FUJI Digital Quatro Correlator

Quattro Core LC-5000

Instruction Manual

Instruments for the location of underground utilities and water leaks.

FUJI TECOM INC.

Preface

This is the instruction manual for the FUJI Digital Quatro Correlator, Quatro Core LC-5000.
Be sure to read these instructions before using the equipment to ensure that you understand how to use it correctly.

Application

The LC-5000 correlation-type leakage detector is used by mounting preamplifier-integrated sensors to fittings such as fire hydrants, valves, or meters on the underground pipe to capture the sound of water leakage and detect the locations of leaks.

Safety Instructions

⚠ Warning	This symbol indicates the existence of a potential danger that could cause death or serious injury.
⚠ Caution	This symbol indicates the existence of a potential danger that could cause minor or moderate injuries.
Caution	This symbol indicates the existence of a potential danger that could cause serious damage to the equipment or damage to surrounding property.

⚠ Warning

- When using the equipment to listen for the sound of water leakage through the headphones, be careful because the sounds in the ambient environment will be difficult to hear.
- Do not replace the battery with wet hands.
- Pay attention to the polarity of the battery when inserting it into the battery case.
  (Incorrect polarity may cause leakage, overheating, damage, etc.)
- Do not throw the battery into the fire.
  (This may cause an explosion, fire, or injury.)
- Do not attempt to disassemble the battery.
  (This may cause an explosion, fire, or injury.)

⚠ Caution

- Do not swing the detector when gripping the handle.
- Attach the battery cover securely.
- Do not swing the pre-amplifiers.

Safety Instructions

Caution

- Do not leave or install the equipment in a hot place.
  (This may cause a malfunction.)
- Do not use this equipment for any purpose other than leak detection.
- The main unit is dust-proof and drip-proof, but not completely waterproof.
  Do not submerge it water or use it in bad weather.
- Do not drop the equipment or subject it to strong impact.
- Do not attempt to disassemble the equipment.
- Remove the battery if the device will not be used for an extended period of time.
- Do not bend the antenna forcibly.
- Do not pull the antenna cable unnecessarily.
  (The cable may break, making the antenna unusable.)
- Pay attention to your surroundings.
- When disposing of the equipment, follow local ordinances and regulations.

Safety Instructions

Compliance statement to FCC/IC

This module complies with part 15 of the FCC rules and IC RSS-210.

Operation is subject to the following conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Warning

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

RF exposure compliance

1) To comply with FCC/IC RF exposure compliance requirements, a separation distance of at least 20 cm must be maintained between the antenna of this device and all persons.

2) This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Requirements to end product

This module must be integrated only by OEM integrators under the following conditions.

(1) OEM integrator has to be aware not provide information to the users regarding how to install or remove this module in the user manual of the end product which integrate this module. Installation by end users is strictly prohibited.

(2) Antenna

OEM integrator shall use this module without any modifications including antenna.

If module integrator uses a unique antenna, the FCC certification is required for the end product.

OEM integrator must make sure that 20cm minimum separation is maintained between users and the antenna.

(3) Co-location.

This module must not be co-located or operated in conjunction with any other antenna or transmitter. The module integrator shall obtain FCC approval for the end product, if the module is used for co-location operation.

(4) Markings

To satisfy FCC/IC exterior labeling requirements, the following text must be placed on the exterior of the end product.

Contains Module FCC ID: 2AARD-LC50, IC: 11320A-LC50

Any similar wording that expresses the same meaning may be used.

(5) Caution to user for modification

The following caution is expressed on the user's instruction manual.

The changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the device.

(6) Compliance statement to FCC

The following statement is expressed on the user's instruction manual.

For Class A device;

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

(7) Compliance statement to IC

The following statement is expressed on the user's instruction manual.

Operation is subject to the following conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Déclaration de conformité à IC

L'instruction suivante est exprimée dans le manuel d'instructions de l'utilisateur.

Le fonctionnement est soumis aux conditions suivantes : (1) Cet appareil ne peut pas causer d'interférences nocives et (2) cet appareil doit accepter toute interférence reçue, y compris les interférences qui peuvent provoquer un fonctionnement indésirable.

Warranty Period

The warranty period is one year from the date of purchase.
The warranty card is intended to ensure we can provide you with the highest level of service.
Please enter your name and address on the warranty card.

If a defect occurs in the functioning of the device during the warranty period, it will be repaired free of charge.
You will be required to present the warranty card for repairs during the warranty period, so please keep it in a safe place. Please note that you will be charged for repairs if you do not present the warranty card.
In the event of damage or failure outside the warranty period or at your request, we will repair the device for a fee.
Please contact your agent company for details.

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Table of Contents

1. Components

1−1 List of Components

The equipment consists of the components indicated below. After purchase, check to make sure you have each component. If any of the components are missing, please contact FUJI TECOM immediately.

● Main unit (with rechargeable battery) and antenna × 1 	● Preamplifier-integrated sensor × 4 
● Pre-amplifier antenna and 2 m extension cable × 4 	● Pedestal for pre-amplifier × 4 
● Hand strap × 1 	● Headphones × 1 

1−1 List of Components

● Charger for rechargeable battery in main unit × 1 	● AC adapter for preamplifier-integrated sensor × 4 
● ● Storage case × 1 	● SDHC card (class 10) × 1 ● Instruction manual (CD) × 1 ● Post process software × 1

1−2 Optional Accessories

The following optional items are available for this equipment and may be purchased if needed.
Please contact our sales representative to make your purchase.

- External sensor (pipe wall)
- Coupling-type hydrophone sensor
- Wired cable (10 m reel)
- Spare rechargeable battery for main unit

* All the optional accessories are available on a made-to-order basis.

2. Description of Equipment

(1) Main unit (front panel)

① Menu switch
Display the menu.

② Help switch
Display the help screen.

③ Pre-amplifier switch
Display the pre-amplifier setting screen.

④ SDHC card slot
Insert the SDHC card.

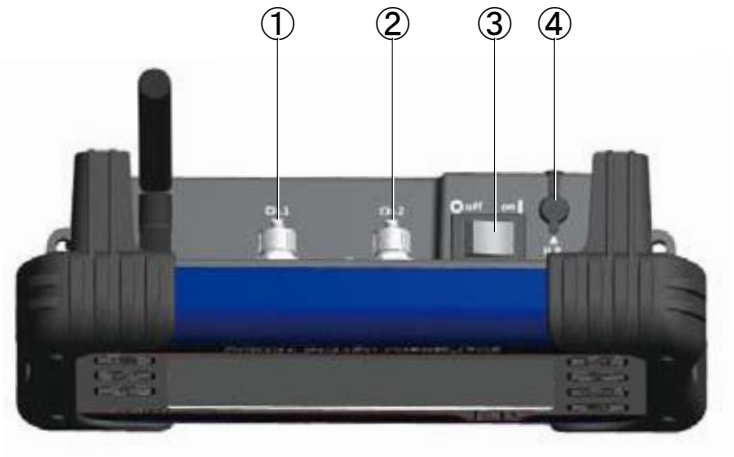
⑤ Correlation switch
Perform correlation processing.

⑥ Filter switch
Display the main unit filter setting screen.

⑦ Setting pipe conditions switch
Display the pipe condition setting screen.

⑧ Return switch
Return to the previous screen.

(2) Main unit (top panel)



① Cable 1 connector

To use the pre-amplifier in cable mode, plug in the cable here.

② Cable 2 connector

To use the pre-amplifier in cable mode, plug in the cable here.

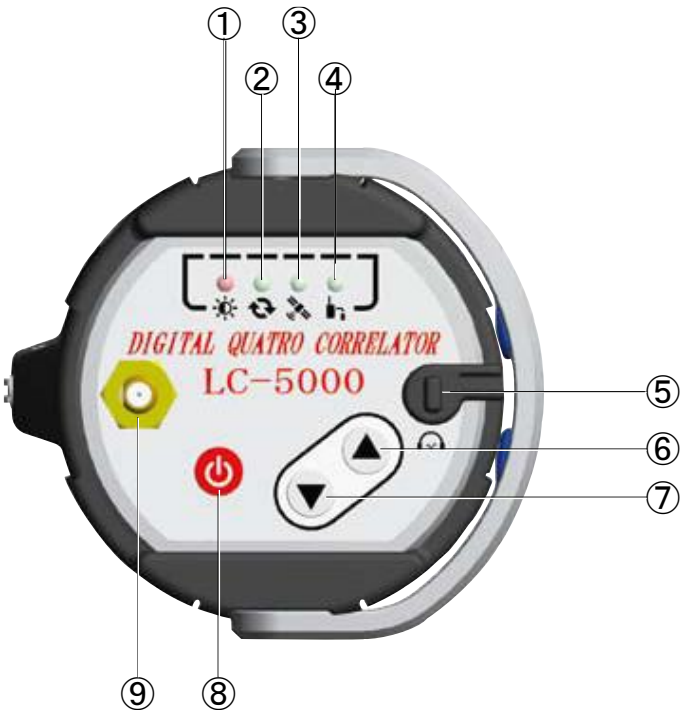
③ Power switch

Turn on the unit.

④ Headphone jack

Plug in the headphones to listen for the sound of water leakage through the headphones.

(1) Pre-amplifier (top panel)



① Power LED

Lights up when the power is turned on.

② Mode LED

Indicates the mode of operation.

③ GPS LED

Indicates the GPS status.

④ Sensor/adjustment LED

Indicates the sensor sensitivity.

⑤ Headphone jack

Plug in the headphones to listen for the sound of water leakage through the headphones.

⑥ Sensitivity up switch

Increases sensitivity.

⑦ Sensitivity down switch

Decreases sensitivity.

* If you press and hold one of the sensitivity switches, the LED will fully illuminate and auto-adjust will execute.

⑧ Power switch

A short press turns the power on and a long press turns the power off.

⑨ Antenna and extension cable connector

Attach the radio transmitter antenna or antenna extension cable.

(2) Pre-amplifier (side panel)

① AC adapter jack for charging

Insert the AC adapter for charging.

② Cable connector

Connect to the main unit for wired use.

③ External sensor connector

Insert the external sensor.

(1) Display of LEDs during operation

<table>
<tr><td>Function*1</td><td>Power</td><td>Mode</td><td>GPS</td><td>Sensor/adjustment</td></tr>
<tr><td>LED color</td><td>Red/yellow</td><td colspan="3">Green</td></tr>
<tr><td>Power OFF</td><td colspan="4">Unlit</td></tr>
<tr><td>Battery replacement warning*2</td><td>Flashing</td><td>N/A (henceforth, —)</td><td rowspan="2">—</td><td rowspan="2">—</td></tr>
<tr><td>Charging*3</td><td>Lit</td><td>—</td></tr>
<tr><td>Radio channel display</td><td colspan="4">See P.17 for details</td></tr>
<tr><td>Pre-amplifier</td><td rowspan="16">Lit</td><td>Unlit</td><td rowspan="3">—</td><td rowspan="7">—</td></tr>
<tr><td>Relay</td><td>Flashing</td></tr>
<tr><td>Logger mode</td><td>Lit</td></tr>
<tr><td>GPS OFF</td><td rowspan="4">—</td><td>Unlit</td></tr>
<tr><td>GPS satellite search in progress</td><td>Flashing</td></tr>
<tr><td>GPS coordinate acquisition + unsynced</td><td>Flashing</td></tr>
<tr><td>GPS sync complete</td><td>Lit*6</td></tr>
<tr><td>Adjusting sensitivity</td><td rowspan="3">Flashing or unlit</td><td rowspan="3">—</td><td>Flashing</td></tr>
<tr><td>Built-in sensor</td><td>Unlit</td></tr>
<tr><td>External sensor</td><td>Lit</td></tr>
<tr><td>Logger mode Not recorded, not ready to record, syncing</td><td rowspan="5">Lit</td><td>Flashing</td><td rowspan="2">Lit*7</td></tr>
<tr><td>Logger mode Not recorded, not ready to record*4</td><td rowspan="2">Lit</td></tr>
<tr><td>Logger mode
Recording</td><td rowspan="3">Unlit*7</td></tr>
<tr><td>Logger mode
Post-recording, uncorrected</td><td>Unlit</td></tr>
<tr><td>Logger mode
Post-recording, uncorrected (GPS searching)</td><td>Flashing</td></tr>
<tr><td>Logger mode Post-recording, corrected, ready for collection*5</td><td colspan="3">Unlit</td></tr>
<tr><td>Excessive input*2</td><td colspan="4">Lit</td></tr>
</table>

*1 All of these operations, except "Power off" and "Charging", require the power to be on (for example, the battery replacement LED does not flash when the power is off)

*2 If "Battery replacement warning" and "Excessive input" occur at the same time, the battery replacement warning takes priority.

*3 During charging, the power LED is lit in a color other than red.

*4 Recording in logger mode is possible with all LEDs lit.

*5 Recording and time correction are complete, and the recorded data is ready to be collected by the main unit.

*6 Once GPS sync is complete, the LED will remain lit even if GPS is lost.

*7 When “logger mode” is set, “sensor connection status and adjustment” is replaced by “logger mode recording status”.
Lit: Not recording Unlit: Recording in progress or complete
When an external sensor is connected, logging is performed using the external sensor, but the connection status is not displayed on the LEDs.

(2) Radio channel

Function	Power	Mode	GPS	Sensor
LED color	Red/yellow	Green		
Radio channel 1	N/A (henceforth, —)	○	○	●
Radio channel 2	—	○	●	○
Radio channel 3		○	●	●
Radio channel 4		●	○	○
Radio channel 5		●	○	●
Radio channel 6		●	●	○
Radio channel 7		●	●	●

● Lit
○ Unlit

(3) Display of power LED during charging

	When power is off	When power is on	
		Battery replacement warning	Operating state
Not charging	Unlit	Red flashing	Red lit
Charging	Yellow	Yellow ⇔ Orange	Orange

When charging is complete, the power LED turns off.

* When fully charged
The power LED does not light even when the AC adapter is connected.

3. What to Check Before Use

3−1 Checking and Replacing the Battery (Main Unit)

(1) Checking the battery power

- Make sure that the battery level is high enough before use.
  When checking the battery level, turn on the main unit.
  When the battery is not fully charged, you will see empty space inside the battery power indicator as shown on the left.
  If the battery power indicator is flashing, immediately replace the battery with a charged one.
  Be sure to turn off the main unit before replacing the battery.
- It is recommended that you bring a spare battery when performing detection work so that the device can be used even if the battery runs out during the work.

(2) Opening and closing the battery cover and replacing the battery

The battery of the main unit is rechargeable.
Remove the battery cover and remove the battery.
Insert the battery in the charger until it is charged, then reinstall it.
Be sure to close the battery cover after inserting the battery.

⚠ Warning

- Pay attention to the orientation of the battery during replacement. (Failure to do this may cause an explosion, fire, or injury.)
- Dispose of unneeded batteries in accordance with your local regulations.

Note

- If a battery not specified by FUJI TECOM is used, the warranty is invalidated even if a malfunction occurs.
- Be careful not to throw away the battery cover when disposing of the battery.

3−2 Backup Battery

Since the data is stored on the SDHC card (Class 10), there is no need a backup power source for data retention.

The main unit has a built-in rechargeable battery for clock operation.
This battery is automatically charged when the rechargeable battery (RRC2020) is inserted.
Please note that the date and time will not show correct values if the clock battery runs out.
After the main unit has been turned off for a long period, check the date and time for correctness after power-on.
If they are not correct, refer to “3-6 Date and Time Adjustment” on p. 25 for instructions on how to set them.

(1) Checking the battery power

- Be sure to check all four pre-amplifiers: blue, red, yellow, and green.
- Make sure that the battery level is high enough before use.
  When checking the battery level, turn on the pre-amplifier and the main unit.
  Check the remaining battery levels of the blue, red, yellow, and green units on the main unit screen.
  If the battery level is low, insert the charging AC adapter to charge the battery.

3−4 Pre-Amplifier Check

There are four pre-amplifiers (blue, red, yellow, and green).
Check each pre-amplifier in the same way.

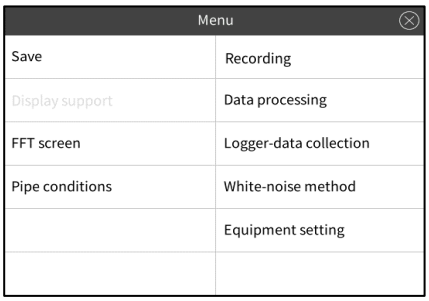
① Press the power switch.
② Connect the headphones to the pre-amplifier.
③ Lightly rub the magnet at the bottom of the pre-amplifier and verify that sound can be heard from the headphones. If the sound is not audible, there may be a problem with the sensitivity of the sensor. Compare it with the other pre-amplifiers.

(1) Main unit and pre-amplifier

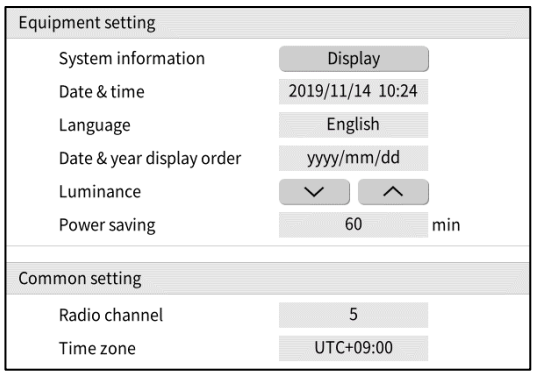
① Turn on the main unit.

② Press the menu switch  .

③ Tap Equipment setting.



④ Make a note of the radio channel number under Common setting.

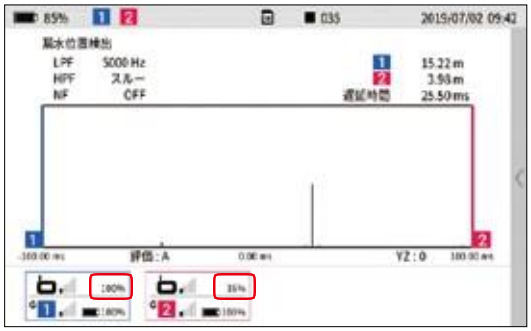


⑤ Turn on the pre-amplifier and verify that the green LED is lit and the radio channel of the main unit matches the description in "(2) Radio channels" in "2-3 Explanation of Pre-Amplifier LEDs" on p. 17.
If the radio channels do not match, tap the radio channel under Common setting to change it.

⑥ Verify that the console shows an icon of the same color as the pre-amplifier. If the icon is not displayed, the main unit is not receiving the radio signal.
Check the following:

- If the radio signal is not being received due to the surrounding environment, tap the radio channel under Common setting to change it as described earlier.
- If the radio unit on either the pre-amplifier or the main unit is faulty, check another unit in the same way to determine whether the problem is specific to the pre-amplifier or the main unit. If the problem is with a specific pre-amplifier, try replacing the antenna or extension cable.

⑦ Make sure the data arrival rate is not 0.



If the data arrival rate is between 0 and 50, it is possible that the radio signal is not getting through due to the surrounding environment. Tap the radio channel under Common setting to change it as shown at left.

(2) Correlation calculation check

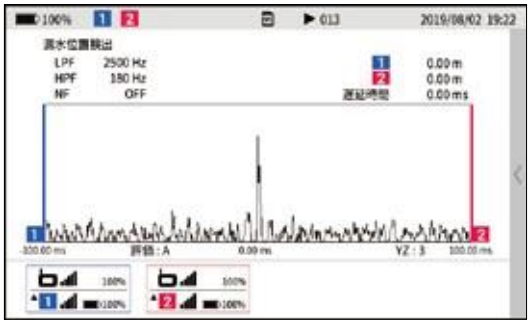
① Turn on the main unit.

② Turn on two pre-amplifiers.

③ Make sure the data arrival rate is not 0 and then press the correlation switch [ ].

④ Lightly rub the magnet at the bottom of each pre-amplifier.

⑤ Verify that the calculation result and correlation waveform are displayed on the leak location screen as shown in the screen shot below.



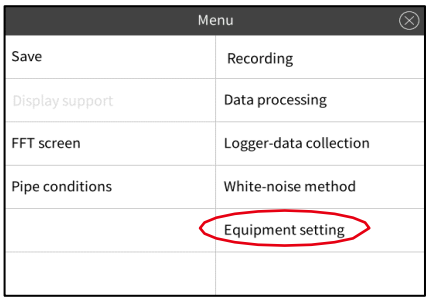
The delay time is 0.00 ms, and the correlation waveform shows a peak at 0.00 ms.

Note

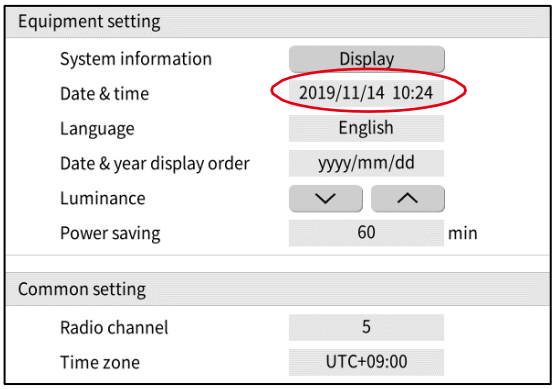
- Do not rub the pre-amplifier too strongly. Otherwise, the delay time may not be 0.00 ms.
- If the unit is on its pedestal, or the magnet is dirty, the delay time may not be 0.00 ms.

3−6 Date and Time Adjustment

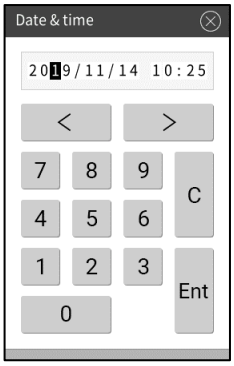
The year, month, day, hour and minute are displayed in the upper right corner of the screen.
Check whether the date and time are correct.
If the date and time are incorrect, adjust them using the following procedure.
The date and time are saved together with the measurement data, so make sure they are set correctly.



Press the main unit menu switch .
Tap "Equipment setting" under Menu.



Tap “Date & time” under Equipment setting.

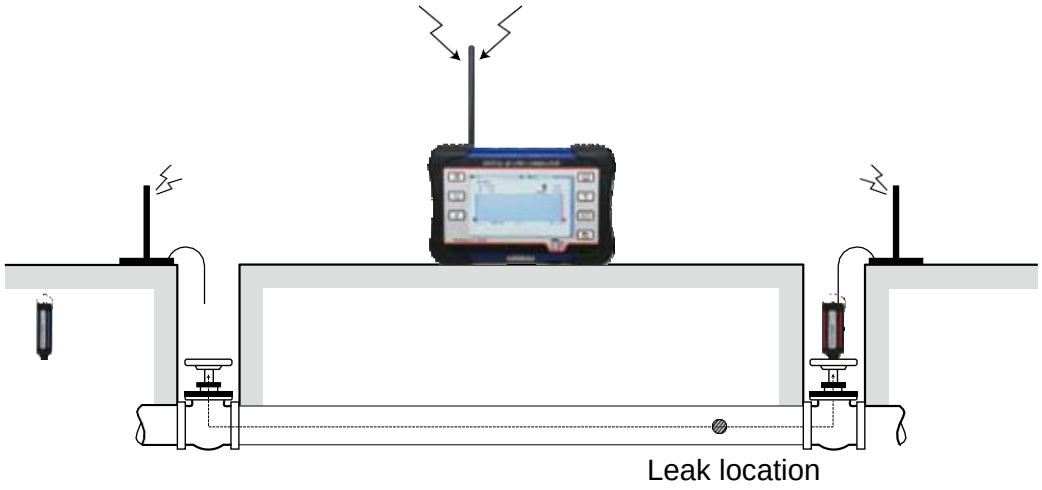


Set the date and time on the input screen, and then tap the × in the upper right corner.

4. How to Use the Correlator

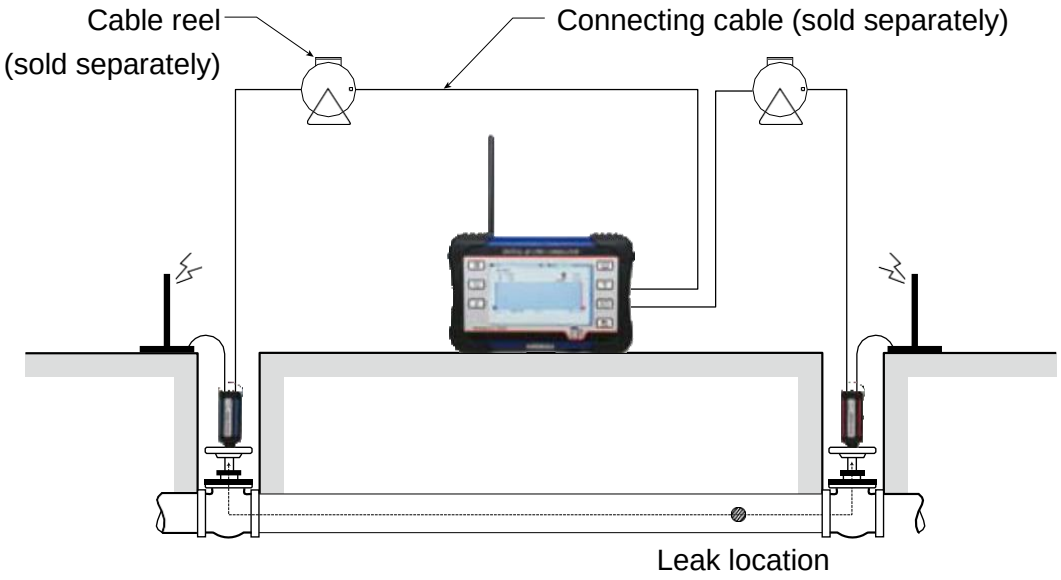
4−1 Radio and Cable Modes

(1) Radio mode



(2) Cable mode

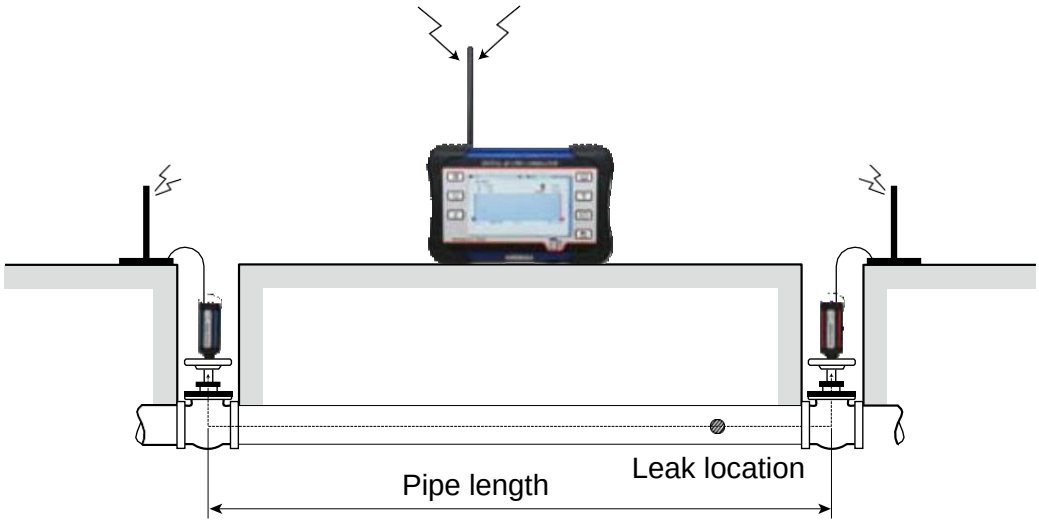
Cable mode is used when radio communication cannot be established between the leak detector and the pre-amplifiers due to interference from buildings or other radio stations etc.
Normally, leak detection is done in radio mode as shown in (1) above.



4−2 Example of Detecting a Leak in a Pipe

This section explains how to perform leak detection for the pipe shown below.

In this example, it is assumed that the water leaks from a certain location in the pipe. The pre-amplifiers detect the leak noise and send the signals to the main unit.



4−3 False Leak Noise

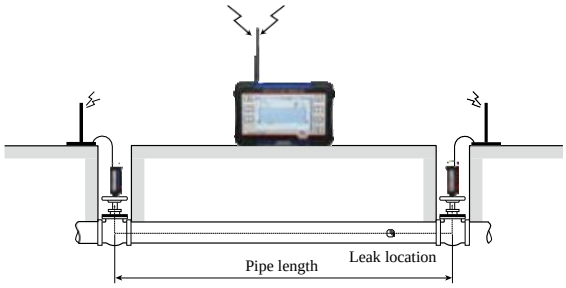
When the pre-amplifiers detect sound other than the sound of water leakage, the correlator will sometimes misinterpret the sound and display it as the leak location.
When the correlator reports a leak, you should confirm the leak with other leak detection equipment, confirm by boring and investigate how the pipe is buried.

● False leak noise can include the following

① The sound of friction between the pipe and running water
② Noise generated from sewage
③ Noise generated from running water by normal daily use
④ Mechanical noise
and so on

4−4 Preparations

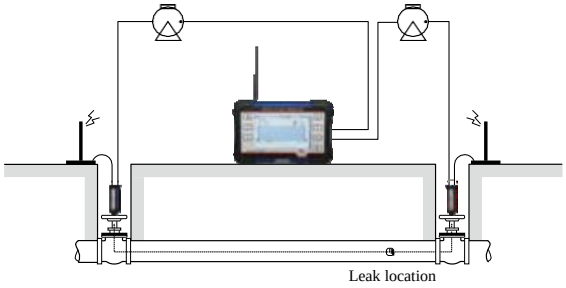
(1) Radio mode preparations



- Insert the rechargeable battery into the main unit.
- Attach the antenna to the main unit and pre-amplifier.
- Turn on the main unit and the pre-amplifiers.

(2) Cable mode preparations

(cable reel and connecting cable are sold separately)



- Insert the rechargeable battery into the main unit.
- Attach the antenna to the main unit and pre-amplifier.
- Extend the cable from the cable reel to the location of each pre-amplifier.
- Screw the cable plug into the pre-amplifier.
- Use the connecting cable to connect the main unit and the cable reel.
  * When connecting the pre-amplifiers, do not mix up which is which.
- Turn on the main unit and the pre-amplifiers.

Note:

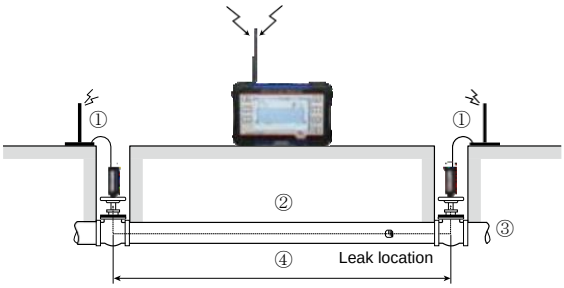
- Verify that the icon shown below appears on the screen when you turn on the main unit.

 : Cable mode icon

- After unspooling the cable from the cable reel, plug it into the main unit. Do not connect the cable to the main unit first, or the connecting cable may be twisted and damaged when it is unspooled from the reel.

(1) Preparation of necessary conditions and data

To find the location of the leak with the correlator as shown in the figure below, the necessary data is required, and the following four conditions must be met.



① The sound from the location of the leak must be transmitted to two or more pre-amplifiers.

- If the leak sound is transmitted to only one pre-amplifier, the location of the leak cannot be identified.
  In that case, try reducing the distance between the pre-amplifiers.

- It is assumed that existence of the sound of water leakage was established by prior investigation.

② The material of the target pipe is known.

- This is because the sound velocity (the speed at which the sound of the water leak propagates) depends on the pipe material.

③ The diameter of the target pipe is known.

- This is because the sound velocity (the speed at which the sound of the water leak propagates) depends on the pipe diameter.

④ The pipe length between the pre-amplifiers is known.

(2) Installation of pre-amplifiers

① Candidate installation locations include fire hydrants, gate valves, and meters.
Determine the installation locations and install the pre-amplifiers.

- There are four pre-amplifiers: blue, red, yellow, and green. Often only two or three units need to be installed, not all four.

- Since the pre-amplifier is completely waterproof, it can be immersed in the water.

- Make sure the signal reaches the pre-amplifier as described in “3-4 Pre-Amplifier Check” on p. 22.

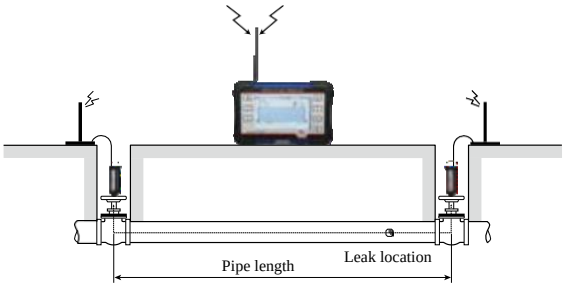
- Make sure the installation site and magnet of the pre-amplifier are free from mud and dirt. Mud and dirt may prevent correct leak detection.

② When several leak locations exist on the same pipe (including branch pipes), choose two installation locations where the leak noise between them is the maximum.

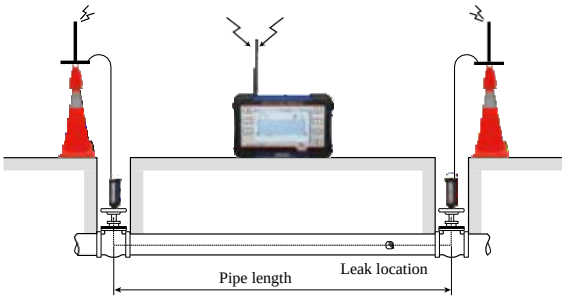
Caution

Connect the antenna and extension cable securely.
If water enters the pre-amplifier through the connectors for the antenna and extension cable, it may cause a serious failure.
If you do not connect the antenna and extension cable, cover the connectors with the supplied caps to ensure waterproofness.

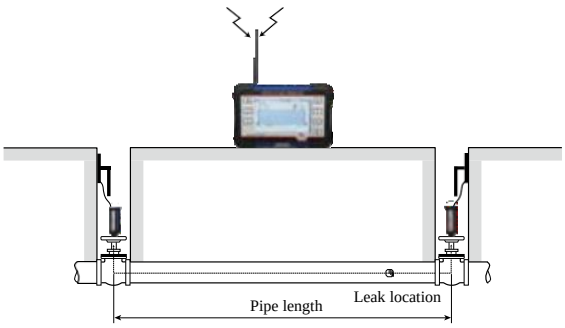
(3) Installation of antennas



In general, the higher the antenna is installed, the more vulnerable the signal is to radio interference. Position the antennas and extension cables on the ground whenever possible.



If the radio signal is not received well, use traffic cone or some other stand etc. to mount a high-gain antenna.



If the valve is deep and the antenna cannot be extended to the ground, mount it on the pipe wall.

(4) Precautions when using the pre-amplifier

Note

- The pre-amplifier is equipped with a radio. Please use the equipment according to The Radio Law of your country,

(1) Switches on the main unit


Menu switch

Toggle the display of the menu on each display screen.


Help switch

Display the help screen for the current screen.


Pre-amplifier switch

Display the pre-amplifier setting screen.


Correlation switch

● Switch operation on the correlation screen

Status	Multiple correlation screen	
	Correlation in progress	Stop correlation
Operation when switch is pressed	Stop correlation	Start new multiple correlation
Status	Single correlation screen	
	Correlation in progress	Stop correlation
Operation when switch is pressed	Stop correlation	Start new single correlation

● Switch operation on the FFT screen

Status	Multiple FFT processing screen	
	FFT processing in progress	Stop FFT processing
Operation when switch is pressed	Stop FFT processing	Start new multiple FFT processing
Status	Single FFT processing screen	
	FFT processing in progress	Stop FFT processing
Operation when switch is pressed	Stop FFT processing	Start new single FFT processing

● Other screens

Displays the multi-correlation stopped screen.


Filter switch

Display the main unit filter setting screen.


Setting pipe conditions switch

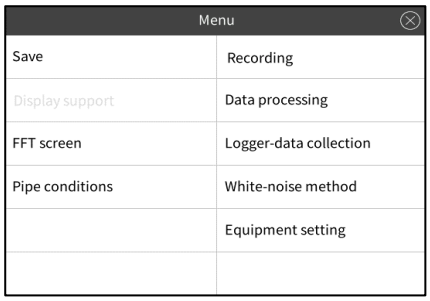
Display the pipe condition screen.


Return switch

Correlation/FFT processing: Pause
Correlation/FFT paused: Resume
Other: Return to previous screen

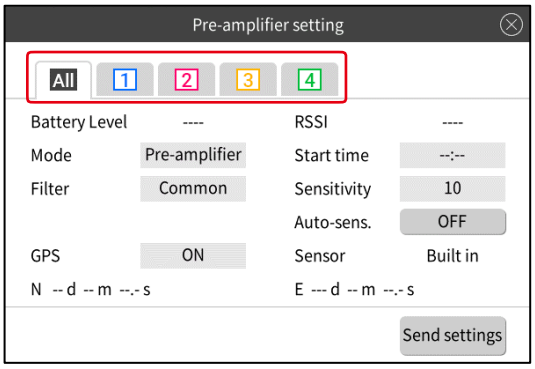
(2) Touch panel operation

Only tap (touch and release) is supported.
If no selection is offered and you need to close the screen, tap the × in the upper right corner.



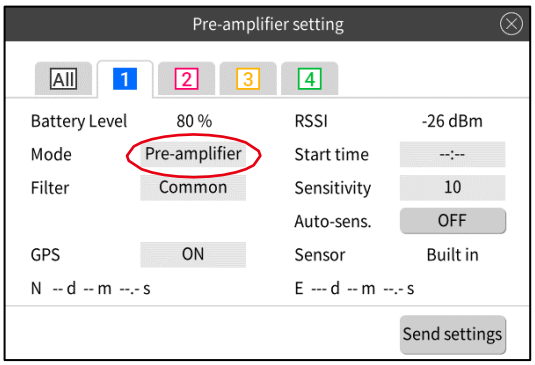
<Pre-amplifier setting>

Press the pre-amplifier switch  .



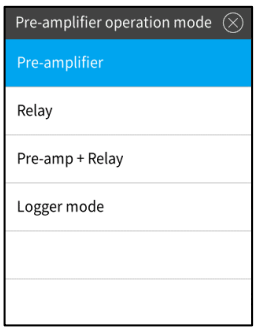
Tap the icon of the pre-amplifier to be configured. Alternatively, tap the "All" tab to simultaneously configure a group of common settings (operation mode, recording start time, filter, sensitivity, GPS). The All tab shows only settings that match all the pre-amplifiers.

Changing the Operation Mode



The pre-amplifiers function as radio relays.
They can also be used in logger mode.

Tap the pre-amplifier number tab and then tap the mode box.

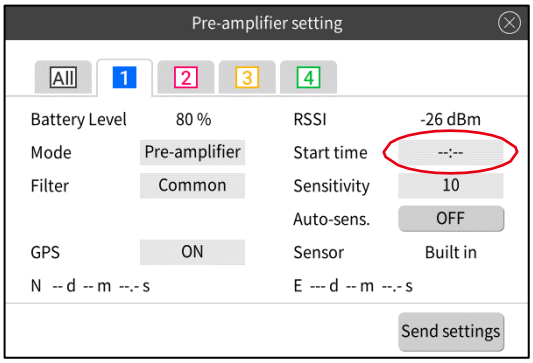


The following modes can be selected on the Pre-amplifier operation mode setting screen.

- Pre-amplifier (normal correlation mode)
- Relay
- Pre-amplifier + Relay
- Logger mode

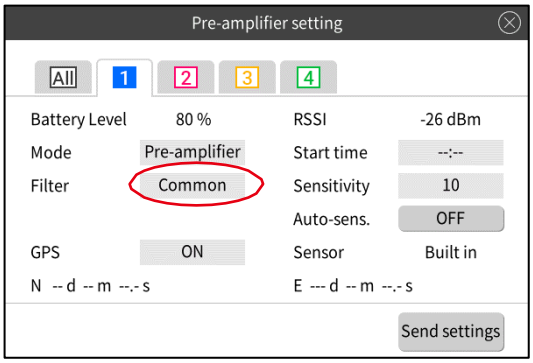
In the All screen, only Pre-amplifier and Logger mode are available.

Setting the Recording Start Time



This setting configures the recording start time in logger mode.
It can be set within a 24-hour range.
Tap the value for Start time and then set the value in the 24-hour display.
You cannot tap this unless the Logger mode is selected as the Mode.

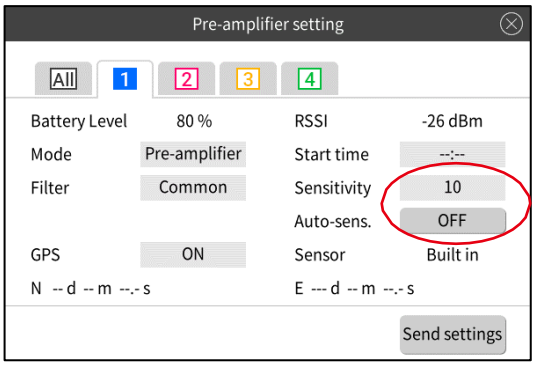
Filter Settings



The logger has two filters available: Common and Through. The default setting is Common.
Tap Common to change it to Through.

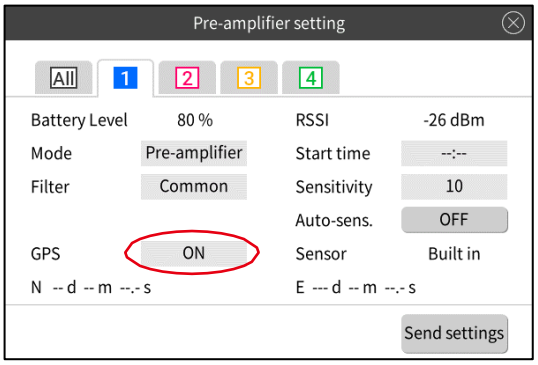
Select a filter.

Setting the Sensitivity



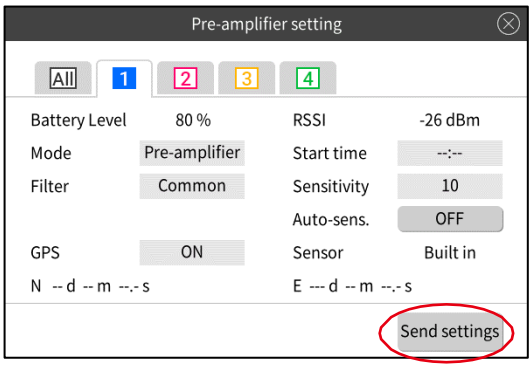
The sensitivity can be set manually and automatically.
Enter a value in 00 if you want to set it manually.
If you want to set it automatically, tap Auto-sens.
Once the setting is complete, it shows the sensitivity that was set.

GPS Setting



You can toggle the GPS setting.
The default setting is ON.
If you do not want to use GPS, tap ON to switch it OFF.

Sending Settings



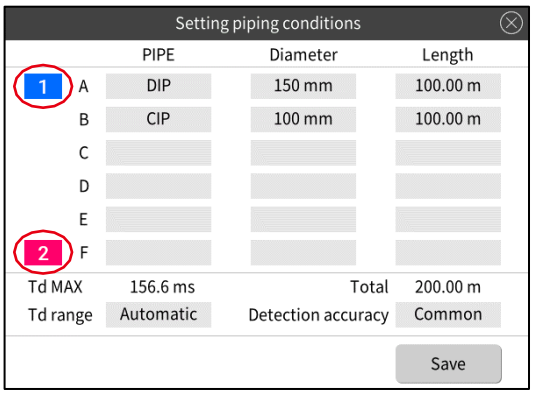
When all the pre-amplifier settings are complete, tap Send settings to send the settings to the pre-amplifier.

<Setting piping conditions>

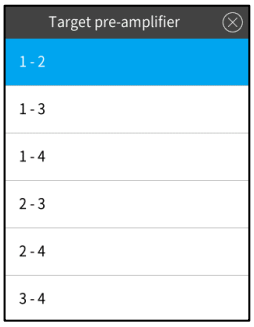
Press the setting piping conditions switch  .

Pre-Amplifier Combination Settings

Select the combination of pre-amplifiers whose pipe conditions are to be set.

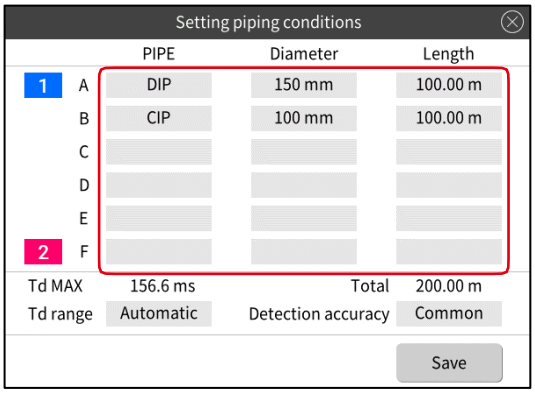


Tap the icons of the pre-amplifiers.

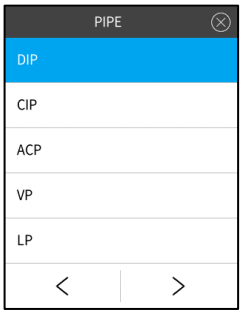


Select a combination of pre-amplifiers from the Target pre-amplifier set selection screen.

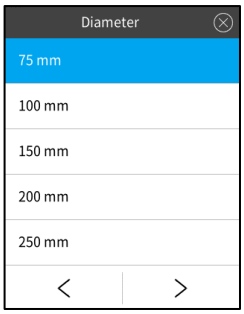
Adding or Changing Pipe Conditions



To add or change the pipe type (material), diameter, or length, tap the corresponding box and enter the value.



Select a material.
For the list of materials, see "6-1 Pipe Data Handling (Main Unit)" on p. 74.
Tap “Delete” to delete the information.
When a row of data is deleted, the rows below it are shifted upwards.



Select a diameter.
For the list of diameters, see "6-1 Pipe Data Handling (Main Unit)" on p. 73.

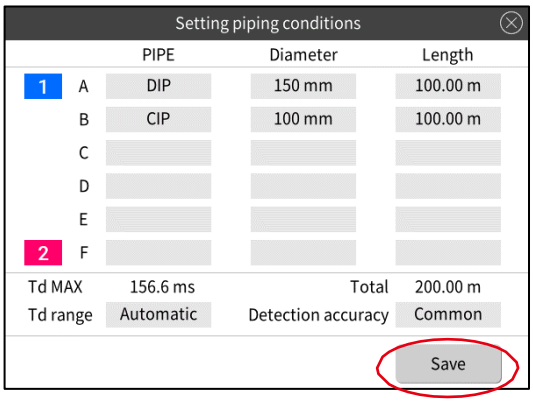
Enter the length from the numeric keypad screen.

When you are done, click × to close the Setting piping conditions screen.

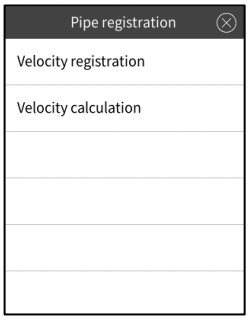
[Tip]
If you have no data (pipe type or pipe diameter) for the pipe to be investigated, see “6-8 Manual Calculation of Sound Velocity" on p. 85.

Sound Velocity Registration

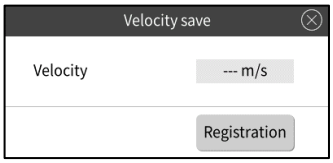
This function is for manually setting the sound velocity value.



Tap Velocity save.

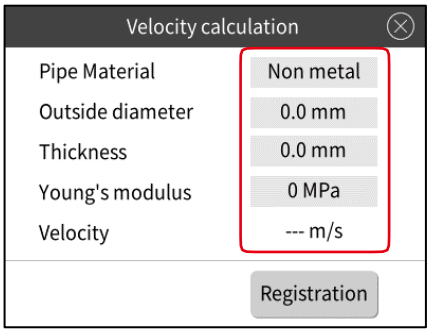


From the sound velocity registration settings screen, select Velocity registration or Velocity calculation.



When Velocity registration is selected

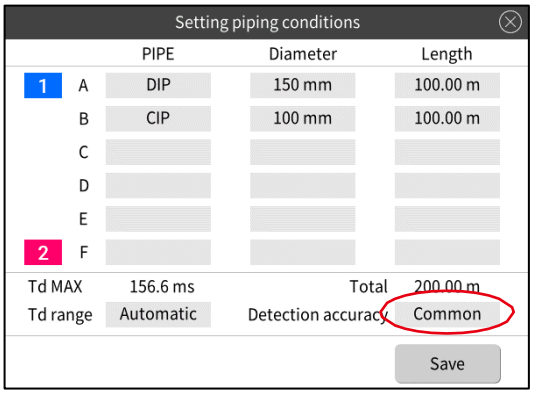
Enter a velocity value and tap Registration.



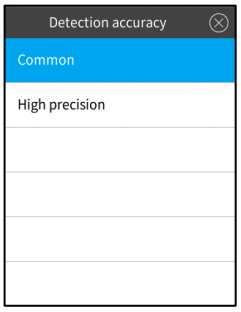
When Velocity calculation is selected

Enter the required information and tap Registration.

Setting the Detection Accuracy



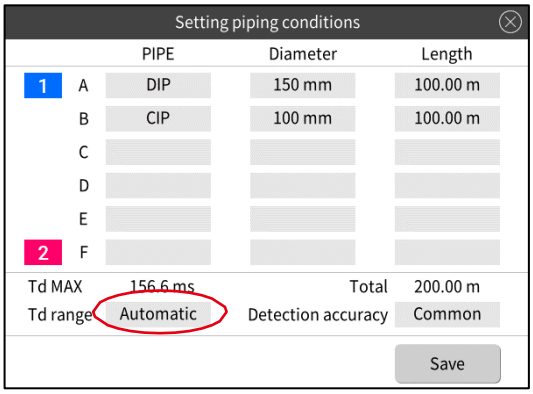
The detection accuracy can be set to Common or High precision. The default setting is Common. Tap Common to change it to High precision.



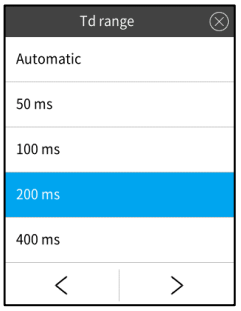
Select detection accuracy.

Setting the Td Range

This function sets the Td range (delay time).



Tap the value for Td range.



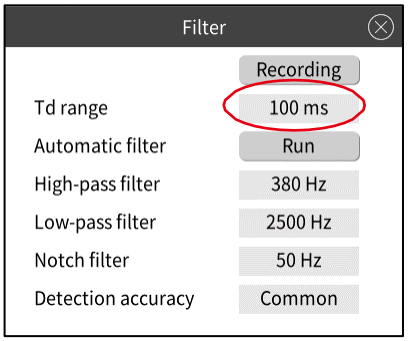
Select a Td range from the following choices.

- Common correlation
  Automatic, 50 ms, 100 ms, 200 ms, 400 ms, 800 ms, 1600 ms, or 3200 ms
- High precision correlation
  Automatic, 200 ms, 400 ms, 800 ms, 1600 ms, 3200 ms, 6400 ms, or 12800 ms

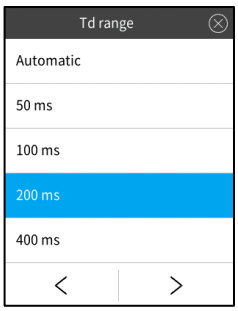
<Filter setting>

Press the filter switch  .

Setting the Td Range



Tap the value for Td range.

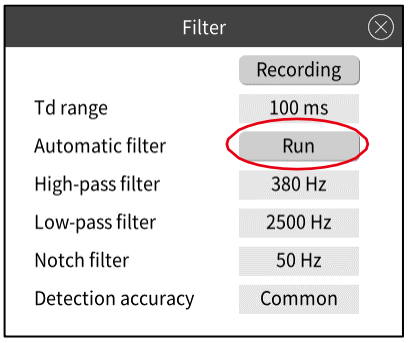


Select a Td range from the following alternatives.

- Common correlation
  Automatic, 50 ms, 100 ms, 200 ms, 400 ms, 800 ms, 1600 ms, or 3200 ms
- High precision correlation
  Automatic, 200 ms, 400 ms, 800 ms, 1600 ms, 3200 ms, 6400 ms, or 12800 ms

Running the Automatic Filter

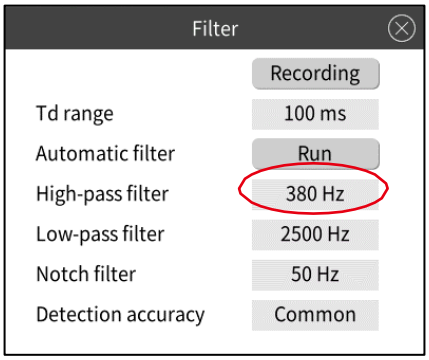
This function performs FFT processing and sets the appropriate filter (high pass, low pass).



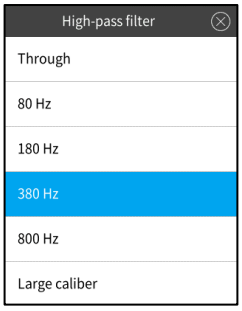
Tap Run for Automatic filter.

The FFT screen appears for a certain amount of time, and then the appropriate filter is set.
After the filter is set, the FFT result is displayed.

Setting the High Pass Filter



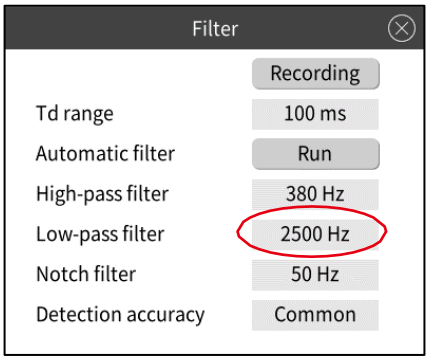
Tap the value for High-pass filter.



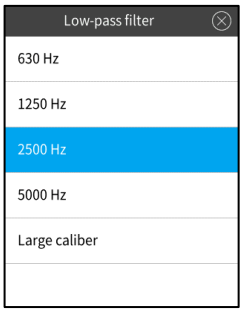
Select a high pass filter from the following alternatives.

Through, 80 Hz, 180 Hz, 380 Hz, 800Hz, or Large caliber

Setting the Low Pass Filter



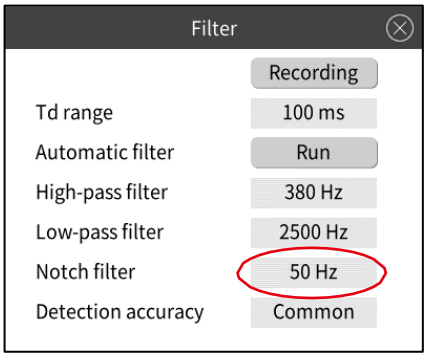
Tap the value for Low-pass filter.



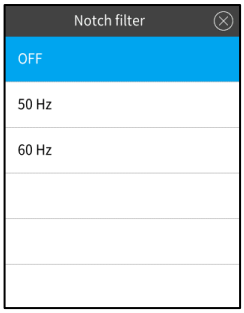
Select a low pass filter from the following alternatives.

630 Hz, 1250 Hz, 2500 Hz, 5000 Hz, or Large caliber

Setting the Notch Filter

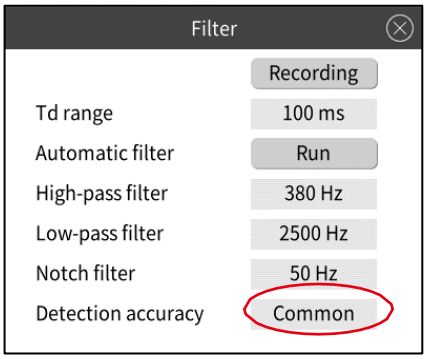


Tap the value for Notch filter.



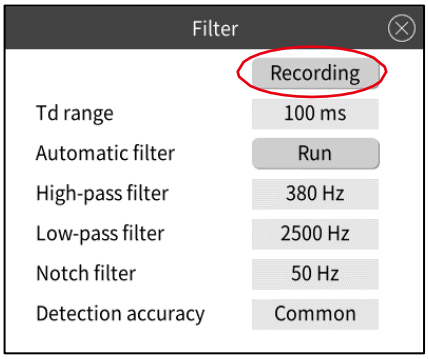
Select a notch filter from the following choices.
OFF, 50 Hz, or 60 Hz

Setting the Detection Accuracy



The detection accuracy can be set to Common or High precision. The default setting is Common. Tap Common to change it to High precision.

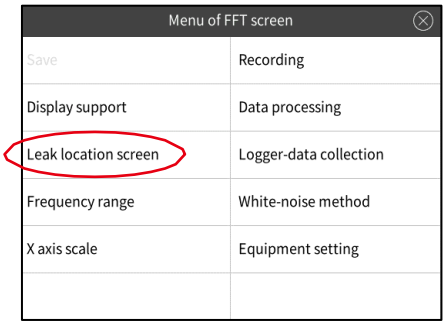
Starting Recording



Tap Recording to start recording with the filters you set.

<Correlation processing>

Press the menu switch  .

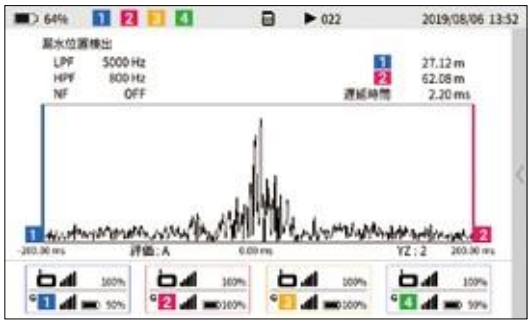


Tap Leak location screen under Menu of FFT screen.

Press the correlation switch  .

Switching between Multiple and Single Correlation

When the correlation screen opens, either the multiple correlation screen or the single correlation screen is displayed.



Tap the graph area to switch between the single correlation screen and the multiple correlation screen.

Zooming and Moving the Cursor on the Single Correlation Screen

① Zoom out along the X axis (horizontal axis)
② Zoom in along the X axis (horizontal axis)
③ Zoom out along the Y axis (vertical axis)
④ Zoom in along the Y axis (vertical axis)
⑤ Move the cursor far to the left
⑥ Move the cursor to the left
⑦ Move the cursor to the right
⑧ Move the cursor far to the right

Starting and Stopping Correlation Processing

Press the correlate switch  to start a new correlation or stop the correlation.

Because correlation and FFT processing are done in parallel, it is possible to switch back and forth to FFT processing without stopping correlation processing.

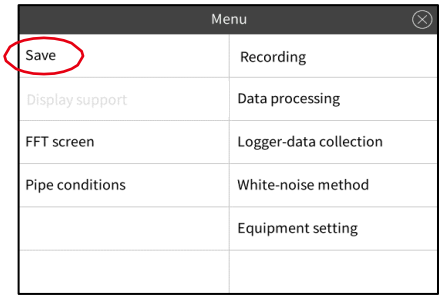
Pausing and Resuming Correlation Processing

Press the return switch  to pause processing.

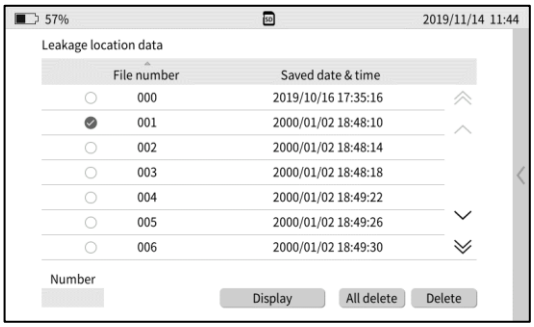
Tap the right edge of the correlation screen to display the quick menu.
Tap the triangular playback icon to start correlation processing.
Tap the pause icon to pause processing.

Saving Correlation Data

Tap the right edge of the correlation screen to display the quick menu.
Tap the SD card icon to save the data under the number that is shown.



If you want to specify where to save the data, press the menu switch .
Tap Save under Menu.



A list of file numbers appears.
Tap the number you want to save the data under, or enter a number in the Number box, and then tap the Save button.

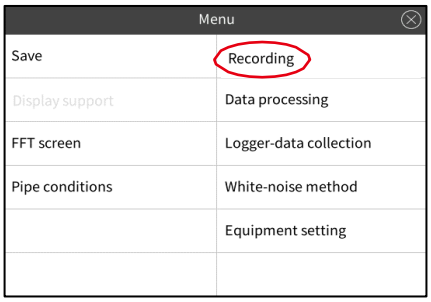
Recording Sound Data

You can record sound data during correlation processing.

To start recording with the filters you set, tap the right edge of the correlation screen to display the quick menu.

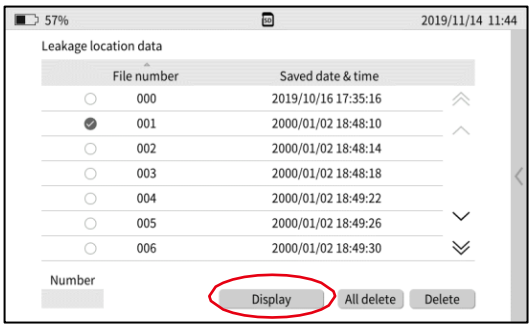
Tap the recording icon to start recording from the point you tapped.

The data is saved in the next available file number, which is shown on the screen. Recording ends after 300 seconds or when correlation stops.



If you want to record without filtering, press the menu switch .

Tap Recording.

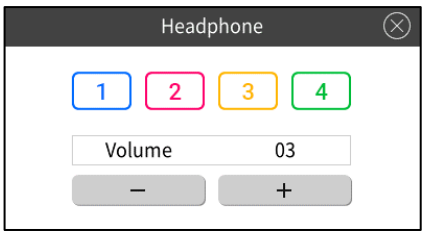


A list of file numbers appears.

Tap the number you want to save the data under, or enter a number in the Number box, and then tap the Recording button.

Listening for Leaks

To listen to the sound of each pre-amplifier from the headphones connected to the main unit, tap the right edge of the correlation screen to display the quick menu.



Tap the icon corresponding to the headphone you want to listen to.
You can adjust the volume you hear from the headphones by tapping + or -.

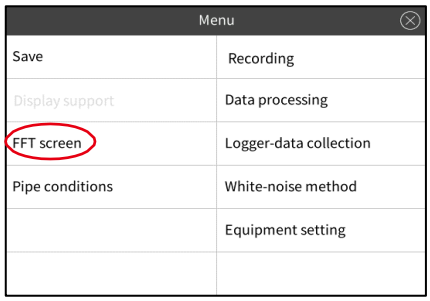
Caution

- When listening to sound through headphones, make sure the volume is not high enough to damage your ears.

<FFT Processing Settings>

This function performs FFT (Fast Fourier Transform) processing.
For an explanation of FFT, see “8-1 Definitions” on p. 90.

Press the menu switch  in the phase correlation processing screen.



Tap FFT screen.

Switching between Multiple and Single FFT
This operation is the same as for correlation processing.
See p. 45.

Zooming and Moving the Cursor on the Single Correlation Screen
See p. 46.

Starting and Stopping FFT Processing
This operation is the same as for correlation processing.
See p. 45.

Pausing and Resuming FFT Processing
This operation is the same as for correlation processing.
See p. 45.

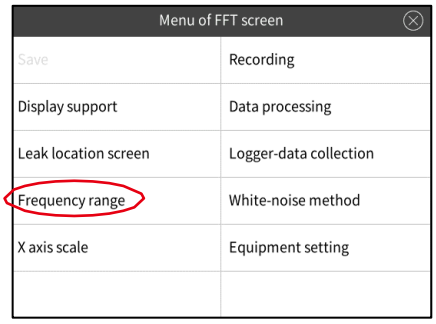
Saving FFT Data
This operation is the same as for correlation processing.
See p. 45.

Recording FFT Data
This operation is the same as for correlation processing.
See p. 45.

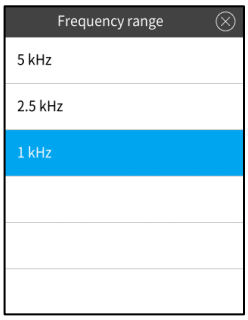
Listening for Leaks
This operation is the same as for correlation processing.
See p. 49.

Changing the Frequency Range

Press the menu switch .



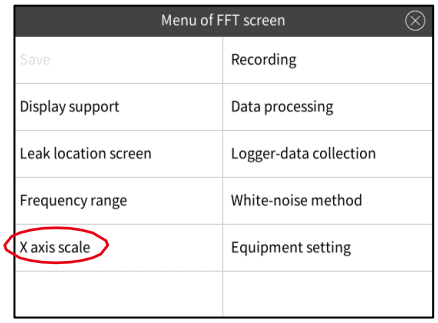
Tap Frequency range.



Select a frequency.

Changing the Graph Display

Press the menu switch .



Tap X axis scale.

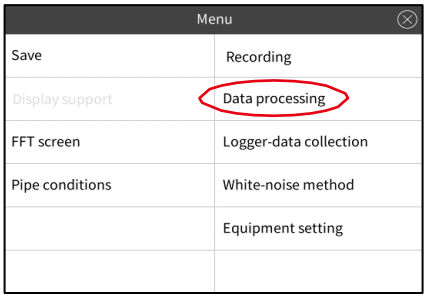
Select an X axis scale.

<Data processing>

These operations are for processing the stored correlation data, recorded data, waveform data, or white noise data, or for initializing the SD card.

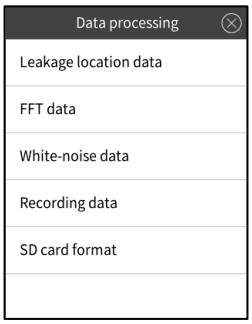
Attaching Check Marks to Data

Press the menu switch .

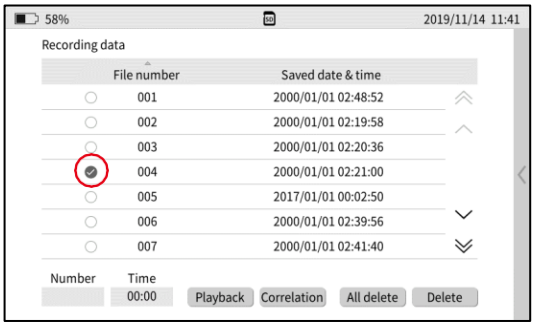


You can attach check marks to saved data files to identify them as important.

Tap Data processing.



Select the content to be processed.

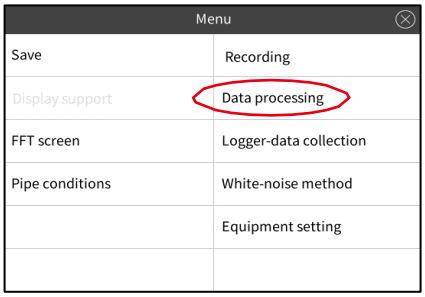


Tap the file you want to attach a check mark to, or enter its file number in the Number box. A check mark will appear next to the file.
To remove the check mark, tap again or enter the file number again.

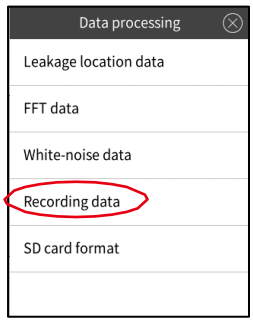
Playback and Correlation of Recorded Data

This function lets you can listen to the data recorded on the main unit with headphones. It also enables correlation processing.

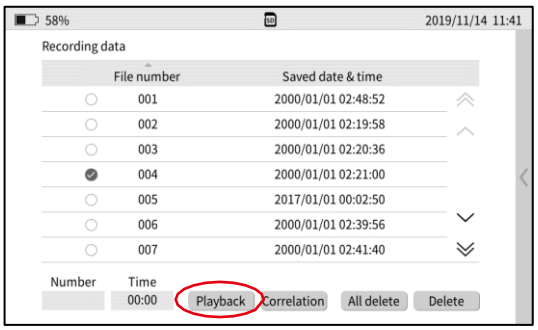
Press the menu switch .



Tap Data processing.



Tap Recording data.



Tap the file or enter the file number in the Number box and then tap the Playback button or the Correlation button.

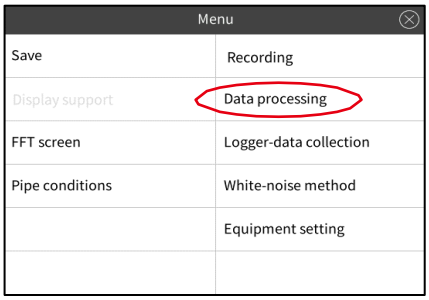
For details on configuring the pre-amplifier so you can listen from the headphones during playback, see "Listening for Leaks" under "4-7 Explanation of Equipment Settings and Operations" on p. 49.

In the case of correlation processing, correlation is performed with the filter conditions and pipe conditions set in the main unit.

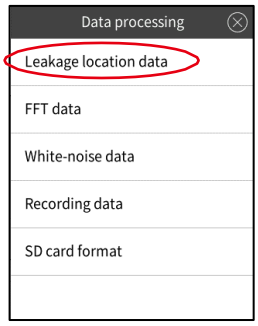
The results of the correlation processing should be saved in the same way as the real-time correlation processing.

Graphing the Leakage Location Data

Press the menu switch  .

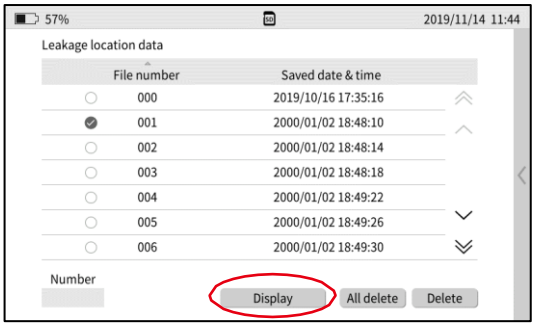


Tap Data processing.



Tap Leakage location data.

* The same procedure is used to graph the FFT data and white noise data.



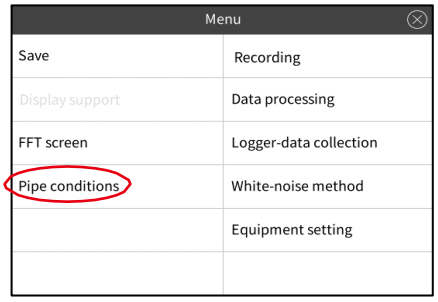
Tap the file or enter the file number in the Number box to be graphed and then tap the Display button.

A graph is displayed based on the saved data. Zooming and cursor operations can be performed in the same way as common correlation.

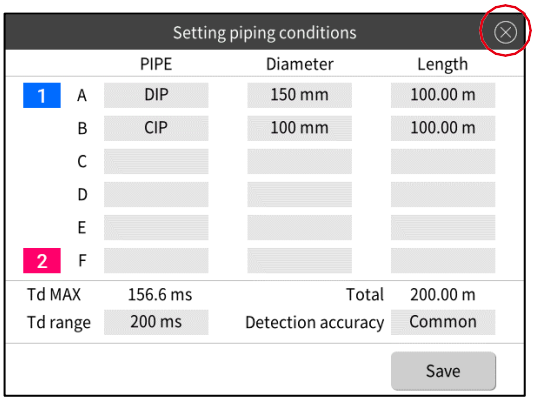
Recalculating the Leakage Location Data

You can change the pipe length in the saved leakage location data and recalculate the distance to the leak location.

Press the menu switch  .



Tap Pipe conditions.

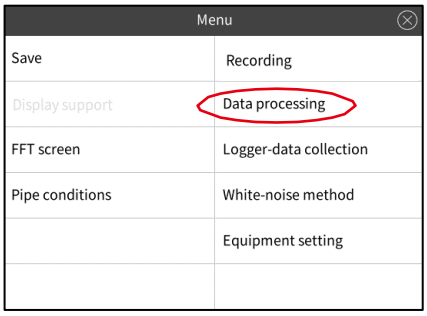


Change the length in the displayed pipe conditions. When you are done, click × in the top right to close the Setting piping conditions screen.

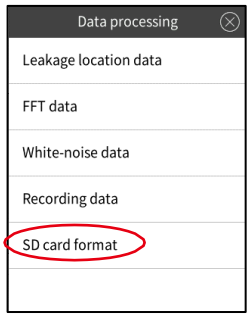
The distance to the leak location is recalculated and displayed with the total length condition changed. The method for saving changes is the same as for normal correlation.

Formating the SD Card (Class 10)

Press the menu switch  .



Tap Data processing.



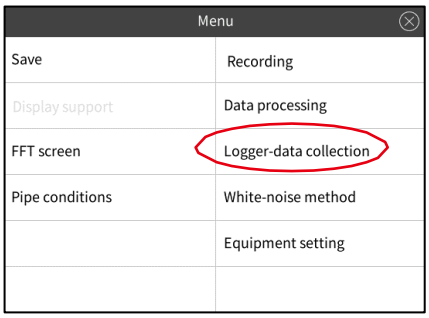
Tap SD card format.

Tap OK on the Confirmation screen.

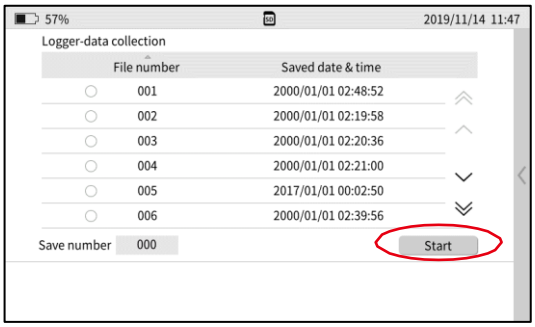
<Logger-data collection>

This function collects the recorded data stored on the pre-amplifier and saves it to the main unit.

Press the menu switch  .



Tap Logger-data collection.

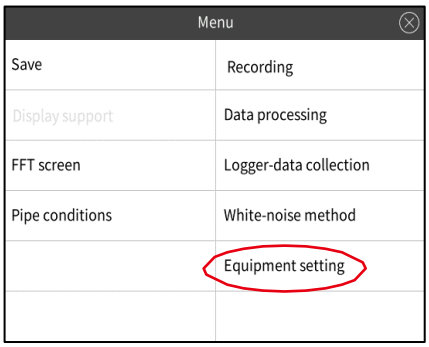


Tap the file you want to save the data or enter the file number in the Number box and then tap the Start button.
The recorded data is collected from the connected pre-amplifier via wireless communication.
When the collection is finished, you will be returned to the previous screen.

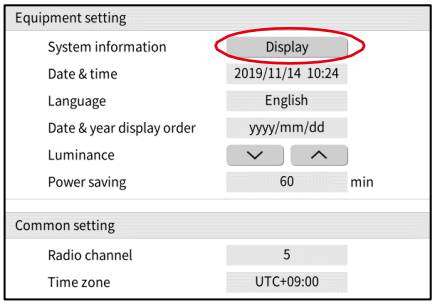
<Equipment setting>

System information

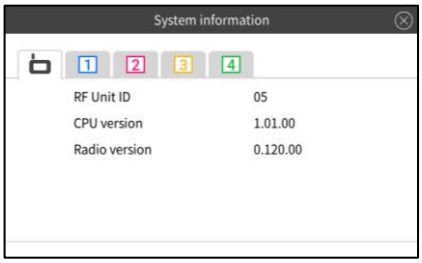
Press the menu switch  .



Tap Equipment setting.



Tap the Display button.

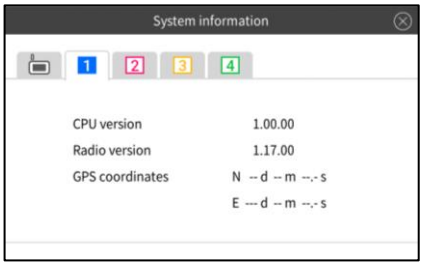


Information on the main unit is displayed.

RF Unit ID: Number related to the country of use

CPU version: Firmware version of the main unit

Radio version: Radio firmware version



Tap a pre-amplifier icon to display the information for that pre-amplifier.

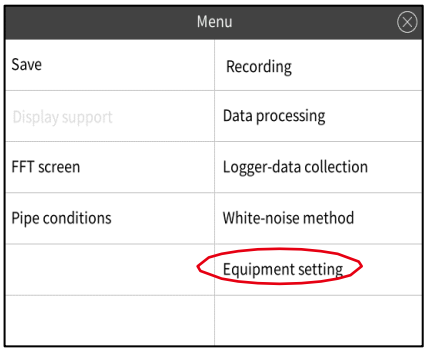
CPU version: Firmware version of the main unit

Radio version: Radio firmware version

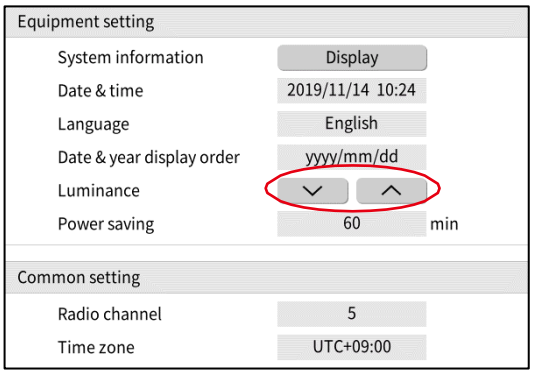
GPS coordinates: Latitude and longitude information

Luminance Setting

Press the menu switch .



Tap Equipment setting.



Tap the Luminance up/down buttons.

Up: brighter.

Down: darker.

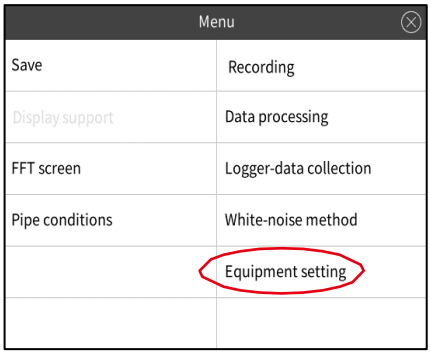
Power Saving Setting

This function reduces the screen brightness after the specified time has elapsed to reduce battery consumption.

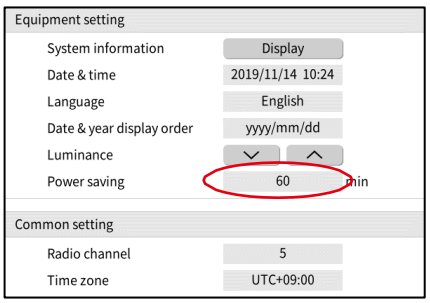
Tap the screen or press an external switch to return to normal brightness.

Set the length of time before power saving mode takes effect.

Press the menu switch  .



Tap Equipment setting.

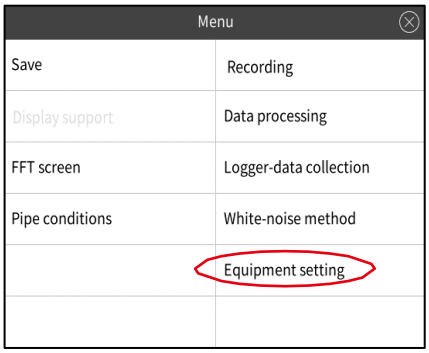


Tap the Power saving box.

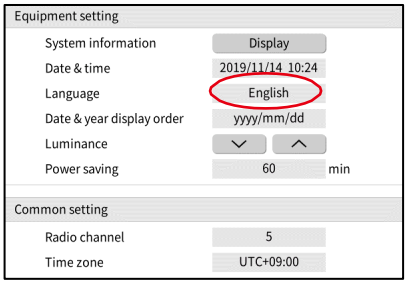
Configure the setting on the make changes screen, and then tap the × in the upper right corner.

Language Setting

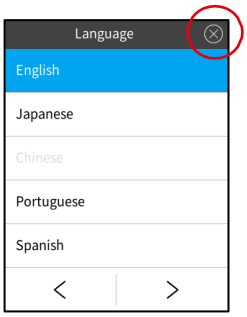
Press the menu switch  .



Tap Equipment setting.



Tap the Language box.



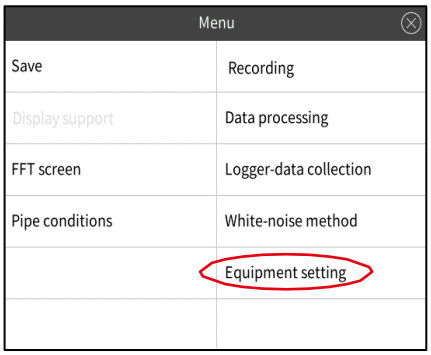
Configure the setting on the make changes screen, and then tap the × in the upper right corner.

Changing Radio Channel

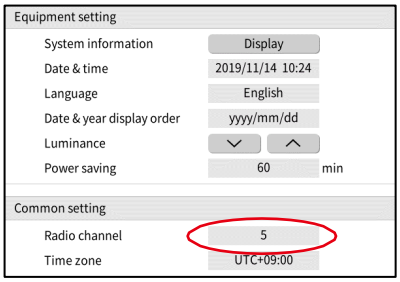
This function lets you use a different radio channel.

The wireless connection is temporarily interrupted while changing the radio channel connecting the pre-amplifier to the main unit.

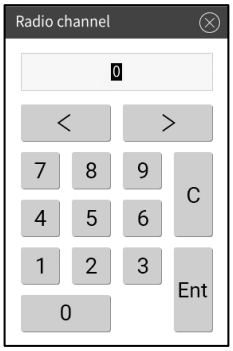
Press the menu switch  .



Tap Equipment setting.



Tap the Radio channel box.



Configure the setting on the make changes screen, and then tap the × in the upper right corner.

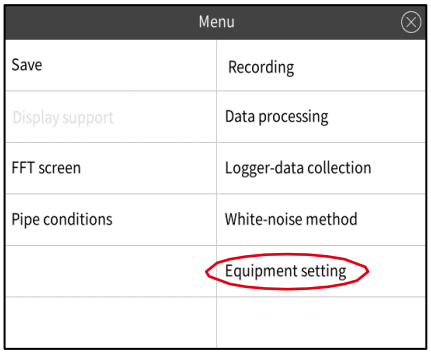
The radio channel displayed on this screen is the one used by the main unit.

If the pre-amplifier has not established a wireless connection to the main unit, you can identify the radio channel being used by the pre-amplifier by checking the LED illumination pattern at startup.

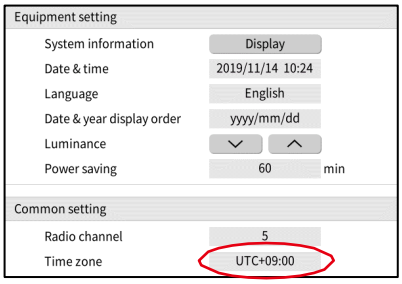
Change Time Zone

The date and time obtained from GPS is based on UTC (Coordinated Universal Time).
When using the logger mode of the pre-amplifier, you need to set the time zone.
If the time zone is set incorrectly, recording will not start at the desired time.
Use the instruction manual or the Internet to set the appropriate time zone.

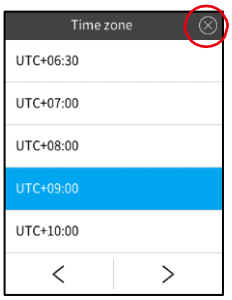
Press the menu switch  .



Tap Equipment setting.



Tap the Time zone box.



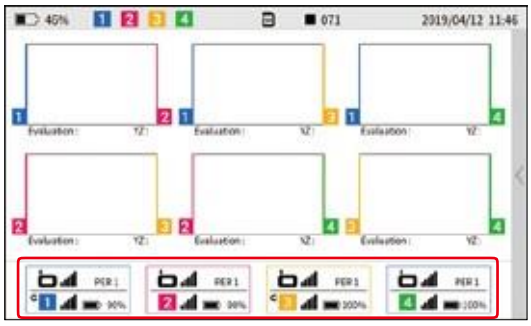
Configure the setting on the make changes screen, and then tap the × in the upper right corner.

5. How to Detect Leaks

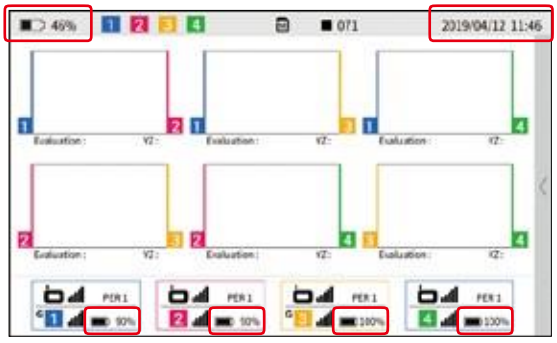
① Turn on the pre-amplifiers.

② Turn on the main unit.

③ Verify that the pre-amplifier icons are lit.



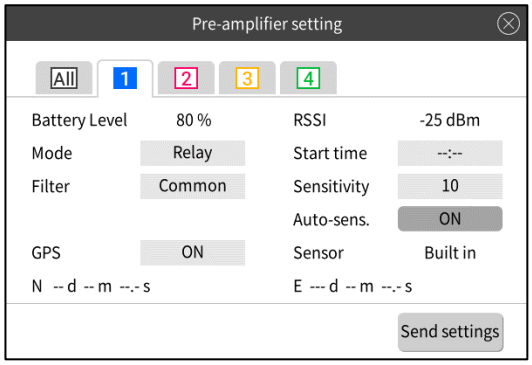
④ Check the battery level and date and time of the main unit and pre-amplifiers.



To change the date and time, see “3-6 Date and Time Adjustment” on p. 25.

⑤ Press the pre-amplifier switch  .

⑥ Set the pre-amplifier operation mode, filter, sensitivity, GPS, and other conditions.



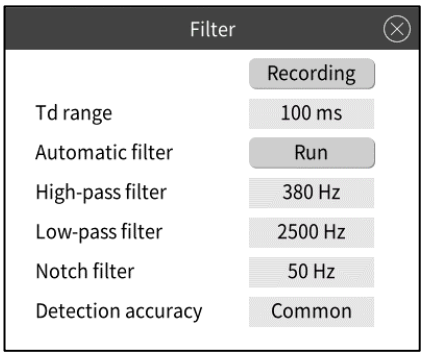
For details on configuring the pre-amplifier, see "Pre-Amplifier Settings" under "4-7 Explanation of Equipment Settings and Operations" on p. 35.

⑦ Install the pre-amplifier on the valve etc. at the installation location.

⑧ Press and hold the sensitivity up or down switch on the pre-amplifier to perform automatic adjustment.
If you are unable to press the sensitivity switch on the pre-amplifier, turn on "Auto-sens." in the pre-amplifier settings on the main unit and then tap Send settings.

⑨ Verify that the pre-amplifier icon on the main unit is lit, and then press the filter switch  .

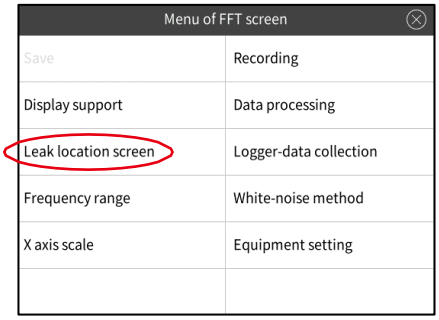
⑩ Configure the Td range, automatic filter, and other settings.



For details on configuring the filter, see "Filter Setting" under "4-7 Explanation of Equipment Settings and Operations".

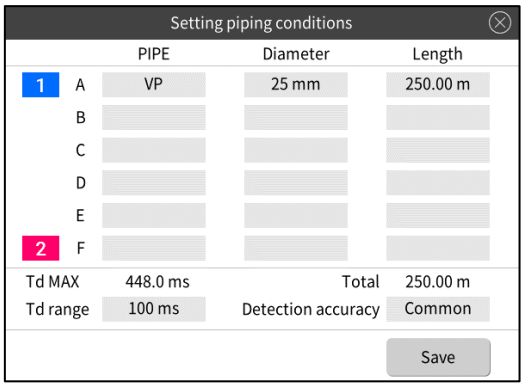
⑪ Press the menu switch  .

⑫ Tap “Leak location screen” to switch from the FFT display to the leak location screen.



⑬ Verify that the pre-amplifier icon is lit, and then press the Setting piping conditions switch  .

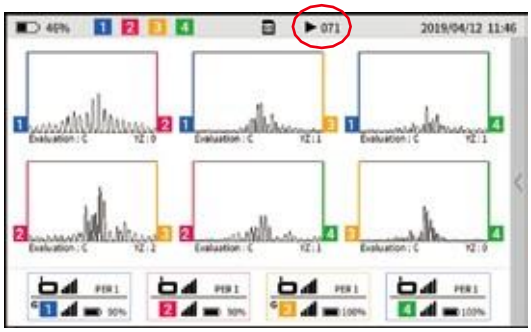
⑭ Set the material, diameter, length, etc.



For details on configuring the pipe conditions, see "Setting piping conditions" under "4-7 Explanation of Equipment Settings and Operations" on p. 38.
The pipe information can be set later if necessary. Suspend correlation processing, set the pipe information, and then restart correlation processing. It is also possible to reset the pipe information after saving it. The saved data other than the pipe information cannot be modified.

⑮ Verify that the pre-amplifier icon on the main unit is lit, and then press the correlation switch  .

⑯ Correlation processing starts and the screen is updated.
The number next to the SD card icon is the number of additions.



⑰ Press the correlation switch  to stop correlation processing.
For details on saving the data, see "Saving Correlation Data" under "4-7 Explanation of Equipment Settings and Operations" on p. 47.

(1) Using the pre-amplifiers to listen for leaks

Connect the headphones to the headphone jack to listen for leakage sound.
To avoid damage to your ears, do not wear the headphones when connecting them to the headphone jack.

(2) Listening on the main unit

① Connect the headphones to the main unit and verify that the headphone icon is displayed on the screen.
To avoid damage to your ears, do not wear the headphones when connecting them to the headphone jack.

② When you put on the headphones, you will hear the sound from the pre-amplifier number that is displayed inside the headphone icon.

For details on listening for leaks on the main unit, see "Listening for Leaks" under "4-7 Explanation of Equipment Settings and Operations" on p. 49.

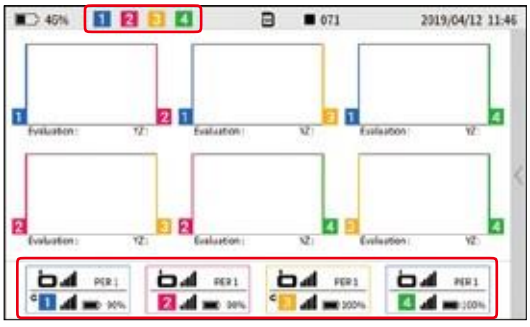
5−3 From Configuration of Logger Mode to Completion of Measurement

Work outdoors to get the signal directly from the GPS and adjust the time.
A location that is away from roofs or buildings and open to the south is recommended to reduce the time it takes to complete the sync (at which point the GPS LED illuminates). Also, because the GPS is located directly under the switch, if it is covered or if you check it continuously, the sync may take longer to complete.

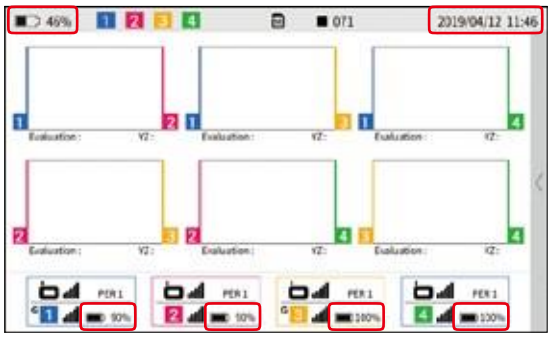
① Turn on the pre-amplifiers.

② Turn on the main unit.

③ Verify that the pre-amplifier icons are lit.



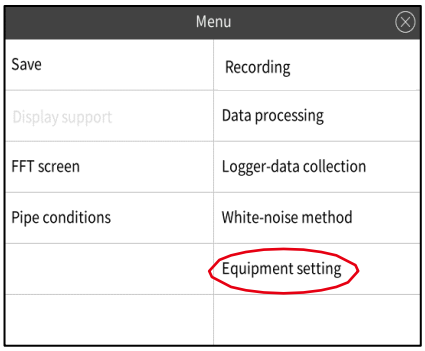
④ Check the battery level and date and time of the main unit and pre-amplifiers.



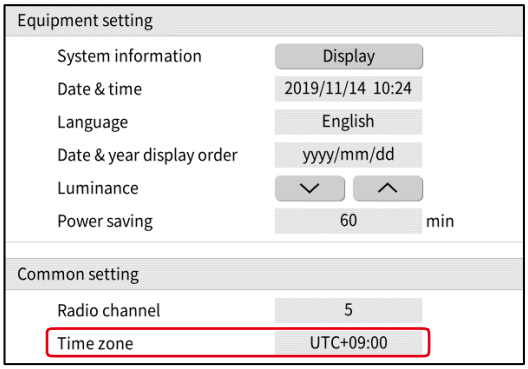
To change the date and time, see “3-6 Date and Time Adjustment” on p. 25.

⑤ Press the menu switch  .

⑥ Tap Equipment setting.



⑦ Check the time zone.



The date and time information obtained from GPS is based on UTC (Coordinated Universal Time). Set the time zone that meets to your local time. If this setting is incorrect, recording will not start at the set time because the time on the pre-amplifier and main unit will not match the triggering GPS signal.

⑧ Press the pre-amplifier switch  .

⑨ Select the All tab on the pre-amplifier setting screen.

⑩ Set GPS to ON and the operation mode to logger mode.

⑪ Set the filter and the recording start time.

For details on configuring the pre-amplifier, see "Pre-amplifier setting" under "4-7 Explanation of Equipment Settings and Operations" on p. 35.

It is not necessary to set the sensitivity because the sensitivity is automatically adjusted before recording starts.
When setting the recording start time, remember to take into account the time required to install the logger.
Note that the logger's circuitry starts up approximately 1 minute before the recording start time in order to perform various adjustments.

⑫ Verify that the GPS LED on the pre-amplifier is lit.
When it is lit, the sync with GPS is complete and measurement is possible.

⑬ After sending the pre-amplifier settings, press the pre-amplifier switch  again and verify that the settings of each pre-amplifier are correct.

Ten minutes after the settings are sent, the pre-amplifier enters recording standby mode and the settings can no longer be changed wirelessly. Once the pre-amplifier is in standby mode, it is necessary to start again from ① to change the settings.

⑭ Verify that all the LEDs on the pre-amplifier are lit.
If all the LEDs are lit, the transition to logger mode was successful.
If there is a pre-amplifier that is not lit, try setting the pre-amplifier again.

⑮ Turn off the main unit.

When the main unit is turned on, the main unit and the pre-amplifiers communicate wirelessly.

⑯ The pre-amplifier circuit is activated, the sensitivity is automatically adjusted, and then recording starts 1 minute after the automatic adjustment.

If the main unit is on, the pre-amplifier recording will not start.

⑰ After 5 minutes of recording, the post-processing starts.
The post-processing tries to acquire a 1-second timing pulse with GPS and acquire the time delay information. If it is not possible to acquire a 1-second timing pulse, it tries to acquire the GPS signal by cycling the power on and off.

⑱ When the lamps other than the power LED turn off, press and hold the power switch to turn off the pre-amplifier.

Recording and acquisition of correction information for improving correlation accuracy have been completed.

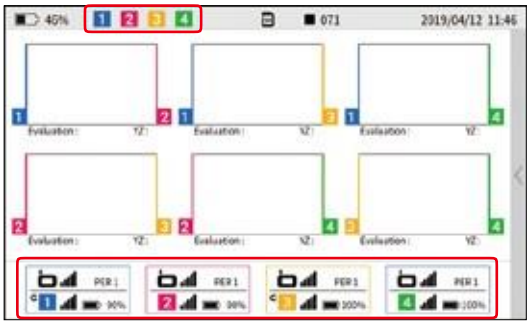
5−4 Collection of Recorded Data

Transfer the data recorded in the pre-amplifier to the main unit.
Correlation of the transferred data can be done using the Correlation function (correlation from recorded data).
For details on the correlation function, see "Playback and Correlation of Recorded Data" under "4-7 Explanation of Equipment Settings and Operations" on p. 53.

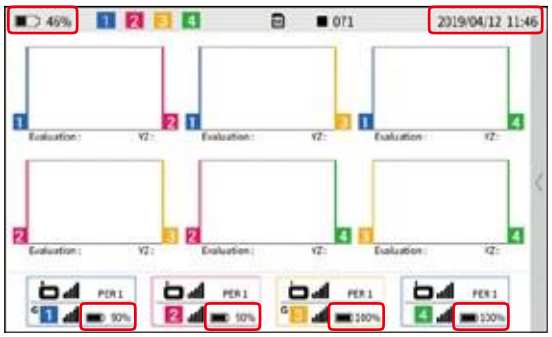
① Turn on the pre-amplifiers.

② Turn on the main unit.

③ Verify that the pre-amplifier icons are lit.



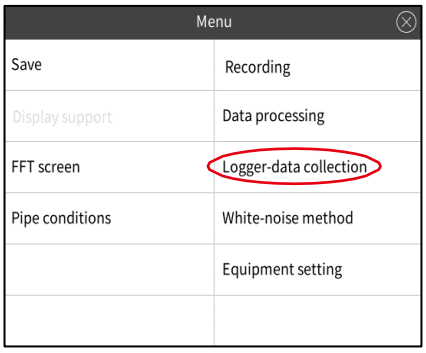
④ Check the battery level and date and time of the main unit and pre-amplifiers.



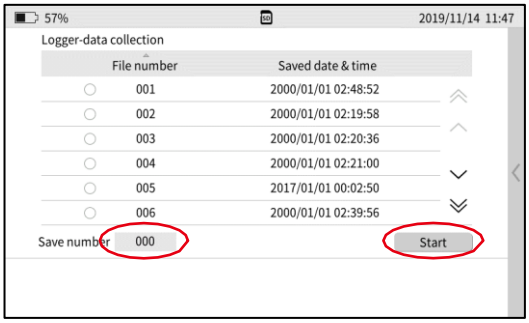
To change the date and time, see “3-6 Date and Time Adjustment” on p. 25.

⑤ Press the menu switch  .

⑥ Tap Logger-data collection.

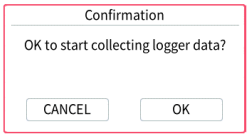


⑦ The list of recorded data is displayed. Specify the file number for saving the data and tap Start.



If you do not specify a number for saving the data, it will be saved in the next available file number.

⑧ A confirmation message is displayed. Tap OK to start collecting the recorded data.
No matter how many pre-amplifiers (1-4) are used, it takes 5 minutes to record 5 minutes.

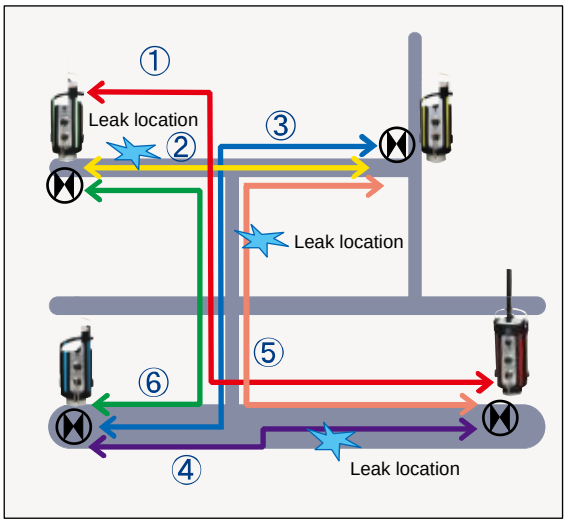


If you fail to read the recorded data after several attempts, connect the SDHC card to your computer to scan and repair the files.

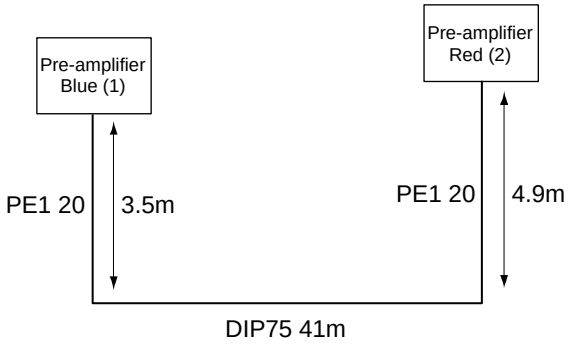
⑨ After the logger data is collected, the list of recorded data is updated.

When you are done collecting the logger data, press the menu switch to move on to other tasks.

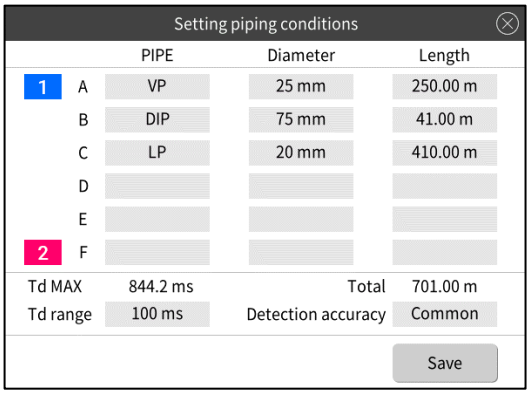
6. Techniques for Using the Equipment



Using four pre-amplifiers, correlation processing for up to six routes can be performed.



In this example, there are three types of pipes as shown in the figure at left.
The same applies when using four pre-amplifiers.



You can enter six types of pipe data into the fields A through F.

6−1 Pipe Data Handling (Main Unit)

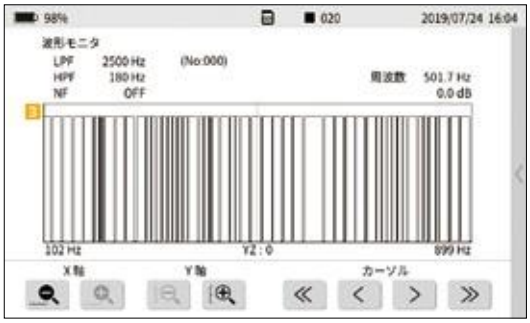
For details on entering the pipe conditions, see "Setting piping conditions" under "4-7 Explanation of Equipment Settings and Operations" on p. 38.

The types of pipe and their diameters are listed below.

Pipe material	Diameter (mm)
DIP	75 to 2600
CIP	75 to 1500
ACP	75 to 500
VP	13 to 300
LP	10 to 50
PE1	10 to 50
PE2	10 to 50
PE100	90 to 335
HPPE	50 to 300
SUS	8 to 300
SSP	13 to 50
CUP	8 to 150
SGPW	10 to 800
STPY	350 to 2000
FRPM	200 to 3000
SGPV	15 to 150

6−2 FFT Screen Function (Main Unit)

This function uses the DSP (Digital Signal Processor) on the main unit to perform FFT (Fast Fourier Transform) frequency analysis on the leak noise data obtained by the pre-amplifier.
This function can be used to analyze the frequency components of the leak sound obtained by the pre-amplifiers, which can be useful when configuring the filter settings (manually).



6−3 White Noise Method

To detect the location of a leak with the correlator, it is necessary to know the following data about the pipes: the pipe material, the pipe diameter (sound velocity), and the distance between the pre-amplifiers.
Measurement is not possible if any of the above three items are missing.

However, depending on the site, some of the pipe data may be unknown.
The white noise method is a workaround for such cases.
The white noise method can be used in the following three cases.

Required items

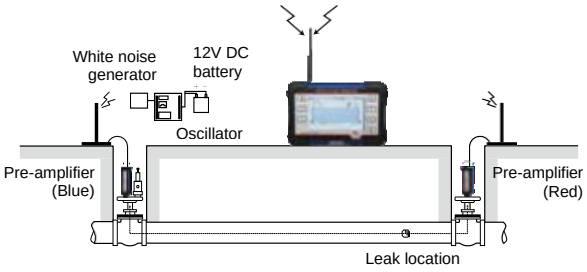
Case	Pipe material	Pipe diameter	Velocity	Distance
①	?	[?]	[?]	○
②	○	○	○	[?]
③	○	?	(Estimated value)	[?]

Using the white noise method, calculate the item identified with [?].
After calculating the unknown items, enter the pipe data.

- Principle of the white noise method -

In the white noise method, a vibration generator is installed at the same position as one of the pre-amplifiers, and the speed of sound and the distance between the pre-amplifiers are calculated from the time difference between the vibration sounds transmitted between the pre-amplifiers.

The setup for the white noise method is shown below.
Install a vibration generator (oscillator and vibrator) at the same position as one of the pre-amplifiers.



Note

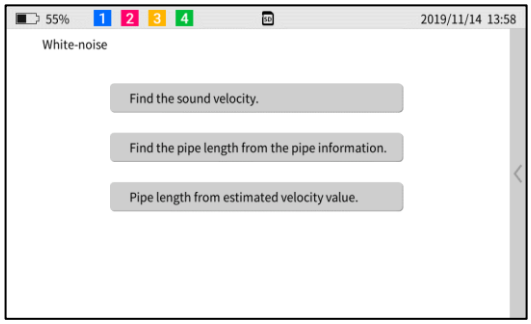
The white noise method can be used as long as the section between pre-amplifiers consists of only one type of pipe.
It cannot be used when there are multiple types of pipe.

- The vibration generator system is sold separately.
  Please contact your agent for details.
- The same procedure applies when using four pre-amplifiers.

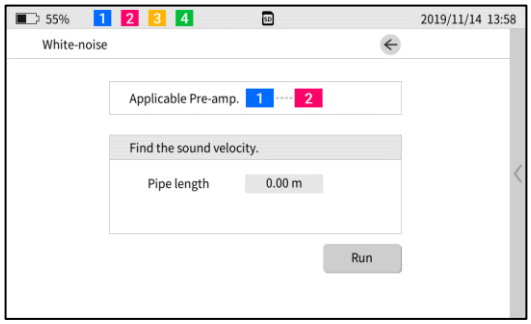
The specific procedures are explained starting on the next page.

6−3 White Noise Method

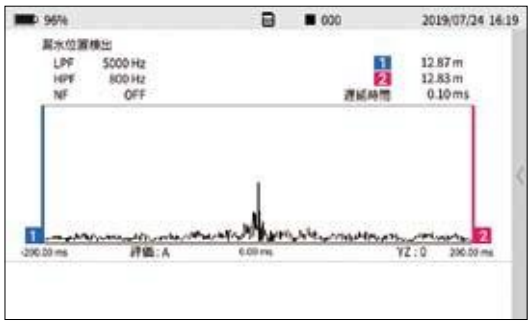
- Case ① -



Press the menu switch  .
Tap “White noise” to display the screen on the left.
Since the length of the pipe is known but the sound velocity is unknown, tap Find the sound velocity.



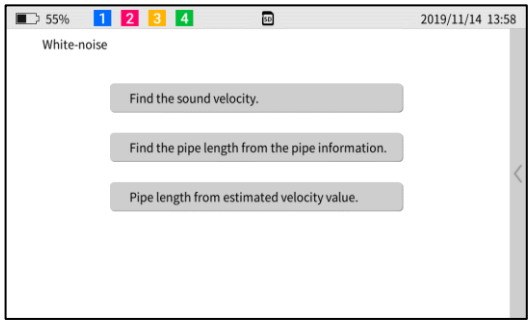
The screen on the left is displayed.
Tap the pre-amplifier to be used and enter the pipe length.
Tap "Run".



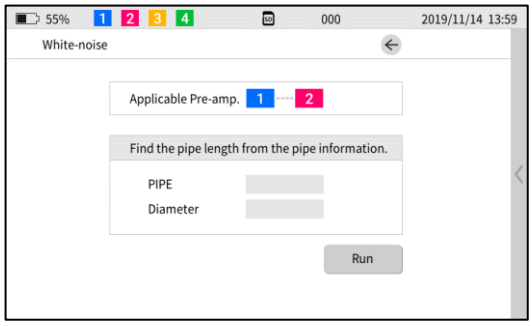
The correlation screen appears and the sound velocity is calculated.
Pause at an appropriate time and save the sound velocity value.
For details on using the correlation screen, see "Correlation processing" under "4-7 Explanation of Equipment Settings and Operations" on p. 45.

6−3 White Noise Method

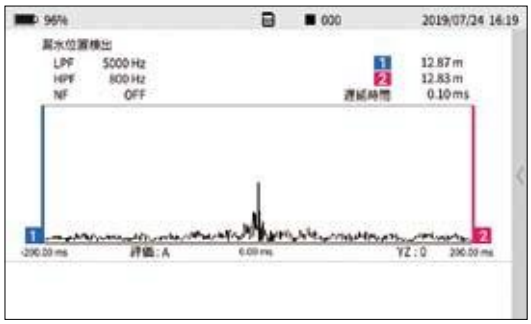
- Case ② -



Press the menu switch  .
Tap “White noise” to display the screen on the left.
Since the pipe material and pipe diameter are known but the pipe length is unknown, tap Find the pipe length from the pipe information.



The screen on the left is displayed.
Tap the pre-amplifier to be used and enter the pipe material and diameter.
Tap "Run".



The correlation screen appears. The calculated distance is displayed next to the pre-amplifier icon.
Enter this value as the pipe length in the pipe data.

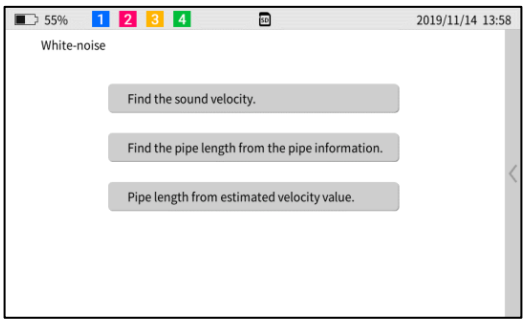
- Case ③ -

In this case, since both the pipe diameter (sound velocity) and pipe length are unknown, the sound velocity value obtained from the pipe material type is input as an estimated value to temporarily detect the leak location.

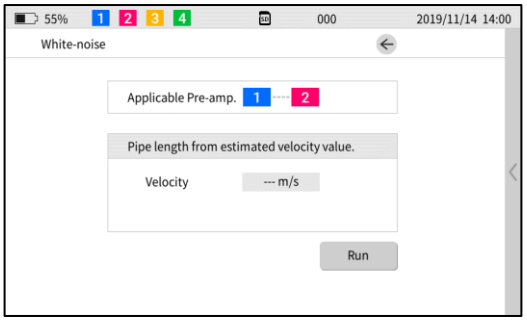
Refer to the table below for a list of sound velocities.

● In general, the speed at which the leaked sound propagates in the pipe varies depending on the material and diameter. Metal pipes allow higher velocities than plastic pipes, and if the material is the same, the sound velocity is slower for larger diameters.

Pipe material	Diameter (mm)	Sound velocity (m/s)
Ductile iron pipe (DIP)	75 to 1500	1346 to 1057
PVC pipe (VP)	13 to 500	622 to 345
Polyethylene pipe (PE1)	10 to 50	200 to 179
Polyethylene pipe (PE2)	10 to 50	360 to 341

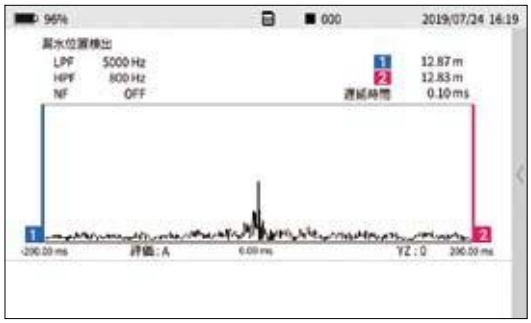


Press the menu switch  .
Tap “White noise” to display the screen on the left.
In this case, since the pipe diameter and pipe length are unknown, the sound velocity estimated from the pipe material is entered.
Tap Pipe length from estimated velocity value.



The screen on the left is displayed.
Tap the pre-amplifier to be used and enter the estimated sound velocity value.
Tap "Run".

6−3 White Noise Method



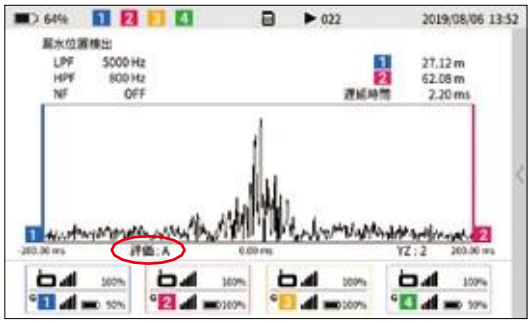
The correlation screen appears. The calculated distance is displayed next to the pre-amplifier icon. Enter this value as the pipe length in the pipe data.

> Note
>
> The distance L obtained in this way is calculated from the estimated sound velocity and therefore should be treated as an approximate value.

6−4 Leak Noise Record Function

This function lets you record and replay the leak noise data collected with the pre-amplifiers.
The frequency analysis can also be executed at the same time using the FFT screen function.
During recording and playback, you can see the frequency analysis results on the FFT screen while listening to the leak noise.

6−5 Evaluation of Detected Position



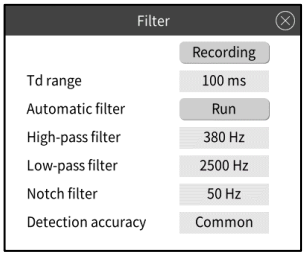
The evaluation is displayed at the lower left of the waveform graph on the leak location screen.
This is an evaluation of the degree of correlation based on the results obtained from leak detection.
The evaluation is divided into the three grades A, B, and C as follows:

A: High confidence
B: Medium confidence
C: Low confidence

The evaluation here is based only on the correlation waveform, so it should only be used as a guideline for detecting the leak location.
Even when the evaluation result is A, it does not necessarily mean that it has detected the sound of water leakage.

- The evaluation baseline is set based on experimental data from our test course.

6−6 Automatic Filter



Automatic filter is a function that automatically configures the filter settings on the main unit. This function performs an FFT calculation on the leak noise signals sent from each pre-amplifier, processes the frequency components under certain conditions, and sets an appropriate filter value. Basically, the filter value is set so that the main frequency components of the leak noise data acquired by each pre-amplifier are included.

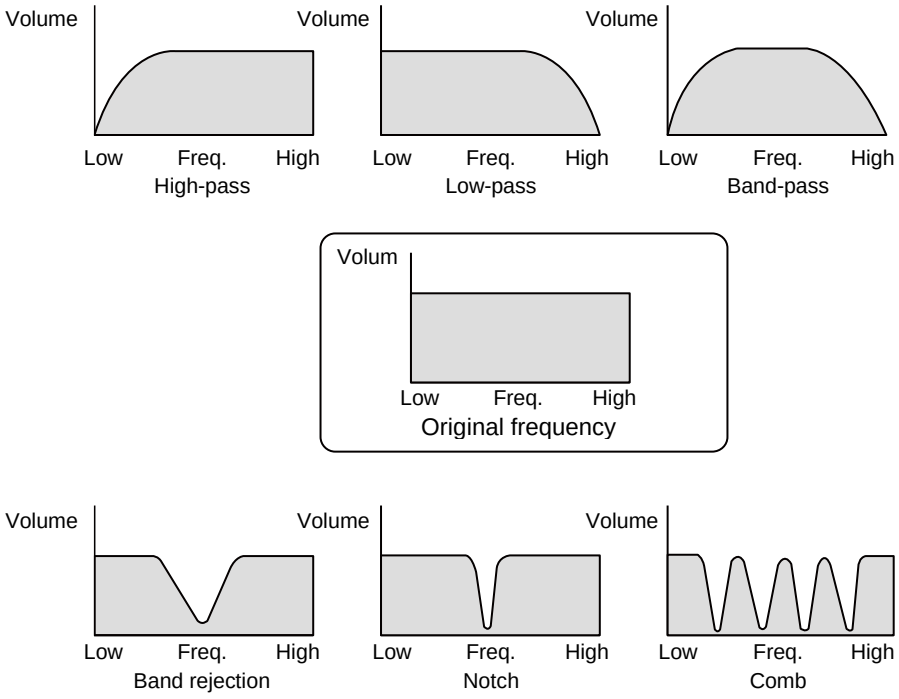
For details on auto filter configuration, see "Filter setting" under "4-7 Explanation of Equipment Settings and Operations" on p. 42.

6−7 Notch Filter

The notch filter can be set to OFF, 50 Hz, or 60 Hz.
OFF is the normal setting.
Use the notch filter when you hear a buzzing sound from your headphones or speakers, such as the sound of a power pole transformer or a compressor in a vending machine.

For details on configuring the notch filter, see "Filter setting" under "4-7 Explanation of Equipment Settings and Operations" on p. 42.

Below is a brief description of the different types of filters.
In addition to the high-pass filter and the low-pass filter, which cut off the frequency components above or below a certain level, there are various filters such as the band-pass filter (BPF) that passes only a certain frequency band, or the band rejection filter (BRF) that does not pass only a certain frequency band to some extent (this filter does not remove the relevant frequency band completely and therefore is not called a "band cut filter"). The notch filter (NF) is one type of band rejection filter that handles a narrower band. A comb filter is an aggregation of multiple notch filters.



As shown above, the notch filter is a filter that cuts only the components in a certain frequency band.
Since this leak detector uses a combination of multiple notch filters, strictly speaking this function should be called "comb filter," but here the term "notch filter" is used for convenience.
Five notch filters are applied at intervals of either 50 Hz or 60 Hz.
In 50 Hz band mode, the filters cut the harmonics in the 50, 100, 150, 200, and 250 Hz bands.
In 60 Hz band mode, the filters cut the harmonics in the 60, 120, 180, 240, and 300 Hz bands.
If the pre-amplifier seems to pick up harmonics in the 50 and 60 Hz commercial bands, try using this function to detect the leakage location.

6−8 Manual Calculation of Sound Velocity

The main unit stores the sound velocity values of various pipes in its internal memory.
The built-in values cover the basic pipe materials and diameters that are used, but might not cover all the applications that can be encountered.
In cases where the pipe conditions (material and diameter) are known but the type is not in the internal memory, the sound velocity value of the pipe can be calculated from the outer diameter, thickness, and Young's modulus (longitudinal elastic modulus).
Enter the necessary information on the Velocity calculation screen.
For details on velocity calculation, see "Sound Velocity Registration" under "4-7 Explanation of Equipment Settings and Operations" on p. 40.
For the pipe type, select Metal or Non-metal.

The reason why metal and non-metal pipes are separated is that different equations are needed to calculate the sound velocity even when the data (outer diameter, wall thickness, and Young's modulus) is the same. Refer to the relevant specifications to obtain the outer diameter, wall thickness, and Young's modulus of the pipe.

● The manufacturer of the pipe has the relevant data. Please refer to your local standard.

— Pipe types and Young's modulus —

Pipe material	Young's modulus (MPa)	Pipe material	Young's modulus (MPa)
DIP	156,906	HPPE	696
CIP	117,680	SUS	193,191
ACP	23,536	SSP	193,191
VP	3,040	CUP	124,544
LP	15,200	SGPW	210,843
PE1 (WPE50)	216	STPY	205,940
PE2 (WPE80)	804	FRPM	8,728
PE100	785	SGP-V*	205,940

* The above figures reflect FUJI TECOM's research and are given for reference purposes only.

Select Metal or Non metal, enter the outer diameter, wall thickness, and Young's modulus, and tap Registration.

● The saved data can be recalled when the pipe data is entered later.

6−9 Data Transfer to PC Using SD Card

Data (leakage location data, FFT data, and leakage noise data) is stored on the SD card.
Be sure to insert the SD card when using the correlator.
The data stored on the SD card can be processed on a PC using the dedicated software LC-50W for Windows.
Follow the instructions in the LC-50W for Windows instruction manual.

7. Storage

7−1 Storage Method

When this correlator will not be used for an extended period of time, store it according to the following procedures.

① Make sure that you have all the components including the operating instructions.

② Remove the battery.

③ Do not store the equipment in a damp place.

Storage after use

Please observe the following precautions for storage after use.

① Clean the mud and dirt from each pre-amplifier and put it in the storage case. Mud and dirt can contaminate the main unit and accessories and cause a malfunction.

② If the equipment gets wet in the rain, wipe it clean before storing it.

③ Do not put anything other than the equipment in the storage case. Otherwise, it may be damaged or lose functionality.

8. Technical Data

8−1 Definitions

This section explains the terms used in this manual.

● Correlator

A device that obtains the correlation coefficient of the signals captured by each pre-amplifier.
The pre-amplifiers send the signals from two or more locations to the main unit, which then calculates the correlation coefficient of the signals, calculates the time difference between the signals, and obtains the leakage location.

● Velocity

The leak detector displays the velocity of the sound propagating in the pipe (when it is full of water). Metal pipes allow higher velocities than plastic pipes, and if the material is the same, the sound velocity is slower for larger diameters.

● Filter

As already explained in the section on notch filters, filters are used to extract only the frequency components required for measurement.

● Td range

This is the delay time setting.
Delay time is the difference between the time it takes for one pre-amplifier to acquire a signal and another pre-amplifier to acquire it.
If there is a signal source in the center of the span between pre-amplifiers, the signal propagation times are identical and the time difference (Td) will be 0.
If the source is closer to the reference pre-amplifier, Td will be a positive value, and conversely if it is farther away, it will be negative.

● DSP (Digital Signal Processer)

A microprocessor capable of high-speed processing of digital signals such as audio, image, and video in real time.

● FFT (Fast Fourier Transform)

In technical terms, the FFT operation calculates the Fourier coefficients of the Fourier series. The leak detector digitally samples the input signal waveform, stores it as data, performs the FFT operation, and displays the result. The data acquired by the pre-amplifier is time-dependent, and it is difficult to analyze the frequencies in this kind of raw data. Performing the FFT operation makes it is possible to analyze the frequencies of signals that change over time.

* The main frequency components of the sound cannot be identified by listening to the sound obtained with the pre-amplifier. (What you can identify are changes in the signal over time.) After the FFT operation, the frequency analysis can be performed to identify the main frequency components of the signal.

● White noise

White noise refers to noise that uniformly contains all the frequency components within a certain frequency band.

● Young's modulus (longitudinal elastic modulus)

This property refers to the ability of an object to return fully to its original state once a load that was applied within a certain range is removed. This property is called "elasticity".
Within this elastic region, the displacement is proportional to the load. The relationship is expressed as follows.
$\sigma = E \cdot \varepsilon$ (where σ is the stress, E is the Young's modulus, and ε is the strain)
The proportional coefficient E is called the Young's modulus.

● LPF (Low Pass Filter)

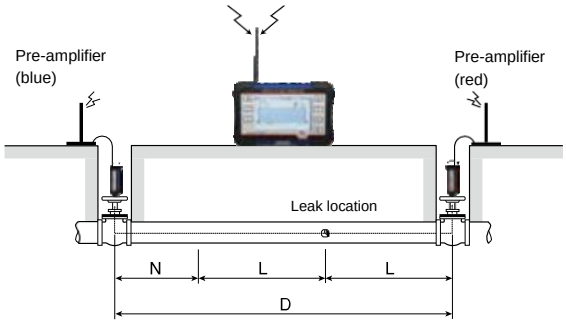
A filter that allows frequencies below a certain frequency to pass through.
When the LPF is set to 1250 Hz, frequency components below 1250 Hz are allowed to pass through the filter.

● HPF (High Pass Filter)

A filter that allows frequencies above a certain frequency to pass through.
When the HPF is set to 180 Hz, frequency components above 180 Hz are allowed to pass through the filter.

8−2 Principle of Leak Noise Correlator

Below is a brief description of the principle of the leak noise correlator.



Before the leak location can be detected, the following four conditions must be met:

① The sound from the location of the leak must reach two or more pre-amplifiers.
② The material of the target pipe must be known.
③ The diameter of the target pipe must be known.
④ The distance between the pre-amplifiers receiving the sound must be known.

If any of these conditions is not met, the leak location cannot be detected.

− Calculation of leak location −

Assume that the leak location is near the red pre-amplifier. The sound of water leakage from the leak location is first obtained by the red pre-amplifier. The sound propagates in both the red and blue directions from the leak point. The propagation speeds are identical. When the water leakage sound arrives at the red pre-amplifier at a given time, it has also traveled toward the blue pre-amplifier by distance L, which is equal to the distance from the leak location to the red pre-amplifier. The leak noise then travels the remaining distance N to reach the blue pre-amplifier.

Therefore, an additional time equal N divided by the sound velocity is required for the leak noise to reach the blue pre-amplifier (this additional time is called the "time difference"). Since the time difference is found by calculating the correlation coefficient, N can be calculated as the product of the time difference and the sound velocity.

If N is known, the distance from the leak location to the red pre-amplifier can be calculated as (D-N)/2 (note that D is known because that is one of the preconditions).

The equation is expressed as follows.

$$L = \frac{D - N}{2} = \frac{D - (V \times T_d)}{2}$$

where Td is the delay time (time difference)

8−3 Specifications of Main Unit

- Applicable standards: Protection grade IP52 (LCD surface at top)
  Radio Act (Japan)
  Vibration/Shock JIS C 60068-2-6/-2-27
  RoHS
- Storage temperature range: -25 to 60°C
- Storage humidity range: 10 to 90% RH with no condensation
- Operating temperature range: -20 to 50°C
- Operating humidity range: 30 to 90% RH with no condensation
- External dimensions: 273 mm (W) × 176 mm (H) × 82 mm (D) (excluding protrusions)
- Weight: Approx. 2.2 kg (including battery)
- Battery: Lithium ion battery
- Continuous operation time: 8 hours or more (20°C)
- Display: 7-inch TFT LCD with touch panel
- Controls: Membrane switches, touch panel
- Interface and terminals: Antenna terminal
  Headphone output
  SD card connector
  Power switch
  RS-232C cable
  Cable connector × 2
- Input: Radio input × 4
  Cable input × 2 (radio input is not possible during cable input)
- Functions
  - Correlation function
    - Calculation method: Polarity correlation
    - Delay time range: For common correlation
      ±50 ms, ±100 ms, ±200 ms, ±400 ms,
      ±800 ms, ±1600 ms, ±3200 ms
    - Delay time range: For high-precision correlation
      ±200 ms, ±400 ms, ±800 ms, ±1600 ms,
      ±3200 ms, ±6400 ms, ±12800 ms
    - Time resolution: For common correlation
      25 μs / ±50 ms range, 50 μs / ±100 ms
      100 μs/±200 ms, 200 μs/±400 ms
      400 μs/±800 ms, 800 μs/±1600 ms
      1600 μs/±3200 ms
    - Time resolution: For high-precision correlation
      25 μs / ±200 ms range, 50 μs / ±400 ms
      100 μs/±800 ms, 200 μs/±400 ms
      400 μs / ±3200 ms, 800 μs / ±6400 ms
      1600 μs / ±12800 ms

Average processing iterations:
999
High-pass filter: Through, 80 Hz, 180 Hz, 380 Hz, 800 Hz, Large caliber
Low-pass filter: 630 Hz, 1250 Hz, 2500 Hz, 5000 Hz, Large caliber
Notch Filter: OFF, 50 Hz, 60 Hz
Automatic filter
Save calculation results
Search function
Zoom function

- Pipe conditions: Pipe type, pipe diameter (XXXX mm), sound velocity (XXXX m/s), Pipe length (XXXX.XX m)
- Correlation function: WAV data correlation
- Recalculation function: Recalculation of stored data (correlation results)
- Manual calculation of sound velocity
- Automatic setting of the delay time range
- Leakage detection evaluation function grades: A, B and C
- White noise method: 2 channels (1 pair) including via relay
- FFT screen function (FFT)
  - Display channels: 1-4
  - Graph horizontal axis (frequency) display: Linear / log scale switching function
  - Frequency range: 1 kHz, 2.5 kHz, 5 kHz (common across channels)
  - Search function: Cursor
  - Zoom: Zoom function by increasing / decreasing YZ
  - Monitor screen data memory: Up to 50 data sets
- Recording function
  - Recording channels: Up to 4 channels
  - Data: 16 bit / 40 kHz, 300 seconds
- Playback function
  - Playback channels: Up to 4 channels
  - Playback: Listen through headphones (select playback channel)
    FFT screen display (all channels)
  - Data: 16 bit / 40 kHz
- Logger mode data storage
- Monitor function: Headphone output
- Clock function
- Backlight function: Display device
- Low battery OFF function
- Brightness adjustment function
- Pre-amplifier status monitoring and remote control

8−4 Specifications of Pre-Amplifier

●Applicable standards:	IP68 equivalent
	Radio Act (Japan)
	Vibration/Shock JIS C 60068-2-6/-2-27
	RoHS
●Storage temperature range:	-25 to 60°C
●Operating temperature range:	-20 to 50°C
●External dimensions:	73 mm diameter (80 mm maximum protrusion) x 183 mm (H)
	* Excluding antenna and handle
●Weight:	Approx. 1 kg
●Battery:	Lithium ion battery
●Continuous operation time:	8 hours or more (20°C) during correlation and radio communication
	24 hours or more (20°C) in logger mode
●Sensor:	Built-in, external (optional)
●Functions	
• Operation modes:	Correlation / Relay / Logger / Relay + Correlation
• Sensitivity settings:	20 (1 to 20) steps Manual / Auto
• Filter setting modes:	Common/Through
• Recording:	Audio signal recording (300 seconds, logger mode only)
• GPS function:	Transmit position coordinates and elevation to the main unit
• Cable output	
●External interfaces:	Power switch, gain switch, external sensor connector, antenna terminal, cable output connector, monitor terminal, charging connector
●Display:	Microphone displaying each status by four LED lamps (Power supply, operation mode, GPS, sensor)
●Radio	
• Transmission frequency:	920.6 MHz to 923.4 MHz band
• Number of channels:	7
• Transmission output:	500 mW

9. Troubleshooting

9−1 Troubleshooting

Use the procedures described in this chapter when trouble occurs in the operation of the leak detection system.
If the appropriate troubleshooting does not restore the equipment or the problem is not covered in this chapter, please contact your agent company.

① If the main unit does not turn on:	● Make sure the battery is inserted. ● Replace the battery with a charged one.
② If the pre-amplifier does not turn on:	● Try charging the battery.
③ If a switch or button on the main unit does not work:	● Press the switch or button firmly. Pressing the key will produce a confirmation sound.
④ If the main unit does not receive radio signals or reception is bad:	● Make sure the pre-amplifier is powered on. ● Make sure the receiving antenna is securely connected to the main unit. ● Check whether there are buildings etc. between the main unit and pre-amplifiers. These can block the radio signal from reaching the main unit. Try to bring the pre-amplifier closer to the main unit. ● The range of the radio signal is about 100 m in a place with good visibility. (Distance between main unit and pre-amplifier) ● Try placing the pre-amplifier antenna in a higher location.
⑤ If the pipe type, pipe diameter, and pipe length are unknown:	● Use the white noise method to calculate the unknown parameters. * For details see "6-3 White Noise Method" on p. 76.

Instruments for the location of underground utilities and water leaks.
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