SubSurface Leak Detection™

DigiCorr
Leak Noise Correlator
Operation Manual

DIGICORR

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DigiCorr Equipment and Accessories

The DigiCorr system requires a desktop or laptop PC (not included in the standard DigiCorr system) running on a Windows 98, 2000, XP, and Windows 7 (32- and 64-bit Operating System), Windows 8, or Windows 10. A minimum of at least 64 MG RAM and a Pentium processor are required.

Description	Part Number
Standard DigiCorr System (does not include PC)	DGC-017
Standard laptop computer	DGC-001
Rugged laptop computer	CMP-002
DigiCorr Field Sensor Unit (FSU), blue	DGC-007
DigiCorr Field Sensor Unit (FSU), red	DGC-008
DigiCorr Data Transceiver	DGC-015
DigiCorr Accelerometer (magnet not included)	DGC-016
Accelerometer Magnet	MAG-004
Power Supply, 12V AC	PWR-002
AC adaptor, Panasonic Toughbook	PWR-003
Power cord, USB	PWR-006
Power cord, 12V DC, auto	PWR-007
Serial Data Cable	CBL-025
USB - Serial Adapter	CBL-055
Rugged Equipment Case	BAC-008
Antenna, magnetic roof-mount A	NT-001
Antenna, permanent mount	ANT-008
Antenna, RF SMA	ANT-004
Accelerometer Bag	BAC-003
Field Service Unit Bag (FSU), blue	BAC-005
Field Service Unit Bag (FSU), red	BAC-004
DigiCorr Headphones, Koss QZ/99	HDP-002
Distance Measuring Wheel	ACS-004
DigiCorr Leak Noise Correlator Software	SFL-1127-000
DigiCorr Replacement Battery	REP-002
DigiCorr Software Upgrade	DGC-020
DigiCorr Software Kit (ships with all new systems)	SWK-0091-XXX

DigiCorr Technical Specifications

Field Sensor Unit (FSU)	
Pipeline Sensor	Accelerometers Sensitivity: 12V/g Noise: <0.016 g/√Hz Bandwidth: 1 - 4,000 Hz Hydrophones are available for in-flow measurements
FSU Radio Transceiver	ISM/LAN 2.4 GHz spread spectrum, license-free worldwide FCC/ETSI approved Range (line-of-sight): up to 10,000 feet (3 km) Two-way communications with base station radio transceiver
Power Supply	Intelligent power management Up to 32 hours battery life, rechargeable & replaceable Recharger for FSU from AC outlet or standard auto DC (The Base Station transceiver does not have a battery. Power is supplied by the USB connection to the computer or by the standard - supplied - FSU re-charger cord assembly)
Data Acquisition	Intelligent automatic gain 10 - 80,000 16-bit data acquisition, 92 dB dynamic range, Sampling rate = 5 kHz
Physical Characteristics	Dimensions: 4.25” x 4” x 8” (10.8 cm x 10.2 cm x 20.3 cm) Weight: 6.5 lbs (3 kg) Rugged, metal weatherproof enclosure

Base Station Radio Transceiver	
Power Supply	Power over PC USB port with power cord Standard AC outlet or auto DC
Physical Characteristics	Dimensions: 5” x 3.25” x 1” Weight: 1 lb. 0.5 kg) Rugged metal, weatherproof enclosure

DigiCorr Software

Windows® 98, 2000, XP, Windows 7 (32- or 64-bit Operating System), Windows 8, or Windows 10.

- Automatic Leak Frequency Analysis (ALFA™)
- Easy-to-use Microsoft Windows
- High resolution display of correlation function, onscreen, land-marked location of detected leaks
- Correlation range: + 880 milliseconds
- Pipe materials: 15 types including multiple sections of different pipe types
- Automatic sound velocity measurement
- 16-bit stereo/mono sound playback
- Visual inspection of sound recording
- Spectral (FFT) analysis capability
- Digital Filters with full manual frequency band selection available:
- High-pass: 10 - 2,000 Hz
- Low-pass: 10 - 2,500 Hz in 1 Hz steps
- Automatic assessment of leak probability
- Manual selection of possible leaks from correlation function
- Elimination of spurious noise events
- Re-analysis of same data possible
- Data storage (any number of studies)
- Database & mapping module

NOTE DigiCorr software runs on any PC using the Windows Operating System with (at least) 32 MB RAM and an 800 x 600 display resolution. SubSurface Leak Detection recommends a Pentium 300 MHz processor and (at least) 64 MB RAM for machines running the Windows XP, Windows 7 (32- or 64-bit Operating System), Windows 8, or Windows 10.

Tips for Deploying DigiCorr Hardware

1. **Choose your deployment points.**

   Consider these basic questions when choosing deployment sites:

   - Where is the probable leak?
   - Leaks most often occur at stress points.
     Old repairs are a good starting place.
   - Where does the sound travel? Sound travels in water, not the pipe material, and is attenuated in lateral connections.
     Sound is proportional to pressure.

   Select points that span the suspected leak site but keep the sensors as close together as possible.

   - Locate the first sensor as close to the suspected leak site as possible.
   - Locate the second sensor where the suspected leak sound will most likely travel:
     – On the same pipe.
     – On a lateral line with a diameter close to the suspected leak pipe size.
     – Point physically nearest to the suspected leak (for example, a meter).

   Listening (sounds) helps in the selection of sensor point deployment but:

   - Sound is attenuated inversely to an increase in pressure.
   - Sound levels attenuate at:
     0.05 dB/m - cast iron.
     0.25 dB/m - PVC.
   - It is difficult to hear leaks in plastic pipes at distances >100 ft.

   Selecting sensor sites on mains and service lines:

   - Accelerometers attach to in-line main valves away from a lateral pipe connection (avoid 4-way) or pressurized (for example, water-filled) hydrants (connected to base or on hydrant valve).
   - Accelerometers can be connected to meters. Fittings are typically not magnetic so the sensor must rest on a pipe (not recommended for non-ferrous pipe. Subsurface Leak Detection recommends using a magnet-enhanced connection via vise-grips, C-clamps, or welding clamps). Use accelerometers only on short distances (<200 feet.) Avoid standpipes or any fittings that may vibrate with water flow.

Tips for Deploying DigiCorr Hardware

2. **Attach sensors.**

   Accelerometers

   - SubSurface Leak Detection recommends connecting accelerometers to metal fittings (unpainted, rustfree, clean metal).
   - Verify a rigid physical contact.
   - Verify connection in the DigiCorr III software using View Data (F6) with no filters.
   - Use a B6 magnet if you have trouble getting a firm connection. (A B6 magnet provides 70 lbs. pull-force versus 45 lbs. pull-force with a B5 magnet).

3. **Set up the FSUs.**

   - Attach the antenna.
   - Turn the power switch ON. In the ON position, the power light goes through the power-up flash sequence: red - yellow - green/green. If the FSU is not linked to the transceiver, the LED turns red after the power-up flash sequence. The FSU LED turns green when the FSU links to the base transceiver.

4. **Setup the Data Transceiver and Base Station Computer.**
   *See **"Installing the DigiCorr Base Station"** on page 10.*

Configuring the DigiCorr III USB to Serial Adapter

Today's new laptops are not equipped with a physical RS-232 Com port. The DigiCorr III includes a USB to serial converter cable to enable connections to laptop computers without RS-232 serial ports. The DigiCorr converter cable provides a standard USB connector on one end and a 9-pin Male D type connector on the other. A mini CD that contains the USB to Serial Adapter drivers ships with the DigiCorr system. If your operating system is Windows 64-bit, you may need to visit the USB to serial cable manufacturer's website to download the latest 64-bit system drivers.

To install the USB to serial cable drivers

- Place the mini DigiCorr software CD in the laptop's CD/DVD drive. The setup program will automatically run. (If the software CD does not automatically run, navigate to the CD and double-click setup.exe.)
- Use the defaults for any software prompts that display.

After you install the USB to serial cable drivers, install the DigiCorr software. By default, the DigiCorr III uses the Com1 port as the communication path between the PC/laptop and the DigiCorr Transceiver.

To determine which Com port is used by the USB to serial adapter cable, plug the cable into a USB port on the laptop/PC. The installed drivers will assign a Com port to the cable. You may need to set the correct Com port in the DigiCorr III software.

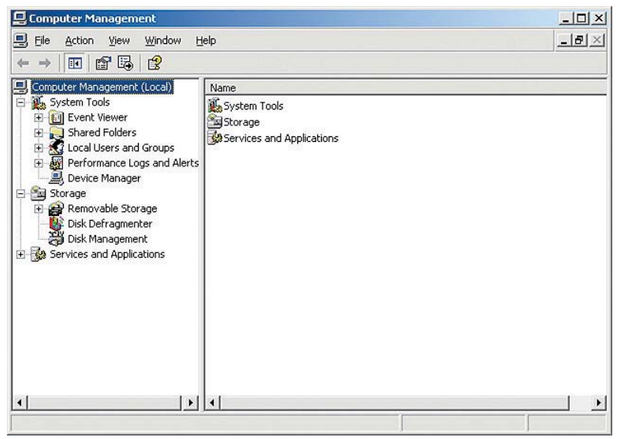
ZCorr Digital Correlating Logger (DCL) Panel

To determine the USB to serial cable Com port assignment

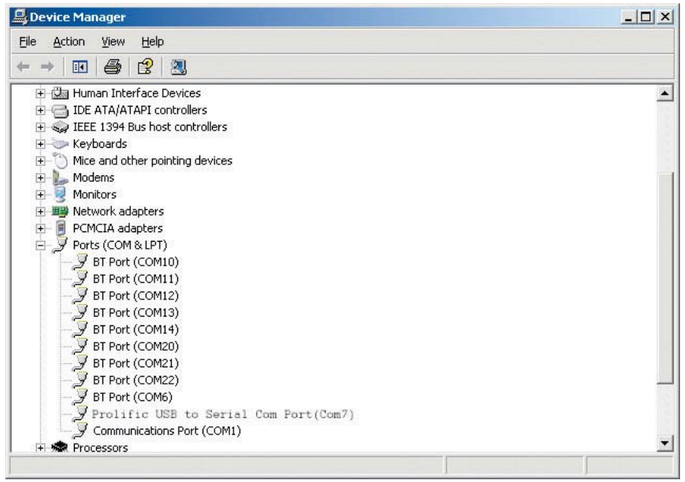
1. Plug the USB to serial cable into the PC/laptop USB port. Verify the serial cable is connected to the DigiCorr.
2. Right-click your My Computer desktop icon.

3. Select ***Manage.***

4. The Computer Management window opens. Select ***Device Manager.***



5. Select Ports ***(COM & LPT).***



6. Note the Com port assigned above to the Prolific USB to Serial Adapter is Com7.

To edit the DigiCorr software Com port setting

NOTE Editing the SiteInfo.txt file in Windows may require opening Notepad as an Administrator due to the operating system's security settings.

1. Navigate to `C:\Program Files\Flow Metrix\DigiCorr`. Double-click the file named `SiteInfo.txt`.

2. The file opens displaying:

Language=English

Units=US

ComPort=COM1

SoundVelocity=TABLE

SerialType=APRO

3. Edit the ComPort line to match the Com port assigned to the USB to Serial Com Port (see the example in ***"To determine the USB to serial cable Com port assignment"*** on page 7).

ComPort=COM7

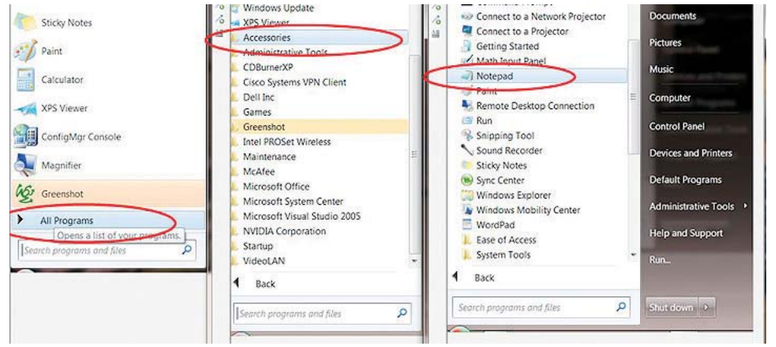
4. Save the file.

5. Launch the DigiCorr software and verify communications to the FSU.

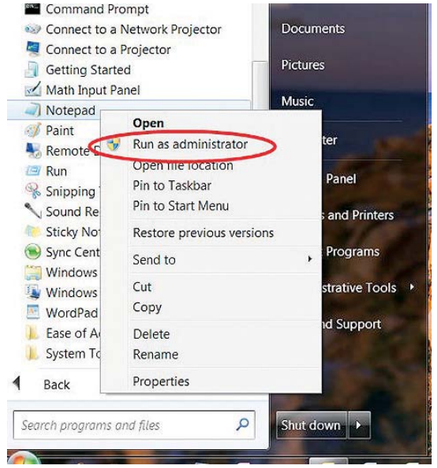
NOTE Communications may return an error message the first time you connect. Re-try the communications, and it should connect on this second attempt.

Open Notepad as administrator

1. Navigate to your computer's **Notepad** application.



2. Right-click on **Notepad.** Select ***Run as > Administrator.***



3. After Notepad opens, follow the steps in ***"To edit the DigiCorr software Com port setting"*** on page 8 to open and edit the DigiCorr `SiteInfo.txt` Com port setting.

Installing the DigiCorr Base Station

TIP If you are working with the field-computer for extended periods of time, the computer's power management program may interfere with DigiCorr. If you are working in the field, use your vehicle's AC power converter. If you are working in an office, connect to a DC outlet with your power cord.

To install the DigiCorr Base Station (Data Transceiver)

1. Turn on your computer.
2. Attach the serial cable to the computer COM port (COM1) and to the DigiCorr Data Transceiver. Verify the connections are secure.

Serial to USB Adaptor Cable

Serial Cable for Computers with a Serial Port

3. Connect the USB power cord to the power socket on the Data Transceiver and a USB port on the computer.

Attach to a USB port on a computer

NOTE The USB power cord supplies power to the Data Transceiver. The LED on the Data Transceiver should turn solid green after completing the connection.

4. Attach an antenna to the antenna socket on the Data Transceiver.
   - If you are operating the DigiCorr from a vehicle, connect the magnetic RF roofmount antenna.

   - If you are operating the DigiCorr from an office or away from a vehicle, connect the RF SMA antenna.

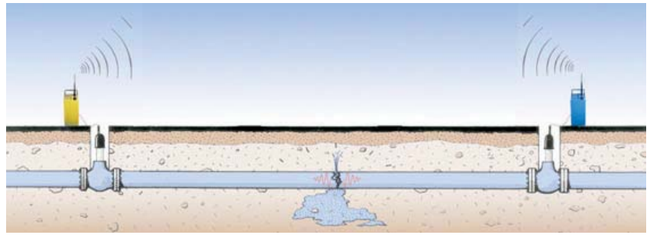
5. Attach an Accelerometer to each Field Sensor Unit (FSU.)

Note special pin configuration

Red FSU with Accelerometer and Antenna

WARNING Inspect Accelerometer cables for damage prior to each use. Any cut or tear in the cable's outer jacket may indicate internal damage and could adversely affect recording data.

6. Place each Accelerometer on a pipe access point (for example, a hydrant or valve).



7. Turn on the Field Sensor Unit (FSU). The FSU is digital and fully automated.

a. Connect the sensor cable to the black, chrome connector on the FSU.

b. Connect the antenna to the TNC antenna socket on the FSU.

c. Press the power switch on the FSU. The FSU power LED follows a power up flash sequence: red - yellow - green - green. If the FSU is not communicating to the Digital Transceiver, the LED turns red. The LED turns green when the FSU is communicating to the Base Transceiver. The blue LED flashes once to indicate the unit is prepared to transmit data. The blue LED flashes continuously when the unit is actively transmitting data.

Installing the DigiCorr Software

DigiCorr is designed to run on any computer with the following minimum configuration requirements.

DigiCorr Software Minimum PC Hardware Requirements	
Processor	266 MHz Pentium
Memory 3	2 MB RAM
Hard disk space	120 MB
Sound card	16-bit Sound Blaster™ (or compatible card)
Display	640 x 480 standard VGA, active matrix (Subsurface Leak Detection recommends a daylight readable display set for 800 x 600 for best screen reading)
Serial port	Standard port capable of 115 kB/seconds with UART 16550 assigned to COM255
Operating system	Windows XP, Windows 7 (32- or 64-bit operating system) Windows 8, or Windows 10

For those who purchased a complete system, no customization is necessary. If you are using a separately purchased computer, install the DigiCorr software.

To install the DigiCorr Base Station (Data Transceiver)

1. Start your computer.
2. Insert the DigiCorr CD.
3. Navigate to the CD-ROM drive and click the DigiCorr setup.exe executable file.
4. Follow the on-screen instructions.

After setup is complete, the DigiCorr system is ready to use. Chapters 5 and 6 of this guide provide examples and tips from a DigiCorr system user.

If you purchased your DigiCorr III system through a worldwide distributor, you may:

- Use the DigiCorr User Interface optional supported language interface.
- Use the sound velocity values adjusted for your country.

Contact your vendor for more information.

Setting up Your Computer's Display for DigiCorr Use

1. Select a compatible graphics display for the DigiCorr software interface. DigiCorr works best at a screen resolution of 800 x 600 pixels. DigiCorr also supports resolutions of 640 x 480 and 1024 x 768. If the standard VGA resolution is used, large font at ***Windows > Control Panel > Display.***
2. Set the color depth (number of colors) to 16- or 256-bit if you will be recording data from the pipeline sensors.

CAUTION If the message Radio Transmission Interrupted - Please Restart appears repeatedly when recording pipeline sensor data, there may be a problem with the Windows interrupt latency. Resolve the problem by setting the display number of colors to 16- or 256-bit. You may have to disable Windows power management.

The message Radio Transmission Interrupted - Please Restart may appear if:

The radio link between the FSU and the base is periodically lost due to extreme range, adverse weather conditions, or a large number of obstructions exits (for example, heavy foliage, buildings.)

FSU or base unit batteries are low (low battery condition is indicated by a yellow power light LED.)

Setting up the Serial Port

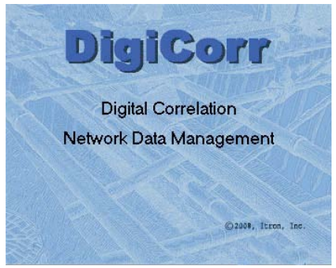
NOTE New computers may require a USB to serial converter (See ***"Configuring the DigiCorr III USB to Serial Adapter"*** on page 6.)

DigiCorr software requires a serial connection for data recording. Set up the serial port for real-time data acquisition at: ***Start > Control Panel > System > Hardware > Device Manager > Ports*** (COM & LPT).

COM1 Settings for DigiCorr Serial Port Setup

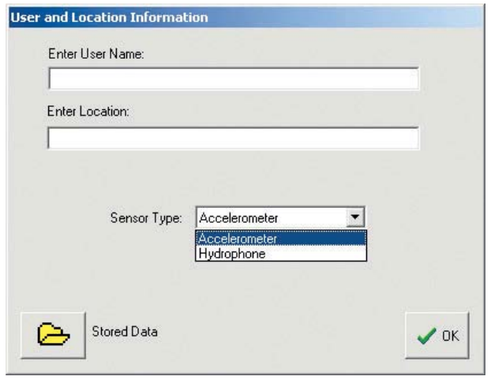
Processor	266 MHz Pentium
Baud Rate	115200
Number of Data Bits	8
Parity	None
Number of Stop Bits	1
Flow Control	Hardware

Navigating the DigiCorr Software User Interface



To navigate the DigiCorr software user interface

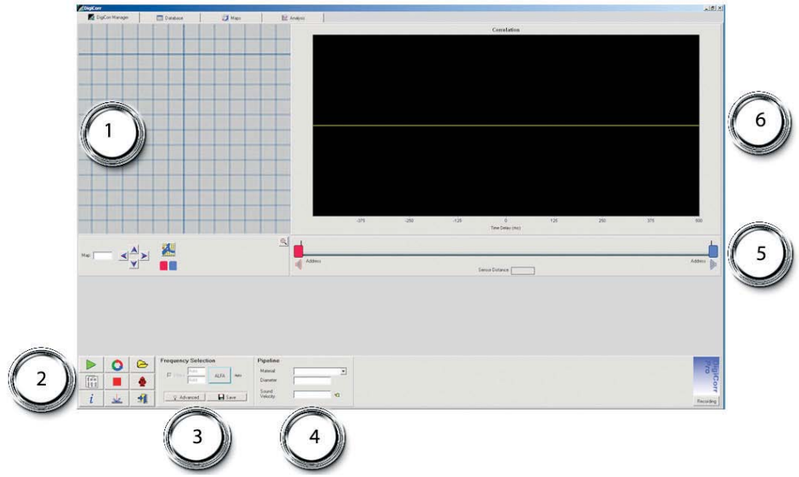
1. Start the DigiCorr software from the desktop icon or task bar. The DigiCorr software start-up window displays for approximately 10 seconds. During this time, the DigiCorr software attempts to link to the Field Sensor Units (FSU). If the radio link is successful, the FSUs are placed in low-power consumption mode. If the radio link is unsuccessful, the attempt is automatically repeated every five minutes.
2. New users must enter user information in the User and Location Information dialog box. User and location information is saved with any stored data. Sensor Type is a required field and is stored with any stored data. Returning users can click ***Stored Data*** to bypass the login dialog and open a previously stored data file.



3. After the requested information is entered, click OK. The DigiCorr Manager Tab window appears.

DigiCorr Manager Tab Window

The DigiCorr Manager Tab window appears with a grid or map in the upper left corner. If your system's distribution maps have been integrated into the DigiCorr Software, your system map appears.

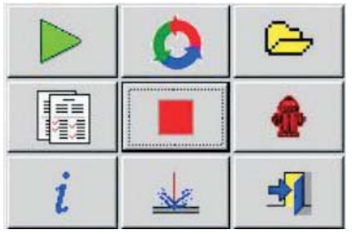


DigiCorr Manager Window

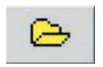
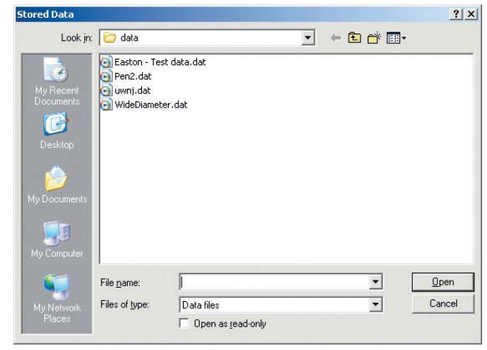
Window link	Description
1. Map/Grid	Place sensors on grid or map (if integrated) to show approximate placement of sensors in the field.
2. Button Pad	Controls DigiCorr software
3. Frequency Selection	Shows the status of Automatic Leak Frequency Analysis (ALFA), manual digital filter settings, and FSU electronic gain of the Field Service Units (FSU). Default is ALFA enabled. The Advanced button allows users to change default values. The Save button allows users to save the current settings.
4. Pipeline Panel	Critical pipeline information required to calculate the velocity of sound propagation in the pipe.
5. Pipeline Graphic	Schematic representation of the FSUs and any leak positions.
6. Correlation Window	Displays cross-correlation function in real-time as data is processed.

The Button Pad

The Button Pad on the DigiCorr Manager window provides a field for quickly accessing leak analysis tools.



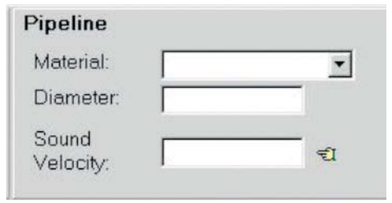
DigiCorr Button Pad Icon Descriptions

	Start	Click Start. The correlation process begins immediately with the pipeline reading data transmitted from the Field Sensor Units (FSU)
	Re-analyze	Click to correlate data just analyzed. Re-analyze is useful when repeating data analysis after changing filter settings.
	Open Stored Data	Click to open the Stored Data dialog window. The data file resides at `c:\digicorr\data`.  Correlation analysis begins when the file opens. (Click Cancel to stop the process.)
	Print Report	Click Print Report to send a report of the current correlation analysis to your printer.
	Stop Recording	Click Stop Recording to stop the current DigiCorr correlation calculation. Pressing Stop at any other time has no effect.
	Velocity Calibration	Click Velocity Calibration to enable automatic measurement of the pipe's sound velocity.

DigiCorr Button Pad Icon Descriptions		
	Information	Click Information to display the information dialog box.
	Leak Analysis	Click Leak Analysis. DigiCorr software searches for peaks in the current correlation waveform. Click this button to return the cursor to the originally pinpointed location, if the user double-clicked on a peak to super-impose another cursor location (indicated by a broken, not solid, red cursor).
	Exit	Click Exit. The software displays a dialog box to confirm your wish to close the DigiCorr software.

Entering Pipeline Information

Before a leak can be detected, enter the pipeline material and pipe diameter information to determine the velocity of sound propagation in the pipeline:



Material

Select the pipeline material from the options in the drop-down list.
The material list includes:

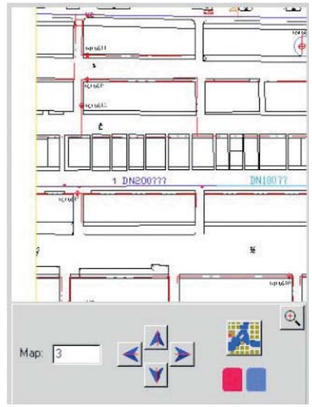
- **Ductile iron**
- **Cast itron**
- **Cast iron (cement-lined)**
- **Cast iron (>60 years)**
- **Steel**
- **PVC**
- **LDPE (low-density poly)**
- **MDPE (mid-density poly)**
- **HDPE (high-density poly)**
- **Multiple sections**
- **Reinforced concrete**
- **Concrete**
- **Asbestos cement**
- **Copper**
- **Steel**
- **Lead**

To enter the pipe diameter

1. Click in the text box to enter the pipe diameter.
2. Press ***Enter*** or click on another section of the window. The DigiCorr Software adds the units (inches or mm for millimeters) and calculates the sound velocity based on the entered information.

To place sensors on the map (or grid) & enter the distance between sensors

1. Click on the map icon in the Map Panel to bring a map or the grid into the Map Window. (You may enter the map name, if known.)
2. Navigate through the maps to find the valve or hydrant location of the sensors. (The ***Zoom*** icon expands the map for easier navigation.)



3. Click the Red FSU box.
4. Click the FSU's location on the map. The red FSU location is set.
5. Repeat for the blue FSU.

FSU locations are saved with the file. The DigiCorr software calculates the distance between the FSUs. You may enter the distance by clicking in the Sensor Distance text box and entering the distance.

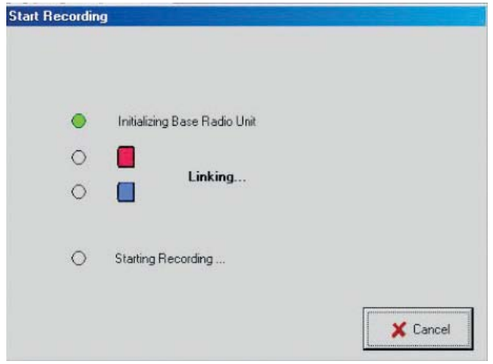
To enter red and blue FSU addresses

1. Click Address next to the red FSU box on the pipeline graphic.
2. Enter the address of the red FSU (for example, V152 for valve number 152.)
3. Press ***Enter***.

The software prompts you for the address of the blue FSU. Sensor addresses are saved with the correlation recording.

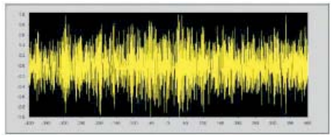
Starting a Correlation Analysis

Click ***Start*** to begin real-time analysis from the pipeline. The DigiCorr software initiates a link with the FSUs and the Start Recording dialog box opens:

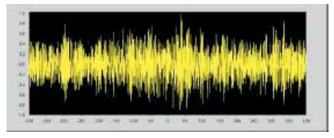


Acquiring Real-time Correlation Analysis

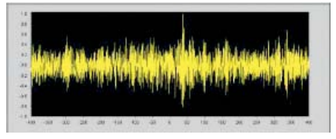
After DigiCorr's Digital Data Transceiver (DDT) links with the FSU radios, the correlation process begins. An example of a correlation analysis after one, two, four and eight seconds is shown below:



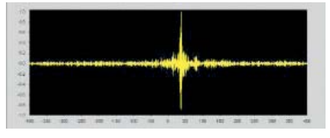
(One Second)



(Two Seconds)



(Four Seconds)

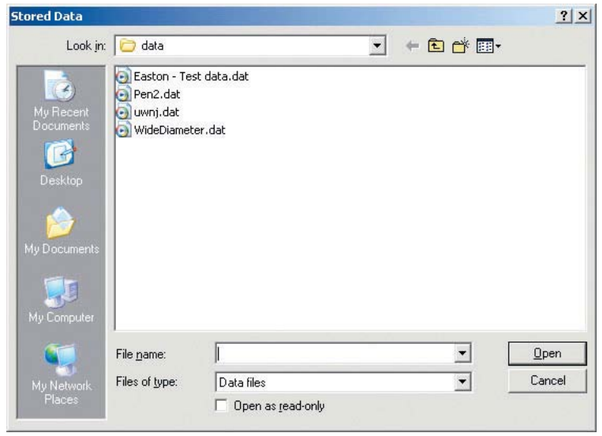


(Eight Seconds)

The peak developed in the correlation function indicates a leak. The correlation process typically takes between one and thirty seconds (maximum: 130 seconds) for a distinct peak to develop, if a leak exists. The example panels illustrate noise attenuation and the correlation peak growth as additional leaK data are processed. The consistently developed correlation peak is a good indicator of a leak. After the peak in the correlation function develops, click Stop (recording automatically stops after 130 seconds). The recording is completely analyzed automatically. Click the ***Manager Tab*** to display the Manager window and analysis information.

Recalling Previously Stored Data from Saved Files

Files automatically saved by using the Recording applet are saved to Survey Data, not Stored Data. Browse with ***Look In*** to access Survey Data.



Select the data file by clicking on the file name and clicking open. The correlation analysis automatically begins.

Troubleshooting Radio Communications Errors

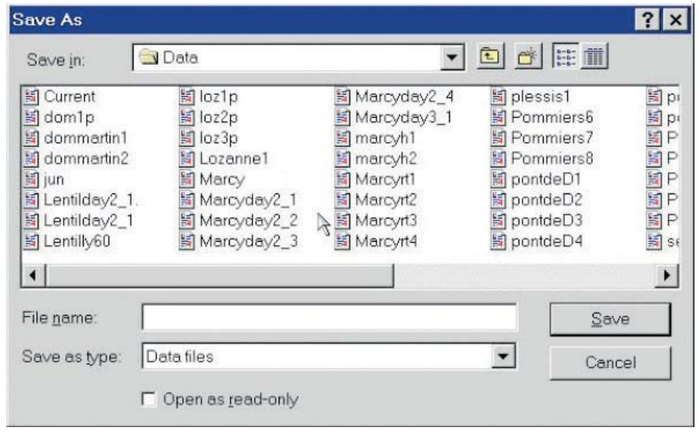
If a FSU radio communications error occurs, a Radio Communication Troubleshooting window appears with the problem noted in red at the top of the window. One of two errors may occur:

DigiCorr FSU Radio Communications Errors

Error	Possible Solutions
Base Radio unit not found	• Verify Base Radio (Data Transceiver) is connected to the serial port of the base station PC • Verify the Base Radio (Data Transceiver) has power (green LED is lit).
FSU 1 or 2 is not linked to the base station radio	• Range: If the Base Radio (Data Transceiver) is more than 1500 feet from either FSU, there is no line-of-sight communications, or the weather conditions limit communications, move the base radio to a position between the FSU units where the antenna is unobstructed. • FSU: The FSU may not be functioning or may be incorrectly set up Verify the FSU switch is ON, the battery has a sufficient charge (power light is green, not yellow), and the FSU antenna is connected. • Base Radio: Position the Base Radio (Data Transceiver) midway between the remote radios.

Saving Correlation Data File

DigiCorr software gives the user the opportunity to save any recorded data along with the correlation analysis parameters and any user-added information (including pipeline characteristics.) If a user attempts to exit the program or acquire new data, a prompt alerts the user to save the present data.



Users may enter a new file name or over-write an existing file. An ***Open as read-only*** check box allows users to protect files from corruption.

Pipeline, Processing, and Data Information

Click ***Information***. The Pipeline, Processing, and Data Information dialog window opens. Information includes five groups:

User Information

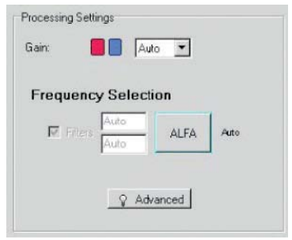
User Information is located in the upper left portion of the Pipeline, Processing, and Data Information dialog window. It includes the user's location, date and time. Notes can be added in the text boxes and are stored with any saved file.

Sensor Selection

Sensor Selection allows the user to choose the sensor type from a list. AC01 Accelerometer and Hydrophone are the two supported sensor types for the DigiCorr III.

Processing Settings

Processing Settings allows the user to optimize gain/filter settings. Automatic Gain is selected (default) and is the optimum setting for correlation in most situations. Headphone audio level at the FSU is adjusted by the gain value (initial volume is Gain - 40.) With Auto gain selected, the FSUs scale data for the best resolution. If manual gain settings are needed, click the down-arrow and select a gain between 20 and 80,000.

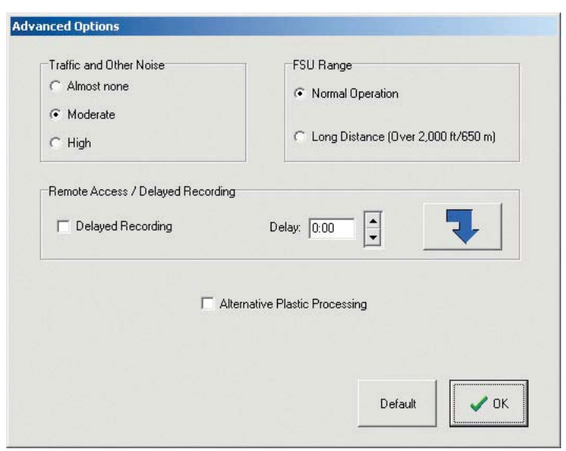


Processing Settings/Frequency Selection

The ALFA setting is active (default.) With ALFA active, the DigiCorr software performs automatic optimal filtering to detect any present correlations. Digital filter settings may be changed manually by clicking the ALFA button OFF. Enter the desired filter values in the text boxes; values range from 1 to 2,450 Hz in 1 Hz steps. A Spectrum Analyzer can provide guidance in setting filter values (see ***"Optimizing DigiCorr System Performance"*** on page 36). Clicking the check box to the left of the Filters label disables filters.

Advanced Options

Advanced Options in the Processing Settings window are accessed by clicking ***Advanced***.



Advanced Processing Settings allow the user to change Traffic and Other Noise levels, FSU Range, and Remote Access / Delayed Recording time. User can also select Alternative Plastic Processing parameters.

Traffic and Other Noise

- **Almost None** – select this setting for areas with little or no traffic or other noise levels
- **Moderate** – select this setting for areas with normal traffic and other noise levels (default)
- **High** – select this settings in areas with high traffic and other noise levels

FSU Range

- N**ormal Operation** – select this setting for normal FSU range (500 meters, default)
- **Long Distance** – select this setting for long distance FSU range (over 2000 ft/650 meters)

CAUTION Changing this setting can reduce recorded FSU data.

To set Remote Access/Delayed Recording

1. Click the checkbox to select delayed FSU data recording. Recording may be delayed up to 30 hours.
2. After selecting a time delay, click OK to return to the Manager Panel. The Start button (green, triangular arrow) will have a clock face.
3. While both FSU's are near the Base Radio, click on the green arrow to initiate the delay timer's countdown (which is now displayed). The FSUs must be de ployed before the countdown reaches zero. At zero, the FSU begins recording. A clock will display the ensuing countdown. The display will state when recording is complete. A blue downward arrow will appear. FSU units must be near the Base Radio before clicking the blue arrow to upload the recording.

CAUTION For recording programming and uploading, the recording radio must link with the Base Radio. Remember to un-check the Delayed Recording check box in the Advanced Options panel to resume standard operation.

Alternative Plastic Processing

Clicking the Alternative Plastic Processing check box, turns ALFA off and sets the Frequency Selection/Filters to 20 Hz/250 Hz.

If Advanced Options settings are changed, the Advanced dialog button light bulb on the Processing Settings window illuminates. Advanced Processing Settings can be reset to Factory Settings by clicking the Default button. Click ***OK*** to close the Advanced Processing Settings window.

Product and Serial Number

The DigiCorr Software Serial Number is unique to your system. Product and Serial Number settings are not user programmable.

NOTE Each FSU has a unique serial number different from the Digi-Corr software serial number.

Pipeline Data

The Pipeline Data panel allows the user to enter more detailed information than the Main window. Items in bold are required to perform automatic leak analysis.

Processing Settings/Advanced Pipeline Data Parameters

Setting	Description
Sensor Distance	Distance between FSU units
Material	Pipeline composition
Diameter	Pipeline diameter
Sound Velocity	Automatically computed from Material and Diameter information
Liner	Select from a drop-down list: • None • Single cement-lined • Double cement-lined
Thickness	Pipe wall thickness

NOTE If Sound Velocity is entered in the text box, Pipeline Material, andDiameter are not required.

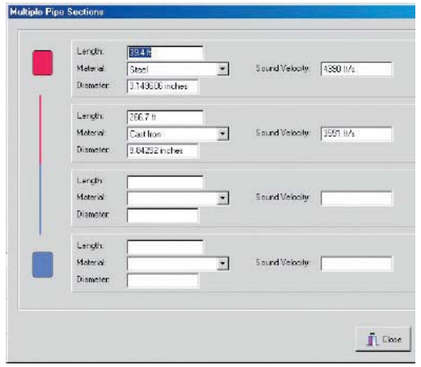
If distances over one mile exist between FSU sensors, the sound velocity calculation is improved by entering the thickness of the pipe wall.

Pressing the Sections button, displays the Multiple Pipe Sections dialog window.

Multiple Pipe Sections

Multiple pipe sections, sections with different materials, or different pipe diameters are specified by:

- Selecting Multiple Sections as the pipe material.
- Selecting more than one pipe section in the Information Dialog window.
- Clicking ***Multiple Pipe Sections***



The Multiple Pipe Sections window allows the user to enter data for each section (up to four pipe sections). Length, Material, and Diameter information are required for each pipe section or the user may enter the Sound Velocity for each section.

NOTE Multiple Pipe Sections information assumes the first pipe section is closest to the red FSU with the last filled-in section closest to the blue FSU.

Press Clear to reset the dialog box. All information is cleared. Click Close to return to the Manager Panel. Entries made in Multiple Pipe Sections are calculated automatically.

Calibrating Pipeline Sound Velocity

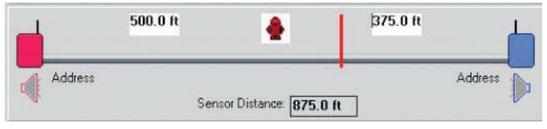
Pipeline Sound Velocity is received in one of three ways:

- Calculated from a formula using pipe material, pipe diameter, and pipe wall thickness (option for extra accuracy, entered on the Information Dialog box. (See ***"Pipeline, Processing, and Data Information"*** on page 23).
- Calibrated from an open hydrant or other noise source (see ***"To calibrate sound velocity"*** on page 28).
- Calculated from data entered directly in the Sound Velocity text box (see ***"DigiCorr Manager Tab Window"*** on page 16 or ***"Pipeline, Processing, and Data Information"*** on page 23 for more information).

To set Remote Access/Delayed Recording

1. Click ***Velocity Calibration*** to automatically measure the pipeline sound velocity.
2. After you click ***Velocity Calibration***, a hydrant appears in the pipeline graphic on the main DigiCorr Manager window. The hydrant represents a noise source. Text boxes appear for the user to enter:
   - Selecting Multiple Sections as the pipe material.
   - Selecting more than one pipe section in the Information Dialog window.

   The example shows a Velocity Calibration pipeline graphic.



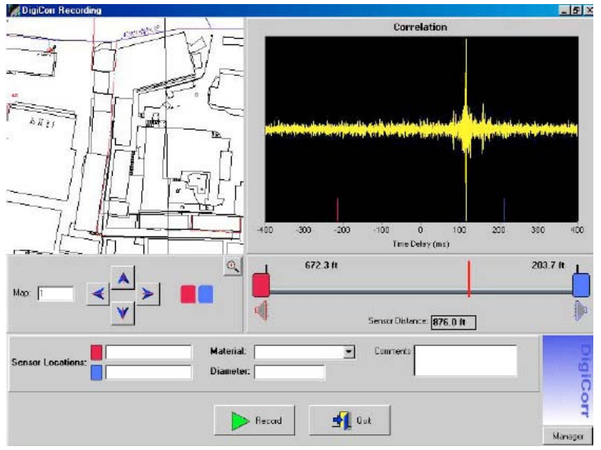
3. If a correlation peak does not display, click ***Start*** to begin the correlation procedure. In Velocity Calibration Mode, the Pipeline Dialog text boxes (Material, Diameter, and Sound Velocity) change to read-only. A hydrant icon appears next to the Sound Velocity text box.
4. Terminate the correlation procedure by clicking ***Stop***.
5. Exit the Velocity Calibration mode by clicking the Velocity Calibration button to ***OFF***.
6. AAfter the pipeline's sound velocity is calculated, it is stored until a new sound velocityis computed by:
   - changing the pipeline material and diameter or
   - entering a new value in the Sound Velocity text box.
7. If a new sound velocity is computed, click ***Velocity Calibration*** to retrieve the calibrated value.

Analyzing Leaks

Press ***Leak Analysis***  to begin a search for peaks in the existing correlation wave form. Strong peaks represent a good measurement of the time difference in the leak sound heard at both FSU sensors. Peak timing is translated as the leak distance from each FSU (based on the distance between FSU sensors) and the sound velocity propagation in the pipeline. If distance or sound velocity information is missing, DigiCorr software prompts the user to enter the missing information.

To record field data

1. Click ***Recording*** to display the Field Recording window.



2. Enter the red and blue FSU sensor locations in the Sensor Locations text boxes and mark their locations on the map.
3. Select the pipe material from the ***Material*** drop down list. Enter the pipe diameter in the Diameter text box.
4. Click ***Record***. 60 seconds of data is recorded and automatically saved. The recorded information is added to the database. The recorded file is also saved to Survey Data (not Stored Data).
5. Click the ***Manager*** button to return to the DigiCorr Manager window.

DigiCorr Database Tab Window

The DigiCorr software includes a database module (HydroData Management) where system leak information is tracked. This DigiCorr software feature provides advanced acoustic data analysis for the entire distribution system in the field or office. Every DigiCorr recording is saved in the database.

DigiCorr Database (HydroData Management) Fields

Heading	Description
1. Action	Enter an action for any record.
2. Activating records	Click once on any row to highlight the record.
3. Search	Initiate search by entering any text (for example, 5/18/08 [date or time], sensor location, Correlation Result [L3], or Pipe Material [ductile iron]).
4. Previous	Click once to return to the full database window after a search.
5. More	Click once to display the next 500 data recordings.
6. Analysis	Click once to re-analyze the recorded data. Double-clicking any row causes the database to re-analyze the row's data.

HydroData Management displays the most recent 500 data recordings in the database. Users can customize the HydroData Management database by adding new fields. The database file is edited using Microsoft Excel, Microsoft Access, or any other ODBC compliant database program. Any added fields are visible in the HydroData Management window.

DigiCorr Maps Window

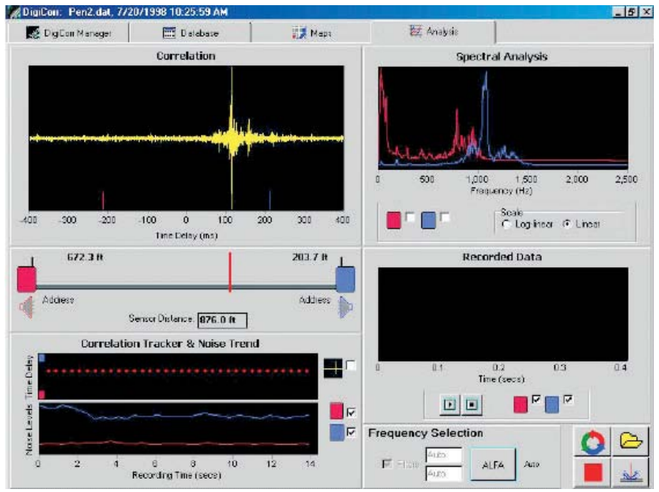
Distribution system maps are easily integrated into the DigiCorr software (See ***"DigiCorr Equipment and Accessories"*** on page 7.) After distribution maps are integrated into the software, field crews can record FSU sensor locations on the maps.

DigiCorr Maps Window Fields

Window feature	Description
1. Thumbnail Panel	The red box in the Thumbnail Panel shows the relative location of the panel map to the overall utility map.
2. Map Control Panel	Map control arrows provide navigation for system maps.
3. Map ID	Maps are selected by clicking in the Thumbnail Panel or entering a map name in the Map ID text box.
4. Zoom Buttons	Increases or reduces map views.
5. Print	Click to print the current map.

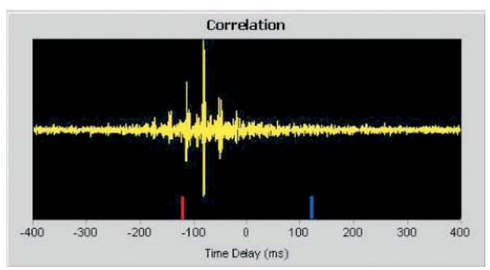
DigiCorr Analysis Tab Window

The DigiCorr Analysis Tab window includes Correlation, Spectral Analysis, Correlation Tracker & Noise Trend, and Recorded Data panels showing analysis information for recorded system data.



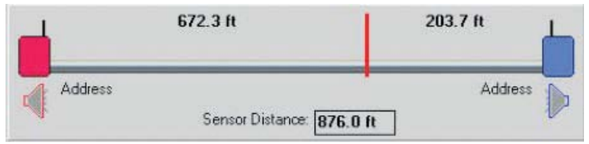
Correlation Graph

The Correlation Graph illustrates the acoustic data correlation from the red and blue FSU sensors. In-span correlation limits are marked by the red and blue markers at the bottom of the graph. The horizontal graph marks represent milliseconds (thousandths of a second) and show the sound's arrival time difference at both FSU sensors. In the example, a peak closer to the red sensor determines the sound arrived at the red FSU sensor first so the leak is closer to the red sensor.



Pipeline Panel

The Pipeline Panel illustrates the current correlation pipeline study. The red bar shows the position of a leak relative to the red and blue FSU sensors.

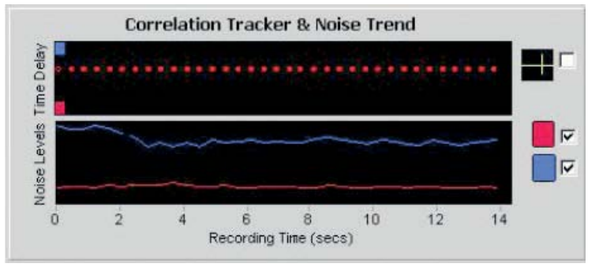


Click ***Address*** to enter the address of the corresponding FSU sensor. Enter the distance between the red and blue FSU sensors. (The DigiCorr software estimates a distance based on placement of the sensors on the digitized map if no data is entered in the Sensor Distance text box.)

Click the ***Smart Listen*** symbol (speaker icon) next to a sensor to listen to the quietest 8 second portion of the total recording.

Correlation Tracker & Noise Trend

The Correlation Tracker shows the location of the strongest correlation peak at 1/2 second intervals during a recording. The graph represents noise levels along the recording time.



- A silver dot on the Correlation Tracker represents an unrecognized peak.
- A red dot on the Correlation Tracker represents a peak with a modest probability of a leak.
- A red open circle on the Correlation Tracker represents a peak with a moderate probability of a leak.
- A red solid circle on the Correlation Tracker represents a peak with a high probability of a leak.

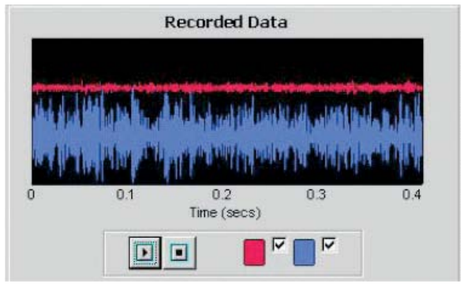
The Correlation Tracker distinguishes leakage from usage. Correlation peaks appearing when noise levels are low are most likely leakage (leakage noise is always present and never fades away). Correlation peaks appearing with increases in noise levels are most likely usage (usage typically increases noise at one FSU sensor).

Correlation Update Button

If unchecked, the Correlation Tracker & Noise Trend updates rapidly. The Correlation Graph appears at the end of the analysis. If checked, the Correlation Tracker & Noise Trend updates once per second (much slower than if Correlation Update Button is unchecked). The Correlation Graph updates simultaneously.

Recorded (Audio) Data

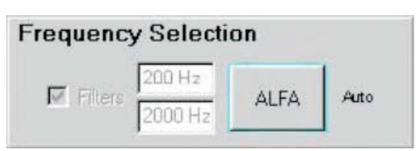
Sound from one or both FSU sensors (mono or stereo sound) may be played as recorded data is viewed.



Data is processed with the current filter settings. The DigiCorr's default and Automatic Leak Frequency Analysis (ALFA) settings are 200 to 2,000 Hz. Select 100 to 400 Hz filters to simulate a ground microphone or geophone. Select 400 to 1,200 Hz filters to simulate a contact probe. In some cases, leak noise from service lines or hydrant leaks is only audible in the higher default frequency ranges.

The Frequency Selection Panel

The Frequency Selection Panel permits automatic and manual filter settings.



When the Automatic Leak Frequency Analysis (***ALFA***) Button is ON, all digital filtering is automatic. For all metal pipelines, concrete pipes, and asbestos cement pipes the ALFA digital filtering setting is recommended. Make manual filter settings by typing directly into the text box. The high-pass filter is adjustable between 1 and 2,000 Hz, in 1 Hz steps. The low-pass filter is adjustable between 10 and 2,450 Hz in steps of 1 Hz. Filters can be disabled by clearing the check box to the left of the Filters label after clicking ***ALFA*** OFF.

The Recorded Audio Button Pad

See ***"The Button Pad"*** on page 23 for Recorded (Audio) Data Button descriptions and usage.

Optimizing DigiCorr System Performance

These tips for optimizing DigiCorr system performance are from customers with experience deploying and using DigiCorr in the field.

Accelerometer Placement

Accelerometers must be in direct contact with the pipe or metal fitting and have firm positioning. Magnet flat bases may make it difficult to attach them to deep, underground valve nuts. Small valve nuts do not always provide a smooth contact surface. A PVC tube can be used to slide the accelerometer and magnet down to the valve nut. This provides support for the accelerometer and prevents it from being dislodged after initial placement.

If the valve nut is covered with difficult-to-remove dirt, sand, or rust, a good contact can be made using a pointed metal rod to cut through the dirt and supply direct contact to the valve nut. If a metal rod is used, the connection from the rod to the accelerometer must be rigid. An iron or steel adapter plate between the rod and the accelerometer magnet will facilitate a rigid connection. The rod may be directly screwed into the accelerometer's threads after removing the magnet.

When using a rod, avoid touching the sides of the valve box (may introduce a vibration artifact). Use a styrofoam block, cloth towel, large rag, etc. to isolate the rod from the valve box wall in order to minimize vibration artifacts.Hydrants can cause resonance which amplifies leak sounds.

Hydrant resonance can increase correlation distances making hydrants a good choice for sensor deployment. Do not attach accelerometers to the top-operating nut on a hydrant. Top hydrant nuts operate a shaft typically isolated from the structure by a rubber, neoprene, or leather gasket. Attach accelerometers to the base of the iron hydrant for the best contact and the least wind noise. For accuracy remember, hydrant measurements are not line-to-line and distance values must include additional piping from the main line to the hydrant.

Inter-Sensor Distance

Accurate inter-sensor distances are necessary to achieve accurate leak pinpointing. Span measurements can be made using:

- A measuring tape.
- A distance measuring wheel (periodically check your wheel's calibration against a tape to verify measurements are correct).
- An engineering scaling ruler with an accurately scaled map.

NOTE Correlation accuracy is directly impacted by the accuracy of the distance measurement.

A recording can be completed and saved without entering the inter-sensor distance and may be useful when completing an initial, preliminary recording at a site. If a correlation peak is observed, accurate measurement can be made and entered after a recording is completed.

When making distance measurements remember:

- Water mains do not always run in straight lines.
- Water main lines are not at uniform depths - particularly true at river crossings.

Records of actual pipe profiles are occasionally available to calculate true distances between sensors.

If a stream or river crossing with no pipe profile is found, Topo USA (a software program) may help with topographical maps from the U.S. Geological Survey giving you the capability to trace and measure routes.

Sound Velocity

Accurate sound velocity is critical in obtaining an accurate leak location from correlation results. In most cases, the sound velocity automatically gathered with user-entered pipe diameter and material gathers good results. If pipe diameter or material is unknown or you suspect a large degree of tuburculation or build-up in the pipe (changing the pipe diameter), then manually measure the sound velocity. Manual measurement is done by simulating a leak with an open hydrant using the Velocity Calibration feature in the DigiCorr software. DigiCorr software automatic Sound Velocity Calibration assumes the fluid in the pipe is water. If pipe fluid is not water, use the Velocity Calibration feature to measure the true sound velocity.

Filter Settings

Default filter settings typically yield good results. Occasionally, filtering require alterations to achieve results. When reviewing or re-analyzing data, use the Frequency Analysis option to determine the optimal frequency band. A fullsized monitor may be connected to the DigiCorr's rugged computer when re-analyzing or reviewing data.

Adverse Weather Conditions

Radio communications can be sporadic in wet or foggy conditions. 2.4 GHz spreadspectrum radio transmissions are adversely affected by moisture in the atmosphere. DigiCorr hardware is designed to withstand moisture and can be used during wet and snowy conditions. Accelerometers are fully submersible in water to a depth of 20 feet. The FSUs and rugged base station Data Transceiver can be exposed to snow and temperatures as low as -5º Fahrenheit (- 20.8º Celsius).

Always store the electronics warm and dry. If the equipment is left in a vehicle in far below freezing conditions for an extended time, let the system warm up before operating.

DigiCorr Field Examples

The field examples in this section are presented to guide users through the process of locating hard-to-find leaks with DigiCorr.

Exploring DigiCorr Advanced Features to Pinpoint Hard-to-Find Leaks

In typical applications (systems with metal pipes), DigiCorr default settings (ALFA) often reveal a leak after a few seconds of data acquisition. DigiCorr advanced features are helpful for the following situations:

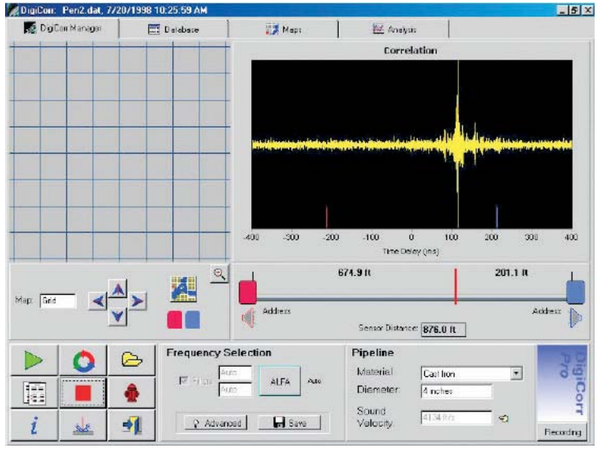
- Pipes being measured are plastic (PVC or polyethylene).
  - Plastic pipes attenuate leak noise along the pipe length.
  - Plastic pipes allow vibration, resonance, or standing waves within the pipe.
  - Properties of plastic pipes (for example, section joints) cause peaks to appear in the correlations.
- Limited access points.
- Greater distance between access points.
- Direct access to the suspected leak source pipeline is not available (for example, service line meters must be used or several pipeline sections are used to access the sensor).
- Flow disturbances exist (for example, pipelines with high flow rates can produce small correlations at bell and spigot pipe joints).
- Water leak noise is not transmitted through the complete distance between the sensors (for example, a complete break in the pipe or land settling creates a u-shaped pipe with air in the depression).
- Large diameter pipes may create significant sound reflections from air in the pipe.
- Probability of multiple leaks.

Identifying Multiple Leaks in One Correlation

DigiCorr software installs with the files to complete the following test correlations.

To complete a test correlation

1. Press the ***Start*** button.
2. Select ***Stored Data [F3]***.
3. Open the file `Pen2.dat`.
4. DigiCorr filters are in the default position for metal pipes (ALFA). The stored leak noise data reads and is correlated (as shown).



Three peaks are visible in the above correlation.

- The automatically detected main peak pinpoints a significant leak. A distinct peak that develops consistently for several seconds (as shown) on any pipe material has a high probability of being a leak. Leaks create a point source of turbulent noise within a pipe. Since the pipe is a closed system, this leak noise can only travel through the pipe wall and the fluid in the pipe. The correlator measures the difference in time of arrival of this leak sound at the red and blue sensors. The correlation graph shows the time difference in milliseconds (thousandths of a second).
- The second peak (at the right of the tallest peak) indicates a probable leak on a lateral line. This leak was confirmed after noting a lateral line junction is present at the position on the main pipeline predicted by the correlation result. The leaks's location is immediately found by double-clicking over the peak on the correlation graph.

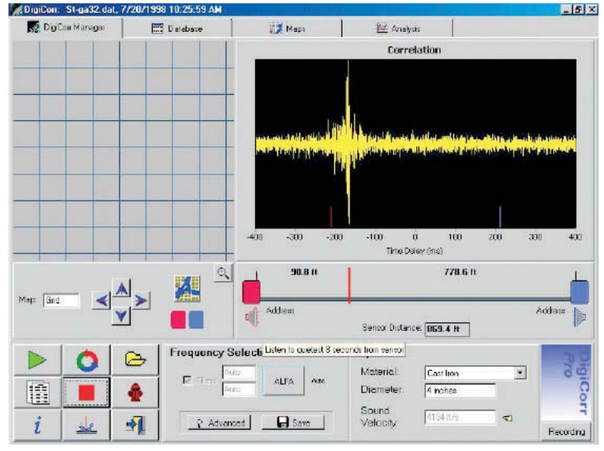
- The third peak (to the left of the tallest peak) is considered to be usage. A residence is located near the point on the pipeline corresponding to the peak. Repeated correlation studies did not consistently show a third peak. This leak probability can be ruled out by performing another correlation study after repairs are complete on the first two leaks.

The noise level away from the peaks shown in the correlation study is low. These results are typical results from those received on iron (cast or ductile) or steel pipes. If pipe material and diameter are defined and consistent, the inherent error in the correlation result is likely a few inches or up to four feet over distances of up to 2,000 feet or more.

Eliminating Artifacts

Digital filters may be adjusted to focus on probable leak noise and eliminate artifacts. Digital filtering offers three possible strategies:

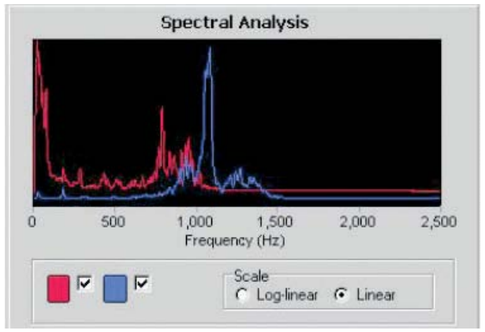
- Choose a quiet part on the pipe sounds frequency spectrum to avoid artifacts.
- Identify a coherent part of the spectrum (plastic pipes).
- Identify peaks in the spectrum corresponding to leak noise (non-plastic pipes). In the example, there is no apparent peak in the correlation function. In this recording:
- The correlation result is frequency sensitive.
- The leak is directly under the red correlation spike.



To eliminate an artifact

1. Click the ***Analysis*** Tab. Verify both the blue and red boxes are checked and push the green Go button. The sound intensity is greater in the red channel due to the leak's proximity. If the sensor is directly over the leak (or very close), the leak sound wave may not propagate in a laminar flow at the sensor. The lack of propagation can disrupt the correlation function. In the example, spectral analysis is used to identify frequency ranges containing large amounts of interference vibrations.

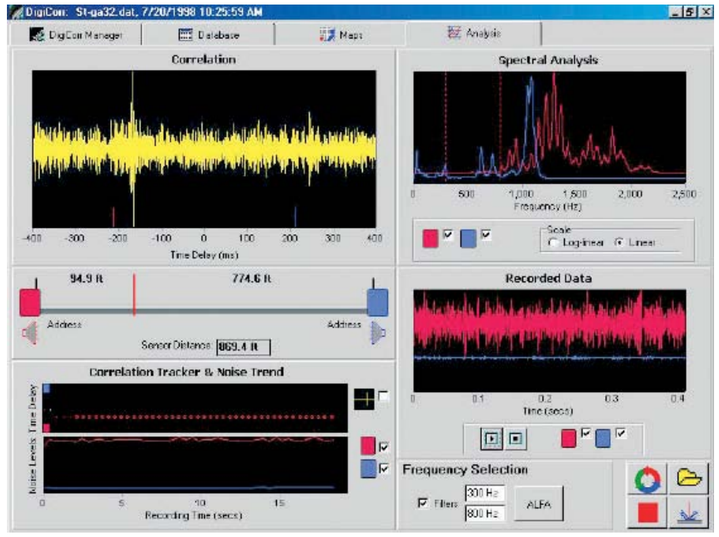
2. Click ***ALFA*** in the Frequency Selection Panel and verify filters are set to 20 - 2,000 Hz. Verify the scale is set to Linear and the blue and red boxes are checked on the Spectral Analysis Panel.



3. Press the ***Re-analyze*** Button. The frequency spectra for the red and blue sensors display. Significant energy exists at the high frequencies in the red channel (800 Hz and greater). A strong low frequency component exists in the blue channel. Selecting frequencies of 300 to 800 Hz for correlation helps to avoid these components of the spectrum.

NOTE In this example, the strategy is to correlate on the quiet part of the frequency spectrum to avoid artifactual noise. The same strategy is useful in applications with pumps, loud highway or construction noise or any other loud noise sources (either internal or external to the pipe).

4. Change the filter settings in the Frequency Selection Panel to 300 - 800 Hz and press the Re-analyze Button. After the Correlation Analysis is completed, the correlation panel displays a peak with the leak identified 91.2 feet from the red sensor.



CAUTION With metal pipes, the following frequency ranges are often effective. If the correlation analysis is not successful with ALFA switched ON then turn ALFA to OFF and try correlation analyses in the following filter ranges:

200 - 2,000 Hz

300 - 800 Hz

250 - 450 Hz

100 - 300 Hz

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