

NORBAR

USM-II

ULTRASONIC BOLT METER

OPERATION AND REFERENCE MANUAL VER. 1.4

This manual applies to USM-II units with “Rel. 1.2” Firmware
and includes an Addendum covering the mods found in “Rel. 1.4”

To update the USM-II with the latest firmware see Appendix E

Release date 2 February 2004

NORBAR USA INC.

Addendum for USM-2 Firmware Version REL 1.4

1) MENU CHANGES

In version REL 1.4 one additional screen has been added to the SETUP menus. To access this screen, from the main menu, press the F1 button (Setup), then the F3 (Next Page) three times. You should see a screen that shows Temperature Mode and Resolution.

2) RESOLUTION

The resolution setting is displayed as either NORMAL or EXTENDED. Pressing the F2 key will toggle the setting. A resolution setting of EXTENDED causes one additional digit of resolution to be displayed in both the INCHES and MM modes. NOTE: this increased resolution only appears when measuring elongation. The EXTENDED resolution setting is useful in small bolts where very small elongations occur.

3) OPTIONAL TEMPERATURE SENSOR

3.1) Purpose

Temperature is a very important variable to measure and/or control in order to make accurate ultrasonic measurements of elongation. The USM-2 can be upgraded by the addition of an optional temperature sensor allowing the user to determine the surface temperature of a fastener and either manually or automatically update the temperature data in the USM-2.

3.2) Required Equipment

The temperature measure feature of the USM-2 requires firmware version REL 1.4 or later, a special hardware modification to ECO #4, and the USM-2 optional temperature sensor.

3.3) Accuracy

3.4) Modes of Operation

There are many factors affecting the accuracy of the temperature measurement. The accuracy of the sensor is one, and is addressed in the specifications below. However, an equal if not more important problem is the consistency of the temperature throughout the fastener, and also the effects of handling the temperature sensor.

The temperature sensor is designed with a copper disk, which acts to conduct the temperature of the surface of the fastener to the actual internal measuring transducer in the sensor. The temperature of the actual transducer is close to the surface temperature of the bolt, but it will also reflect, to a certain extent the air temperature and case temperature of the sensor.

Sometimes, the surface temperature of the fastener may not represent the average temperature of the fastener. For example, the head bolts in a reactor will have much larger internal temperatures than surface temperature. Since the ultrasonic signal passes through the entire length of the fastener, a measurement of the surface temperature can be inaccurate. In general, anytime there is a temperature gradient across the fastener, using a surface probe to determine fastener temperature is at best an approximation of the average temperature.

Even in situations where there is no temperature gradient on the fastener, error can be introduced if handling or an air temperature different from the fastener temperature heats the sensor body. In these cases a thermal grease compound (like zinc oxide) is recommended to maximize thermal conductivity between the fastener and the sensor.

Pressing the F1 key will toggle through the Temperature Modes. The choices are as follows:

3.4.1) MANUAL ENTRY

In the Manual Entry mode, the USM-2 does not use the external sensor, and the temperature must be determined by the user and input into the USM-2.

3.4.2) AUTO EXT. SENSOR

In the Automatic External Sensor mode, the temperature is continually updated whenever the system is reading ultrasonic length or elongation.

3.4.3) MAN. EXT. SENSOR

In the Manual External Sensor mode, the user can measure the temperature anytime they like, but the temperature is never changed without the users knowledge. To make a temperature measurement, the user simply goes to the temperature input screen and presses the F3 key. The temperature will begin to update automatically as measurements are made. When the desired measurement is made, the user exits the window with an ENTER or BACK key press. Note that in this mode the user can also manually type in a temperature measurement.

3.5) Specifications

3.5.1) Temperature Range and Accuracy

10°C to 50°C $\pm 0.50^\circ\text{C}$

-10°C to 85°C $\pm 1.0^\circ\text{C}$

3.5.2) Mechanical

Stainless steel housing with copper temperature sensing surface.

Dimensions 0.76 inch diameter by 0.92 inch depth, side entry cable.

Cable 6ft with DB15 connector

Hi strength magnet holds sensor to ferrous surface

4) ANALOG OUT SCANNING MODE

The ANALOG output is always updated when measuring elongation or load. Because the microprocessor in the unit must share time updating the display with updating the analog out, the rate of the analog out is slowed down slightly. In order to eliminate this delay, a new mode has been added to the unit called HIGH SPEED SCANNING.

To use this mode, the analog output must be connected to an external chart recorder or oscilloscope. The unit is then placed in elongation mode, measuring a bolt. Before capturing a run down, press the "H" key (for high speed). The display will show HIGH SPEED SCAN MODE. By not updating the display, the microprocessor is able to update the analog output at a rate of approximately 60 times per second.

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Warranty & Safety Information

Limited Warranty

The Norbar USM-II carries a two year limited warranty. The warranty only applies to USM-II units being operated as described in this manual. Software and hardware failures of the unit will be repaired or replaced at Norbar discretion. Norbar will not be held liable for any damage caused, interruption of business, loss of profits, etc., resulting from such failures. Norbar will not be liable to repair or replace a unit, which has been damaged, used inappropriately, or subject to unauthorized repair by the purchaser.

Safety Information

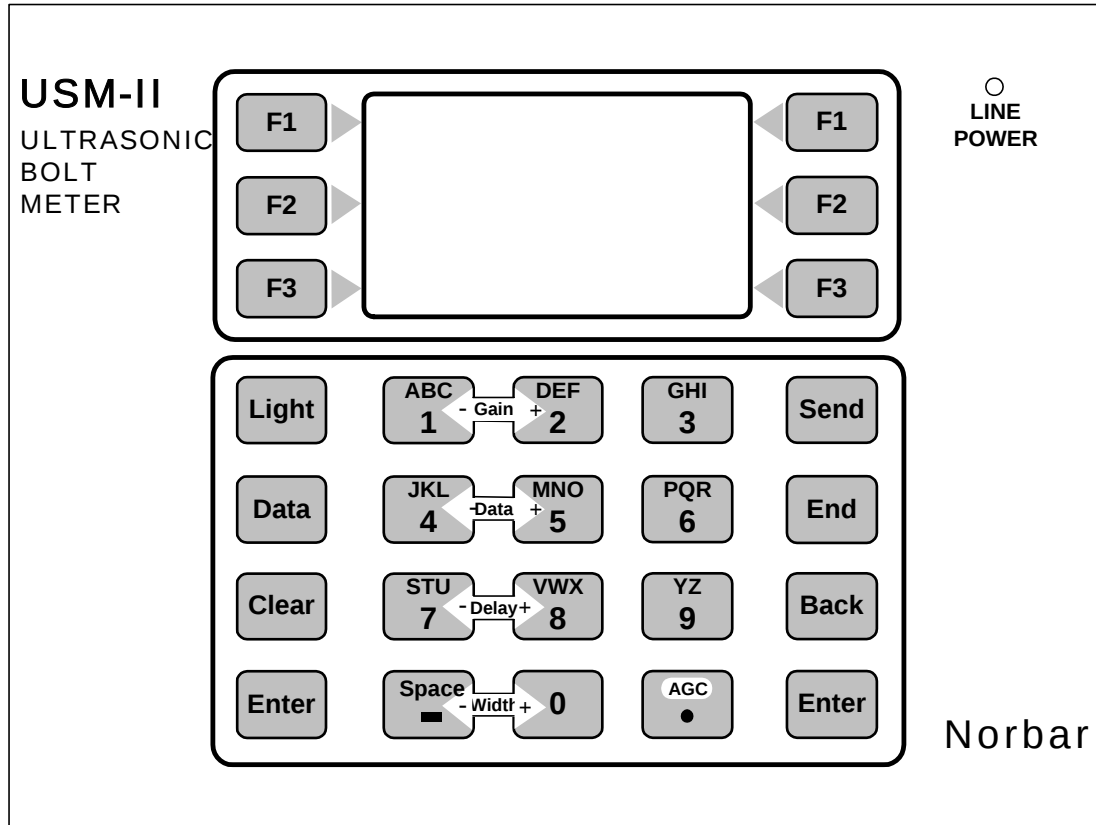
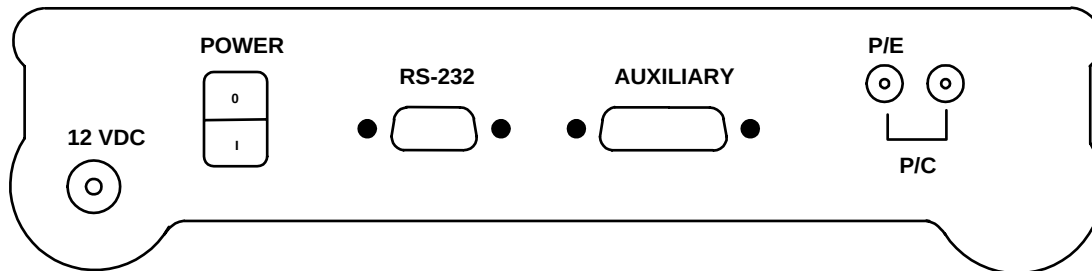
- Failure to read this manual and understand the proper operation of the USM-II can result in inaccurate measurements, which can lead to decisions, which cause property damage, personal injury.
- Use of the USM-II for any other purpose, or in any other manner than described in this manual invalidates the warranty and can result in serious electric shock, or personal injury.

CE Specification

- | | |
|-------------------------|--|
| • Environment | Use in a light industrial environment |
| • EMC Directive | In conformance with EN 61326:1997 |
| • Low Voltage Directive | In conformance with EN 61010-1:1993 |
| | POLLUTION DEGREE 2 &
INSTALLATION CATEGORY
(OVERVOLTAGE CATEGORY) II |
| Cleaning | No abrasives or solvent based cleaners |

Due to product improvement specifications are subject to change without notice.

Diagram of the USM-II



Norbar USM-II Specifications

PHYSICAL DESCRIPTION	ULTRASONIC SPECIFICATIONS
Size: 8.5 " W X 6.4" H X 2" D	Resolution: 0.0001 inch (0.002mm)
Weight: 3.8 lbs.	General: Pitch catch, pulse echo measurement modes.
Keypad: Membrane switch with tactile keys.	Automatic peak signal and phase selection.
Display: 128 x 64 pixels with EL Back-light	Pulser: 160 volt push / pull tone burst Selectable burst width.
Case: Sealed Aluminum.	Selectable frequencies 1, 2.25, 5, 7.5, 10 MHz.
Battery Power 4 "C" Cells Optional	Receiver: Low noise preamplifier. Automatic gain control. Automatic waveform and signal diagnostic display
Line power: 90 - 250 VAC 47 to 63 Hz	Timing: 160 MHz 10 ppm TCXO controlled digitizer.
Operating Temperature: 0 to 40°C / 32°F to 104°F	Memory: 2 megabit non-volatile. 1000 bolts, 5000 measurements.
Automatic Compensation for Temperature Of Fastener	2 YEAR LIMITED WARRANTY
Calibration: Automatic verification of system calibration Field verification of bolt material calibration constants	
Data Output: RS232 I/O. 0 to 10 V Analog Output	

The Norbar USM-II system

The USM-II Bolt Meter system includes:

- Unit and carrying case and storage case
- 10 foot transducer cable, with Lemo to MicroDot connectors
- Line power adapter (12VDC)
- RS232 Data Transfer Cable DB9 M/F
- 4 oz. Bottle of ultrasonic couplant
- Operation & Reference Manual
- Price list for transducers and accessories

How the Norbar USM-II Bolt Meter works

Features of the Norbar USM-II

Note: The terms *bolt*, *fastener*, and *threaded fastener* are used interchangeably.

The Norbar USM-II, Ultrasonic Bolt Meter, defines the State of the Art in the measurement of the actual clamp load produced by tightening a fastener. The USM-II can measure clamp load or the resulting elongation extremely accurately in bolts of virtually any material from 1 inch to 50 feet in length.

Through the use of digital signal processing and automated signal diagnostics the USM-II minimizes operator training and preparation. The Norbar USM-II provides state of the art hardware and software to achieve measurements with Maximum automation, minimizing operator interpretation. Offering digital recordation and transmission of data, as well as calibrated analog signal output, the USM-II offers a complete system for measurement, recordation, and control of bolt tension in the most demanding applications.

Ultrasonic measurement of bolts

Ultrasonic measurement has proven to be the most reliable and cost effective solution when:

- Variations in friction or joint geometry prevent applied torque from controlling the actual clamping force produced by the fastener with the required accuracy.
- The clamping force must be monitored over the service life of the bolt.

Ultrasonic measurement of clamping load is obtained through a predictable decrease in the sound velocity within the body of the bolt as the tensile load is increased. By introducing a sonic pulse at one end of the bolt and accurately measuring the time required for the echo to return from the opposite end, the ultrasonic length is determined. As the fastener is tightened, the change in this ultrasonic length is used to calculate and display the actual fastener elongation or the clamping force produced.

The physics governing this process are clearly understood, and have been employed for many years in the fields of active sonar, or radar. Send a pulse of energy toward an object (in this case the opposite or reflecting end of the fastener), and then measure the time between the initial pulse and the returning echo.

While the concept is comparatively simple and ultrasonic measurement can produce astoundingly accurate results, the selection of the optimum bolt and transducer, and their coupling can be difficult.

The USM-II minimizes these difficulties to the greatest extent possible:

- The selectable tone burst pulser system can send the maximum amount of energy to the ultrasonic transducer, allowing the broadest possible range of transducers for a given application.
- The low noise and automatic gain features of the receiver system allow signal detection and measurement in the most difficult applications.
- Automatic digital signal analysis optimizes the measurement process and warns of potential problems.

Low frequency versus high frequency

Ultrasonic measurement requires the transmission of a suitable quantity of ultrasonic energy through the length of the bolt. The relationship of the energy pulse frequency to its penetration is important in energy transmission. Lower frequencies produce longer wavelengths that will travel further through a given substance: while higher frequencies produce shorter wavelengths. To use a familiar example: AM radio signals are broadcast at relatively low frequencies and can be received hundreds of miles away, over the horizon. Higher quality FM radio and television signals are broadcast at much higher frequencies, and can only be received within a comparatively short line-of-sight distance.

The same phenomenon exists with ultrasound. A low frequency 1 MHz pulse travels much farther through metal than a 5 MHz pulse. Therefore, a lower frequency transducer is able to achieve an echo in a longer bolt, or in a bolt made of metal with higher resistance to sound transmission (attenuation). While the lower frequency has more penetration power, it also produces more unwanted noise. Low frequency energy tends to spread, much like an unfocussed beam of light. When low frequency energy is introduced at the end of a bolt, a significant portion is bounced from side to side within the cylindrical shape, producing a noisy and distorted echo. Higher frequency pulses tend to travel more directly down and back the centerline of a bolt, with less noise and distortion.

Effect of transducer diameter

The best balance between Maximum signal and noise suppression requires selecting the best transducer for bolt measurement. The diameter of the transducer (which is generally specified by the diameter of the actual piezoelectric crystal) directly effects energy transmission: Larger diameter crystals have greater ability to send and receive energy, and less of the energy tends to spread laterally. The USM-II Bolt Meter strives to achieve this ideal balance: direct transmission of the strongest possible pulse, with the least amount of noise and distortion, down and back the center of the bolt to obtain the most accurate measurement.

Bolt end conditions effecting measurement

Dirty, rusty, heavily painted, or uneven bolt ends create uneven echoes and interfere with precise ultrasonic measurement. The echo ricocheting back through the bolt travels further than the echo returning directly along the bolt axis, reaching the transducer at a slightly different time. The overlapping echoes are interpreted by the USM-II as a single distorted signal, which does not match the frequency of the transmitted pulse. A reduction in the bar indicator of frequency match, described in Signal Analysis, will alert the operator of this discrepancy.

Bending of the bolt under load and nonperpendicular bolt ends create similar problems. Bending of the bolt is a fairly common occurrence, normally due to nonparallel faces of materials being clamped, or by bending these faces to nonparallel during tightening. Pipe flanges or joints with partial gaskets are prone to this problem. When the bolt is bent, both ends of the bolt are forced out of perpendicular to the path of the ultrasonic pulse.

Tone burst pulser system

Adjustment of the tone burst pulser system optimizes the amplitude of the ultrasonic signal. This is accomplished by adjusting the number of synchronized impulses sent to the transducer. This is similar to delivering multiple pushes to a schoolyard swing causing the swing to go higher. Increased ultrasonic signal amplitude is useful for long fasteners or materials of high acoustic attenuation.

Analog output

The USM-II offers a linear 0-10 VDC high-speed analog signal output via the AUXILARY connector located on the rear panel. This signal can be calibrated to be directly proportional to either Elongation or Load. It is used to interface the USM-II to analog recording devices, visual and audio alarms, and various control devices used to stop power tightening tools at a selected Load or Elongation.

Use of ultrasonic couplant

Sonic energy of the frequency used by the USM-II travels well through solid materials and most liquids. It does not travel well through air. This variable resistance to the passage of sonic energy is called *sonic impedance*. It is the sudden change in impedance which occurs when the sound pulse attempts to cross the metal / air boundary at the end of the bolt, which causes most of the energy to be returned as an echo. To make a familiar comparison: light crossing the transparent glass boundary of a mirror and reflecting back an image from the nontransparent silvered back is much like an echo.

Any air gap between the face of the transducer and the end of the bolt will prevent the sonic energy from crossing. The gap must be filled with a suitable coupling fluid. Normally, a liquid ultrasonic couplant is applied between the transducer and the bolt. Since liquid has sonic impedance closer to the transducer and bolt material than air, it forms a continuous path for the outgoing pulse and the returning echo.

Many liquids can serve as an adequate couplant, however, liquids with lower sonic attenuation will produce better results. Liquids containing glycerin offer such low impedance, and couplant manufactured for ultrasonic testing, such as the one shipped with the USM-II, produce the best results. Water or even saliva can be used in a pinch, but the results will not be as good, and may be dangerous in certain environments.

The single purpose of the couplant is to fill the air gap between the transducer and the bolt end. This is accomplished more easily with a liquid that is viscous enough to stay in place. Very viscous substances can create such a thick layer between the transducer and bolt that measurement errors may occur. Also, viscous substances can trap air bubbles, which prevent adequate energy transmission. Again, the ultrasonic couplant provided with the USM-II works best. Apply only the smallest quantity of couplant required to fill the air gap, and carefully seat the transducer so that any trapped air or excess couplant is squeezed out of the interface.

System zeroing

System zeroing is the method of calculating the internal time required for each USM-II and transducer combination to detect the echo. When an echo travels back through the bolt to the transducer face, there is an electronic delay before the USM-II detects the echo. Because of differences in the electronic parts, or the transducer and cable, the delay is slightly different for each combination of USM-II and transducer. The time delay is called the *delay factor* or *zero time offset*.

The USM-II is designed for use with two calibration bars having a known ultrasonic velocity and known length. Comparing their known physical length and measured ultrasonic length determines the system delay factor, or zero time offset. The system delay factor makes the USM-II interchangeable with all other calibrated USM-II systems.

Once the delay factor is determined, the USM-II software automatically subtracts it from the apparent measurement of the time required for the sonic signal to travel through the bolt. Thus, the actual time of signal travel is determined, and compensation is made for the slight difference in each system. Since every *zeroed* USM-II makes the same time measurement, the systems give the same result and are interchangeable.

System Zeroing is only required if changing between USM-II units, or changing between transducers, while measuring a set of bolts. If the same USM-II and

transducer are used, the amount of the delay is constant. If unloaded length measurements were made with one USM-II, and the load measurements were made with another, the difference in the delay factor could cause an error, though in most cases the error would be very small. Since it is uncertain that the same unit and transducer will always be used, it is strongly recommended that System Zeroing be checked whenever the USM-II is used.

Preparing for measurement

The goal is to transmit as much sonic energy as possible from the transducer into the bolt, and to send that energy, to the greatest extent possible, down and back to the center of the bolt, as shown in Figure 1.

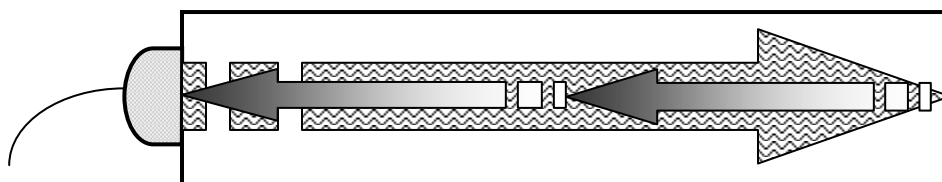


Figure 1

Selecting the appropriate transducer

- Select the largest diameter transducer that will seat completely on the end of the bolt.
- Select the highest frequency transducer of that diameter.
- Using the “SET ULTRASONICS” function in the SETUP MENU match the frequency of the USM-II pulser to the frequency of the transducer, and set the pulse width to 1 pulse.
- If the signal magnitude is too small, select a lower frequency transducer of the same diameter, and reset the frequency of the USM-II pulser.
- If the lower frequency transducer does not produce an acceptable echo, send a greater pulse width (2 or 4 pulses) by adjusting the tone burst pulser in the USM-II Setup Menu. This sends more energy to the transducer, producing a larger signal.

Requirements for connecting bolt ends

Smooth, even surfaced bolt ends that seat the entire active surface of the transducer with minimum gap are required for accurate signal transmission. Bolt ends may need to be cleaned, ground, etc. to achieve the required surface.

Avoid:

- Rough or irregular surfaces, which prevent adequate contact with the transducer. Energy will ricochet off the sidewalls. Small irregularities or surface roughness can be filled with couplant, but energy transmission will still be reduced and dispersed, as shown in Figure 2.
- Bolt ends not perpendicular to the axis of the bolt, as shown in Figure 3. Energy will be transmitted toward the side wall and ricochet along the bolt, yielding poor signal quality and possible measurement errors. Avoid alignment errors exceeding 2 degrees.

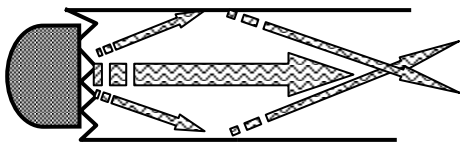


Figure 2

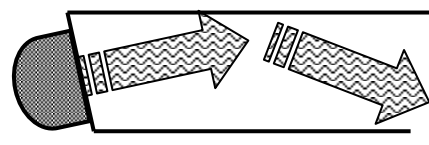


Figure 3

- Rusted, dirty, or thick paint-covered bolt ends. These coatings prevent sonic energy from traveling between the transducer and the bolt. Very thin well-adhered coating or plating is acceptable.
- Bolt ends with recessed grademarks, as shown in Figure 4. Couplant can be used to fill small recessed grademarks. Small indentations cause some loss of signal strength, but normal measurement is still possible. Large or numerous indentations cause the signal to be too weak for reliable measurement.
- Bolt ends with raised grade marks, or indentations with a raised edge, which cause the transducer to sit at an angle to the axis of the bolt, preventing adequate contact, as shown in Figure 5.

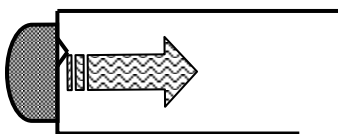


Figure 4

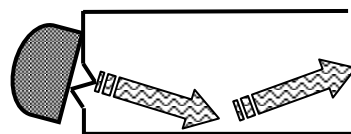


Figure 5

Requirements for reflecting bolt ends

Smooth, flat reflecting bolt ends that are perpendicular to the axis of the bolt are required for accurate echo reception. Bolt ends may need to be cleaned, ground, etc. to achieve the required surface.

Note: Misalignment exceeding 2 degrees can cause significant errors.

Avoid:

- Rough reflecting bolt ends. As shown in Figure 6, if the reflecting end of the bolt is rough or curved, most of the reflected energy will be dispersed and a weak or distorted echo will be received.
- Reflecting bolt ends not perpendicular to the axis of the bolt. Sonic energy will be reflected toward the sidewall of the bolt, as shown in Figure 7.
- Nonperpendicular reflecting bolt ends due to bending of the bolt as shown in Figure 8.

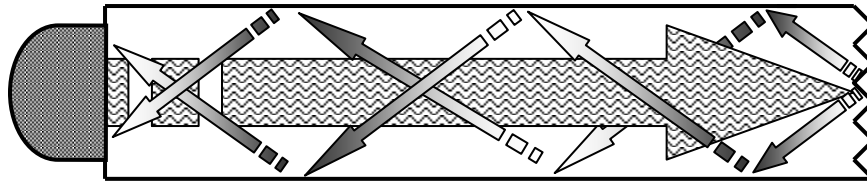


Figure 6

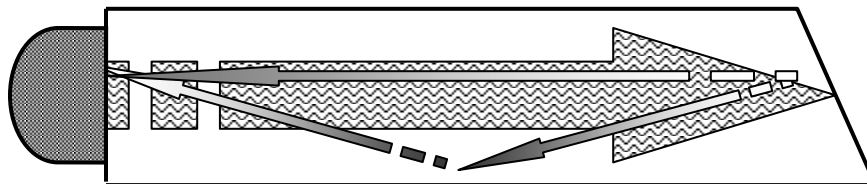


Figure 7

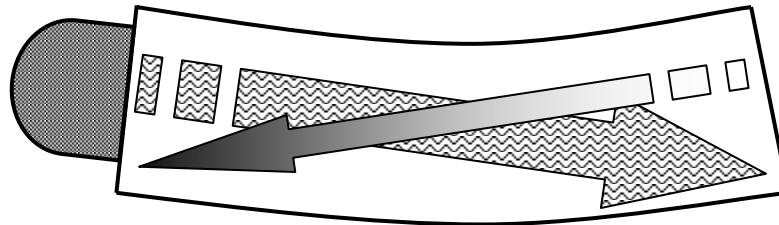


Figure 8

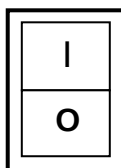
Preparing the USM-II for operation

1. Insert 4 “C” batteries as shown on the back label (The USM-II is designed to operate with alkaline batteries. Rechargeable batteries may be substituted at the users option. However, this will result in reduced operating time between battery charges.

Or Connect the USM-II power adapter to the 12 VDC power input connector on the unit and to a grounded A/C power supply of 90 to 240 VAC.

2. Connect the appropriate transducer(s) and cable(s) to the transducer port(s) on the back of the unit.
 - Use the P/E (Pulse/Echo) port when using a single transducer.
 - Connect the sending transducer to the P (Pitch) port, and the receiving transducer to the C (Catch) port when using two transducers.

Turn on the USM-II with the power switch located on the top end of the unit.



The Norbar Logo is displayed:

If no password has been established the Logo will appear for 3 seconds before the USM-II proceeds to the Main Menu

If a password has been established the Logo will remain on the display until the Corrected password is input and the ENTER key is pressed



3. If password is established

Enter password.

The USM-II is delivered with the password set at zero (0.0) allowing free access to all functions. If a password other than zero has been established, it must be entered while the Norbar logo is displayed by using the numeric keypad. Page 28 describes how to establish a numeric password. The password controls access to all functions of the unit (unit settings, unit calibration, and bolt group data) other than those used in the actual bolt measurement, and data recordation process. An operator without the password can only measure bolts and record data as preprogrammed by the person with password control.

Note: There is no password prompt, or any visual acknowledgement of password entry.

4. The Main Menu is displayed.

The software version is shown in lower right corner of the display:

F1	SETUP USM
F2	BOLT OR GROUP DATA
F3	MEASURE
	Software rel.X.X

- **F1** (SETUP USM) allows the operator to set the variables, which control the overall operation of the USM-II.
- **F2** (BOLT GROUP DATA) allows programming of the variables associated with the bolts to be measured and the management of the data collected.
- **F3** (MEASURE) moves the USM-II to the actual measurement function.

Note: Without entry of an established password, the USM-II will skip the Main menu and go directly to MEASURE menu.

SETUP USM-II functions

Note: Press the END key at any point in the SETUP program to return to Main menu.

Select SETUP USM to review or change the operational settings of the USM-II.

1. Press F1 (SETUP USM) on the Main menu to display operational settings.

F1	DISPLAY CONTRAST 1 TO 15
F2	CHECK BATTERY XX
F3	NEXT PAGE

2. Press F1 (DISPLAY CONTRAST) to change screen contrast.

Then press F1 or F2 to increase /decrease contrast by increments of one.

F1	INCREASE 1 TO 15
F2	DECREASE
F3	EXIT

3. Press F3 (EXIT) when contrast is satisfactory.

Display returns to contrast / check battery menu:

F1	DISPLAY CONTRAST 1 TO 15
F2	CHECK BATTERY XX
F3	NEXT PAGE

The percent of full charge remaining in the batteries appears below CHECK BATTERY.

If a more precise indication of the remaining battery charge is desired:

4. Press F2 (CHECK BATTERY) to display a bar graph depicting the amount of charge in the batteries.

5. Press F3 (NEXT PAGE) when contrast setting and battery check are satisfactory.

F1	SELECT UNIT SYSTEM POUNDS / INCHES
F2	SET ULTRASONICS
F3	NEXT PAGE

Selecting units of measure

Press F1 (SELECT UNIT SYSTEM) to scroll through the unit systems available in the USM-II.

When the desired unit system is displayed beneath the SELECT UNIT SYSTEM prompt:

Press F3 (NEXT PAGE) to continue setup, or

Press END to return to the main menu.

Setting ultrasonics

1. Press F2 (SET ULTRASONICS) to adjust the ultrasonic pulse and receive system.

F1	RECEIVER MODE PULSE/ ECHO
F2	TRANSDUCER FREQUENCY 5 MHZ
F3	PULSE WIDTH 1 PULSE

2. Press F1 (RECEIVER MODE) to scroll through the ultrasonic measurement modes available in the USM-II.
When the desired measurement mode is displayed beneath the RECEIVER MODE prompt the USM-II is set in that mode.
 - Use (PULSE / ECHO) when using a single transducer. Connect single transducer to the USM-II connector marked P/E.
 - Use (PITCH / CATCH) when using two transducers placed at opposite ends of the fastener to transmit and receive the sonic signal. Two transducers can transmit ultrasonic signals over greater lengths and through material of high acoustic attenuation.

Selecting transducer frequency

F1	RECEIVER MODE PULSE/ ECHO
F2	TRANSDUCER FREQUENCY 5 MHZ
F3	PULSE WIDTH 1 PULSE

1. Press F2 (TRANSDUCER FREQUENCY) to scroll through the available transducer frequencies of the USM-II.
When the frequency displayed beneath the TRANSDUCER FREQUENCY prompt matches the ultrasonic transducer being used, the USM-II pulser is properly set.
This matching function optimizes generation and reception of ultrasonic energy, and allows precise evaluation of the signal.

F1	RECEIVER MODE PULSE/ ECHO
F2	TRANSDUCER FREQUENCY 5 MHZ
F3	PULSE WIDTH 1 PULSE

2. Press F3 (PULSE WIDTH) to scroll through the available settings for the width of the tone burst (number of pulse contained in each burst) transmitted to the transducer by the USM-II tone burst pulser.

Note: Increasing the pulse width increases the amount of energy delivered to the transducer. Thus the ultrasonic signal is stronger and able to traverse greater length of material, or materials of greater sonic attenuation.

It must be noted however, that increasing signal energy also increases acoustic noise or interference. Therefore select the minimum pulse width that yields a measurable signal.

Ultrasonics are now set.

Press the ENTER or BACK key to return to page 2 of the setup menu.

F1	SELECT UNIT SYSTEM POUNDS / INCHES
F2	SET ULTRASONICS
F3	NEXT PAGE

Press F3 (NEXT PAGE) to continue setup

F1	MEASURE SYSTEM ZERO
F2	SET ANALOG OUTPUT
F3	NEXT PAGE

Measuring System Zero

The purpose of measurement of the zero point of the USM-II and transducer combination is done to set each USM-II system so that it can be used interchangeably with all other systems. By making the systems interchangeable measurement data taken with any USM-II system can be used in all other zeroed systems without error.

The process of measuring the zero setting is fairly complex. Fortunately it need only be performed once for any one USM-II and transducer combination.

Press F1_(MEASURE SYSTEM ZERO) to begin zeroing the USM-II and transducer combination.

Norbar offers calibration bars approximately 1.5 inch (38mm) diameter x 3 inches (76mm) in length and 1.5 inch (38mm) diameter x 6 inches (152mm) constructed of vacuum melt steel with the sound velocity of approximately 232,000 inches per second (5892800 mm/sec).

Entering temperature of calibration bars

Use this menu to verify or input the temperature of the calibration bars. The USM-II requests the temperature and the sonic temperature factor for the material of the calibration bars. Temperature and temperature factor shown are from the previous calibration.

Note: Prior to delivery the USM-II is programmed with the temperature factor imprinted on the side of the Norbar calibration bars. If other calibration bars are used, care must be taken to accurately determine its sonic velocity and sonic temperature factor. APPENDIX A presents approximate values for a number of materials.

1. Determine the temperature of the calibration bars.

F1	TEMPERATURE 68.1
F2	TEMPERATURE FACTOR 58.0
F3	CONTINUE

2. Press F1 (TEMPERATURE) if the temperature of the calibration bars at the time of use is different from the temperature shown.

F1	TEMPERATURE CAL. BAR XXX.XX PRESS ENTER KEY
F2	
F3	

3. Use the number keys to enter correct temperature.

4. Press ENTER key after data is entered.

USM-II returns to the Temperature menu:

F1	TEMPERATURE 68.1 TEMPERATURE FACTOR 58.0 CONTINUE
F2	
F3	

1. Press F2 (TEMPERATURE FACTOR) if the temperature factor of the calibration bars is different from the temperature factor shown.

F1	TEMPERATURE FACTOR XXX.XX PRESS ENTER KEY
F2	
F3	

2. Use the number keys to enter correct temperature factor.

3. Press ENTER key after data is entered.

F1	TEMPERATURE 68.1 TEMPERATURE FACTOR 58.0 CONTINUE
F2	
F3	

4. Press F3 (CONTINUE) when temperature and temperature factor are set.

Entering known length of calibration bars

USM-II displays data from memory of the previous calibration:

F1	CAL. BAR 1 X.XXXX X.XXXX
F2	CAL. BAR 2 X.XXXX X.XXXX
F3	VELOCITY SYS ZERO XXXXXX X.XXX

1. Press F1 (CAL BAR 1) to set data on calibration bar #1.

F1	CAL. BAR 1
F2	KNOWN LENGTH X.XXX
F3	ULTRASONIC LENGTH X.XXX

2. If it is different than previous data, press F2 (KNOWN LENGTH) to enter the physical length of calibration bar #1 measured at 68°F (20° C).

F1	ENTER KNOWN LENGTH CAL. BAR 1
F2	X.XXXXX
F3	PRESS ENTER KEY

3. Use the number keys to enter data.

4. Press ENTER key after data is entered.

USM-II returns to the calibration menu:

F1	CAL. BAR 1 X.XXXX X.XXXX
F2	CAL. BAR 2 X.XXXX X.XXXX
F3	VELOCITY SYS ZERO XXXXXX X.XXX

5. Press F2 to select calibration bar #2.

6. Repeat steps 2 through 4 to enter known length of calibration bar #2.

Entering ultrasonic velocity of calibration bars

F1	CAL. BAR 1 X.XXXX X.XXXX
F2	CAL. BAR 2 X.XXXX X.XXXX
F3	VELOCITY SYS ZERO XXXX X.XXX

1. Press F3 (VELOCITY SYS ZERO).

F1	VELOCITY XXXXXX
F2	SYSTEM ZERO XXXXX
F3	OPTIMIZE SYSTEM ZERO

2. Press F1 (VELOCITY) to input material velocity other than that shown.

F1	VELOCITY
F2	XXXXXXXX
F3	PRESS ENTER KEY

3. Enter data with number keys.

4. Press the ENTER key.

F1	VELOCITY 232000
F2	SYSTEM ZERO XXXXX
F3	OPTIMIZE SYSTEM ZERO

5. Press Back to return to calibration data menu

F1	CAL. BAR 1 X.XXXX X.XXXX
F2	CAL. BAR 2 X.XXXX X.XXXX
F3	VELOCITY SYS ZERO XXXX X.XXX

6. Press F2 (CAL. BAR 2) to select calibration bar #2.

Measuring ultrasonic length of calibration bars

1. Apply couplant.

- Apply a small quantity of liquid ultrasonic couplant between the transducer and the end of the calibration bar.
- Use the ultrasonic liquid couplant shipped with the USM-II for best results.
- Order additional couplant from Norbar.

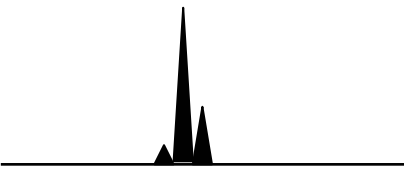
2. Attach transducer to end of calibration bar.

- Seat the transducer directly and completely on the end of the calibration bar.
- Squeeze out any trapped air and excess couplant.

F1	CAL. BAR 1
F2	KNOWN LENGTH 4.100
F3	ULTRASONIC LENGTH X.XXX

3. Press F3 (ULTRASONIC LENGTH).

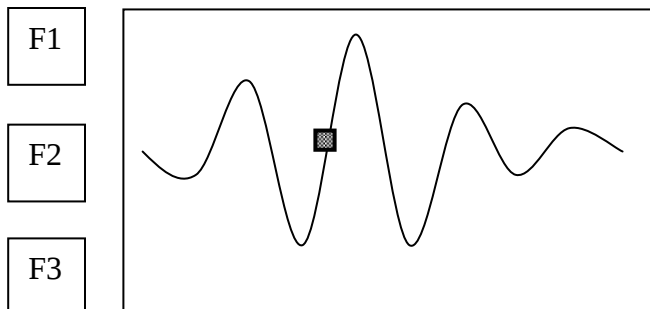
Note: If the USM-II automatic trigger mode is OFF, the USM-II displays a graphic image of the echo received from the opposite end of the calibration bar. The Gain required to achieve it is shown at bottom of screen.

F1	PRESS ENTER KEY
F2	
F3	XXXX GNXXX XXXX

4. Adjust the position of the transducer on the bar end to minimize the gain value displayed, and obtain, as closely as possible, a single spike of Maximum height.

5. Press ENTER key when lowest gain is obtained.

The USM-II selects the best measurement point and displays the time of flight (echo):



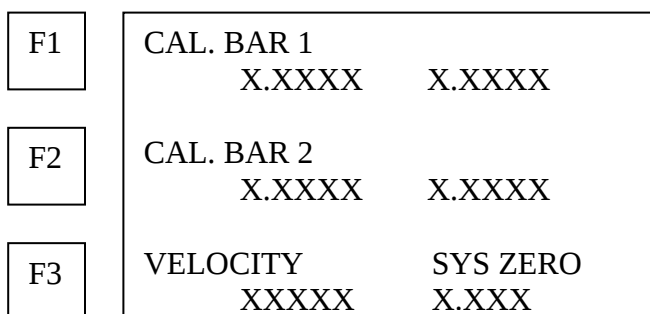
The ultrasonic length value is displayed:



Note: If the automatic trigger is ON, the USM-II goes directly to the above display.

6. Press ENTER key for calibration status display.

USM-II displays the calibration data:



7. Press F2 to select calibration bar #2.

8. Repeat steps 3 through 7 to obtain ultrasonic length for calibration bar #2.

Press F3 (VELOCITY SYS ZERO) to displays calibration options.

Manually entering system zero

If the system zero, or delay factor for the USM-II is known from previous calibration, may be entered manually as follows:

F1	VELOCITY XXXXXX
F2	SYSTEM ZERO XXXXX
F3	OPTIMIZE SYSTEM ZERO

1. Press F2 (SYSTEM ZERO) to manually input a delay value for the system.

F1	SYSTEM ZERO
F2	XXXXXXX
F3	PRESS ENTER KEY

7. Use the number keys to enter the data.

8. Press the ENTER key.

USM-II returns to the calibration options:

F1	VELOCITY XXXXXX
F2	SYSTEM ZERO XXXXX
F3	OPTIMIZE SYSTEM ZERO

Calculating system zero

1. Press F3 (OPTIMIZE SYSTEM ZERO) to calculate the internal delay based on the known lengths and measured ultrasonic lengths recorded for the cal bars.

USM-II displays calculated delay values and places them in memory for use in all subsequent measurements.

F1	CAL. BAR 1 X.XXXX X.XXXX
F2	CAL. BAR 2 X.XXXX X.XXXX
F3	VELOCITY SYS ZERO 233000 X.XXX

To verify that the system zero factor has been properly determined, check to see that the known length and ultrasonic length displayed, match to within ± 0.0002 inch or ± 0.002 mm. Repeat the ultrasonic measurements to verify.

2. Press the ENTER key to exit calibration and return to page 3 of the setup menu.

F1	MEASURE SYSTEM ZERO
F2	SET ANALOG OUTPUT
F3	NEXT PAGE

Setting analog output

1. Press F2 (SET ANALOG OUT) to program the analog signal output.

F1	SCALE ELONGATION xxxxx
F2	SCALE LOAD xxxxx
F3	CAL VOLTS OUT

2. Press F1 (SCALE ELONGATION) to calibrate the analog signal output to correspond to elongation.

F1	ENTER FULL SCALE ELONGATION
F2	0.XXXXX
F3	PRESS ENTER KEY

3. Using the number keys, enter the fastener elongation value, which corresponds, to a Maximum analog signal output voltage of 10 VDC.

4. Press the ENTER key.

USM-II returns to page 3 of the setup menu:

F1	MEASURE SYSTEM ZERO
F2	SET ANALOG OUTPUT
F3	NEXT PAGE

Press F2 (SET ANALOG OUT) to continue programming the analog signal output.

F1	SCALE ELONGATION
F2	SCALE LOAD
F3	CAL VOLTS OUT

5. Press F2 (SCALE LOAD) to calibrate the analog signal output to correspond to load.

F1	ENTER FULL SCALE LOAD
F2	XXXXXXXXXX
F3	PRESS ENTER KEY

6. Use the number keys to enter the fastener load value, which corresponds, to the Maximum analog signal output voltage of 10 VDC.

7. Press the ENTER key.

Output Test Voltage to Analog Receiving Device

Connect the peripheral device to the AUXILARY (15 pin "D" connector) port on the back of the USM-II.

F1	SCALE ELONGATION
F2	SCALE LOAD
F3	CAL VOLTS OUT

Press F3 (CAL VOLTS OUT) to output test voltage.

F1	OUTPUT 0.00 VOLTS
F2	OUTPUT 10.00 VOLTS
F3	EXIT

- Press F1 (OUTPUT 0.00 VOLTS) to output 0.000 VDC.
Adjust zero setting on the peripheral device
- Press F2 (OUTPUT 10.00 VOLTS) to output 10.000 VDC (nominal)
Adjust full scale setting on the peripheral device

8. Press F3 (EXIT) to exit Set Analog Out and return to the setup USM menu.

Setting automatic triggering

F1	SET ULTRASONICS
F2	SET ANALOG OUTPUT
F3	NEXT PAGE

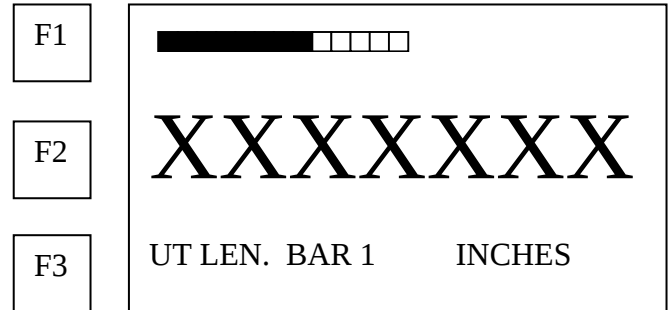
1. Press F3 (NEXT PAGE).

F1	AUTO TRIGGER OFF
F2	PASSWORD 0
F3	EXIT

2. Press F1 (AUTO TRIGGER) to toggle the automatic triggering on and off.

- **AUTO TRIGGER ON**

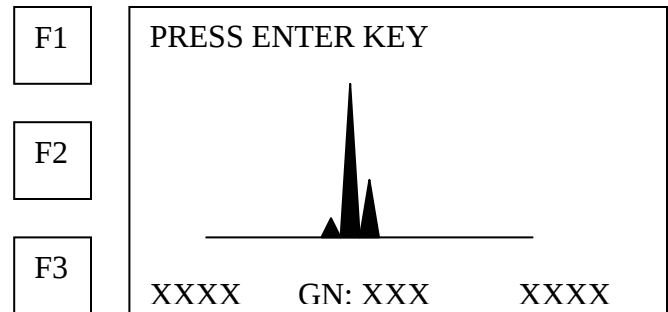
Use this mode for bolts that can be measured without difficulty. The USM-II bypasses the rectified signal display, and signal acquisition, to go directly to digital measurement.



- **AUTO TRIGGER OFF**

This is the normal mode for the USM II. This mode allows the user to place the transducer with maximum echo signal.

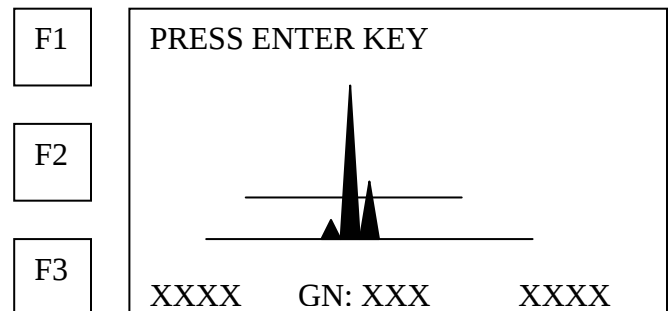
The USM-II displays the received echo signal as a rectified (histogram) waveform.



- **AUTO TRIGGER GATE**

This mode displays and allows the user to select a zone where the USM will measure.

This mode can be used when multiple echoes confuse the automatic peak selection software.



Establishing a password

Note: Password restricts access to all but the measurement function of the USM-II. Set up a password before programming a bolt group data.

F1	AUTO TRIGGER OFF
F2	PASSWORD 0
F3	EXIT

1. Press F2 (PASSWORD) to establish a password.

F1	PASSWORD
F2	XXXXXXXXXX
F3	PRESS ENTER KEY

2. Use the number keys to enter a number up to seven digits, but not beginning with 0.

3. Press the ENTER key to place the password in memory.

	AUTO TRIGGER OFF
	PASSWORD 0
F3	EXIT

4. Press F3 (EXIT) or the END key to return to the main menu.

Note: If a password has been programmed at this point, it must be entered whenever the USM-II is restarted. Be sure to write down your password and keep it in a safe place, as you will not be able to program the USM-II without it.

BOLT OR GROUP DATA functions

The BOLT GROUP DATA allows input of calibration factors for the bolts to be measured, and management of data already stored in the memory of the USM-II.

Use BOLT GROUP DATA to:

- Create a new bolt group
- Modify bolt groups
- Delete a bolt group
- Remeasure bolt data
- Delete bolt data
- experimentally determine load factors

F1	SETUP
F2	BOLT OR GROUP DATA
F3	MEASURE
	Software rel.X.X

Press F2 (BOLT OR GROUP DATA) on the main menu to access **BOLT GROUP DATA**.

F1	CREATE MODIFY GROUP
F2	MODIFY BOLT DATA
F3	CALIBRATE BOLT LOAD

Creating and changing bolt groups

Press F1 (CREATE MODIFY GROUP)

F1	ADD GROUP
F2	DELETE GROUP
F3	VIEW OR MODIFY GROUP

1. Press F1 (ADD GROUP) to add a new bolt group to memory.

F1	ENTER NAME OF BOLT GROUP
F2	XXXXXXXXXXXXXXXXXXXXX
F3	PRESS TO SCROLL

- **Enter the name of the bolt group (UP TO 18 CHARACTERS) using the alphanumeric keys.**

The alphanumeric keys are used by repeatedly pressing the appropriate key until the desired letter or number is displayed. For example the first key is 1, A,B,C and the second 2,E,F,G.

Press **F3** (NXT CHAR) to space right, when using the same key for successive characters.

- **Or F3 (PRESS TO SCROLL LIST) to scroll through bolt groups in memory.**

2. Press the ENTER key when the desired bolt group is displayed.

If the group is not listed in memory, the USM-II inquires if a new group is being created:

F1	CREATE NEW GROUP
F2	NO
F3	YES

- **Press F2 (NO) to cancel creation of a new bolt group and return to previous screen. Or, press F3 (YES) to create a new group.**

F1	HOW MANY BOLTS IN THIS GROUP
F2	XXX
F3	PRESS ENTER KEY

Use the number keys to enter the number of bolts (1 to 999) in the new group.

NOTE: The number of bolts cannot be revised after the bolt group has been created. Therefore make certain to allow enough space for all possible bolts in the group.

3. Press the ENTER key after number of bolts has been entered.

4. The USM- II will ask if the operator wishes to enter comments regarding the bolt group.

The USM-II will allow entry of two comments. Both of which may be 20 characters in length.

F1	COMMENT 1
F2	COMMENT 2
F3	CONTINUE

3. Press F1 (COMMENT 1) to input the first comment.

F1	COMMENT NUMBER 1
F2	
F3	PRESS ENTER KEY

- Enter up to a 20-character comment using the alphanumeric keys.**

The alphanumeric keys are used by repeatedly pressing the appropriate key until the desired letter or number is displayed. For example the first key is A,B,C, 1 and the second E,F,G,2.

Press **F3** (NXT CHAR) to space right, when using the same key for successive characters.

1. Press the ENTER key when the first comment is input.

F1	COMMENT 1
F2	COMMENT 2
F3	CONTINUE

2. Press F2 (COMMENT 2) and repeat the above procedure to input the second comment.
3. Press the ENTER key when second comment has been input
4. Press F3 (CONTINUE) to exit comment procedure
5. The USM-II displays the following menu.

For a new bolt group, the Sonic Stress Factor will default to 0.275 and the Approximate Length will be zero:

F1	SONIC STRESS FACTOR 0.275
F2	APPROX LENGTH XXX.XX
F3	CONTINUE

Entering or changing the sonic stress factor

The sonic stress factor is an empirically determined value for the bolt material or type of bolt being measured. It expresses the ratio of the actual elongation, or stretch, of the bolt, to the apparent ultrasonic change in length.

Note:

- Appendix A presents approximate Sonic Stress Factor values for many fastener materials and types.
- Appendix B discusses how to determine the Sonic Stress Factor experimentally.

The USM-II defaults to Sonic Stress Factor = 0.275, the average value for common steel bolts.

F1	SONIC STRESS FACTOR 0.275
F2	APPROX LENGTH XXX.XX
F3	CONTINUE

1. Press F1 (SONIC STRESS FACTOR) to change the sonic stress factor for the bolt type being measured.

F1	ENTER SONIC STRESS FACTOR
F2	X.XXX
F3	PRESS ENTER KEY

2. Use the number keys to enter or change the sonic stress factor.

3. Press the ENTER key.

Entering or changing the approximate length

The USM-II requires the approximate length of the bolts in the group to eliminate interference by background noise or secondary echoes, and locate the correct echo from the reflecting end of the bolt.

Note: Approximate length entered must be within plus or minus 5% of the actual bolt length.

F1	SONIC STRESS FACTOR 0.275
F2	APPROX LENGTH XXX.XX
F3	CONTINUE

1. Press F2 (APPROXIMATE LENGTH) to change the approximate length value or enter a new value.

- USM-II displays from memory the previously recorded length of an existing Bolt Group.
- For a new bolt group, the value will be 0.0.

F1	ENTER APPROXIMATE LENGTH OF BOLT
F2	XXX.X
F3	PRESS ENTER KEY

2. Use the number keys to enter or change the value.

3. Press the ENTER key.

F1	SONIC STRESS FACTOR 0.275
F2	APPROX LENGTH XXX.XX
F3	CONTINUE

4. Press F3 (CONTINUE).

The USM-II displays the Velocity and Temperature Factor menu:

Entering or changing the velocity

The velocity is the velocity of sound in the bolt material.

Note: The value of the sound velocity for a range of fastener materials and types is presented in Appendix A.

F1	VELOCITY XXXXXX
F2	TEMPERATURE FACTOR XX.X
F3	CONTINUE

Note: The USM-II defaults to the average velocity for steel: V= 232000 inches/sec (5892800 mm/sec).

1. Press F1 (VELOCITY) to change the velocity value.

F1	ENTER VELOCITY
F2	XXXXXXXXXX
F3	PRESS ENTER KEY

2. Use the number keys to enter the velocity.

3. Press the ENTER key.

Entering or changing the temperature factor

The temperature factor is an empirically determined value for the bolt material or type of bolt being measured. More specifically, it is the change in the velocity of sound within the bolt material, per degree of change in the bolt temperature.

Note:

- Appendix A presents the average value of the Temperature Factor for a range of fastener materials and types.
- Appendix C discusses how to determine the temperature factor experimentally.

F1	VELOCITY XXXXXX
F2	TEMPERATURE FACTOR XX.X
F3	CONTINUE

1. Press F2 (TEMPERATURE FACTOR) to change the value of the temperature factor.

The USM-II defaults to the average Temperature Factor for common steel bolts. TF = 58 /°F (104.4 /°C).

F1	ENTER TEMPERATURE FACTOR
F2	XX.X
F3	PRESS ENTER KEY

2. Use the number keys to enter or change the value.

3. Press the ENTER key.

F1	VELOCITY XXXXXX
F2	TEMPERATURE FACTOR XX.X
F3	CONTINUE

4. Press F3 (CONTINUE).

Entering or changing the load factor

F1	LOAD FACTOR XXXX
F2	LOAD OFFSET XX.XX
F3	SAVE GROUP

Note: Load factor and offset are not necessary for measuring elongation. If calculation of load is not required, both the load factor and load offset may be left at the default value of zero.

The load factor is an empirically determined value for the geometry of the bolt. It is the amount of load required to elongate the bolt 0.001 inch in English Units or 0.001mm in Metric Units. The accurate load factor for the bolts being measured is determined by the Calibrate Bolt function.

An approximate value of this geometry dependent factor can be calculated as

$$LoadFactor = \frac{A_{\sigma} E}{(L_g + D)} \times 10^{-3}$$

follows:

Where: A_{σ} = Cross Sectional Area of the Bolt
 E = Modulus of Elasticity of Bolt Material
 L_g = Grip Length of the Bolt
 D = Diameter of the Bolt

If no load factor has been entered, the USM-II defaults to a value of zero.

1. Press F1 (LOAD FACTOR) to enter a load factor calculated by the equation above or previously determined by the Bolt Calibration function.

F1	ENTER LOAD FACTOR
F2	XXXXX
F3	PRESS ENTER KEY

2. Use the number keys to enter the load factor.
3. Press the ENTER key.

Entering or changing the load offset

The load offset is an empirically determined value for the geometry of the bolt and compensates for the erroneous load reading, which may occur at zero elongation measurement. The theoretical value is zero. Compression of the bolted connection or uneven loading of the bolt cross-section can cause some errors. The load offset is determined by the Calibrate Bolt function for the bolts being measured. If no load offset has been entered, the USM-II defaults to a value of zero.

F1	LOAD FACTOR XXXX
F2	LOAD OFFSET XX.XX
F3	SAVE GROUP

1. Press F2 (LOAD OFFSET) to enter the value of a previously determined load offset.

F1	ENTER LOAD OFFSET
F2	XXXX
F3	PRESS ENTER KEY

2. Use the number keys to enter the load offset.
3. Press the ENTER key.

F1	LOAD FACTOR XXXX
F2	LOAD OFFSET XX.XX
F3	SAVE GROUP

Press F3 (STORE GROUP) to complete the creation of the Bolt Group and to store the data in the USM-II memory.

DO NOT PRESS THE END KEY BEFORE PRESSING F3 (SAVE GROUP), OR THE USM-II WILL NOT CREATE THE BOLT GROUP AND ALL INPUT DATA WILL BE LOST.

USM-II returns to main menu

F1	SETUP
F2	BOLT OR GROUP DATA
F3	MEASURE
	Software rel.X.X

Deleting a bolt group

Note:

- When a group is deleted the data will be marked deleted, and that space will remain used until there is not sufficient memory to accommodate a new bolt group. At that point the USM-II will verify if there is sufficient space available to accommodate the new group. If there is enough memory space, the USM-II will automatically repack the memory, and a screen will warn that data will be lost if power is interrupted. See Troubleshooting in Appendix B.
- If there is any question regarding the reliability of this process, press the BACK key to abort the function.

Press F2 (BOLT OR GROUP DATA)

F1	CREATE MODIFY GROUP
F2	MODIFY BOLT DATA
F3	CALIBRATE BOLT LOAD

1. Press F1 (CREATE MODIFY GROUP) to delete one or more bolt groups from memory.

F1	ADD GROUP
F2	DELETE GROUP
F3	VIEW OR MODIFY GROUP

2. Press F2 (DELETE GROUP) to delete one or more bolt groups from memory.

F1	DELETE ONE GROUP
F2	DELETE ALL GROUPS
F3	

3. Press F1 (DELETE ONE GROUP) to remove a single bolt group from memory.

F1	ENTER NAME OF BOLT GROUP
F2	XXXXXXXXXXXXXXXXXX
F3	PRESS TO SCROLL

- **Use the alphanumeric keys to enter the name of the group to be deleted.**
The alphanumeric keys are used by repeatedly pressing the appropriate key until the desired letter or number is displayed. For example the first key is 1,A,B,C and the second key is 2,E,F,G.
Press **F3** (NXT CHAR) to space right, when using the same key for successive characters.
 - **Or press F3 (PRESS TO SCROLL LIST) to display the list of the bolt groups in memory.**
4. Press the ENTER key when the desired bolt group name is displayed.
USM-II requests confirmation:

F1	DELETE ONE GROUP XX
F2	NO
F3	YES

- **Or press F2 (NO) to cancel.**
- **Press F3 (YES) to delete the selected bolt group.**

USM-II returns to deletion option menu.

Deleting all bolt groups

F1	DELETE ONE GROUP
F2	DELETE ALL GROUPS
F3	

1. Press F2 (DELETE ALL GROUPS) to delete all bolt groups from USM-II memory.

F1	DELETE ALL GROUPS
F2	NO
F3	YES

- Or press F2 (NO) to cancel deletion and return to DELETE BOLT GROUP menu.
- Press F3 (YES) to confirm deletion of all bolt groups.
The USM-II will display PLEASE WAIT while each page of memory is erased.

The USM-II will return to the bolt or group data menu when deletion is completed

F1	ADD GROUP
F2	DELETE GROUP
F3	VIEW OR MODIFY GROUP

Reviewing or changing bolt group data

Press F3 (VIEW OR MODIFYGROUP)to review and or change information for a bolt group previously entered in memory.

The USM-II will request the name of the bolt group, which is to be reviewed.

F1	ENTER NAME OF BOLT GROUP
F2	XXXXXXXXXXXXXXXXXXXXX
F3	PRESS TO SCROLL

Use the alphanumeric keys to enter the name of the bolt group to be reviewed.

Press the ENTER key

The USM-II will proceed through the same set of menus used when entering a new bolt group as described above.

All of the information in memory for the bolt group will be displayed in sequence and can be revised by overwriting the previous entry.

When the bolt group data has been reviewed or changed;

Press F3 (STORE GROUP) to place the group in memory with any changes made.

The USM-II returns to the main menu.

F1	SETUP USM
F2	BOLT OR GROUP DATA
F3	MEASURE
	Software rel.X.X

Viewing bolt data in memory

SHORT CUT: At any time during USM-II operation the data in memory for any bolt may be viewed by pressing the DATA key. Please see section on Reviewing, Reporting, and transferring Data

Changing bolt data in memory

Press F2 (BOLT OR GROUP DATA)

F1	CREATE MODIFY GROUP
F2	MODIFY BOLT DATA
F3	CALIBRATE BOLT LOAD

Press F2 (MODIFY BOLT DATA)

F1	CHANGE DATA
F2	CLEAR ONE BOLT
F3	CLEAR BOLTS IN GROUP

Press F1 (CHANGE DATA)

The USM-II requests input of the bolt number (in the active bolt group) for which data is to be changed.

F1	ENTER NUMBER OF BOLT
F2	XXX
F3	PRESS TO SCROLL LIST

Press the number keys to enter the bolt number or scroll to the desired bolt number and press **ENTER**

F1	CHANGE LENGTH XXX.XXXX
F2	CHANGE ELONGATION A X.XXXX
F3	CHANGE LOAD A XXXX

Changing or viewing length

1. Press F1 (CHANGE LENGTH) to make a change to the measurement of the unloaded length.

F1	TEMPERATURE XX.X
F2	UNLOADED LENGTH XXX.XXXX
F3	

2. Press F1 (TEMPERATURE) to change the measurement, which will change the unloaded length measurement.

F1	TEMPERATURE
F2	XXX.XX
F3	PRESS ENTER KEY

3. Press the ENTER key to place the new temperature in memory.

F1	TEMPERATURE XX.X
F2	UNLOADED LENGTH XXX.XXXX
F3	

4. Press F2 (UNLOADED LENGTH) to make a new measurement of the unloaded length.

After the ENTER key is pressed at the completion of the signal quality presentation, the USM-II displays the values for the new measurement:

F1	
F2	XXXXXXXXXX
F3	UNLOADED LEN. INCHES

5. Press the ENTER key to place the new length measurement in memory.

Changing or viewing elongation

F1	CHANGE LENGTH XXX.XXXX
F2	CHANGE ELONGATION A X.XXXX
F3	CHANGE LOAD A XXXX

1. Press F2 (CHANGE ELONGATION) to make a change in the elongation measurement.

F1	TEMPERATURE XX.X
F2	ELONGATION X.XXXX
F3	PRESS TO SCROLL

- Press F3 (SKIP TO POINT AFTER) to scroll through the elongation measurements in memory for the selected bolt, or to select the elongation measurement, which is to be changed.
- Press F1 (TEMPERATURE) to adjust the temperature for recalculation of elongation.

F1	TEMPERATURE
F2	XXX.XX
F3	PRESS ENTER KEY

2. Use the number keys to enter the new temperature.
3. Press the ENTER key to recalculate elongation and place values in memory.

F1	TEMPERATURE XX.X
F2	ELONGATION X.XXXX
F3	PRESS TO SCROLL

4. Press F2 (ELONGATION) to make a new measurement of the elongation

F1	
F2	0.XXXX
F3	ELONGATION INCHES GO TO LOAD

5. Press the ENTER key to place new elongation measurement in memory.

Changing or viewing load

F1	CHANGE LENGTH XXX.XXXX
F2	CHANGE ELONGATION A X.XXXX
F3	CHANGE LOAD A XXXX

1. Press F3 (CHANGE LOAD) to change or make a new measurement of load on the selected bolt, or to change the value of the known load.

F1	MEASURED LOAD XXXXX
F2	GIVEN LOAD XXXXX
F3	PRESS TO SCROLL

2. Press F3 (SKIP TO POINT AFTER) to scroll through the load measurements in memory for the selected bolt, or to select the measurement point to be changed.

NOTE: The measurement point shown under the SKIP TO POINT AFTER prompt is the current measurement point, and corresponds to the MEASURE LOAD shown. Pressing skip moves to the next point.

F1	MEASURED LOAD XXXXX
F2	GIVEN LOAD XXXXX
F3	PRESS TO SCROLL

3. Press F1 (MEASURED LOAD) to make a new measurement for the selected load. USM-II displays the new measurement values:

F1	
F2	XXXXXXXXXX
F3	LOAD POUNDS GO TO ELONGATION

4. Press the ENTER key to place the new load in memory.

F1	MEASURED LOAD XXXXXX
F2	GIVEN LOAD XXXXXX
F3	PRESS TO SCROLL

5. Press F2 (GIVEN LOAD) to change the known load, which corresponds to the elongation measurement at the selected point.

Note: this value is used to calculate load factor and load offset in the calibration mode.

F1	GIVEN LOAD
F2	XXX.X
F3	PRESS ENTER KEY

6. Use the number keys to enter the known load.

7. Press the ENTER key to place known load in memory.

8. Press the END key to return to main menu

F1	SETUP
F2	BOLT OR GROUP DATA
F3	MEASURE
	Software rel.X.X

Deleting bolt data from the active Bolt Group

Press F2 (BOLT OR GROUP DATA)

F1	CREATE MODIFY GROUP
F2	MODIFY BOLT DATA
F3	CALIBRATE BOLT LOAD

Press F2 (MODIFY BOLT DATA)

F1	CHANGE DATA
F2	CLEAR ONE BOLT
F3	CLEAR BOLTS IN GROUP

1. Press F2 (CLEAR ONE BOLT) to delete data for a single bolt in the active Bolt Group.

F1	ENTER BOLT NUMBER TO CLEAR
F2	XXX
F3	PRESS TO SCROLL

- Use the number keys to enter the number of the bolt group to be cleared.
- Or press F3 (PRESS TO SCROLL) to scroll through the list of bolt numbers in the active group.

Press the ENTER key when the correct bolt number is displayed.

F1	CLEAR ONE BOLT XX
F2	NO
F3	YES

Press F2 (NO) or press F3 (YES) to cancel or confirm deletion of data for the bolt group selected.

Press the ENTER or BACK key to return to the Measure menu.

2. Press F3 (CLEAR BOLTS IN GROUP) to clear the data for all the bolts in the active Bolt Group.

F1	CLEAR BOLTS IN GROUP XXX
F2	NO
F3	YES

3. Press F2 (NO) or F3 (YES) to cancel or confirm deletion of all bolt data in the Bolt Group shown.
4. Press END to return to main menu

Calculating the bolt load factor

This function allows the operator to calculate the load factor for any bolt group in memory if known loads have been entered for at least two measurements of elongation on a bolt within the selected bolt group. See **Measuring elongation and load**, for more detailed discussion.

F1	SETUP USM
F2	BOLT OR GROUP DATA
F3	MEASURE Software rel.X.X

1. Press F2 (BOLT OR GROUP DATA) to go to bolt group options menu.

F1	CREATE MODIFY GROUP
F2	MODIFY BOLT DATA
F3	CALIBRATE BOLT LOAD

2. Press F3 (CALIBRATE BOLT LOAD).

F1	ENTER NAME OF BOLT GROUP
F2	XXXXXXXXXXXXXXXXXXXXX
F3	PRESS TO SCROLL LIST

- Use the alphanumeric keys to enter the bolt group name.
 - Or press F3 (PRESS TO SCROLL LIST) to scroll through the bolt groups in memory.
3. Press the ENTER key when the desired bolt group is displayed.
- The USM-II will calculate and display the correct load factor and load offset for the selected Bolt Group based on the known loads entered to correspond to elongation measurements.

F1	LOAD FACTOR XXXX
F2	LOAD OFFSET XXXX
F3	SAVE GROUP

4. Press F3 (STORE GROUP) to store calculated values of load factor and load offset for the selected Bolt Group and return to the main menu.

MEASURE function

Use the MEASURE functions to perform the actual measurement of bolts.

F1	SETUP USM
F2	BOLT GROUP DATA
F3	MEASURE
	Software rel.X.X

Press F3 (MEASURE) on the Main menu to enter the MEASURE menu.

Entering bolt temperature

The USM-II displays the last temperature entered.

F1	TEMPERATURE XX.X
F2	BOLT GROUP XXXXXXX
F3	CONTINUE

1. Press F1 (TEMPERATURE) to enter the bolt temperature

Note: The temperature entered here combined with the temperature factor entered in Bolt Group Data are used to normalize the calculation of length and elongation values to 68°F (20°C).

F1	TEMPERATURE
F2	XXX.XX
F3	PRESS ENTER KEY

2. Use the number keys to enter the value.

3. Press the ENTER key to store the data.

Selecting the Bolt Group to measure

F1	TEMPERATURE XX.X
F2	BOLT GROUP XXXXXXX
F3	CONTINUE

1. Press F2 (BOLT GROUP) to access a different bolt group.

NOTE: The Bolt Group must have been previously placed in memory using the Create Bolt Group function.

F1	ENTER NAME OF BOLT GROUP
F2	XXXXXXXXXXXXXXXXXXXXX
F3	PRESS TO SCROLL LIST

- **Use the alphanumeric keys to enter the bolt group name. (UP TO 18 CHARACTERS)**

The alphanumeric keys are used by repeatedly pressing the appropriate key until the desired letter or number is displayed. For example the first key is A,B,C,1 and the second E,F,G,2.

Press **F3** (NXT CHAR) to space right, when using the same key for successive characters.

- **Or press F3 (PRESS TO SCROLL LIST) to scroll the list of bolt groups in memory.**

2. Press the ENTER key when the desired Bolt Group name is displayed.

F1	TEMPERATURE XX.X
F2	BOLT GROUP XXXXXXX
F3	CONTINUE

3. Press F3 (CONTINUE).

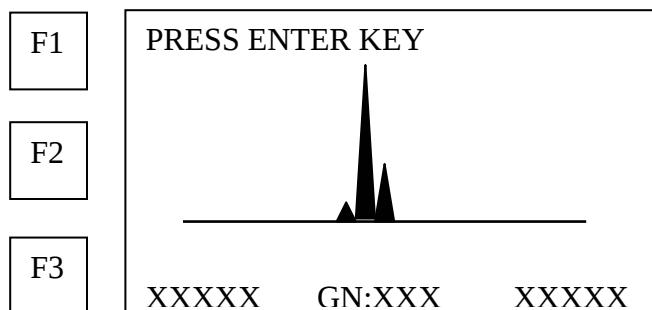
Measuring a bolt in the selected Bolt Group

1. Press F3 (MEASURE BOLT) to begin actual measurement of bolts in the active Bolt Group.

F1	ENTER NUMBER OF BOLT XXX PRESS TO SCROLL LIST
F2	
F3	

- Use the number keys to enter the number of the bolt to be measured.
 - Or press F3 (PRESS TO SCROLL LIST) to scroll through bolt numbers in the active group.
2. Press the ENTER key when the correct bolt number is displayed.

3. Couple the transducer to the end of the bolt to be measured.
With automatic trigger OFF, the USM-II mode displays a graphic image of the echo received from the end of the bolt:



4. Adjust the position of the transducer on the bolt end to minimize the gain value displayed, and obtain, as closely as possible, a single spike of Maximum height.

If the automatic trigger mode is ON, the USM-II will skip the above display and proceed directly to measurement of unloaded length.

5. Press the ENTER key.

USM-II displays the ultrasonic length measurement:

NOTE: The function keys (F1, F2, F3) may be used to activate Signal Analysis. See page 62.

F1	 XXXXXXXXXX UNLOADED LEN. INCHES
F2	
F3	

6. Press the ENTER key to place unloaded length measurement in memory. The USM-II allows continuous measurement of a selected bolt, or sequential measurements of all bolts in the active Bolt Group.

F1	MEASURE ELONGATION? A
F2	MEASURE NEXT BOLT?
F3	

- Press F2 (MEASURE NEXT BOLT) for the next bolt in the active Bolt Group, then repeat steps 1 – 6.
- Or press F1 (MEASURE ELONGATION) to measure elongation or load on the currently selected bolt.

Measuring elongation and load

Note:

- If the Load Factor for the active bolt group is 0.0 (no entry), the unit will automatically begin the measurement of Elongation.
- If a Load Factor other than 0.0 has been entered for the active bolt group, the USM-II will automatically begin the measurement of Load.
- If the bolt selected has an unloaded length in memory, the USM-II will go directly to measurement of Elongation or Load.
- If the bolt number selected does not have an unloaded length in memory, the unit will proceed with measurement of the unloaded length.

1. Tighten bolt to point where elongation or load will be measured.

USM-II displays measurement of elongation:

NOTE: The function keys (F1, F2, F3) may be used to activate Signal Analysis. See page 62.

F1	 0.XXXX ELONGATION INCHES GO TO LOAD
F2	
F3	

2. Press F3 (GO TO LOAD) to toggle to measurement of load.

NOTE: If no Load Factor has been entered for the bolt group dashes will be displayed.

F1	 XXXXXXXXXX LOAD POUNDS GO TO ELONGATION
F2	
F3	

3. Press F3 (GO TO ELONGATION) to toggle back to measurement of elongation.

4. Press the ENTER key for the first elongation / load measurement (point A) on the selected bolt to be placed in memory.

F1	NEXT ELONGATION? B MEASURE NEXT BOLT? ENTER A GIVEN LOAD
F2	
F3	

5. Press F1 (NEXT ELONGATION) to measure elongation or load at a second point (B) on the same bolt.

6. Repeat steps 1-5.

Note: The USM-II can record up to 5 measurements on an individual bolt, identified as A, B, C, D, and E, in the order of measurement made. If 5 measurements have been recorded for a given bolt, the USM-II warns that the memory for this bolt is full.

F1	NEXT ELONGATION? B MEASURE NEXT BOLT? ENTER A GIVEN LOAD
F2	
F3	

7. Press F2 (MEASURE NEXT BOLT?) to measure another bolt.

Note: USM-II will automatically display the next higher bolt number. However, any number may be entered using the number keys, or by scrolling the bolts in memory.

8. Repeat all steps for measuring a bolt in the active Bolt Group.

Entering a known load for calibration

F1	NEXT ELONGATION? B
F2	MEASURE NEXT BOLT?
F3	ENTER A GIVEN LOAD

1. Press F3 (ENTER A GIVEN LOAD) to enter independently measured load data to calculate the load factor and load offset for the active Bolt Group.

Note: A minimum of two known loads must be entered to calculate the load factor and load offset. Up to 5 loads for all bolts in the selected Bolt Group can be used in the calculation.

F1	GIVEN LOAD
F2	XXX.X
F3	PRESS ENTER KEY

2. Use the number keys to enter the value.
3. Press the END key when all measurements have been entered for the current group.

Reviewing, Reporting, and Transferring Data

Unless changed or deleted, the data entered is preserved in the USM-II memory indefinitely. Back-up copies should be made frequently by transferring data to a PC, as discussed later in this section.

Note: A data review, data transfer, or printed report can be sent at any time during operation, except when the USM-II is actually measuring of length, elongation, or load.

Reviewing Data in Memory

1. Press the DATA key
2. Press the ENTER key when the desired bolt group name is displayed.

F1	SELECT BOLT	X
	A	XXXXXXXX XXXXXXXX
	B	XXXXXXXX XXXXXXXX
F2	C	XXXXXXXX -----
	D	-----
	E	XXXXXXXX -----
F3	SELECT GROUP	
	X	

The USM-II displays a tabulation of the 5 (A thru E) elongation and load readings recorded for the first bolt in the active Bolt Group. If no value is recorded for any of the measurements in the tabulation, the USM-II will display dashes in the appropriate location.

To change the active Bolt Group press F3 (SELECT GROUP)

The USM-II requests the name of the bolt group to be reviewed

F1	ENTER NAME OF BOLT GROUP
F2	XXXXXXXXXXXXXXXXXXXXX
F3	PRESS TO SCROLL LIST

- **Enter the name of the bolt group using the alphanumeric keys.**

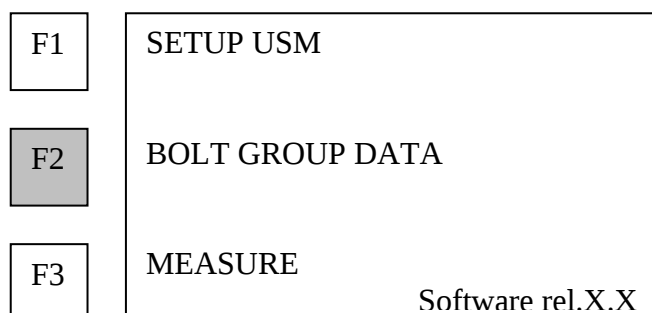
The alphanumeric keys are used by repeatedly pressing the appropriate key until the desired letter or number is displayed. For example the first key is A,B,C, 1 and the second E,F,G,2. Press **F3** (NXT CHAR) to space right, when using the same key for successive characters.

- Or F3 (PRESS TO SCROLL LIST) to scroll through bolt groups in memory.

To select a bolt in the active bolt group;

- Press the DATA arrows between the 4 and 5 keys to scroll forward or back through the Bolts in the selected Bolt Group
- Press END when review of the data for the Bolt Group is complete.

The USM-II returns to the Main Menu.

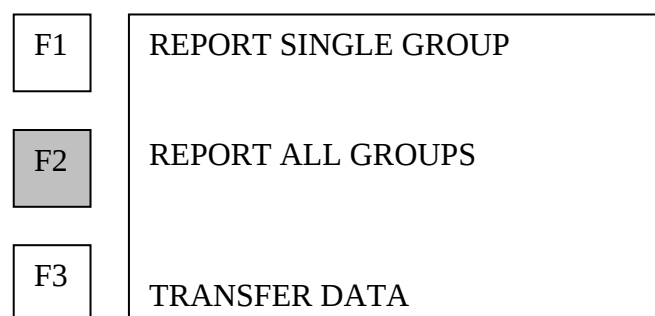


Sending reports to a PC or printer

A USM-II report includes calibration data, comments, unloaded reference data, and all elongation and load measurements. A sample report is shown in Appendix G.

1. Connect compatible PC or printer to the USM-II through the RS232 port using the interface cable provided with the USM-II. The cable is standard 9 to 9 pin. (Pin-out: pin 2 Transmit; pin 3 Receive; pin 5 Ground)
Interface is 9600 baud, 1 stop, no parity.
2. Press the SEND key to access the report options menu.

Reporting all groups



1. Press F2 (Report ALL GROUPS) to transmit a report for All Bolt Groups in the USM-II memory.
2. Press the BACK key to abort report output

Note: Reports of all bolt groups in memory are transmitted automatically. If the memory contains numerous bolts, transmission of the report may require several minutes.

Reporting single group

F1	REPORT SINGLE GROUP
F2	REPORT ALL GROUPS
F3	TRANSFER DATA

1. Or press F1 (REPORT SINGLE GROUP) to transmit a report for any single Bolt Group in the USM-II memory.

F1	ENTER NAME OF BOLT GROUP
F2	XXXXXXXXXXXXXXXXXXXXX PRESS TO SCROLL LIST
F3	

2. Use the alphanumeric keys to enter the name of the single group.
3. Or press F3 to scroll through bolt groups in memory.
4. Press the ENTER key to transmit the report.

Transferring data between USM-II units

The USM-II can exchange data for any bolt group in memory between USM-II units, using internal software.

1. Connect the two USM-II units together through the RS232 ports (9 pin "D" connector).

NOTE: This will require the use of a non-standard null modem cable, which is available from NORBAR.

2. Press the SEND key to access the report options menu.

F1	REPORT SINGLE GROUP
F2	REPORT ALL GROUPS
F3	TRANSFER DATA

3. Press F3 (TRANSFER DATA) to begin the transfer of data for any bolt group in memory to or from the USM-II.
4. Press F2 (RESTORE GROUP) on the receiving USM-II to enable it to receive the data.
 - Receiving USM-II notifies the operator that it is waiting for group data:

F1	WAITING FOR GROUP TO BE SENT
F2	
F3	

The sending unit is ready to transmit data with the following display

F1	BACKUP GROUP
F2	RESTORE GROUP
F3	

5. Press F1 (BACKUP GROUP) on the sending USM-II to transmit bolt group data to the receiving USM-II.

F1	ENTER NAME OF BOLT GROUP
F2	XXXXXXXXXXXXXXXXXXXXX
F3	PRESS TO SCROLL LIST

- Use the alphanumeric keys to enter the name of the bolt group to be transmitted.
 - Or press F3 (PRESS TO SCROLL LIST) to scroll the list of bolt groups in memory.
6. Press the ENTER key when the desired bolt group name is displayed.
The USM-II requests the operator to wait while data for the selected bolt group is transmitted:

F1	PLEASE WAIT SENDING DATA
F2	
F3	

The USM-II will display the bolt numbers as the data is transmitted.
When data transfer is complete the USM-II returns to the **BACKUP / RESTORE** menu:

F1	BACKUP GROUP
F2	RESTORE GROUP
F3	

NOTE: Data for a bolt group, which already exists in the memory of the receiving USM-II cannot be overwritten. When data transmission begins, the USM-II checks to see if the bolt group name being received is already in memory. The USM-II will refuse to accept the data and will alert the operator with the following display:

F1	TRANSFER ABORTED NO OVERWRITE! PRESS ENTER KEY
F2	
F3	

- To replace the existing data with the data being sent under the same bolt group name, the bolt group must be deleted as discussed under

Deleting bolt data from the active Bolt Group, page 38, and then repeat the RESTORE GROUP function.

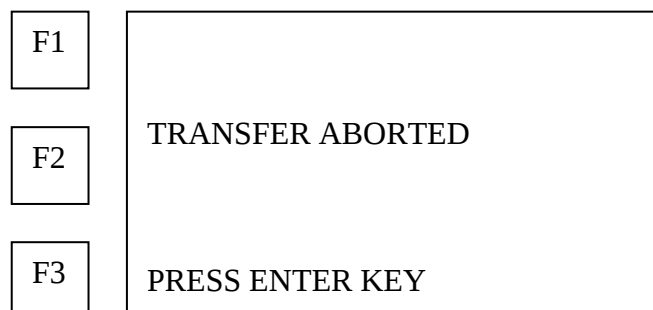
- If sufficient memory space is not available in the USM-II to receive the bolt group data being transmitted, the unit displays **INSUFFICIENT MEMORY**. To create the required memory space, it is necessary to repack the USM-II memory or clear the memory by using the **DELETE ALL GROUPS** function. Existing data should be sent to backup prior to this procedure.

Transferring data from the USM-II to a PC

1. Connect the USM-II RS-232 port (9 pin “D” connector) to the serial port on the PC using the standard serial interface cable provided with the USM-II
The cable is standard 9 to 9 pin. (Pin-out: pin 2 Transmit; pin 3 Receive; pin 5 Ground)
Interface is 9600 baud, 1 stop, no parity.
2. Install Norbar “USM-IIUtils” utility software on the PC. Be sure to check for the latest version on the Norbar website at www.norbar-usa.com.
3. Once USM-IIUtils has been installed, refer to the USM-IIUtils help section for complete instructions on transferring data between the PC and USM-II systems.

Canceling data transmission

1. Press the **BACK** key or the **END** key to cancel data transmission.
USM-II will display that transfer has been aborted:

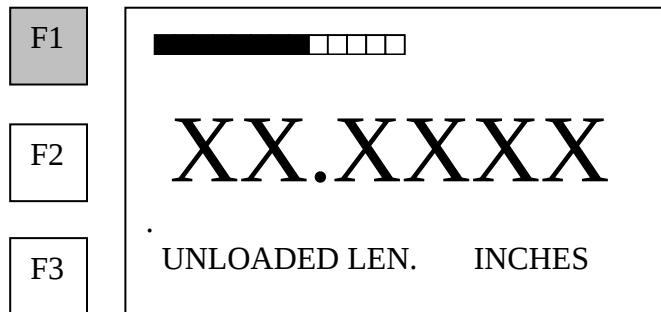


Press the **ENTER** key to return to the **BACKUP / RESTORE** menu.

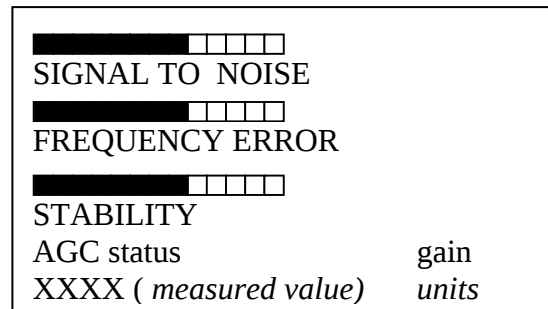
Signal Analysis

The Norbar USM-II offers advanced signal digitization and analysis. In all but the most difficult applications, the USM-II is able to select the best signal available and display a graphic representation of the composite signal quality. When the USM-II is in measurement mode, (unloaded length, elongation, load), a bar graph appears at the top of the display, which darkens from left to right as signal quality improves. A completely darkened bar indicates the best possible signal quality. To increase operator control, the USM-II also provides graphic representations of each signal characteristic used for the composite analysis.

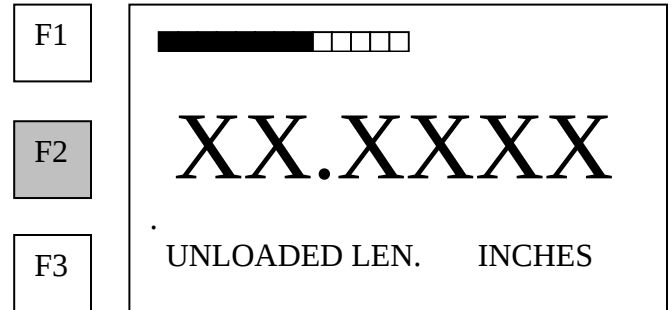
When measuring unloaded length



1. Press F1 for a bar graph presentation of signal components.

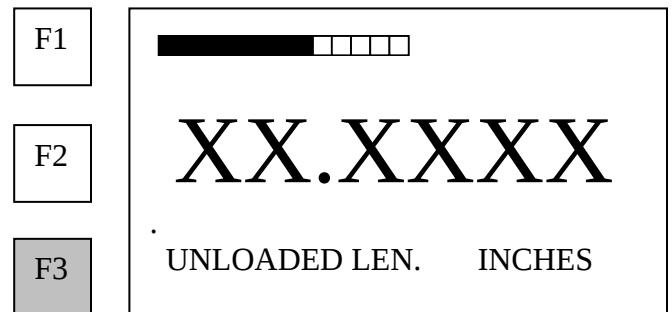
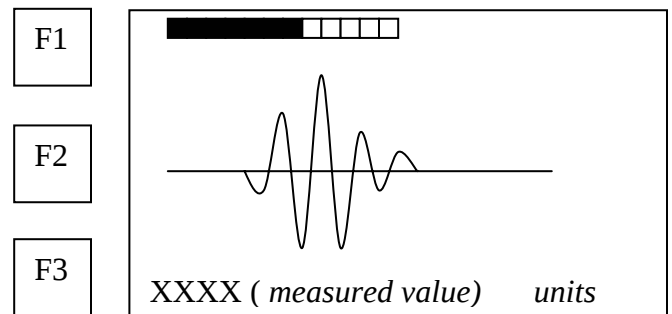


- SIGNAL TO NOISE represents the ratio of signal amplitude to background noise.
- FREQUENCY ERROR represents the ratio of signal frequency to that of the transducer.
- STABILITY represents the stability or consistency of the signal.
- AGC displays whether the automatic gain control is ON or OFF and the present Gain value.
AGC is normally ON during measurement of unloaded length.
- The measured value (length, elongation or load) and units appear at the bottom.



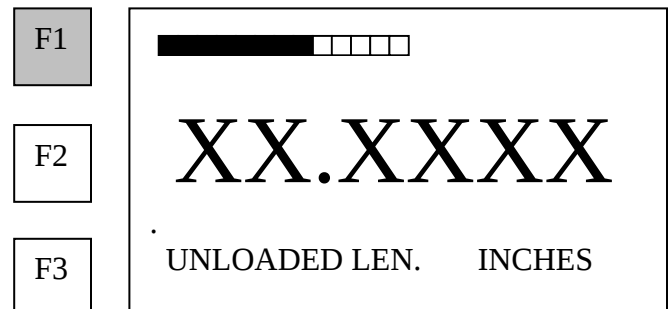
2. Press F2 to view the shape and relative amplitude of the echo, as shown below.

NOTE: Press F2 to cycle the horizontal scale of the waveform display through four values.

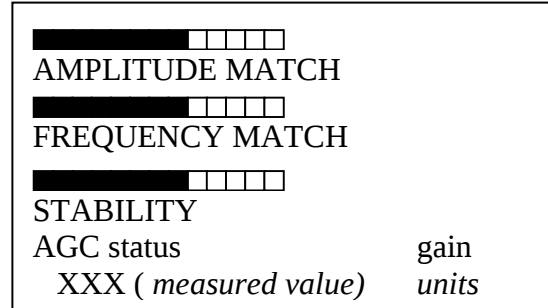


3. Press F3 to return to length measurement.

When measuring elongation and load

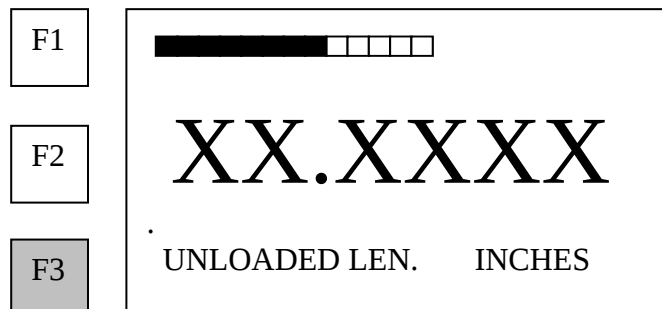
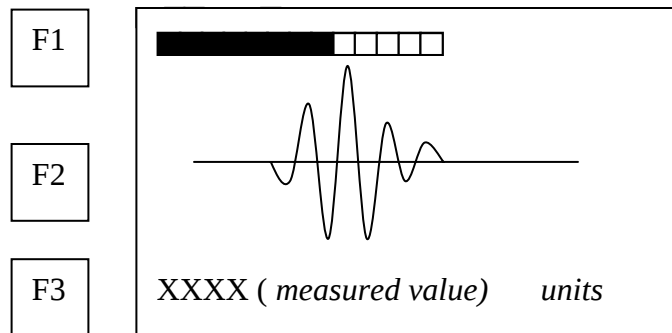


1. Press F1 for a graphic comparison of the present signal to the signal used for unloaded length measurement.



- AMPLITUDE MATCH compares the signal amplitude being used to measure Elongation or Load to the signal amplitude used to measure Unloaded Length.
- FREQUENCY ERROR compares the signal frequency being used to measure Elongation or Load to the signal frequency used to measure Unloaded Length.
- STABILITY represents the stability or consistency of the signal.
- AGC: displays whether the automatic gain control is ON or OFF and the presents gain value.
AGC is normally OFF during measurement of elongation or load.
- Length (*measured value*) and *units* appear at the bottom.

2. Press F2 to view the shape and relative amplitude of the echo.



4. Press F3 to return to elongation or load measurement.

Rectified signal display

The display of the rectified signal that occurs when the USM-II is placed in an active measurement mode (when automatic triggering is off) is presented to assist the operator in positioning the transducer on the bolt end.



The operator should adjust the position of the transducer on the bolt end so the gain displayed in the lower portion of the display is the minimum achievable value, and the rectified display of the echo is, as close as possible, a single spike, of maximum height.

On the bottom of the display, the bolt lengths are shown lengths which corresponding to the left and right edges of the display. These will initially be set to $\pm 5\%$ of the entered approximate length.

In the event that a clean sharp spike is not visible, it may be that the approximate length is not centered properly or there may be a flaw in the bolt causing the echo to return at a shorter length. In order to investigate, the scanning range distance and width can be modified as follows:

To move the scanning window along the length of the bolt use the DELAY arrows between the "7" and "8" keys. The (-) arrow moves the scanning window toward the transducer, and the (+) arrow moves the window toward the reflecting end of the bolt. As the window is moved along the bolt the bolt length at which the USM-II begins scanning appears in the lower left of the display. The bolt length at which scanning is stopped appears in the lower right of the display.

The scanning window may be widened by using the WIDTH arrows between the "Space" and "0" key. The arrows move the stop point of scanning, while holding the beginning point of the scan constant. Thus the scan window is widened or narrowed.

Note The DELAY and WIDTH arrows keys are only active in the rectified signal display mode.

Appendix A

Bolt calibration factors

Note: These are approximate values and should only be used when accuracy of plus minus 10% is acceptable.

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
4140 STEEL	0.274	56	101	232000	5890000	29.9	205
4340 STEEL	0.285	55	99	232000	5890000	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	5890000	30	207
A193 B16	0.280	57	103	232000	5890000	30	207
A325	0.274	56	101	232000	5890000	29.9	205
A490	0.299	60	108	232000	5890000	29.9	205
A540	0.299	60	108	232000	5890000	30	207
SAE SPECIFICATIONS 1038							
Gr.2	0.275	57	103	232000	5890000	29.9	205
Gr.5	0.275	57	103	232000	5890000	29.9	205
Gr.6	0.277	60	108	232000	5890000	29.9	205
Gr.8	0.274	57	103	232000	5890000	29.9	205
Gr.9	0.275	58	104	232000	5890000	29.9	205
ISO SPECIFICATIONS R898							
Gr.9.8	0.276	58	104	232000	5890000	29.9	205
Gr.10.9	0.274	57	103	232000	5890000	29.9	205
Gr.12.9	0.274	57	103	232000	5890000	29.9	205

Appendix B

Determining sonic stress factor by measuring length

Following are steps for determining the Sonic Stress Factor for bolts of a specific bolt material and specific geometry by measurement of the actual change in bolt length.

Required Equipment:

- A laboratory or room in which the temperature can be maintained from 66° to 70° F (19°- 21°C).
- A means of applying load to the bolt. Ideally this would be a tensile load machine, capable of measuring the applied load to within 100 lbs. However, since the actual value of the applied load is not used in calculating the stress factor, any means of applying an approximate load to the bolt will suffice. This includes tightening the bolt against a fixture that simulates the actual joint. A mechanical means of traceable measurement of the physical length of the sample fasteners at various tensile loads to an accuracy of plus or minus 0.0001 inch. Examples of such devices include the following
 - Length measurement function of sophisticated tensile test machine
 - Mechanical or electronic height gages
 - Averaged values of length measurement with mechanical and electric micrometers.
- A Norbar USM-II Ultrasonic Bolt Meter.
- A minimum of three sample bolts which are representative of the bolt type and geometry for which the Sonic Stress Factor is to be determined.

NOTES:

- The Norbar USM-II must be calibrated, or zeroed, as described in the procedure entitled System Zeroing in the Setup section of the USM-II Operation.
- The sample bolts must be left to soak in the controlled temperature environment for a period of not less than 24 hours. Care must be taken through out the measurement process to avoid significant change in the bolt temperature due to handling of the sample bolts, or the process of applying load.
- The mechanical apparatus for measurement of length must be calibrated in accord with governing QA procedures. The device should be configured so that minimum handling of the sample bolts will be required during the measurement process.

Determination of the Sonic Stress Factor is accomplish by solving the equation:

$$SonicStressFactor = \frac{\Delta L_{MECHANICAL}}{\Delta L_{ULTRASONIC}} = \frac{L_{Ml} - L_{M0}}{L_{Ul} - L_{U0}}$$

Where:

$$L_{U0} = \text{UltrasonicLength@ ZeroLoad}$$

$$L_{M0} = \text{MechanicalLength@ ZeroLoad}$$

$$L_{Ul} = \text{UltrasonicLength@ Load}$$

$$L_{Ml} = \text{MechanicalLength@ Load}$$

Acquire data as follows:

1. Using the mechanical measuring device, measure and record the Mechanical Length at Zero Load “ L_{M0} ” for each sample bolt.
2. Using the USM-II in the Unloaded length measurement mode, measure and record the Ultrasonic Length at Zero Load “ L_{U0} ” for each sample bolt. NOTE: Ultrasonic measurements will be more easily accomplished, and more accurate, if the transducer remains undisturbed on the bolt through out the loading process.
3. Place the first sample bolt in the loading apparatus.
4. Apply approximately 1/3 of the Maximum load, which is to be placed on the bolt under actual working conditions.
5. Using the mechanical measuring device, measure and record the Mechanical Length at Load 1 “ L_{M1} ” for the current sample bolt.
6. Using the USM-II in the Unloaded length measurement mode, measure and record the Ultrasonic Length at Load 1 “ L_{U1} ” for the current sample bolt.
7. Increase the applied load to approximately 2/3 of the Maximum load, which is to be placed on the bolt under actual working conditions.
8. Using the mechanical measuring device, measure and record the Mechanical Length at Load 2 “ L_{M2} ” for the current sample bolt.
9. Using the USM-II in the Unloaded length measurement mode, measure and record the Ultrasonic Length at Load 2 “ L_{U2} ” for the current sample bolt.
10. Increase the applied load to approximately the Maximum load, which is to be placed on the bolt under actual working conditions.
11. Using the mechanical measuring device, measure and record the Mechanical Length at Load 3 “ L_{M3} ” for the current sample bolt.
12. Using the USM-II in the Unloaded length measurement mode, measure and record the Ultrasonic Length at Load 3 “ L_{U3} ” for the current sample bolt.
13. Repeat steps 4 through 12 for the second and third sample bolt.
14. Calculate the value of the Sonic Stress Factor at each load on each sample bolt.

$$SSF_{B1L1} = \frac{L_{M1} - L_{M0}}{L_{U1} - L_{U0}} \quad SSF_{B1L2} = \frac{L_{M2} - L_{M0}}{L_{U2} - L_{U0}} \quad SSF_{B1L3} = \frac{L_{M3} - L_{M0}}{L_{U3} - L_{U0}}$$

AND SO ON FOR EACH SAMPLE BOLT

15. Determine the average value of the Sonic Stress Factor by dividing the sum of all SSF values calculated by the total number of SSF values

The above data collection and calculations can be performed easily by use of an **MS Excel** spreadsheet. For the convenience of our customers, a preprogrammed spreadsheet is available for download from our web site at www.norbar-usa.com, or on disk by contacting Norbar USA. Tel. (831) 464-7155. Fax (831) 464-0146.

Estimating the Sonic Stress Factor by measuring load

The following describes a procedure by which the Sonic Stress Factor can be calculated by measurement of the applied load.

It must be noted that this procedure is inherently less accurate than the measurement of actual change in bolt length, as described in Appendix B Part 1. The inaccuracy results from the calculation of theoretical change in bolt length under applied load. This calculation, which is the expression of Hooke's Law, requires assumptions as to the effective, or working length, and the stressed cross-sectional area of the bolt, as well as the Modulus of Elasticity of the bolt material. Therefore the final calculation of the Stress factor will be only as accurate as those assumptions.

It is therefore recommended be used only where apparatus for measurement of length is not available, and where bolt geometry allows reasonably accurate estimation of effective length and cross-sectional area.

As discussed in Part 1 the equation for the Sonic Stress Factor is:

$$\text{SonicStressFactor} = \frac{\Delta L_{\text{MECHANICAL}}}{\Delta L_{\text{ULTRASONIC}}} = \frac{\Delta L_{\text{MECHANICAL}}}{L_{U1} - L_{U0}}$$

In this procedure we will be measuring the change in Ultrasonic Length in the same manner as in Part 1. However, we will be calculating the change in Mechanical Length (Elongation) by use of Hooke's Law:

$$\Delta L = \frac{PL}{AE}$$

Where:

$$\Delta L = \Delta L_{\text{MECHANICAL}} = \text{Elongation}$$

P = Applied Load

L = Effective Length (Normally the clamping length + one diameter)

A = Cross-sectional Area of the Stressed Portion of the Bolt

E = Modulus of Elasticity of the Bolt Material (Young's Modulus)

Estimate the value of L, A, as accurately as possible given the bolt geometry. The value of E is published for virtually all materials. The values for common bolt materials are presented in Appendix A.

Acquire data as follows:

1. Using the USM-II in the Unloaded length measurement mode, measure and record the Ultrasonic Length at Zero Load " L_{U0} " for each sample bolt.
NOTE: Ultrasonic measurements will be more easily accomplished, and more accurate, if the transducer remains undisturbed on the bolt through out the loading process.
2. Place the first sample bolt in the loading apparatus.
3. Apply approximately and record 1/3 of the Maximum load, which is to be placed on the bolt under actual working conditions. " P_1 "
4. Using the USM-II in the Unloaded length measurement mode, measure and record the Ultrasonic Length at Load 1 " L_{U1} " for the current sample bolt.

5. Increase and record the applied load to approximately 2/3 of the Maximum load, which is to be placed on the bolt under actual working conditions. "P₂"
6. Using the USM-II in the Unloaded length measurement mode, measure and record the Ultrasonic Length at Load 2 "L_{U2}" for the current sample bolt.
7. Increase and record the applied load to approximately the Maximum load, which is to be placed on the bolt under actual working conditions. "P₃"
8. Using the USM-II in the Unloaded length measurement mode, measure and record the Ultrasonic Length at Load 3 "L_{U3}" for the current sample bolt.
9. Repeat steps 4 through 12 for the second and third sample bolt.
10. Calculate the value of the Sonic Stress Factor at each load on each sample bolt.

$$SSF_{B1L1} = \frac{P_1 L}{(L_{U1} - L_{U0})AE} \quad SSF_{B1L2} = \frac{P_2 L}{(L_{U2} - L_{U0})AE} \quad SSF_{B1L3} = \frac{P_3 L}{(L_{U3} - L_{U0})AE}$$

AND SO ON FOR EACH SAMPLE BOLT

11. Determine the average value of the Sonic Stress Factor by dividing the sum of all SSF values calculated by the total number of SSF values

$$SSF_{AVERAGE} = \frac{SSF_{B1L1} + SSF_{B1L2} + SSF_{B1L3} \cdots + SSF_{B3L3}}{9}$$

The above data collection and calculations can be performed easily by use of an **MS Excel** spreadsheet. For the convenience of our customers, a preprogrammed spreadsheet is available for download from our web site at www.norbar-usa.com, or on disk by contacting Norbar USA. Tel. (831) 464-7155. Fax (831) 464-0146.

Estimating the Load Factor

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

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 as described in this manual under “Calculating the Bolt Load Factor”.

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

In the USM-1 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 0.001 inch of elongation (lbs/0.001in.). In metric unit systems the factor is defined as Kilonewtons or Kilograms per 0.001mm.

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:

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

Where: $P = \text{Load}$

$\Delta l = \text{Elongation}$

$A = \text{Cross Sectional Area of the Bolt}$

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 Behavior 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.

$$A_{average} = \frac{A_1 L_1 + A_2 L_2 + A_3 L_3 \cdots A_n L_n}{L_1 + L_2 + L_3 + \cdots L_n}$$

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 USM-II reveals that no single theory is valid for all bolt configurations. Thus, for the estimation of the Load Factor discussed here, it is sufficient assume that the

$$L = L_g + D$$

approximate stressed length is equal to the clamp length of the joint plus the nominal bolt diameter.

The Load Factor (the load required for 0.001 elongation) is calculated by solving the above equation for Hooke's Law while setting the value of the elongation at 0.001.

$$LoadFactor = P_{0.001} = \frac{0.001AE}{L} = \frac{AE}{(L_g + D) \times 1000}$$

Appendix C

Determining the Temperature Factor

The following presents the procedure for experimental determination of the Temperature Factor for a bolt made of a specific bolt material and having specific geometry.

Required Equipment.

- A means of varying, and measuring the temperature of the sample bolts between 32° to 212° F (0° to 100° C) to an accuracy of plus or minus 2° F. The device must allow contact of the end of the sample bolt by the ultrasonic transducer of the USM-II.
Many sophisticated temperature chambers are commercially available, and ideally suited for this function. However, a simple and inexpensive method can be achieved by immersion of the sample bolts in a water bath, which can be heated to boiling or cooled by adding ice. At sea level this will reliably vary the bolt temperature between approximately 212°F and 32° F (100° and 0° C) depending on water purity and atmospheric pressure. By measuring the temperature of the stirred water bath with a precise mercury thermometer, while reading the ultrasonic length of the bolt, accurate calibration points can be obtained.
- A Norbar USM-II Ultrasonic Stress Meter
- A minimum of three sample bolts, which are representative of the bolt type and geometry for which the Temperature Factor is to be determined.

NOTES:

- The Norbar USM-II must be calibrated, or zeroed, as described in the procedure entitled System Zeroing in the Setup section of the USM-II Operation.
- The sample bolts should be left to soak at the measured temperature points for a period of not less than 20 minutes, to insure that temperature is uniform through out the sample.
- If a water bath is used, care must be taken to avoid immersion of the ultrasonic transducer.

Determination of the Temperature Factor is accomplish by solving the equation:

$$TemperatureFactor = \frac{(L_0 - L_T)}{L_T (T_0 - T)} \times 10^6$$

Where:

L_0 = Ultrasonic Length at Beginning Temperature (T_0)

L_T = Ultrasonic Length at Ending Temperature (T)

T_0 = Beginning Temperature

T = Temperature at Present Measurement Point

Acquire data as follows:

1. Stabilize the sample bolt at approximately 32° F (0° C). If the water bath method is used this is accomplished in a stirred bath of ice and water.
2. Measure and record this minimum temperature as T_0 .

3. Using the USM-II in the “Unloaded Length” measurement mode, measure the ultrasonic length “ L_0 ” of the sample bolt at the above minimum temperature.
4. Increase the temperature of the sample bolt to approximately 68° F (20° C).
5. Measure and record the exact temperature at this measurement point as T_1 .
6. Using the USM-II in the “Unloaded Length” measurement mode, measure and record the ultrasonic length “ L_1 ” of the sample bolt at temperature T_1 .
7. Increase the temperature of the sample bolt to approximately 104° F (40° C).
8. Measure and record the exact temperature at this measurement point as T_2 .
9. Using the USM-II in the “Unloaded Length” measurement mode, measure and record the ultrasonic length “ L_2 ” of the sample bolt at temperature T_2 .
10. Increase the temperature of the sample bolt to approximately 140° F (60° C).
11. Measure and record the exact temperature at this measurement point as T_3 .
12. Using the USM-II in the “Unloaded Length” measurement mode, measure and record the ultrasonic length “ L_3 ” of the sample bolt at temperature T_3 .
13. Increase the temperature of the sample bolt to approximately 176° F (80° C).
14. Measure and record the exact temperature at this measurement point as T_4 .
15. Using the USM-II in the “Unloaded Length” measurement mode, measure and record the ultrasonic length “ L_4 ” of the sample bolt at temperature T_4 .
16. Increase the temperature of the sample bolt to approximately 212° F (100° C).
17. Measure and record the exact temperature at this measurement point as T_5 .
18. Using the USM-II in the “Unloaded Length” measurement mode, measure and record the ultrasonic length “ L_5 ” of the sample bolt at temperature T_5 .
19. Repeat steps 1 through 18 for the second and third sample bolt.
20. By solving the above equation calculate the Temperature Factor for each data point on each sample bolt.

$$TF_{B1T1} = \frac{(L_0 - L_1)}{L_1(T_0 - T_1)} \times 10^6 \quad TF_{B1T2} = \frac{(L_0 - L_2)}{L_2(T_0 - T_2)} \times 10^6$$

AND SO ON FOR EACH SAMPLE BOLT

Determine the average value of the Temperature Factor by dividing the sum of all TF values calculated by the total number of TF values

$$TF_{AVERAGE} = \frac{TF_{B1T1} + TF_{B1T2} + TF_{B1T3} \cdots + TF_{B3T4}}{12}$$

The above data collection and calculations can be performed easily by use of an **MS Excel** spreadsheet. For the convenience of our customers, a preprogrammed spreadsheet is available for download from our web site at www.Norbar-usa.com, or on disk by contacting Norbar USA.

Appendix D

Messages

NO GROUPS PRESS ENTER KEY

Alerts operator that no bolt group data is stored in memory. Refer to **BOLT GROUP DATA functions** beginning on page 29.

CANNOT SCROLL! NO GROUPS PRESS ENTER KEY

Occurs after the last or only bolt group is deleted. No action is required.

CANNOT MEASURE SO CLOSE TO BANG

Appears when the bolt length is set for ½ inch (18mm) or less, or if the group velocity is set to 0.0. Verify correct length and velocity settings. Also may occur when the units have been changed in the **SETUP USM-II** function.

FLASH MEMORY ERROR UNIT NEEDS SERVICE

Appears when the flash programming cycle of the flash memory chip has been exceeded, or when the chip has been corrupted. **Return the USM-II to Norbar USA for service, or call the Service Department for further instructions.** Other peripheral damage may have occurred

WARNING! MEMORY MUST BE REPACKED TO MAKE ROOM FOR NEW GROUP. DO NOT TURN OFF OR INTURRUPT POWER. THIS WILL RESULT IN LOSS OF DATA. PRESS ENTER TO BEGIN

Appears when the **Delete one group** function has been used repeatedly. Because the data pages are renamed rather than cleared, they still take up memory space, just as a ream of blank paper takes up as much room as a ream of printed material. **PRESS ENTER** to begin clears the memory space, but makes all stored data vulnerable to loss or corruption if the power is interrupted while data is being repacked.

Troubleshooting

Blank screen when power is turned on.

Usually caused by AC supply failure, power supply failure, or software-related problems.

- Connect USM-II to an AC power supply by use of the 12VDC adapter
- If screen is activated perform Battery Check as described under SETUP.
- If batteries read low, replace all 4 “C” cells in the USM-II.
- Press the **F1** key repeatedly and observe the screen. If the display contrast increases and becomes readable, power the unit off and back on. If the display returns, the problem may have been repeated use of the **F2** key during the **Display contrast** function during last use.
- If screen remains blank, call the Service Department for further instructions.

Blank screen every time power is turned on.

If using the **F1** and **F2** scenario above restores the display, or if any other setup parameter requires repeated reentry, the non-volatile memory IC has probably failed. **This is considered a field-serviceable condition only for qualified personnel. Call the Service Department for further instructions, or return the unit to Norbar USA.**

Unable to acquire an echo.

Almost always caused by poor bolt/transducer interface.

- Check bolt end. See page **Error! Bookmark not defined.** for required bolt surface, and replace if necessary.
- Make sure that the transducer cable is connected to the correct transducer port. Use the P/E port for a single transducer.
- Try another equivalent transducer and/or cable.
- Verify that the frequency setting of the USM-II matches that of the transducer.
- Verify that the transducer and the receiver mode are appropriate for the measurement method being used.
- If all attempts are unsuccessful, call the Service Department for further instructions.

Unable to change unit system for bolt group.

- Once a bolt group has been created, its units cannot be changed using **Select unit system** in the **SETUP USM** menu.
- A duplicate group can be made and measured using different units by first changing the units, then creating a new group. **All subsequent groups will be made using those units.**

Appendix E

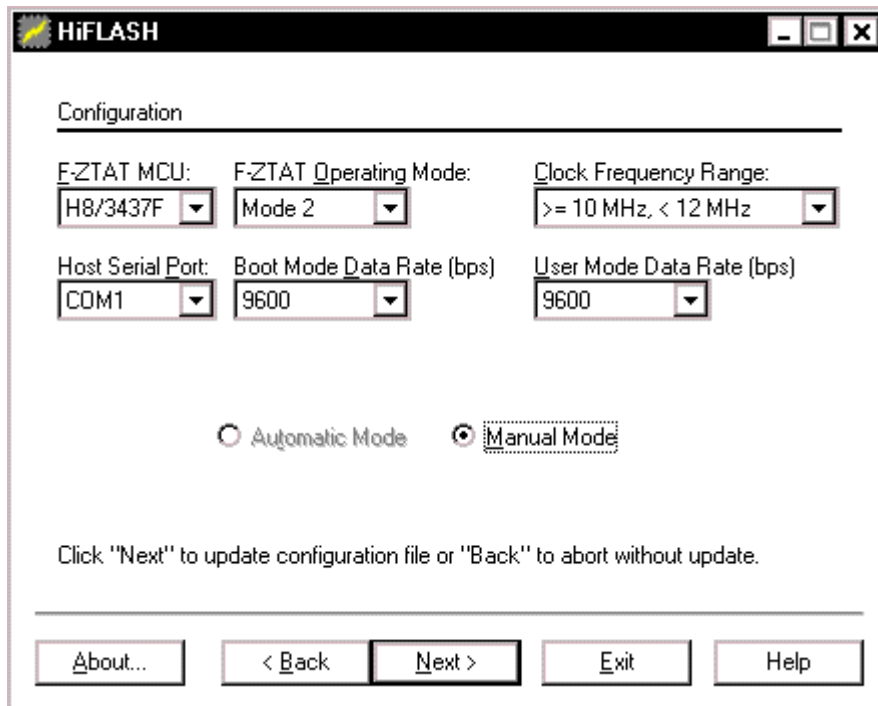
Reprogramming the USM-II

1. Download the usm2.mot file from the website (www.norbar-usa.com/firmware) and save to Desktop.
2. Download the HiFLASH.exe file from the website and save to Desktop. (You may wish to create a special folder on your desktop for these files.)
3. **Verify the power is OFF on the USM-II.**
4. Place Firmware Reprogramming Adapter (AVAILABLE FROM NORBAR-USA) on the USM-II Auxiliary Connector (15 pin “D” connector).
DO NOT CONNECT OR REMOVE THE REPROGRAMMING ADAPTER WHILE POWER IS ON TO THE USM-II. THIS MAY CAUSE SEVERE DAMAGE TO THE ELECTRONICS
5. Connect an RS 232 cable from the computer to the USM-II RS-232 port (9 pin “D” connector).
This is accomplished with the 9-pin male to a 9-pin female, straight through wired cable that is included with the USM-II. Your computer may require a 25 pin to 9 pin standard adapter.
6. Double click the HiFlash icon you created on your desktop to start the HiFlash program. The main menu of the HiFlash program should appear.
7. Click the **CONFIGURATION** button and then click **NEXT**. The Configuration menu should appear.
8. Set the parameters as follows:

F-ZTAT MCU: **H8/3437F**
F-ZTAT Operating Mode: **Mode 2**
Clock frequency Range: **>=10MHz<12MHz**
Boot Mode Data Rate: **9600**
User Mode Data Rate: **9600**

Note that the HOST SERIAL PORT may be COM1, COM2, COM3, or COM4, depending on your computer.

The completed configuration screen should look like this:



9. Click **NEXT**.

10. Click **BOOT PROGRAMMING MODE/QUICK FLASH**.

11. Click **BROWSE**.

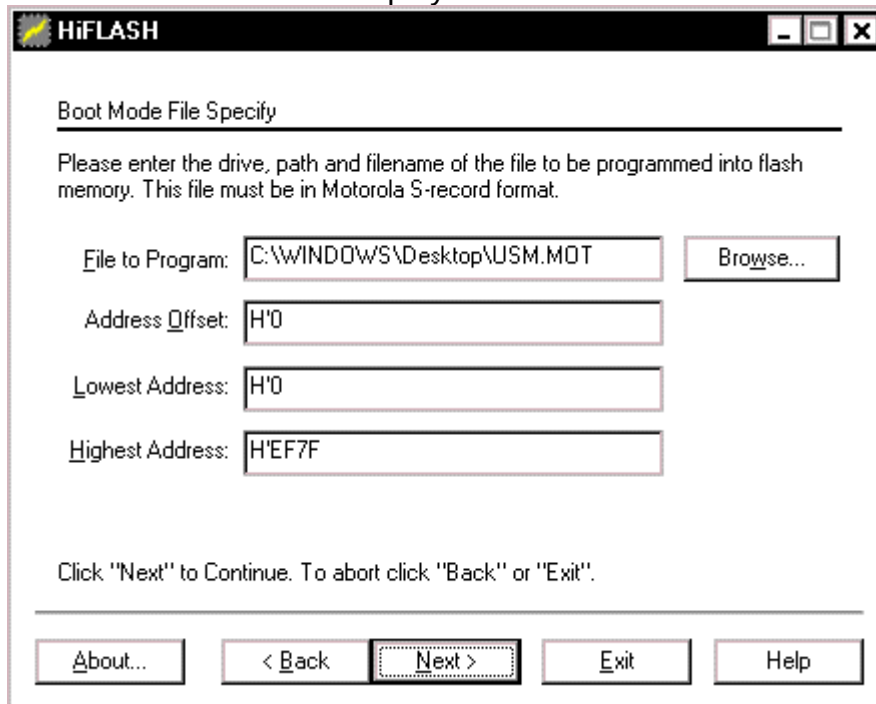
12. Select **DESKTOP**.

13. Click on **usm2.mot**.

14. Click **OPEN**

Do not change any of the other settings.

The screen should now display the file name and look like this:



15. Click **NEXT**. . A message should appear in the HiFlash display "Warning, do not turn power off"
16. Turn the on to the USM-II and wait one second.
17. Click **NEXT**
18. Wait while a string of black or blue squares fills the box above the **Abort** box. If this fails to occur, check the RS 232 connection, turn the USM-II off, cycle the computer to the proper screen by clicking **NEXT** three times, and retry, waiting 1.5 seconds before clicking **NEXT**.
19. Wait as a second box fills at a much slower rate.
20. Turn the USM-II off immediately after the box is filled with squares and the HiFlash screen indicates completion of programming.
EXCESSIVE POWER ON TIME WHILE THE REPROGRAMMING ADAPTER IS CONNECTED MAY DAMAGE THE USM-II
21. Allow a few seconds for the power supply to drain. then remove the Firmware Reprogramming Adaptor from the USM-II Auxiliary port
22. Restart the USM-II, and verify that the new software version (REL X.X) appears in the lower right corner of the display, and reprogramming is complete.

Appendix F

Units of Measure

MEASURED ITEM	ENGLISH	METRIC 1	METRIC 2
DISPLAY CONTRAST	1 TO 15	DIMENSIONLESS	
BACK LIGHT	ON / OFF	DIMENSIONLESS	
MEASUREMENT MODES	PULSE/ECHO, PITCH/CATCH		
TRANSDUCER FREQUENCY	MHz		
TONE BURST LENGTH	PULSES		
ANALOG OUTPUT	VOLTS		
UNIT SYSTEMS	POUNDS / INCHES	KILONEWTONS/MM	KILOGRAMS/MM
LENGTH	INCHES	MILLIMETERS	MILLIMETERS
ELONGATION	INCHES	MILLIMETERS	MILLIMETERS
DIAMETER	INCHES	MILLIMETERS	MILLIMETERS
LOAD	POUNDS	KILONEWTONS	KILOGRAMS
STRESS	PSI	MPA	KG / SQ. MM
STRAIN	DIMENSIONLESS		

Appendix G

Sample report

A USM-II report includes calibration data, comments, unloaded reference data, and all elongation and load measurements in the following format:

```

GROUP      XXXXXX...XXX                      ZERO FAC  XX
COMMENT 1  XXX.....XXX
COMMENT 2  XXX.....XXX
LAPPROX    STRSFAC  VELO      TEMPFAC  LFACT      LOFFSET
XXX.X0.XXX      232000    XX.X      XXX.XXX.X

```

REFERENCE DATA

BOLT NUM	REFLEN	PHASE	GAIN	POS.THR	NEG.THR
1	XX.XXXX	2	8	22	10
2	XX.XXXX	1	9	28	12
3	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----

ELONGATION REPORT

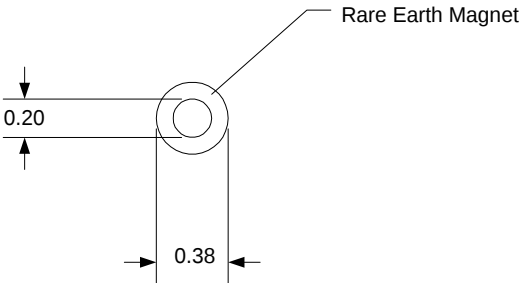
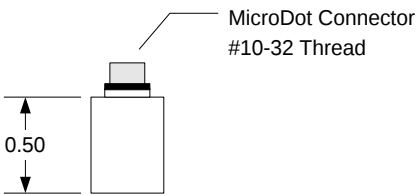
BOLT NUM	ELONG A	ELONG B	ELONG C	ELONG D	ELONG E
1	0.XXXX	0.XXXX	0.XXXX	0.XXXX	0.XXXX
2	0.XXXX	0.XXXX	0.XXXX	0.XXXX	0.XXXX
3	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----

LOAD REPORT

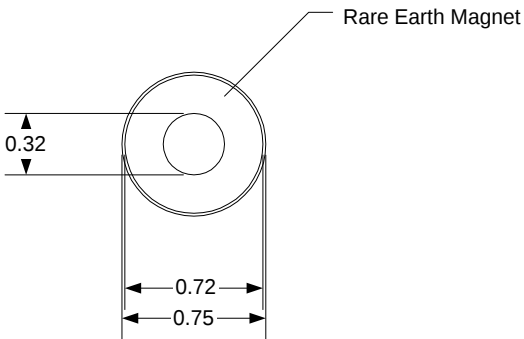
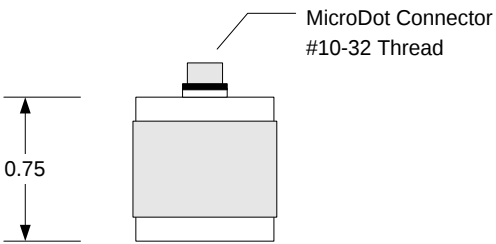
BOLT NUM	LOAD A	LOAD B	LOAD C	LOAD D	LOAD E
1	XXXX	XXXX	XXXX	XXXX	XXXX
2	XXXX	XXXX	XXXX	XXXX	XXXX
3	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----

Standard Norbar Ultrasonic Transducers

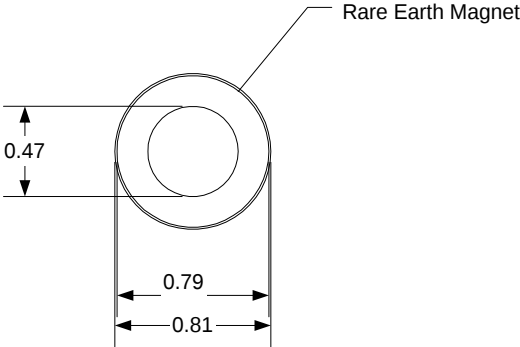
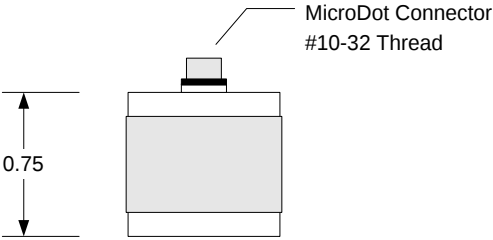
Ordering Information	
19001	1/8 in 10 MHz
19002	1/8 in 5 MHz



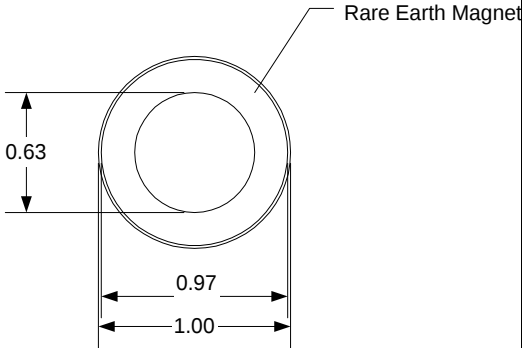
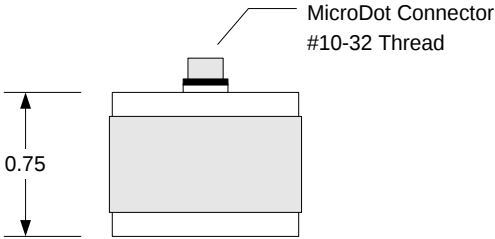
Ordering Information	
19003	1/4 in 10 MHz
19004	1/4 in 5 MHz



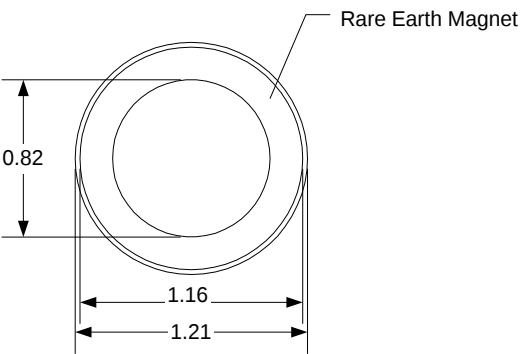
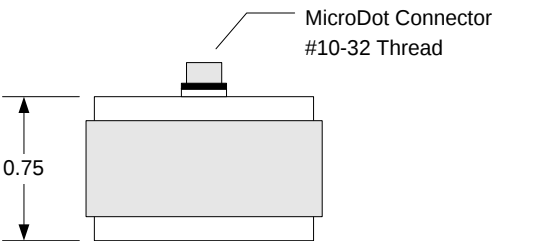
Ordering Information	
19005	3/8 in 5 MHz
19006	3/8 in 2.25 MHz



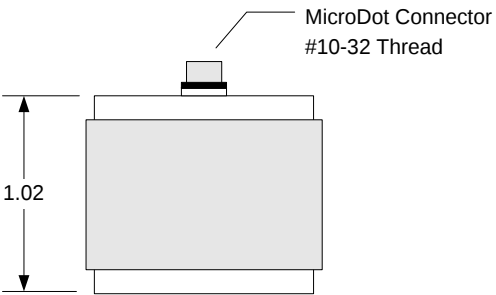
Ordering Information	
19007	1/2 in 5 MHz
19008	1/2 in 2.25 MHz



Ordering Information	
19010	3/4 in 5 MHz
19011	3/4 in 2.25 MHz



Ordering Information	
19012	3/4 in 1.0 MHz



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