INSTRUCTION MANUAL

PRECISION INTEGRATING SOUND LEVEL METER

NL-15

RION CO., LTD.

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Quantifier Notation of NL-15, International Standards, and JIS

(Excerpts from ISO 1996, 3891, IEC Pub. 804, JIS Z8202, 8731)

NL-15 notation	Description	Frequency weighting	ISO notation	IEC notation	JIS notation
L_P	Sound pressure level	Flat	L_p	—	L_p
L_A	A-weighted sound pressure level	A	L_{pA}	—	L_A
L_C	C-weighted sound pressure level	C	L_{pC}	—	—
L_{Aeq}	Equivalent continuous A-weighted sound pressure level	A	$L_{Aeq,T}$	$L_{Aeq,T}$	$L_{Aeq,T}$
L_{Ceq}	Equivalent continuous C-weighted sound pressure level	C	$L_{Ceq,T}$	$L_{Ceq,T}$	—
L_{AE}	A-weighted sound exposure level	A	L_{AE}	$L_{AE,T}$	L_{AE}
L_{Amax}	Maximum A-weighted sound pressure level	A	L_{max}	—	—

PRECAUTIONS

- Operate the unit as described in this manual.

- Protect the unit from shocks and vibration.
  Be especially careful not to touch the delicate microphone membrane to avoid damage.

- Ambient conditions for operation of the unit are a temperature of -10 to +50°C and relative humidity from 30 to 90%.
  Protect the unit from water or dust, extreme temperatures or humidity, and direct sunlight during storage and use. Also avoid air with high salt or sulphur content, gases, and the vicinity of stored chemicals.

- Always turn the unit off after use.
  Remove the batteries from the unit if it is not to be used for a long time.
  When disconnecting cables, always hold the plug and do not pull the cable.

- Clean the unit only by wiping it with a soft, dry cloth or, when necessary, with a cloth lightly moistened with water. Do not use any solvents, cleaning alcohol or cleaning agents.

- Do not try to disassemble the unit.
  In case of an apparent malfunction, do not attempt any repairs. Note the condition of the unit clearly and contact the supplier.

- In order to ensure continued measurement precision, regular maintenance must be performed.

CONTENTS

OUTLINE

The Precision integrating sound level meter NL-15 allows not only conventional sound level measurements, but also incorporates processing functions which make it possible to determine L_{eq} (equivalent continuous sound pressure level), L_E (sound exposure level) and L_{max} (maximum sound pressure level).

The LCD panel shows measurement results in numerical form and on a graphical scale. The wide display range of 60 dB for both numerical indication and graphical indication makes range switching virtually unnecessary during normal measurements.

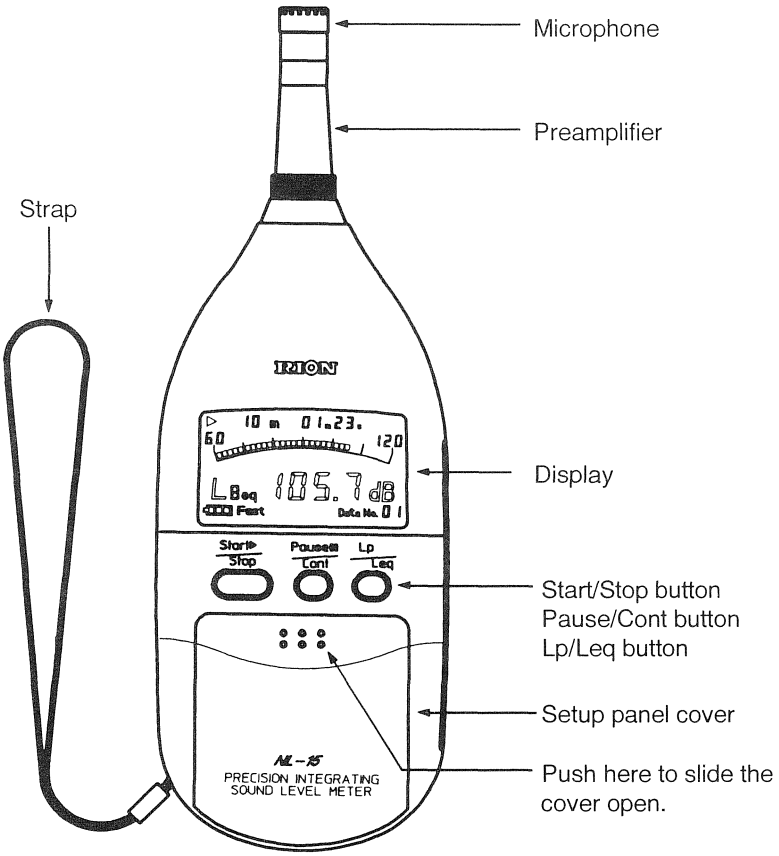
All internal settings such as level range and frequency weighting selections are preserved also while the unit is switched off. This makes it easy to maintain measurement consistency.

An internal memory can store up to 50 L_{eq} data. These data are stored automatically while the measurement is being carried out. Stored data can be easily recalled to the display, printed out on the optional printer CP-10, or sent to a computer via the built-in RS-232-C interface.

AC and DC outputs allow recording of sound pressure level data on the level recorder LR-04/LR-06.

CONTROLS AND FUNCTIONS

Front Panel



- **Microphone/preamplifier**
  The microphone and preamplifier are combined in an integrated assembly. The assembly can be removed from the sound level meter and connected via an optional extension cable, for measurements a distance.

- **Display**
  The LCD panel shows numerical readings and a bar graph representing the measured sound pressure level. It also shows information about operation status and selected measurement parameters.

- **Start/Stop button**
  Press to start the L_{eq} measurement. When the button is pressed during a measurement, the measurement is terminated at that point.

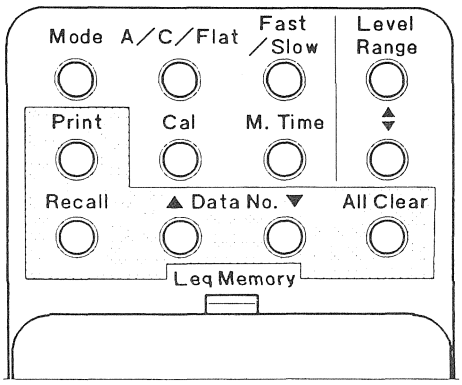
- **Pause/Cont button**
  Press to pause the L_{eq} measurement, and press again to resume the measurement. If the button is pressed while L_{eq} measurement is not being carried out, the value currently shown on the display is held constant (fixed). Pressing the button again cancels the hold condition.

- **Lp /Leq button**
  This button switches the display between indication of instantaneous sound pressure level (L_p) and L_{eq}.

- **Strap**
  Makes the unit easy to carry and hold on your palm.

• Setup panel

Opening the setup panel cover gives access to various buttons used for setting measurement parameters and storing data. The functions of these buttons are described below.



Setup panel (cover open)

Mode: Switches the display between instantaneous sound pressure level, L_{eq}, L_E, and L_{max}.

A/C/Flat: Determines the type of frequency weighting.

Fast/Slow: Determines the time weighting.

Cal: Activates the built-in oscillator for electrical calibration.

M. Time: Sets the measurement time for L_{eq} processing.

Level Range: These buttons serve to select the level range for measurement.

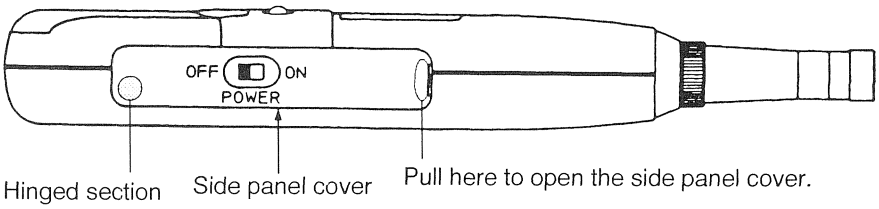
Print: Serves to print out L_{eq} data (stored in memory) on the printer CP-10.

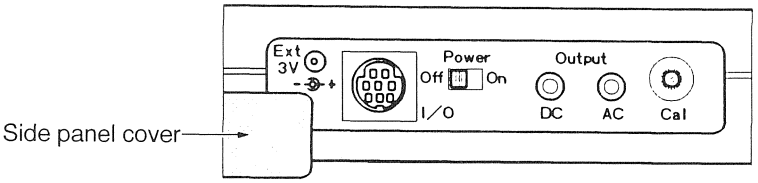
Recall: Serves to recall L_{eq} data from the internal memory.

Data No.: The NL-15 can store up to 50 sets of L_{eq} data in memory. These buttons serve to select the memory data number for storing or recalling data.

All Clear: Press to clear all data stored in the memory of the unit.

Side Panel





Side panel (cover open)

POWER: Turns the unit on and off.

Ext 3V: This jack allows connection of an external power supply. The optional AC adapter NC-27 series can be used to power the unit from an AC line.

I/O: The input/output terminal has the following functions:
- Data output to printer CP-10
- Communication with a computer (RS-232-C interface)

Output

DC: A DC signal corresponding to the measurement result is output here. The signal has been processed by the frequency weighting, RMS detection and logarithmic compression circuits.

AC: An AC signal corresponding to the measurement result is output here. The signal has been processed by the frequency weighting circuit.

Cal: This control is used when calibrating the sound level meter.

PREPARATIONS

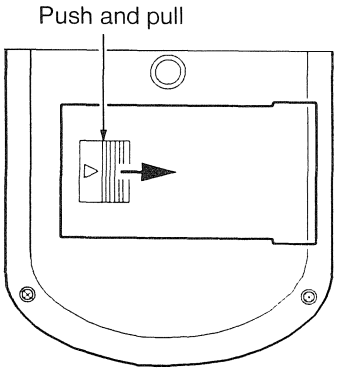
This section describes how to prepare the unit for use. Set the POWER switch to "OFF" while you make preparations.

Power Supply

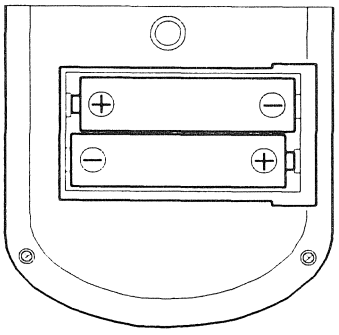
The NL-15 can be powered from two IEC R6 (size "AA") batteries or from the optional AC adapter NC-27 series. When the adapter is plugged in, the unit is powered by the adapter even if batteries are inserted.

Inserting the Batteries

1. Open the cover of the battery compartment on the rear of the unit.
2. Insert two IEC R6 (size "AA") batteries with correct polarity as marked in the battery compartment.



Open cover of battery compartment



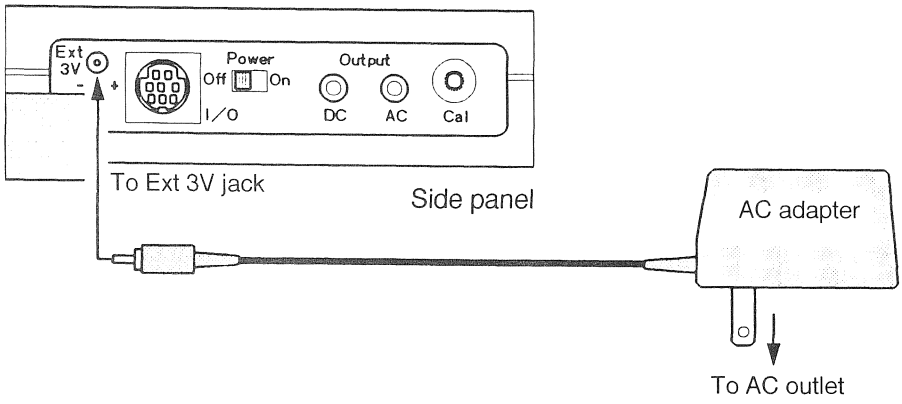
Insert two IEC R6 batteries

3. Close the cover of the battery compartment.

Battery life for continuous operation is about 20 hours with alkaline batteries (LR6) and about 10 hours with manganese batteries (R6P).

Connecting the AC Adapter

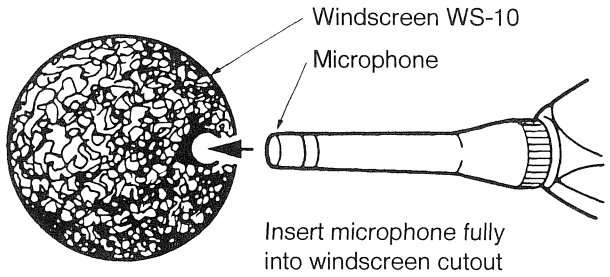
Connect the AC adapter NC-27 series (NC-27 for 100 V AC, NC-27A for 120 V AC, NC-27B for 230 V AC) as shown below.



Mounting the Windscreen

When making outdoor measurements in windy weather or when measuring air conditioning equipment or similar, wind noise at the microphone can cause measurement errors. To prevent this, you should use the supplied windscreen WS-10.

The windscreen will reduce wind noise by about 25 dB with "A" weighting, and by about 15 dB with "C" weighting. The acoustical influence of the windscreen on the microphone response is within ±1.0 dB up to 8 kHz.

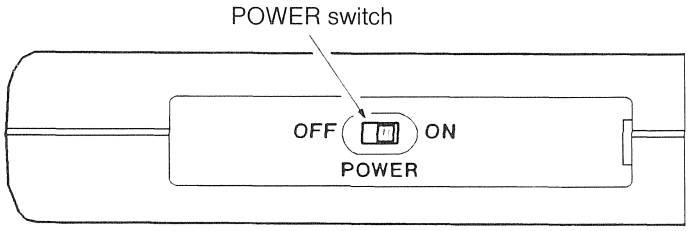


BASIC OPERATION AND DISPLAY FUNCTIONS

Turning the Unit On and Checking the Batteries

- **Turning the unit on**

  Set the POWER switch to "ON".



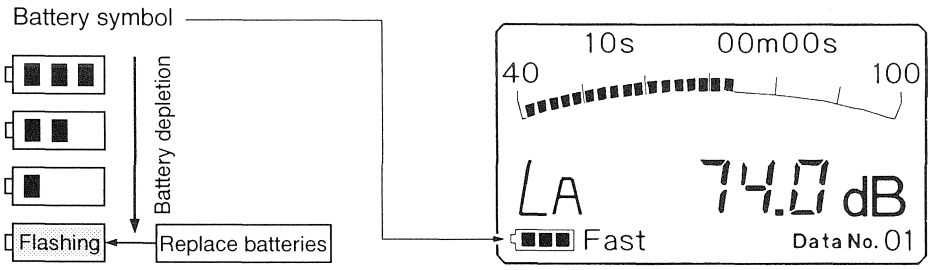
Side panel

- **Checking the battery condition**

  The battery symbol in the lower left of the display shows the battery condition. When all three segments are visible, the batteries are fresh. During use, the segments will gradually go out. When the batteries are nearing exhaustion, all three segments will flash. In this condition, correct measurements are not assured, and you should replace both batteries with fresh ones.

  Battery life for continuous operation is about 20 hours with alkaline batteries and about 10 hours with manganese batteries.

  Before starting a longer measurement, you should make sure that the batteries are fresh, i.e. that all three segments of the battery symbol are visible.



- ***Turning the unit off***

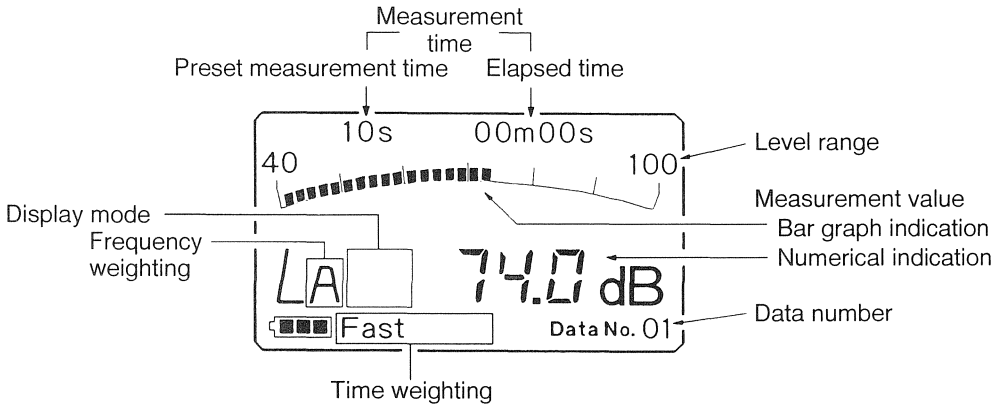
  Set the POWER switch to "OFF".

  If the unit will not be used for a long time, you should remove the batteries.

  All measurement setup parameters and all data stored in memory will be retained also while the unit is switched off. Data will not be lost even if the batteries are removed.

Basic Setup Steps and Display Functions

This section explains basic operation steps common to all measurements, such as selecting frequency weighting and time weighting. The section also gives general information on how to read the display. Specific steps for the various measurement types and specific display functions are explained in the subsequent sections starting on page 12. Please refer to the sections "Measurement", "Using the Internal Memory", and "Optional Equipment".



Reading the display

- **Setting the level range (measurement range)**
  Use the Level Range buttons to select a suitable range. The ▲ button increases the range and the ▼ button decreases it. The bar graph scale reflects the selected level range.

- **Selecting the frequency weighting characteristic**
  Press the A/C/Flat button to cycle through the settings "A weighting", "C weighting", and "Flat". The selected frequency weighting is shown on the display as follows.

  A weighting: L_A
  C weighting: L_C
  Flat: L_P

• Selecting the time weighting

Press the Fast/Slow button to switch between the "Fast" and "Slow" time weighting setting.

• Measurement value display

Bar graph display: The bar graph display has a resolution of 2 dB and a range of 60 dB. The display is updated every 0.1 seconds.

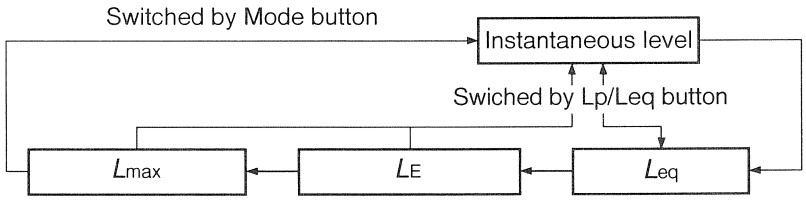
Numerical display: The numerical reading has a resolution of 0.1 dB and is updated every second.

• Selecting the display mode

The Lp/Leq button and the Mode button are used to select the function of the numerical display. The bar graph always shows the instantaneous value.

Lp/Leq button: Switches between instantaneous sound pressure level display (L_p) and L_{eq} display.

Mode button: Cycles through the settings for instantaneous sound pressure level, L_{eq}, L_E, and L_{max} display.



The display mode is indicated on the display as follows. (The example is for "A" weighting.)

Instantaneous sound pressure level: L_A (no indication)

Equivalent continuous sound pressure level: L_{Aeq}

Sound exposure level: L_{AE}

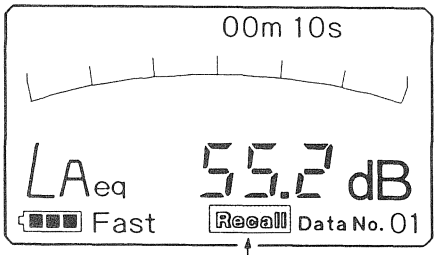
Maximum sound pressure level: L_{Amax}

The "A" indication depends on which frequency weighting is selected (see page 9).

- **Measurement time**
  The measurement time set for L_{eq} measurement and the elapsed time are shown on the display. For details, please refer to "Measurement of L_{eq}, L_E, L_{max}" on page 16.

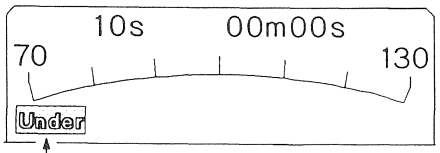
- **Data number**
  This number serves to distinguish L_{eq} data stored in the memory of the unit. For details, please refer to "Using the Internal Memory" on page 19.

- **Switching between measurement mode and recall mode**
  Measuring the instantaneous sound pressure level or L_{eq} is called the measurement mode. Calling up data stored in the internal memory of the unit is called the recall mode (see "Using the Internal Memory" on page 19). To activate recall mode, press the Recall button. The indication "Recall" appears on the display and the bar graph indication disappears. To return to the measurement mode, press the Recall button once more.

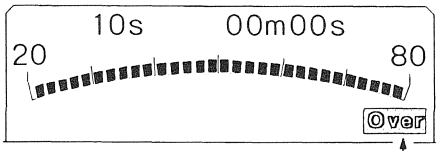


Recall mode indication

- **Under-range and overload indication**
  When the input signal is too low for the selected level range, the indication "Under" appears on the display. Likewise, when the input signal is too high, causing overload, "Over" is displayed. Use the Level Range buttons to select a suitable setting.



Under-range indication



Overload indication

MEASUREMENT

This section describes how to perform calibration, and how to measure instantaneous sound pressure level and L_{eq} (equivalent continuous sound pressure level) etc.

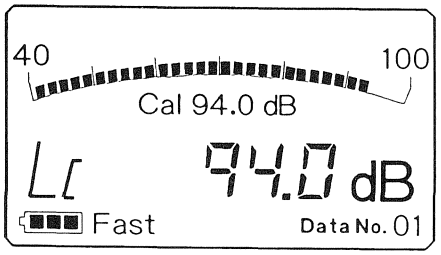
Calibration

Before starting a measurement, you should calibrate the NL-15. There are two types of calibration, namely electrical calibration and acoustic calibration. Normally, electrical calibration only is required.

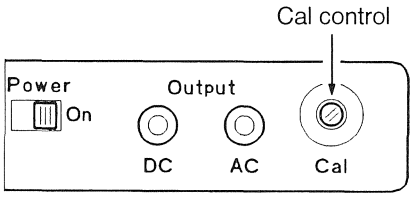
- Electrical calibration: Calibrates the electrical circuits of the unit, using the built-in oscillator. The microphone is not included in this type of calibration.
- Acoustic calibration: Calibrates the entire system including the microphone, using the pistonphone NC-72 (option).

Electrical Calibration

1. Turn on the sound level meter.
2. Press the Cal button to activate the calibration mode.
   The indication "Cal 94.0 dB" appears on the display (see illustration below).
3. Adjust the Cal control with the supplied screwdriver so that the numerical display reads "94.0 dB".
4. Press the Cal button again to terminate the calibration mode and activate the measurement mode.
   The indication "Cal 94.0 dB" disappears from the display.



Calibration display



Side panel

Acoustic Calibration

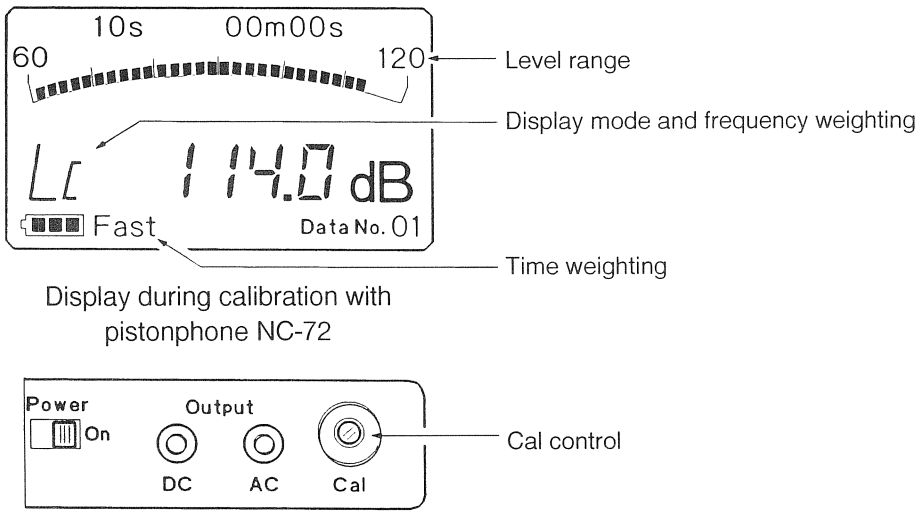
For acoustic calibration, mounting the Rion pistonphone NC-72 (option) to the sound level meter, adjust the sound level meter so that the reading of the meter is equal to the sound pressure level inside the coupler. The sound pressure level in the coupler of the NC-72 is shown below.

- Pistonphone NC-72: SPL 114 dB ±0.2 dB, frequency 250 Hz ±1%

1. Turn off the sound level meter and the calibration equipment.
2. Mount a 1/2-inch adapter on the coupler of the calibration equipment, and carefully insert the microphone of the sound level meter all the way into the coupler.

Note: The inserting and removing should be done gently and slowly. The abrupt inserting and removing can cause the sudden change of the pressure in the coupler and the membrance of the microphone could be destroyed.

3. Turn on the sound level meter and establish the following settings:
   Display mode: Instantaneous value
   Frequency weighting: C
   Time weighting: Fast
   Level range: 120 dB for NC-72
4. Turn on the calibration equipment.
5. Adjust the Cal control of the sound level meter with the supplied screwdriver so that the numerical display reading corresponds to the sound pressure level inside the coupler (NC-72: 114 dB).



Display during calibration with pistonphone NC-72

Side panel

6. Turn off the sound level meter and calibration equipment, and carefully remove the microphone from the coupler.

Measurement of Instantaneous Sound Pressure Level

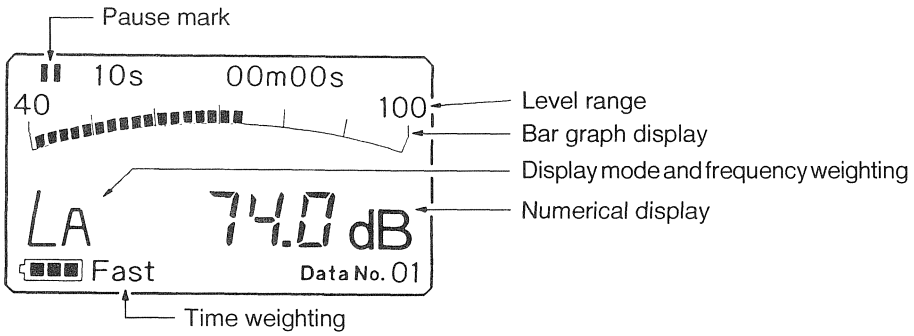
After turning the unit on and performing calibration, carry out the following steps for instantaneous value measurement.

1. If the unit is not in the instantaneous value display mode, press the Lp/Leq button to select the mode (see illustration below).

2. Select the frequency weighting characteristics with the A/C/Flat button and the time weighting with the Fast/Slow button. For A-weighted sound pressure level (L_A) measurement, select "A" weighting, and for sound pressure level (L_p) measurement, select "Flat" weighting. The time weighting should normally be set to "Fast".
   When carrying out a measurement according to a standard, establish the settings prescribed by the standard.

3. Set the level range with the Level Range buttons so that the bar graph registers to about the center of the scale, and the "Under" or "Over" indication does not appear on the display.

4. Read the measured instantaneous value from the display. The numerical display is updated every second and the bar graph display every 0.1 seconds.



By using the Pause/Cont button, you can interrupt and resume the measurement. During pause, the pause mark (❚❚) is displayed. In this condition, no other button operation is possible.

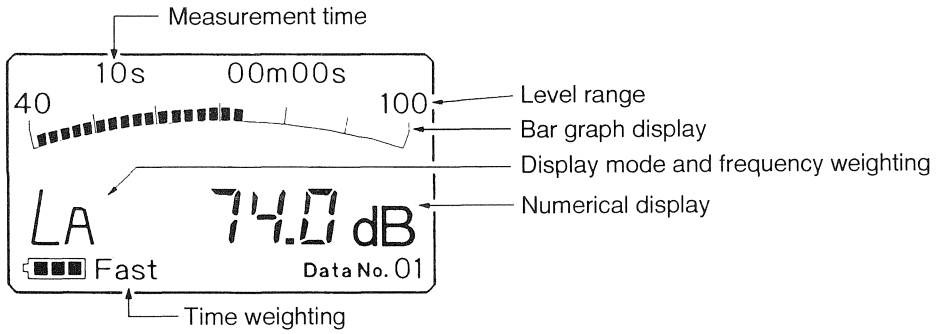
Measurement of L_{eq}, L_E, L_{max}

The NL-15 simultaneously calculates the L_{eq} (equivalent continuous sound pressure level), L_E (sound exposure level), and L_{max} (maximum sound pressure level). After processing, the display can be switched to show any of these values. The measurement procedure is explained below. After turning on the unit and performing calibration, carry out the following steps.

1. Select the frequency weighting with the A/C/Flat button and the time weighting with the Fast/Slow button.
2. Set the level range with the Level Range buttons so that the bar graph registers to about the center of the scale. If high levels are expected during measurement, the level range should be set with a sufficient margin.
3. Select the measurement time with the M.Time button. With each push, the button cycles through the following settings:

   [no display] (manual start/stop) → 10 s → 1 m → 5 m → 10 m → 15 m → 30 m → 1 h → 8 h → 24 h → [no display] → ···
   (s = seconds, m = minutes, h = hours)

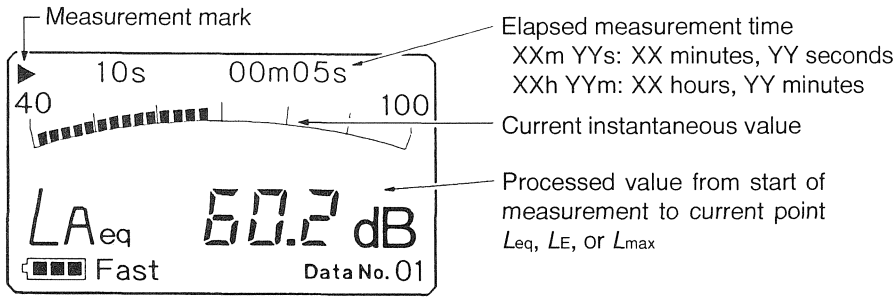
   In the [no display] condition, you can start and stop the measurement manually with the Start/Stop button. Maximum measurement time in this case is 99 hours 59 minutes 59 seconds.



Settings for L_{eq}, L_E, L_{max} measurement

4. Press the Start/Stop button to start the measurement.
   A mark (►) indicating that measurement is being carried out appears, and the elapsed measurement time is displayed.
   The display mode depends on which mode was selected before the start of processing.
   - Processed value display: No change
   - Instantaneous value display: Display mode changes to the mode selected previously, either L_{eq}, L_E, or L_{max}.

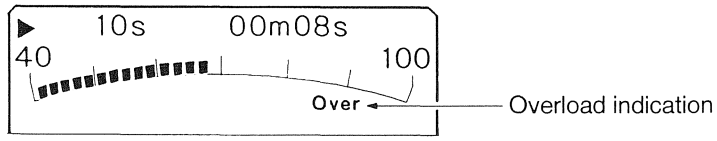
   The bar graph display always shows the instantaneous value.



Display during measurement

By using the Pause/Cont button, you can pause and resume the measurement. During pause, the pause mark (❚❚) is displayed. The time during which measurement was paused will not be included in the measurement time.
During the measurement, you can switch the display mode with the Lp/Leq button or the Mode button. However, the bar graph display always shows the instantaneous value. The only operation steps possible during measurement are switching the display mode, pause and resume, and stopping the measurement with the Start/Stop button.

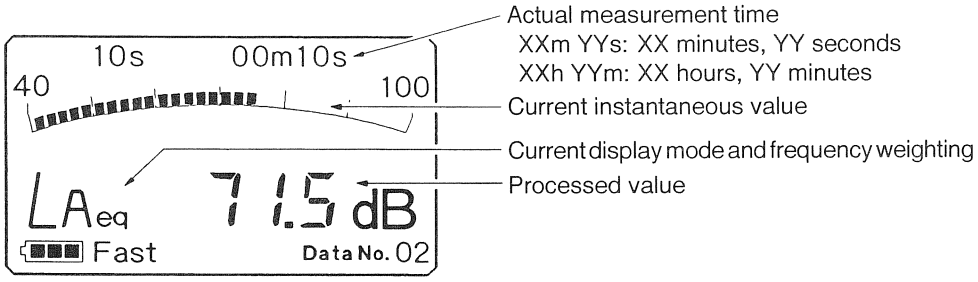
If an overload condition occurs during the measurement, the "Over" indication appears on the display. This indication remains visible until the start of the next measurement.



Measurement stops automatically when the time set in step 3 has elapsed. The measurement may also be stopped before the preset time by pressing the Start/Stop button. If no measurement time was selected, the Start/Stop button must be used to stop the measurement.

When the measurement is completed, the L_{eq} data are automatically stored in the memory of the unit. For information on this function, please refer to "Using the Internal Memory" on page 19.

5. To read the results, use the Lp/Leq button and the Mode button to switch the display. The Lp/Leq button switches between instantaneous sound pressure level display and L_{eq} display, and the Mode button cycles through the settings for instantaneous level, L_{eq}, L_E, and L_{max} display.



Display after measurement

Note: If the frequency weighting or time weighting setting was changed, the weighting shown on the display and the actual weighting used during measurement will be different.
When the next measurement is started, the previous results are cleared.

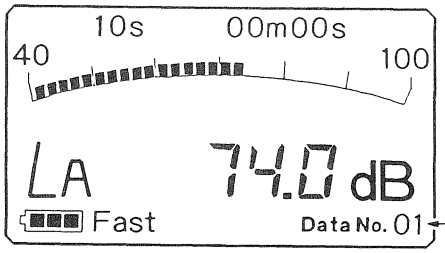
USING THE INTERNAL MEMORY

The NL-15 has an internal memory for storing L_{eq} data. The stored data can then be called up on the display (data recall), printed out on the printer CP-10 (option), and sent to a computer via the RS-232-C interface.
This section explains how to store, recall, and erase data. For information about printing, please refer to page 22, and for information about data transfer to page 30.

All data stored in memory will be retained also while the unit is switched off. Data will not be lost even if the batteries are removed.

Storing L_{eq} Data

When calculation of L_{eq} has been completed, the data are automatically stored in the memory of the unit. The data number shown at the start of the measurement is used to store the data.



Data number display

Note: • Data will always be stored. It is not possible to disable this function.
• Only L_{eq} data are stored. Instantaneous value, L_E, and L_{max} data are not stored.

Data are stored according to the following procedure.

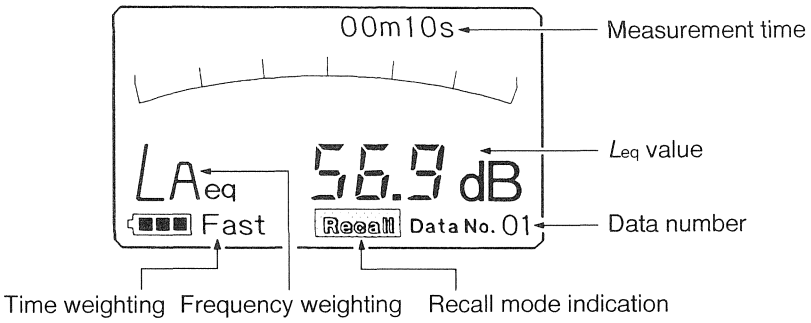
1. Select the data number with the Data No. buttons (01 - 50). Pressing the ▲ button increases the number and pressing the ▼ button decreases it.
   You can skip this step if the currently displayed data number is acceptable.

2. Perform measurement of L_{eq} (see page 16). When the measurement is completed, the result is stored in the data number selected in step 1. If this data number already contains data, the previous data will be overwritten.
   After the data have been stored, the next data number is shown on the display.

3. Repeat steps 1 and 2 to store more L_{eq} data. After data have been stored in data number 50, the indication "50" flashes, and the data number will not be incremented further. When wishing to store more data, select a data number as described in step 1.

Recalling L_{eq} Data

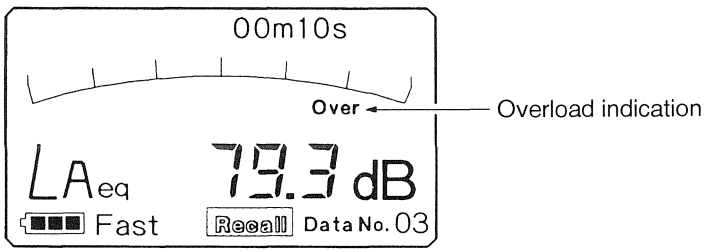
To call up stored data on the display, press the Recall button. The indication "Recall" appears, and the L_{eq} (numerical indication only) as well as the measurement time, frequency weighting, and time weighting stored in the currently selected data number are shown.



L_{eq} display in recall mode

You can use the Data No. buttons to select the desired data number. Pressing the ▲ button increases the number and pressing the ▼ button decreases it. Keeping a button depressed will continuously change the number.
If no data are stored in a data number, the display reads "0.0 dB".

If overload has occurred during processing, the indication "Over" is shown.



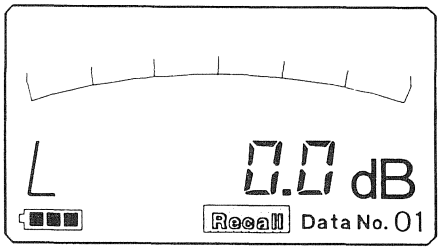
To cancel the recall mode and return to the measurement mode, press the Recall button once more.

Clearing Stored Data

To erase all L_{eq} data stored in memory, proceed as follows.

Note: The following procedure will clear all stored data. It is not possible to selectively clear data in a certain data number. If the memory currently contains data that you wish to keep, print them out on the optional printer CP-10 or transfer the data to a computer via the RS-232-C interface.

1. Press the Recall button to set the unit to the recall mode.
2. Press the All Clear button.
   All stored data are cleared. The data number display shows "01" and the numerical display reads "0.0 dB".



Display after clearing stored data

3. Press the Recall button again to return to the measurement mode.

OPTIONAL EQUIPMENT

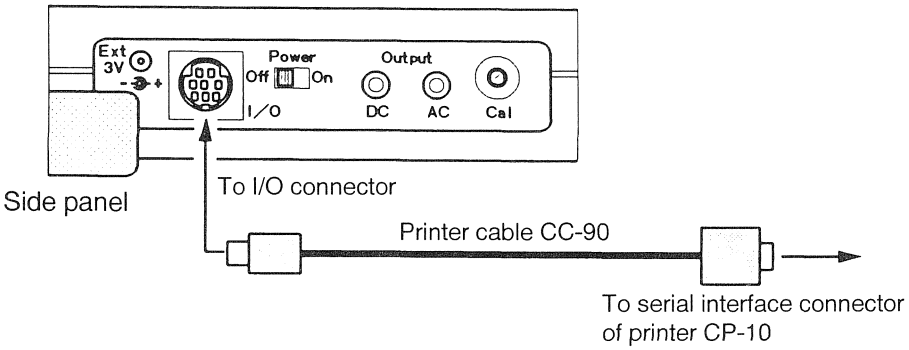
This section explains the use of optional accessories such as a printer, level recorder, microphone extension cable, etc.

Printer CP-10

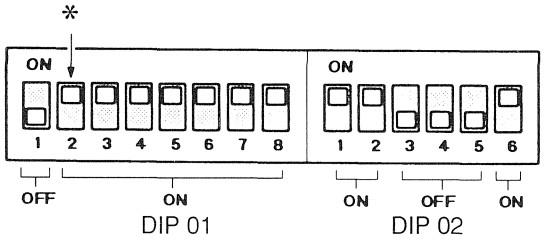
The printer CP-10 can be used to print out L_{eq} measurement results or L_{eq} data stored in the internal memory. This section describes operation steps at the sound level meter. For details on operation of the printer, please refer to the instruction manual of the CP-10.

Connecting the Printer and Setting the Printer DIP Switches

Connect the serial interface connector of the printer CP-10 to the I/O connector of the NL-15, using the printer cable CC-90.



Set the two DIP switches of the printer CP-10 as shown below.



Printer CP-10 DIP switch settings

*: When switch 2 of DIP 01 is set to "ON", data are printed with a blank line in between (double line spacing). When the switch is set to "OFF", the data are printed with single line spacing.

Printout Procedure

• Printing L_{eq} data during measurement

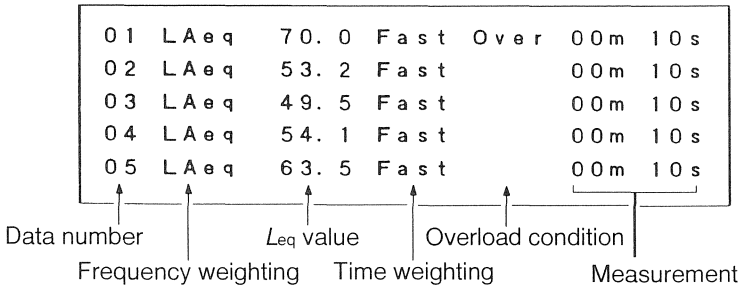
1. Turn on the NL-15 and the CP-10 and set the printer to the on-line condition.
2. Perform L_{eq} measurement.
   When the measurement is completed, the results are automatically printed out.

• Printing stored L_{eq} data

1. Turn on the NL-15 and the CP-10 and set the printer to the on-line condition. It does not matter whether the NL-15 is in measurement mode or recall mode.
2. Press the Print button.
   All L_{eq} data stored in memory are printed out, starting with lower data numbers. Data numbers which contain no data are not printed. If there are no data in any data number, the message "NO DATA" is printed.

Printout Format

The L_{eq} data from a measurement or from memory are printed in the following format.



Data number: "01" - "50"
When printing L_{eq} data from a measurement, this number is the same as the number under which the data have been stored in memory. If the data number "50" was flashing (see page 19), no data number is printed.

Frequency weighting: "A", "C", or "p"
When no weighting was used (flat characteristics), a "p" is printed.

L_{eq} value: This is the L_{eq} value from measurement or stored in memory.

Time weighting: "Fast" or "Slow"

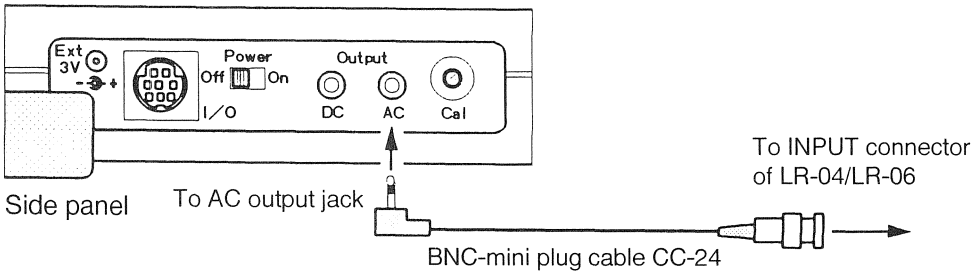
Overload condition: "Over" or blank
If overload has occurred, the indication "Over" is printed.

Measurement time: □□h □□m or □□m □□s
The L_{eq} measurement time, in hours and minutes or minutes and seconds.

Level Recorder LR-04/LR-06

By connecting the AC output of the sound level meter to the level recorder LR-04 or LR-06, the sound pressure level changes over time can be recorded.

Connect the level recorder as shown below.



In the calibration mode of the sound level meter, a calibration signal (1000 Hz sine wave signal, corresponding to 94.0 dB) is supplied at the output. Use this signal to calibrate the level recorder. The calibration level is 6 dB below the full-scale value of the sound level meter. You should therefore adjust the level recorder so that the pen is 6 dB below the maximum point.

The signal at the AC output of the sound level meter reflects frequency weighting. To record A-weighted sound pressure levels, you should therefore select the "A" weighting characteristic at the sound level meter. To record sound pressure levels, use the "Flat" setting. The time weighting must be set at the level recorder.

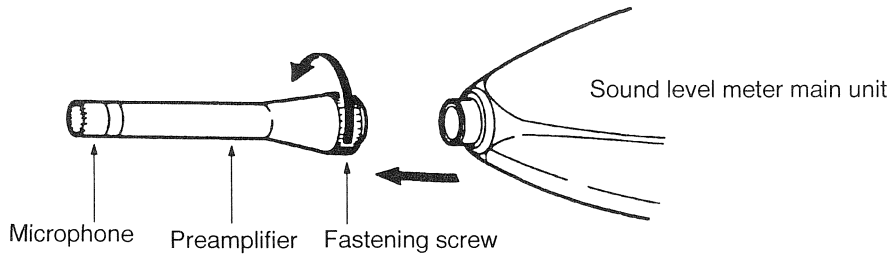
Microphone Extension Cable EC-15 Series

For measurements requiring special precision, the microphone can be removed from the main unit and connected by means of an extension cable. This reduces measurement deviations due to diffraction effects and the acoustic influence of the operator.
Two types of cables are available: EC-15 (length 2 meters) and EC-15A (length 5 meters).

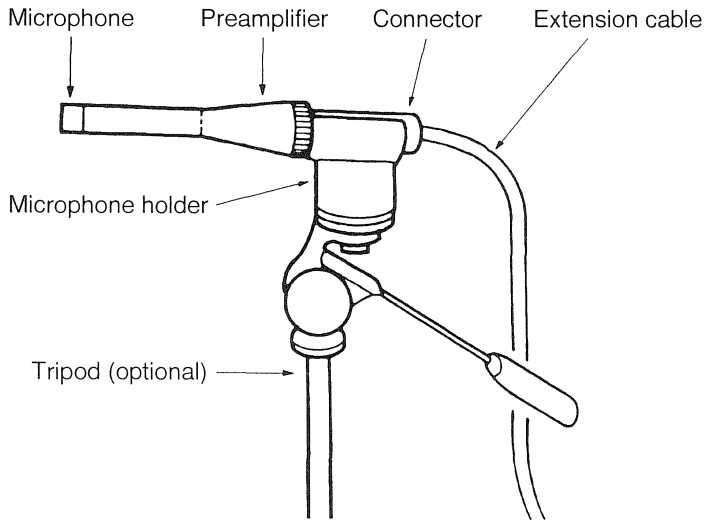
• Attaching the extension cable

1. Turn off the sound level meter.
2. Loosen the preamplifier fastening screw and remove the preamplifier from the main unit.

Note: Do not separate the microphone from the preamplifier.

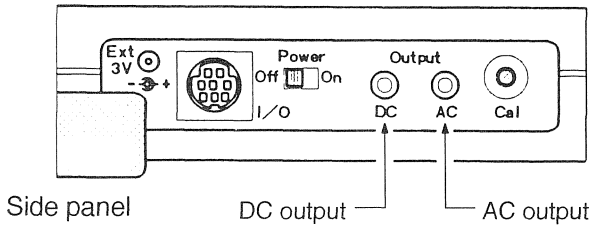


3. Connect the sound level meter to the preamplifier, using the extension cable. Fasten the cable with the fastening screw at both ends.
4. When mounting the microphone on a tripod, first fasten the microphone holder (supplied with the extension cable) to the tripod, then insert the extension cable connector into the microphone holder.



Other Equipment (Use of the AC and DC Output Jacks)

This section lists other equipment such as analyzers which can be connected to the AC output and DC output of the NL-15.

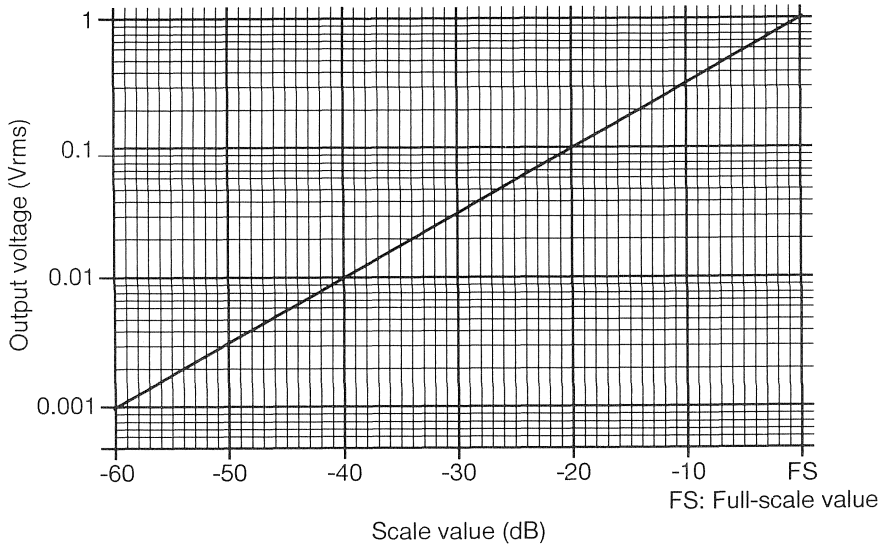


- **AC output**

The signal at the AC output of the sound level meter reflects frequency weighting.

Output voltage:	1 Vrms (at full-scale)
Output impedance:	Approx. 600 Ω
Load impedance:	10 kΩ or more
Cable type:	BNC-mini plug cable CC-24 (option)
Suitable equipment:	Level recorder LR-04/LR-06
	1/3 octave band real-time analyzer SA-25/SA-27
	FFT signal analyzer SA-71
	Signal analyzer SA-77
	Data recorder
	Other equipment with AC signal input

By activating the calibration mode of the sound level meter, level range is set to 100 dB (40 - 100) and a calibration signal (1000 Hz sine wave signal, corresponding to 94.0 dB) can be supplied at the output. Use this signal to calibrate the connected equipment. The calibration level is 6 dB below the full-scale value.



Scale values and AC output voltage

[Example]

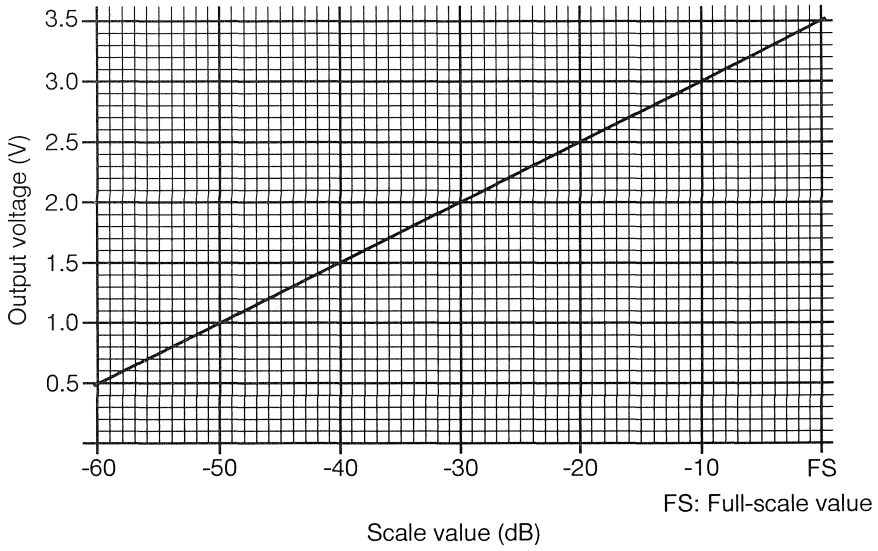
- If the level range of the sound level meter is set to 100 dB (full-scale value = 100 dB), the output voltage will be as follows.
  At 60 dB: 0.01 V rms
  At 80 dB: 0.1 V rms
  At 100 dB: 1 V rms

- If the level range of the sound level meter is set to 120 dB (full-scale value = 120 dB), the output voltage will be as follows.
  At 80 dB: 0.01 V rms
  At 100 dB: 0.1 V rms
  At 120 dB: 1 V rms

• DC output

The signal at the DC output of the sound level meter reflects the frequency weighting, RMS detection, time weighting setting and logarithmic compression of the sound level meter.

Output voltage: 3.5 V (at full-scale), 0.5 V/10 dB
Output impedance: Approx. 50 Ω
Load impedance: 10 kΩ or more
Cable type: BNC-mini plug cable CC-24 (optional)
Suitable equipment: Equipment with DC signal input



Scale values and DC output voltage

[Example]

- If the level range of the sound level meter is set to 100 dB (full-scale value = 100 dB), the output voltage will be as follows.
  At 40 dB: 0.5 V
  At 70 dB: 2.0 V
  At 100 dB: 3.5 V
- If the level range of the sound level meter is set to 120 dB (full-scale value = 120 dB), the output voltage will be as follows.
  At 60 dB: 0.5 V
  At 90 dB: 2.0 V
  At 120 dB: 3.5 V

RS-232-C INTERFACE

The integrated RS-232-C interface allows sending stored data or current measurement data to a computer.

This chapter explains the use of the RS-232-C interface. The chapter is divided into the following sections.

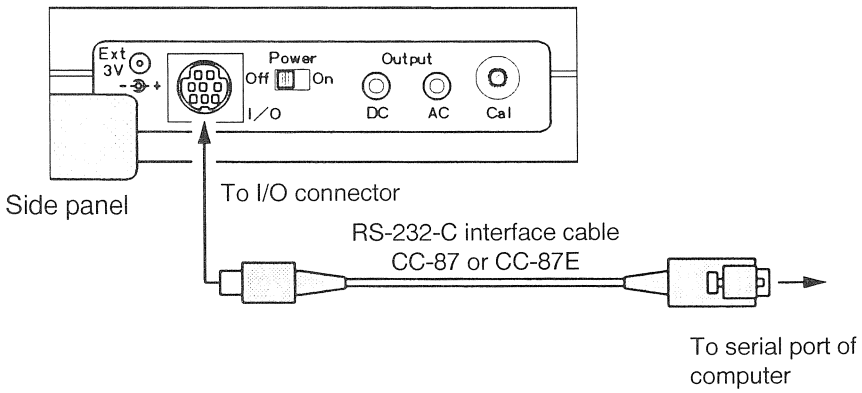
- Connection to a computer (⇒ page 31)
  The separately available RS-232-C interface cable CC-87 or CC-87E is required for connection to a computer. This section explains how to make the connection and gives information on the wiring of the RS-232-C interface cables CC-87 and CC-87E.

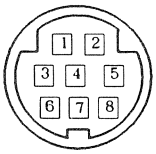
- Transfer protocol and transfer procedure (⇒ page 33)
  This section explains the RS-232-C interface transfer protocol and the procedure to send and receive data.

- Commands (⇒ page 36)
  This section lists all commands which can be used to control the NL-15, and explains the output data format.

Connection to a Computer

The illustration below shows how to connect the NL-15 to a computer. Use the separately available RS-232-C interface cable CC-87 or CC-87E.



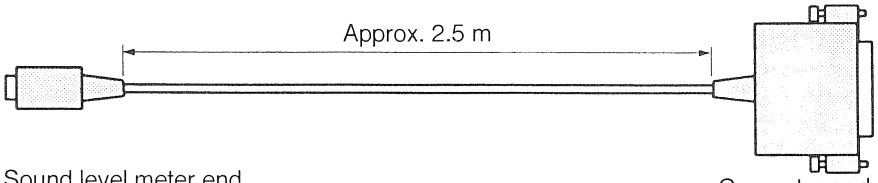


I/O connector of
sound level meter

RS-232-C interface cable CC-87 wiring

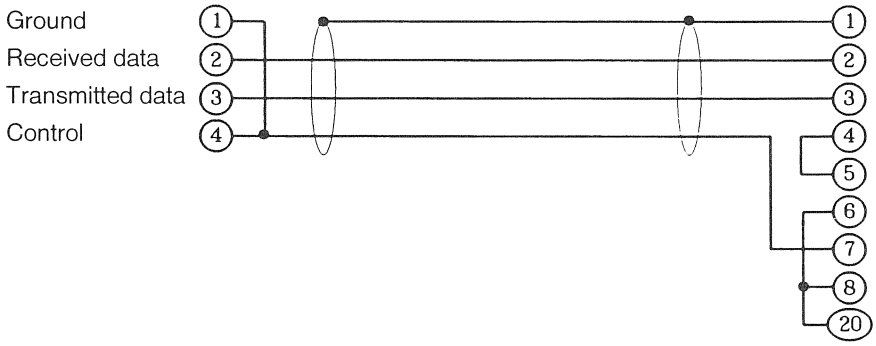
Hoshiden Electronics
TCP8080-01-020

Japan Aviation Electronics
DB-25P-N/DB-C2-J9
(25-pin male connector)



Sound level meter end

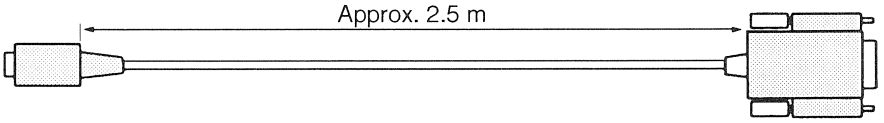
Computer end



RS-232-C interface cable CC-87E wiring

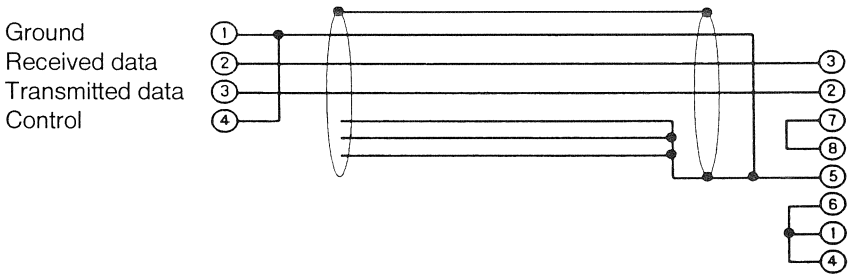
Hoshiden Electronics
TCP8080-01-020

Hirose Electric
HDE-CTH/HDEB-9S
(9-pin female connector)



Sound level meter end

Computer end



Transfer Protocol and Transfer Procedure

Transfer Protocol

Flow control:	Yes
Transmission:	Asynchronous, half-duplex
Baud rate:	4800 bps
Data word length:	8 bit
Stop bits:	2
Parity:	None
Xon/Xoff control:	Yes

Remote Mode/Local Mode

- **Remote mode**
  In this condition, the sound level meter receives commands from the computer, and the operation buttons on the sound level meter are inactive. The indication "Remote" appears on the display.

- **Local mode**
  The sound level meter is operated with its operation buttons. No commands from the computer except the command to switch to remote mode are accepted. The "Remote" indication is out.

- **Remote mode/local mode switching**
  The RMT command serves to switch between local mode and remote mode (see page 37).

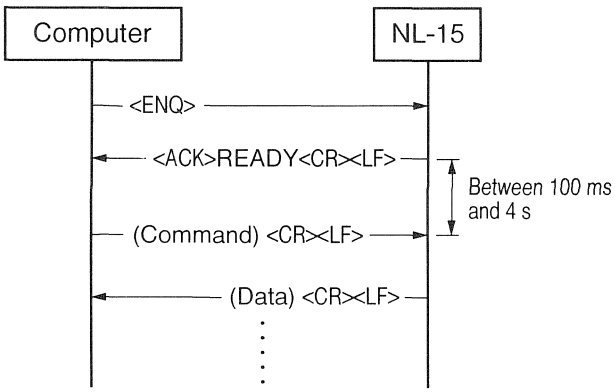
  Note: When the NL-15 is in the local mode, only the command to switch to remote mode (RMT1) is accepted. Therefore data transfer must always be initiated by sending a RMT1 command from the computer, to activate the remote mode of the NL-15.

Transfer Procedure

In order to allow data transfer to a computer, the NL-15 must be in the measurement mode, and a certain command must be sent from the computer to the sound level meter. The data exchange must be performed according to certain rules, to ensure that both the sound level meter and the computer recognize the commands and data properly.

To send commands to the sound level meter, the following procedure must be observed.

1. Verify that the NL-15 is in the measurement mode (see page 11), and that L_{eq} measurement is not currently being carried out.
2. Send an <ENQ> from the computer to the NL-15.
3. When the <ENQ> has been received, the NL-15 returns <ACK>READY<CR><LF> to the computer.
4. The computer must verify receipt of the <ACK>READY<CR><LF> and send a command after 100 milliseconds but within 4 seconds.
   If the command from the computer requests data, the NL-15 outputs the data.
5. When sending next command, wait at least 100 milliseconds and repeat steps 2, 3, and 4.



First <ENQ> is not followed by <CR><LF>.

<ENQ>:	Control code 05 H (enquire)
<ACK>:	Control code 06 H (acknowledge)
<CR>:	Control code 0D H (carrier return)
<LF>:	Control code 0A H (line feed)
<EOT>:	Control code 04 H (end of transfer)
READY:	ASCII string
(Command):	ASCII string (command and parameters)
(Data):	ASCII string (requested data)

Error Handling

• No response from NL-15

- The computer has sent <ENQ>, but no response is received from NL-15.
  Wait about 4 seconds and send <ENQ> again. Repeat this 5 to 6 times. If there is still no response from the NL-15, one of the following conditions may exist:
  Transfer parameters are not matched.
  RS-232-C interface cable is defective or not properly connected.
  NL-15 is not in measurement mode.
  NL-15 is not turned on.

- A valid command was sent from the computer, but no response is received from NL-15.
  Wait about 4 seconds and repeat the procedure by sending <ENQ> again.

• Other errors

In order to ensure correct data exchange between the NL-15 and the computer, the rules described on previous page must be observed. If an error occurs, the following steps should be taken.

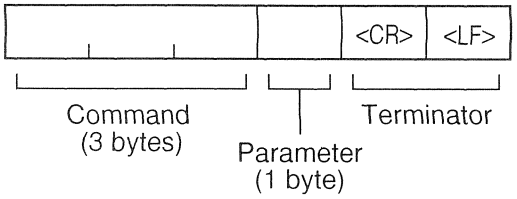
- <ACK>READY<CR><LF> from the NL-15 was received, but the computer has not completed the sending of commands within 4 seconds.
  The NL-15 terminates the standby condition for receiving commands. Commands received after more than 4 seconds are disregarded. Restart the procedure by sending <ENQ> again.

- The computer has not sent <ACK>NEXT<CR><LF> within 4 seconds to receive the next block of data (see explanation of DOR? command on page 38).
  The NL-15 cancels the transfer of the remaining data. If <ACK>NEXT<CR><LF> is received after more than 4 seconds, it is disregarded.

- A wrong command was sent.
  When the computer has sent a wrong command (invalid string or parameter out of range), the NL-15 disregards the command.

Commands

Commands that can be used by the NL-15 consist of 3 characters (3 bytes), followed by a parameter. The parameter is 1 character (1 byte). This can be either a numeral or "?". The question mark signifies a data request.



The following 3 commands are available.

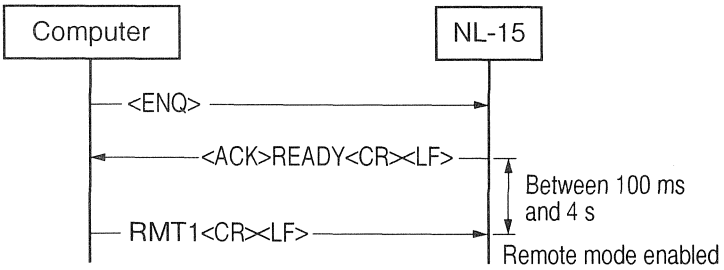
RMT0/RMT1:	Enable local mode/remote mode
DOR?:	Request data stored in memory
DOC?:	Request continuous output of instantaneous value data

Note: It is not possible to send multiple commands together.
For data transfer with a computer, the NL-15 must be in the measurement mode, but L_{eq} measurement must currently not be carried out.

RMT0 Enable local mode
RMT1 Enable remote mode

When the NL-15 is in local mode, it does not accept any external commands except for RMT1 (enable remote mode). Therefore data transfer must always be initiated by sending a RMT1 command from the computer, to activate the remote mode of the NL-15.

When remote mode is enabled, the NL-15 accepts external commands, but the panel buttons are inactive. In this condition, the indication "Remote" is shown on the display.



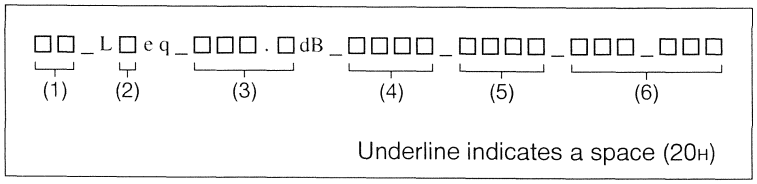
First <ENQ> is not followed by <CR><LF>.

<ENQ>: Control code 05 H (enquire)
<ACK>: Control code 06 H (acknowledge)
<CR>: Control code 0D H (carrier return)
<LF>: Control code 0A H (line feed)
READY: ASCII string

Even if the NL-15 was in remote mode when switched off, it will be in local mode the next time it is switched on.

DOR? Request data stored in memory

When the NL-15 receives the DOR? command, it outputs L_{eq} data stored in the unit's memory. The format of each set of L_{eq} data is as follows.



(1) Data number: "01" - "50"

(2) Frequency weighting: "A", "C", or "p" (Flat)

(3) L_{eq} value: If the level is less than 100 dB, the leading digit is a space.

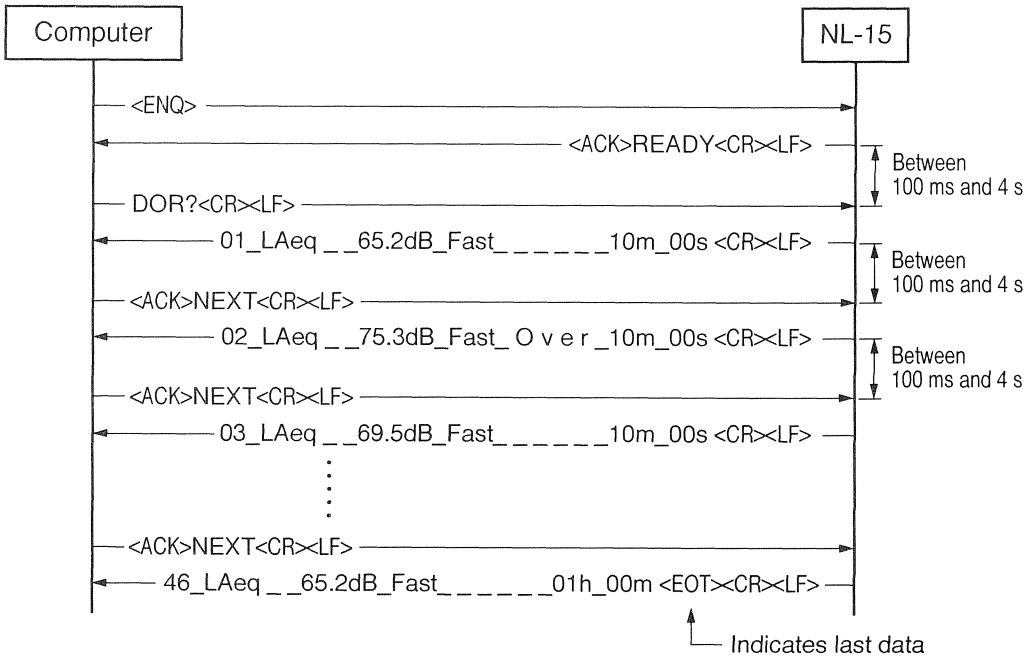
(4) Time weighting: "Fast" or "Slow"

(5) Overload condition: Four spaces (no overload) or "Over"

(6) Measurement time
If less than one hour: □□m_□□s (□□ minutes □□ seconds)
If more than one hour: □□h_□□m (□□ hours □□ minutes)

The data are output in the above format for each data number.
When the NL-15 receives a DOR? command, it first outputs the data for the lowest data number which contains data. The NL-15 then waits for an <ACK>NEXT<CR><LF> command from the computer. If no command is received within 4 seconds, the process terminates. If the <ACK>NEXT<CR><LF> command is received within 4 seconds, the data for the next data number which contains data are sent. (Data numbers without data are skipped.)

This process is repeated until the last set of data is reached.
The NL-15 appends a <CR><LF> after each data set, but after the last data set, it appends <EOT><CR><LF>. By checking for the presence of <EOT>, the computer program can determine whether there are still data to be sent.
If there are no data in memory, the NL-15 outputs NO_DATA<EOT><CR><LF>.



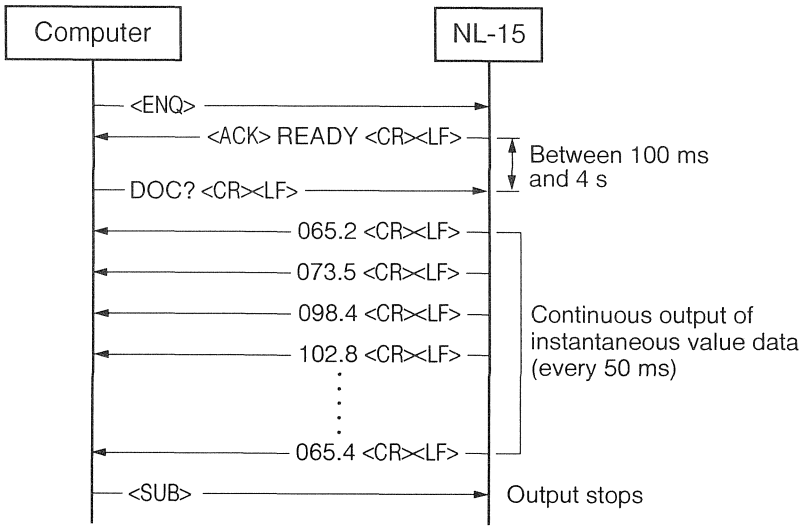
First <ENQ> is not followed by <CR><LF>.

<ENQ>: Control code 05 H (enquire)
<ACK>: Control code 06 H (acknowledge)
<CR>: Control code 0D H (carrier return)
<LF>: Control code 0A H (line feed)
<EOT>: Control code 04 H (end of transmission)
READY: ASCII string
NEXT: ASCII string

DOC? Request continuous output of instantaneous value data
When the NL-15 receives the DOC? command, it outputs instantaneous value data every 50 milliseconds. The format of each data set is as follows.

□□□ . □

□□□ . □ is the instantaneous value in numerical representation. If the level is less than 100 dB, the first digit is a zero.
To terminate the instantaneous value output, send a <SUB> to the computer.



First <ENQ> and <SUB> are not followed by <CR><LF>.

<ENQ>: Control code 05 H (enquire)
<ACK>: Control code 06 H (acknowledge)
<CR>: Control code 0D H (carrier return)
<LF>: Control code 0A H (line feed)
<SUB>: Control code 1A H
READY: ASCII string

SPECIFICATIONS

Applicable standards

IEC 651:1979 Type 1, IEC 804:1985 Type 1

Measurement functions

Instantaneous sound pressure level
Equivalent continuous sound pressure level (L_{eq})
Sound exposure level (L_E)
Maximum sound pressure level (L_{max})

L_{eq}, L_E, L_{max} processing functions

Digital processing for L_{eq}, L_E, L_{max}
Sampling interval: 10 ms
Measurement time: 10 s, 1 min, 5 min, 10 min, 15 min, 30 min, 1 h, 8 h, 24 h (selectable)
Manual setting up to 99 h 59 min 59 s possible
Measurement pause function available

Reference sound pressure level

85 dB

Reference range

50 - 110 dB

Pulse range

73 dB

Linearity range

70 dB

Reference frequency

1 kHz

Reference direction

Perpendicular to microphone diaphragm

Max. measurement level

137 dB rms (130 dB at CF 3)

Noise floor

Typical 17 dB (A) rms (Max. 20 dB (A) rms)

Display range

20 to 140 dB

Frequency range

20 Hz - 12.5 kHz (including microphone)
10 Hz - 20 kHz (electrical characteristics)

Frequency weighting

A, C, Flat

RMS detection

True RMS detection circuit

Time weighting

Fast, Slow

Crest factor capability

CF 3 at upper graph scale limit
CF 10 at upper graph scale limit –10 dB

Level range selection

6 ranges in 10-dB steps
20 - 80 dB, 30 - 90 dB, 40 - 100 dB, 50 - 110 dB, 60 - 120 dB, 70 - 130 dB

Calibration

Electrical calibration with 1000-Hz sine wave signal from built-in oscillator

Display

LCD panel for indication of measurement value, warning messages, and battery condition

measurement value:	4-digit numerical display, update cycle 1 s, resolution 0.1 dB
	Bar graph display, scale range 60 dB in 2-dB steps, update cycle 0.1 s
Warning messages:	Over (overload), upper graph scale limit +9 dB
	Under (under-range), lower graph scale limit –1 dB
Battery condition:	3 segments

Memory

Up to 50 equivalent continuous sound pressure level data (automatic store after measurement)

Microphone

1/2-inch prepolarized condenser microphone

Model:	UC-53A
Sensitivity level:	– 28 dB (0 dB = 1 V/Pa)

Preamplifier

Model: NH-16 (for 1/2-inch prepolarized condenser microphone)

AC output

Output voltage:	1 Vrms (at full-scale)
Output impedance:	Approx. 600 Ω
Load impedance:	10 kΩ or more

DC output

Output voltage:	3.5 V (at full-scale), 0.5 V/10 dB
Output impedance:	Approx. 50 Ω
Load impedance:	10 kΩ or more

I/O connector

For data output to computer (RS-232-C interface) and printer CP-10

RS-232-C interface

Flow control:	Yes
Transmission:	Asynchronous, half-duplex
Baud rate:	4800 bps
Data word length:	8 bit
Stop bits:	2
Parity:	None
Xon/Xoff control:	Yes

Printer output

Output of equivalent continuous sound pressure level data after processing
Output of data stored in memory when Print button is pressed

Power requirements

Two IEC R6 (size "AA") batteries

Continuous operation:	Approx. 10 h (manganese batteries)
	Approx. 20 h (alkaline batteries)

AC adapter NC-27 series (option)

NC-27 (for 100 V AC), NC-27A (for 120 V AC), NC-27B (for 230 V AC)

Current rating:	Approx. 70 mA (3 V DC)

Ambient conditions for operation

−10 to +50°C, 30 to 90% RH

Dimensions

Approx. 227 (length) × 78 (width) × 31 (thickness) mm

Weight

Approx. 300 g

Supplied accessories

Windscreen WS-10	1
IEC R6 batteries	2
Carrying case	1
Miniature screwdriver	1
Instruction manual	1

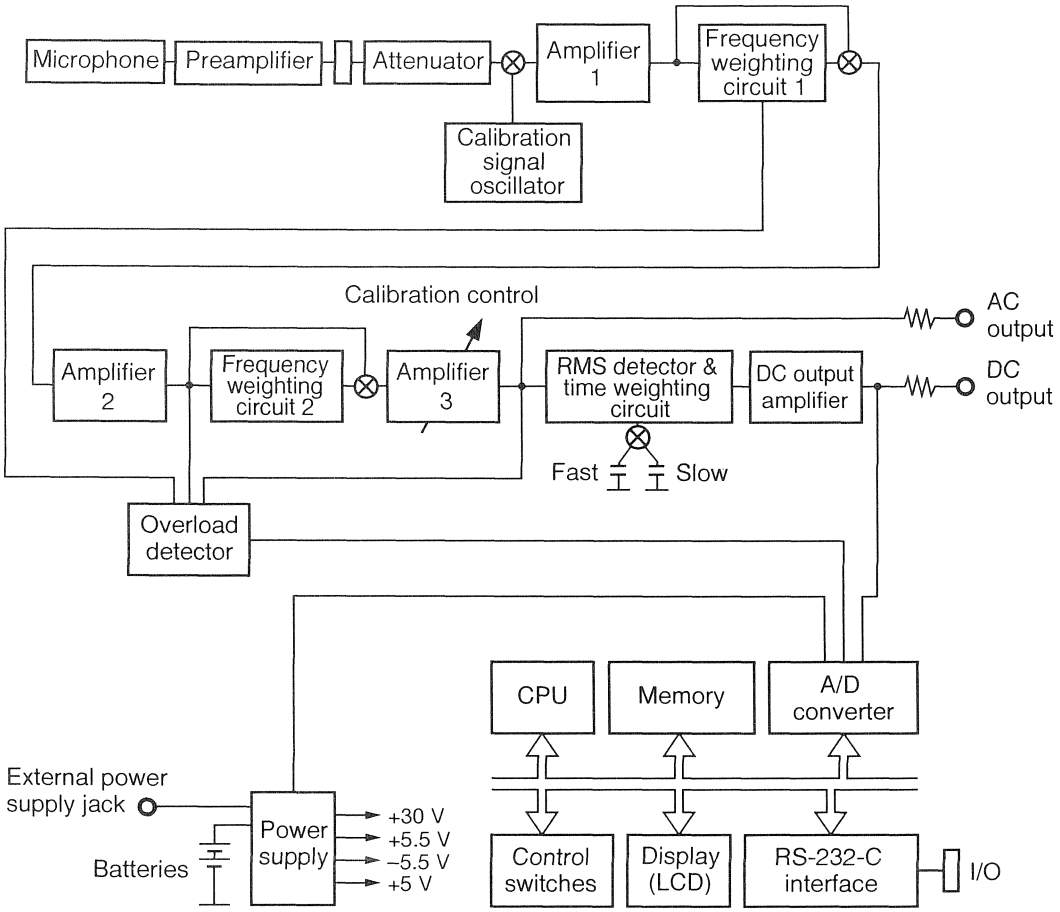
Optional equipment

AC adapter NC-27 (for 100 V AC), NC-27A (for 120 V AC), NC-27B (for 230 V AC)
Microphone extension cable EC-15 (2 m), EC-15A (5 m)
Printer CP-10
Printer cable CC-90
RS-232-C interface cable CC-87 (25-pin male connector), CC-87E (9-pin female connector)
BNC-mini plug cable CC-24 (for connection of AC and DC output to external equipment)
Level recorder LR-04
Level recorder LR-06

REFERENCE MATERIAL

Block Diagram

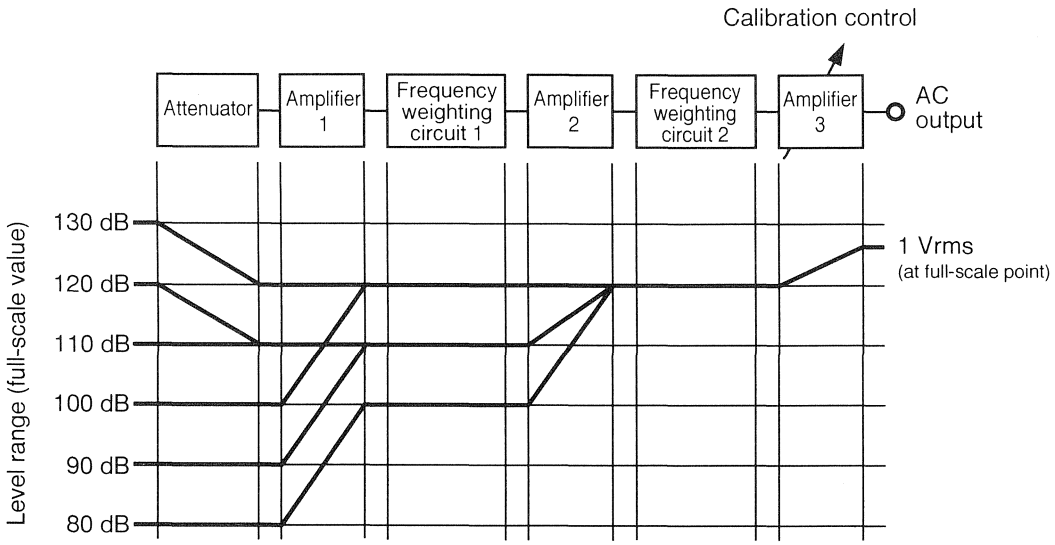
The block diagram of the NL-15 is shown below.



Block Diagram

Amplifier Circuit Configuration and Level Diagram

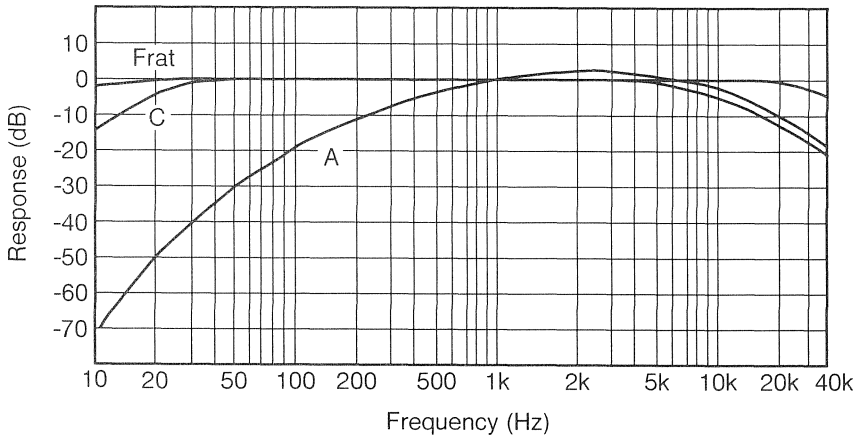
The amplifier circuit configuration and level diagram of the NL-15 are shown below. The attenuation of the attenuator and the gain of amplifiers 1 and 2 depends on the level range setting. The gain of amplifier 3 is adjusted by the calibration control.



Level diagram

Frequency Weighting Circuit

The NL-15 offers a choice of A weighting, C weighting, and flat response. The electrical characteristics of the frequency weighting circuit are shown below.



Frequency weighting characteristics

The volume impression (loudness) of a sound depends not only on the sound pressure level, but also on the frequency. At high or low frequencies, a sound is perceived to be less loud than a sound of equal level in the midrange. The "A" weighting curve compensates for this effect and produces measurement results which are close to the actual impression of loudness. For this reason, this type of frequency weighting is widely used for purposes such as noise level evaluation.

At the "Flat" setting, frequency response is linear, which is suitable for straight sound pressure level measurements and for using the sound level meter output for frequency analysis.

The "C" weighting curve produces almost flat response, but with a rolloff below 31.5 Hz and above 8 kHz. This is suitable for sound pressure level measurements in situations with unwanted low-frequency or high-frequency components.

L_{Aeq}, L_{AE}, L_{Amax} Processing

L_{Aeq} (equivalent continuous A-weighted sound pressure level)

For a sound pressure level signal that changes over time, the L_{Aeq} is a hypothetical constant A-weighted sound pressure level that has the same energy as the actually measured signal in the measurement interval. It is determined by the following equation.

$$L_{Aeq} = 10 \log_{10} \frac{1}{T_m} \int_{t_1}^{t_2} \frac{p_A^2(t)}{p_0^2} dt$$

t_1: Measurement start time
t_2: Measurement end time
T_m: Measurement time (integrated time) $T_m = t_2 - t_1$
p_0: Reference sound pressure 20 μ Pa (2×10^{-5} N/m^2)
$p_{A(t)}$: Instantaneous A-weighted sound pressure

Expressing the above equation for sound pressure level yields the following.

$$L_{Aeq} = 10 \log_{10} \frac{1}{T_m} \int_{t_1}^{t_2} 10^{L_{A(t)}/10} dt$$

$L_{A(t)}$: Instantaneous sound pressure level

In the sound level meter NL-15, this is used as reference, and digital processing is carried out according to the following equation.

$$L_{Aeq} = 10 \log_{10} \frac{1}{N} \sum_{i=1}^{N} 10^{L_{A(i)}/10}$$

Using the output signal of the RMS detection circuit, digital processing is performed to determine the L_{eq} value. For this purpose, a suitable RMS detection time constant and sampling interval must be chosen. In the NL-15, the sampling interval for A/D conversion is 10 ms (100 samples per second), and L_{eq} processing is carried out for every interval. The L_{eq} reading can therefore be displayed already during measurement.

L_{AE} (A-weighted sound exposure level)

The L_{AE} is a hypothetical constant 1-second sound pressure level that has the same energy as a single-event sound pressure level measured with A weighting. It is determined by the following equation.

$$L_{AE} = 10 \log_{10} \frac{1}{T_0} \int_{t_1}^{t_2} \frac{p_A^2(t)}{p_0^2} dt$$

t_1: Measurement start time
t_2: Measurement end time
T_0: Reference time interval (1 second)
p_0: Reference sound pressure 20 μ Pa (2×10^{-5} N/m^2)
$p_{A(t)}$: Instantaneous A-weighted sound pressure

Expressing the above equation for sound pressure level yields the following.

$$L_{AE} = 10 \log_{10} \frac{1}{T_0} \int_{t_1}^{t_2} 10^{L_{A(t)}/10} dt$$

$L_{A(t)}$: Instantaneous sound pressure level

In the sound level meter NL-15, this is used as reference, and digital processing is carried out according to the following equation.

$$L_{AE} = 10 \log_{10} \frac{1}{N_0} \sum_{i=1}^{N} 10^{L_{A(i)}/10}$$

N_0: Number of samples per second

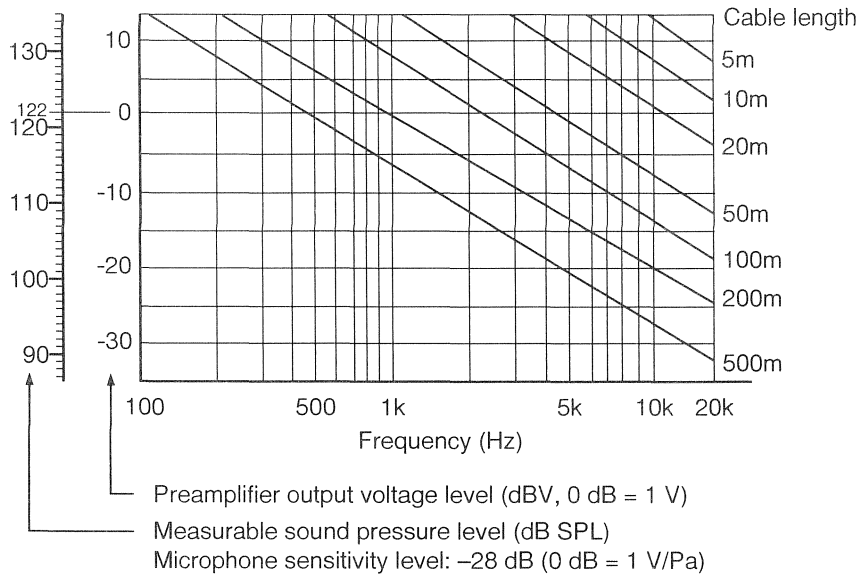
In the NL-15, the sampling interval for A/D conversion is 10 ms (100 samples per second), and L_{AE} processing is carried out every interval. The L_{AE} reading can therefore be displayed already during measurement.

L_{Amax} (maximum A-weighted sound pressure level)

L_{Amax} is the maximum A-weighted sound pressure level encountered during a measurement. In the NL-15, the sampling interval for A/D conversion is 10 ms (100 samples per second), and the L_{Amax} value since the start of the measurement is stored. Therefore the L_{Amax} reading up to the current point can be displayed already during measurement.

Influence of Microphone Extension Cable

When the output of the microphone/preamplifier is routed through an extension cable, certain limitations regarding measurable sound pressure level and frequency range will apply. This is due to the influence of the cable capacitance. The longer the cable, the lower the measurable sound pressure level and the lower the frequency limit. The diagram below shows the relationship between cable length, measurable sound pressure level, and frequency.



Relationship between extension cable length
and measurable sound pressure level/frequency

If for example a sound pressure level of 120 dB is to be measured up to 5 kHz, an extension cable length of up to 100 meters is possible.

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