

instructions for

Models 1500 and 2500 (1505 and 2505) Impulse and Integrating Sound Level Meter

56-261
REV. C
11/97

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I. INTRODUCTION TO THE MODEL 1500/2500

The Quest models 1500 and 2500 are Impulse and Integrating Sound Level Meters for measuring frequency weighted and time averaged SPL, weighted or unweighted Peaks or frequency weighted Leq. Applications include laboratory, industrial, community and military measurement or analysis.

The models 1500 and 2500 are user-friendly hand held meters with an LCD display that provides a numerical readout. They are housed in a tough die-cast metal case. The meter is operated with easy-to-use slide switches. Two output jacks are provided for connecting to peripheral devices such as chart recorders, oscilloscopes, audio recorders, etc.

The model 1500 provides Type 1 accuracy for critical measurements. The model 2500 provides Type 2 accuracy for general field survey work. As both meters are operationally identical, this manual will refer only to the model 1500 except where appropriate.

A. MODELS 1505 and 2505 LAVG METERS

The models 1505 and 2505 LAVG meters use a 5dB exchange rate for integration instead of 3dB. They are operationally identical to the 1500 and 2500 except that the integrated quantity displayed is LAVG rather than Leq.

The 1500 and 2500 calculate Equivalent Continuous Level or Leq by summing sequential samples of Sound Pressure Level with a 3.01dB exchange rate. The expression for Leq is:

$$LEQ = 3.01 \cdot \log_2 \left[\frac{1}{N} \sum_{i=1}^N 2^{\frac{L_i}{3.01}} \right]$$

Where: N is the total number of samples
 L_i is the Sound Level in dB

The 1505 and 2505 calculate Lavg rather than Leq using a 5 db exchange rate. The expression for Lavg is:

$$Lavg = 5 \cdot \log_2 \left[\frac{1}{N} \sum_{i=1}^N 2^{\frac{L_i}{5}} \right]$$

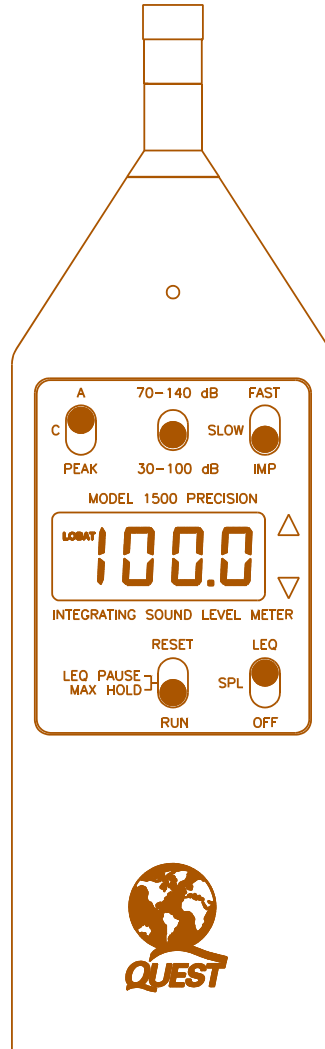


Figure 1 1500 Sound Level Meter

II. ABOUT THE METER

(Refer to Figure 1.)

A. The Display

The LCD display provides a numeric readout in 0.1dB increments along with a LOBAT (low battery) indicator. In the SPL mode the numeric display provides a reading of the maximum sound pressure level or peak sound pressure measured during the previous second. In the MAX HOLD mode the display holds the highest reading encountered since the meter was placed in MAX HOLD, or since the last time RESET was pushed. In LEQ mode, the display indicates the integrated, or average level since the meter was placed in LEQ mode. In addition, the elapsed measurement time will be briefly displayed every five seconds.

The LOBAT indicator will turn on when the voltage of either battery is too low to allow an accurate reading.

A red OVERRANGE LED to the right of the display will light when signal peaks cause an overload condition in the electronics. If the overload indicator is on while taking measurements in the 30-100 dB range, setting the RANGE switch to 70-140 dB should cause the overload to disappear. If you are already on the 70-140 dB range setting and an overload condition still exists, the sound level that you are measuring is beyond the capability of the meter due to either an extremely high rms value or a high crest factor (peak to rms ratio). If an overload occurs while performing an LEQ measurement, the '+' indicator in the display will remain lit until the meter is reset.

The underrange indicator is a yellow LED to the right of the display. When the meter is in either range and the signal is below the linear measuring range of the meter, this indicator will light. If set for 70-140dB you should switch to the 30-100 dB range to prevent misinterpreting the displayed value as being accurate.

B. Meter Controls

OFF/SPL/LEQ Switch

With the switch set to SPL the meter continuously displays sound pressure level or peak sound level, according to the setting of the A/C/PEAK switch. The meter automatically updates the current reading at a rate of once per second.

Setting the switch to LEQ causes the meter to begin calculating the frequency weighted equivalent continuous SPL. All measurements are integrated into a single number representing the equivalent SPL for the entire measurement period. The elapsed time will be displayed briefly every five seconds. This measurement will continue until the meter is placed in the LEQ PAUSE mode or reset.

RUN/ (MAX HOLD/LEQ PAUSE) /RESET Switch

This three position switch determines whether or not the displayed value is continuously updated. Its function depends upon the settings of the other switches.

Position 1 (RUN):

In SPL mode, the displayed value is the maximum value that occurred during the previous second. In LEQ mode, the displayed value is the equivalent level for the current measurement period. The elapsed time for the measurement period is briefly displayed every five seconds.

Position 2 (MAX HOLD):

In the SPL mode, the displayed value is the maximum level that has occurred during the measurement period since the meter was RESET or set to MAX HOLD. This value may be the weighted, time averaged SPL or, if set to PEAK, the peak level. The value is held until a higher level occurs or the meter is RESET.

Position 2 (LEQ PAUSE):

In the LEQ mode, the displayed value is the LEQ calculated during the elapsed measurement period while the switch was set to RUN. The elapsed time for the measurement period is briefly displayed every five seconds. Neither the LEQ or elapsed time are changing while in LEQ PAUSE. Returning this switch to RUN will continue the LEQ calculation. Setting this switch to RESET will set both the LEQ and elapsed time to zero.

Position 3 (RESET):

In SPL mode, depress and hold this switch in the RESET position to clear the maximum SPL or PEAK level held in the display. Holding RESET until the yellow under-range LED lights ensures that the model 1500 is fully reset. Releasing the switch returns it to the MAX HOLD position. In LEQ mode, depress this switch to set the LEQ value and elapsed time to zero. Releasing this switch returns it to the LEQ PAUSE position.

FAST/SLOW/IMP RESPONSE Switch

The RESPONSE switch controls the rate at which the meter responds to changing input signals. Most sound measurements are done with the response set to SLOW. The FAST response is generally used when measuring short duration noises such as moving vehicles. IMP (Impulse) is used for impulsive or transient sounds.

The RESPONSE switch positions are as follows:

- FAST - 125 millisecond time constant. (See Figure 11)
- SLOW - 1 second time constant. (See Figure 12)
- IMP - 35 millisecond rise time constant, 1.5 second decay time constant. (See Figure 13)

A/C/PEAK Switch

The A/C/PEAK switch controls the frequency response (weighting) of the SPL or LEQ measurements, or selects PEAK measurements. Weightings A or C may be selected for SPL or LEQ measurements. The frequency weighting for PEAK measurements is selectable among A, C or linear (flat). This is accomplished via a jumper inside the meter. Refer to section V. C. regarding the setting of this jumper and for further information on frequency weighting.

dB RANGE Switch

The displayed range of the model 1500 is 70 dB and is switchable between LOW (30-100 dB) and HIGH (70-140 dB). After switching ranges allow several seconds for the meter electronics to stabilize. If a range change is necessary during a LEQ study, it is good practice to first set the meter to LEQ PAUSE, change range and then set the meter to RUN. This will avoid integrating any handling or switching noise into the LEQ measurement.

C. Output Jacks

The model 1500 provides output jacks for measuring the weighted AC signal before the rms/log detector and the DC output of that detector. Both signals are real time, i.e. LEQ is not represented at the DC output. These jacks may be connected to any load without affecting the operation of the meter. Connection to low impedance loads will require correction for the 1 Kohm impedance of these outputs and will also decrease battery life.

All output jacks use a 3.5mm phone plug, either 2 or 3 conductor.
(See Figure 2, Output Jack Connections.)

The following describes each output function:

DC - The SPL or PEAK level over the range selected is linearly represented by a DC output. One volt is equal to 100dB on the 30 - 100 dB range setting, and 140dB on the 70 - 140 dB range. The output changes 16.7mV/dB or 1V/60dB. This output is provided for connecting a 0 to 1 volt span data recorder. (See section IV. D., Data Recording)

AC - This jack provides the amplified, frequency weighted AC signal at the input of the RMS detector. A SPL of 100dB corresponds to a voltage of 0.85 volts RMS on the LOW range and 8.5 millivolts RMS on the HIGH range setting.

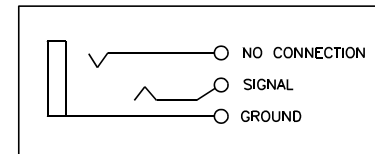


Figure 2 Output Jack Connections

III. OPERATING PROCEDURE

A. Power ON and Battery Check

Set the OFF/SPL/LEQ switch to either the SPL or LEQ position as desired. At any time, if the LOBAT indicator on the display is activated it is recommended that the user replace both 9 volt batteries. Alkaline batteries are recommended for best performance.

Refer to the meter bottom for battery replacement.

B. Calibration

To check the calibration of the model 1500, perform the following procedure using a Quest Calibrator. There is no warm up period required, but for maximum accuracy calibration of the model 1500 should be performed at the temperature of the environment to be measured.

1. Check that the LOBAT indicator is not on.
2. Turn the calibrator ON. If optional, set the frequency to 1KHz. Note the SPL of the calibrator.
3. Insert the microphone fully into the calibrator adapter ring.
4. Place the calibrator onto the adapter.
5. Set the model 1500 to SPL, RUN, SLOW or FAST, A or C weighting, HIGH or LOW range as appropriate.
6. Use a small screwdriver to adjust the calibration control, located through the small hole on the front of the meter, until the display indicates the correct SPL. Take into account any corrections for altitude or temperature. Refer to your calibrator's manual.
7. The model 1500 may be calibrated in PEAK mode if desired by adjusting the reading to 3dB greater than the output of the calibrator, provided the frequency is 1kHz or less.

C. Switch Settings to Select Measurement

To Measure :	Set Switches to :	Display:
SPL	SPL, A or C, RUN	1 second update
SPL MAX HOLD	SPL, A or C, MAX HOLD	Holds MAX until RESET
PEAK	SPL, PEAK, RUN (FAST/SLOW/IMP does not apply)	1 second update
PEAK HOLD	SPL, PEAK, MAX HOLD	Holds the highest PEAK until RESET
LEQ	Before starting - RESET LEQ, A or C, RUN (PEAK not allowed) After study - RESET	1 second update, Time displayed every 5 seconds
LEQ PAUSE	LEQ, A or C, LEQ PAUSE	Holds LEQ value, 'PS'and Time displayed each 5 sec

During an LEQ RUN, weighting and response switch settings should not be changed. If these switches are changed, the LEQ measurement will stop, the value will be held in the display, as if in PAUSE, and the display will read 'END' just before displaying the time. The unit must be reset before returning to LEQ RUN.

The way the time is displayed during an LEQ measurement will change depending upon the elapsed time. Initially the display will read 0:00 (minutes:seconds). After 19:59 is displayed, the reading will display 0:20 (hours:minutes) up to a maximum of 19:59.

IV. GENERAL OPERATING CONSIDERATIONS

Before taking measurements, there is a series of quick checks that should be performed. After switching the unit ON check for a LOBAT indication on the display, and replace the batteries if needed. Allow several seconds before any making measurements.

Although the model 1500 will maintain accurate calibration over a long period of time, the calibration should be checked and slightly adjusted, if necessary, before each use. The calibration should also be checked and verified after each use.

Set the RESPONSE, WEIGHTING, MEASUREMENT MODE, and dB RANGE switches as needed. Hold, set, or tripod mount the meter in the desired location. If a MAX HOLD, LEQ or PEAK HOLD measurement is needed, be sure to reset the meter before taking the measurements.

It is good practice to document all measurement conditions and meter settings for possible future reference.

A. Meter / Microphone Placement

Whenever possible, the meter should be tripod-mounted in a relatively open area to minimize reflections from the body or other large reflective structures. Avoid placement against a wall or in a corner. A threaded bushing on the back will accept a standard 1/4-20 tripod fitting.

The microphone cartridge used on the models 1500 and 2500 is a free-field microphone. Point it directly at the noise source (0 degrees).

B. Background Noise

Background noise can cause considerable error in measurement when its level is close to that of the particular sound source of interest. When it is not possible to eliminate or reduce the background noise, use the curve shown in Figure 3 to correct for the effect of the background noise on the measurement.

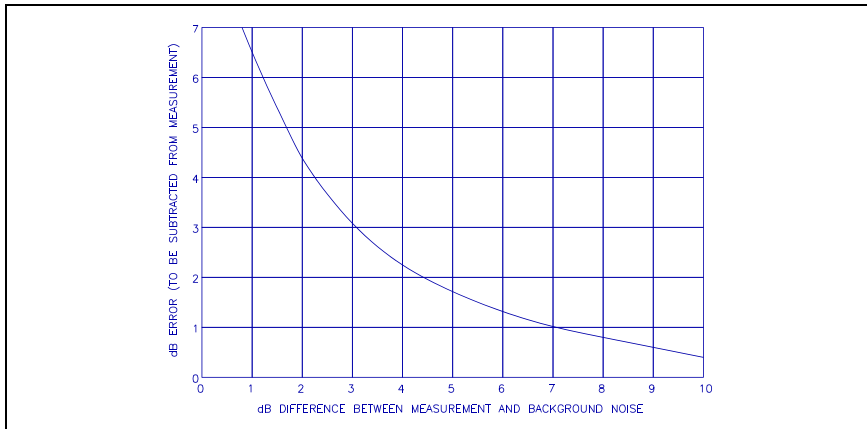


Figure 3 Effects of Background Noise

For example, if the background noise is 45dB and the sound of interest measures 51dB, the difference between measurement and background noise is 6dB. From Figure 3, for a 6dB difference, 1.3dB should be subtracted from the measurement. The correct measurement is therefore 51dB - 1.3dB = 49.7dB.

C. Wind Screen Effects

To prevent erroneous measurement of sound levels caused by wind blowing across the microphone, the use of a windscreen is recommended. The wind screen will reduce wind effects and will also help protect the microphone under dusty, oily, or humid conditions. Acoustic attenuation effects of the windscreen used on the model 1500 model 2500 (WS-7) are shown in Figure 4.

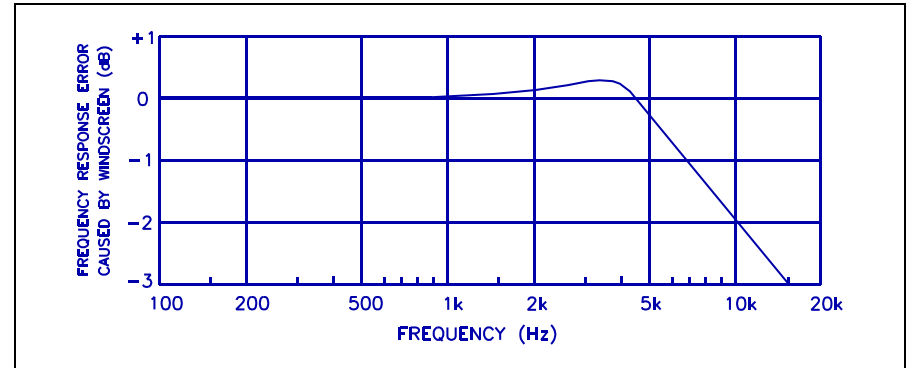


Figure 4 Effects of Windscreen

To assess the effects of wind noise on your measurement, consider wind noise as background noise and refer to the previous section.

D. Data Recording

The model 1500 has a DC output that is linearly related to the deciBel reading on the LCD display by 16.7mV/dB (1V/60db). Nominal output voltages for a range of readings are as follows:

SOUND PRESSURE READING	LOW RANGE DC VOLTAGE (+/-15mV)	HIGH RANGE DC VOLTAGE (+/-15mV)
30dB	-.167VDC	----
40dB	0VDC	----
50dB	.167VDC	----
60dB	.333VDC	----
70dB	.500VDC	-.167VDC
80dB	.667VDC	0VDC
90dB	.833VDC	.167VDC
100dB	1VDC +/-15mV	.333VDC
110dB	----	.500VDC
120dB	----	.667VDC
130dB	----	.833VDC
140dB	----	1VDC +/-15mV

This output, capable of driving up to 100 feet of shielded or twisted pair cable, is intended for use with a chart recorder or data acquisition device that has a high input impedance. The output impedance is 1000 ohms. Recorder input impedance may cause loading of this output, which should be taken into account. Multiplication factors for the above numbers are given below for various recorder input impedances.

INPUT IMPEDANCE OF RECORDER	MULTIPLY DC VOLTAGE BY:
10 KOHM	0.909
20 KOHM	0.952
50 KOHM	0.980
100 KOHM	0.990

Connect the model 1500 to the recorder input with proper polarity such that the pen is on the proper side of the chartpaper with respect to time and that the pen moves in the proper direction with increasing decibel level. A zero volt signal corresponding to 40dB (or 80dB on the 70-140dB range) may be obtained by shorting together the inputs to the chart recorder (some recorders have a momentary 'ZERO' button) and using the 'zero pen position' control on the recorder to position 40dB at a desired level on the recorder. All measurements on the recorder will be relative to this 40dB reference. Note that this 40dB value has a +/-1dB tolerance.

A more accurate method would be to use an acoustic calibrator to calibrate the chart recorder as follows:

1. Turn the meter to ON. Place the adapter onto the microphone.
2. Place the calibrator onto the adapter.
3. Turn the calibrator ON to produce 94dB (or other level) at 1 kHz. Use the zero adjust control on your chart recorder to set the pen to the desired level corresponding to 94dB (or other level) on your chart recorder. Refer to Figure 5, Chart Recording of SPL.
4. Be sure to document all chart recorder settings and meter settings when taking measurements.

The Quest model 411 chart recorder is recommended for time-history recording using the model 1500. The use of QUEST CHART PAPER 58-653, which has 12 major divisions corresponding to 5dB/division or 60dB full scale, will simplify the chart recorder setup and reading.

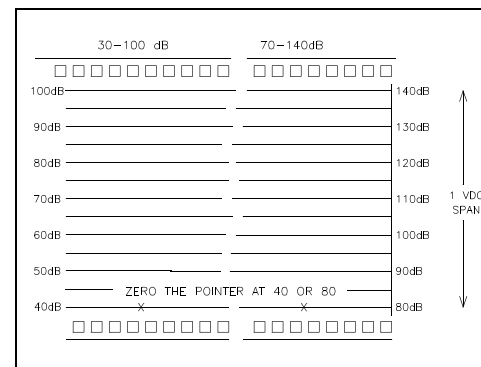


Figure 5 Chart Recording

V. TECHNICAL INFORMATION

A. Principles of Operation

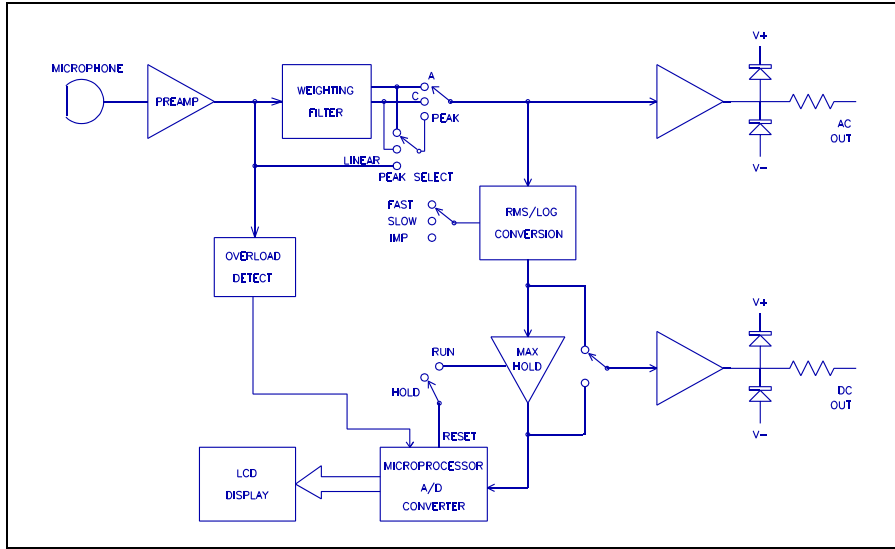


Figure 6 Block Diagram of Models 1500 and 2500

The Quest model 1500 utilizes low noise, low power analog and digital integrated circuitry to ensure long battery life, maximum stability, and superior reliability over a wide range of environmental conditions. Figure 6 is a block diagram of the model 1500's internal circuit operations.

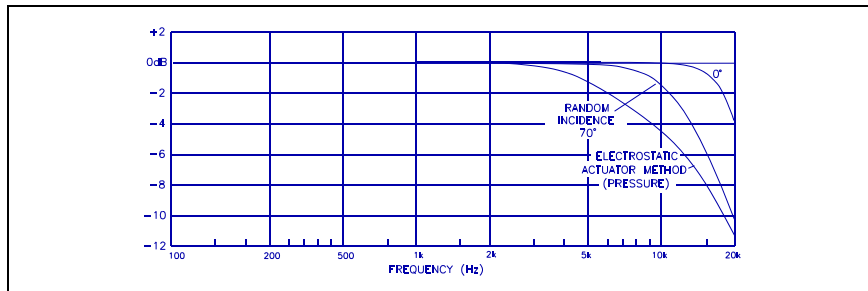


Figure 7 QE4846 Microphone Response

B. Microphone

The model 1500 is designed to accept a prepolarized (electret) microphone Model QE4846 exclusively. The impedance of this microphone is 12pF. The microphone screws directly onto the microphone extension which is part of the meter case.

A typical response curve for the QE4846 microphone is shown in Figure 7.

The model 2500 is designed to accept a prepolarized (electret) microphone Model QE7052 exclusively. The impedance of this microphone is 17pF. The microphone screws directly onto the microphone extension which is part of the meter case.

A typical response curve for the QE7052 microphone is shown in Figure 8.

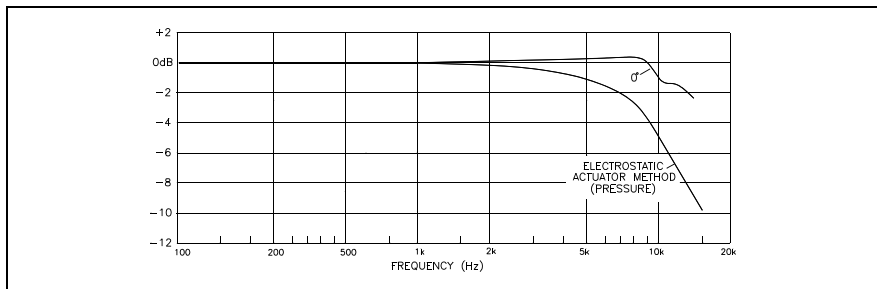


Figure 8 QE7052 Microphone Response

CAUTION : When installing or removing the microphone, do not unscrew the protective grid. Do not touch the microphone diaphragm under this grid as permanent damage may result.

C. Weighting Characteristics

The weighting characteristics (frequency response) for A and C are shown in Figure 9. The "A" weighting response emulates the response of the human ear and is used for most industrial and community noise measurements. Generally, "C" weighting is used for measuring noise reduction in hearing protectors and for other scientific purposes.

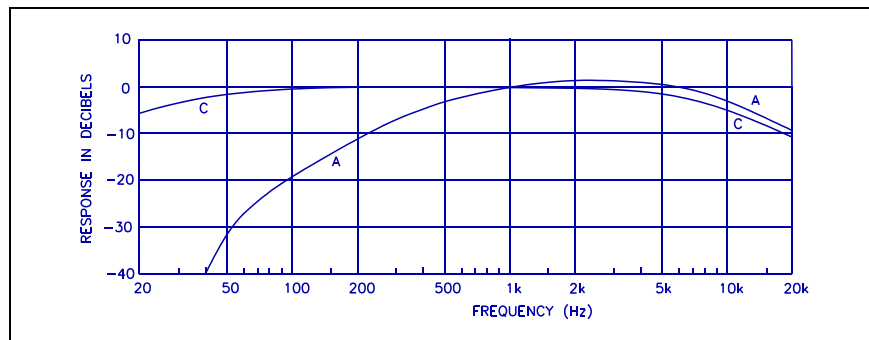


Figure 9. A & C Weighting

The frequency response (relative to 1kHz) for unweighted (linear) peak measurements is 5 Hz to 20kHz, +0 / -3dB.

To select the frequency response for PEAK measurements, an internal jumper must be set. To select A, C or unweighted response, perform the following steps.

1. Turn the meter off and remove the batteries.
2. Place the meter face down and remove the two black philips head screws. Remove the slotted screw located inside the threaded tripod mounting bushing. Remove the bushing.
3. Place the meter face up and remove the front cover. Locate the PEAK response jumper next to the A/C/PEAK switch. With a needle nosed pliers, remove the jumper and place it over the two posts for the desired response. See Figure 10.

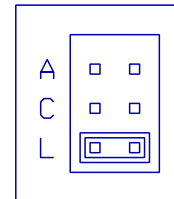


Figure 10 Peak Weighting Selection

D. Tone Burst Response

Figures 11, 12 and 13 show how the meter responds to a sinewave input of varied pulse duration for each response setting.

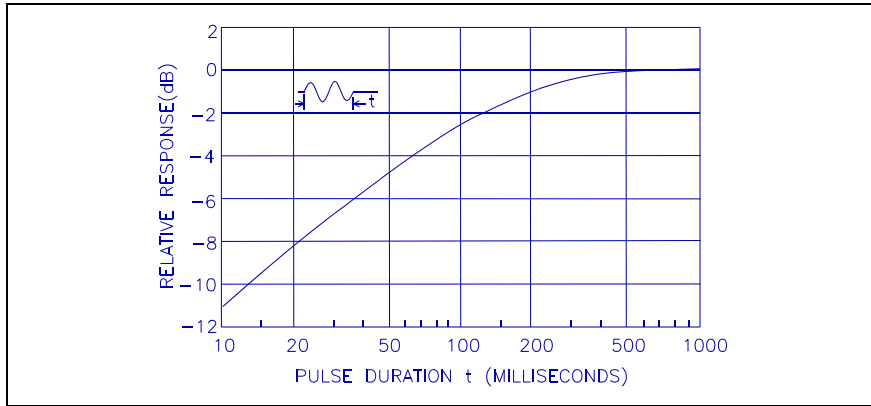


Figure 11 Fast Response

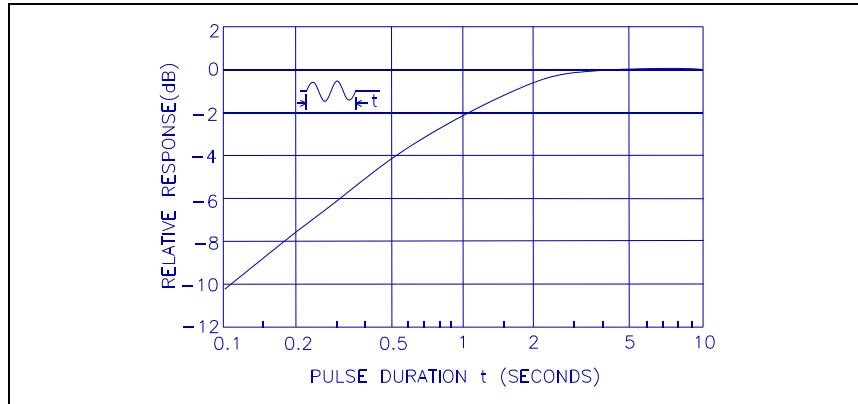


Figure 12 Slow Response

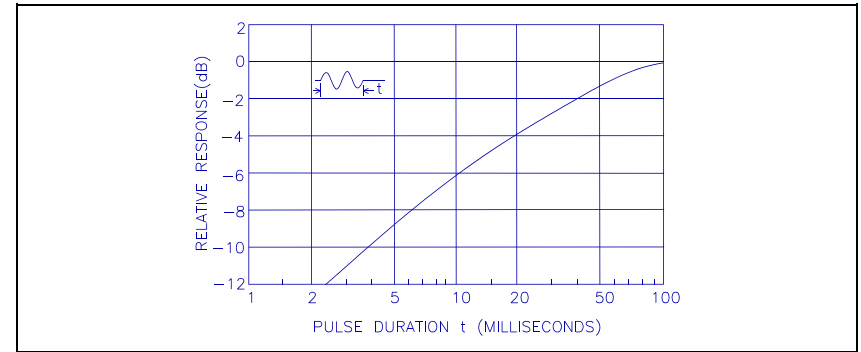


Figure 13 Impulse Response

Nominal decay times for each time response setting are as follows:

FAST - 34.7 dB per second

SLOW - 4.35 dB per second

IMPULSE - 2.9 dB per second

PEAK measurements have a rise time constant of 50 μ s. The displayed value is the highest peak occurring prior to a reset. Resets occur every second in RUN. MAX HOLD requires a manual reset.

VI. SPECIFICATIONS

Standards: Model 1500 : Type 1 ; Model 2500 : Type 2
ANSI S1.4-1983, IEC 651-1979, IEC 804-1985

Display: 3 1/2 Digit Liquid Crystal Display. Level display indicates to 0.1 dB resolution. Annunciator is included for Battery Check. LED indicators are used for overrange and underrange conditions.

Modes of Operation: Measures sound pressure level (SPL) maximum level (MAX), 1 second peak sound pressure level (PEAK), overall peak level (PEAK HOLD) and equivalent continuous sound pressure level (Leq) .

Range: 30 to 140 dBA SPL, 43 to 143 dBA PEAK.
40 to 140 dBC SPL, 43 to 143 dBC PEAK.

Pulse Range: 63 dB

Electrical Noise Floor: 23 dBA typ., 30dBC typ.

AC Gain Calibration: External calibration adjustment available on front of meter near the microphone. Calibrate using a 1000Hz acoustic calibrator that is properly adapted to the microphone.

Frequency Weighting Networks: SPL or Leq - A, or C.
PEAK - A, C or Linear (5Hz - 20kHz,
+0/-3dB relative to 1kHz)

Meter Response: Fast, Slow, Impulse or Peak (50uS rise time constant).

Microphone: Removable .52 inch (13.5mm) prepolarized condenser (electret) microphone.
Model 1500 - QE4846 type 1 accuracy
Model 2500 - QE7052 type 2 accuracy

AC Output: 0.85V RMS at 100 dB on LOW range
8.5mV RMS at 100 dB on HIGH range
1 Kohm output impedance, 1/8 inch phone jack

DC Output: 1VDC +/- 15mV at 100 dB when set to 30-100dB Range
1VDC +/- 15mV at 140 dB when set to 70-140dB Range
Each 0.167V change equals 10dB (1V/60dB)
1 Kohm output impedance, 1/8 inch phone jack

Detector: True RMS. For crest factor capability see figure 14

Integration Time : Signal Dependent - approximately 2.5 hours at a constant 140dB SPL. Time will double with each 3dB decrease in average SPL, until limited by battery life.

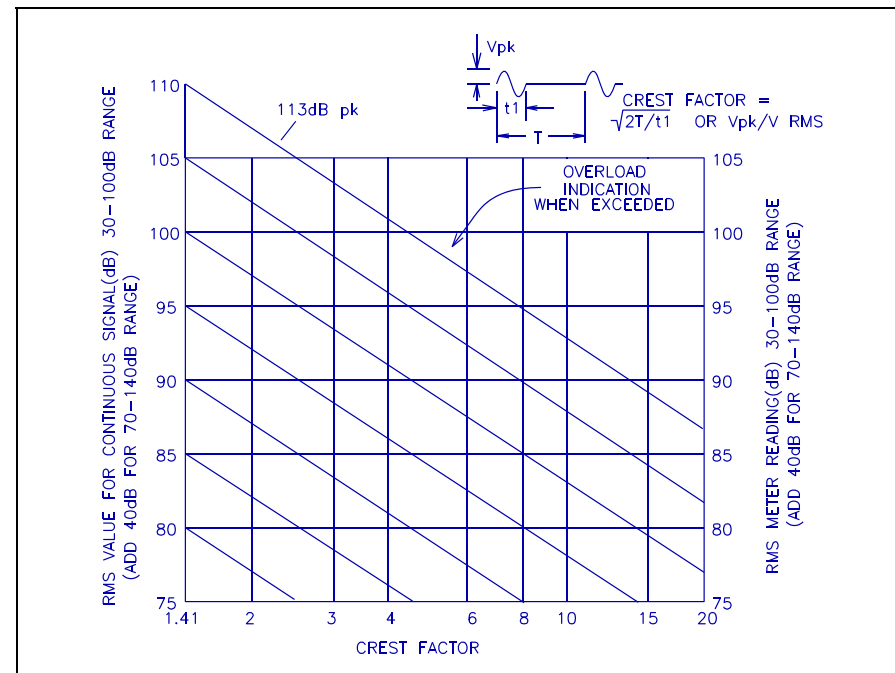


Figure 14 Maximum Crest Factor Capability

Crest Factor: 15 (23dB) up to 88dB LOW Range, 128dB HIGH Range. 5 (14dB) up to 98dB LOW range, 138dB HIGH Range. 3 (10dB) up to 103dB LOW range, 143dB HIGH range.

Crest factor is always sufficient to handle the signal if the overload indicator does not light.

Overload Indication: A red LED indicates momentary overload.
A '+' sign in the display indicates overload during Leq measurement.

Attenuator Accuracy: +/- 0.5dB from 20-8kHz
+/- 0.7dB from 20-12.5kHz. (Model 1500 only)

Accuracy: Within 0.5 dB at 25 C; Within 1.0 dB over the temperature range of -10 C to +50 C

Temperature Range: Operation: -10 C to +50 C

Storage (less batteries): -20 C to +60 C

Operating Humidity: 0 to 95% relative humidity, non-condensing.

Effect of Electromagnetic Fields:

A magnetic field of 1 Oersted (80A/m) at 60Hz produces a maximum reading of 40 dB on C weighting.

Less than 1 dB error when exposed to RF fields up to 10 V/m over a frequency range of 10MHz to 500MHz.

Effect of Electrostatic Fields: Negligible.

Batteries: Two 9-volt alkaline batteries (NEDA 1604A) will provide approximately 30 hours of operation.

Tripod Mount: A threaded insert on back of the meter accepts a standard 1/4-20 tripod mounting screw.

Size: 2.75 x 7.6 x 1.0 inches (70 x 193 x 25mm) not including the height of the microphone housing. The microphone extends 1.5 inches (38mm).

Weight: 15 oz. (425g) including batteries.

VII. ACCESSORIES

56-990 Calibrator Adapter for 0.50 inch diameter microphone for Quest "QC-" series calibrators

58-928 Calibrator Adapter for 0.50 inch diameter microphone for Quest "CA-" series calibrators

59-344 WS-7 Windscreen for 0.50 inch microphone (pkg. of 3)

59-45 Tripod (Larger)

59-46 Tripod (Smaller)

58-948 Recorder Input Cable - 1/8 inch phone plug to double banana plug

59-703 Input Adapter - Female BNC jack to 1/2" microphone thread

VIII. SERVICE AND WARRANTY POLICY

Service Policy

The Quest product you have purchased is one of the finest acoustic instruments available. It is backed by our full one year warranty which seeks complete customer satisfaction. This is your assurance that you can expect prompt courteous service for your equipment from the entire Quest service organization.

Should your Quest equipment need to be returned for repair or recalibration, please contact the Service Department at 1(800)245-0779 (USA) or Fax (262)567-4047 for a Return Authorization Number. The RA number is valid for 30 days, and must be shown on the shipping label and purchase order/cover letter. If you are unable to return instruments in that time call for a new RA number. Send it prepaid and properly packed in the original shipping carton directly to Quest Technologies, 1060 Corporate Center Dr., Oconomowoc, WI 53066 U.S.A.

Repair or replacement work done under warranty will be performed free of charge, and the instrument will be returned to you prepaid. Your copy or a photocopy of the Quest Registration Card will serve as proof of warranty should the factory require this information.

If for any reason you should find it necessary to contact the factory regarding service or shipping damage, please direct your calls or letters to the attention of the Service Manager, Quest Technologies, (262) 567-9157 or (800) 245-0779. Office hours are from 8 AM to 5 PM (Central Standard Time) Monday through Friday.

Warranty:

Quest Technologies warrants our instruments to be free from defects in materials and workmanship for one year under normal conditions of use and service. For U.S.A. customers we will replace or repair (our option) defective instruments at no charge, excluding batteries, abuse, misuse, alterations, physical damage, or instruments previously repaired by other than Quest Technologies. Microphones, sensors, printers and chart recorders may have shorter warranty periods. This warranty states our total obligation in place of any other warranties expressed or implied. Our warranty does not include any liability or obligation directly resulting from any defective instrument or product or any associated damages, injuries, or property loss, including loss of use or measurement data.

For warranty outside the U.S.A., a minimum of one year warranty applies to the same limitation and exceptions as above with service provided or arranged through the authorized Quest sales agent or our Quest European Service Laboratory. Foreign purchasers should contact the local Quest sales agent for details.