

# FUJI DIGITAL QUATRO CORRELATOR

## LC-5000

### INSTRUCTION MANUAL



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## **Preface**

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This manual describes the Fuji Digital quatro correlator Model: LC-5000.

Before using your equipment, be sure to read this manual to comprehend proper operating and handling procedures.

## **Applicability**

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Pick-ups are mounted to the fittings such as fire hydrant, valve, or meter on the underground piping to capture the leak noise and identify the leak position.

## Precautions

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Before using this correlator, completely read and comprehend the safety notes listed below.

- Follow the instructions and procedures described in this manual to operate this instrument.
- Always observe the precautions indicated on this instrument and manual.

### <Symbols>

The following symbols are used in this manual for the purpose of warning so that you can avoid property and personal damages.

|                                                                                                  |                                                                                                                               |
|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b> | This symbol indicates the existence of a potential danger that may cause death or serious injury.                             |
|  <b>CAUTION</b> | This symbol indicates the existence of a potential danger that may cause slight or moderate injury.                           |
| <b>CAUTION</b>                                                                                   | This symbol indicates the existence of a potential danger that may cause serious damage of LC-5000 or surrounding properties. |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <ul style="list-style-type: none"><li>• While listening the leak noise with a headphone set during the operation of this unit, be completely careful since it will be difficult to hear the background sounds.</li><li>• Do not replace the batteries and/or operate this unit with wet hands.</li><li>• When the batteries have been mounted to the battery box, handle this unit with great care. If the terminals are short-circuited, heat generation, bursting, fire, and/or injury will occur.</li><li>• When inserting the batteries into the battery case, pay attention to the polarity. Incorrect polarity will result in leakage, heat generation, damage, and other troubles.</li><li>• Do not put the batteries into the fire. Otherwise, you will suffer from bursting, fire, and/or injury.</li><li>• Do not disassemble the batteries. Otherwise, you will suffer from bursting, fire, and/or injury.</li></ul> |



## CAUTION

- Do not hold the handle to swing the detector.
- Mount the battery cover certainly. Otherwise, the battery box may come off.
- Do not swing the pick-up.

## CAUTION

- Do not leave or install this unit in a hot place. Otherwise, the detector may fail.
- Use this unit only for the leak noise detection.
- This detector is not a complete waterproof model.
- Avoid immersion into water or operation in the rain.
- Do not drop the detector nor apply strong impact to it.
- Do not disassemble the detector.
- Do not touch the panel display strongly. Otherwise, the detector may fail.
- When the detector will not be used for a long period, remove the batteries.
- Do not bend the antenna by applying unreasonable force.
- Do not pull the pick-up cable unreasonably. Otherwise, the cable may be broken to dysfunction the pick-up.
- Always be aware of the ambient conditions.
- When disposing this detector, follow your local rules and regulations.

## Warranty Period

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FUJI TECOM warrants this correlator LC-5000 to be free from defects in material and/or workmanship for one (1) year from the purchase.

The written warranty is an effective tool with which FUJI TECOM can provide utmost service operations to the customer.

If this correlator fails within the warranty period, FUJI TECOM will repair it free of charge.

The repair within the warranty period needs showing the written warranty with the serial numbers of this instrument. So the customer should keep it carefully.

If the customer does not or fails to notify its serial numbers, FUJI TECOM will claim repair fees.

If this correlator fails after the expiration of the warranty period or the failure is attributable to customer's abuse, misuse, modification, and any other unauthorized actions, the repair will be non-gratuitous. Please consult FUJI TECOM for details.

# **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.

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

## 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 acceleration pick-up sensor (pipe wall)
- Coupling-type hydrophone sensor
- Wired cable (100 m reel + 2.9m connection cable)
- Additional extension antenna cable (2.5m)
- Spare rechargeable battery for main unit
- High gain antenna
- Telescopic triangular cone
- Cone adaptor for preamp extension antenna
- Carrying bag for telescopic cone and adaptor set

\*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.

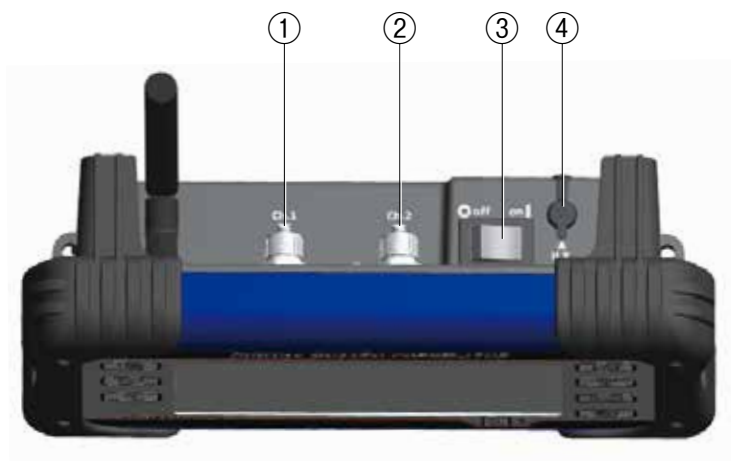
⑦ Setting pipe conditions switch

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.

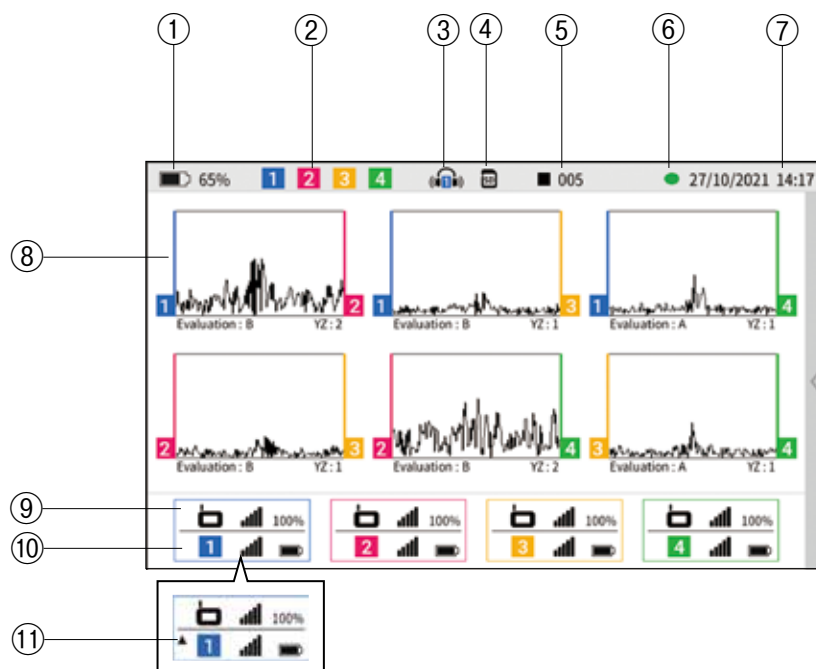
③ Power switch

Turn on the unit.

④ Headphone jack

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

## (3) main unit (LCD screen)



## ① Main unit battery level

Display the main unit battery level.

## ② Connecting pre-amplifier

Display the connecting pre-amplifier by color and number.

## ③ Headphon

Displayed when headphones are connected to the main unit or preamplifier.

## ④ SD card



SD card is inserted.



The SD card is inserted in locked state.

## ⑤ Correlation addition number

Displays the number of additions for correlation processing.

## ⑥ Radio indicator

Displayed when selected radio channel is communicable.

Green : No interference

Orange : Caution, slight interference

Off : Communication with preamplifier not Possible

## ⑦ Date and time

Displays the current date and time.

## ⑧ Correlation waveform

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

## ⑨ Data arrival rate

Indicates the data arrival rate (communication strength) between the main unit and the preamplifier.

## ⑩ Preamplifier battery level

Indicates battery level of each preamplifier.

## ⑪ Excessive input display

The excessive input state is indicated by ▲.

**Relay unit and sensor unit mark**

《When there is one large square》

1

The number inside the square indicates the preamplifier number. The large square indicates that the preamplifier operates as a sensor unit.

This figure shows that the preamplifier 1 is operating as a sensor.

《If there is a small square next to the large square》

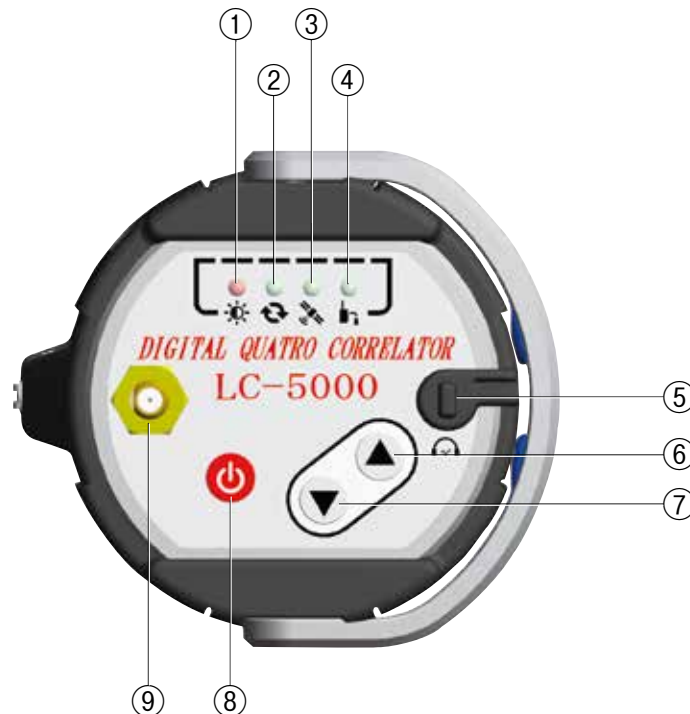
1 2

The large square indicates the relay unit or the relay unit (sensor unit + relay unit) for which the sensor unit function is set, and the small square indicates that the sensor unit is connected to the end.

This figure shows that the preamplifier 2 operates as a relay unit (including sensor unit + relay unit), and the preamplifier 1 that operates as a sensor unit is connected to the preamplifier 2.



### (1) Pre-amplifier (top panel)



① Power LED

Lights up when the power is turned on or charging.

② Mode LED

Indicates the mode of operation.

③ GPS LED

Indicates the GPS status.

④ Sensor/adjustment LED

Indicates the sensor type and adjustment in progress.

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 autoadjust 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.

## 2-3 Explanation of Pre-Amplifier LEDs

### (1) Display of LEDs during operation

#### (1) Display of LEDs during operation

| Function*1                                                                       | Power                | Mode                  | GPS      | Sensor/adjustment |        |
|----------------------------------------------------------------------------------|----------------------|-----------------------|----------|-------------------|--------|
| LED color                                                                        | Red/yellow           | Green                 |          |                   |        |
| Power OFF                                                                        | Unlit                |                       |          |                   |        |
| Battery charge warning*2                                                         | Flashing             | N/A<br>(henceforth,—) | —        | —                 |        |
| Charging*3                                                                       | Lit                  | —                     |          |                   |        |
| Radio channel display                                                            | See P.17 for details |                       |          |                   |        |
| Pre-amplifier                                                                    | Lit                  | Unlit                 | —        | —                 |        |
| Relay                                                                            |                      | Flashing              |          |                   |        |
| Logger mode                                                                      |                      | Lit                   |          |                   |        |
| GPS OFF                                                                          |                      | —                     | Unlit    |                   |        |
| GPS satellite search in progress                                                 |                      |                       | Flashing |                   |        |
| GPS coordinate acquisition+<br>unsynced                                          |                      |                       | Flashing |                   |        |
| GPS sync complete                                                                |                      |                       | Lit*6    |                   |        |
| Adjusting sensitivity                                                            |                      | Flashing or unlit     | —        | Flashing          |        |
| Built-in sensor                                                                  |                      |                       |          | Unlit             |        |
| External sensor                                                                  |                      |                       |          | Lit               |        |
| Logger mode Not recorded, not<br>ready to record, syncing                        |                      | Lit                   | Flashing | Lit*7             |        |
| Logger mode Not recorded,<br>ready to record*4                                   |                      |                       | Lit      |                   |        |
| Logger mode<br>Record (Including waiting for the<br>second and third recordings) |                      |                       |          | Unlit             | Unlit* |
| Logger mode<br>Post-recording, uncorrected                                       |                      |                       |          | Flashing          |        |
| Logger mode<br>Post-recording, uncorrected<br>(GPS searching)                    |                      |                       | Unlit    |                   |        |
| Logger mode Post-recording,<br>corrected, ready for collection*                  | Lit                  |                       |          |                   |        |
| Excessive input*2                                                                | Lit                  |                       |          |                   |        |

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

\*2 If "Battery charge warning" and "Excessive input" occur at the same time, the battery charge 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.

## 2-3 Explanation of Pre-Amplifier LEDs

(2) Radio channel

(3) Display of power LED during charging

### (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 charge 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
- (2) Opening and closing the battery cover and replacing the battery

### (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 charge the battery or 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.

Rechargeable battery

Battery cover



#### 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.27 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.

〈Sensor check〉



### Warning

Do not wear headphones at first as it may produce a loud volume. Please wear headphones after adjusting the volume in ③ below.

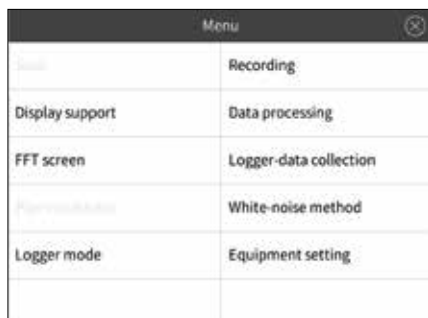
- ① Press the power switch.
- ② Connect to the preamplifier without wearing headphones.  
There may be a loud beeping sound, but proceed to ③.
- ③ To protect your ears from loud sounds, first press the sensitivity down switch to minimize the volume. Bring the headphone speaker close to your ear and lightly rub the magnet at the bottom of the preamplifier to hear the sound (If the sound is low, press the sensitivity up switch to adjust).
- ④ If you cannot hear the sound well, the sensitivity of the sensor may be reduced. Compare it with other preamps.

### (1) Main unit and pre-amplifier

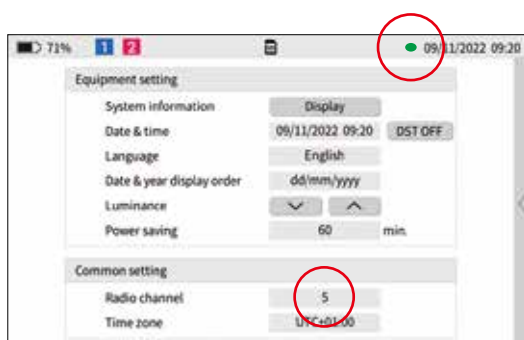
① Turn on the main unit.

② Press the menu switch 

③ Tap Equipment setting.



④ If the selected radio channel is communicable, a radio indicator will be displayed. 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.19.

If the radio channels do not match, tap the radio channel under Common setting to change it.

⑥ Verify that the main unit screen 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.

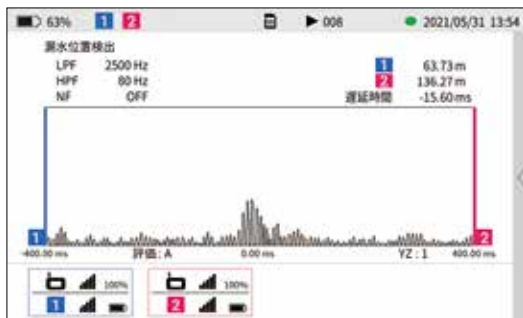


If the data arrival rate is between 0 to 50, it is possible that the radio signal is not getting through due to the surrounding environment.

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.

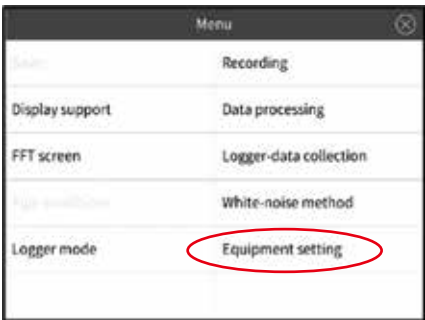
### 3-6 Date and Time Adjustment

The year, month, day, hour and minute are displayed in the upper right corner of the screen.

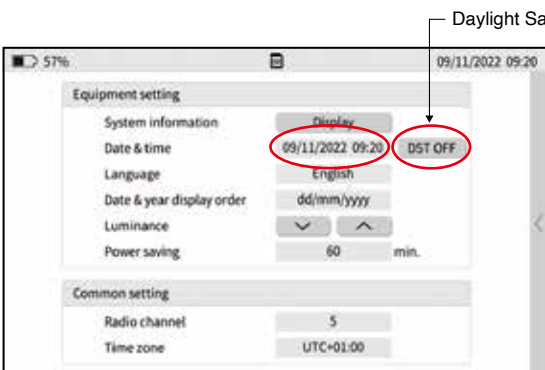
Check whether the date and time are correct.

If the date and time are incorrect, adjust them by the following procedure.

The date and time are saved together with the measurement data, so make sure they are set correctly.

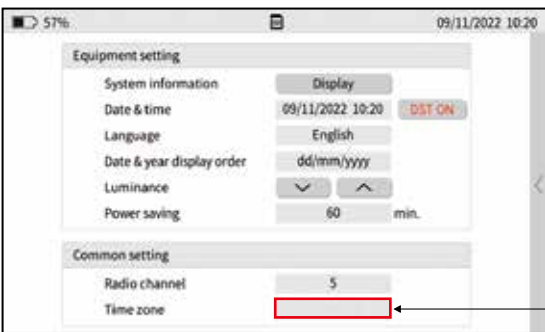


Press the main unit menu switch  .  
Tap "Equipment setting" under Menu.



Tap "Date & time" under Equipment setting.  
Tapping the Daylight Saving Time button displays DST ON and switches from normal time to daylight saving time (Figure 2).

Fig.1. Device setting screen when daylight saving time is OFF



Set the date and time on the input screen, and then tap the 'Ent' in the bottom right corner.  
When daylight saving time is set, the time advances by one hour. The difference between summer time and normal time is fixed at 1 hour.

Press the daylight saving time button again to turn daylight saving time off. (Figure 1).

Fig.2. Device setting screen when daylight saving time is ON

Unoperable when DST is ON

## 3-6 Date and Time Adjustment



Fig.3. Time setting screen when daylight saving time is OFF



Fig.4. Time setting screen when daylight saving time is ON

Set the date and time, and tap 'Ent' on the bottom right.

The time setting screen displays the current daylight saving time setting.

Please note that you cannot set DST ON/OFF from this screen. Please set the DST on the device setting screen. (Fig.1, Fig.2).

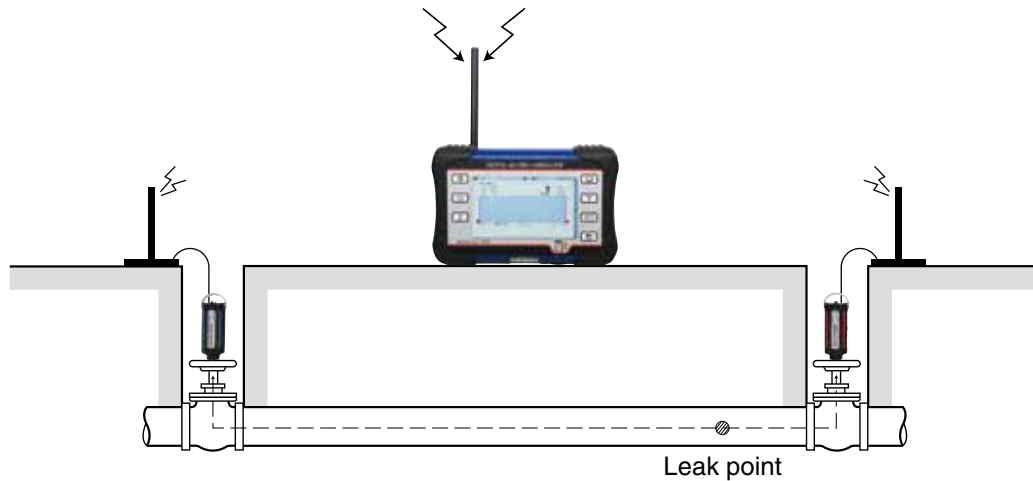
## **4. How to Use the Correlator**

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## 4-1 Radio and Cable Modes

- (1) Radio mode
- (2) Cable mode

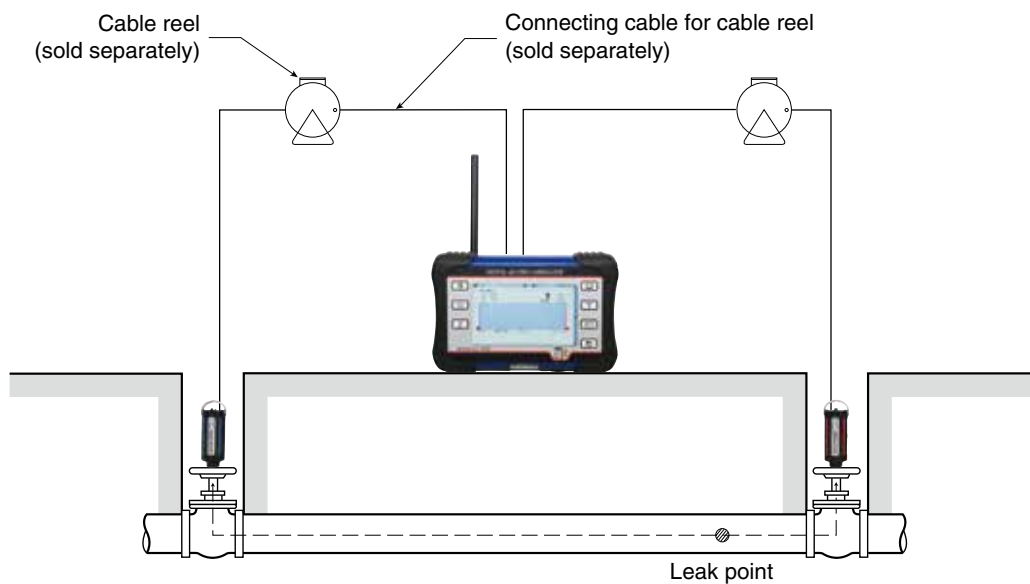
### (1) Radio mode



### (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.

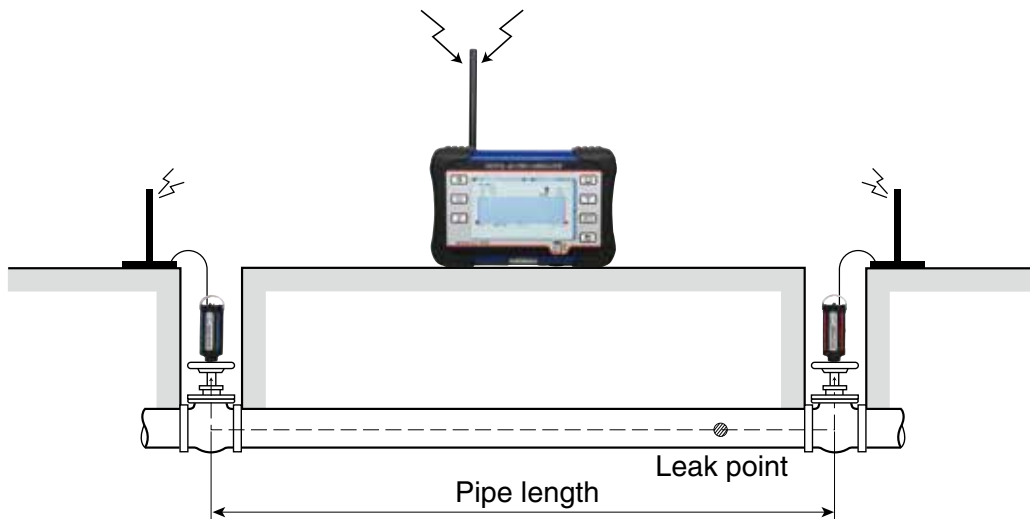


## 4-2 Example of Detecting a Leak in a Pipe

---

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. Each 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 sufficiently confirm the leak point with other leak detection equipment, confirm by boring and investigate how the pipe is buried.

- False leak noise can include the following

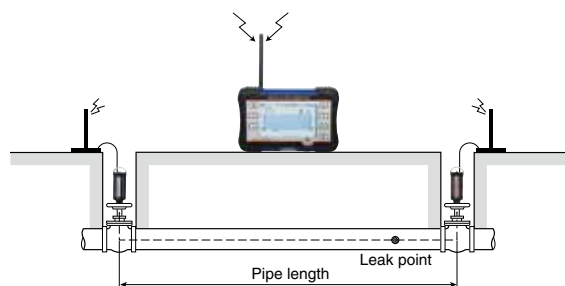
- ① The sound of friction between the pipe and running water
- ② Noise generated from sewage
- ③ Noise generated from running water by normal daily use
- ④ Mechanical noise and so on.

## 4-4 Preparations

### (1) Radio mode preparations

### (2) Cable mode preparations

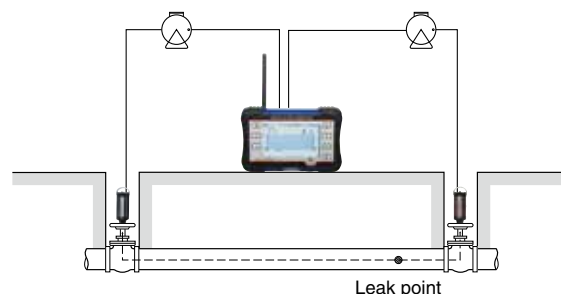
#### (1) Radio mode preparations



- 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.
- 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.
- Insert SD card into the main unit.
- Turn on the main unit and the pre-amplifiers.

#### Note:

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



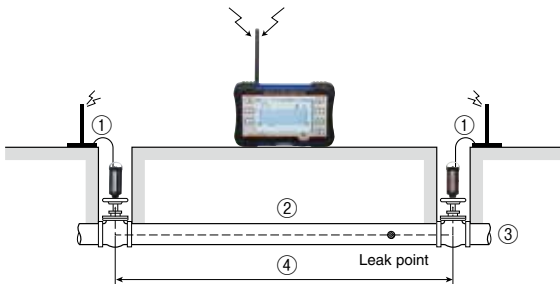
- After unspooling the cable from the cable reel, plug it into the main unit. Do not connect the cable to the main unit first, or the connecting cable may be twisted and damaged when it is unspooled from the reel.

## 4-5 Preparation at Site

- (1) Preparation of necessary conditions and data
- (2) Installation of pre-amplifiers

### (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.24.

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

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

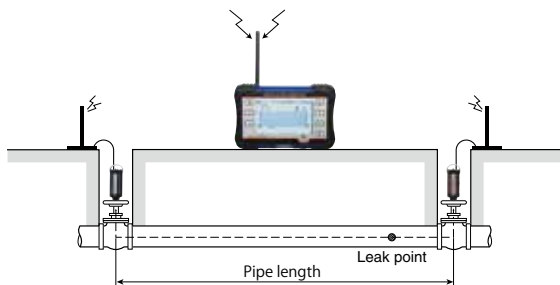
- If the antenna is immersed, the radio reach distance will be shorter. Do not immerse the antenna into water.

**Caution**

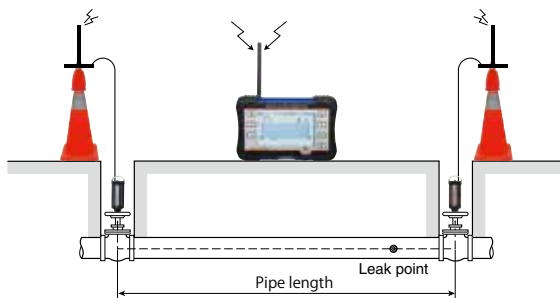
Connect the antenna and extension cable securely.

If water enters the pre-amplifier through the connectors for the antenna and extension cable, it may cause a serious failure.

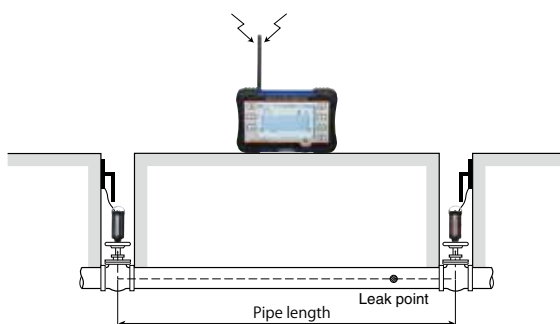
If you do not connect the antenna and extension cable, cover the connectors with the supplied caps to ensure waterproofness.

**(3) Installation of antennas**

In general, the higher the antenna is installed, the longer the radio reach distance. 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. or 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 preamplifier

##### Note

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

## 4-6 Main Unit Switches and Operation

- (1) Switches on the main unit  
(2) Touch panel operation

### (1) Switches on the main unit



Menu switch

Toggles the display of the menu on each display screen.



Help switch

Displays the help screen for the current screen.



Pre-amplifier switch

Displays 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 multiple 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 multiple FFT processing |

#### ● Other screens

Displays the multi-correlation stopped screen



Filter switch

Displays 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

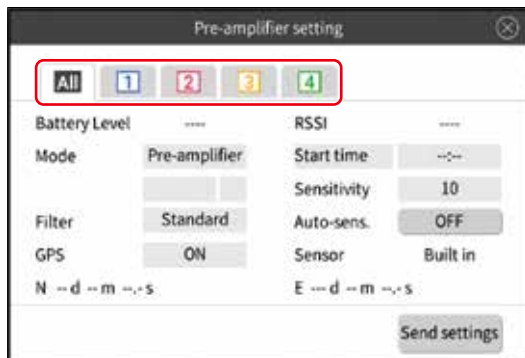
Only tap (touch and release) is supported.

If no selection is offered and you need to close the screen, tap the × in the upper right corner.



## &lt;Pre-amplifier setting&gt;

Press the pre-amplifier switch .

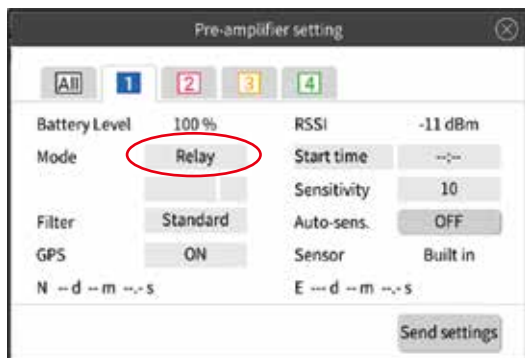


Tap the icon of the pre-amplifier to be configured.

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.

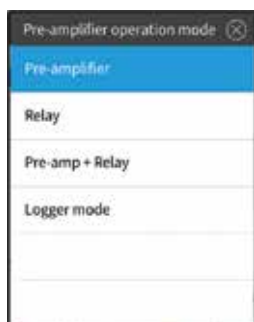
They can also be used in logger mode.

The logger mode has a quick mode and a high precision mode.

It is possible to specify the countdown timer (until the start of recording) in the quick mode and the recording start time in the high-precision mode.

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

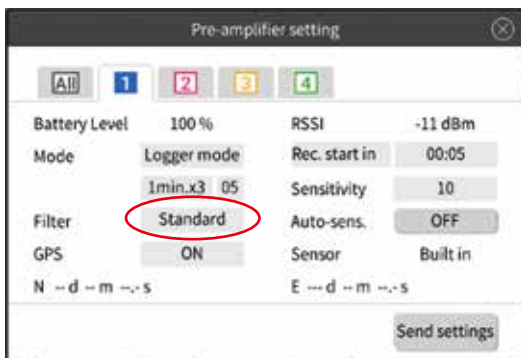
The following modes can be selected on the Pre-amplifier operation mode setting screen.



- Pre-amplifier: normal correlation mode
- Relay: No correlation or FFT display
- Pre-amplifier + Relay: Correlation and FFT are displayed
- Logger mode

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

### Filter Settings



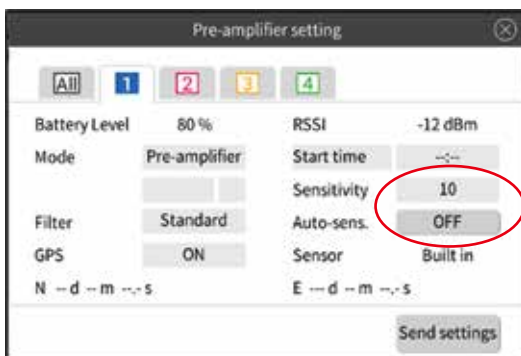
The logger has two filters available: 'Common' and 'Through'. The default setting is 'Common'.

Tap 'Common' to change it to 'Through'



Select a filter.

### Setting the Sensitivity



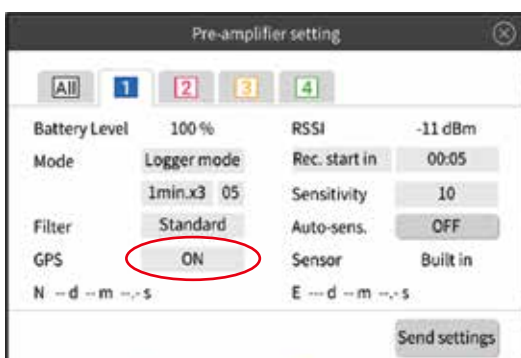
The sensitivity can be set manually and automatically.

Enter a value in 01 - 20 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.

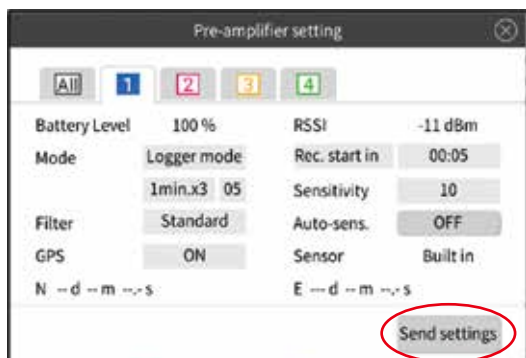
The default setting is ON.

If you do not want to use GPS, tap ON to switch it OFF.

Turn on GPS in high precision logger mode.



## Sending Settings



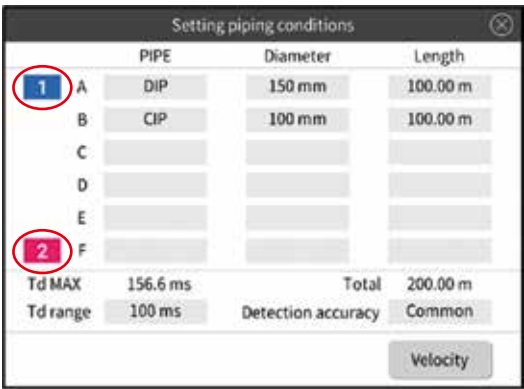
When all the pre-amplifier settings are complete, tap 'Send settings' to send the settings to the pre-amplifier.

<Setting pipe conditions>

Press the setting pipe conditions switch .

Pre-Amplifier Combination Settings

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



The 'Setting piping conditions' screen displays a table for configuring pre-amplifiers. It includes columns for 'PIPE', 'Diameter', and 'Length'. Pre-amplifiers A through F are listed. A red circle with the number '1' highlights the selection of pre-amplifier A. A red circle with the number '2' highlights the selection of pre-amplifier F. Summary statistics at the bottom show 'Td MAX' as 156.6 ms, 'Td range' as 100 ms, 'Total' length as 200.00 m, and 'Detection accuracy' as Common. A 'Velocity' button is located at the bottom right.

|          | PIPE | Diameter | Length                    |
|----------|------|----------|---------------------------|
| 1        | A    | DIP      | 150 mm                    |
|          | B    | CIP      | 100 mm                    |
|          | C    |          |                           |
|          | D    |          |                           |
|          | E    |          |                           |
| 2        | F    |          |                           |
| Td MAX   |      | 156.6 ms | Total 200.00 m            |
| Td range |      | 100 ms   | Detection accuracy Common |

Tap the icons of the pre-amplifiers.



The 'Target pre-amplifier' screen shows a list of pre-amplifier combinations. The first option, '1-2', is highlighted in blue.

| Target pre-amplifier |
|----------------------|
| 1-2                  |
| 1-3                  |
| 1-4                  |
| 2-3                  |
| 2-4                  |
| 3-4                  |

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

## &lt;Setting pipe conditions&gt;

|     | PIPE | Diameter | Length   |
|-----|------|----------|----------|
| 1 A | DIP  | 150 mm   | 100.00 m |
| B   | CIP  | 100 mm   | 100.00 m |
| C   |      |          |          |
| D   |      |          |          |
| E   |      |          |          |
| 2 F |      |          |          |

Td MAX 156.6 ms      Total 200.00 m  
Td range Automatic      Detection accuracy Common

Save

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

PIPE

- DIP
- CIP
- ACP
- VP
- LP

Select a material.

For the list of materials, see “6-1 Pipe Data Handling (Main Unit)” on p.82.

Tap ‘Delete’ to delete the information.

When a row of data is deleted, the rows below it are shifted upwards.

Diameter

- 75 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm

Select a diameter.

For the list of diameters, see “6-1 Pipe Data Handling (Main Unit)” on p.82.

Length

019.20 m

0 1 2 3 4 5 6 7 8 9 C Ent

Enter the length from the numeric keypad screen and press ‘Ent’.

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.93.

Sound Velocity Registration

This function is for manually setting the sound velocity value.

|   | PIPE | Diameter | Length |
|---|------|----------|--------|
| 1 | A    | DIP      | 150 mm |
|   | B    | CIP      | 100 mm |
|   | C    |          |        |
|   | D    |          |        |
|   | E    |          |        |
| 2 | F    |          |        |

Td MAX 156.6 ms      Total 200.00 m  
Td range Automatic      Detection accuracy Common

Save

Tap 'Save'.

Pipe registration

Velocity registration

Velocity calculation

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

Velocity save

Velocity --- m/s

Registration

When Velocity registration is selected  
Enter a velocity value and tap 'Registration'

Velocity calculation

Pipe Material Non metal

Outside diameter 0.0 mm

Thickness 0.0 mm

Young's modulus 0 MPa

Velocity --- m/s

Registration

When Velocity calculation is selected  
Enter the required information and tap 'Registration'.

Setting the Detection Accuracy

|   | PIPE | Diameter | Length |
|---|------|----------|--------|
| 1 | A    | DiP      | 150 mm |
|   | B    | CiP      | 100 mm |
|   | C    |          |        |
|   | D    |          |        |
|   | E    |          |        |
| 2 | F    |          |        |

Td MAX 156.6 ms      Total 200.00 m  
Td range Automatic      Detection accuracy Common  
Save

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

Detection accuracy

Common

High precision

Select detection accuracy.

Setting the Td Range

This function sets the Td range (delay time).

|   | PIPE | Diameter | Length |
|---|------|----------|--------|
| 1 | A    | DiP      | 150 mm |
|   | B    | CiP      | 100 mm |
|   | C    |          |        |
|   | D    |          |        |
|   | E    |          |        |
| 2 | F    |          |        |

Td MAX 156.6 ms      Total 200.00 m  
Td range Automatic      Detection accuracy Common  
Save

Tap the value for Td range.

Td range

Automatic

50 ms

100 ms

200 ms

400 ms

< >

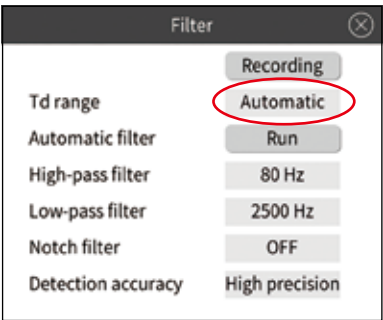
Select a Td range from the following choices.

- 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.

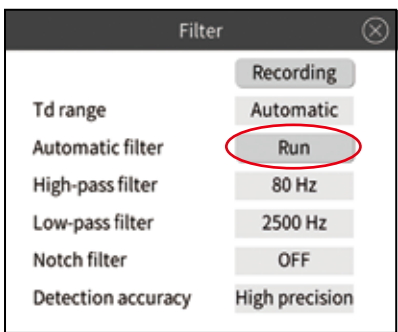


Select a Td range from the following alternatives.

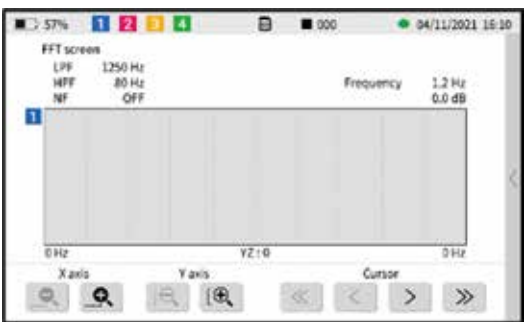
- Common correlation Automatic, 50 ms, 100 ms, 200 ms, 400 ms, 800 ms, 1600 ms, or 3200 ms
- High precision correlation Automatic, 200 ms, 400 ms, 800 ms, 1600 ms, 3200 ms, 6400 ms, or 12800 ms

Running the Automatic Filter

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

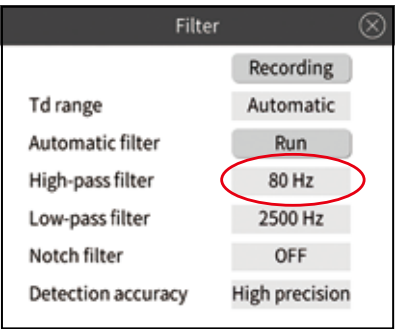


Tap 'Run' for Automatic filter.



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

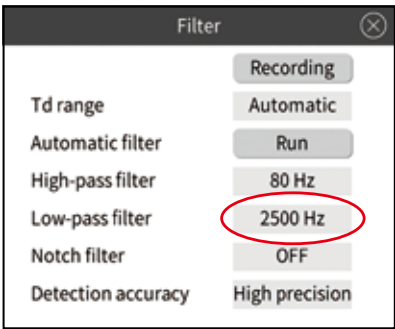


Tap the value for High-pass filter.



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

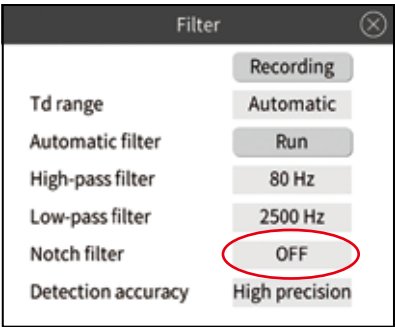


Tap the value for Low-pass filter.



Select a low pass filter from the following alternatives.  
630 Hz, 1250 Hz, 2500 Hz, 5000 Hz, or Large caliber

Setting the Notch Filter

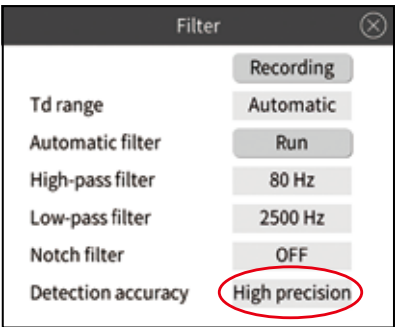


Tap the value for Notch filter.



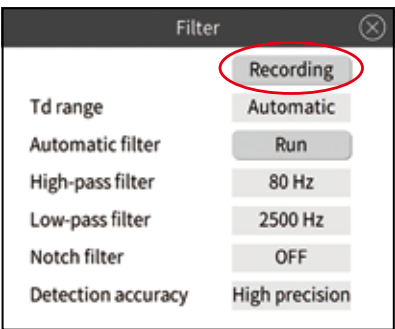
Select a notch filter from the following choices.  
OFF, 50 Hz, or 60 Hz

Setting the Detection Accuracy



Tap the pilldown menu next to 'Detection accuracy' and select accuracy from 'Common' or 'High precision'.

Starting Recording



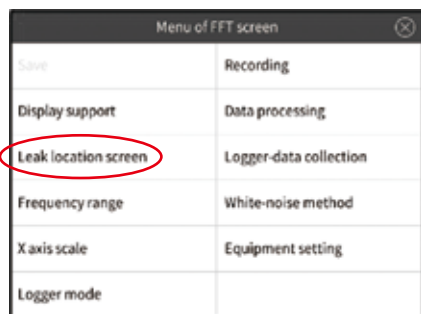
Tap 'Recording' to start recording with the filters you set.



## &lt;Correlation processing&gt;

If the FFT screen is displayed, switch to the leak location screen.

Press the menu switch .



Tap 'Leak location screen' under Menu of FFT screen.

Press the correlation switch .

## Switching between Multiple and Single Correlation

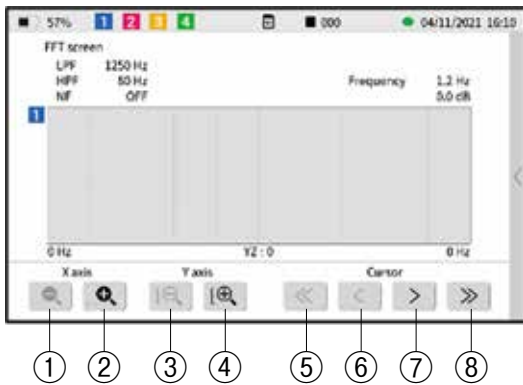


When the correlation screen opens, either the multiple correlation screen or the single correlation screen is displayed.



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



Press 'Menu' switch and tap 'Display support' to display screen below.

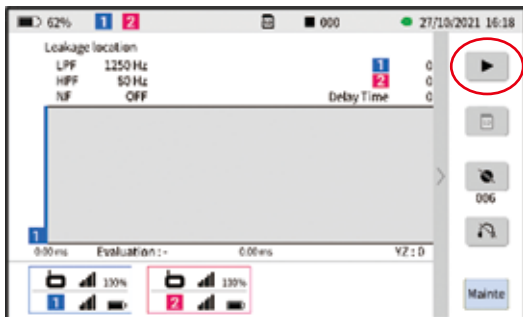
- ① Zoom out along the X axis (horizontal axis)
- ② Zoom in along the X axis (horizontal axis)
- ③ Zoom out along the Y axis (vertical axis)
- ④ Zoom in along the Y axis (vertical axis)
- ⑤ Move the cursor far to the left
- ⑥ Move the cursor to the left
- ⑦ Move the cursor to the right
- ⑧ Move the cursor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

### Starting and Stopping Correlation Processing

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

### 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.

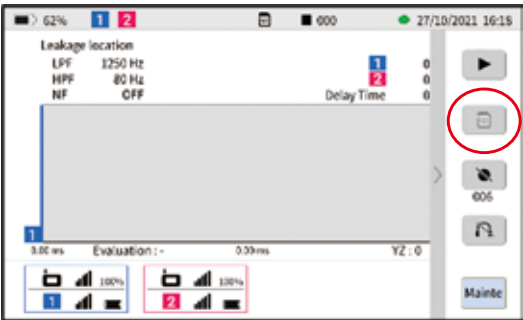
Tap the triangular playback icon to start correlation processing.

Tap the pause icon to pause processing

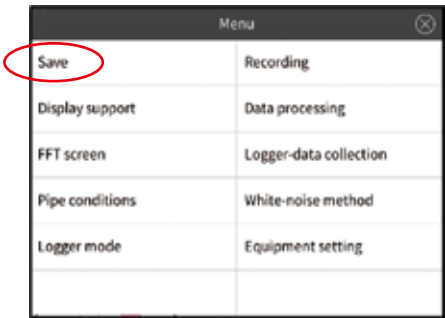
Warning

Use a Class 10 SDHC card. If you use SDHC card below Class10, an error may occur when importing data.

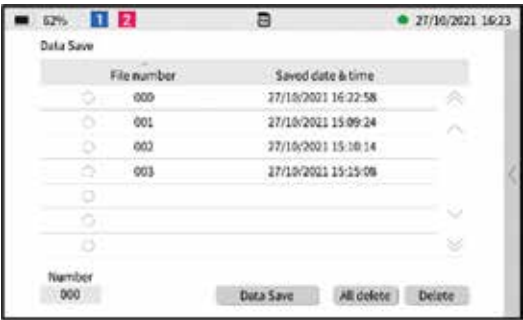
Saving Correlation Data



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.



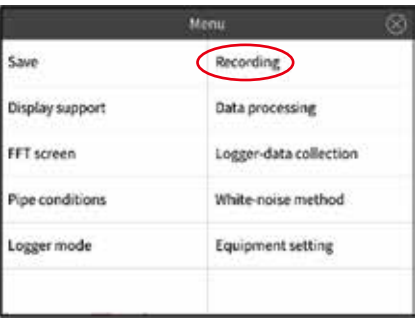
A list of file numbers appears.  
Tap the number you want to save the data under, or enter a number in the Number box, and then tap the 'Data Save' button.

Recording Sound Data

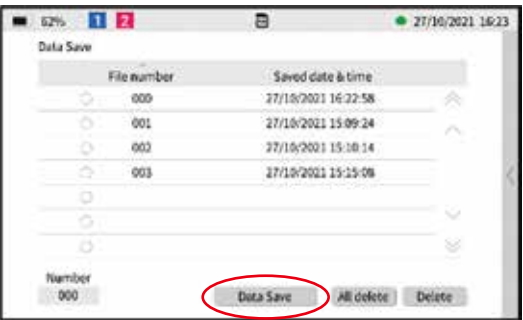
You can record sound data during correlation processing.



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.

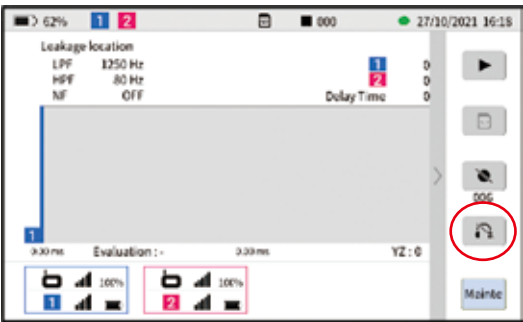


If you want to record without filtering, press the menu switch . Tap 'Recording'.

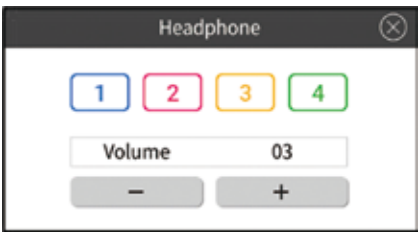


A list of file numbers appears. Tap the number you want to save the data under, or enter a number in the Number box, and then tap the 'Data save' button.

Listening to Leakage Sound



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 -.



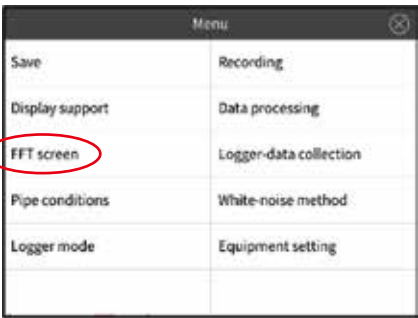
Caution

- 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.98.

Press the menu switch  in the correlation processing screen.



Tap ‘FFT screen’.

Switching between Multiple and Single FFT

This operation is the same as for correlation processing.  
See p.47.

Zooming and Moving the Cursor on the Single Correlation Screen

See p.48.

Starting and Stopping FFT Processing

This operation is the same as for correlation processing.  
See p.48.

Pausing and Resuming FFT Processing

This operation is the same as for correlation processing.  
See p.48.

Saving FFT Data

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

Recording FFT Data

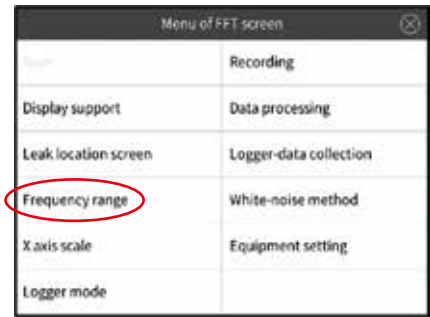
This operation is the same as for correlation processing.  
See p.50.

Listening for Leakage Sound

This operation is the same as for correlation processing.  
See p.51.

Changing the Frequency Range

Press the menu switch  .



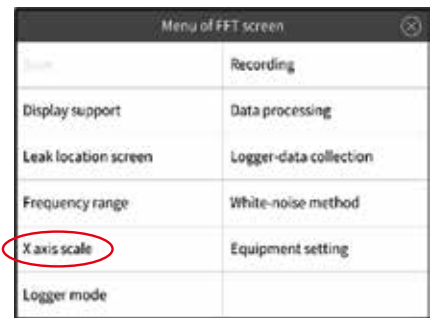
Tap 'Frequency range'.



Select a frequency.

Changing the Graph Display

Press the menu switch  .



Tap 'X axis scale'.



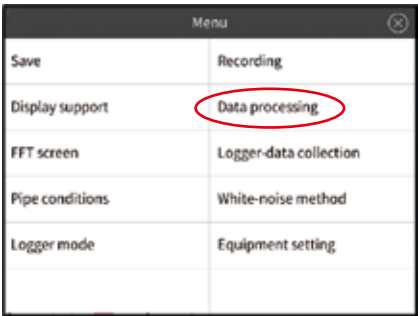
scale. Select an X axis.

<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.

Adding Check Marks to Data

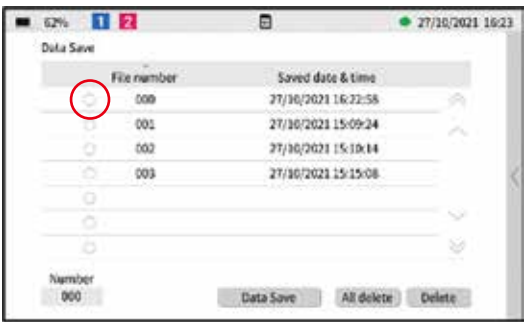
Press the menu switch  .



You can add check marks to saved data files to identify them as important.  
Tap 'Data processing'.



Select the content to be processed.



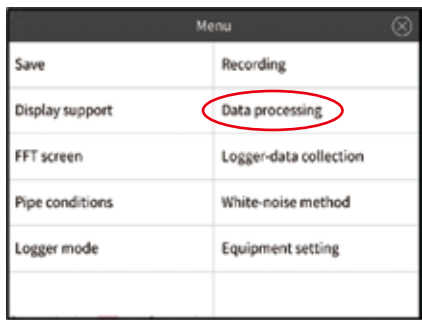
Tap  aside of the file you want to add a check mark to. A check mark will appear next to the file.  
To remove the check mark, tap again.



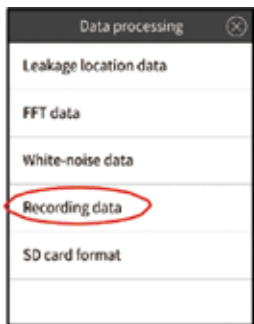
Playback and Re-correlation of Recorded Data

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

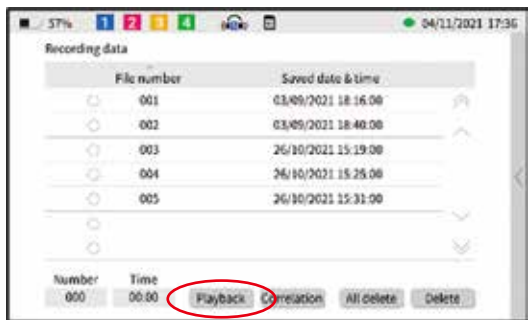
Press the menu switch  .



Tap 'Data processing'.



Tap 'Recording data'.



Tap the file and then tap the 'Playback' button or the 'Correlation' button.

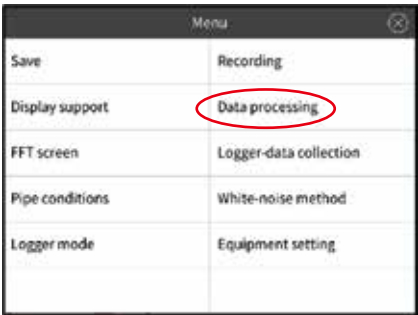
For details on configuring the pre-amplifier so you can listen from the headphones during playback, see “Listening for Leakage Sound” under “4-13 Pre-amplifier Settings and Operations” on p.52.

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

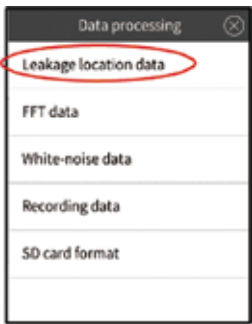
The results of the correlation processing should be saved in the same way as the real-time correlation processing.

Graphing the Leakage Location Data

Press the menu switch .

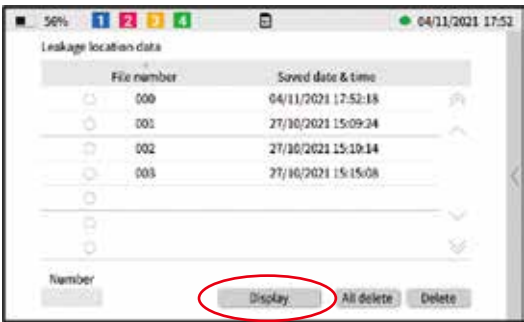


Tap 'Data processing'.



Tap 'Leakage location data'.

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



Tap the file to be graphed and then tap the 'Display' button.



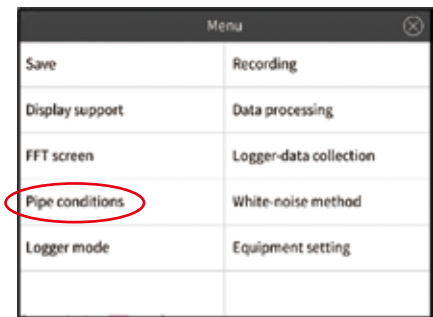
A graph is displayed based on the saved data.  
Zooming and cursor operations can be performed in the same way as common correlation.

Recalculating the Leakage Location Data

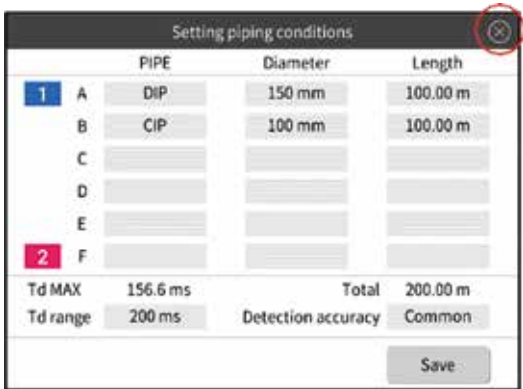
You can change the pipe length setting in the saved leakage location data and recalculate the distance to the leak location.

Operate while the graph of leakage location data is displayed.

Press the menu switch .



Tap 'Pipe conditions'.



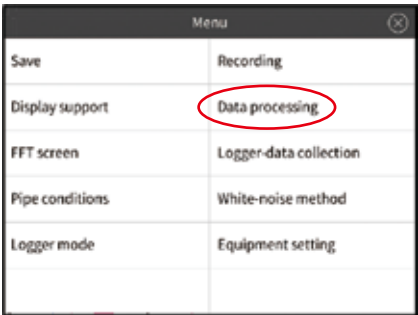
Change the length in the displayed pipe conditions.  
When you are done, click '×' in the top right to close the Setting piping conditions screen.



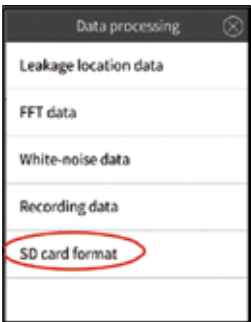
The distance to the leak location is recalculated and displayed with the total length setting changed.  
The method for saving changes is the same as for normal correlation.

Format the SD Card (Class 10)

Press the menu switch .



Tap 'Data processing'.



Tap 'SD card format'.



Tap 'OK' on the Confirmation screen.

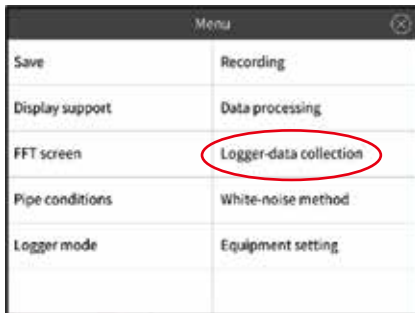
**Warning**

Formatting the SD card will delete all the data on the SD card. If you have data that you want to save, we recommend that you copy the data on the SD card to another device such as a computer in advance. Since the data is sorted and stored in folders, you can view old correlation data and play back recorded data by returning it to the corresponding SD card folder.

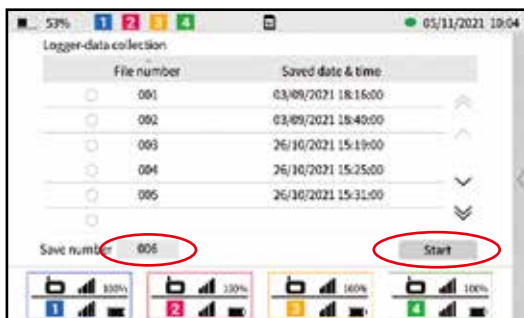
## &lt;Logger-data collection&gt;

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

Press the menu switch  .



Tap 'Logger-data collection'



For the file number, the smallest available number is automatically displayed as a candidate.

In logger mode 1 minute x 3 times, 3 consecutive files are created, so the candidate numbers are displayed so that the file numbers are 3 consecutive free numbers.

When setting the number manually, 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.

Time required for data collection

Logger mode (5 minutes): 5 minutes

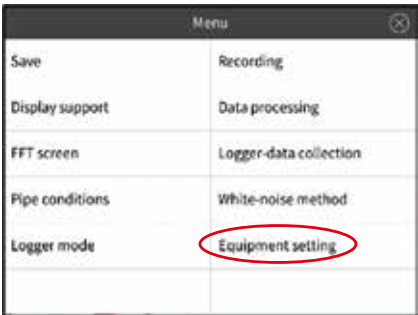
Logger mode (1 minute): 1 minute

Logger mode (1 minute x 3 times): 3 minutes

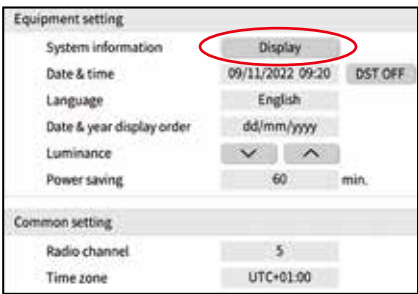
<Device setting>

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.

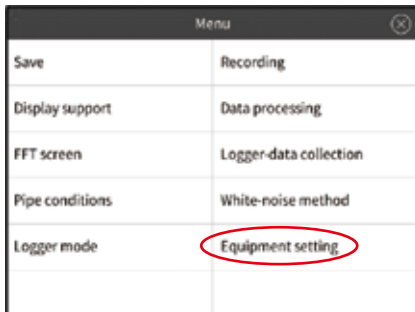
CPU version: Firmware version of the main unit

Radio version: Radio firmware version

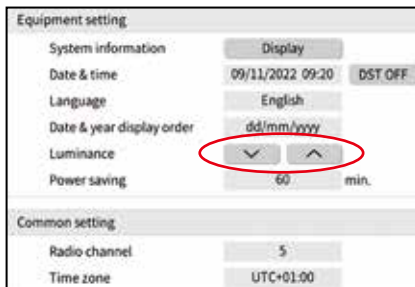
GPS coordinates: Latitude and longitude information

### Luminance Setting

Press the menu switch



Tap 'Equipment setting'



Tap the Luminance up/down buttons.

Up: brighter.

Down: darker.

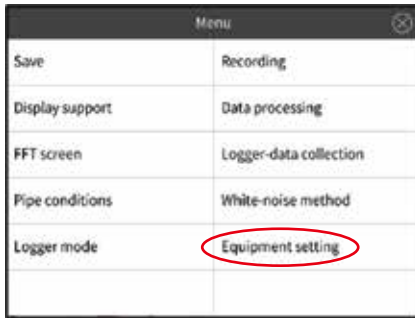
### Power Saving Setting

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

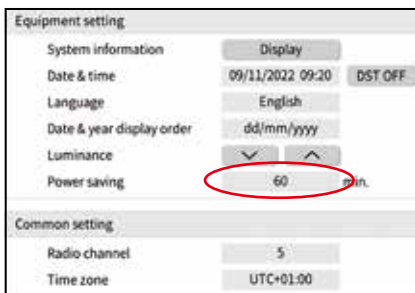
Tap the screen or press an external switch to return to normal brightness.

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

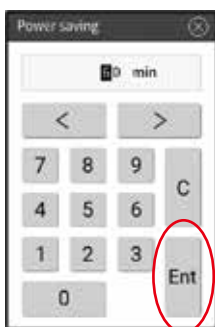
Press the menu switch .



Tap 'Equipment setting'.



Tap the Power saving box.

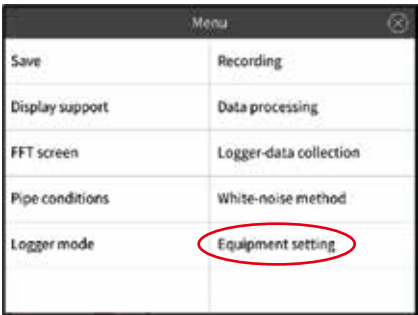


Enter the time until power saving mode starts and tap 'Ent'.

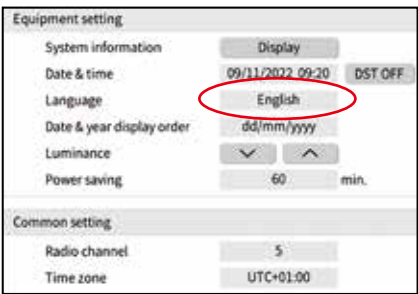


Language Setting

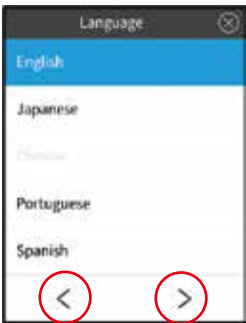
Press the menu switch .



Tap 'Equipment setting'.



Tap the Language box.

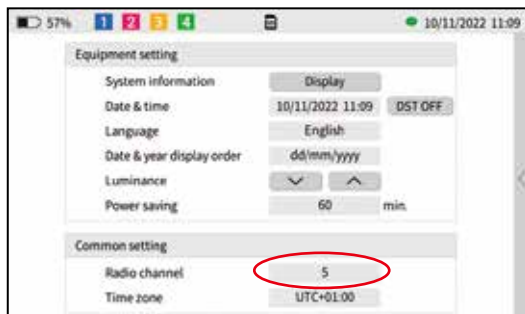


Select language from alternatives.

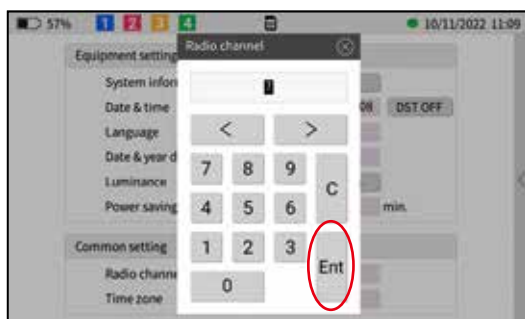
If you can't find the language you want to display, tap '<' or '>' to show more alternatives.

### Changing Radio Channel

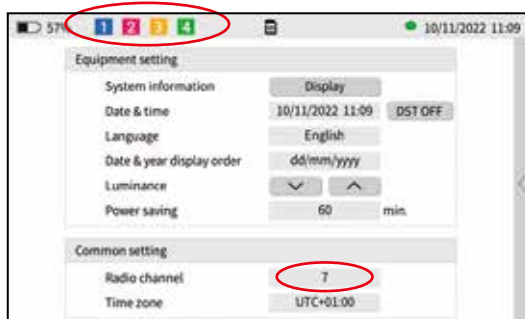
Change the radio channel currently used.



Tap Radio channel.



Enter new channel number and tap 'Ent'.



The radio channel number is changed, and the channel of the main unit and the preamplifier is changed.

Normally, the preamp channel changes immediately, but in some cases it can take a second or two. In that case, the preamplifier symbol goes off once, and once communication is resumed on the new channel, the preamplifier symbol turns on again in the order in which it was restarted.

If you want to change to another channel immediately after changing the channel, wait about 5 seconds before changing to another channel to complete the process.

If the preamplifier and the main unit are not connected, you can check the wireless channel of the preamplifier by checking the LED lighting pattern at startup.

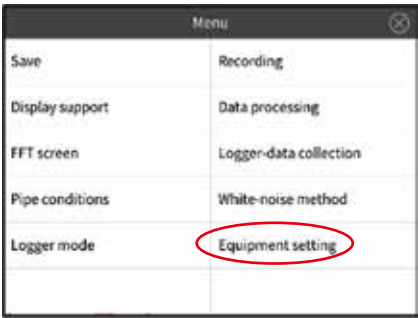
If the wireless channel is different between each preamplifier and the main unit, it will be set for each preamplifier (refer '2-3 Explanation of Pre-Amplifier LEDs' on P.19). You can connect to the preamplifier by turning off the power of the preamplifier, turning on only the main unit, changing to the channel number confirmed earlier according to the procedure in this chapter, and then turning on the power of the target preamplifier.

Then, if you change the wireless channel to the desired channel according to this chapter again, you can change the wireless channel of the preamplifier. By repeating this operation for the number of preamps you want to change, you can align the channels of the preamps.

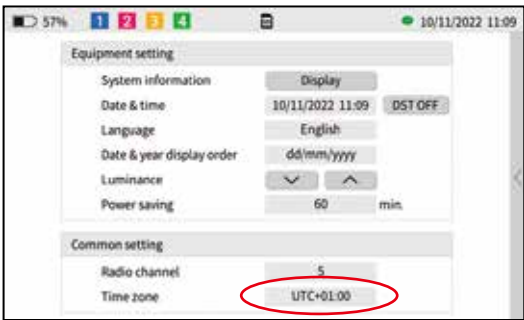
Change Time Zone

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 check the appropriate time zone.

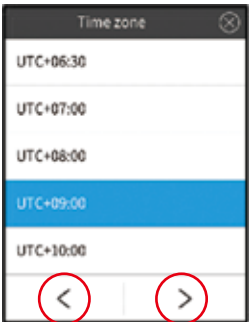
Press the menu switch .



Tap 'Equipment setting'.



Tap the Time zone box.



Select the time zone.  
If you can't find the appropriate time zone, tap '<' or '>' to show more alternatives.

## **5. How to Detect Leaks**

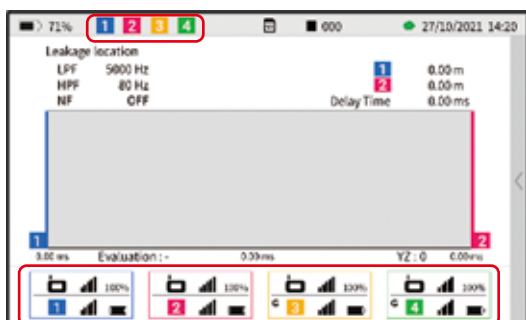
---

## 5-1 Common Correlation Detection Method

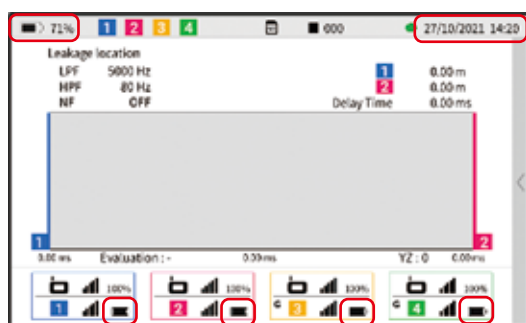
① Turn on the pre-amplifiers.

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.

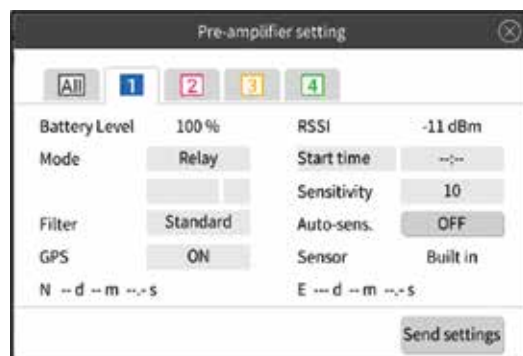


To change the date and time, see “3-6 Date and Time Adjustment” on p. 27.

⑤ Make sure LED of GPS on the preamp is lit.

⑥ Press the pre-amplifier switch .

⑦ Set the pre-amplifier operation mode, filter, GPS, and other conditions.



For details on setting the pre-amplifier, see “Pre-Amplifier Settings” under “4-7 Pre-amplifier Settings and Operations” on p.38.

However, the sensitivity is automatically adjusted, so there is no need to set it here.

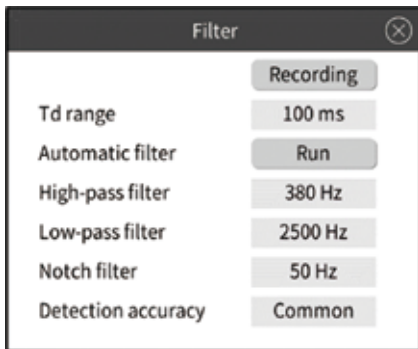
After setting the preamplifier, tap "Send Settings".

⑧ Install the pre-amplifier on the valve etc. at the installation location.

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

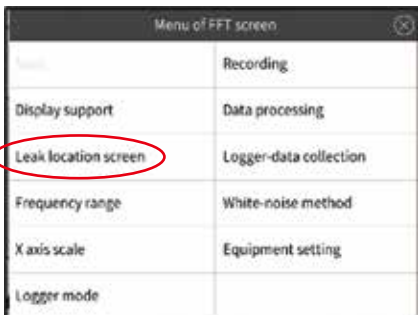
# 5-1 Common Correlation Detection Method

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



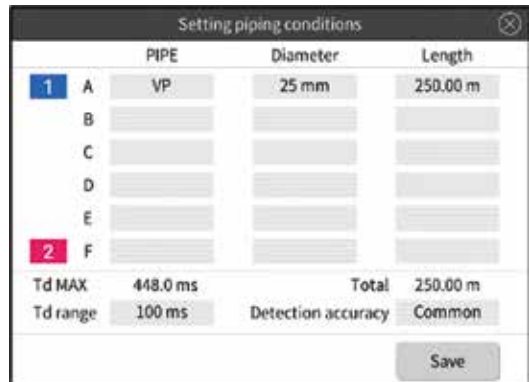
For details on configuring the filter, see “Filter Setting” under “4-9 Filter Settings and Operations” on p.45.

- 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 “4-8 Pipe Condition Settings and Operations” on p.41.

The pipe information can be set later if necessary. Suspend correlation processing once, 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 “4-11 Saving Correlation Data” on p.50.

## 5-2 Listening for Leaks

- (1) Using the pre-amplifiers to listen for leaks
- (2) Listening on the main unit

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

Connect the headphones to the headphone jack to listen for leakage sound.

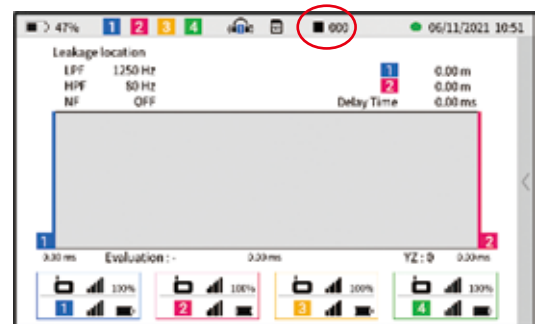
To avoid damage to your ears, do not wear the headphones when connecting them to the headphone jack.

### (2) Listening on the main unit

- ⑱ 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.

- ⑲ 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 to Leakage Sound” under “4-13 Pre-amplifier Settings and Operations” on p.52.



## 5-3 From Configuration of Logger Mode to Completion of Measurement

LC-5000 has two logger modes (quick mode and high precision mode).

### Quick mode

This is a logger mode that uses the timing of wireless communication at 1 second intervals. Since there is no waiting time due to timing synchronization, the result can be obtained quickly, but the accuracy is inferior to the high precision mode.

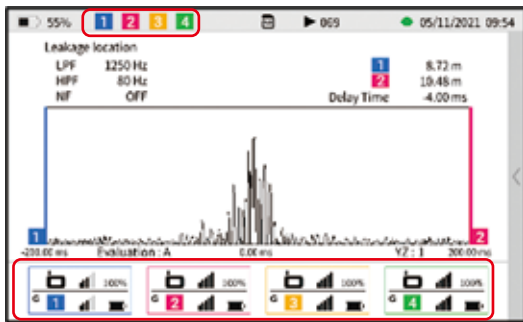
### High precision mode

This is a logger mode that uses GPS synchronization. Since it synchronizes with GPS, highly accurate correlation results can be obtained, but it may take some time to synchronize.

The setting procedure for each mode is shown below.

#### (1) Quick mode

- ① Attach the antenna to the pre-amplifiers and turn it on (do not turn off the power of the preamplifier until the procedure of ⑬ is completed).
- ② Turn on the main unit.
- ③ Verify that the pre-amplifier icons are lit.



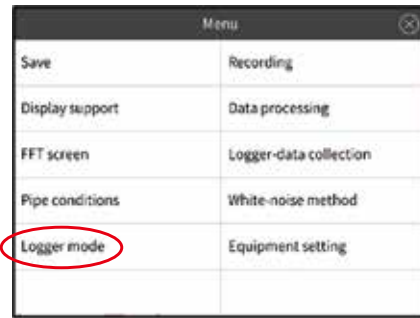
- ④ Check the battery level and date and time of the main unit and pre-amplifiers.



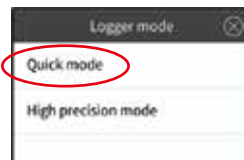
To change the date and time, see “3-6 Date and Time Adjustment” on p.27.

- ⑤ Press the menu switch .

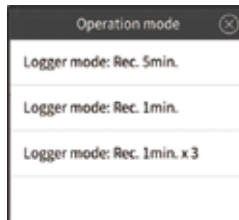
- ⑥ Tap ‘Logger mode’.



- ⑦ Tap ‘Quick mode’.



- ⑧ Select operation mode. There are three operation modes: 5 minutes, 1 minute, and 1 minute x 3 times.



- ⑨ Set the time to start recording from 3 minutes to 30 minutes, and tap ‘Ent’.



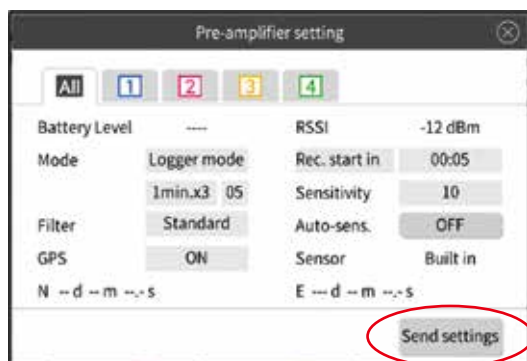
## 5-3 From Configuration of Logger Mode to Completion of Measurement

Consider the time it takes to install the pre-amplifier and set the time to start recording. The circuit of the pre-amplifier starts 20 seconds before the start of recording, and adjustments are made.

- ⑩ If you select 1 minute x 3 times in the operation mode, set the recording interval from 5 minutes to 30 minutes.



- ⑪ The screen will change to the preamplifier setting confirmation screen.



Filters can be set on this screen. Tap filter option ('Standard' on this figure).

For filter setting, see "4-7 Preamp setting and operation" on p.38.

The sensitivity is automatically adjusted before the start of recording, so there is no need to set it.

From this screen, you can make the final changes such as operation mode and start time. Please note that it will not be possible after sending the settings.

Check the set information and tap 'Send settings'.

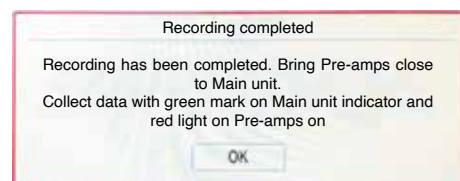


After sending the settings, the logger mode will be activated and you will not be able to operate the keys.

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. For LED lighting, see 'Logger mode Not recorded, ready to record' under "2-3 Explanation of Pre-Amplifier LEDs,"

Do not turn off the power until the recording is finished and returned to the correlation screen.

- ⑫ Install a preamplifier. Attach the attached cap to the antenna to prevent malfunction due to flooding.
- ⑬ At the set time, recording of the preamplifier will start.
- ⑭ When the recording is finished, the following message will be displayed.



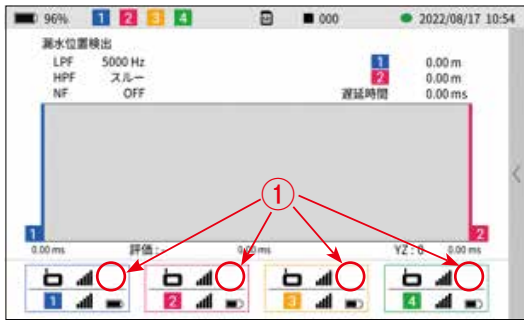
Tap 'OK'.

Collect the preamplifier, attach the antenna, and check the symbol of the recorded preamplifier on the main unit screen. If it is not displayed, move the preamplifier closer to the main unit.

When the pre-amplifier is brought close to the main unit with the power of the main unit and preamplifier turned on, the arrival rate will not be displayed.

(Part ① in the following figure)

# 5-3 From Configuration of Logger Mode to Completion of Measurement



Make sure that the power LED on the preamp is on and the others are off. For LED lighting, see ‘Logger mode Post-recording, corrected, ready for collection’ under “2-3 Explanation of Pre-Amplifier LEDs,” on p.18.

## LED display of pre-amplifier in quick logger mode



| Explanatory notes                             |
|-----------------------------------------------|
| <span style="color: green;">●</span> Lit      |
| <span style="color: green;">⦿</span> Blinking |
| <span style="color: green;">○</span> Off      |

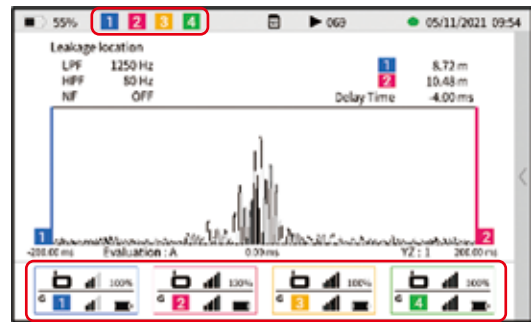
| Status (Work flow on quick logger mode)                                             | LED display                                                                                                                                       |
|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| After starting                                                                      | <span style="color: red;">●</span> <span style="color: green;">○</span> <span style="color: green;">⦿</span> <span style="color: green;">○</span> |
| After turning on the quick logger mode from the main unit                           | <span style="color: red;">●</span> <span style="color: green;">●</span> <span style="color: green;">●</span> <span style="color: green;">●</span> |
| Logging (Including waiting for the second and third recordings)                     | <span style="color: red;">●</span> <span style="color: green;">●</span> <span style="color: green;">●</span> <span style="color: green;">○</span> |
| Waiting for the main unit to turn on (Before turning on the power to the main unit) | <span style="color: red;">●</span> <span style="color: green;">●</span> <span style="color: green;">⦿</span> <span style="color: green;">○</span> |
| Logging data can be collected                                                       | <span style="color: red;">●</span> <span style="color: green;">○</span> <span style="color: green;">○</span> <span style="color: green;">○</span> |
| After collecting data (automatically turns off the power)                           | <span style="color: red;">○</span> <span style="color: green;">○</span> <span style="color: green;">○</span> <span style="color: green;">○</span> |

## (2) High precision mode

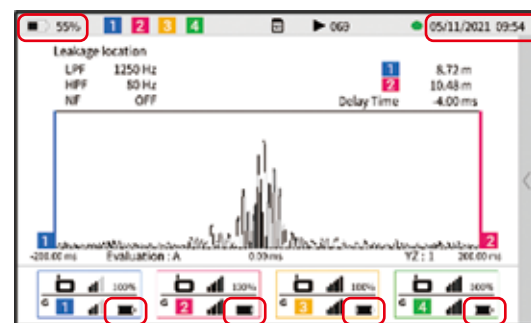
Work outdoors as the time is adjusted by getting the signal directly from GPS.

Working outside not near the roof or building, and opening the south side will reduce the time it takes to complete the sync. Since GPS is located directly under the switch, it may take some time to complete synchronization if you cover it or keep looking into it.

- ① Attach the antenna to the pre-amplifiers and turn it on.
- 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.



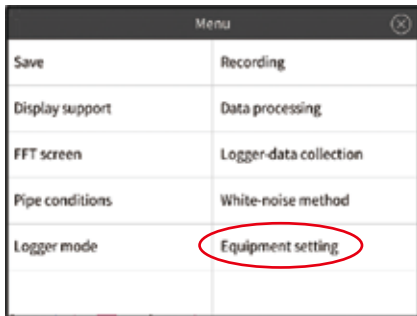
To change the date and time, see “3-6 Date and Time Adjustment” on p.27.

The date and time correction will be explained in step ⑦ .

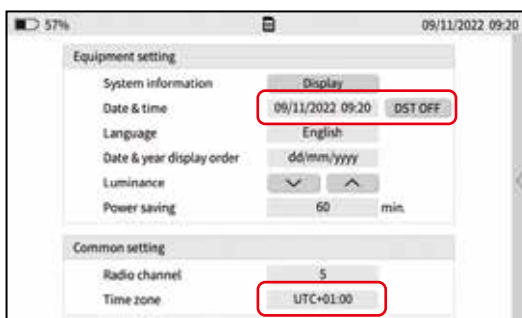
- ⑤ Press the menu switch .

## 5-3 From Configuration of Logger Mode to Completion of Measurement

- ⑥ Tap 'Equipment setting'.



- ⑦ Check time zone.



Date and time information obtained from GPS is UTC (Coordinated Universal Time). Please set the correct time zone, current time and daylight saving time. (For how to change, see "3-6 Date and time adjustment" on page 27.) If this setting is incorrect, recording will not start at the set time because it will not match the time displayed on the preamplifier that works with the GPS signal and the time displayed on the main unit.

- ⑧ Press the correlation switch . Confirmation message will appear, so tap 'OK'.

- ⑨ Press the pre-amplifier switch .

- ⑩ Select 'All' tab on pre-amplifier setting screen.

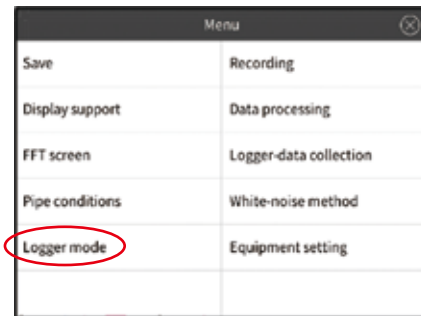
- ⑪ Make sure GPS is on and tap the x in the upper right corner of the preamp settings window.

If GPS is off, tap 'OFF' to set it to ON. Press 'Send settings'.

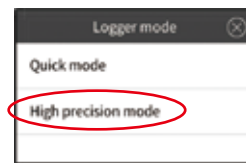
- ⑫ Make sure all preamp GPS LEDs are lit. If it is blinking, wait until it lights up.

- ⑬ Press the menu switch  again.

- ⑭ Tap 'Logger mode'.



- ⑮ Tap 'High precision mode'.



- ⑯ Select operation mode.  
There are 3 operation modes.  
5minutes, 1 minute and 1 minute x 3 times



- ⑰ Enter the recording start time.



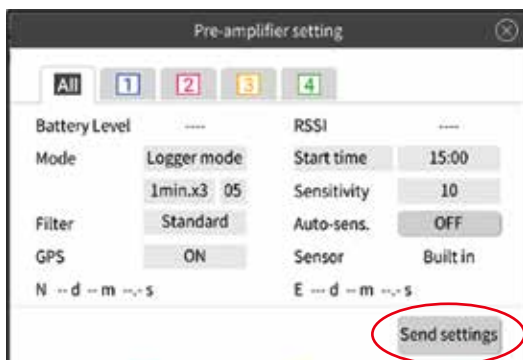
## 5-3 From Configuration of Logger Mode to Completion of Measurement

Consider the time it takes to install the pre-amplifier and set the time to start recording. The circuit of the pre-amplifier starts 20 seconds before the start of recording, and adjustments are made.

- ⑮ If you select 1 minute x 3 times in the operation mode, set the recording interval from 5 minutes to 60 minutes.



- ⑯ The screen will change to the preamplifier setting confirmation screen.

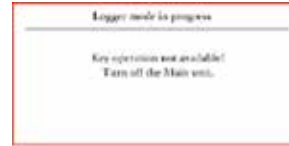


Filters can be set on this screen. Tap filter option ('Standard' on this figure). For filter setting, see "4-7 Preamp setting and operation" on p.38.

The sensitivity is automatically adjusted before the start of recording, so there is no need to set it.

From this screen, you can make the final changes such as operation mode and start time. Please note that it will not be possible after sending the settings.

Make sure the GPS LED on the pre-amplifier is lit and tap 'Send settings'. When the GPS LED is lit, synchronization with GPS is complete and recording is possible.



After sending the settings, the logger mode will be activated and you will not be able to operate the keys. If you want to change the settings, start over from the beginning.

Make sure all the LEDs on the pre-amplifiers are lit. For LED lighting, see 'Logger mode Not recorded, ready to record' under "2-3 Explanation of Pre-Amplifier LEDs," on p.18. If all the LEDs are lit, the logger mode transition is successful. If there is a pre-amplifier that is not lit, set the logger mode again.

- ⑰ Turn off the power of the main unit and install the pre-amplifier. Please note that, in the high precision mode, recording of the pre-amplifier will not start when the power of the main unit is turned on. Attach the attached cap to the antenna to prevent damage due to flooding.
- ⑱ Recording of the preamplifier will start at the set time.
- ⑳ When the recording is finished, the post-processing operation starts. In the post-processing, it tries to acquire the 1-second timing with GPS and acquires the time lag information. If the timing cannot be taken for 1 second, GPS will periodically turn ON / OFF the power and try to acquire GPS connection.
- ㉑ When the post-processing is completed, it will be in the collection waiting state and the power of the pre-amplifier will be turned off. Recording and acquisition of correction information for improving correlation accuracy are completed.

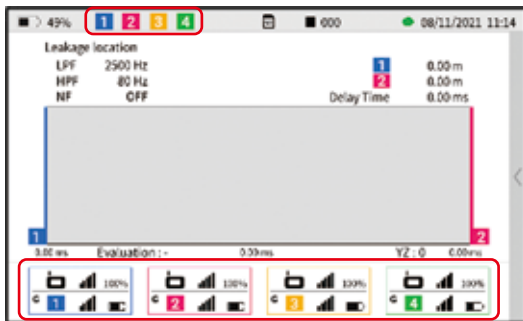
## 5-4 Collection of Recorded Data

Transfer the data recorded in the pre-amplifier to the main unit.

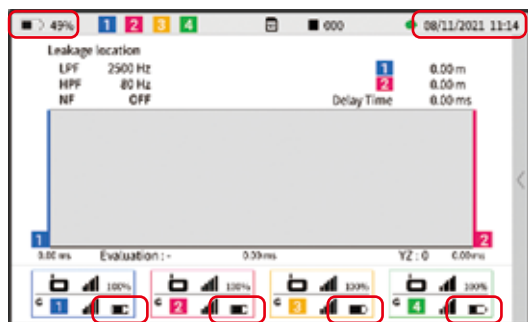
The transferred data can be correlated using the re-correlation function (correlation from recorded data). See “4-15 Data Processing” on p.55 for re-correlation function.

When collecting recorded data, make sure that the data arrival rate is 100% and stable.

- ① Turn on pre-amplifier.
- ② Turn on main unit.
- ③ Make sure the preamp symbol is lit.



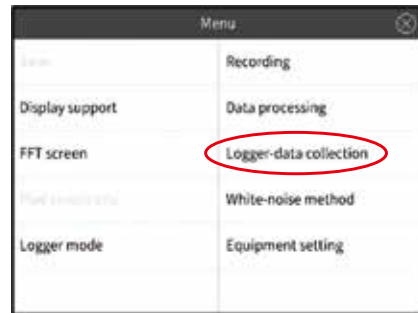
- ④ Check the battery level and date and time of the main unit and pre-amplifier.



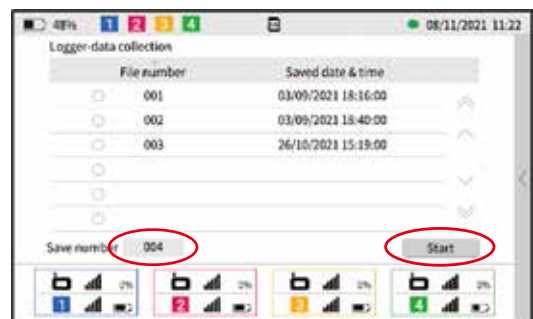
See “3-6 Date and Time Adjustment” on p.27 for changing time and date.

- ⑤ Press the menu switch .

- ⑥ Tap ‘Logger-data collection’



- ⑦ A list of recorded data is displayed. Specify the file number to save and tap ‘Start’.

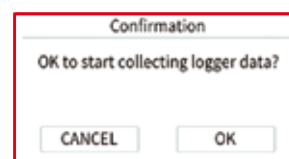


If you do not specify a number to save, it will be saved to a free smaller number.

- ⑧ The following confirmation message will be displayed. Tap ‘OK’ to start collecting recorded data.

In the case of logger mode 5mins., no matter how many pre-amplifiers you used, it takes 5 minutes to collect data because the recording time is 5 minutes. In the case of logger mode 1 min., it will take 1 minute as well.

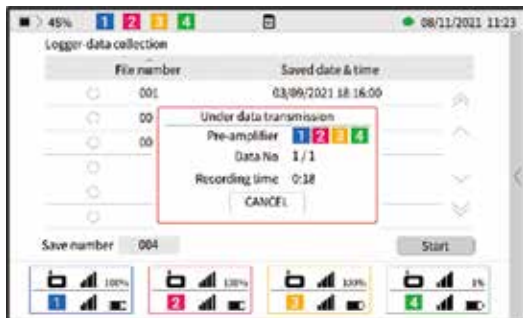
In case of logger mode 1 min. x 3 times, no matter how many pre-amplifiers you used, it takes 3 minutes because the total recording time is 3 minutes.





## 5-4 Collection of Recorded Data

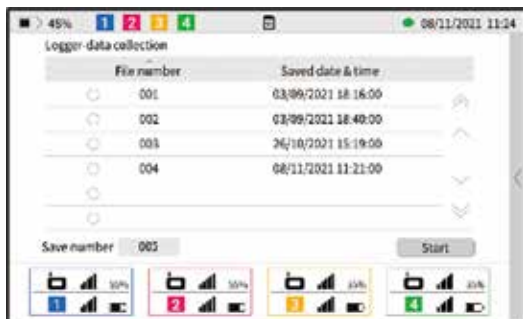
The preamplifier number is displayed during data collection as in the below figure.



If the measured pre-amplifier number is not displayed, press 'CANCEL', confirm that the preamplifier symbol is displayed, and then collect the logger data again.

If reading the recorded data fails continuously, connect the SDHC card to your computer and perform "Repair File".

- ⑨ When the collection of logger data is completed, it will be reflected in the list of recorded data.



Move to another work by pressing the menu switch.

If the measurement was performed in the quick logger mode, turn the power of the main unit and pre-amplifier off and then on again before performing any other work.

### Warning

- Confirm that the preamplifier number for which you are about to collect data is displayed in the "Data collection" message box (See Fig. 1 ①).

<Fig.1>



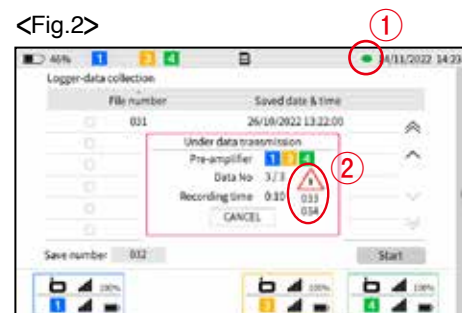
In particular, while collecting data for 1 minute x 3 times, the data number (Fig. 1 ②) changes from 1/3 to 2/3 and 3/3 every 1 minute, so make sure that the target pre-amplifier number is displayed each time.

- Before collecting data, make sure that the color of the wireless indicator is green <Fig.2> ①.

If the reception condition deteriorates due to external noise or radio wave interference during data collection, a red triangle warning will appear and blink in the message during data collection <Fig.2> ②.

The number under the triangle mark indicates the file number where data loss occurred. Tap Cancel to return to the logger data collection screen and collect data again.

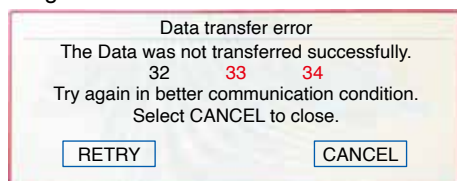
<Fig.2>



If data missing occurs, the following screen will appear after data collection is completed.

## 5-4 Collection of Recorded Data

<Fig.3>

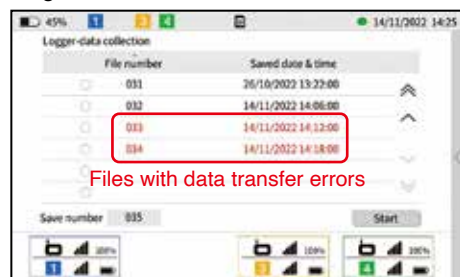


If you want to collect data again, move to a location with a good wireless environment and tap 'RETRY', or tap 'CANCEL' and move to a different location, and then collect data from the menu screen again.

Press 'CANCEL' to return to the "Logger-data collection" screen <Fig.4>.

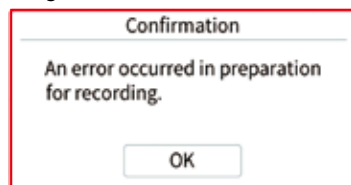
Successfully collected data is displayed in black, and files with missing data are displayed in red.

<Fig.4>



If the following error <Fig.5> occurs during data collection, please check whether the slide switch of the SD card is on the lock side. If it is on the locked side, unlock it and insert it again.

<Fig.5>

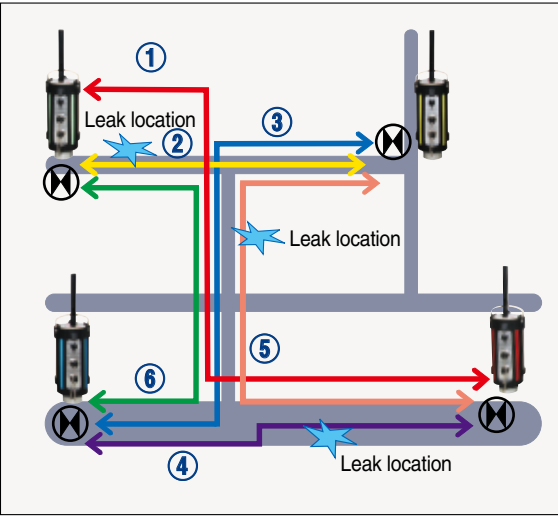




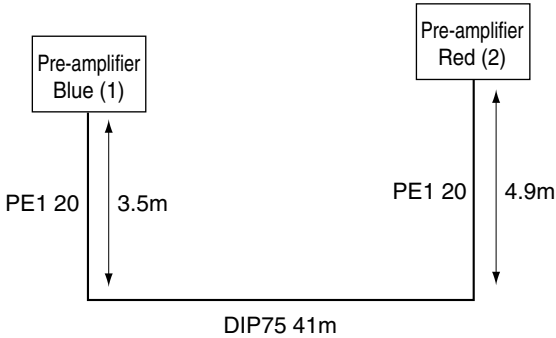
## **6. Techniques for Using the Equipment**

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# 6-1 Pipe Data Handling (Main Unit)



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.

Setting piping conditions

|          | PIPE | Diameter | Length                    |
|----------|------|----------|---------------------------|
| 1        | A    | VP       | 25 mm                     |
|          | B    | DIP      | 75 mm                     |
|          | C    | LP       | 20 mm                     |
|          | D    |          |                           |
|          | E    |          |                           |
| 2        | F    |          |                           |
| Td MAX   |      | 844.2 ms | Total 701.00 m            |
| Td range |      | 100 ms   | Detection accuracy Common |
| Save     |      |          |                           |

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

## 6-1 Pipe Data Handling (Main Unit)

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For details on entering the pipe conditions, see “Setting piping conditions” under “4-8 Pipe Condition Settings and Operations” on p.41.

The types of pipe and their diameters are listed below.

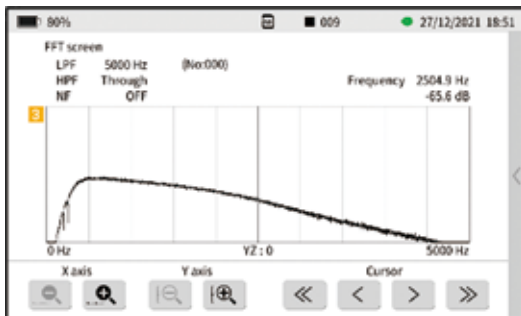
| Pipe material | Diameter (mm) |
|---------------|---------------|
| D I P         | 75 to 2600    |
| C I P         | 75 to 1500    |
| A C P         | 75 to 500     |
| V P           | 13 to 300     |
| L P           | 10 to 50      |
| P E 1         | 10 to 50      |
| P E 2         | 10 to 50      |
| P E 1 0 0     | 90 to 335     |
| H P P E       | 50 to 300     |
| S U S         | 8 to 300      |
| S S P         | 13 to 50      |
| C U P         | 8 to 150      |
| S G P W       | 10 to 800     |
| S T P Y       | 350 to 2000   |
| F R P M       | 200 to 3000   |
| S G P V       | 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 preamplifiers.

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.

| Case | Pipe material | Pipe diameter | Required items    |          |
|------|---------------|---------------|-------------------|----------|
|      |               |               | Velocity          | Distance |
| ①    | ?             | ?             | ?                 | ○        |
| ②    | ○             | ○             | ○                 | ?        |
| ③    | ○             | ?             | (Estimated value) | ?        |

Using the white noise method, calculate the item identified with [?].

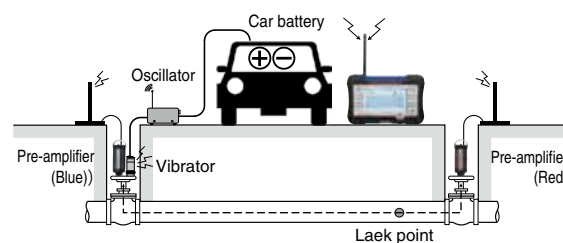
After calculating the unknown items, enter the pipe data.

### – 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

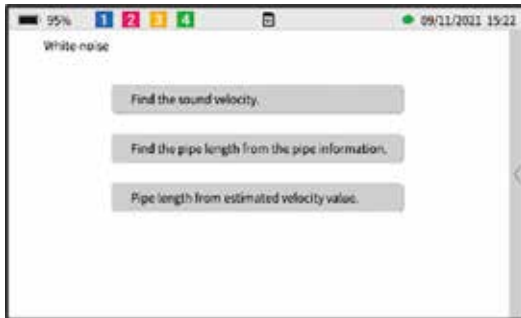
The white noise method can be used as long as the section between pre-amplifiers consists of only one type of pipe.  
It cannot be used when there are multiple types of pipe.

- 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.

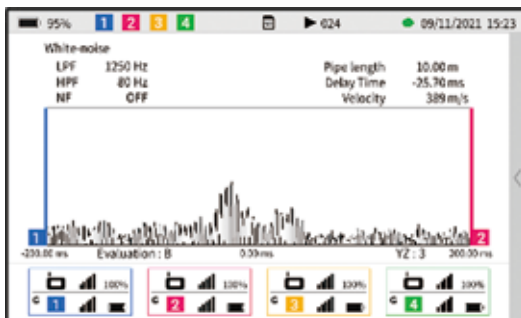
Since the length of the pipe is known but the sound velocity is unknown, tap ‘Find the sound velocity’.



The screen on the left is displayed.

Tap the pre-amplifier to be used and enter the pipe length.

Tap ‘Run’.



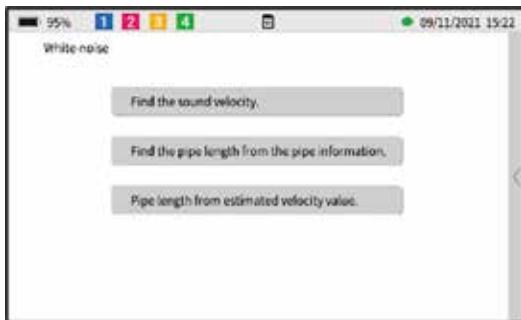
The correlation screen appears and the sound velocity is calculated.

Pause at an appropriate time and save the sound velocity value.

For details on using the correlation screen, see “Correlation processing” under “4-10 Correlation Processing and Operations” on p.48.

## 6-3 White Noise Method

### -Case ②-



Press the menu switch .

Tap 'White noise' to display the screen on the left.

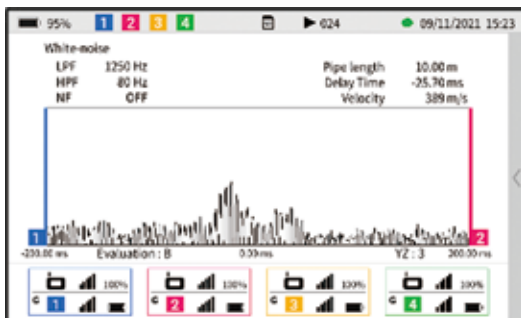
Since the pipe material and pipe diameter are known but the pipe length is unknown, tap 'Find the pipe length from the pipe information'.



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.

## 6-3 White Noise Method

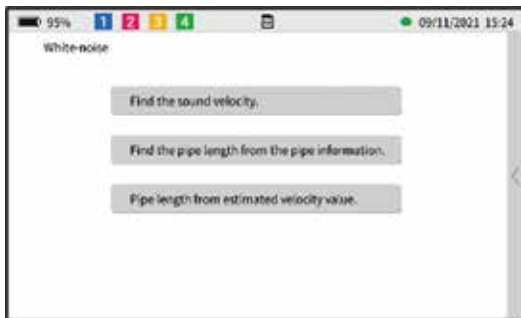
### –Case ③–

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.



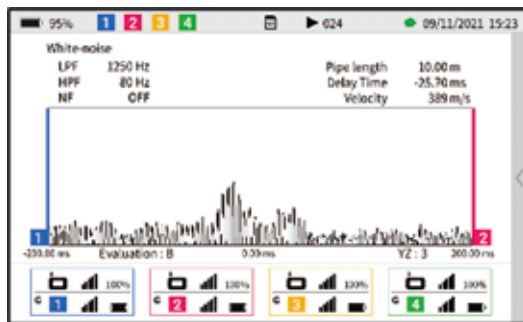
The screen on the left is displayed.

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

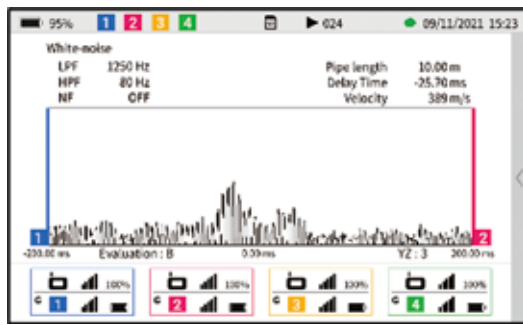
---

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

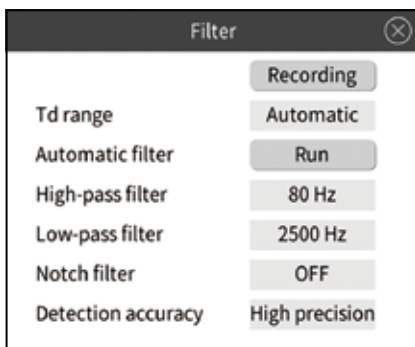
The evaluation here is based only on the correlation waveform, so it should only be used as a guideline for detecting the leak location.

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 “4-9 Filter Settings and Operations” on p.45.

## 6-7 Notch Filter

The notch filter can be set to OFF, 50 Hz, or 60 Hz.

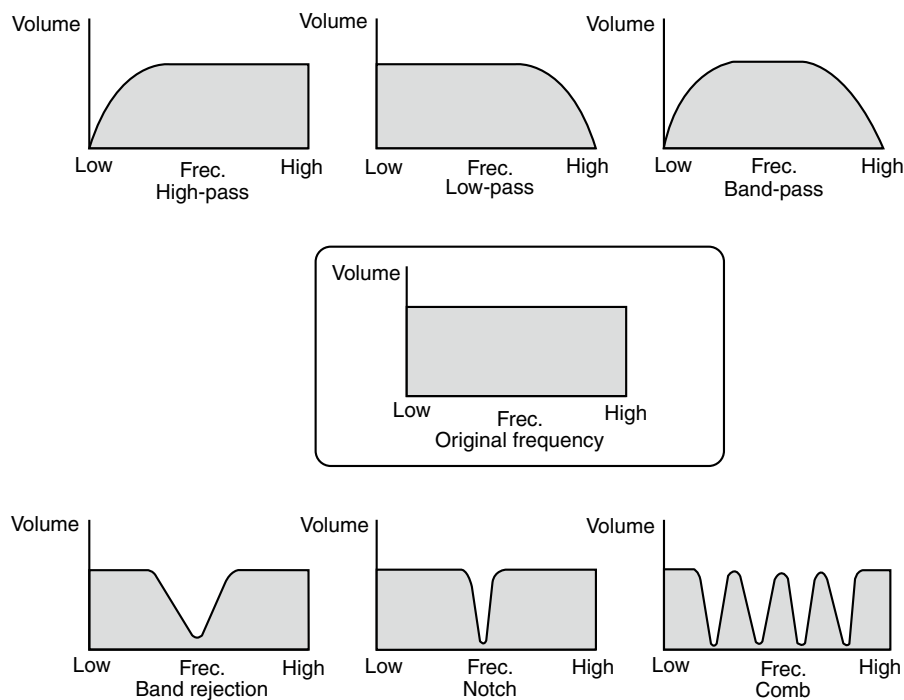
OFF is the normal setting.

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 “4-9 Filter Settings and Operations” on p.45.

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.

## 6-7 Notch Filter

The notch filter can be set to OFF, 50 Hz, or 60 Hz.

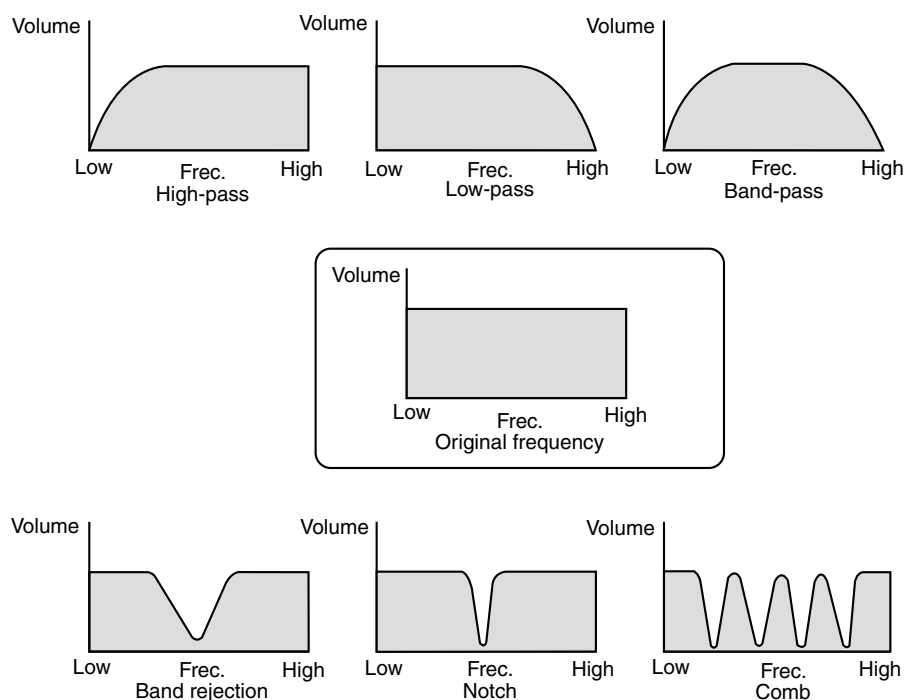
OFF is the normal setting.

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 “4-9 Filter Settings and Operations” on p.44.

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.

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Five notch filters are applied at intervals of either 50 Hz or 60 Hz.

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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 “4-8 Pipe Condition Settings and Operations” on p.42.

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**

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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**

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## 7-1 Storage Method

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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**

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## 8-1 Definitions

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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 Processor)**

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 wave-form, 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 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.

$\sigma = E \cdot \epsilon$  (where  $\sigma$  is the stress,  $E$  is the Young's modulus, and  $\epsilon$  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.

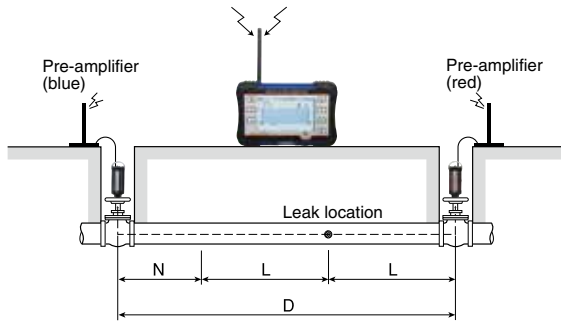
- **HPF (High Pass Filter)**

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  $T_d$  is the delay time (time difference)

## 8-3 Specifications of Main Unit

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- 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

## 8-3 Specifications of Main Unit

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- 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

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- 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: 300 mW



## **9. Troubleshooting**

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## 9-1 Troubleshooting

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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                                   | <ul style="list-style-type: none"><li>● Make sure the battery is inserted.</li><li>● Replace the battery with a charged one.</li></ul>                                                                                                                                                                                                                                                                                                                               |
| ② If the pre-amplifier does not turn on                               | <ul style="list-style-type: none"><li>● charging the battery.</li></ul>                                                                                                                                                                                                                                                                                                                                                                                              |
| ③ If a switch or button on the main unit does not work                | <ul style="list-style-type: none"><li>● Press the switch or button firmly. Pressing the key will produce a confirmation sound.</li></ul>                                                                                                                                                                                                                                                                                                                             |
| ④ If the main unit does not receive radio signals or reception is bad | <ul style="list-style-type: none"><li>● Make sure the pre-amplifier is powered on.</li><li>● Make sure the receiving antenna is securely connected to the main unit.</li><li>● 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.</li><li>● Try placing the pre-amplifier antenna in a higher location</li></ul> |
| ⑤ If the pipe type, pipe diameter, and pipe length are unknown        | <ul style="list-style-type: none"><li>● Use the white noise method to calculate the unknown parameters.</li></ul> <p>* For details see "6-3 White Noise Method" on p.84.</p>                                                                                                                                                                                                                                                                                         |



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