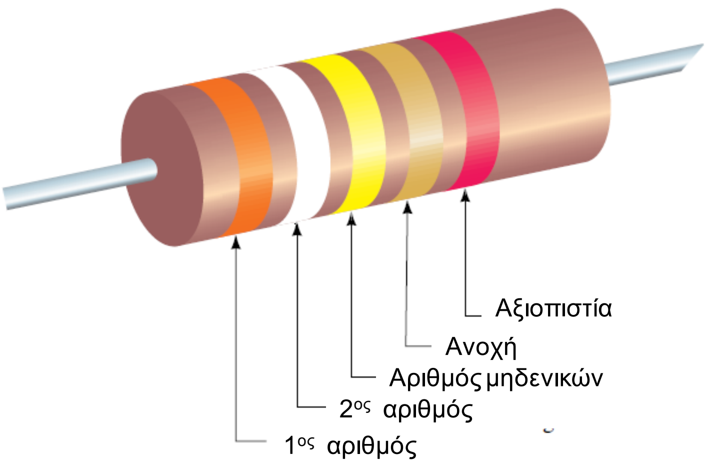
ΠΑΡΑΡΤΗΜΑΤΑ

ΠΑΡΑΡΤΗΜΑ Ι
Χρωματικός κώδικας αντιστάσεων

Οι μεγαλύτερες σε διαστάσεις αντιστάσεις που χρησιμοποιούνται στα κυκλώματα με διάκριτα στοιχεία φέρουν τυπωμένη επάνω τους την τιμή τους σε Ohm και την ακρίβειά της. Οι υπόλοιπες αντιστάσεις φέρουν στην επιφάνειά τους έγχρωμους δακτυλίους οι οποίοι αποτελούν έναν χρωματικό κώδικα αποτύπωσης της τιμής της αντίστασης, της ακρίβειας (ανοχής) και -σε μερικές περιπτώσεις- της αξιοπιστίας της.

Όπως φαίνεται στο σχ. Ι.1, οι δύο πρώτοι δακτύλιοι αντιστοιχούν στα δύο πρώτα ψηφία της τιμής της αντίστασης (σε Ohm). Ο τρίτος δακτύλιος φανερώνει τον αριθμό των μηδενικών που ακολουθούν. Ο τέταρτος δακτύλιος αντιστοιχεί στην ακρίβεια της τιμής της αντίστασης και ο πέμπτος (αν υπάρχει) δείχνει την αναμενόμενη αξιοπιστία της αντίστασης.



Σχήμα Ι.1 – Αποτύπωση της τιμής της αντίστασης με έγχρωμους δακτυλίους.

Πίνακας Ι.1:
Χρωματικός κώδικας αντιστάσεων

ΧΡΩΜΑ	**Αριθμ.τιμή**
Μαύρο	0
Καφέ	1
Κόκκινο	2
Πορτοκαλί	3
Κίτρινο	4
Πράσινο	5
Μπλε	6
Μωβ	7
Γκρίζο	8
Λευκό	9
Χρυσαφί	5%
Ασημί	10%

Στον Πίνακα Ι.1 φαίνεται η αντιστοιχία των χρωμάτων των δακτυλίων με αριθμούς. Π.χ. αν οι δακτύλιοι μιας αντίστασης έχουν κατά σειρά τα χρώματα: πορτοκαλί, λευκό, κίτρινο, χρυσαφί (όπως στην αντίσταση του σχ.Ι.1), τότε η τιμή της αντίστασης θα είναι 390000 Ω (ή 390kΩ) ±5%.

ΠΑΡΑΡΤΗΜΑ ΙΙ
Παλμογράφος

Ο παλμογράφος είναι ένα όργανο με το οποίο μπορούμε να αποτυπώνουμε και να μετράμε τάσεις και συγκεκριμένα το δυναμικό ενός σημείου του κυκλώματος ως προς τη «γη».
Με τον παλμογράφο μπορούμε να μετρήσουμε τόσο συνεχείς όσο και μεταβλητές τάσεις.
Σε ένα περιοδικό σήμα μπορούμε να μετρήσουμε την τιμή από κορυφή σε κορυφή (pp), το πλάτος, τη χρονική μέση τιμή (συνεχή-DC συνιστώσα) και την περίοδο.

Στη συνέχεια δίνεται το εγχειρίδιο χρήσης του παλμογράφου που θα χρησιμοποιήσετε στο εργαστήριο.

PANEL EXPLANATION

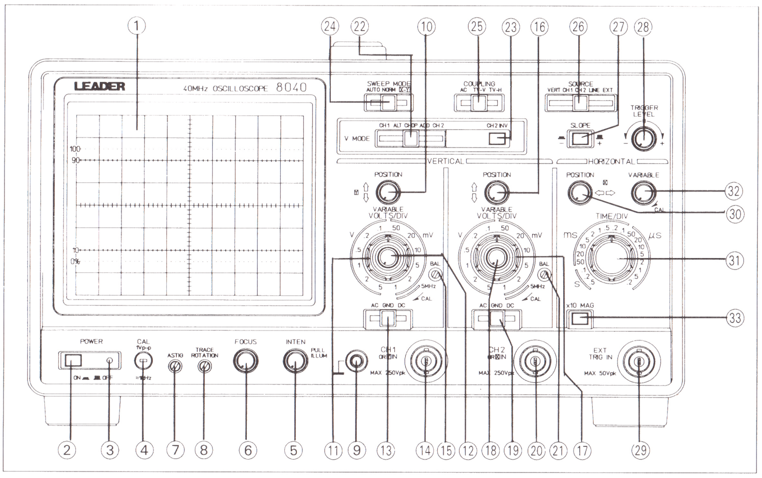


Figure 1. Front Panel

FRONT PANEL

1) **Cathode Ray Tube (CRT)**

The effective display screen surface runs over an area of eight 1 cm divisions along the vertical axis and ten 1 cm divisions along the horizontal axis. With an inner graticule etched right onto the tube face, the chance of measurement errors due to parallax occurring between the trace and the graticule have been significantly reduced. There is also a % display for measuring rise time on the left edge of the graticule.

2) **POWER (▁ ON/ █ OFF)**

A push-button type switch that turns the power source on and off. Pressing the switch turns the power on. Pressing it again turns the power off.

3) **Pilot lamp**

Light ups when the power is turned on.

4) **CAL**

A voltage terminal for calibration. To be used for adjusting the probe. Capable of 1 volt peak to peak, positive polarity, square wave signals with twice the frequency of a commercial-use power source [approx. 1 kHz for Model 8040 and 8021] is enabled.

5) **INTEN/PULL ILLUM**

INTEN: For adjusting the brightness of the trace line.

PULL ILLUM: The brightness of the scale on the CRT can be adjusted by pulling this knob and turning it.
[Model 8020 does not have this function]

6) **FOCUS**

For adjusting the focus and attaining the clearest displays possible.

⑦ **ASTIG**

For adjusting the astigmatism of the trace and the spot. Use a screwdriver to adjust this control in conjunction with the FOCUS control for attaining the clearest displays possible. (Once the correct adjustment is made, no further re-adjustment is necessary during normal use.)

⑧ **TRACE ROTATION**

For adjusting the slope of the horizontal trace line. The slope of the line will change due to such influences as the earth's magnetic force. Use a screwdriver to keep the trace line parallel with the horizontal axis graticule.

⑨ **⏊ GND**

This is the ground terminal to be used when setting up a common ground with other equipment.

⑩ **⇕ POSITION**

For adjusting the vertical position of the CH1 waveform displayed on the CRT screen. During X-Y operation it is used to adjust the position of Y-axis.

⑪ **VOLTS/DIV**

For setting the vertical axis sensitivity with the CH1 vertical axis attenuator. It can be set in steps of 1, 2 and 5. Setting the VARIABLE Control all the way to the right at CAL enables calibrated vertical sensitivity. During X-Y operation, it becomes the attenuator control for the Y-axis.

⑫ **VARIABLE**

For fine adjustment of CH1 vertical axis sensitivity. Allows continuous variable adjustment within the VOLTS/DIV range. When set to the right at CAL, the attenuator can be calibrated. During X-Y operation, it becomes the fine adjustment control for the Y axis.

⑬ **AC-GND-DC**

For selecting the CH1 vertical axis input signal coupling mode.

AC: The input signal will be capacitively coupled, and all DC components will be eliminated. The low range −3 dB attenuation point will be 10 Hz or less when using either a 1:1 probe or a coaxial cable, and 1 Hz or less when using a corrected 10:1 probe.

GND: Vertical amplifier input is grounded, and the ground potential can be checked. At an input resistance of 1MΩ relative to the ground, the input signal is not grounded. In this mode, the anti-trace line jump circuit prevents the trace position from changing suddenly when switching from GND to AC.

DC: Provides direct coupling of the input signal, and measurement can be carried out with the direct current component intact.

During X-Y operation, this control becomes the Y-axis input switch.

⑭ **CH1 OR [Y] IN**

The CH1 vertical axis input terminal.
During X-Y operation, it becomes the Y-axis input terminal.

⑮ **BAL**

For adjusting CH1 DC balance. Upon delivery of the oscilloscope, adjustments have already been made. However, discrepancies can occur due to various room temperatures. Using a screwdriver adjust this control so that the trace line does not move up and down when rotating the VOLTS/DIV control.

(16) **POSITION**

For adjusting the vertical position of the CH2 waveform when displayed on the CRT screen.

Note:

When this control is rotated during X-Y operation, the trace may move a little in the horizontal direction. This is a normal occurrence and no cause for any adjustment.

(17) **VOLTS/DIV**

The vertical attenuator for CH2. It is operated in the same way as the CH1 VOLTS/DIV control.
During X-Y operation, it becomes the X-axis attenuator.

(18) **VARIABLE**

For fine adjustment of CH2 vertical axis sensitivity. It is operated in the same way as the CH1 VARIABLE control.
During X-Y operation, it is used for fine adjustment of X-axis sensitivity.

(19) **AC-GND-DC**

For selecting the CH2 vertical axis input signal coupling mode. It is operated in the same way as the CH1 AC-GND-DC Switch.
During X-Y operation, it becomes the X-axis input switch.

(20) **CH2 OR X IN**

The CH2 vertical axis input terminal.
During X-Y operation it becomes the X-axis input terminal.

(21) **BAL**

For adjusting CH2 DC balance. It is operated in the same way as the CH1 BAL control.

(22) **V MODE**

For selecting the vertical axis operation mode.

CH1: For displaying the CH1 input signal on the CRT screen.

ALT: Switches between CH1 and CH2 input signals for each sweep and displays them on the CRT screen.

CHOP: For displaying CH1 and CH2 input signals one after the other on the CRT screen, irregardless of sweep and at an occurrence rate of about 250 kHz.

ADD: For displaying combined waveforms of CH1 and CH2 input signals on the CRT screen. However, when CH2 is set at INV, the difference between CH1 and CH2 will be displayed.

CH2: For displaying CH2 input signals on the CRT screen.

Alternate (ALT) and Chop (CHOP) Modes:
When using these modes during dual trace operation, the display will be divided up according to time.
In the chop mode, each channel will be subdivided according to time within each sweep. Normally, this kind of measurement is carried out with signals of either slower sweep rates from 1 ms/div or low repetition rates where flicker is quite noticeable.
In the alternate mode, each channel will be displayed one after the other as soon as one sweep has been made. Therefore, each channel display appears much clearer. Normally, a faster sweep is employed.

㉓ **INV**
When the button is pushed all the way in, the polarity of the CH2 input signal display will be inverted.

㉔ **SWEEP MODE**
For selecting sweep operation modes.

AUTO: Sweep is performed by a trigger signal. However, in the absence of a trigger signal, free run will commence and a trace will appear.

NORM: Sweep is performed by a trigger signal. In the absence of a suitable trigger signal, a trace will not appear.

X-Y: Ignores the V MODE setting and commences operation as an X-Y oscilloscope with CH1 as the Y-axis and CH2 as the X-axis.

㉕ **COUPLING**
For selecting trigger coupling.

AC: The trigger signal is capacitively coupled to the trigger circuit. The direct current component is eliminated. Use AC coupling for normal waveform measurements.

TV-V: Composite video signal vertical sync pulses are selected out and coupled to the trigger circuit.

TV-H: Composite video signal horizontal sync pulses are selected out and coupled to the trigger circuit.

㉖ **SOURCE**
For selecting the trigger signal source.

VERT: The trigger signal source will be selected by the V MODE setting. When the V MODE Selector Switch is set at CH1, ALT, CHOP, or ADD, the CH1 input signal will become the trigger signal source. When set at CH2, the CH2 input signal will become the trigger signal source.

CH1: The CH1 input signal will become the trigger signal source.

CH2: The CH2 input signal will become the trigger signal source.

LINE: The commercial-use power source voltage waveform will become the trigger signal source.

EXT: The signal being input into the EXT.TRIG IN terminal will become the trigger signal source.

7) **SLOPE (█+ / ▄−)**
For selecting the slope polarity of the triggered sweep signal. When the push-button is out (█+), triggering will be performed with the trigger source signal rising. When the push-button is pressed in (▄−), triggering will be performed with the trigger source signal falling.

8) **TRIGGER LEVEL**
For adjusting the trigger threshold level. This will determine at what point on the signal waveform slope sweep will commence.

9) **EXT.TRIG IN**
The input terminal for externally generated trigger signals. When the SOURCE switch is set at EXT, signals input through this terminal will become the trigger signal source.

0) **⇦⇨POSITION**
For adjusting the horizontal position of waveforms displayed on the CRT screen.

1) **TIME/DIV**
For setting the sweep time. Setting can be carried out over 19 steps between 0.5 μs/div and 0.5 s/div in 1-2-5 step sequence. [Model 8040 and 8021: 20 steps, 0.2 μs/div to 0.5 s/div]
When the VARIABLE control is set all the way to the right at CAL, sweep rate values will become calibrated.

2) **VARIABLE**
Continuous sweep time adjustment can be carried out within the SWEEP TIME/DIV range by this fine control. The sweep time becomes compensated by turning the CAL all the way clockwise.

3) **×10 MAG**
Press this switch to magnify the display 10× left and right from the center of CRT screen.

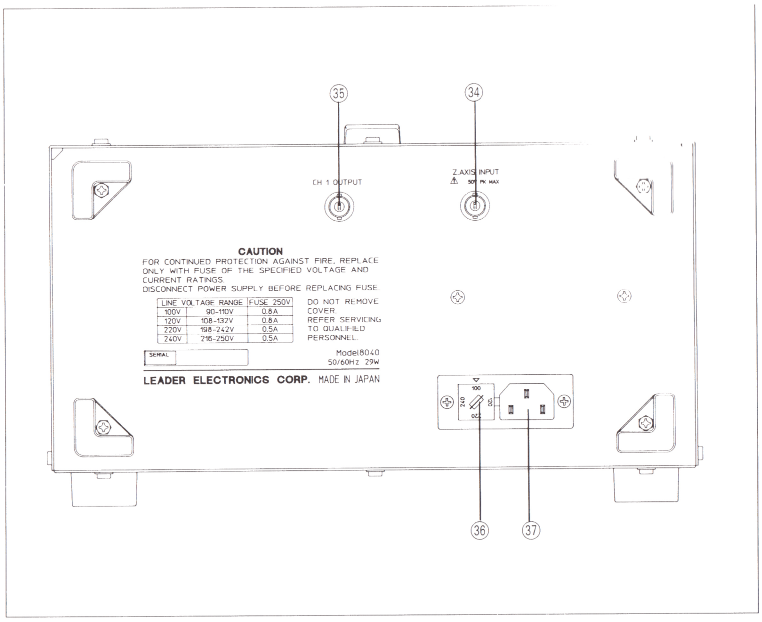


Figure 2. The Rear Panel

REAR PANEL

㉞ Z. AXIS INPUT

Input terminal for intensity modulation of CRT electron beam. Positive voltage decreaces intensity. TTL level intensity modulation possible.

㉟ CH1 OUTPUT

CH1 vertical output terminal. Output occurs at AC coupling. For connecting a counter when measuring frequencies. When using a counter to measure frequencies, there is the possibility that accurate measurements will not be displayed due to noise interference. When this occurs, either set the CH1 VOLTS/DIV to another range, or set the VARIABLE control to a position other than CAL.

㊱ Fuse Holder, Line voltage selector

Use 0.8 A fuses in 100 and 120 V areas.
Use 0.5 A fuses in 220 and 240 V areas.
Changing the voltage rating should be done strictly according to the directions in the section entitled ''FUSE REPLACEMENT AND CHANGING VOLTAGE REQUIREMENTS'' and after disconnecting the power cord from the power source inlet.

㊲ Power Cord Receptacle

A commercial-use power source input connector.

CHECKING AND ADJUSTMENTS PRIOR TO MEASUREMENT

In order to operate the oscilloscope at its optimum performance level, carry out the following checks and adjustments before doing your measurements. The instructions which follow concerning basic operation techniques and applications assume that the checks and adjustments described here have been completed.

1. Adjust the control panel to the following settings.

    SWEEP MODE .... AUTO
    COUPLING .... AC
    SOURCE .... VERT
    V MODE CH1
    (INV:OFF)
    SLOPE .... +
    TRIGGER LEVEL .... 12 O'CLOCK
    VERTICAL: CH1 (Y), CH2 (X)
    ⇕ POSITION .... 12 O'CLOCK
    VARIABLE .... CAL
    VOLTS/DIV .... 5 V/DIV
    AC-GND-DC .... GND
    HORIZONTAL
    ⇔ POSITION .... 12 O'CLOCK
    VARIABLE .... CAL
    TIME/DIV .... 2 ms/DIV
    ×10 MAG .... OFF

    Next, after checking the power source voltage ratings, switch the POWER control on. The pilot lamp will light up, and a trace line will appear in 10 to 15 seconds. Check to see that rotating the INTEN control to the right increases trace brightness, and rotating it to the left decreases brightness.
    Then rotate the INTEN control all way to left and extinguish the trace line to begin preheating. For the most accurate measurement results, it is necessary to preheat the oscilloscope for about 30 minutes. However, if you intend only to display waveforms, preheating is not necessary.

2. After preheating, adjust the INTEN control so that the trace line is easy to see, and adjust the FOCUS and ASTIG controls to attain the clearest display image possible. Then use the TRACE ROTATION control to bring the trace line parallel with the horizontal graduation lines.

3. As soon as the trace line is able to move up and down by rotating the VOLTS/DIV control, adjust the BAL control. Then switch the V MODE control to CH2 and adjust the BAL control for Channel 2.

    CAUTION:
    Do not attempt to adjust the BAL control during preheating.

4. Plug the (LP-040) probes into the INPUT terminal of each channel. Set the AC-GND-DC control at DC and the V MODE control at CH1. Plug the CH1 probe to the CAL terminal and set the VOLTS/DIV control at 20mV/DIV. Adjust the ⇕POSITION control so that all of the waveform can be seen. With the waveform in this position, carry out probe compensation adjustment using Figure 3 and the probe Instruction Manual.

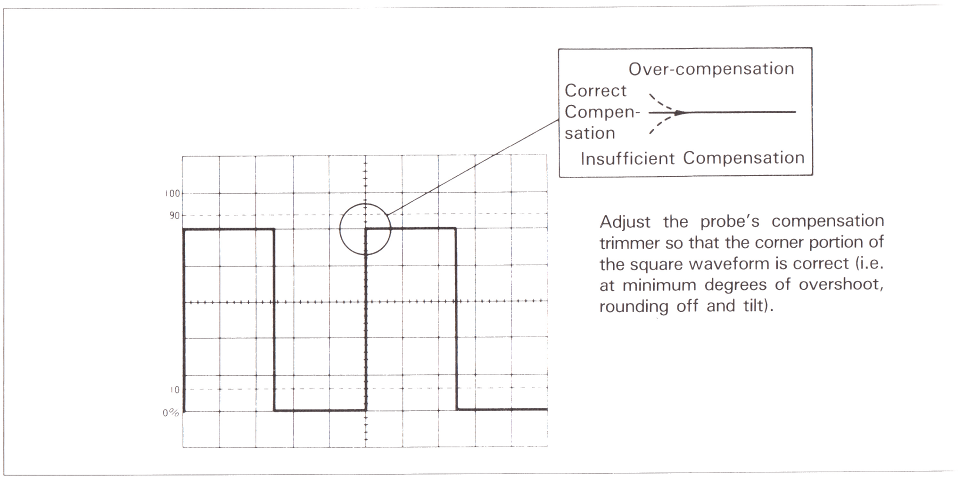


Figure 3. Probe Compensation Adjustment

Set the V MODE control to CH2 and carry out compensation adjustment of the Channel 2 probe. After compensating the channel probes, use the CH1 probe exclusively in Channel 1, and the CH2 probe exclusively in Channel 2. This is necessary because there is a slight capacitance variation between the two channels, and confusing probes will cause changes in compensation adjustments.

5. Return the V MODE control to CH1, each channel's AC-GND-DC control to the AC setting, each channel's VOLTS/DIV control to 5 V/DIV, and the ⇕POSITION and ⇔POSITION controls to 12 o'clock.
This is what we refer to as the ''initial setting'' condition.

OPERATING PROCEDURES

SINGLE TRACE OPERATION

Alternating Current Display

With the oscilloscope in the initial setting condition (refer to Section 5 of CHECKING AND ADJUSTMENTS PRIOR TO MEASUREMENT), display on the CRT screen the signal applied to the CH1 INPUT terminal. Adjust the signal amplitude to an easy to measure size by changing the VOLTS/DIV control setting. The CH1 VARIABLE control may be rotated to change the amplitude in continuous fashion. However, if this is not necessary leave the setting at CAL.

Next, adjust the horizontal TIME/DIV control to attain an easy to measure display. Make sure to leave the VARIABLE control setting at CAL.

Whenever the waveform begins to destabilize, it is necessary to use the triggering operation. Rotating the TRIGGER LEVEL left or right will stabilize the waveform. Depending on the type of signal, switching the SLOPE control will also give you clearer displays. These kinds of operations using the TRIGGER LEVEL and SLOPE controls are referred to as **Setting the Trigger Point**. The oscilloscope begins sweeping from pre-set trigger points.

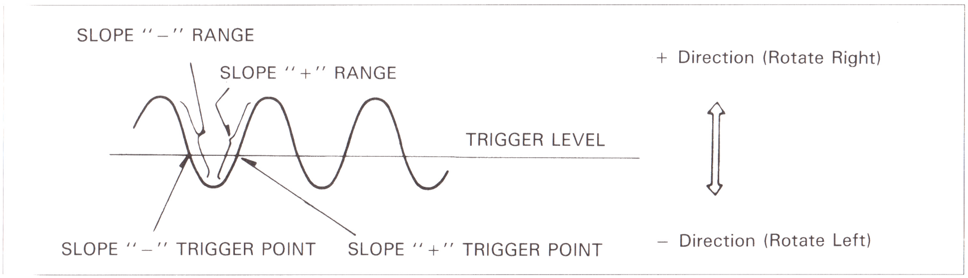


Figure 4. Relationships between Trigger Level and Slope

When inputting low frequency signals or slow occurrence rate signals, switch the SWEEP MODE control to the NORM setting. Even though the waveform display may disappear from the CRT screen when signal amplitudes are relatively small or the trigger point setting is inappropriate, the NORM setting will allow more stable triggering than can be attained in the AUTO setting.

Composite Video Signal Display

When inputting composite video signals, set the COUPLING control to either TV-V or TV-H. Also switch the SLOPE control in accordance with signal polarity.

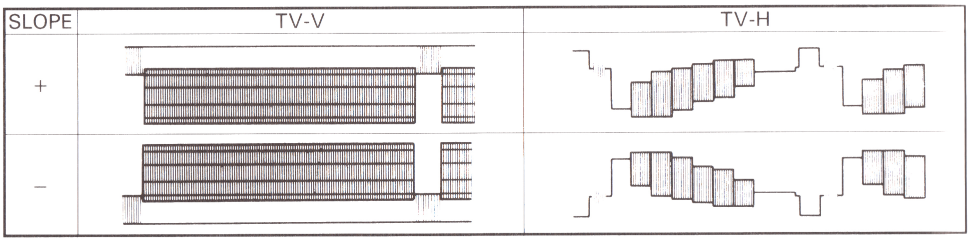


Figure 5. The Relationship between COUPLING and SLOPE

DUAL TRACE OPERATIONS

Switching Vertical Operation Modes

When the V MODE control is set at CH2, the CRT screen will display the signal applied to the channel 2 INPUT terminal. The amplitude can be altered using the channel 2 VOLTS/DIV control. The procedures for switching the sweep time and setting the trigger point are the same as for channel 1.

When the V MODE control is set at ALT, the CH1 and CH2 signals are displayed one after the other for each sweep.

When the V MODE control is set at CHOP, the CH1 and CH2 signals are sub-divided according to time and displayed on the screen.

When the V MODE control is set at ADD, CH1 and CH2 signals will be combined (CH1 + CH2) on the CRT display screen. If the INV control is pressed in this condition the differential (CH1 − CH2) of the two channels will be displayed. In order to measure displayed waveforms at the ADD setting, it is necessary that the VOLTS/DIV control settings be the same for both channels.

Switching Trigger Sources

When the V MODE control is set at CH1, ALT, CHOP, or ADD and the SOURCE control is set at VERT, the signal source for the trigger becomes channel 1. At this time, if the CH1 signal is too complicated, making the trigger point too difficult, switch the SOURCE control to the CH2 setting. The CH2 signal will be simple enough for a stable trigger point setting. However, when the waveforms of both channels are too complicated, use an external source to set the trigger point.

External Trigger

Set the SOURCE control at EXT and apply a signal to the EXT.TRIG IN terminal. It is necessary that this signal have a fixed timing relationship to either CH1 or CH2. Also, in order to simplify the trigger point setting process, you should use as simple an external signal as possible.

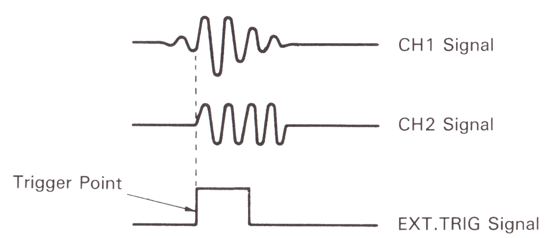


Figure 6. EXT.TRIG

Line Trigger

When the CH1 or CH2 signal is synchronized with a commercial-use power source frequency, setting the SOURCE control at LINE will stabilize the trigger.

SWEEP MAGNIFICATION OPERATION

When carrying out measurements by magnifying a portion of the displayed waveform in terms of time, increasing sweep speed may cause the waveform portion to be measured to disappear from the screen. When this happens, waveform measurement can still be done by magnifying the sweep.

Work the ⇦⇨ POSITION control to move the waveform portion to be magnified to the middle of the CRT display screen. Then press the ×10MAG control to magnify the waveform 10 times in the horizontal direction.

X-Y OPERATION

The oscilloscope not only has all the functions of a conventional oscilloscope, but may also be operated as an X-Y oscilloscope. With X-Y operation, signals applied to the CH1 OR [Y] IN terminal are deflected on the Y-axis, signals applied to the CH2 OR [X] IN terminal are deflected on the X-axis, and Lissajous patterns is depicted. Lissajous patterns makes it possible to find out phase differences between the two signals and find out their relative frequency proportion.

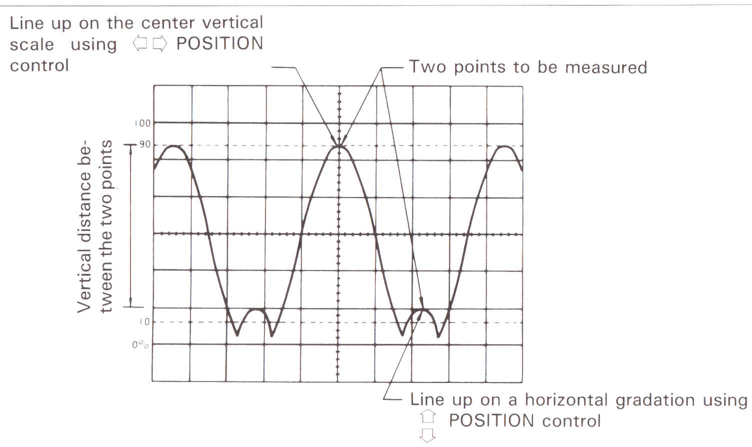
APPLICATIONS

Because both the vertical and horizontal axes of the oscilloscope are calibrated, the oscilloscope is capable of not only displaying waveforms but can also quantitatively measuring voltage or time. When performing these latter measurements, rotate the three VARIABLE controls (CH1 [Y-axis], CH2 [X-axis] and horizontal) all the way in the clockwise direction to the CAL setting. All of the oscilloscope's VARIABLE controls will click when rotated into their CAL settings.
In addition, the oscilloscope comes with LP-040 model probes. These probes should all be plugged into their proper terminals in order to assure a minimum of interference to the signals you want to measure.

Measuring Voltage Between Two Points on a Waveform

Use the following procedures for measuring voltage, etc. between two points or from peak to peak on a waveform.

1. Apply a signal to the INPUT terminal and adjust the VOLTS/DIV and TIME/DIV controls. Also reset the trigger point if necessary. Set the AC-GND-DC control at AC.
2. Work the ⇕ POSITION control so that one of the points (A) to be measured falls on one of the horizontal graduation lines, while the other point (B) can still be observed on the CRT display screen.
3. Work the ⇔ POSITION control so that point B falls on the vertical scale at the center of the CRT screen.
4. Measure the vertical distance between the two points and multiply that value by the VOLTS/DIV setting. When using a LP-040 probe, also multiply the value by the probe's attenuation rate.



Voltage between 2 points = Vertical distance (div) × VOLTS/DIV setting × Probe attenuation rate

Figure 7. Measuring the Voltage Between Two Points

EXAMPLE:

In Figure 7, the vertical distance between the two points is 4.4 div. If the VOLTS/DIV control is set at 0.2 V/div and a 10:1 LP-040 probe is used, the voltage is calculated as follows:

Voltage between 2 points = 4.4 (div) × 0.2 (V/div) × 10 = 8.8 V

Common-Mode Rejection

By using the V MODE control's ADD setting, unnecessary signal components can be eliminated allowing only desired signal components to be displayed.

1. Apply the whole signal (including its unnecessary components) to the CH1 OR [Y] IN terminal. Now apply the component you want eliminated to the CH2 OR [X] IN terminal.
2. Set the V MODE control to ALT or CHOP. Set the SOURCE control at CH2. Set the trigger point at the CH2 signal, and verify that CH2 contains the unnecessary component of CH1.
3. Press the INV control, and verify that the CH2 signal represents the unnecessary component in reverse polarity. When the V MODE control is set at ADD under these conditions, only the necessary signal components will be displayed on the CRT screen.

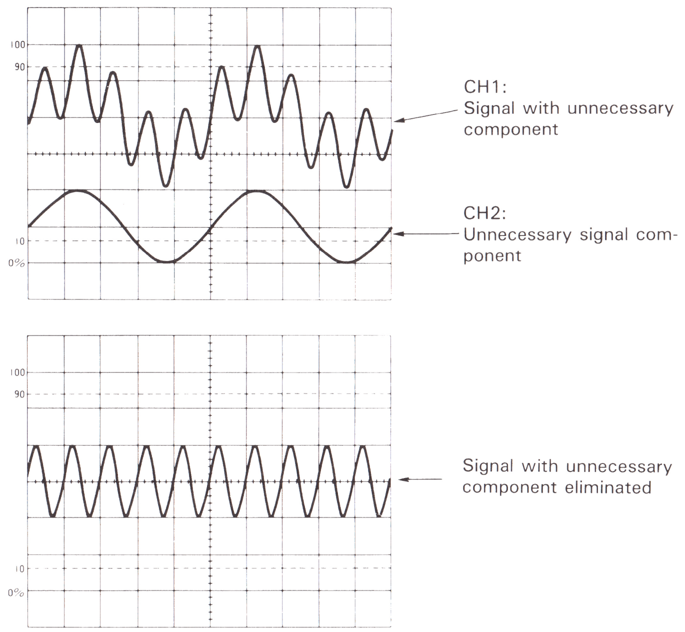


Figure 8. Common-Mode Rejection

Note:

Elimination capabilities vary with the size of the unnecessary component. In order to attain the best results, display the CH2 signal with a slightly higher VOLTS/DIV setting. After pressing the INV control, and activating the ADD function, adjust the VARIABLE control of CH2 to get a good waveform.

Also, after pressing the INV control and switching to the ADD setting, the displayed waveform may move up or down. Move it back to the display position using the ⇕ POSITION control for CH2.

Measuring Direct Current (DC) Voltage

The oscilloscope's vertical amplification is provided by a direct current amplifier circuit characterized by excellent stability. By switching the AC-GND-DC control to the DC setting direct current voltage can be measured.

1. Apply the signal to the INPUT terminal. Work the VOLTS/DIV and TIME/DIV controls to display the waveform at an easy to see size. Also adjust the TRIGGER LEVEL control if necessary.
2. Set the SWEEP MODE control to AUTO, and then set the AC- GND-DC control to GND. The trace will be displayed on the CRT screen. This trace will become the ground potential. Work the ⇕ POSITION control to bring the trace in line with one of the horizontal graduation lines. Usually signals with positive potentials are lined up at the 0% graduation and signals of negative potential at the 100% graduation. Once lined up, the trace's position will become the reference potential, so do not touch the ⇕ POSITION control during the measurement process.
3. Set the AC-GND-DC control at DC. The signal will be displayed on the CRT screen with the direct current component intact. If in this case either the VOLT/DIV or reference potential setting is inappropriate, the waveform may disappear from the display screen. Make sure to check these settings.
4. Measure the potential using the procedure for measuring the voltage between two points. The potential sign will be plus if above the reference and minus if below the reference.

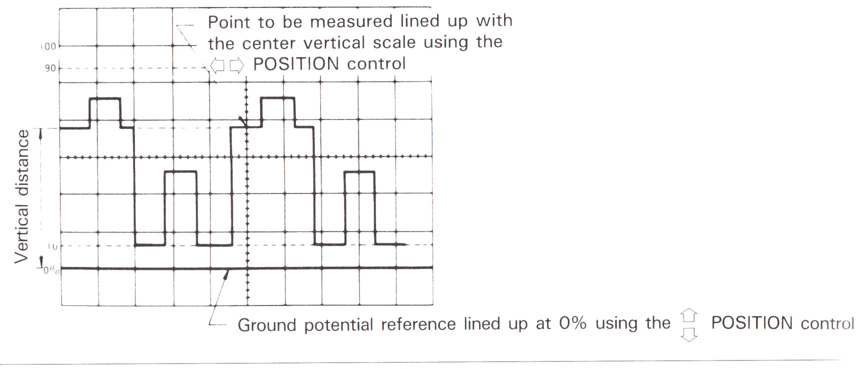


Figure 9. DC Voltage Measurement

5. There is a REF button on the LP-040 probe. Press this button to display the ground potential on the CRT screen. This eliminates the bother of having to set the AC-GND-DC control to GND.
6. If there is only one signal to be measured, apply it to CH1, and work the CH2 ⇕ POSITION control so that CH2 displays the ground potential. If the V MODE control is set at either ALT or CHOP after this adjustment is made, you will be certain of the ground potential throughout the procedure. However, make certain that the ground potentials of both channels are always the same.

Measuring Signals with Low Frequency Components

When the oscilloscope's AC-GND-DC control is set at AC, there is a chance that errors may occur in the voltage measurement. This inaccuracy is caused by low range cut-off frequencies. At AC, the most accurate frequency measurements are realized above the 40 to 50 Hz range. Therefore, when measuring frequencies below this range switch the AC-GND-DC control to the DC setting.
If, however, you are using a LP-040 probe, accurate measurements of frequencies as low as 4 to 5 Hz can be realized at AC.

Measuring Signals with High Frequency Components

Always use a probe when measuring pulses or signals of a few hundred kHz or above. This is because distortion will occur in the waveform's high frequency component due to the use of long leads. This makes it difficult to conduct accurate waveforms. This is also true for probes with long ground leads, so keep them as short as possible. In addition, make sure to connect the ground lead clip to the ground potential lying closest to the signal to be measured.

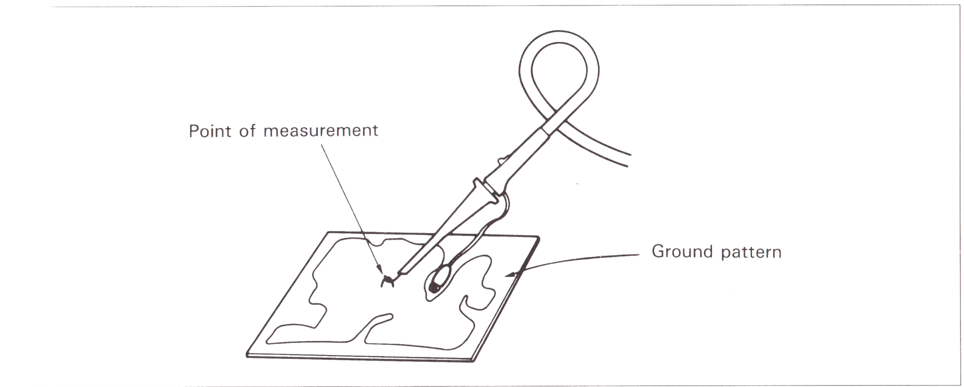
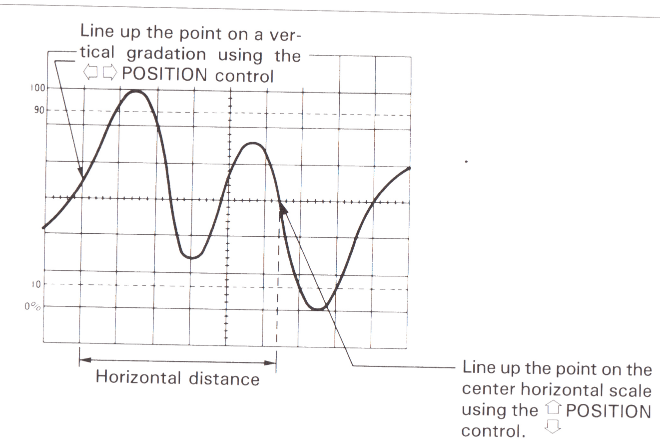


Figure 10. Measuring Signals with High Frequency Components

Measuring Time Between Two Points

When measuring time between two points, measurements can be determined from TIME/DIV and horizontal distance.

1. Display the waveform by adjusting each control. Set all the VARIABLE controls to the CAL position.
2. Work the ⇦⇨ POSITION control to bring one point to be measured in line with a vertical graduation line. Then work the ⇧⇩ POSITION control to bring the other point to be measured in line with the horizontal scale in the middle of the CRT display screen.
3. Measure the horizontal distance between the two points. Multiply this value by the TIME/DIV setting value. If the ×10 MAG function has been activated, multiply the value by 1/10.



Time between two points = horizontal distance (div) × TIME/DIV setting value

When using the ×10 MAG function:
Time between two points = horizontal distance (div) × TIME/DIV setting value × 1/10

Figure 11. Time Measurement

EXAMPLE:

In the case of Figure 11, the horizontal distance between the two points is 5.4 div. If the TIME/DIV setting value is 0.2 ms/div, the time between the two points may be calculated as follows.

Time between two points = 5.4 div × 0.2 ms/div = 1.08 ms

If the ×10 MAG function is in use:

Time between two points = 5.4 div × 0.2 ms/div × 1/10 = 0.108 ms
= 108 μs

Measuring Frequencies

Since the frequency is found as a reciprocal of a period, measure the time (period) of one cycle and calculate its reciprocal value.

1. Measure the time of one cycle.
2. Calculate the reciprocal value of the period found.

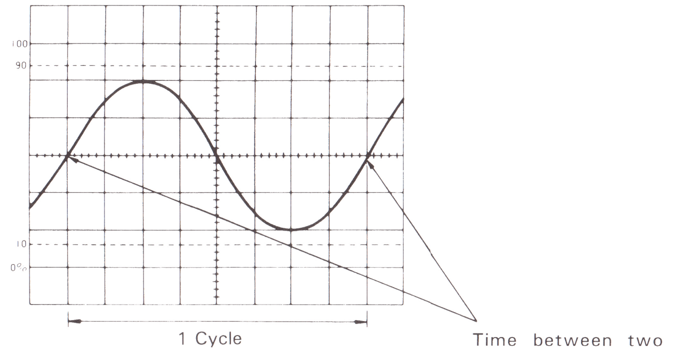


Figure 12. Measuring Frequency

EXAMPLE:

In the case of Figure 12, the period found comes to 40 μs. The frequency is calculated as follows:

$$\text{Frequency} = \frac{1}{40 \times 10^{-6}} = 25 \times 10^{3} = 25 \text{ kHz}$$

Measuring Pulse Rise and Fall Times

Rise (fall) time is found by measuring the time between 10% and 90% of the peak value. For this purpose the oscilloscope has been equipped with additional graduations at 10% and 90%.

1. Apply the signal. Adjust the VOLTS/DIV and VARIABLE control so that the amplitude is 6 div [5 div for Model 8040 and 8021].
   Set the horizontal VARIABLE control at CAL.
2. Rotate the TIME/DIV control as fast a setting as possible until the the section showing rise (fall) becomes visible. Press the ×10 MAG control if necessary.
3. Work the ⇳ POSITION control to move the waveform between 0% and 100%. Then work the ⇦⇨ POSITION control to move the starting point of rise to the 10% graduation with a vertical graduation line. Measure the horizontal distance to the 90% graduation. The time is found from this distance measurement.

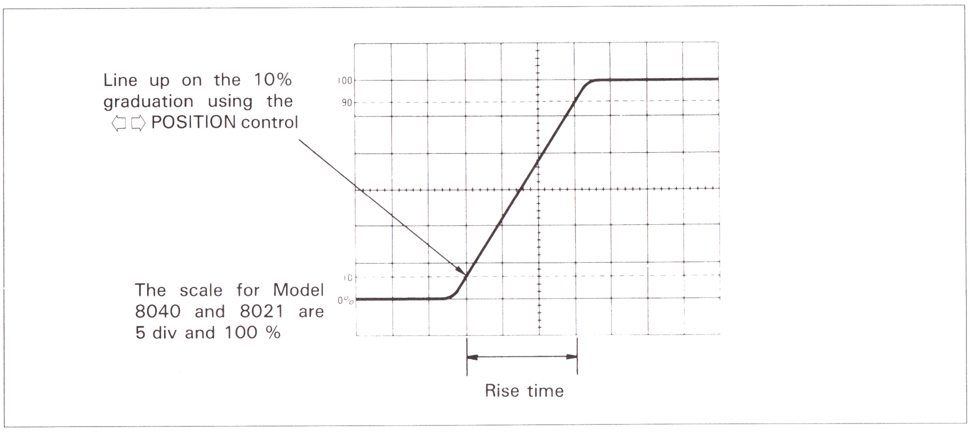


Figure 13. Measuring Rise Time

Note:

When measuring high speed rise (fall) times, you must use the following correction formula to calculate the true rise time, t_o, since there is rise time inherent to the oscilloscope itself.

$$t_o = \sqrt{t_m^2 - t_r^2}$$

where t_m is the actually measured value, and t_r is the oscilloscope's inherent rise time.

Since the rise time of the Model 8020 and 8021 itself is 17.5 ns [8.75 ns for Model 8040],
when, for example, the value actually measured is 50 ns, the true rise time comes to:

(Case of Model 8020 and 8021)

$$t_o = \sqrt{50^2 - 17.5^2} = 46.8 \text{ ns}$$

(Case of Model 8040)

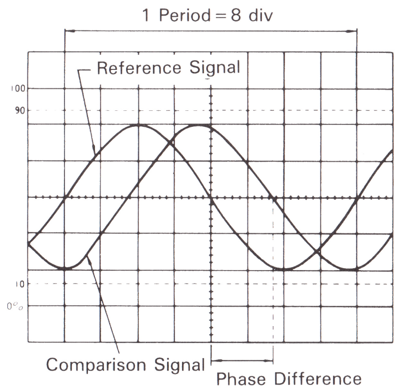
$$t_o = \sqrt{50^2 - 8.75^2} = 49.2 \text{ ns}$$

However, this correction factor is not significant when the actually measured value, t_m, is above 200 ns.

Measuring Phase Differences

When carrying out dual trace operations, phase differences can be measured between, for example, two sine wave signals of identical frequency.

1. Apply the two signals to their respective INPUT terminals. Adjust the VOLTS/DIV and VARIABLE controls so that the two signals are at identical amplitude.
2. Adjust the TIME/DIV and VARIABLE controls so that one period of the waveforms is 8 div.
3. Work the ⇧⇩ POSITION controls of both channels to bring the waveforms to the center of the CRT display screen.
4. Measure the horizontal distance between corresponding points on the two signals. There is a phase difference of 45 degrees for every 1 division of horizontal distance.



Phase difference (deg) = Horizontal distance (div) × 45 degrees/div

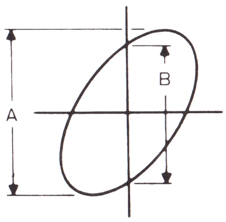
Figure 14. Measuring Phase Difference

Displaying Lissajous Patterns

When operating the oscilloscope in the X-Y mode, Lissajous patterns can be displayed. With Lissajous patterns it is possible to find even the slightest phase difference or signal distortion and also find relative frequency proportions.

1. Apply the signal to be measured to the CH1 OR [Y] IN terminal and a reference signal to the CH2 OR [X] IN terminal.
2. Set the SWEEP MODE control to X-Y.
3. Adjust the VOLT/DIV and VARIABLE controls of both channels to attain an acceptable display.

Phase difference can be measured with Lissajous patterns in the following manner.



$$\phi = \sin^{-1} \frac{B}{A}$$

or

$$\sin\phi = \frac{B}{A}$$

where ϕ is the phase difference

Figure 15. Measuring Phase Difference with Lissajous Patterns

The following represent Lissajous patterns indicating the presence of signal distortion or phase difference.

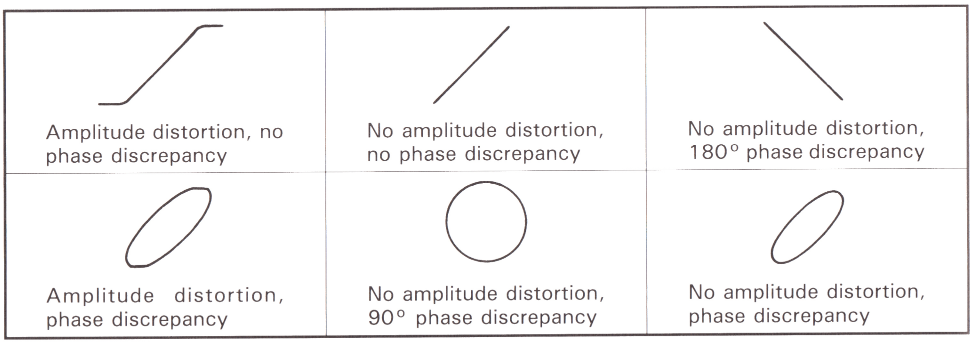


Figure 16. Representative Lissajous Patterns

The following represent Lissajous patterns when input frequency proportions are altered.

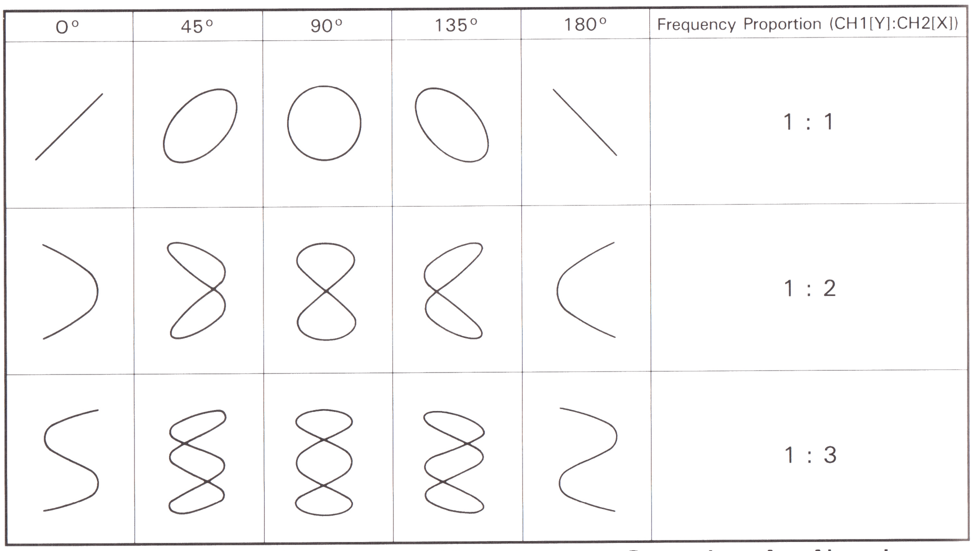


Figure 17. Lissajous Patterns When Frequency Proportions Are Altered

Note:
In the phase difference measuring process using Lissajous patterns, the value will not change even if the VARIABLE controls are rotated.
Therefore carry out the measurement at the clearest display possible.

ΠΑΡΑΡΤΗΜΑ ΙΙΙ
Πολύμετρο

Το πολύμετρο είναι ένα όργανο με το οποίο μπορούμε να μετρήσουμε τάσεις, ρεύματα και αντιστάσεις.
Είναι δυνατή η μέτρηση τόσο συνεχών (DC) όσο και εναλλασσόμενων (AC) τάσεων και ρευμάτων. Στα εναλλασσόμενα σήματα το πολύμετρο μετράει την **ενεργό** τιμή τους (rms) και **όχι** το πλάτος ή την τιμή από κορυφή σε κορυφή.

Στη συνέχεια παρατίθεται το εγχειρίδιο χρήσης του πολύμετρου που θα χρησιμοποιήσετε στο εργαστήριο.

CONTENTS

1. INTRODUCTION

This instrument is a compact, rugged, battery operated, handheld 3½ digit multimeter for measuring DC and AC voltage, DC and AC current, Resistance and Diode, for testing Audible continuity and transistor hFE. The Dual-slope A-D Converter uses C-MOS technology for auto-Zeroing, polarity selection and over-range indication. Full overload protection is provided.
It is an ideal instrument for use in the field, laboratory, workshop, hobby and home applications.

2. FEATURES

* Push-button ON-OFF power switch.
* Single 30 position easy to use rotary switch for FUNCTION and RANGE selection.
* 0.5″ high contrast LCD.
* Automatic overrange indication with the "1" displayed.
* Automatic polarity indication on DC ranges.
* All ranges fully protected plus Automatic "ZERO" of all ranges without short circuit except 200 ohm Range which shows "000 or 001 ".
* High Surge Voltage protection 1.5 KV-3 KV.
* Diode testing with 1 mA fixed current.
* Audible Continuity Test.
* Transistor hFE Test.

3. SPECIFICATIONS

Accuracies are ± (% reading + No. of digits) Guranteed for 1 year, 23°C ± 5°C, less than 75% RH.

DC Voltage

Range	Accuracy	Resolution
200 mV	±0.5%, of rdg +1 digit	100 μV
2 V		1 mV
20 V		10 mV
200 V		100 mV
1000 V		1 V

Input Impedance: 10 M ohm on all ranges. Overload Protection: 1000V dc or peak ac on all ranges.

AC Voltage

Range	Accuracy	Resolution
200 mV	±1.2%, of rdg +3 digits	100 μV
2 V	±0.8%, of rdg +3 digits	1 mV
20 V		10 mV
200 V		100 mV
700 V	±1.2%, of rdg +3 digits	1 V

Input impedance: < 10M ohm in parallel with > 50PF (ac coupled).
Frequency Range: 40 Hz to 1 KHz.
Overload Protection: 750V rms or 1000V peak continuous on ac ranges, except 200 mV ac ranges (15 seconds maximum above 300V rms).
Indication: Average (rms of sine wave).

DC Current

Range	Accuracy	Resolution
200 μA	±0.5%, of rdg +1 digit	0.1 μA
2 mA		1 μA
20 mA		10 μA
200 mA	±1.2%, of rdg +1 digit	100 μA
2 A		1 mA
20 A, 20 μA	±2.0%, of rdg +5 digits	10 mA, 10 nA

Overload Protection: 2 A/250V fuse (20 A range unfused).
Maximum Input Current: 20 A (up to 60 seconds).
Measuring Voltage Drop: 200 mV.

AC Current

Range	Accuracy	Resolution
200 μA	±1.0%, of rdg +3 digits	0.1 μA
2 mA		1 μA
20 mA		10 μA
200 mA	±1.8%, of rdg +3 digits	100 μA
2 A		1 mA
20 A , 20 μA	±3.0%, of rdg +7 digits	10 mA , 10 nA

Overload Protection: 2A/250V fuse (20A range unfused).
Maximum Input Current: 20A (up to 60 seconds).
Frequency Range: 40 Hz to 1 k Hz.
Indication: Average (rms of sine wave).
Measuring Voltage Drop: 200 mV.

Resistance

Range	Accuracy	Resolution
200 ohm	±0.5%, of rdg +3 digits	0.1 ohm
2 K ohm	±0.5%, of rdg +1 digit	1 ohm
20 K ohm		10 ohm
200 K ohm		100 ohm
2 M ohm		1 K ohm
20 M ohm	±1.0%, of rdg +2 digits	10 K ohm

Overload Protection: 500V dc/ac rms on all ranges,
except 200Ω range (200V dc/ac rms).
Open Circuit Voltage: Less than 700 mV.
Relative Humidity: 0 to 75%, 0°C to 35°C on 2 MΩ, 20 MΩ
0 to 90%, 0°C to 35°C on all other ranges.
0 to 70%, 35°C to 50°C.

Diode and Audible Continuity Test

Range	Description	Test Conditioin
♫ ▶|	Display read approximate forward voltage of diode	Foward DC current approx imately 1mA. Reversed DC voltage approximately 2.8 Volts.
♫ ▶|	Built-In buzzer sounds if conductance is less than approximately 30Ω	Open Circuit Voltage approximately 2.8 Volts.

Transistor hFE Test

Range	Description	Test Condition
hFE	Display read approximate hFE value (0-1000) of transistor under test (ALL TYPE)	Base Current approx 10.μA VCE approximately 2.8 Volts.

4. GENERAL CHARACTERISTICS

Maximum Display	: 1999 counts (3½ digits) with automatic polarity indication.
Indication Method	: LCD display.
Measuring Method	: Dual-Slope integration A-D converter system.
Overrange Indication	: "1" Figure only in the display.
Maximum common mode voltage	: 500V dc/ac rms.
Reading rate time	: 2-3 reading per sec (approximate).
Temperature for guaranteed accuracy	: 23°C ±5°C.
Temperature Ranges	: Operating 0°C to 40°C, 32°F to 104°F. Storage −10°C to 50°C, 14°F to 122°F.
Power Supply	: One 9-volt battery (NEDA 1604, 6F22 TYPE or equivalent).
Low Battery Indication	: LO BAT or BAT on the left of display.
Size	: 88W × 172D × 36H m/m.
Weight	: 340g (including 9 volt batteries).
Accessories	: Operating manual, 9V Battery (Zinc-Carbon TYPE). Set of test leads, Spare fuse (2A/250V fast blow TYPE), and Carrying case.

5. OPERATION

PRELIMINARY NOTE

1. Check the 9-volt battery by setting the ON-OFF switch to ON. If the battery is weak, a "LO BAT" or "BAT" sign will appear on the left of the display.
   If this does not appear on the display, proceed as below. See MAINTENANCE if the battery has to be replaced.
2. The mark, or sign, ⚠ next to the test lead jacks, is for warning that the input voltage or current should not exceed the indicated values.
   This is to prevent demage to the internal circuitry.
3. The function switch should be set to the range which you want to test before operation.

5-1 DC Voltage Measurement

1. Connect the BLACK test lead to the COM jack and the RED test lead to the V/Ω jack.
2. Set the FUNCTION switch to the DC V range to be used and connect the test leads across the source or load under measurement ,see Fig. 5-1.
   The polarity of the RED lead connection will be indicated at the same time as the voltage.

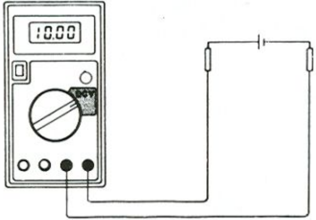


Fig. 5-1 DC Voltage measurement

Note : 1. If the voltage range is not known beforehand set the FUNCTION switch to the highest range and work down.

2. When only the figure "1" is displayed, overrange is being indicated and the FUNCTION switch must be set to a higher range.

3. ⚠: Do not apply more than 1000V to the input. Indication is possible at higher voltages but there is danger of damaging the internal circuitry.

4. Use extreme caution to avoid contact with high tension circuits when measuring high voltage.

5-2 AC Voltage measurement

1. Connect the BLACK test lead to the COM jack and the RED test lead to the V/Ω jack.
2. Set FUNCTION switch to the AC V range to be used, and connect the test leads across the source or load under measurement. See Fig. 5-2.

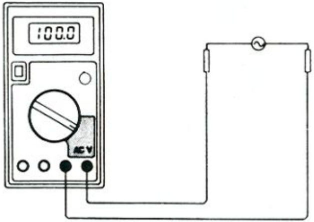


Fig. 5-2 AC Voltage measurement.

Note : 1. See DC Voltage measurement Note 1.2.
2. ⚠ : do not apply more than 700V rms to the input Indication is possible at higher voltages but there is danger of damaging the internal circuitry.
3. Use extreme caution to avoid contact with high tension circuits when measuring high voltage.

5-3 DC Current Measurement

1. Connect the BLACK test lead to the COM jack and the RED test lead to the A jack for a Maximum of 2A. For a maximum of 20A move the red test lead to the 20A jack.
2. Set the FUNCTION switch to the DC A range to be used and connect the test leads in series with the load under measurement see Fig. 5-3.
   The polarity at the RED test lead connection will be indicated at the same time as the current.

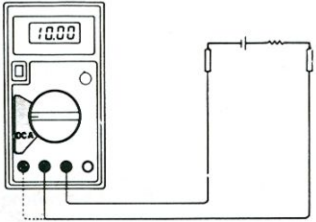


Fig. 5-3 DC Current measurement

Note : 1. If the current range is not known beforehand, set the FUNCTION switch to the highest range and work down.

2. When only the figure "1" is displayed overrange is being indicated and the FUNCTION switch must be set at higher range.

3. ⚠: The Maximum input current is 2A, or 20A depending upon the jack used. Excessive current will blow the fuse which must be replaced. The 20 A Range is not protected by a fuse. The fuse rating should not be over 2A, to prevent damage to the internal circuitry.

4. The Maximum terminal voltage drop is 200 mV.

5-4 AC Current Measurement

1. Connect the BLACK test lead to the COM jack and the RED test lead to the A jack, for a maximum of 2A.
   For a maximum of 20A move the RED test lead to the 20A jack.
2. Set the FUNCTION switch to the AC A range to be used and connect the test lead in series with the load under measurement. See Fig 5-4.

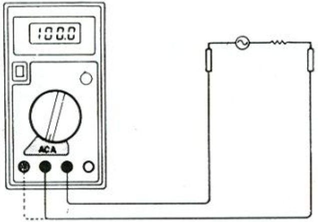


Fig. 5-4 AC Current measurement

Note : 1. If the current range is not known beforehand, set the FUNCTION switch to the highest range and work down.

2. When only the figure "1" is displayed overrange is being indicated and the FUNCTION switch must be set to at higher range.

3. ⚠: The Maximum input current is 2A, or 20A depending on the jack used. Excessive current will blow the fuse which must be replaced.
The 20 A range is not protected by a fuse.
The fuse rating should not be over 2A.
This is to prevent damage to the internal circuitry.

4. The Maximum terminal voltage drop is 200 mV.

5-5 Resistance Measurement

1. Connect the BLACK test lead to the COM jack and the RED test lead to the V/Ω jack. (Note: The polarity of the RED test lead is "+")
2. Set the FUNCTION switch to the Ω range to be used and connect the test leads across the resistance under measurement see Fig. 5-5.

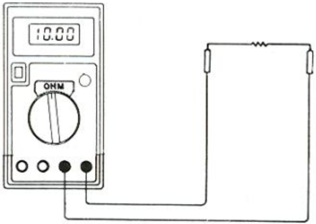


Fig. 5-5 Resistance measurement

Note: 1. If the resistance value being measured exceeds the maximum value of the range selected, an over-range indication will be displayed ("1"). Select a higher range. For resistance of approximately 1 Megohm and above, the Meter may take a few seconds to stabilize. This is normal for high resistance readings.

2. When the input is not connected, i.e. at open circuit, the figure "1" will be displayed for the overrange condition.
3. When checking in-circuit resistance, be sure the circuit under test has all power removed and that all capacitors are fully discharged.
4. The resistance ranges of this instrument are protected by a posister above 500V and a resistor network below 500V, except 200Ω range (250V).
5. Some devices may be damaged by the current applied during resistance measurements. The following table lists the voltage and current available on each range.

Range	A	B	C
200 Ω	0.65	0.08	0.44
2 K	0.65	0.3	0.27
20 K	0.65	0.42	0.06
200 K	0.65	0.43	0.007
2 M	0.65	0.43	0.001
20 M	0.65	0.43	0.0001

A is open circuit voltage at the jack.
B is voltage across a resistance equal to full scale value.
C is current in milliamperes thru a short circuit at the input jacks. All values are typical.

5-6 Diode Measurement

1. Connect the BLACK test lead to the COM jack and the RED test lead to the V/Ω jack. (Note: The polarity of the RED test lead is "+")
2. Set the FUNCTION switch to the ⊣▶⊢ range and connect the test leads across the diode under measurement see Fig. 5-6.

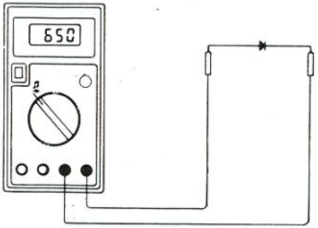


Fig . 5-6 Diode measurement

Note:
1. When the input is not connected, i.e. at open circuit, the figure "1" will be displayed for the overrange condition.
2. There is 1 milliamp Current flow through the device under test.
3. The meter displays the forward voltage drop in millivolts, and overload when the diode is reversed.

5-7 Audible Continuity Test

1. Connect the BLACK test lead to the COM jack and the RED test lead to the V/Ω jack.
2. Set the FUNCTION switch to the ♫ range (same ⏵| range) and connect the test leads across the resistance under measurement. See Fig. 5-7.
3. Buzzer sounds if the resistance between two prods is less than approximately 30 ohms.

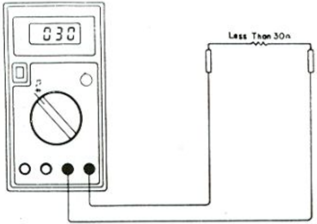


Fig. 5-7. Audible Continuity test

Note:
1. When the input is not connected, i.e. at open circuit, the Figure "1" will be displayed for the overange condition.
2. The circuit to be tested must be in power off status during the continuity check.

5-8 Transistor hFE Test

1. Set the FUNCTION switch to the hFE range.
2. Determine whether the transistor is NPN or PNP and locate the Emitter, Base and Collector leads. Insert the leads into the proper holes in the socket on the front panel See Fig. 5-8.
3. The display will read the approximate hFE value at the test condition of base current 10 μA VCE2.8V.

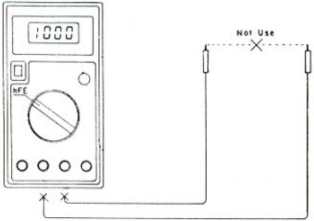


Fig. 5-8 Transistor hFE Test.

6. MAINTENANCE

Your Digital Multimeter is a precision electronic device. Do not tamper with the circuitry.
To avoid damage:

A. Never connect more than 1,000 Volts DC or 700 Volts RMS AC.
B. Never connect a source of voltage with Function Switch in OHM position.
C. Never operate the DVM unless the battery cover is in place and fully closed.
D. Battery and/or fuse replacement should only be done after the test leads have been disconnected and POWER IS OFF.

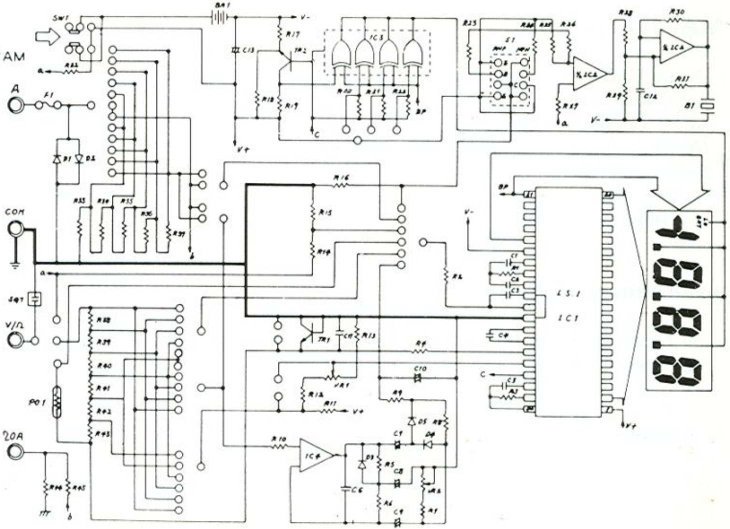
6-1 9-Volt Battery Replacement

Note the condition of the 9-volt battery using the procedure described above. If the battery needs to be replaced, open the Back cover, remove the spent battery and replace it with a battery of the same type.

6-2 Fuse Replacement

Should the fuse need replacement, use only 2-amp fuses identical in physical size to the original or use the spare fuse in the storage compartment adjacent to the main fuse in the **Case** (Top Cover)

SCHEMATIC DIAGRAM



ΠΑΡΑΡΤΗΜΑ IV
Γεννήτρια σήματος.

Η γεννήτρια σήματος του εργαστηρίου μπορεί να μας δώσει διάφορες περιοδικές κυματομορφές σήματος, όπως ημιτονικό σήμα, τεραγωνικό παλμό ή τριγωνικό παλμό, σε μια εκτεταμένη περιοχή συχνοτήτων.

Τα τεχνικά χαρακτηριστικά και ο τρόπος χρήσης της γεννήτριας περιλαμβάνονται στο εγχειρίδιο του κατασκευαστή, που ακολουθεί.

3. SPECIFICATION

	GFG-8215A/8216A/8217A/8219A	GFG-8250A/8255A
1.Main		
Frequency Range	0.3Hz～3MHz(7 Range)	0.5Hz～5MHz(7 Range)
Amplitude	≧10Vpp(into 50Ω load)	≧10Vpp(into 50Ω load)
Impedance	50Ω±10%	50Ω±10%
Attenuator	-20dB±1dB×2	-20dB±1dB×2
DC Offset	＜-5V～＞5V (into 50Ω load)	＜-5V～＞5V (into 50Ω load)
Duty Control	80%:20%:80% to 1MHz Continued variable	80%:20%:80% to 1MHz Continued variable
Display	6 digits LED display ***GFG-8215A does not have display.**	6 digits LED display
Range Accuracy	±5%+1Hz(at 3.0 position) ***only for GFG-8215A.**	----------------------------
2.Sine Wave		
Distortion	≦1%,0.3Hz～200kHz	≦1%,0.5Hz～100kHz
Flatness	＜0.3dB,0.3Hz～300kHz ＜0.5dB,300kHz～3MHz	≦0.3dB,below 500kHz ≦1dB,below 5MHz
3.Triangle Wave		
Linear	≧98%,0.3Hz～100kHz ≧95%,100kHz～3MHz	≧98%,0.5Hz～100kHz ≧95%,100kHz～5MHz
4.Square Wave		
Symmetry	±2%,0.3Hz～100kHz	±2%,1Hz～100kHz
Rise or Fall Time	≦100ns at maximum output. (into 50Ω load)	≦50ns at maximum output (into 50Ω load)

	GFG-8215A/8216A/8217A/8219A	GFG-8250A/8255A
5.CMOS Output		
Level	4Vpp±1Vpp～14.5Vpp ±0.5Vpp adjustable	4Vpp±1Vpp～14.5Vpp ±0.5Vpp adjustable
Rise or Fall Time	≦120ns	≦120ns
6.TTL Output		
Level	≧3Vpp	≧3Vpp
Fan Out	20 TTL load	20 TTL load
Rise or Fall Time	≦25ns	≦25ns
7.VCF		
Input voltage	0V～10V±1V(100:1)	0V～10V±1V(100:1)
Input Impedance	10kΩ±10%	10kΩ±10%
8.GCV(for GFG-8219A/8255A only)		
Output voltage	To set the voltage between 0V～2V as per different frequency.	To set the voltage between 0V～2V as per different frequency.
9.Sweep Operation(for GFG-8217A/8219A/8255A only)		
Sweep/Manual	Switch selector	Switch selector
Sweep/Rate	100:1 ratio max. and adjustable	100:1 ratio max. and adjustable
Sweep/Time	0.5Sec～30Sec adjustable	0.5Sec～30Sec adjustable
Sweep/Mode	Lin./Log. switch selector	Lin./Log. switch selector
10.Amplitude Modulation(for GFG-8219A/8255A only)		
Depth	0～100%	0～100%
MOD.Freq.	400Hz(INT),DC～1MHz(EXT)	400Hz(INT),DC～1MHz(EXT)
Carrier BW	100Hz～3MHz(-3dB)	100Hz～5MHz(-3dB)
EXT Sensitivity	≦10Vpp for 100% modulation	≦10Vpp for 100% modulation

	GFG-8215A/8216A/8217A/8219A	GFG-8250A/8255A
11.Frequency Modulation (for GFG-8219A/8255A only)		
Deviation	0～±5％	0～±5％
MOD.Freq.	400Hz(INT),DC～20kHz(EXT)	400Hz(INT),DC～20kHz(EXT)
EXT Sensitivity	≦10Vpp for 10％ modulation	≦10Vpp for 10％ modulation
12.Frequency Counter		
Int./Ext.	Switch selector	Switch selector
Range	0.3Hz～3MHz (5Hz～150MHz EXT)	0.5Hz～5MHz (5Hz～150MHz EXT)
Accuracy	Time base accuracy±1count	Time base accuracy±1count
Time base	±20ppm(23℃±5℃) after 30 minutes warm up	±20ppm(23℃±5℃) after 30 minutes warm up
Resolution	The maximum resolution is 10nHz for 1Hz and 0.1Hz for 100MHz.	The maximum resolution is 10nHz for 1Hz and 0.1Hz for 100MHz.
Input Impedance	1MΩ/150pF	1MΩ/150pf
Sensitivity	≦35mVrms(5Hz~100MHz) ≦45mVrms(100MHz~150MHz) ***GFG-8215A does not have Frequency Counter function.**	≦35mVrms(5Hz~100MHz) ≦45mVrms(100MHz~150MHz)
13.General		
Power Source	AC115V, 230V±15%,50/60Hz	AC115V, 230V±15％,50/60Hz
Operation Environment	Indoor use, altitude up to 2000m. Ambient Temperature 0℃ to 40℃. Relative Humidity 80%(Maximum). Installation category II Pollution Degree 2	
Storage temperature & Humidity	-10℃ to 70℃. 70% (Maximum).	

	GFG-8215A/8216A/8217A/8219A	GFG-8250A/8255A
Accessories	GTL-101×2 *GTL-101×1 for GFG-8215A Instruction manual×1	GTL-101×2 Instruction manual×1
Dimension	251(W)x91(H)x291(D) m/m	251(W)x91(H)x291(D) m/m
Weigh	Approx. 2.0kgs-GFG-8215A 2.1kgs-GFG-8216A 2.15kgs-GFG-8217A 2.2kgs-GFG-8219A	Approx. 2.3kgs-GFG-8250A 2.4kgs-GFG-8255A

Measurement category I is for measurements performed on circuits not directly connected to MAINS.
Measurement category II is for measurements performed on circuits directly connected to the low voltage installation.
Measurement category III is for measurements performed in the building installation.
Measurement category IV is for measurements performed at the source of the low-voltage installation.

WARNING：To avoid electrical shock, the power cord protective grounding conductor must be connected to ground.

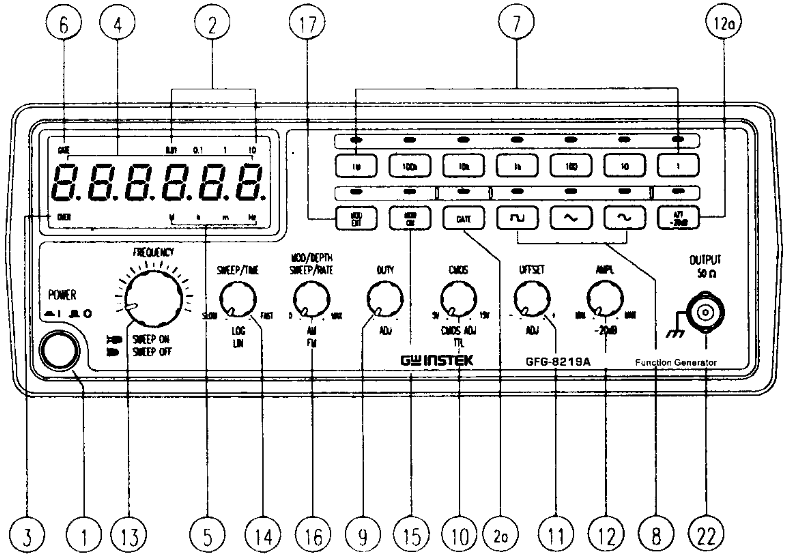
CAUTION：To avoid damaging the instrument, do not use it In a place where ambient temperature exceeds 40℃.

CAUTION：To avoid damaging the instrument, do not input more than DC15V to V.C.F.(V.C.G.).

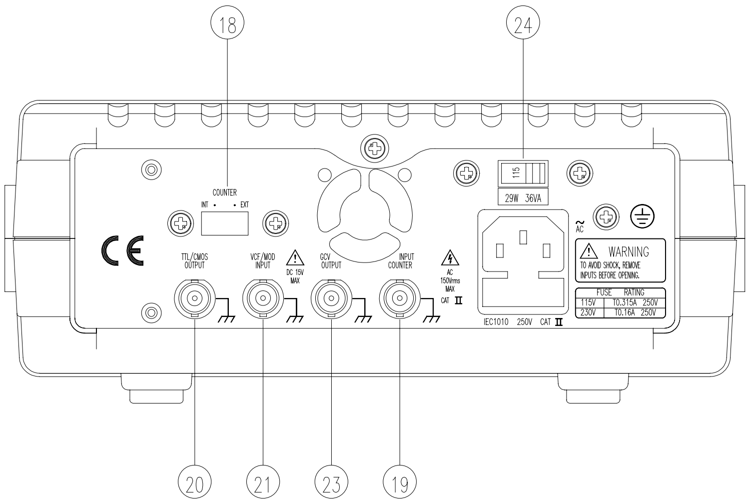
CAUTION：To avoid damaging the instrument, do not input more than AC150V to Frequency Counter (for GFG-8216A, GFG-8217A, GFG-8219A, GFG-8250A, and GFG-8255A).

CAUTION：To avoid damaging the instrument, do not input more than AC10Vpp when proceed EXT modulation operation (for GFG-8219A, GFG-8255A).

- **Fig 4.1 FRONT PANEL**



- **Fig.4-2 REAR PANEL**



4. FUNCTION DESCRIPTION

1.	Power Switch	Connect the AC power, then press power switch.
2.	Gate Time Indicator	Press the power switch, Gate time indicator will start to flash (the gate time of internal counter is 0.01 second).
2a.	Gate Time Selector	Press this key to change gate time when use external counter mode. The change order is according to 0.01s, 0.1s, 1s, 10s cycle by pressing these keys.
3.	Over Indicator	In the external counter mode, the indicator is illuminated when the output frequency is greater than the range selected.
4.	Counter Display	Shows the external frequency by 6 × 0.3" green display, and shows the internal frequency by 5 × 0.3 green display.
5.	Frequency Indicator	Indicate the current frequency value.
6.	Gate Time Indicator	Indicate the current Gate time (external. counter mode use only).
7.	Frequency Range Selector	To select the required frequency range by pressing the relevant push button on the panel as shown in Table 1 and Table 2.

Table 1(for GFG-8215A/8216A/8217A/8219A)

Push bottom	1	10	100	1k	10k	100k	1M
Frequency Range	0.3Hz ｜ 3Hz	3Hz ｜ 30Hz	30Hz ｜ 300Hz	300Hz ｜ 3kHz	3kHz ｜ 30kHz	30kHz ｜ 300kHz	300kHz ｜ 3MHz

Table 2(for GFG-8250A/8255A)

Push bottom	1	10	100	1k	10k	100k	1M
Frequency Range	0.5Hz ｜ 5Hz	5Hz ｜ 50Hz	50Hz ｜ 500Hz	500Hz ｜ 5kHz	5kHz ｜ 50kHz	50kHz ｜ 500kHz	500kHz ｜ 5MHz

8.	Function Selector	Press one of the three push buttons to select the desired output waveform.
9.	Duty Function	Pull out and rotate the knob to adjust the duty cycle of the waveform.
10.	TTL/CMOS Selector	When push in the knob, the BNC terminal of ⑳ will output a TTL compatible waveform. If pull out and rotate the knob can adjust the CMOS compatible output (5-15Vpp) from the output of BNC ⑳ .
11.	DC Offset Control	Pull out the knob to select any DC level of the waveform between ±10V, turn clockwise to set a positive DC level waveform and invert for a negative DC level waveform.
12.	Output Amplitude Control with Attenuation Operation	Turn clockwise for MAX. output and invert for a –20dB output. Pull the knob out for an additional 20dB output attenuation.

12a.	20dB Attenuation	Press the knob to adjust a –20dB output.
13	MANU/SWEEP Selector and Frequency Adjustment (Sweep On/Off)	Press and turn clockwise the knob for MAX frequency and invert for MIN frequency. (Keep the pointer within the scale range on the panel.). Pull out the knob to start the auto sweep operation; the upper frequency limit is determined by the knob position.
14	Sweep Time Control and LIN/LOG Selector	(1) Rotate the knob clockwise to adjust sweep time for MAX, or invert for MIN. (2) To proceed Linear sweep mode by pushing in the knob, or select LOG sweep mode by pulling out the knob.
15.	Control MOD ON/OFF Selector	Pull out the knob, the output can be modulated by internal 400Hz Sine wave or an external signal via VCF/MOD in connector ㉑.
16.	Sweep Width & Modulation Carrier &AM/FM Selector &FM Selector	(1) Sweep width can be controlled from 0 to 1000 times. (2) To adjust modulation ratio by turning the knob clockwise for MAX, or invert for MIN. (3) Press the knob to get AM function or pull it out for FM function.
17	INT/EXT MOD Selector	When press the button once, the indicator will lighten, then the EXT MOD has been selected. Press the key again, the indicator will be off, then INT MOD has been selected.
18.	INT/EXT Counter Selector	Select internal counter mode (count the frequency of model) or select EXT counter mode for an independent counter (input signal from BNC ⑲).

19.	EXT. Counter Input Terminal	Accepts external signals for measurement.
20.	TTL/CMOS Output Terminal	TTL/CMOS compatible signal output
21.	VCF/MOD Input Terminal	Used to connect the input voltage required to perform the "voltage control frequency" operation or the EXT modulation operation.
22.	Main Output Terminal	Main signal output.
23.	GCV Output	This is DC voltage output and its voltage amount will follow the change of Frequency.
24.	Power Switch	115V and 230V selectable.

- **Remark:**

(1) The functions of item 2, 2a, 3, 4, 5, 6, 14, 15, 16, 17, 19 and 23 can not be applied to model GFG-8215A.

(2) The functions of item 14, 15, 16, 17 and 23 can not be applied to GFG-8216A, and GFG-8250A.

(3) The function of item 15, 16-2, 16-3, 17 and 23 can not be applied to GFG-8217A.

(4) The function of item 20 for GFG-8216A/8250A can be selected from front panel.

(5) The function of item 20 and 21 for GFG-8215A can be selected from front panel.

5. USAGE DESCRIPTION

These function generators can provide versatile waveforms of high efficiency and convenient operation. Familiarize yourselves with these functions thoroughly through Operation Manual and practice with all accurate operation procedures can lead you to easily master the performance of these Function Generators.

It is one of the best ways to observe waveforms by connecting the instruments to Oscilloscope. Watch the effect in different control of waveforms through Oscilloscope carefully when proceeding the following steps:

5-1.First-step check:

(1) Ensure that the voltage of the main supply is compatible with this instrument. The label on the rear panel states the required AC voltage.

(2) Connect the instrument to the main supply using the power cord supplied.

(3) Press PWR switch ① and ensure all the rotary controls are pushed in, then rotate AMPL ⑫ knob to make the indication point up forward.

(4) Rotate the FREQ ⑬ control fully anticlockwise.

5-2.Triangle, square and sine wave

(1) First select Function ⑧ , and select Range ⑦, rotate FREQ ⑬ , to set the required frequency.(read out from display window).

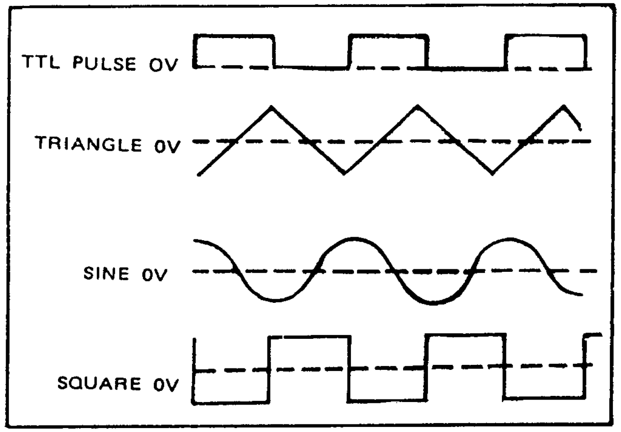
(2) At this moment, connect Output ㉒ , to oscilloscope for observing output signal, or connect to other experiment circuit.

(3) Rotate AMPL ⑫ again to control waveform amplitude.

(4) If attenuation output signal is required, pull out AMPL ⑫ knob to obtain 20dB attenuation or press (12a) knob for additional 20dB attenuation.

(5) The phase-relation of Output Waveform shown in Figure 1 as below:

- **Figure 1.**



5-3.Pulse wave generation

(1) First press the key ( ) of Function ⑧ ; then select Range ⑦ , and rotate FREQ ⑬ , to set required frequency range.

(2) Connect output-terminal ㉒ to oscilloscope for observing output signal.

(3) Pull out and rotate Duty ⑨ to adjust the width of pulse waveform.

(4) Adjust AMPL ⑫ knob to control pulse amplitude.

(5) Pull out AMPL ⑫ knob to get 20dB attenuation of output.

5-4.Ramp wave generation

(1) First press the key ( ) of Function ⑧ , then select Range ⑦ , rotate FEEQ ⑬ switch to set required frequency range.

(2) Connect output-terminal ㉒ to oscilloscope for observing output signal.

(3) Pull out and rotate DUTY⑨ to adjust the slope of ramp waveform.

(4) Adjust AMPL ⑫ knob to control output amplitude of ramp waveform.

(5) Pull out AMPL ⑫ knob to obtain 20dB attenuation of output.

5-5.TTL/CMOS signal output

(1) First select Range ⑦, rotate FREQ ⑬ to set required frequency range.

(2) Connect BNC connector of TTL/CMOS⑳ to oscilloscope or to other experiment circuit for observing output signal.

(3) At this moment, output is square waveform fixing to TTL level; suits for general TTL integrated circuit.

(4) If square waveform of CMOS level is required, can pull out CMOS ⑩ knob to adjust voltage level.

5-6.Variation of external voltage-controlled frequency

This mode of operation allows the user to adjust the frequency of the function generator with an external DC control Voltage. It also provides an easy way for your adjustment.

(1) Select Function ⑧ first, then select Range ⑦, rotate FREQ ⑬ to set required frequency range.

(2) Connect external control voltage (0 ~ 10V) to the VCF ㉑ connector via a suitable lead, and generate signal from Output ㉒.

(3) Other adjustments, such as AMPL ⑫ switch can change amplitude of signal, or get attenuation; adjust Offset ⑪ for DC level, rotate Duty ⑨ switch can change output signal of pulse or ramp waveform etc.

5-7.Auto Sweep

(1) First select the required waveform by pressing Function ⑧ button, then select required frequency range by pressing range ⑦ push button.

(2) Connect output terminal ㉒ to oscilloscope for observing output signal.

(3) Rotate frequency ⑬ to determine the upper limit frequency.

(4) Pull out frequency ⑬ to perform auto-sweep operation.

(5) Rotate SWEEP/TIME ⑭ and SWEEP/RATE ⑯ to adjust sweep time and rate.

(6) Pull out (press) LIN/LOG ⑭ to obtain LOG (LIN) sweep mode.

Note: The sweep width can only be adjusted during the sweep cycle and it can not be stopped.

5-8.AM/FM operation

(1) Select function ⑧ first; then select Range ⑦, rotate FREQ ⑬ to set required frequency range.

(2) Connect output terminal ㉒ to oscilloscope for observing output signal.

(3) Press MOD ⑮ and pull out (press) MOD ⑯ to obtain FM/AM modulation mode.

(4) Adjust MOD ⑯ to achieve required modulation ratio.

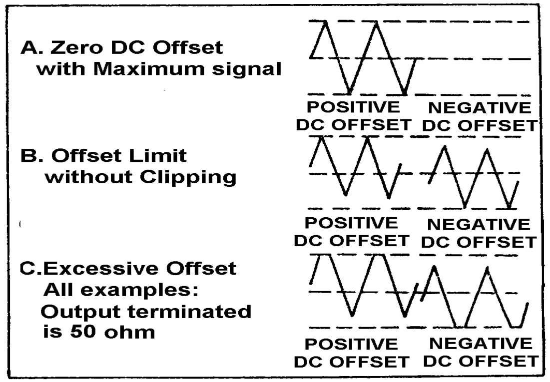
5-9. Precaution item

(1) Adjust DC OFFSET, will provide to change voltage of ±10V (no load) or ±5V (50Ω load). However, signal added DC level, is still limited to ±20V (no load) or ± 10V (50Ω load). In case of over-voltage, clip will appear as shown in Figure 2:

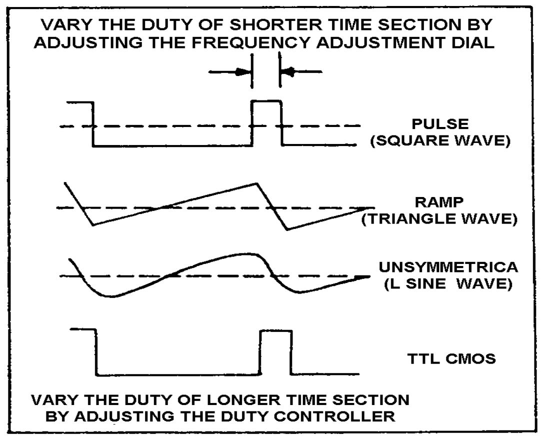
(2) Output connector label 50Ω, indicated that signal source impedance is 50Ω. Connect to any of impedance circuit, but output voltage and terminal impedance will be rated. To avoid oscillation, terminal shall be connected to 50Ω (When using high frequency and square output), and its connecting line shall be as short as possible.

(3) When adjust Duty knob to leftward position, the ratio of positive state to negative state, expand to not less than 80:20. It can expand Square wave to Pulse wave, expand Triangle wave to Ramp wave and Sine wave to unsymmetrical Sine wave. As shown in Figure 3 is for adjustment of Duty control to obtain required waveform.

- **Figure 2.**



- **Figure 3.**



6. APPLICATION NOTE

This section describes the application of the Function Generators in details as well as a brief description relating to the block diagram. Only for the essential application method.

(A) Trouble-shooting using signal-tracing method.

This method is similar to signal replacing way. The signal of model will be fixedly sent to input terminal. Observing its signal wave on the oscilloscope from front stage to rear stage orderly until appear a signal with normal input but with abnormal output.

(B) Use as bias source and signal source circuit.

Utilize the Figure 4 of connecting type, which can provide bias of a transistor and signal input. The output waveform can be observed from oscilloscope. Adjust to the best condition with output max. amplitude and no distortion. Adjust DC OFFSET to see the different effect of different bias condition.

(C) Amplifier over-load characteristics

The Sine wave input will be different from output the overload point. Using Triangle wave will easily observe the display of oscilloscope. It can decide the linear range of output waveform. And the largest no-distortion output amplitude.

(D) Using the Square wave test the characteristics of amplifier circuit.

It can't actually explain the transient response of amplifier by using Sine wave for the frequency response curve observation, but using the high order poly-wave, Square wave, instead to display its waveform from the oscilloscope can show up many characteristics of amplifier.

(a) Using the circuit of figure 5, the 50 Ω connector trim the oscillation effect of Square wave.
(b) Use the output of Triangle wave, adjust the amplitude until there are no clipping happened in the applied frequency.
(c) Select Square wave, adjust frequency, choose to watch the wave-form of middle of amplifier pass band, like 20Hz, 1kHz, 10kHz and etc.
(d) The output waveform of (c), must get something with frequency Figure 6 shows some possible conditions.

CAUTION: The composed poly-wave frequency of Square wave is quite large, so it's not suitable for the narrow band amplifier testing.

(E) Test of logic circuit

This equipment is suitable for logic circuit testing. Using Square or Pulse wave can analyze or watch the frequency waveform of a designed testing circuit. Also the DC Offset effect, drive the plug-in model board or logic circuit trouble-shooting and etc. Used as signal tracing and signal replacing operation:

(a) Connect the lines as Figure 7.
(b) According to the operation guide in this manual, set Square wave or Pulse wave output.
(c) Use the label TTL, CMOS output terminal testing TTL logic circuit.
(d) To test CMOS circuit by pulling up the switch of TTL/CMOS, and adjust CMOS level by rotating the switch to set the proper level
(e) Use dual-trace scope to show the input-output timing relation judged by the two waves shown in Figure 4.

(F)Testing of speaking and impedance network

This equipment can be used to test the frequency characteristics of speaker or any impedance network. It also can get the resonant frequency of network.

(a) Connect the device under test as in Figure 8, can use oscilloscope in stead of voltmeter.
(b) When use voltmeter, adjust the frequency of instrument record down voltage relative to frequency.
(c) When testing speaker, if there is a peak volt value, when in low freq., this must be the resonant freq. of this speaker, see Figure 10. Whether installation may cause any effect to this frequency or not? The proper design of case-installation will cause two small ramps on both sides of this sharp ramp.
(d) In testing other impedance network, the resonant may not occur in low frequency. But in approaching the resonant frequency, there are still increasing in voltage, then the impedance can be tested as following:

FUNCTION GENERATOR-SERIES
INSTRUCTION MANUAL

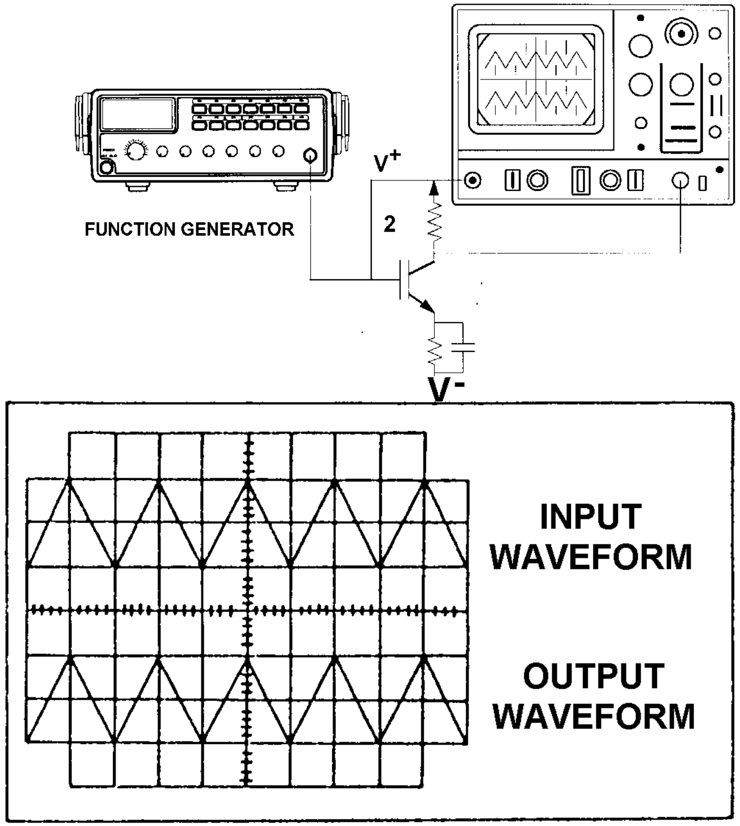
(1) Series connect a R1 to the network under test as in Figure 9.
(2) Get voltage read out in E1, E2, adjust R1 until E2 is equal to one half of E1.
(3) Under this frequency, the impedance network is the same as the R1.

(G)Act as automatic test of speaker

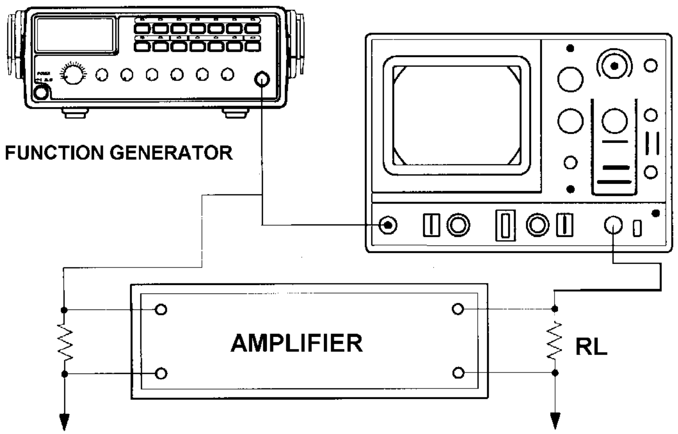
Because there provide the auto feature in this equipment, the output can drive to amplifier for testing the frequency response of speaker.

(a) Set Auto/Manual to Auto position.
(b) Set function to Sine wave
(c) Set Range to 20kHz
(d) Sweep mode (LIN, LOG), sweep width, sweep time can be set in any value.
(e) The line connected is showed in Figure 11.

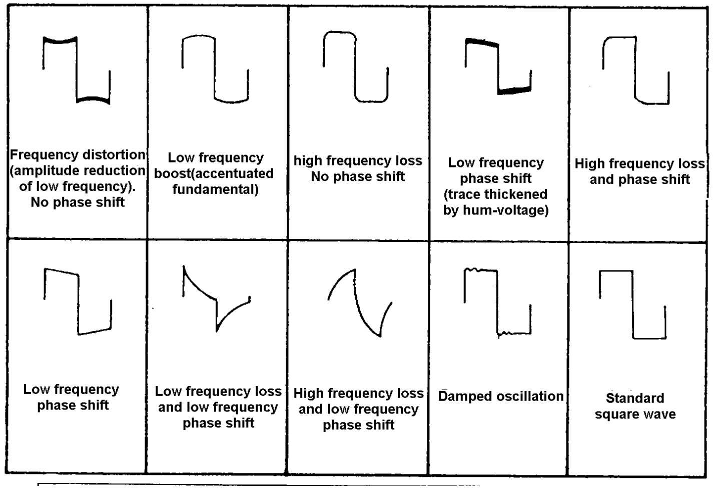
- **FIGURE 4**



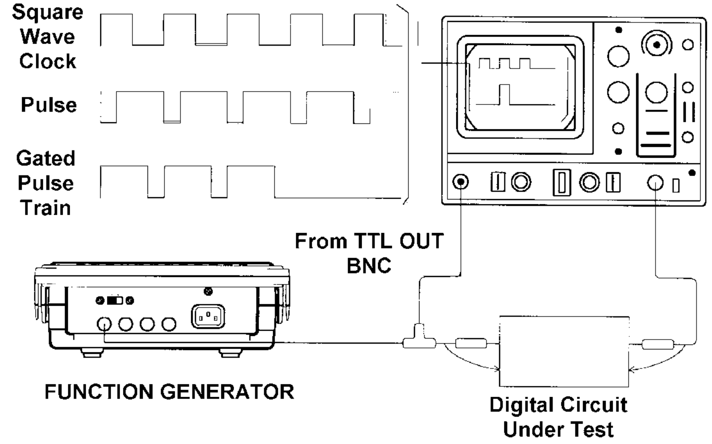
- **FIGURE 5**



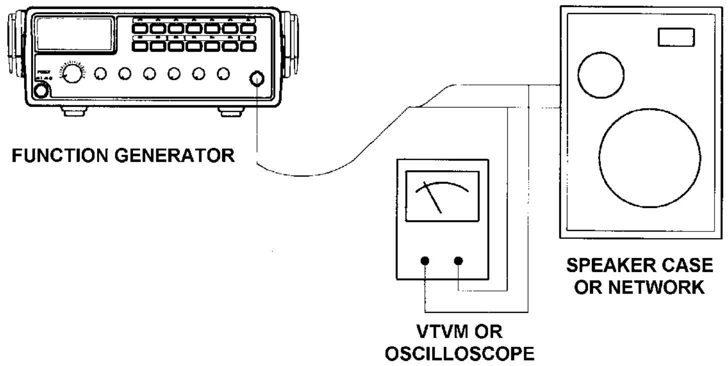
- **FIGURE 6**



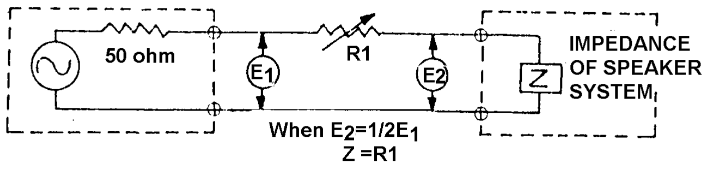
- **FIGURE 7**



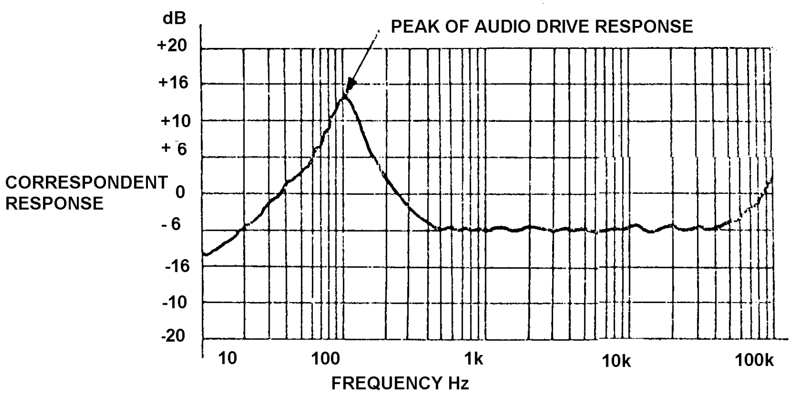
- **FIGURE 8**



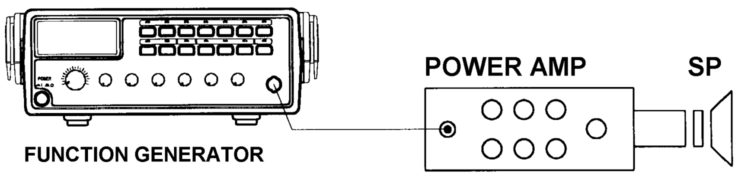
- **FIGURE 9**



- **FIGURE 10**



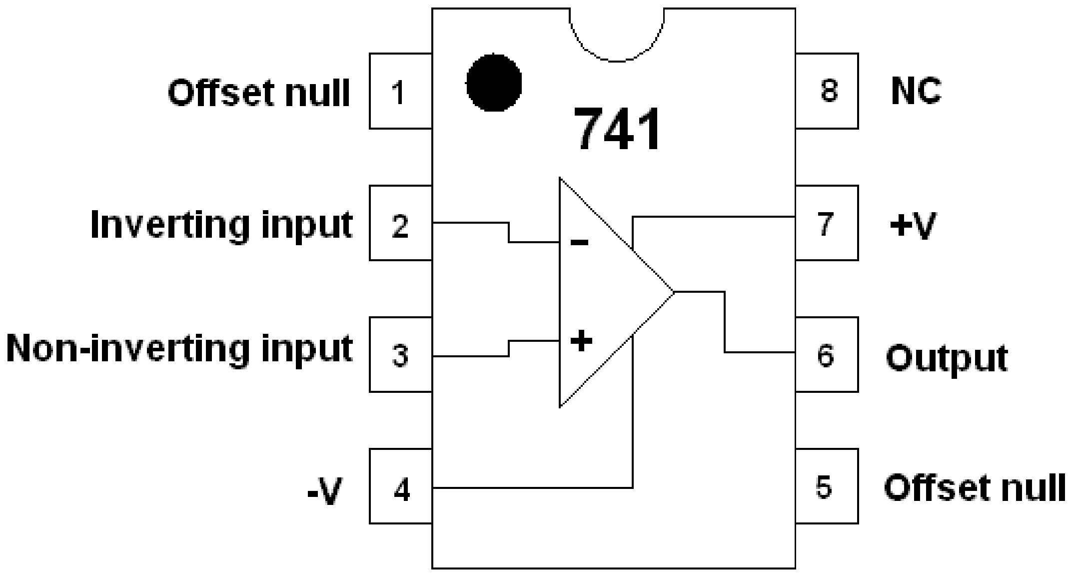
- **FIGURE 11**



ΠΑΡΑΡΤΗΜΑ IV
Ο τελεστικός ενισχυτής LM741.

Ο τελεστικός ενισχυτής που θα χρησιμοποιηθεί στις ασκήσεις του εργαστηρίου είναι ο LM741.
Στο σχήμα που ακολουθεί δίνεται η αντιστοιχία των ακροδεκτών του ενισχυτή με τα «ποδαράκια» του ολοκληρωμένου κυκλώματος.

Στη συνέχεια παρατίθεται το φύλλο με τα τεχνικά χαρακτηριστικά του συγκεκριμένου ΤΕ.



LM741 Operational Amplifier

Check for Samples: LM741

FEATURES

- **Overload Protection on the Input and Output**
- **No Latch-Up When the Common Mode Range is Exceeded**

DESCRIPTION

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications.

The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

The LM741C is identical to the LM741/LM741A except that the LM741C has their performance ensured over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

Connection Diagrams

LM741H is available per JM38510/10101

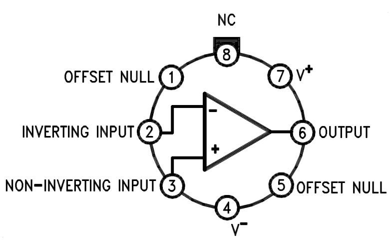


Figure 1. TO-99 Package
See Package Number LMC0008C

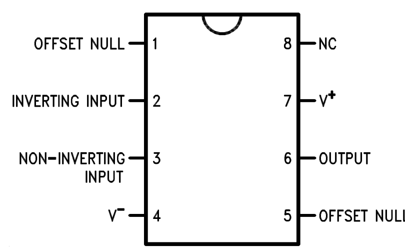


Figure 2. CDIP or PDIP Package
See Package Number NAB0008A, P0008E

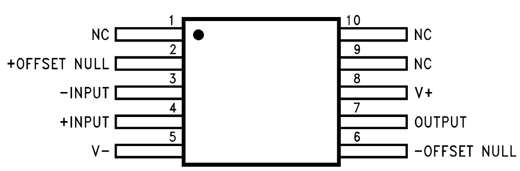


Figure 3. CLGA Package
See Package Number NAD0010A

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

Typical Application

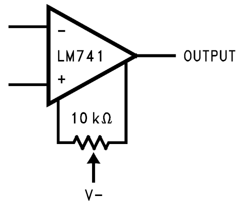


Figure 4. Offset Nulling Circuit

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings(1)(2)(3)

	LM741A	LM741	LM741C
Supply Voltage	±22V	±22V	±18V
Power Dissipation (4)	500 mW	500 mW	500 mW
Differential Input Voltage	±30V	±30V	±30V
Input Voltage (5)	±15V	±15V	±15V
Output Short Circuit Duration	Continuous	Continuous	Continuous
Operating Temperature Range	−55°C to +125°C	−55°C to +125°C	0°C to +70°C
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C	−65°C to +150°C
Junction Temperature	150°C	150°C	100°C
Soldering Information			
P0008E-Package (10 seconds)	260°C	260°C	260°C
NAB0008A- or LMC0008C-Package (10 seconds)	300°C	300°C	300°C
M-Package			
Vapor Phase (60 seconds)	215°C	215°C	215°C
Infrared (15 seconds)	215°C	215°C	215°C
ESD Tolerance (6)	400V	400V	400V

(1) "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits.
(2) For military specifications see RETS741X for LM741 and RETS741AX for LM741A.
(3) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(4) For operation at elevated temperatures, these devices must be derated based on thermal resistance, and T_j max. (listed under "Absolute Maximum Ratings"). $T_j = T_A + (\theta_{jA} P_D)$.
(5) For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
(6) Human body model, 1.5 kΩ in series with 100 pF.

Electrical Characteristics(1)

Parameter	Test Conditions	LM741A			LM741			LM741C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$T_A = 25°C$										
	$R_S \le 10\ k\Omega$					1.0	5.0		2.0	6.0	mV
	$R_S \le 50\Omega$		0.8	3.0							
	$T_{AMIN} \le T_A \le T_{AMAX}$										
	$R_S \le 50\Omega$			4.0							mV
	$R_S \le 10\ k\Omega$						6.0			7.5	
Average Input Offset Voltage Drift				15							μV/°C

(1) Unless otherwise specified, these specifications apply for V_S = ±15V, −55°C ≤ T_A ≤ +125°C (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to 0°C ≤ T_A ≤ +70°C.

Electrical Characteristics[1] (continued)

Parameter	Test Conditions	LM741A			LM741			LM741C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage Adjustment Range	T_A = 25°C, V_S = ±20V	±10				±15			±15		mV
Input Offset Current	T_A = 25°C		3.0	30		20	200		20	200	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$			70		85	500			300	
Average Input Offset Current Drift				0.5							nA/°C
Input Bias Current	T_A = 25°C		30	80		80	500		80	500	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$			0.210			1.5			0.8	μA
Input Resistance	T_A = 25°C, V_S = ±20V	1.0	6.0		0.3	2.0		0.3	2.0		MΩ
	$T_{AMIN} \le T_A \le T_{AMAX}$, V_S = ±20V	0.5									
Input Voltage Range	T_A = 25°C							±12	±13		V
	$T_{AMIN} \le T_A \le T_{AMAX}$				±12	±13					
Large Signal Voltage Gain	T_A = 25°C, R_L ≥ 2 kΩ										V/mV
	V_S = ±20V, V_O = ±15V	50									
	V_S = ±15V, V_O = ±10V				50	200		20	200		
	$T_{AMIN} \le T_A \le T_{AMAX}$, R_L ≥ 2 kΩ,										V/mV
	V_S = ±20V, V_O = ±15V	32									
	V_S = ±15V, V_O = ±10V				25			15			
	V_S = ±5V, V_O = ±2V	10									
Output Voltage Swing	V_S = ±20V										V
	R_L ≥ 10 kΩ	±16									
	R_L ≥ 2 kΩ	±15									
	V_S = ±15V										V
	R_L ≥ 10 kΩ				±12	±14		±12	±14		
	R_L ≥ 2 kΩ				±10	±13		±10	±13		
Output Short Circuit Current	T_A = 25°C	10	25	35		25			25		mA
	$T_{AMIN} \le T_A \le T_{AMAX}$	10		40							
Common-Mode Rejection Ratio	$T_{AMIN} \le T_A \le T_{AMAX}$										dB
	R_S ≤ 10 kΩ, V_{CM} = ±12V				70	90		70	90		
	R_S ≤ 50Ω, V_{CM} = ±12V	80	95								
Supply Voltage Rejection Ratio	$T_{AMIN} \le T_A \le T_{AMAX}$,										dB
	V_S = ±20V to V_S = ±5V										
	R_S ≤ 50Ω	86	96								
	R_S ≤ 10 kΩ				77	96		77	96		
Transient Response	T_A = 25°C, Unity Gain										
Rise Time			0.25	0.8		0.3			0.3		μs
Overshoot			6.0	20		5			5		%
Bandwidth [2]	T_A = 25°C	0.437	1.5								MHz
Slew Rate	T_A = 25°C, Unity Gain	0.3	0.7			0.5			0.5		V/μs
Supply Current	T_A = 25°C					1.7	2.8		1.7	2.8	mA
Power Consumption	T_A = 25°C										mW
	V_S = ±20V		80	150							
	V_S = ±15V					50	85		50	85	

(2) Calculated value from: BW (MHz) = 0.35/Rise Time (μs).

Electrical Characteristics[1] (continued)

Parameter	Test Conditions	LM741A			LM741			LM741C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
LM741A	V_S = ±20V										
	$T_A = T_{AMIN}$			165							mW
	$T_A = T_{AMAX}$			135							
LM741	V_S = ±15V										
	$T_A = T_{AMIN}$					60	100				mW
	$T_A = T_{AMAX}$					45	75				

Thermal Resistance	CDIP (NAB0008A)	PDIP (P0008E)	TO-99 (LMC0008C)	SO-8 (M)
θ_{jA} (Junction to Ambient)	100°C/W	100°C/W	170°C/W	195°C/W
θ_{jC} (Junction to Case)	N/A	N/A	25°C/W	N/A

SCHEMATIC DIAGRAM