

OPERATION MANUAL

DAKOTA ULTRASONICS

UMX-2

Underwater Material & Coating Thickness Gauge



P/N P-185-0004

Rev 1.0, May 2010

CHAPTER ONE INTRODUCTION - CARE & WARRANTY 1

CHAPTER TWO QUICK STARTUP GUIDE 4

CHAPTER THREE OVERVIEW 7

CHAPTER FOUR MENU & CONNECTOR REFERENCE 11

CHAPTER FIVE PRINCIPALS OF ULTRASONIC MEASUREMENT 18

CHAPTER SIX SELECTING THE MEASUREMENT MODE..... 22

CHAPTER SEVEN MAKING MEASUREMENTS 24

CHAPTER EIGHT ADDITIONAL FEATURES & OPTIONS..... 32

CHAPTER NINE THRU PAINT MEASUREMENT TECHNIQUE 37

CHAPTER TEN PULSE-ECHO COATING & COATING TECHNIQUES 39

CHAPTER ELEVEN DATA STORAGE – SETUP, EDIT, & VIEW FILES 43

CHAPTER TWELVE SETUPS – CREATE, STORE, EDIT, & UPLOAD 58

CHAPTER THIRTEEN UPGRADING THE FIRMWARE 65

APPENDIX A - VELOCITY TABLE..... 70

CHAPTER ONE INTRODUCTION - CARE & WARRANTY

The Dakota Ultrasonics model **UMX-2** is an underwater ultrasonic thickness gauge that measures with extreme versatility. It has the ability to simultaneously measure coatings and material thicknesses while maintaining the ability to locate pits, flaws and defects in the material. It can also use a combination of dual and single element transducers, depending on the application requirements. Based on the same operating principles as SONAR, the **UMX-2** is capable of measuring the thickness of various materials with accuracy as high as ± 0.001 inches, or ± 0.01 millimeters. The principle advantage of ultrasonic measurement over traditional methods is that ultrasonic measurements can be performed with access to only one side of the material being measured.

Dakota Ultrasonics maintains a customer support resource in order to assist users with questions or difficulties not covered in this manual. Customer support may be reached at any of the following:

Dakota Ultrasonics Corporation
1500 Green Hills Road, #107
Scotts Valley, CA 95066 USA
Telephone: (831) 431-9722
Facsimile: (831) 431-9723
http://www.dakotaultrasonics.com

1.1 Care & Maintenance

The **UMX-2** housing is made of a clear PVC material that is very durable and well suited for this application given the following conditions are followed:

- Keep the **UMX-2** out of direct sunlight as much as possible to avoid any potential 'crazing' or stress cracking, as well as discoloration.
- Protect the housing from impact.
- Submerge or rinse the enclosure and transducers in fresh water following use.
- **Warning:** Do not exceed the depth limitation of 1000 ft. Failure adhere to this warning may result in leakage, potential implosion and serious injury.

The housing is sealed by o-rings, one on each end cap, which require meticulous care. In order to maintain a watertight seal, the o-rings and their mating surfaces must be clean, free of foreign material, and lubricated with silicone grease.

The following procedure must be performed on the end cap o-rings before each use:

1. Clean all old silicone grease from o-rings and mating surfaces using paper towels.
2. Inspect o-rings for foreign material (sand, seaweed, hair, etc.), cracks, cuts, soft spots, or deformities. Replace o-ring if damaged. Inspect mating surfaces for scratches, rough spots, dents, or cracks.
3. Apply thin, even coat of silicone grease to o-rings on each end cap using finger to spread evenly. Inspect to be sure the o-ring has been properly fitted, and screw the end cap back in place, until it has a nice snug fit.

1.2 Warranty

The **UMX-2** is protected by a 3 year limited liability:

1. The manufacturer inspects and tests every **UMX-2** for watertight integrity before it is delivered.
2. The manufacturer will repair or replace at the manufacturer's option any housing that proves to be defective in construction or materials within three year of date of delivery.
3. The Manufacturer will repair or replace at the manufacturer's option any transducer that proves to be defective in construction or materials within 90 days of date of delivery, evaluated up to 1 years time.
4. The manufacturer is not liable for damage to equipment caused by leakage of water into the housing, nor is the manufacturer liable for loss of data or income there from as may result from such leakage. The manufacturer is not liable for any accidents during which this housing was in use.
5. This warranty is void in the event of negligent handling of the housing including, but not limited to, dropping the housing, modifications to the housing by other than the manufacturer, improper care of the sealing components, and exceeding the specified depth limitation of 1000 feet.
6. There is no express or implied warranty, nor warranty of merchantability, except as stated by the manufacturer above.
7. The buyer understands that, because of the nature of this product, he/she uses the housing at his/her own risk and agrees to hold the manufacturer harmless, except as stated above.

1.3 Disclaimer

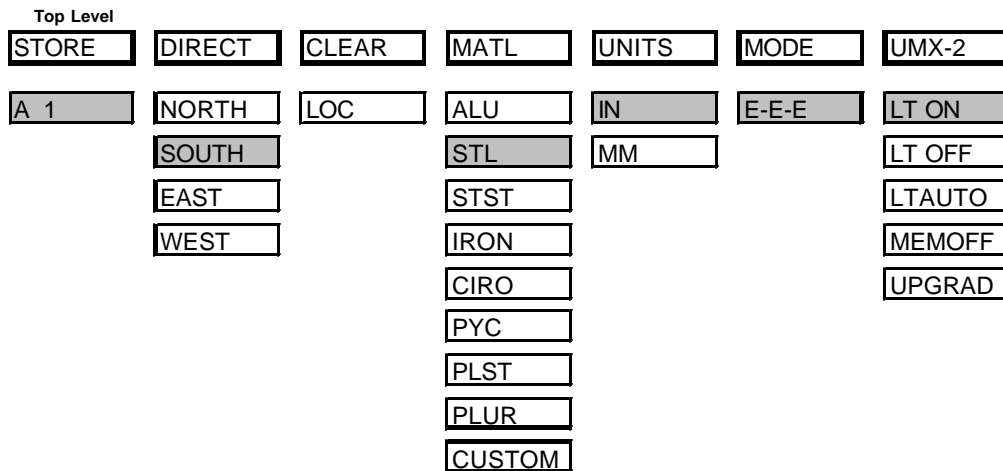
Applies to dual element transducers: Inherent in ultrasonic thickness measurement is the possibility that the instrument will use the second rather than the first echo from the back surface of the material being measured. This may result in a thickness reading that is TWICE what it should be. Responsibility for proper use of the instrument and recognition of this phenomenon rest solely with the user of the instrument. Other errors may occur from measuring coated materials where the coating is insufficiently bonded to the material surface. Irregular and inaccurate readings may result. Again, the user is responsible for proper use and interpretation of the measurements acquired.

CHAPTER TWO QUICK STARTUP GUIDE

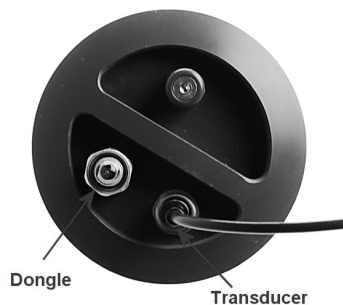
The **UMX-2** is pre-configured at Dakota Ultrasonics with a specific and common setup. As a result, the gauge should be ready to measure once the transducer has been connected. The **UMX-2** can use two different styles of transducers; dual element and single element membrane. As a result, the gauge will be configured according to the transducer style purchased, as follows:

2.1 Factory Setup Parameters (Single)

UMX-2 Single Element Menu Structure & Factory Configuration



2.2 Quick Start (Single Element)



Procedure

- 1) Referring to the diagram above, be sure the dongle and transducer are connected as illustrated. **Note:** in order for the **UMX-2** to recognize the transducer that has been attached, it must be in the proper channel location.
- 2) Press and release the single button located on the end of the **UMX-2**. The displays should illuminate, and led lights will begin flashing.
- 3) The smaller of the two displays will begin scrolling the current configuration settings of the **UMX-2** in the following order: UMX-2, BATT (LO, ME, HI), Probe Type (1/2 2S or 5S)...etc. If 'NO PRB' is displayed, the dongle has been plugged into the wrong channel. Press and hold down the button for approximately 30 seconds, or until the **UMX-2** powers off. Repeat steps 1 – 3 until the probe has been identified.
- 4) The **UMX-2** is ready to begin making measurements.

2.3 Factory Setup Parameters (Dual)

UMX-2 Dual Element Menu Structure & Factory Configuration

Top Level									
STORE	DIRECT	CLEAR	ZERO	GAIN	MATL	UNITS	MODE	UMX-2	
A 1	NORTH	LOC	AUTO	VLOW	ALU	IN	P-E	LT ON	
	SOUTH		MANUAL	LOW	STL	MM	PECT	LT OFF	
	EAST		COATIN	MED	STST		E-E	LTAUTO	
	WEST			HIGH	IRON			MEMOFF	
				VHIGH	CIRO			UPGRAD	
					PYC				
					PLST				
					PLUR				
					CUSTOM				

2.4 Quick Start (Dual Element)

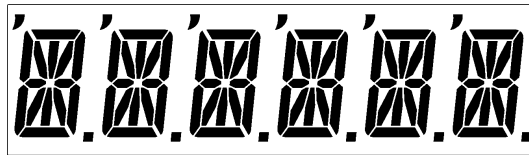
Procedure

- 1) Attached the transducer to the **UMX-2**.
- 2) Press and release the single button located on the end of the **UMX-2**. The displays should illuminate, and led lights will begin flashing.
- 3) The smaller of the two displays will begin scrolling the current configuration settings of the **UMX-2**, and an auto zero will be performed.
- 4) The **UMX-2** is ready to begin making measurements.

CHAPTER THREE OVERVIEW

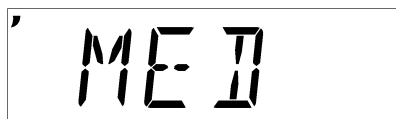
Turn the **UMX-2** on and off using the switch located on the bottom right corner of the keypad. When **UMX-2** is initially turned on, a **UMX-2** logo will be displayed, accompanied by lots of flashing led lights. The **UMX-2** will attempt to 'auto identify' the transducer type that is connected, or display 'NO PRB' if the transducer cannot be identified. The following sections outline each scenario. Note: This section is primarily written as a basic startup guide only.

3.1 UMX-2 Displays

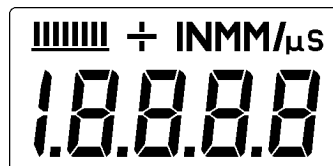


6 Character, 16 Segment Alpha Numeric Display

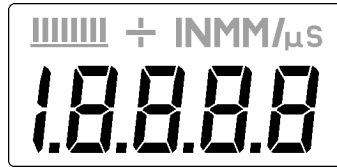
The **UMX-2** is equipped with two segmented LCD displays that are used for entirely different purposes. The 6 Character display above, is used for all the menu options and any text to control the overall operation and functionality of the **UMX-2**. Since the **UMX-2** has the ability to store measurements, this display is also used to view and move to specific cell/storage locations in the grid storage structure of the gauge.



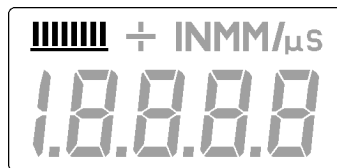
Note: The left most 'comma' located in the top left corner of the display, identifies which sub menu feature option is currently selected, as shown above. In this example the gain is currently set to medium.



4 Digit , 8 Segment LCD Display



The 4 digit display illustrated above, is considered the primary measurement display of the **UMX-2**. The following outlines the measurement display: The numeric portion of the display consists of 4 complete digits preceded by a leading "1", and is used to display numeric values, as well as occasional simple words, to indicate the status of



various settings. When the **UMX-2** is displaying thickness measurements, the display will hold the last value measured, until a new measurement is made.

These eight vertical bars form the Stability Indicator. When the **UMX-2** is idle, only the left-most bar and the underline will be on. When the gauge is making a measurement, six or seven of the bars should be on. If fewer than five bars are on, the **UMX-2** is having difficulty achieving a stable measurement, and the thickness value displayed will most likely be erroneous.

3.2 Single Button Operation

The **UMX-2** is controlled using a single button to move around the menu structure and enable/disable its features. There are 3 basic 'button press' sequences available as follows:

Press & Hold:

Primary function – enter into, or exit out of the menu structure.

When the button is pressed and held down for a specific duration of time, the single level menu structure will begin scrolling through the top level of menu items continuously. If entering into the menu structure, "Enter" will be displayed, followed by scrolling through the menu items. If exiting the menu items, "Exit" will be displayed, followed by advancing to the current storage location (i.e. A 1), or "MEMOFF" if data storage has been disabled by the user. Once either instance has occurred, the button can be released.

Press & Release:

Primary function – selection of menu items.

To select a menu item, press and release the button. The sub menu items will begin scrolling on the display. Finally, to select a sub menu item, press and release again.

Press & Long Hold:

*Primary function – manually turn off the **UMX-2**.*

The **UMX-2** will automatically shut off after 5 minutes if it hasn't detected a measurement. However, to be sure the unit is shut off after use, when the button is pressed and held down for approximately 10 seconds, "**POWER**" "**OFF**" will be displayed, and the unit will manually turn off. Once the unit turns off, the button can be released.

It's really just that simple!

3.3 Gauge Settings

The current settings of the **UMX-2** will be displayed on initial power up and every 30 seconds following. This is intended to provide the user with an easy way to confirm the settings at any time, without having to scroll to the specific menu items individually. The parameters will be displayed in the order that follows:

Gauge Model:	UMX-2
Battery Status:	LO, MED, or HI
Transducer Type Identified:	½ 5, ½ 3.5, ½ 2 S, ½ 5 S
Measurement Mode:	P-E, PECT, E-E or TCG
Current Gain Setting:	VLOW, LOW, MED, HIGH, VHIGH
Material Type:	ALU, STL, STST, IRON, CIRO, PVC, PLST, PLUR, or Custom

However, if the user is in the menus and viewing the sub menu items, the currently selected option/feature can be identified by the "," (comma) illuminated in the top left corner of the small display.

3.4 Menu Structure

The **UMX-2** has been carefully designed to minimize the overall level of drop down menu options in an effort to keep the gauge as simple to operate as possible. The diagram below illustrates the entire menu structure of the **UMX-2**:

UMX-2 Underwater Material & Coating Thickness Gauge

Top Level

STORE	DIRECT	CLEAR	ZERO	GAIN	MATL	UNITS	MODE	UMX-2
LOC	NORTH	LOC	AUTO	VLOW	ALU	IN	P-E	LT ON
	SOUTH		MANUAL	LOW	STL	MM	PECT	LT OFF
	EAST		COATING	MED	STST		E-E	LTAUTO
	WEST			HIGH	IRON			MEMOFF
				VHIGH	CIRO		E-E-E	UPGRAD
					PYC			
					PLST			
					PLUR			
					CUSTOM			

Important comments:

- Depending on the transducer identified by the **UMX-2**, only the menu options applicable to that specific transducer will appear. Therefore, it's important to note that the menus displayed are dynamic and may not be consistent if different types of transducer are interchanged.
- Again, depending on the transducer identified, the modes applicable for that specific probe type will be enabled and displayed. Dual element transducers have mode options of P-E, PECT, or E-E. While the single element membrane transducer options will only use our special TCG (time corrected gain) triple echo mode (E-E-E), and all three modes listed above will be deactivated and not displayed.
- If the **MEMOFF** has been activated, the data logging section of the gauge will be temporarily turned off. This would be deactivated only if the user does not intend to store measurements in the **UMX-2**. As a result, **MEMOFF** will become the first 'top level' menu option, in place of a storage cell location (i.e. A 1). Additionally, the top level menu items 'DIRECT' and 'CLEAR' will also be temporarily deactivated from the menu options, as they pertain only to the data storage facility of the **UMX-2**.
- If a custom material type has not been uploaded into the **UMX-2**, it will not appear in the **MATL** subdirectory.

In general, if features and menu options start appearing/disappearing, as options are activated/deactivated, it's entirely based on the configuration settings and probe identified by the **UMX-2**. The objective is to eliminate those items from the menu structure that do not pertain to the mode or features activated/deactivated by the user. It's our effort to keep the available menu structure 'simple' and 'intuitive'. All the features of **UMX-2** will be further explained in later section of this manual.

CHAPTER FOUR MENU & CONNECTOR REFERENCE

4.1 Menu Options

Top Level
STORE DIRECT CLEAR ZERO GAIN MATL UNITS MODE UMX-2

STORE

LOC

Store: This menu displays the current storage location of the **UMX-2**. This location can refer to either a 'grid' cell location, like an Excel spreadsheet, or a sequential format location, depending on which file format was uploaded into the gauge. If the storage facility has been turned off, the menu label will read "**MEMOFF**". The **UMX-2** will be shipped from the factory with a preloaded 'grid' file structure. Refer to the section on page 43, for a detailed explanation.

DIRECT

NORTH

SOUTH

EAST

WEST

Direct: This menu item is also part of the data storage facility. It specifies which direction to advance the cursor, after a measurement is stored. If a two dimensional grid format is being used, all direction options can be used. However if a 'sequential' file format is used, only north and south are applicable. This menu item will not appear if data storage has been disabled by the user. Refer to the section on page 52, for a detailed explanation.

CLEAR

LOC

Clear: Again, this menu item is also part of the data storage facility. If a measurement is stored by mistake, or in the wrong location, the measurement can be cleared from memory using this option. The direction menu would be used to advance to the location, and the 'clear' option would be used to erase the stored measurement. If data storage has been disabled by the user, this menu item will not appear as an option. Refer to the section on page 54, for a detailed explanation.

ZERO

AUTO

MANUAL

COATIN

Zero: The **UMX-2** can use two different types of transducers, a dual or single element. This menu item will only be visible if the **UMX-2** identified a dual element transducer connected.

- **Auto** – The auto zero feature of the **UMX-2**, performs an “off block” electronic zero automatically, eliminating the need for a manual zero on a specified disk or block. When the **UMX-2** boots up, it will perform an auto zero during the boot sequence. However, another auto zero may be need to account for changes in temperature, or an incorrect zero due to couplant on the end of the transducer during the zeroing process. Refer to the section on page 25, for a detailed explanation.
- **Manual** – The **UMX-2** is also equipped with an “on block” manual zero option. This zero would only be used to reset the internal zero for of the **UMX-2**, as a reference point for the auto zero. Note: the reference disk is located on the end of the **UMX-2** enclosure. Refer to the section on page 25, for a detailed explanation.
- **Coating** - In order to account for very slight electronic differences in transducers of the same type, frequency, and diameter, the **UMX-2** has been equipped with a “zero coating” feature. This zero is only used when the PECT coating mode feature is being used. Although the coating thickness is not displayed on the **UMX-2** actual LCD displays, the coating thickness is stored with the base material thickness when a measurement is saved to memory. Once the data is downloaded to a PC, the coating thickness will be displayed with PECT measurement stored. Refer to the section on page 40, for a detailed explanation.

GAIN

VLOW

LOW

MED

HIGH

VHIGH

Gain: A 5 position gain switch in 2 db increments from 40 to 50 dB. Increase for better penetration or punch, and decrease to eliminate unwanted noise or better resolution. Refer to page 32 for further info.

Material: The *UMX-2* includes a list of common material types with standard set velocities. It's important to note that the velocities associated with these materials are general velocity values only. Materials of the same type, can have varying grades and consistencies. As a result, the material velocity will also have slight variations. A custom velocity has been implemented for this reason, and can be programmed via DakView3 PC software. Refer to page 28 for further info.

Units: Toggle between English or Metric units. The readout will change from inches to millimeters. Refer to page 34 for further info.

Mode: The *UMX-2* is equipped with a number of advanced measurement modes, to satisfy a variety of application scenarios. The following is a brief description of each mode. Refer to page 22 for further info:

- P-E (Pulse-Echo) – Common mode for measuring non-coated material (bare metals).
- PECT (Pulse-Echo Coating) – A special mode used on coated materials to measure the thickness of both; the base material and coating.
- E-E (Echo-Echo) – Common mode for measuring coated materials, and measuring the base material only, without having to remove the coating.

- E-E-E (Triple Echo) – Special multiple echo mode used only with our single element membrane transducers.

UMX-2

LT ON

LT OFF

LTAUTO

MEMOFF

UPGRAD

UMX-2: This is a general utility menu for miscellaneous features and functions. The following is a brief explanation of each sub menu item. Refer to page 32 for further information on upgrading the **UMX-2**:

- LT ON – Enables all the LED's and display back lights.
- LT OFF – Disables all the LED's and display back lights.
- LTAUTO – Powers all the LED's and display back lights 'on' only when an echo is detected (measurement). Refer to page 35 for further info.
- MEMOFF/ON - Toggles the data storage facility On or Off. Refer to page 51 for further info.
- UPGRAD – Feature to upgrade the firmware in the **UMX-2** to the latest version. Refer to page 65 for further info.

4.2 Top & Bottom End Caps



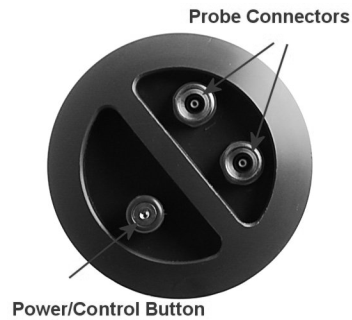
Top End Cap



Bottom End Cap

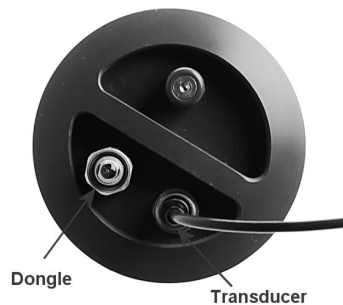
The top & bottom inside end caps are where all connections are made to the **UMX-2**. The bottom outside end cap also has a 'zero reference standard' attached. The diagram above shows the layout and description of the connectors and zero standard:

Top End Cap:



Transducer Connectors

The transducer connectors and single control button are located on the top end cap of the **UMX-2**. The transducer connectors are a special underwater Lemo "00".



Note: There is no polarity associated with connecting a dual element transducer. If a single element membrane style is connected, the **dongle** 'must' be plugged into the connector labeled in the diagram above, in order for the **UMX-2** to 'auto identify' the single element probe type.

Single Control Button

The special magnetic reed found on the top end cap, provides single button operation. Using this button and 3 basic press sequence options, the user can power the **UMX-2** on/off, enter the menu options, and change settings.

Bottom Outside End Cap:



Probe Zero Disk

The **UMX-2** is equipped with an **Auto Zero**, which eliminates the user from having to manually perform a zero on a specified zero standard. However, a **Manual Zero** option has also been included with the **UMX-2**. This provides the user with the ability to reset the internal zero used for the auto zero as a reset option. Other than for the purposes of a safety mechanism, the **Auto Zero** feature will be used.

Bottom Inside End Cap:



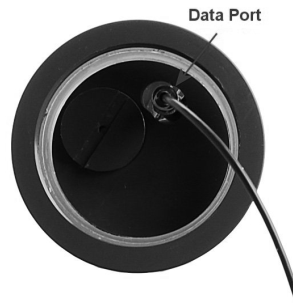
Battery Cover

Simply remove the cover using a standard slot screw driver or other, and replace the batteries.

Important: *be sure the positive (+) battery terminal is facing up towards the battery cover, when inserting them into the battery tube.* This is very important! Failure to do so will result in battery acid leakage cause by a current overload. The leakage can permanently damage the circuit boards, should it leak through the battery tube. The photo above shows demonstrates the polarity of the batteries. There is also a label on the side of the battery tube for reference.

Note: Rechargeable batteries can be used, however they must be recharged outside of the unit in a stand alone battery charger.

RS-232 Connector



Refer to Diagram: The **RS-232** connector is a 2 pin female LEMO connector. It is designed to connect directly from the **UMX-2** to a standard AT serial port on a PC or into the supplied **Serial to USB** converter cable. There are two cables supplied with the **UMX-2**;

- 2 pin LEMO to 9 pin serial cable
- 9 pin serial to USB converter cable.

Note: This connector is also used to upgrade the **UMX-2** to the latest version of firmware.

Serial to USB Converter Cable

A converter cable can be attached to the 9 pin serial cable, for computers that don't have a serial port (part no. N-402-0510). This cable option is included in our kit as standard.

CHAPTER FIVE

PRINCIPALS OF ULTRASONIC MEASUREMENT

5.1 Time versus thickness relationship

Ultrasonic thickness measurements depend on measuring the length of time it takes for sound to travel through the material being tested. The ratio of the thickness versus the time is known as the sound velocity. In order to make accurate measurements, a sound velocity must be determined and entered into the instrument.

The accuracy of a thickness measurement therefore depends on having a consistent sound velocity. Some materials are not as consistent as others and accuracy will be marginal. For example, some cast materials are very granular and porous and as a result have inconsistent sound velocities.

While there are many different ultrasonic techniques to measure thickness, which will be discussed below, all of them rely on using the sound velocity to convert from time to thickness.

5.2 Suitability of materials

Ultrasonic thickness measurements rely on passing a sound wave through the material being measured. Not all materials are good at transmitting sound. Ultrasonic thickness measurement is practical in a wide variety of materials including metals, plastics, and glass. Materials that are difficult include some cast materials, concrete, wood, fiberglass, and some rubber.

5.3 Range of measurement and accuracy

The overall measurement capabilities, based on the wide variety of materials, is determined by the consistency of the material being measured

The range of thickness that can be measured ultrasonically depends on the material as well as the technique being used and the type of transducer. Thickness measurements can be made from a minimum of 0.010 inch to 9.999" in steel. However, the maximum attainable thickness is much less for more attenuative materials (materials that absorb sound).

Accuracy, is determined by how consistent the sound velocity is through the sound path being measured, and is a function of the overall thickness of the material. For example, the velocity in steel is typically within 0.5% while the velocity in cast iron can vary by 4%.

5.4 Couplant

All ultrasonic applications require some medium to couple the sound from the transducer to the test piece. When the **UMX-2** is used underwater as intended, the water itself acts as a couplant. However when the **UMX-2** is used above water, it couplant will be required. Typically a high viscosity liquid is used as the medium.

The sound frequencies used in ultrasonic thickness measurement do not travel through air efficiently. By using a liquid couplant between the transducer and test piece the amount of ultrasound entering the test piece is much greater.

5.5 Temperature

Temperature has an effect on sound velocity. The higher the temperature, the slower sound travels in a material. High temperatures can also damage transducers and present a problem for various liquid couplants.

Since the sound velocity varies with temperature it is important to calibrate at the same temperature as the material being measured.

Normal temperature range

Most standard transducers will operate from 0°F to 180°F.

High temperature measurements

Special transducers and couplants are available for temperatures above 180°F up to 650°F with intermittent contact. It is necessary to cool the transducer, by submerging the transducer in water between readings, when measuring high temperatures.

Modes and temperature errors

In addition to errors caused by velocity changing with temperature, some modes (measurement techniques) are affected more than others. For example, dual element pulse-echo mode has larger errors due to changes in the temperature of the delay line. However, multi-echo techniques offer temperature compensation help to minimize these errors.

5.6 Measurement Modes

In this section we will discuss the different measurements modes the **UMX-2** is capable of operating in, the transducers required, and the reasons for using specific modes:

Pulse-Echo Mode (Flaw & Pit detection) – Coating Off (P-E)

Pulse-echo mode measures from the initial pulse (sometimes referred to as an artificial zero) to the first echo (reflection). In this mode, either an automatic or manual zero can be performed depending on the zero probe function setting. If the manual mode has been selected, the transducer is placed on a reference disk, located on bottom end cap of the **UMX-2**, and a manual zero is performed by selecting the 'manual' sub menu option located in the 'zero' menu. If the Auto Zero feature is enabled, a 'zero reference standard' is not necessary.

In this mode errors result from surface coatings and temperature variations.

Since pulse-echo only requires one reflection, it is the most sensitive mode for measuring weak reflections (flaws) typically found when measuring heavily corroded metals.

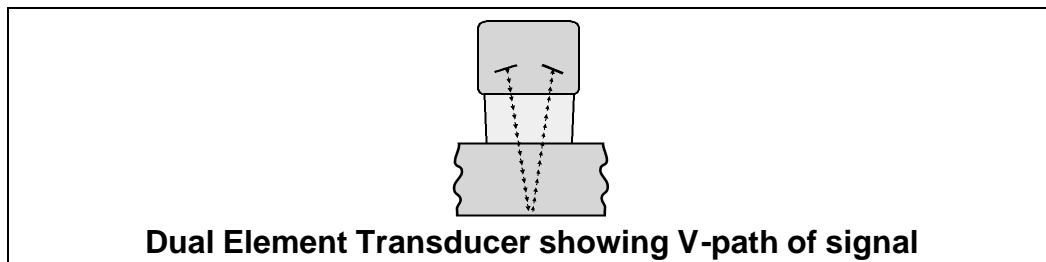
V-Path Correction

Dual element delay line transducers have two piezoelectric elements mounted at an angle on one end of the delay line. One element is used for transmitting sound, while the other element only receives sound. The two elements and their delay lines are packaged in a single housing but acoustically isolated from each other with a sound barrier. This allows the transducer the ability to achieve very high sensitivity for detecting small defects. Also, the surface of the test material does not have to be as flat in order to obtain good measurements.

Dual element transducers are normally used in pulse-echo mode for finding defects, and in echo-echo mode for through coating measurements.

Dual element delay line transducers are usable over a range of 0.025 inches to 20 inches depending on the material, frequency, and diameter.

A limitation of dual element delay-line transducers is the V shaped sound path. Because the sound travels from one element to another, the time versus thickness relationship is non-linear. Therefore, a correction table in the instruments software is used to compensate for this error.

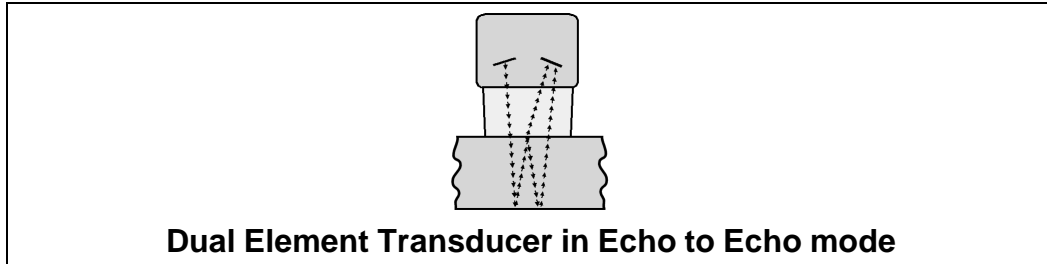


Searching for small defects

Dual element delay line transducers are especially useful in searching for small defects. In the pulse-echo mode with high amplifier gain, very small defects can be measured. This is very useful during corrosion inspections overall. The dual element style transducer will find wall deterioration, pits, and any porosity pockets during tank and pipeline inspections.

Echo-Echo Mode – Thru-Paint (E-E)

The echo-echo mode measures between two reflections. This technique is commonly used to eliminate errors from surface coatings and also to make measurements in multiple layered materials. The disadvantage is that two echoes are needed which requires a much stronger echo (reflection).

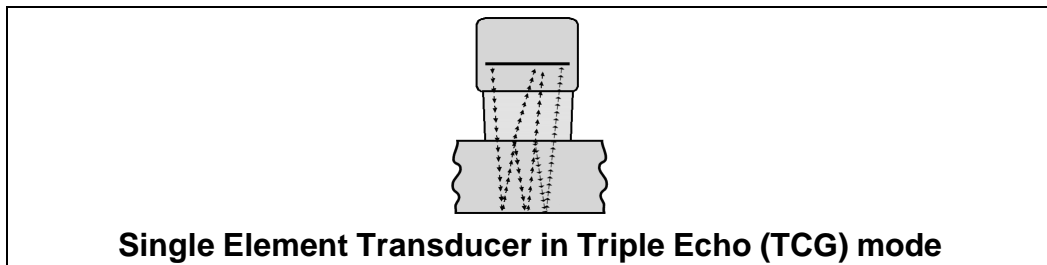


Pulse Echo Coating Mode – Coating On (PECT)

A custom hybrid combination mode using properties from the basic modes along with a group of special techniques and theoretical wave phenomena's to measure coating and material thicknesses at the same time, while still retaining the ability to locate flaws and pits in materials. Therefore, the best description for this hybrid mode is Pulse-Echo Coating mode.

Single Element Triple Echo Mode – Time Corrected Gain (TCG)

The TCG mode measures between 3 reflections. Similar to E-E mode, this technique is commonly used to eliminate errors from surface coatings and also to make measurements in multiple layered materials. The primary benefit of this mode, is that a comparison is made, between the 2nd and 3rd echoes, to verify that a peak jump has not occurred, providing an additional level of confidence to the measurement. Generally the disadvantage is that 3 reflections are needed which requires the use of gates with controllable thresholds to adjust for sensitivity over a given measurement range. However, the time corrected gain feature built into this mode, automatically adjusts the gain setting for each individual echo reflection. Therefore all three return echoes are equal in amplitude or overall signal strength.



CHAPTER SIX

SELECTING THE MEASUREMENT MODE

6.1 Which mode & transducer do I use for my application?

High penetration plastics and castings

The most common mode for these types of applications is pulse-echo. The **UMX-2** has been optimized for cast materials. Cast iron applications require 1 - 5MHz frequencies, and cast aluminum requires higher frequencies from 7 -10MHz frequency. Plastics typically require lower frequencies depending on the thickness and make-up of the material. Larger diameters offer greater penetration power because of the crystal size, for difficult to measure materials.

Corrosion & Pit Detection in steel and cast materials

Use pulse-echo mode whenever attempting to locate pits and flaws. Typically a 5MHz transducer, or higher, will be used for these types of applications. Use low frequencies for greater penetration and use higher frequencies for better resolution.

Measuring Material & Coatings

The pulse-echo coating mode should be used when both material and coating thicknesses are required, while still requiring the ability to detect flaws and pits. A special coating style transducer is required for use in this mode. There are a variety of coating transducers in various frequencies available from Dakota. If a dual element transducer is selected with the **UMX-2** kit, it will be a coating enabled version.

Thru Paint & Coatings

Often times, users will be faced with applications where the material will be coated with paint or some other type of epoxy material. Since the velocity of the coating is approximately 2.5 times slower than that of steel, pulse-echo mode will induce error if the coating or paint is not completely removed. By using echo-echo mode, the user is able to successfully measure through both, the coating and steel, and completely eliminate the thickness of the paint or coating. Therefore, the steel can be measured without having to remove the coating prior to measuring. Users will often use pulse-echo mode and echo-echo mode in conjunction when performing inspections on coated materials.

Thru coating measurements require special high damped transducers. The most common transducers are the 3.5, 5, and 7.5MHz hi damped transducers. These transducers are suitable for use in both pulse-echo and echo-echo modes. This conveniently enables the user to accurately measure overall material thickness using the thru Coating mode, and then conveniently switch to pit detection mode without changing transducers. The ¼" 5MHz Hi damped transducer is the most commonly used transducer for standard thru coating applications.

Thin materials

Use pulse echo mode and a high frequency transducer for these types of applications. The most common transducers are the 7.5MHz and 10MHz models with extra resolution. The higher frequencies provide greater resolution and a lower minimum thickness rating overall.

High temperature

Use and select a special 2.25MHz and 5 MHz High temperature transducer for these types of applications. Both pulse-echo and echo-echo modes will also work for these applications. However, echo-echo mode will eliminate error caused by temperature variations in the delay line of the transducer.

Noisy Material

Materials such as titanium, stainless steel, and aluminum may have inherent surface noise issues. This is a signal that appears at the surface of the material when using a dual element delay line probe. Select a higher frequency transducer to reduce this noise – 7.5MHz and higher for better resolution.

Restricted access

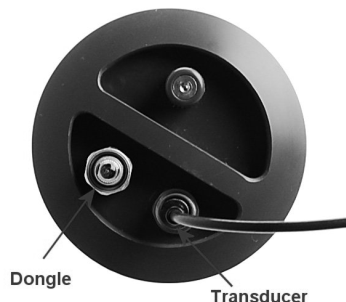
Measuring materials with extreme curvatures or restricted access, higher frequencies with smaller diameters should be considered. The smallest diameter uses 3/16" crystals with a contact area of .250". Custom transducers are available on request.

CHAPTER SEVEN MAKING MEASUREMENTS

The steps involved in making measurements are detailed in this section. The following sections outline how to setup and prepare your **UMX-2** for field use. An automatic or manual zero must always be performed when using a *dual element style transducer only*. The single element membrane probe option uses a special multiple echo mode, and does not require zeroing.

The auto zero is an off block electronic zero that does not require a zero reference block. This will most always be the zero option of choice, as it makes the zeroing process very easy and convenient to perform. However, if the manual zero option is enabled, the probe zero must be measured on the reference disk attached to the bottom end cap of the instrument. The zero compensates electrical variations and delays for a given transducer. Like a mechanical zero, it's a reference point. In all modes the sound velocity must be determined. The sound velocity is used to convert the transit time to a physical length. The sound velocity can be selected from a preset list of material types in the **UMX-2**, or can be programmed with a custom velocity using DakView3 utility software. Refer to page 28 for further info.

7.1 Auto Probe Recognition



The first step in using the **UMX-2** is to plug the transducer into the gauge and power the unit up. If a single element style transducer is used, be sure that the dongle is connected to the correct LEMO connector, as illustrated above. The **UMX-2** has a special built-in automatic probe recognition feature that will check to see if the probe plugged into the gauge was correctly identified. **Note:** only custom Dakota Ultrasonics transducers will work with the **UMX-2**.

Auto Probe Recognition

1/2 5 or NO PRB Err

- 1) Connect the probe to the **UMX-2**.
- 2) Be sure all couplant has been removed from the face of the transducer.
- 3) Press and release the single button located on the end of the **UMX-2**. The displays should illuminate, and led lights will begin flashing.
- 4) The smaller of the two displays will begin scrolling the current configuration settings of the **UMX-2** in the following order: UMX-2, BATT (LO, ME, HI), Probe Type (1/2 2S or 1/2 5)...etc. If 'NO PRB' is displayed and a dual element probe has been connected to the gauge, either the transducer is faulty, or it is not a certified **UMX-2** transducer. If a single element membrane transducer has been connected, be sure the dongle is connected to the correct channel. Press and hold down the button for approximately 30 seconds, or until the **UMX-2** powers off. Repeat steps 1 - 4 until the probe has been identified.
- 5) If the probe was identified, the **UMX-2** will automatically perform a 'probe zero'.

7.2 Probe zero

Continuing on from the previous section, if a dual element transducer was connected to the **UMX-2**, and the mode is currently setup either pulse-echo (P-E) or pulse-echo coating (PECT), a probe zero will automatically be done following startup. Therefore, if the **UMX-2** was previously set to echo-echo mode, the user will first need to set the gauge back to either pulse-echo or pulse-echo coating, before performing a probe zero.

Note: multi-echo modes do not require a probe zero. A probe zero should be done on a regular basis.

The probe zero function is an 'electronic zero' much like a mechanical zero used with a set of calipers. If the **UMX-2** is not zeroed correctly, all the measurements may be in error by some fixed value. is in the echo-echo measurement mode and a manual

zero is being performed, the **UMX-2** will put the gauge into pulse-echo mode automatically before performing the zero. Both zero options are broken down again as follows:

The **UMX-2** is equipped with two zero options:

- 1) **Off Block Zero (Automatic Probe Zero)** – When this feature is enabled the **UMX-2** will do an electronic zero automatically, eliminating the need for a zero disk or block.
- 2) **On Block Zero (Manual Probe Zero)** – When this feature is enabled the transducer must be placed on the probe zero disk located on the bottom end cap.

Both zero procedures are outlined as follows:

Performing an Auto Probe Zero (Off Block)

- 1) Be sure all couplant has been removed from the face of the transducer.
- 2) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to the next in a time delayed sequence, and will display all the menu options in a continuous loop.



The image shows a rectangular box representing an alpha display. Inside the box, the word "ZERO" is displayed in a large, black, seven-segment digital font.

- 3) When **ZERO** is displayed, immediately press and release the button to enter the sub menu options. Again, the options will begin scrolling in a continuous loop.



The image shows a rectangular box representing an alpha display. Inside the box, the word "AUTO" is displayed in a large, black, seven-segment digital font.

- 4) When **AUTO** is displayed, immediately press and release the button to perform the auto zero.

- 5) Press and hold the button to escape out of the menu options at any time.
- 6) The **UMX-2** is now ready to be calibrated for a given material type.

Performing a Manual Probe Zero (On Block)

Note: When the manual probe zero option is either preferred, or needed to reset the internal zero used for the auto zero, the 'zero disk' located on the bottom end cap of the **UMX-2** will be used as the zero reference standard.

- 1) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to the next in a time delayed sequence, and will display all the menu options in a continuous loop.



The image shows a rectangular box representing an alpha display. Inside the box, the word "ZERO" is displayed in a large, bold, black, monospaced font.

- 2) When **ZERO** is displayed, immediately press and release the button to enter the sub menu options. Again, the options will begin scrolling in a continuous loop.



The image shows a rectangular box representing an alpha display. Inside the box, the word "MANUAL" is displayed in a large, bold, black, monospaced font.

- 3) Apply a drop of couplant on the transducer and place the transducer in steady contact with the probe zero disk and obtain a stable reading on the

measurement display. **Note:** Do not remove the transducer from the zero reference standard.

- 4) When **MANUAL** is displayed, immediately press and release the button to perform a manual probe zero.
- 5) Press and hold the button to escape out of the menu options at any time.
- 6) The **UMX-2** is now ready to be calibrated for a given material type.

Note: The value that is displayed will change depending on the current velocity setting in the **UMX-2**. Disregard the number that is displayed. **It is not important.** What is important is accurately performing the steps outlined above to insure reliability of the probe zero calculation.

7.3 Material Calibration

In order for the **UMX-2** to make accurate measurements, it must be set to the correct sound velocity of the material being measured. Different types of materials have different inherent sound velocities. For example, the velocity of sound through steel is about 0.233 inches per microsecond, versus that of aluminum, which is about 0.248 inches per microsecond. If the gauge is not set to the correct sound velocity, all of the measurements the gauge makes will be erroneous by some fixed percentage.

The **UMX-2** has 8 preset material types with common fixed velocities to select from. There is also 1 custom programmable velocity available for non-standard known material velocities.

Basic Material Type

In order to calibrate the **UMX-2** according to a specific material to be tested, the user can select a basic material type from a list with approximate velocity values according to various material types. It's important to note that these velocities will not always be an exact representation of the material being tested. They will typically be more than adequate for ongoing 'historical' material degradation inspections. The following is a list of the preset materials, and the procedure to select and calibrate the **UMX-2**:

UMX-2 Material Chart			
Material Types	Abbreviations	Velocity	Velocity m/sec

		in/msec	
Aluminum	ALU	0.2500	6350
Steel (4340 Mild)	STL	0.2330	5918
Stainless Steel (304)	STST	0.2229	5662
Iron	IRON	0.2320	5893
Cast Iron	CIRD	0.1800	4572
PVC	PVC	0.0940	2388
Polystyrene	PLST	0.0920	2337
Poly Urethane	PLUR	0.0700	1778
Custom	CUSTOM	User	User

Selecting Material Type

- 1) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to the next in a time delayed sequence, and will display all the menu options in a continuous loop.

MATL

- 2) When **MATL** is displayed, immediately press and release the button to enter the sub menu options. Again, the options will begin scrolling in a continuous loop.

IRON

- 3) When the material type is displayed, immediately press and release the button to configure the **UMX-2** to the selected material type. For this example, **IRON** has been selected.
- 4) Press and hold the button to escape out of the menu options at any time.

- 5) The **UMX-2** is now calibrated and ready to begin taking readings.

Preset Material Types & Velocities

If the material velocity is known, the user may wish to simply enter the velocity number into the **UMX-2**, rather than have the **UMX-2** calculate the velocity value using a known thickness on a material sample. The steps for entering the velocity are outlined below:

Using a Known Material Velocity

- 1) Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **CAL** menu is highlighted and displaying the submenu items.
- 2) Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **VELOCITY** is highlighted.
- 3) Press the **ENTER** key to display the **Digits Edit Box**.
- 4) Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
- 5) Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
- 6) Repeat steps **4 & 5** until the velocity number is correctly displayed.
- 7) Press the **OK** key to set the velocity and return to the menu screen, or **ESC** to cancel entering the velocity.
- 8) Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.

To calibrate the **UMX-2** for a specific type of coating using the DakView3 utility software, refer to page 58 for a complete explanation on how to program a known coating velocity into the **UMX-2**.

CHAPTER EIGHT ADDITIONAL FEATURES & OPTIONS

8.1 Power Off

The **UMX-2** will power off automatically after approximately 4 minutes without receiving an echo (measurement). It should be noted that if the transducer face is not wiped clean, there's a chance an echo can continuously be detected. If that happens, the gauge will remain on until the battery life is exhausted. As a result, the **UMX-2** can also be powered down manually as follows:

Manual Power Off

- 1) Press and hold the single **UMX-2** button, located on the top end cap. Once the **UMX-2** is approaching power off status, "**POWER**"..."**OFF**", will be displayed in a loop on the alpha display, and the **UMX-2** will shut down. This takes approximately 10 seconds. Once the gauge is off, the button can be released.

8.2 Gain

The gain feature will only be displayed as a menu option if a 'dual element' style transducer has been connected, and the **UMX-2** is in either 'pulse-echo (P-E) or 'pulse-echo coating (PECT)' modes. Multiple echo modes, which include both single and dual style probes, are equipped with 'automatic gain control (AGC) that optimizes the gain setting automatically in the hardware of the **UMX-2**.

Gain, or amplification of the return echoes, can be adjusted in the **UMX-2** to accommodate a variety of applications. The setting of the gain is crucial in order to obtain valid readings during the measurement process. Too much gain may result in erroneous measurements, by detecting on noise rather than the actual material back wall itself. Not enough gain may result in intermittent detection. It may also result in lack of detection on internal flaws, pits, or porosity. The gain can easily be compared to the volume control of a home stereo system. If you turn it up too much, you can't hear the music clearly. If it's turned down too much, you can't hear it at all.

The **UMX-2** has three gain settings (**VLOW, LOW, MED, HI, VHI**). The gain range is 42dB – 50dB in 2dB increments. **Note:** The **UMX-2** has been optimized for the **MED** gain setting for all common applications. It should be operated in this mode as standard. However, some applications may require the lower or higher gain settings.

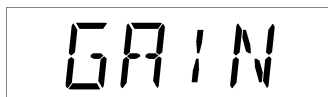
When? The low settings may be necessary for noisy or granular cast materials. How do I know when to lower the gain? If the reading becomes sporadic and won't settle down or resolve on a thickness value, the user can assume that the material is either very noisy aluminum, or granular cast iron. This would be a good time to change the **UMX-2** to lower gain setting and see if the reading settles down and become stable.

How do I know when to increase the gain? Often times the user will be trying to measure a material that is hard to penetrate or pass sound through. This may be due to the material type, or overall thickness of the material. When a material is hard to pass sound through because of the thickness or general make-up, it would be a good time to consider switching the **UMX-2** into a higher gain setting. Another example might be the need to increase overall sensitivity for locating fine pits or flaws. In any case, the selectable gain settings offer the user some additional options to resolve and overcome application issues.

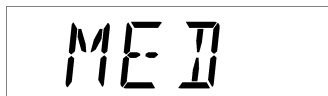
The procedures to adjust the **Gain** are outlined below:

Adjusting the Gain

- 1) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to the next in a time delayed sequence, and will display all the menu options in a continuous loop.

A rectangular box representing an alpha display with the word "GAIN" in a large, black, monospace-style font.

- 2) When **GAIN** is displayed, immediately press and release the button to enter the sub menu options. Again, the options will begin scrolling in a continuous loop (VLOW, LOW, MED, HIGH, VHIGH).

A rectangular box representing an alpha display with the word "MED" in a large, black, monospace-style font.

- 3) When the desired gain setting is displayed, immediately press and release the button to set the gain in the **UMX-2**. For this example, **MED** has been selected.
- 4) Press and hold the button to escape out of the sub menu options at any time.

8.3 Units (in/mm)

The **UMX-2** can be set to either English or Metric units. The procedure below outlines how to set the units in the **UMX-2**:

Setting Units

- 1) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to the next in a time delayed sequence, and will display all the menu options in a continuous loop.



UNITS

- 2) When **UNITS** is displayed, immediately press and release the button to enter the sub menu options. Again, the options will begin scrolling in a continuous loop (IN, MM).



IN

- 3) When the desired units are displayed, immediately press and release the button to set the units in the **UMX-2**. For this example, **IN** has been selected.
- 4) Press and hold the button to escape out of the sub menu options at any time.

8.4 Display Backlights & LEDs

Depending on the required visibility versus power consumption, the **UMX-2** provides three lighting options; On, Off, AUTO. The following describes each option:

LT ON: Toggles both the display backlights and LED's on.

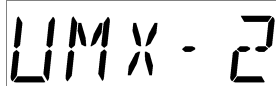
LT OFF: Toggles all the lights off.

LAUTO: Toggles both the display backlights and LED's on, only when receiving an echo (measurement).

The following procedure explains how to set the lighting option in the **UMX-2**:

Setting Light Option

- 1) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to the next in a time delayed sequence, and will display all the menu options in a continuous loop.

The image shows a rectangular alpha display with the text "UMX-2" in a digital, seven-segment font. The "U" and "M" are on the left, "X" is in the middle, and "- 2" is on the right.

- 2) When **UMX-2** is displayed, immediately press and release the button to enter the sub menu options. Again, the options will begin scrolling in a continuous loop (LT ON, LT OFF, LAUTO, MEM ON/OFF, UPGRAD).



The image shows a digital display with the text "LT ON" rendered in a seven-segment font. The characters are black on a white background, and the display is enclosed in a thin black rectangular border.

- 3) When the desired light option is displayed, immediately press and release the button to set the option in the **UMX-2**. For this example, **LT ON** has been selected.
- 4) Press and hold the button to escape out of the sub menu options at any time.

CHAPTER NINE THRU PAINT MEASUREMENT TECHNIQUE

9.1 Introduction to Thru Paint Measurement (Dual Element Probes)

The principle behind thru paint measurement is by measuring the time between two back wall echoes returning from the test material. Since both of these back wall echoes travel the same path through the paint or coating, the thickness of the coating is subtracted out of the measurement so that only the actual material thickness can be measured. This feature saves the user a great deal of time scraping and removing the coating from tanks and pipes during the inspection process.

The primary purpose of thru paint measurement is to determine actual or overall material thickness by eliminating the coating thickness. Thru paint mode cannot be used for flaw or pit detection. Therefore, inspectors may need to use echo-echo thru paint mode in conjunction with the standard pulse-echo flaw detection mode for some applications. Pipe and tube inspectors will use the echo-echo mode for pipes with powder coatings, and pulse-echo mode for pipes without coating. The combination of using both modes is ideal for the advanced inspectors needs.

Note: The procedure to select the measurement mode in the **UMX-2** is located at the end of this chapter.

9.2 Triple Echo (TCG) – Single Element Probes

The TCG mode was added to include single element membrane style transducers, and operates using three individual return echoes. Each echo is then adjusted, in terms of 'gain', to provide sufficient signal amplitude for each individual echo. This is needed because, if you're standing at the edge of a canyon and scream hello there, each return echo becomes weaker than the first until the sound is gone.

Similar to echo-echo mode, the measurement is made between the first two return echoes, eliminating the paint/coating and measuring only the based material. However, a second measurement is made between the second and third echoes, and compared to the first measurement. If both measurements are the same, the stability indicator will fully light up, and a stable measurement will be displayed.

Advantages:

The primary advantage using a single element transducer is linearity. Since only one crystal is used, and perfectly flat, a correction curve is not needed to compensate for focusing issues. A second advantage would be the comparison made between two different sets of echoes.

Disadvantages:

Single element transducers are not capable of detecting pits and flaws with a digital thickness gauge, and are typically not used for corrosion inspections on blind surfaces. Since only one crystal is used to both send and receive sound waves, small defects that reflect very little sound energy back to the transducer are ignored, based on the noise created by the same crystal sending the sound wave. Therefore, these transducers should only be used when general material thickness is required, and 'never' used for corrosion inspections. If there's any interest in locating blind surface pitting or internal material flaws, a 'dual element' transducer should always be used.

CHAPTER TEN

PULSE-ECHO COATING & COATING TECHNIQUES

10.1 Introduction to Pulse-Echo Coating Measurement (PECT)

In the previous sections we've discussed the need for detecting pits and flaws (pulse-echo) in materials, along with the requirement to measure through and eliminate errors caused by coated materials (echo-echo). Until now, both modes were needed in order accomplish both tasks. Pulse-echo mode was used for flaw detection, and echo-echo mode was used to eliminate the coating thickness and provide a nominal material thickness only. With this in mind, it often became cumbersome toggling between both modes respectively.

In a majority of applications involving coated materials, inspectors are often interested in monitoring both the thickness of the material, as well as the thickness of the coating. Therefore, the **UMX-2** has been designed to provide the user with the ability to measure the material and coating thicknesses simultaneously, while maintaining the ability to detect flaws and pits all in a single mode called **Pulse-Echo Coating (PECT)**. This is accomplished by using a custom hybrid combination mode utilizing properties from the basic modes along with a group of special techniques and theoretical wave phenomena's.

The **UMX-2** is preset to a coating velocity of 0.0850 in/ μ sec (2159 m/sec) from the factory. This velocity is a very close approximation of the common coating velocities found in the field. However, this can be changed to another known coating velocity, using DakView3 utility software to set a 'custom' velocity that can be uploaded to the **UMX-2**.

10.2 Enabling Pulse-Echo Coating Mode (PECT)

The special PECT mode is only available for use with 'dual element' transducers. When the **UMX-2** is initially powered up, the gauge will automatically check to see if the transducer plugged into the gauge can be recognized. All Dakota Ultrasonics coating enabled transducers are equipped with the auto recognition feature. If the **UMX-2** doesn't recognize that a special coating enabled transducer is plugged into the gauge, the coating feature will be disabled entirely. There are a number of coating enabled transducers available from Dakota. Please contact us with your application requirements for additional information on frequencies and diameters currently offered.

Note: When PECT mode is used, the coating value cannot be viewed on the **UMX-2**. Only the base material thickness is displayed. However, if the measurements are stored to a file and downloaded to a PC, the coating measurements can be viewed as they are saved within the file. The actual A-Scan waveform is also stored in the file. This can prove very valuable, as it provides the inspector additional confidence that the measurement was successful overall. Finally, all **UMX-2** settings are also

saved for each individual reading, again offering confidence and detail for reporting purposes.

The following procedure demonstrates how to enable PECT mode:

Enabling PECT Mode

- 1) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to the next in a time delayed sequence, and will display all the menu options in a continuous loop.



A rectangular box containing the word "MODE" in a large, black, monospaced, all-caps font, representing the display output of the gauge.

- 2) When **MODE** is displayed, immediately press and release the button to enter the sub menu options. Again, the options will begin scrolling in a continuous loop (P-E, PECT, E-E).



A rectangular box containing the word "PECT" in a large, black, monospaced, all-caps font, representing the display output of the gauge.

- 3) When the desired option is displayed, immediately press and release the button to set the option in the **UMX-2**. For this example, **PECT** has been selected.
- 4) Press and hold the button to escape out of the sub menu options at any time.

10.3 Zero Coating

In order to account for very slight electronic differences in transducers of the same type, frequency, and diameter, the **UMX-2** has been equipped with a “zero coating”

feature. This enables the **UMX-2** to obtain very accurate readings on coatings, eliminating potential errors incurred from slight differences in the manufacturing processes. The coating zero should be performed on an uncoated section of the same material or something similar. The procedure is outlined below:

Performing a Coating Zero

- 1) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to the next in a time delayed sequence, and will display all the menu options in a continuous loop.

A rectangular box representing an alpha display with the word "ZERO" in a digital, seven-segment font.

- 2) When **ZERO** is displayed, immediately press and release the button to enter the sub menu options. Again, the options will begin scrolling in a continuous loop (AUTO, MANUAL, COAT).
- 3) Apply a drop of couplant on the transducer or test material. Place the transducer on an uncoated surface of the material and obtain a stable measurement. *Do not remove the transducer.*

A rectangular box representing an alpha display with the word "COAT" in a digital, seven-segment font.

- 4) When the desired option is displayed, immediately press and release the button to set the option in the **UMX-2**. For this example, **COAT** has been selected.
- 5) Press and hold the button to escape out of the sub menu options at any time.

10.4 Coating Calibration (PECT)

Known Velocity

If the coating velocity is known, and other than the factory set velocity of 0.0850 in/ μ sec (2159 m/sec), the user may wish to program the **UMX-2**. In order to set the coating velocity, the DakView3 PC software must be used to create a setup, and upload the setup into the **UMX-2**. Refer to page 58 regarding setups.

CHAPTER ELEVEN DATA STORAGE – SETUP, EDIT, & VIEW FILES

11.1 Introduction to Grid and Sequential file formats

The **UMX-2** is equipped with two data file format options, **GRID LOG** and **SEQ LOG**. The **GRID** file format is very similar to a spreadsheet format found in popular software programs like Excel. A **GRID** is simply a table of readings. A location in a grid is specified by giving a row and column coordinate. The rows are numbered from 1 to 999 and the columns are labeled from A to ZZ (999 Rows & 52 Columns). The sequential file format can be viewed as a file as a single column of up to 512 possible rows (readings), and a column of corresponding identifiers associated with each individual reading. The identifier can be a combination of up to 10 numeric, alpha, or special characters listed above, while the file name can consist of a combination of up to 20 of the same character set. Note: *The identifier cannot start or end with a special character.* Once a start and end ID are entered into the **UMX-2** and the log created, the **UMX-2** will automatically generate all the identifiers within that range.

The following character set listed below are all the allowable characters that will be used for both file formats: **GRID & SEQ LOG**. Any combination of these characters can be used for creating a Name and Note regardless of the selected format. The allowable characters are as follows:

Numeric characters: 0 – 9 **Alpha Characters:** A – Z

Special Characters: ! ' _ # space / . - ()

*Note: Multiple grids can be created and saved as template files on a PC, using DakView3 utility software, but only one grid can be uploaded into the **UMX-2** at a time.*

The **UMX-2** can store a total of **16,000+ readings** with a corresponding screenshot of the actual waveform, as well as all the **UMX-2** settings for every individual reading. If the graphics option is disabled, not saving screenshots, the **UMX-2** can store a total of **210,000+ readings**.

In the sections that follow, the procedures for creating, using, and editing **GRID's** and **SEQ LOG's** have been combined together for the purpose of similarity in overall functionality and structure. The illustrations below are snapshots of typical **GRID** and **SEQ LOG** file formats:

Grid File Formats

NAME: EX#1				NAME: EX#2			
	A	B	C		D	E	F
1				6			
2				7			
3				8			
4				9			

Sequential Log Formats

NAME: EX#1		NAME: EX#2	
AA		01	
AB		02	
AC		03	
AD		04	
AE		05	

NAME: EX#3		NAME: EX#4	
3A		BCD-4-01	
3B		BCD-4-02	
3C		BCD-4-03	
3D		BCD-4-04	
3E		BCD-4-05	

Important Note: For the duration of this chapter, all references to **GRIDS** and **SEQ LOGS** should be considered synonymous with references to **FILES**.

11.2 Create New Log Field Definitions

Coordinates or Start & Stop ID's

Grid: A grid is defined by using coordinates to define the **Top Left** and the **Bottom Right** corners of the grid. Alpha coordinates are horizontal across the top, and numeric coordinates are vertical down the side. Therefore, to define the top left

corner of the grid, there will be an (X,Y) coordinate. Where X is an alpha column location across the top and Y is a numeric row location down the side. Use the same logic when choosing the lower right corner. An individual grid can be up to 999 rows and 52 columns. If the user attempts to create a grid that is larger than the stated boundaries, an error message box “**OUT OF MEMORY**“ will be displayed.

Sequential: The sequential file format can be viewed as a file as a single column of up to 512 possible rows (readings), and a column of corresponding identifiers associated with each individual reading. The identifier can be a combination of up to 10 numeric, alpha, or special characters listed above, while the file name can consist of a combination of up to 20 of the same character set. Note: *The identifier cannot start or end with a special character.* Once a start and end ID are entered into the **UMX-2** and the log created, the **UMX-2** will automatically generate all the identifiers within that range. If the user attempts to create a grid that is larger than the stated boundaries, an error message box “**OUT OF MEMORY**“ will be displayed.

Selecting the Auto Increment Direction

The **Auto Increment** feature gives the user the ability to specify which direction to advance the cursor after storing a reading.

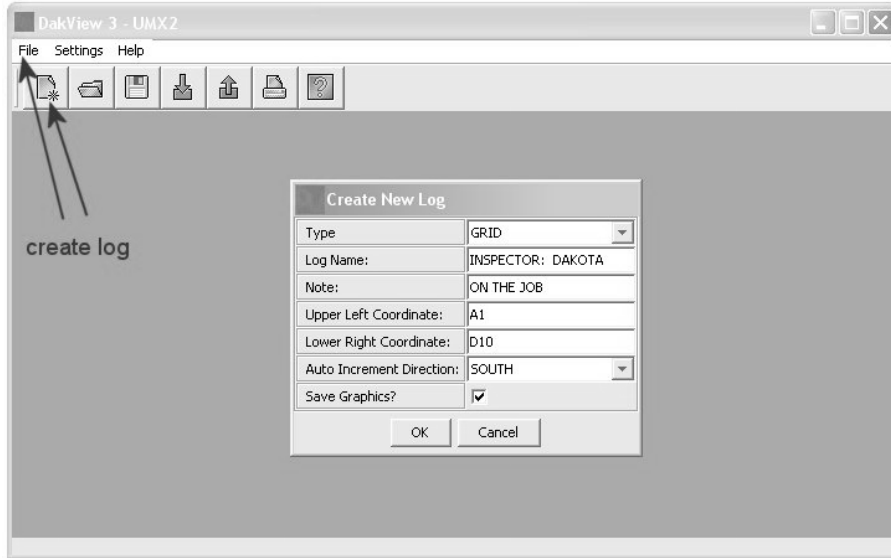
Saving Graphics

The **UMX-2** provides the user with the ability to save a snapshot of the display screen and all the current settings of the **UMX-2** with every reading, or just save the reading only. Saving the graphics might be advantageous to the user for reporting purposes, and additional confidence in the measurements, as a snapshot of the actual A-Scan waveform will be recorded for every individual reading. This offers the user the ability to review and confirm the validity of the measurements, based on the waveforms. Additionally, enabling this feature will store all the current **UMX-2** setup parameters for each measurement.

11.3 Creating a new Grid or Sequential Log (File)

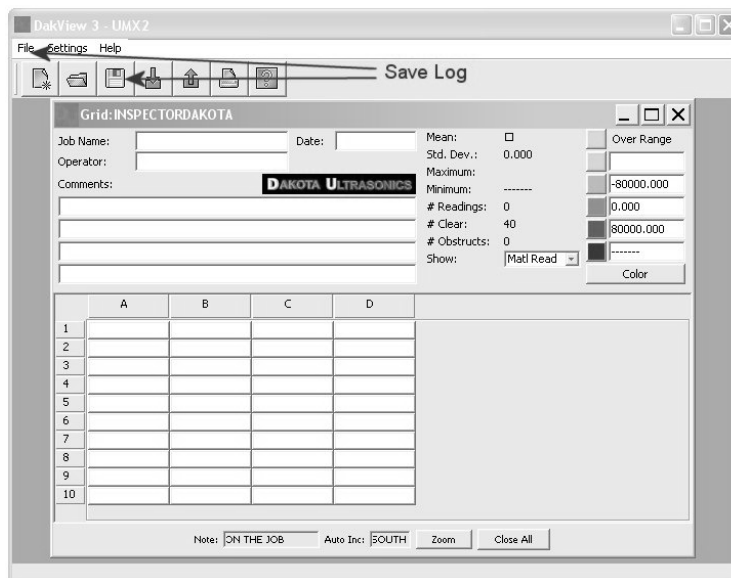
This section will go through the step to create a Grid/Log file and save it on your PC, as follows:

Creating a Grid/Log File



Note: This section assumes that DakView3 has already been installed on your PC, has been executed, and ready to go.

- 1) A log file can be created two different ways; Click the icon button to initiate the 'New Log' dialog box, or click FILE, followed by clicking NEW.
- 2) Click in the 'white space' fields, or on the down arrows next to the fields to enter the options for the file template, as illustrated above.



- 3) When all the information has been entered into the fields, click the OK button to create and display the log file.
- 4) The log file can be saved two different ways; Click the icon button to initiate the 'SAVE' dialog box, or click FILE, followed by clicking SAVE.
- 5) Specify the path to the folder to store the log file in, give the log file a unique name, and click save to store the file on your PC.

11.4 Connecting to a PC

Now that the log file has been created and saved on the PC, the next step is connecting to a PC to transfer the template file into the **UMX-2**. There are 2 cables included with the **UMX-2** kit; LEMO to 9 pin serial and 9 PIN serial to USB.

Serial:

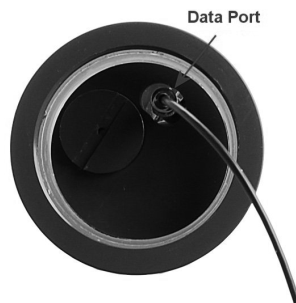
The LEMO to 9 pin RS232 cable can be connect directly to any serial port. However, the serial port number must be known. The actual port reference can be obtained in the device manager of a Windows® based operating system.

USB:

Both the LEMO to 9 pin serial and 9 pin serial to USB can be connected together to use the serial to USB converter configuration. This option requires that a driver is installed for the USB cable. The driver will automatically be loaded when DakView3 PC software is installed. However, the driver files will also be included in the 'examples' folder on your desktop. This folder is created by DakView3 when installed.

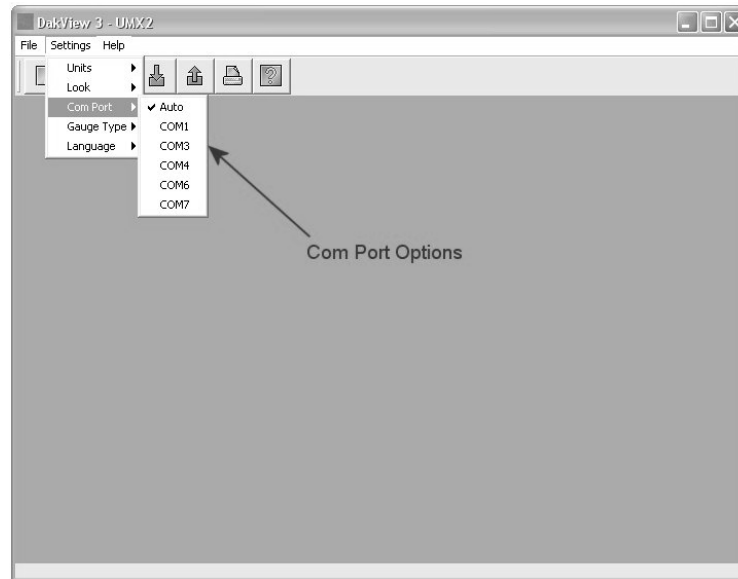
The following procedure outlines the steps for connecting and transferring the template file to the **UMX-2** as follows:

Uploading the Log File

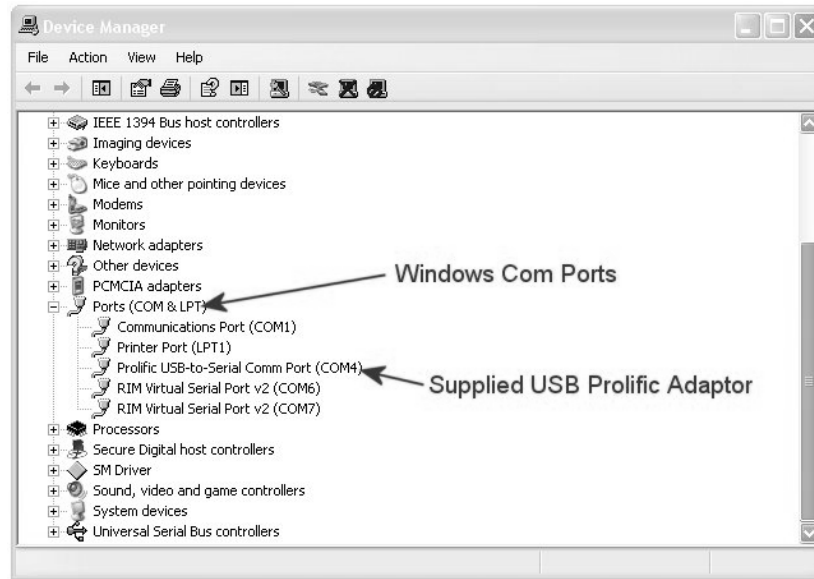


- 1) Remove the bottom end cap of the **UMX-2**, in order to access the LEMO data jack. Remove the rubber plug from the data jack.
- 2) Plug the LEMO connector into the data jack. Note: align the red pin on the connector with the data jack.

- 3) Plug either the RS232 into a serial port, or USB connector into a USB port on the PC.
- 4) Start the DakView3 utility software.

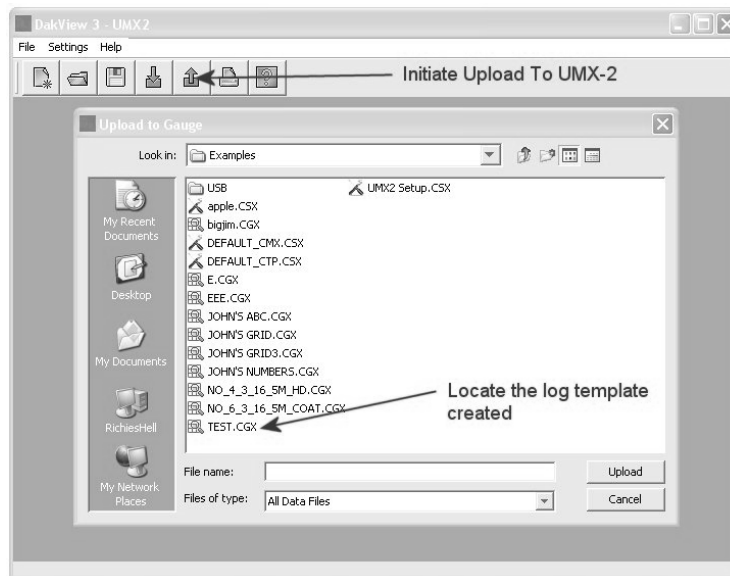


- 5) Click on SETTINGS, followed by clicking on COM PORT, to view the list of available ports. The default setting for DakView3 is always AUTO. The AUTO mode searches through all the possible com port options, and looks for the port 'automatically'. However, this can take some time. Therefore, if the port is already known, manually select the port from the list.



Note: A list of available ports can be determined in the device manager of the Windows® operating system.

6) Power on the **UMX-2**, and give it a minute to fully boot up.



7) Click the UP ARROW icon to initiate the file transfer. A dialog box will appear, displaying the examples folder created by DakView3 on your desktop. Alternatively, the upload can be initiated from the menus by

clicking the FILE menu option, followed by clicking the UPLOAD TO GAUGE option.

- 8) Select the file to be uploaded to the **UMX-2**.
- 9) Finally, click the UPLOAD button in the dialog box to start the transfer. A progress bar will appear on the screen during the transfer process, and disappear once the transfer has completed.


11.5 Activating the Data Logger (UMX-2)

The following procedure explains the necessary steps to activate the data logger in the **UMX-2**:

Turning on the Data Logger

Note: This section assumes the **UMX-2** is powered up and ready to go. The **UMX-2** always boots up and displays the left most top level menu item, which corresponds to the data logger. If anything, other than **MEMOFF**, is currently displayed, the data logger is already active.

- 1) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to the next in a time delayed sequence, and will display all the menu options in a continuous loop.



The image shows a rectangular alpha display with the text "UMX-2" in a digital font. The "2" is slightly larger and more prominent than the other characters.

- 2) When **UMX-2** is displayed, immediately press and release the button to enter the sub menu options. Again, the options will begin scrolling in a continuous loop (LT ON, LT OFF, LAUTO, MEM ON/OFF, UPGRAD).

MEMOFF

- 3) When the desired option is displayed, immediately press and release the button to set the option in the **UMX-2**. For this example, **MEMOFF** has been selected to toggle **MEM ON**.

Note: MEMOFF & ON is a two position toggle switch. Therefore, if MEMOFF is selected, it turn the data logger on, and visa versa.

- 4) Press and hold the button to escape out of the sub menu options at any time.

11.6 Navigating the Data Logger

When the Grid or Sequential log file was created in the DakView3 PC utility software, one of the selection options was an increment direction. The increment direction specifies which 'direction' to advance the cursor following storage of a measurement. The directions are like a compass; North, South, East, West and None. If None is selected, the user will have to manually set the increment direction in the **UMX-2**. The user might also consider changing this direction, even if the original increment direction was previously set in the PC software. The user may opt to use a variety of directions, considering efficient use of inspection locations, not previously considered. Finally, the user may want to go back to previously stored measurements to review them. The section that follows, outline the necessary steps to change the increment direction and navigate through the log file:

Changing the Increment Direction

Note: This section assumes the **UMX-2** is powered up and ready to go.

- 1) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to

the next in a time delayed sequence, and will display all the menu options in a continuous loop.



- 2) When **DIRECT** is displayed, immediately press and release the button to enter the sub menu options. Again, the options will begin scrolling in a continuous loop (NORTH, SOUTH, EAST, WEST, Current Log Location).



- 3) When the desired direction is displayed, immediately press and release the button to set the option in the **UMX-2**. For this example, **SOUTH** has been selected as the increment direction.

Note: If the user wants to 'fast' increment through a variety of storage locations, follow step 3 above, and continuously 'press and release' to move through storage locations. Example: current grid cell location is A1, and user needs to move to A5. Repeat a 'press and release' when SOUTH appears, five times repetitively.

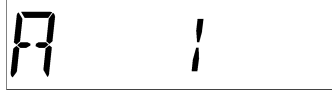
- 4) Press and hold the button to escape out of the sub menu options at any time.

11.7 Storing a Measurement

Now that a grid or sequential log has been created and uploaded to the **UMX-2**, and the user is familiar with moving around through the log file, it's time to take and store a measurement. The following procedures outline this process:

Storing Measurements

Note: This section assumes the **UMX-2** is powered up and ready to go. Also, the **UMX-2** will always return to the left most top level menu item, or the current log file location. This was done to make it convenient for the operator to store measurements without having to scroll through directories.



- 1) Press and release the single **UMX-2** button, located on the top end cap, to store a measurement, and auto increment to the next storage location.

Example: current grid cell location is A1, and auto increment is set to south.

Once the reading is stored, the cursor will automatically advance to A2.

- 2) It's as simple as that!

Important Note: *If the **UMX-2** is currently in a stored location, the gauge will not measure. The measurement must be cleared first, or the user must be in an 'empty' storage location.*

11.8 Clearing a Stored Measurement

The following procedure outlines the steps to clear a cell or log location, where the user has opted to make and store another measurement for that specific location:

Clear Location

Note: This section assumes the **UMX-2** is powered up, and the user has navigated to the storage location that will be cleared.

- 1) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to

the next in a time delayed sequence, and will display all the menu options in a continuous loop.

- 2) When **CLEAR** is displayed, immediately press and release the button to enter the sub menu options. CLEAR followed by the current storage location will alternate (CLEAR...A1...CLEAR...A1).



- 3) When **CLEAR** or **LOCATION(A1)** are being displayed, immediately press and release the button to clear the current location in the **UMX-2**. For this example, **A1** has been selected as the storage location.
- 4) Press and hold the button to escape out of the sub menu options at any time.

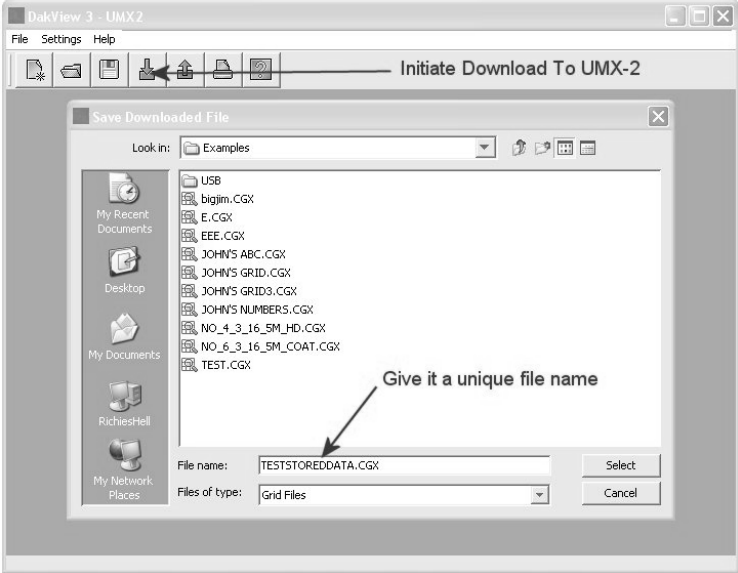
11.9 Downloading the Log File

Once all the measurements have been stored in the log file, the file can be downloaded to a PC using DakView3 for the purpose of reporting and recordation. The procedures are outlined in this section.

Note: REFER TO THE SECTION ON CONNECTING TO A PC SECTION

Download Log File

Note: This section assumes the **UMX-2** is powered up and ready to go. The earlier procedure for 'connecting to a PC' and '**Upload Log File**' procedure should be used for this section, to avoid redundancy. This section outlines only minor changes to that procedure. The steps have been numbered for easy insertion.



7) Click the DOWN ARROW icon to initiate the file transfer. A dialog box will appear, displaying the examples folder created by DakView3 on your desktop. Alternatively, the upload can be initiated from the menus by clicking the FILE menu option, followed by clicking the DOWNLOAD FROM GAUGE option.

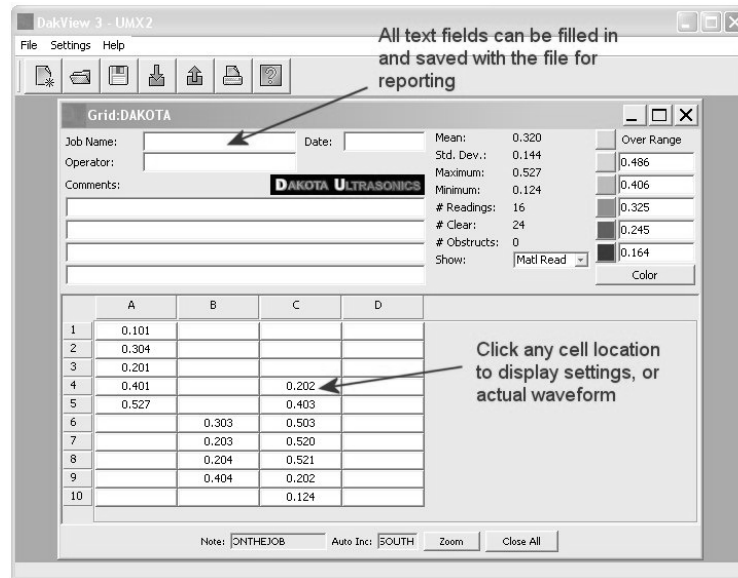
8) Give the log file a unique name to store it on your PC.

9) Finally, click the DOWNLOAD button in the dialog box to start the transfer. A progress bar will appear on the screen during the transfer process, and disappear once the transfer has completed.

11.10 Viewing stored readings

Once the file download is complete, as performed in the previous section, the file will automatically open and be displayed in DakView3. It is sometimes necessary to go back and view the stored readings, their settings, and waveforms displays. The following procedures outline this process:

Viewing a Log File



- 1) Click on any of the measurement cells to review the gauge settings and waveform for that specific measurement.
- 2) Click in the any of the 'white space' text fields' to enter required information for reporting purposes. If the file is then saved, the information entered will also be saved with the file.

Note: Although the **UMX-2** is not equipped with a screen to view an actual live A-Scan waveform, a 'snapshot' of the waveform is captured for each and every measurement saved. These waves can be opened and reviewed in DakView3 at any time. They can provide valuable information, in reference to the quality of the measurements.

CHAPTER TWELVE SETUPS – CREATE, STORE, EDIT, & UPLOAD

12.1 Introduction to Setups

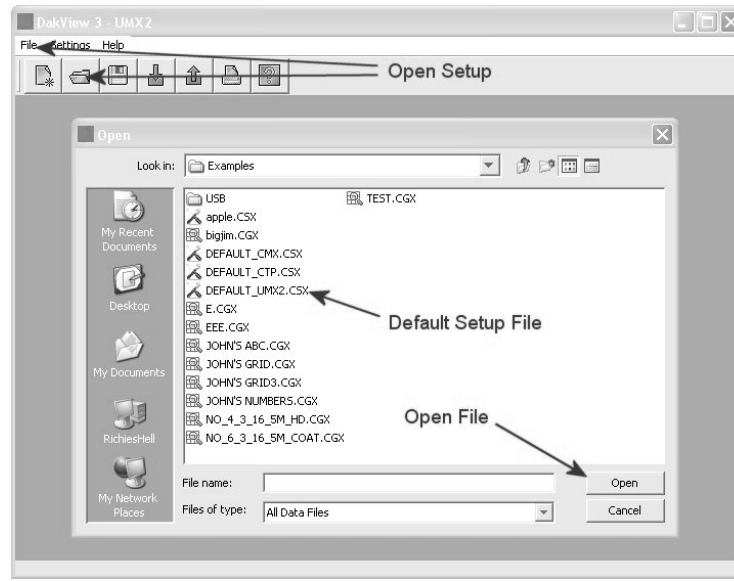
The **UMX-2** has been programmed with 8 of the most common material types used in the field. It's important to note that these are 'set' velocity values and are 'not exact' velocities for each and every grade of the same material. For example: There are a number of different grades of steel that can slightly vary in terms of velocity. However, the amount of variation according to error in thickness is typically not substantial. Inspectors are generally interested in 'historical' data (material degradation) over a period of time. As a result, a standardized velocity setting acts as a consistent reference to monitor degradation over time.

If a user is measuring a material type not preset in the **UMX-2**, and is not a close enough fit for the specific material, the user can program the **UMX-2** for a custom material type, using the DakView3 utility software. This section will guide you through all the necessary steps to create, store, and upload a setup.

12.2 Opening the Default Setup File

When DakView3 is installed on your computer, a folder named 'examples' is automatically created on your desktop. The examples folder includes the **UMX-2** setup file called "**DEFAULT_UMX2.CSX**". This file will be used to create either a custom material or coating velocity to be programmed into the gauge. The following procedures outline how to open the factory setup file:

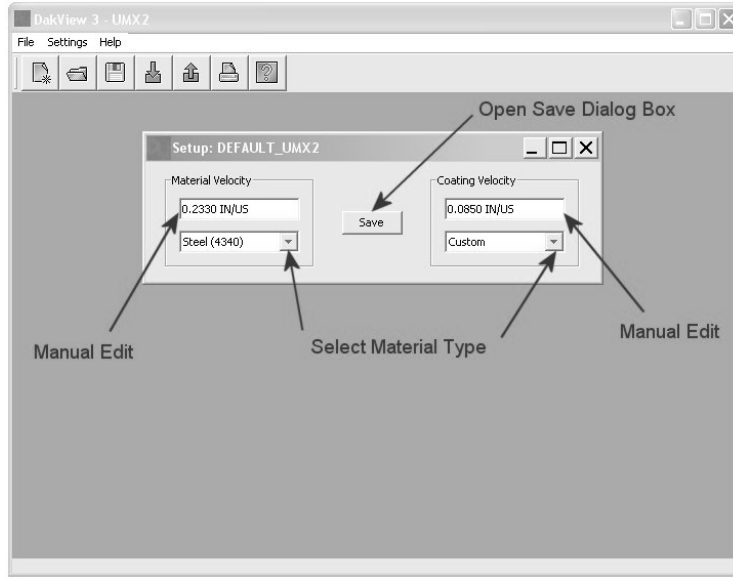
Default Setup File



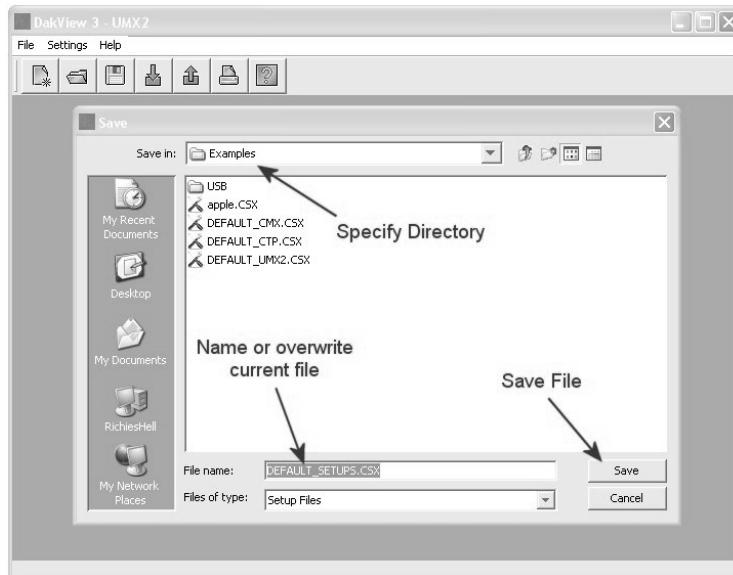
Note: This section assumes that DakView3 has already been installed on your PC, has been executed, and ready to go.

- 1) The default setup file can be opened two different ways; Click the icon button to initiate the 'open' dialog box, or click FILE, followed by clicking OPEN.
- 2) Locate the file “**DEFAULT_UMX2.CSX**”. The file can be opened 2 ways. Single click on the file name to highlight the file, followed by clicking the open button. Alternatively, double click on the file name itself to open the setup dialog box.

Note: This assumes that a setup file was not previously created and saved. If it was, locate the file that was previously created and follow the same procedure above.



- 3) There are two possible velocity settings available; material and coating. The user can enter a known velocity number in either field by clicking in the 'whitespace' and the current velocity number, or select a material by clicking on the DOWN ARROW located next to the material type.



- 4) Once the material and or coating velocities have been set, click the SAVE button in the setup dialog box, to display the SAVE dialog box.

- 5) Specify the path to the folder to store the setup file in. Give the setup file a unique name, or overwrite the default file.
- 6) Finally, click the SAVE button to store the file on your PC.

12.3 Connecting to a PC

Now that the new setup file has been created and saved on the PC, the next step is connecting to a PC to transfer the setup file into the **UMX-2**. There are 2 cables included with the **UMX-2** kit; LEMO to 9 pin serial and 9 PIN serial to USB.

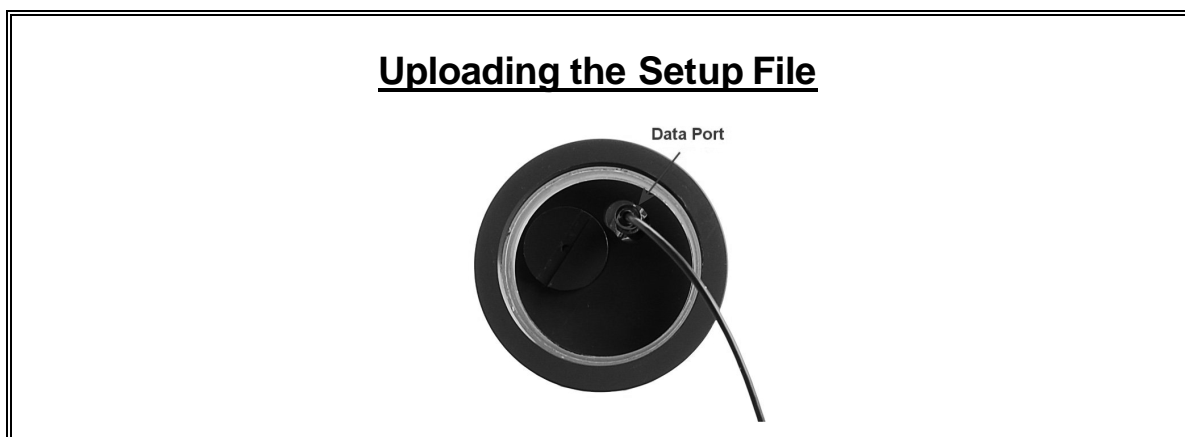
Serial:

The LEMO to 9 pin RS232 cable can be connect directly to any serial port. However, the serial port number must be known. The actual port reference can be obtained in the device manager of a Windows® based operating system.

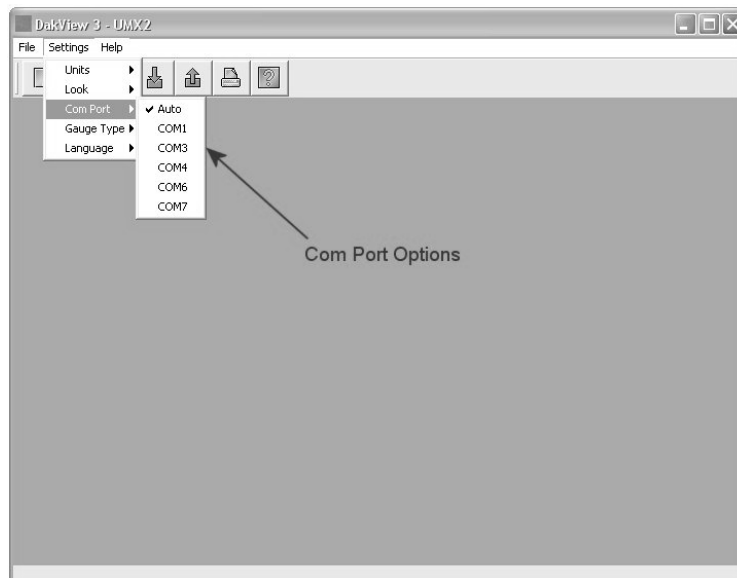
USB:

Both the LEMO to 9 pin serial and 9 pin serial to USB can be connected together to use the serial to USB converter configuration. This option requires that a driver is installed for the USB cable. The driver will automatically be loaded when DakView3 PC software is installed. However, the driver files will also be included in the 'examples' folder on your desktop. This folder is created by DakView3 when installed.

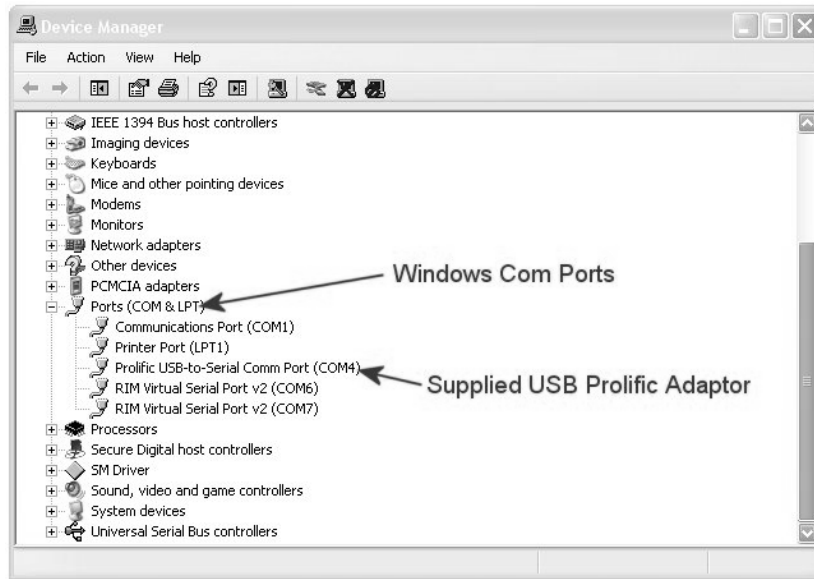
The following procedure outlines the steps for connecting and transferring the setup file to the **UMX-2** as follows:



- 1) Remove the bottom end cap of the **UMX-2**, in order to access the LEMO data jack. Remove the rubber plug from the data jack.
- 2) Plug the LEMO connector into the data jack. Note: align the red pin on the connector with the data jack.
- 3) Plug either the RS232 into a serial port, or USB connector into a USB port on the PC.
- 4) Start the DakView3 utility software.

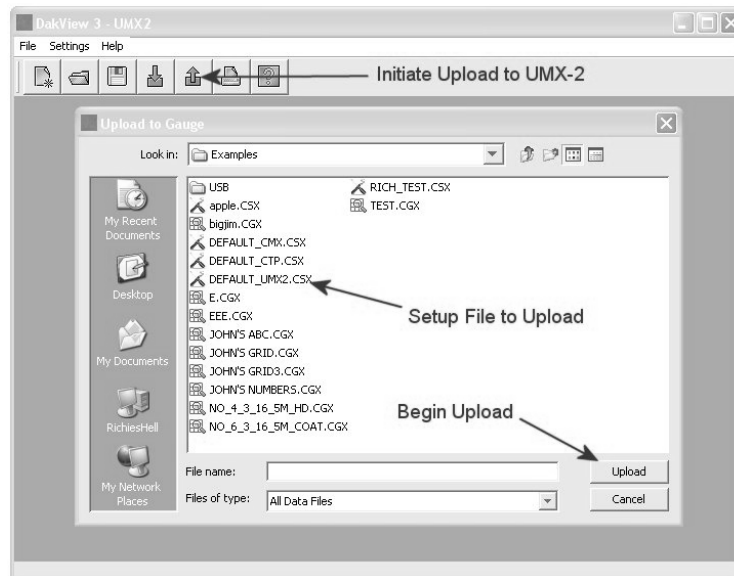


- 5) Click on SETTINGS, followed by clicking on COM PORT, to view the list of available ports. The default setting for DakView3 is always AUTO. The AUTO mode searches through all the possible com port options, and looks for the port 'automatically'. However, this can take some time. Therefore, if the port is already known, manually select the port from the list.



Note: A list of available ports can be determined in the device manager of the Windows® operating system.

6) Power on the **UMX-2**, and give it a minute to fully boot up.



7) Click the UP ARROW icon to initiate the file transfer. A dialog box will appear, displaying the examples folder created by DakView3 on your desktop. Alternatively, the upload can be initiated from the menus by

clicking the FILE menu option, followed by clicking the UPLOAD TO GAUGE option.

- 8) Select the file to be uploaded to the **UMX-2**.
- 9) Finally, click the UPLOAD button in the dialog box to start the transfer. A progress bar will appear on the screen during the transfer process, and disappear once the transfer has completed.

CHAPTER THIRTEEN UPGRADING THE FIRMWARE

13.1 Introduction to Firmware

Firmware is the actual software, in the **UMX-2** itself, that controls the functionality of the gauge. A benefit of the **UMX-2**, is the ability to upgrade the firmware from your desktop. When changes are made to the firmware, to add features or fix bugs, it can be downloaded from our website and programmed from a remote location. This offers our users additional support capability, as the gauge does not have to be sent back to our facility to be upgraded. In this section, we'll provide the necessary steps to program your **UMX-2**.

Note: The sections that follow, assume that the firmware file has been downloaded from our website, unzipped into a temporary file created on your desktop, and the **UMX-2** and all accessory cables are at your disposal.

13.2 Connecting to a PC

Now that the firmware file has been unzipped in a folder on your desktop, the next step is connecting to a PC to flash program the **UMX-2**. There are 2 cables included with the **UMX-2** kit; LEMO to 9 pin serial and 9 PIN serial to USB.

Serial:

The LEMO to 9 pin RS232 cable can be connect directly to any serial port. However, the serial port number must be known. The actual port reference can be obtained in the device manager of a Windows® based operating system.

USB:

Both the LEMO to 9 pin serial and 9 pin serial to USB can be connected together to use the serial to USB converter configuration. This option requires that a driver is installed for the USB cable. The driver will automatically be loaded when DakView3 PC software is installed. However, the driver files will also be included in the 'examples' folder on your desktop. This folder is created by DakView3 when installed.

The following procedure outlines the steps for connecting and programming the **UMX-2** with the latest firmware, as follows:

Connect & Program

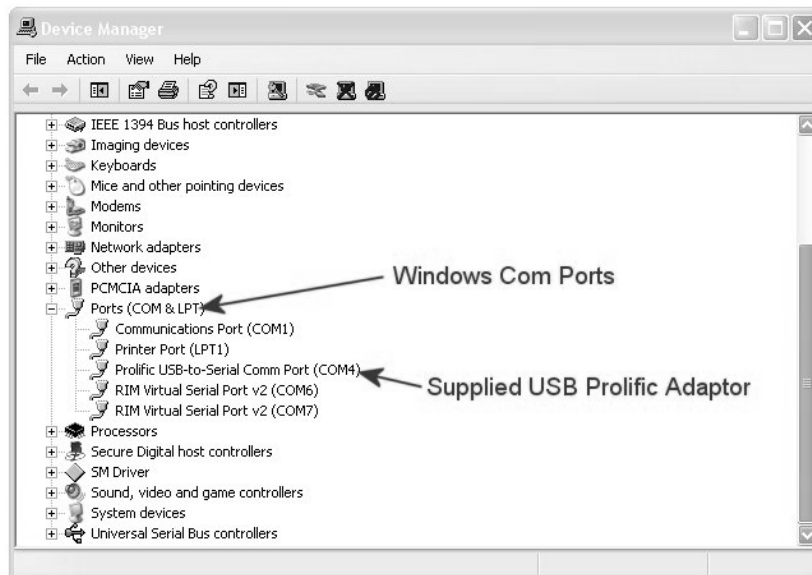


- 1) Remove the bottom end cap of the **UMX-2**, in order to access the LEMO data jack. Remove the rubber plug from the data jack.
- 2) Plug the LEMO connector into the data jack. Note: align the red pin on the connector with the data jack.
- 3) Plug either the RS232 into a serial port, or USB connector into a USB port on the PC.

Note: If the USB cable is used, the com port 'must' be set to ports 1-4.

Otherwise, if a standard serial port is used, skip to step #9.

- 4) We'll assume the USB cable is used for this example. Connect the USB cable to the **UMX-2** and PC.

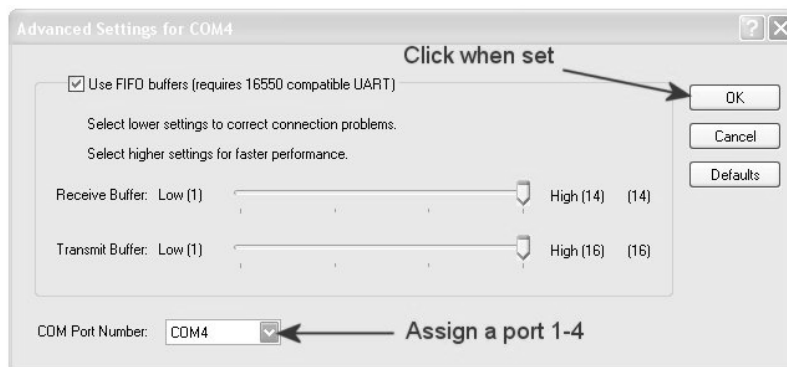


- Open windows® 'device manager' and click the plus sign next to PORTS, in order to display the complete list of all com ports in use. Look for the device named "Prolific USB-to-Serial to determine the current port that windows® has assigned the device.

Note: if the com port is 1-4 skip to step #9.

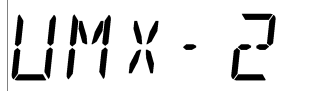


- Assuming the assigned port is other than 1-4, double click on the "Prolific" port to display the properties dialog box, as shown above.

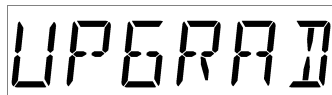


- Assign a com port 1-4 to the device, and click OK to set the port.
- Reboot your computer.
- Power on the **UMX-2** that should already be connected to your PC.

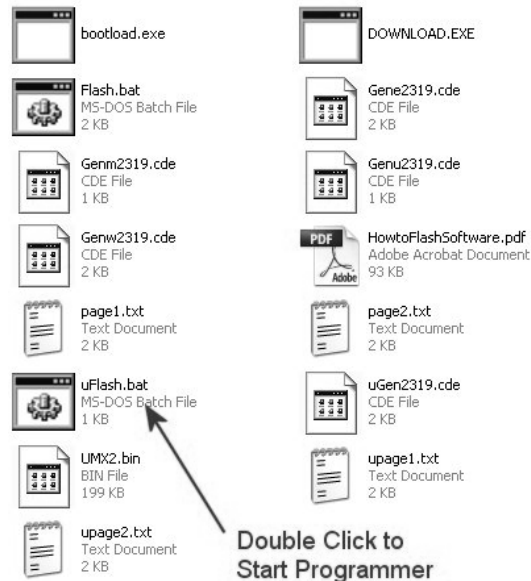
10) Press and hold the single **UMX-2** button, located on the top end cap, until the top level menu options begin scrolling on the alpha display. Once this occurs, the button can now be released. The menu options will scroll one to the next in a time delayed sequence, and will display all the menu options in a continuous loop.



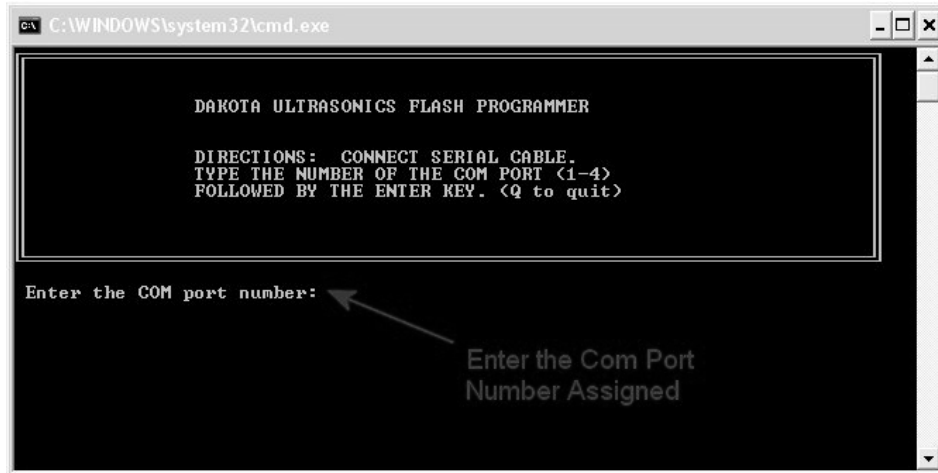
11) When **UMX-2** is displayed, immediately press and release the button to enter the sub menu options. Again, the options will begin scrolling in a continuous loop (LT ON, LT OFF, LAUTO, MEM ON/OFF, UPGRAD).



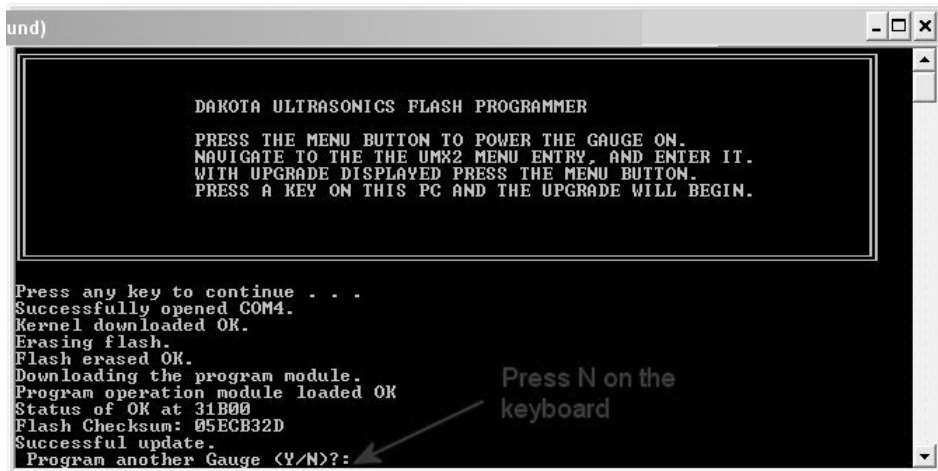
12) When **UPGRAD** is displayed, immediately press and release the button to set put the **UMX-2** into upgrade mode.



13) Open the temporary folder with the unzipped firmware files, and double click the batch file **uflash.bat**.



- 14) Enter the com port number previously assigned to the Prolific USB device, again 1-4, and press ENTER on your keyboard, followed by pressing the spacebar to proceed.



- 15) The flash programming process will begin, and continuously display the active status of the blocks transferred. When the process is complete, press N on your keyboard to end the process.

- 16) The **UMX-2** has successfully been upgraded to the latest version of firmware.

APPENDIX A - VELOCITY TABLE

Material	sound velocity in/us		sound velocity m/s
Aluminum	0.2510		6375
Beryllium	0.5080		12903
Brass	0.1730		4394
Bronze	0.1390		3531
Cadmium	0.1090		2769
Columbium	0.1940		4928
Copper	0.1830		4648
Glass (plate)	0.2270		5766
Glycerine	0.0760		1930
Gold	0.1280		3251
Inconel	0.2290		5817
Iron	0.2320		5893
Cast Iron	0.1800	(approx)	4572
Lead	0.0850		2159
Magnesium	0.2300		5842
Mercury	0.0570		1448
Molybdenum	0.2460		6248
Monel	0.2110		5359
Nickel	0.2220		5639
Nylon	0.1060	(approx)	2692
Platinum	0.1560		3962
Plexiglas	0.1060		2692
Polystyrene	0.0920		2337
PVC	0.0940		2388
Quartz glass	0.2260		5740
Rubber vulcanized	0.0910		2311
Silver	0.1420		3607
Steel (1020)	0.2320		5893
Steel (4340)	0.2330		5918
Steel Stainless"	0.2230		5664
Teflon	0.0540		1372

Tin	0.1310		3327
Titanium	0.2400		6096
Tungsten	0.2040		5182
Uranium	0.1330		3378
Water	0.0580		1473
Zinc	0.1660		4216
Zirconium	0.1830		4648