 at the head and 0,5 for the nut. For a stud bolt the engagement factor is 0,5 and 0,5 for both in standard steel. Ext. See Appendix D.

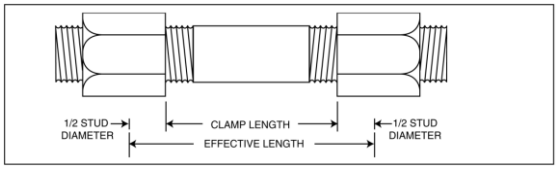
This page displays results from calculation.

The results of the load factor calculation is now displayed on the load factor entry row (make sure to store the value by completeing the bolt type entry sequence)

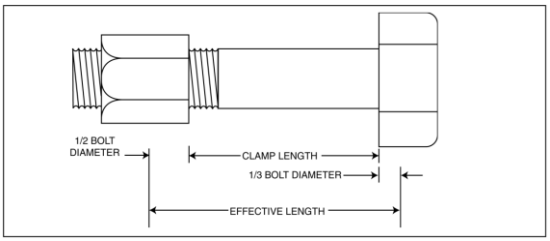
Appendix D – Units of Measure and Geometric properties

Measurement Modes	Pulse/Echo – Pitch/Catch
Transducer Frequency	Megahertz (MHz)
Tone Burst length	Pulses
Analog Output	Volts

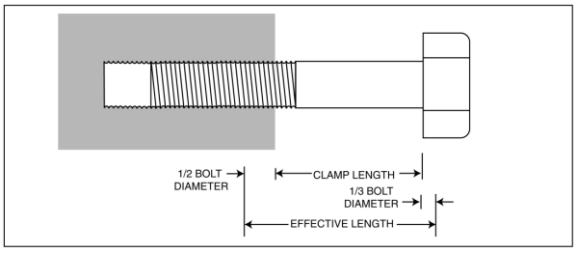
Measured Item	**Metric 1**	**Metric 2**	**Imperial**
Length	Kilonewtons/mm	Kilograms/mm	Pounds / Inches
Elongation	Millimetres	Millimetres	Inches
Diameter	Millimetres	Millimetres	Inches
Load	Kilotons	Kilograms	Pounds
Stress	MPa	Kg/Sq.mm	PSI
Strain	Dimensionless		



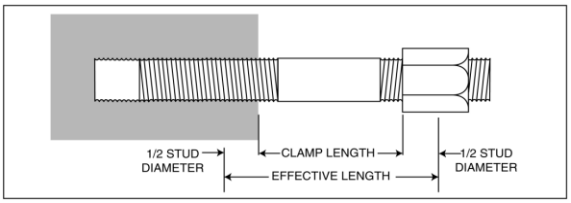
This is a typical stud configuration. The effective length of a stud with nuts on each end is found by adding the stud diameter to the clamp length.
Engagement factor 1: 0,50
Engagement factor 2: 0,50



This is a typical through bolt configuration. The effective length of a bolt with a single nut is found by adding half the diameter to one-third the diameter (5/6 of the diameter total) to the clamp length
Engagement factor 1: 0,50
Engagement factor 2: 0,40



This is typical of a configuration with a bolt (screw) turned into a threaded hole.
Engagement factor 1: 0,50
Engagement factor 2: 0,40



This is typical of a configuration with a stud turned into a threaded hole. When a stud is threaded into a blind hole and a nut is placed on the opposite end, find the effective length by adding the stud diameter to the clamp length
Engagement factor 1: 0,50
Engagement factor 2: 0,50

.

Appendix E – Estimating a Load Factor

The following section describes the method by which one can estimate or calculate the theoretical Load Factor for a specific fastener configuration.

However, were independent measurement of known loads cannot be made, a close estimate of the load factor can be achieved using the following procedure.

The Load Factor is defined as the tensile load required which will produce one unit of elongation in the bolt. When operating in English units the factor is defined as the number of pounds required per inch of elongation. In metric unit systems the factor is defined as Newton's or per 0.1mm.
The relationship between load and elongation is a function of the elasticity of the bolt material, and the geometry of the bolt in the application being measured.

Hooke's Law expresses the relationship:

$$P = \frac{\Delta l \times AE}{L}$$

P = Load
ΔL = Elongation
A = Cross Sectional Area of the Bolt

The cross-sectional area of the bolt is defined as the area of the bolt material, which experiences the applied tensile stress. For a cylindrical bolt the area may be approximated as follows:

$$A = \Pi\left(\frac{D}{2}\right)^2 = \frac{3.1416D^2}{4} = 0.7854D^2$$

Where: D = the root diameter of the bolt thread

More precise calculation of the stressed area, which reflects the effect of thread type and pitch, can be found in a number of reference texts and data published by bolt manufacturers.
John H. Bickford presents an excellent tabulation of Stress Areas in "An Introduction to the Design and Behaviour of Bolted Joints".

For complex bolts, which have sections of different diameters along the loaded length, the accepted method for estimating the stressed area is to calculate a weighted average of the various areas. This is accomplished by multiplying each area by its respective length and dividing the sum by the total stressed length of the bolt. Cross sectional area is determined as discussed above.

$$A_{average} = \frac{A_1L_1 + A_2L_2 + A_3L_3 \cdots A_nL_n}{L_1 + L_2 + L_3 + \cdots L_n}$$

E = Modulus of Elasticity of the Bolt Material
The value of the Modulus of Elasticity (Young's Modulus), of the bolt material should be provided by the manufacturer of the bolts being tested. A tabulation of E for common bolt materials is presented in Appendix A.

L = Stressed Length of the Bolt
The stressed length of the bolt is equal to the actual clamped length of the bolted connection plus that portion of the bolt within the head and nut, which experiences tensile stress. A number of theories have been proposed as to the stressed length within the head of the bolt and the within the nut. However, testing by use of the calibration function of the Delta Sigma reveals that no single theory is valid for all bolt configurations.

$$L = L_g + D$$

Thus, for the estimation of the Load Factor discussed here, it is sufficient to assume that the approximate stressed length is equal to the clamp length of the joint plus the nominal bolt diameter. The Load Factor (elongation in N per 0.1 of a mm is calculated by solving the above equation for Hooke's Law while setting the value of the elongation at 10.

$$LoadFactor = LF = \frac{100AE}{L} = \frac{100AE}{\left(L_g + D\right)}$$

Worked example for a bolted joint in Metric units:
Data: M20 x 2,5: ISO 8.8 Stud Bolt with and 200 mm effective length (clamp length + nuts & washers):

E (Youngs Modulus) for 8.8	= 206,15 kN/ mm²
A (Iso for M20)	= 245 mm²
L- Effective length	= 200 mm

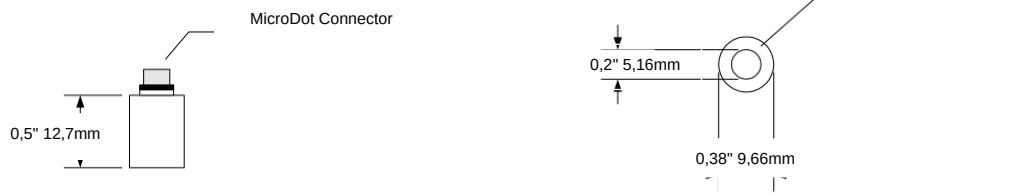
$$LoadFactor = LF = \frac{100x(245x206{,}15)}{200} = 25333N / 0.1mm = 253{,}3kN / mm$$

Hence the load factor entered into the DS for this bolt joint example would be: 25333

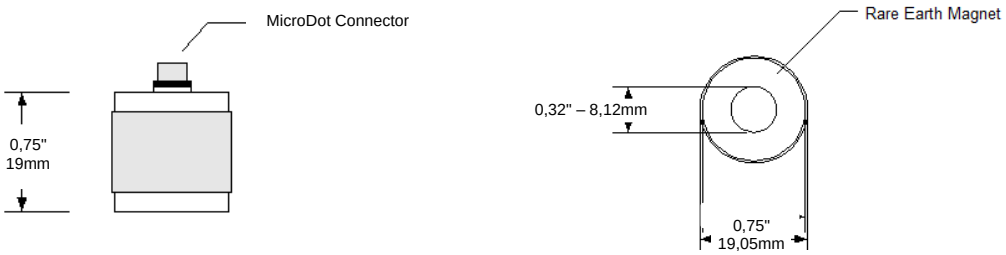
Note: It should be noted that this estimation is inherently less accurate than calibration of the actual Load Factor by using actual known loads which correspond to measured elongation.

Appendix F – Transducers

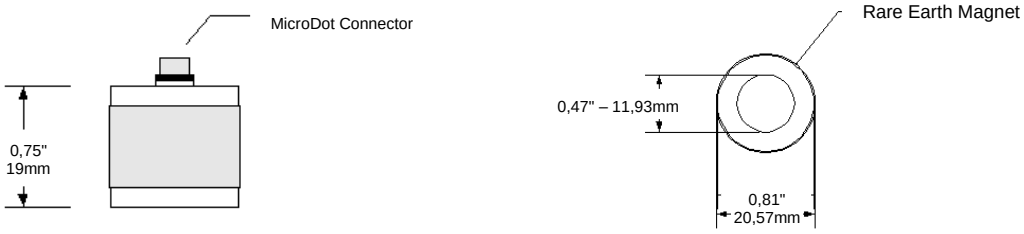
3/16" Magnetic 5MHz – P/N 2050-01



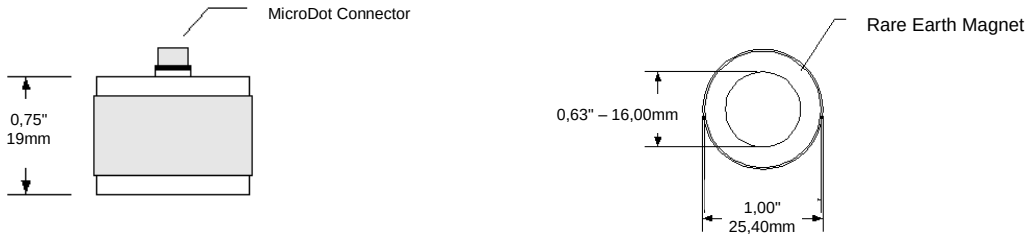
1/4 " Magnetic 5MHz – P/N 2050-02



⅜" Magnetic 5MHz – P/N 2050-03



½" Magnetic 5MHz – P/N 2050-04



¾" Magnetic 5MHz – P/N 2050-05

3x3mm Glue-on transducers – P/N 3000-01

The glue-on transducers comes in sheets of 100 transducers. They are simply glued-on the bolts and tested by using the 4000-TC or 4000-RH cable.

OPERATORS MANUAL
ULTRASONIC INSTRUMENT - DELTA SIGMA

momento

MOMENTO
P.O. Box 14
642 21 Flen
Sweden

VISITING ADDRESS
Kungsvägen 68
642 34 Flen
Sweden

CONTACT US
+46 157-690 00
info@momento.se
www.momento.se