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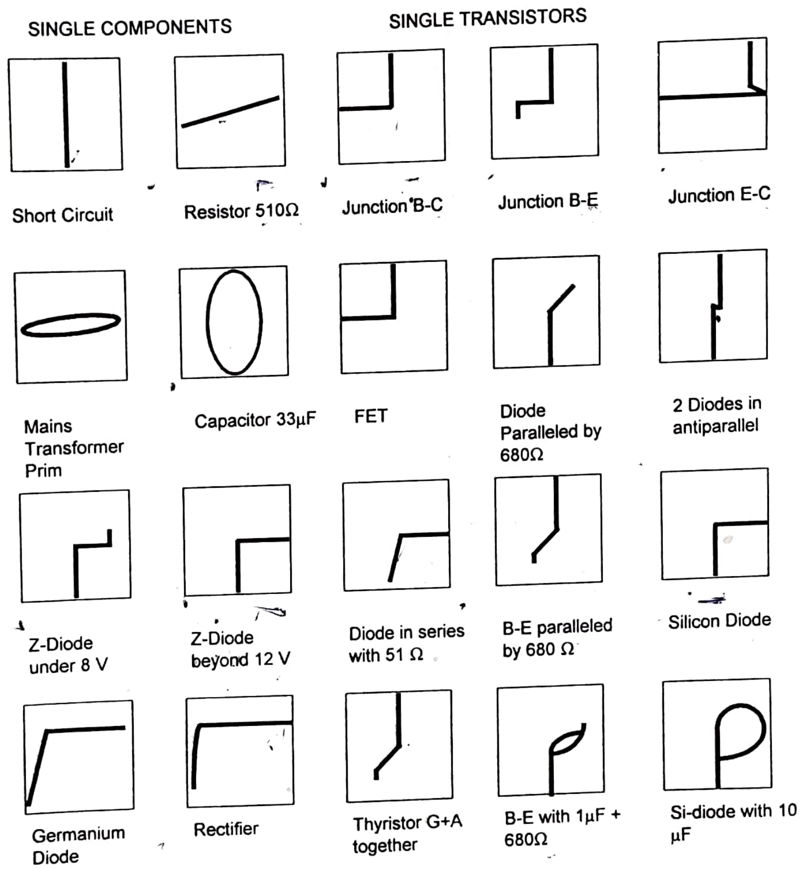
TECHNICAL SPECIFICATIONS

FEATURES	HM605	HM605-B
OPERATING MODES		
Mono:	CH.I, CH.II separate,	
Dual:	CH.I & CH.II alternate or chopped (Chop. freq. 0.5 MHz approx.)	
Sum and difference:	CH.II ± CH.I (with invert switch for CH.I)	
X-Y Mode:	Same sensitivity in both directions. (CH.I as Y & CH.II as X)	
VERTICAL DEFLECTION (Y)		
Both Channels:		
Bandwidth:	DC-60 MHz (-3dB)	
Rise Time:	5.8 ns (approx.)	
Deflection Coefficients:	12 Calibrated steps, 5mV/div. to 20V/div. in 1-2-5 sequence, with variable to 50V/div;	
	with ×5 to 1mV/div. (DC-20MHz)	with ×2.5 to 2mV/div. (DC-20MHz)
Accuracy:	±3% (in cal position)	
Input Impedance:	1M ohm ‖ 25 pF (approx)	
Input Coupling:	DC-AC-GND	
Input Volts (max):	500V (DC+peak AC)	
Y output:	From CH.II, 45mV/div. into 50Ω	
Overscan Indication:	With 2 LEDs	-
TIMEBASE (T)		
Time Coefficients:	23 calibrated steps from 50ns/div. to 1s/div. in 1-2-5 sequence with variable to 2.5s/div., with X magnification x10 to 5ns/div.	
Accuracy:	±3% (in cal position)	
Hold-Off Time:	Variable control 1:10 (approx.)	
Sweep Output:	$5V_{pp}$ approx. (rear side)	
Single Sweep:	Single Reset switch with LED indication	
Sweep Delay:	7 decade steps, 0.1µs to 100ms with variable 10:1 to 1s	-
Modes:	Normal, Search, Delay with LED indication.	-
TRIGGER SYSTEM		
Triggering Modes:	Auto or Normal, LED indication for trigger action	
Source:	CH.I, CH.II, ALT, line, Ext.	
Coupling:	AC-DC-HF-LF	
Slope:	Positive or Negative	
Trigger Bandwidth:	DC-100MHz	
Sensitivity:	Internal 0.5div, Ext.0.1 V	

IN - CIRCUIT TESTS

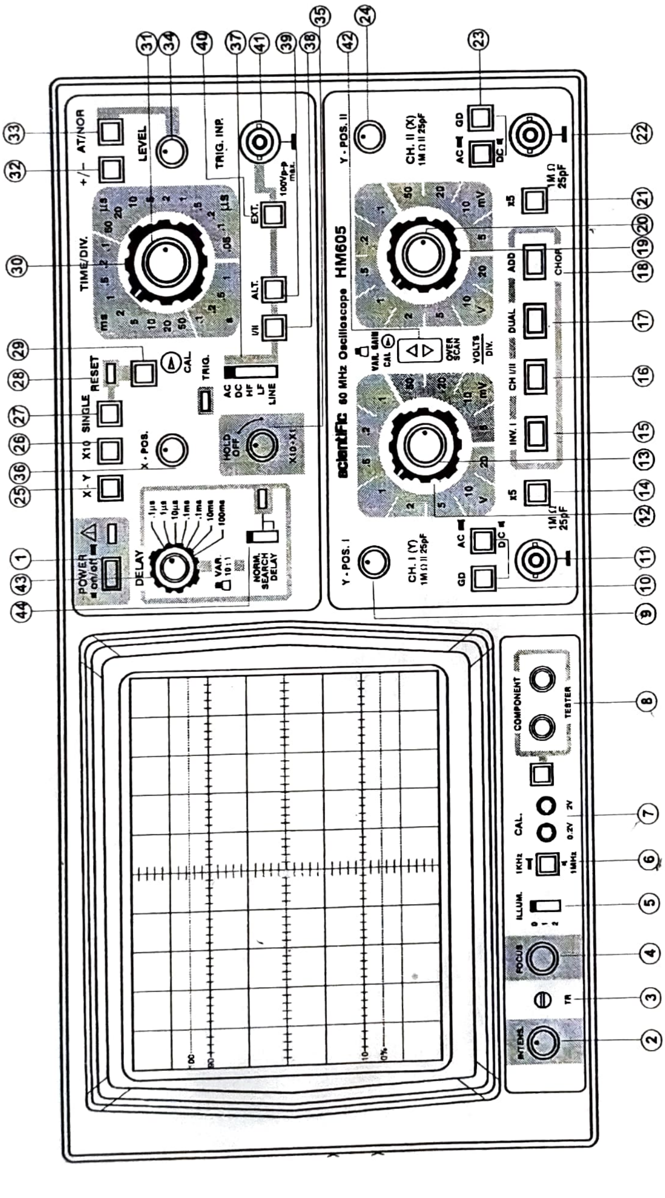
***CAUTIONS* :** *During in - circuit tests make sure that the circuit is dead. No power from mains / line or battery and no signal inputs are permitted. Remove all ground connections inclusive safety earth pull out power plug from outlet.) Remove all measuring cables inclusive probes between oscilloscope and circuit under test.*



FEATURES	HM605	HM605-B
HORIZONTAL DEFLECTION (X)		
Deflection Coefficients:	same as CH.II	
Bandwidth:	DC - 5.0 MHz (-3dB)	
Input:	Via channel II (See Y specification)	
Input Impedance:	1M ohm ‖ 25 pF (approx)	
X-Y Phase Shift:	< 3° upto 100 KHz	
COMPONENT TESTER		
Test Voltage:	approx 8.6 V_{rms} (open circuit)	
Test Current:	approx 8 mA_{rms} (short circuit)	
Test Frequency:	50 Hz (line frequency)	
Test Connections:	2 banana jacks 4 mm dia. One test lead grounded to chassis	
GENERAL INFORMATION		
Cathode Ray Tube:	140mm Rectangular flat face, quick heating, 10 x 8 div. CRT with internal graticule marking and Mu metal shielding and mesh PDA.	
Accelerating Voltage:	14 kV (Approx.)	
Trace Rotation:	Adjustable on front panel	
Z-Modulation:	Positive TTL level (rear side)	
Calibrator:	Square wave 0.2V & 2V ±1%,	
	1 KHz / 1MHz (approx.). for probe compensation	1 KHz (approx.). for probe compensation
Stabilized Power Supply:	All voltages including EHT	
Mains voltages:	220-240V, 50 Hz (switch at rear side)	
Mains Fluctuation:	± 10% (max.)	
Power Consumption:	43 VA (approx.)	
Weight:	8.7 Kg. (approx.)	
Dimensions:	(mm) W:285, H:145, D:380	
Finish:	Cover with Handle cum tilting stand.	
Accessories supplied:	Manual, Test Prods, BNC-BNC cable, BNC- Crocodile Cable.	
Optional Accessories:	Switchable Probes	

(Subject to Change)

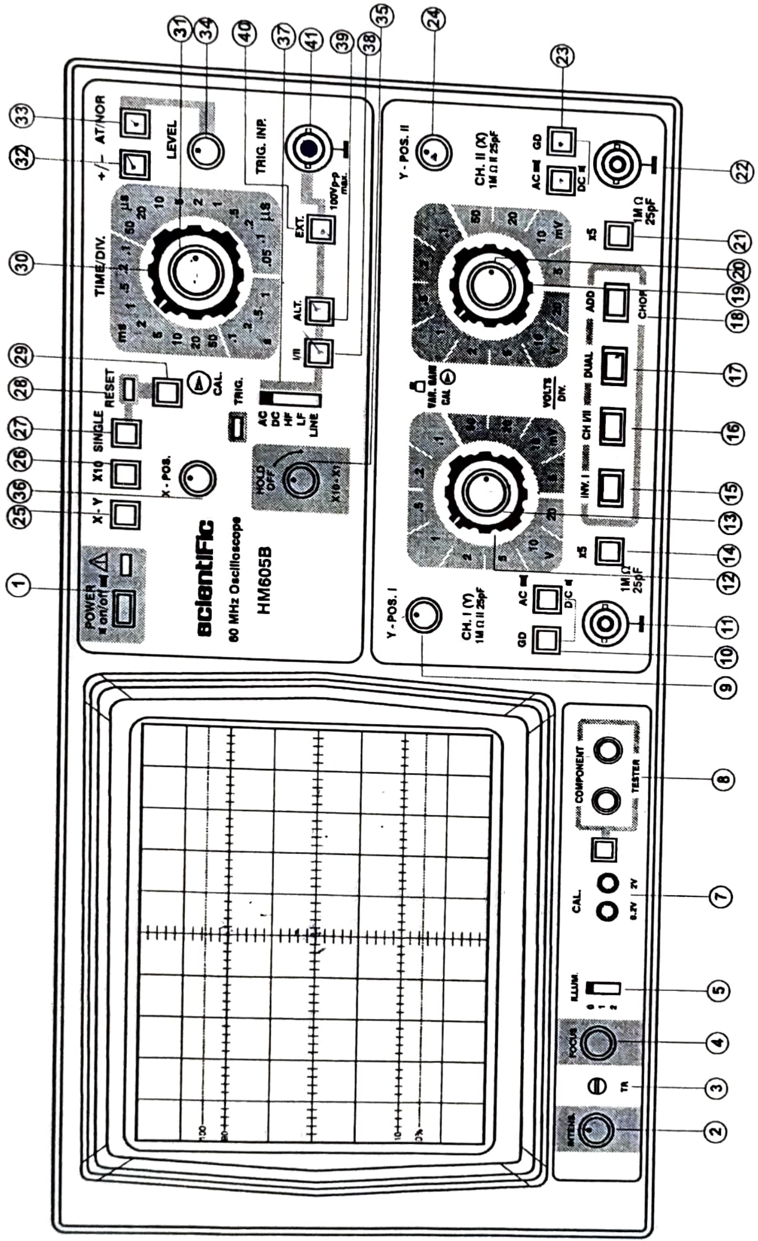
HM605


TIME/DIV.
LEVEL
TRIG. INP.
AT/NOR
RESET
SINGLE
X10
X-Y
X-POS.
DELAY
POWER
HOLD OFF
TRIG.
EXT.
ALT.
Y-POS. II
Y-POS. I
CH. II (X)
CH. I (Y)
60 MHz Oscilloscope HM605
VOLTS DIV.
OVER SCAN
ADD
DUAL
CH I/II
INV. I
CHOP
COMPONENT
TESTER
CAL.
ILLUM.
FOCUS
INTENS.

PRIYESH YADAV
B.Tech(M.E)
1st Year.

Front Panel Diagram

HM605-B



FRONT PANEL CONTROLS

1.	**POWER** (PB switch+LED)	Pushbutton switch for supplying power to Oscilloscope (make sure that you connect 220V, 50Hz supply). LED indicates that power is " **ON** ".
2.	**INTENS** (Knob)	Intensity control to adjust brightness of CRT display.
3.	**TR**	Trace Rotation Pot. Screw driver adjustment for alignment of trace with graticule. Compensates influence of earth's magnetic field.
4.	**FOCUS** (Knob)	Focus control to adjust sharpness of CRT display.
5.	**ILLUM** (Slide switch)	Switch controls the light illumination on the graticule. Switch position 0 : Off Switch position 1 : dim Switch position 2 : bright
6.	**CAL 1kHz/1MHz** (PB switch)	In HM605 switch selects calibrator square wave signal frequency.
7.	**CAL 0.2V/2V** (2mm socket)	Calibrator output sockets provided for probe compensation. Signal available at the socket is flat top square wave. Amplitude : 0.2Vpp and 2Vpp, 0.2Vpp used for 10:1 probes compensation. 2Vpp used for 100:1 probes compensation.
8.	**CT** (PB switch + 4mm sockets)	Switch when pressed converts the instrument from oscilloscope into a useful component Tester mode. One test lead is connected to CT and the second test lead is connected to chassis ground socket.
9.	**Y-POS. I** (Knob)	Controls vertical position of CH.I trace.
10.	**AC / DC / GND** (PB Switches)	Input coupling switches for CH.I. AC : Both switches in out position. Signal is capacitively coupled, through 0.1µF capacitor, DC is blocked. DC : AC/DC switch pressed, GD switch in out position. All components (AC & DC) of the signal are passed. GD : GD switch pressed. AC/DC switch may be at any position. Signal is disconnected, I/P of vertical amplifier is grounded.

11. **CH.I (Y)** (BNC Connector)	Signal input for CH.I, Input impedance 1MΩ || 25pF.
12. **V / DIV.** (Rotary switch)	CH.I input attenuator. Selects the Y amplifier gain and input sensitivity in mV/div. and V/div. in 1-2-5 sequence.
13. **VAR-GAIN** (Center knob)	Continuously variable gain between the calibrated positions of the VOLTS/DIV. switch, by a ratio 2.5:1, for CH.I. Cal. Position – fully clockwise.
14. **× 5 (MAG)** (PB switch)	In HM605, increases Y sensitivity by a factor of 5 for CH.I. When switch pressed on 5mv position, this improves CH.I sensitivity to 1mV.
×2.5 (MAG) (PB switch)	In HM605-B, increases Y sensitivity by a factor of 2.5 for CH.I. When switch pressed on 5mV position, this improves CH.I sensitivity to 2mV.
15. **INVERT I** (PB switch)	Switch when pressed inverts the polarity of signal in CH.I. In combination with ADD switch it can be used for difference of channels (CH.II – CH.I).
16. **CH I / II** (PB switch)	In MONO mode, switch in out position selects CH.I only, Switch when pressed selects CH.II only.
17. **DUAL** (PB switch)	Only DUAL switch pressed gives dual trace operation in alternate mode. DUAL switch pressed along with ADD/CHOP switch gives dual trace operation in CHOP mode.
18. **ADD / CHOP** (PB switch)	When DUAL switch is in out position, pressing of only ADD/CHOP switch selects ADDITION mode i.e. addition of CH.I & CH.II. Along with INV.I switch it gives difference of CH.I & CH.II (i.e. CH.II – CH.I).
19. **V / DIV.** (Rotary switch)	CH.II input attenuator. Selects the Y amplifier gain and input sensitivity in mV/div. and V/div. in 1-2-5 sequence.
20. **VAR-GAIN** (Center knob)	Continuously variable gain between the calibrated positions of the VOLTS/DIV. switch, by a ratio 2.5:1, for CH.II. Cal. Position – fully clockwise.
21. **× 5 (MAG)** (PB switch)	In HM605, increases Y sensitivity by a factor of 5 for CH.II. When switch pressed on 5mv position, this improves CH.II sensitivity to 1mV.
×2.5 (MAG) (PB switch)	In HM605-B, increases Y sensitivity by a factor of 2.5 for CH.II. When switch pressed on 5mV position, this improves CH.II sensitivity to 2mV.

22. CH.II (X) (BNC Connector)	Signal input for CH.II, Input impedance 1 MΩ || 25pF. In X-Y mode, acts as X signal input (for X deflection of CRT).
23. AC / DC / GND (PB Switches)	Input coupling switches for CH.II. AC : Both switches in out position. Signal is capacitively coupled, through 0.1μF capacitor, DC is blocked. DC : AC/DC switch pressed, GD switch in out position. All components (AC & DC) of the signal are passed. GD : GD switch pressed. AC/DC switch may be at any position. Signal is disconnected, I/P of vertical amplifier is grounded.
24. Y-POS. II (Knob)	Controls vertical position of CH.II trace.
25. X-Y (PB switch)	Switch when pressed cuts off internal timebase and converts the scope into X-Y mode of operation. (X signal via CH.II).
26. ×10 MAG (PB switch)	When pressed magnifies signal 10 times in X-direction.
27. SINGLE (PB switch)	Switch when pressed puts timebase into **SINGLE** shot operation.
28. RESET (LED)	The LED glow indicates that instrument is ready to capture next single shot event.
29. RESET (PB switch)	Switch when pressed resets the timebase for another single shot operation.
30. TIME BASE (Rotary sw)	Rotary switch selects timebase speeds, from 50ns/div. to 1s/div.
31. Variable (Center knob)	The center variable controls the speeds between steps in the ratio 2.5:1. The calibration holds good when variable is at ‘ CAL ’
32. SLOPE + / - (PB switch)	Switch selects the slope of trigger signal. + : rising edge, - : falling edge.
33. AT/NORM (PB switch)	Selects Auto or Normal (level) triggering. Switch in out position : Automatic Triggering. Switch pressed : Normal Triggering with Level control.
34. LEVEL (Knob)	Adjusts trigger point of the signal from +ve peak to –ve peak, if AT/NORM switch **(33.)** is pressed.
35. HOLD - OFF (Knob)	Control provided for varying hold off time in the ratio 1:10

22. CH.II (X) (BNC Connector)	Signal input for CH.II, Input impedance 1 MΩ || 25pF. In X-Y mode, acts as X signal input (for X deflection of CRT).
23. AC / DC / GND (PB Switches)	Input coupling switches for CH.II. AC : Both switches in out position. Signal is capacitively coupled, through 0.1μF capacitor, DC is blocked. DC : AC/DC switch pressed, GD switch in out position. All components (AC & DC) of the signal are passed. GD : GD switch pressed. AC/DC switch may be at any position. Signal is disconnected, I/P of vertical amplifier is grounded.
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33. AT/NORM (PB switch)	Selects Auto or Normal (level) triggering. Switch in out position : Automatic Triggering. Switch pressed : Normal Triggering with Level control.
34. LEVEL (Knob)	Adjusts trigger point of the signal from +ve peak to –ve peak, if AT/NORM switch **(33.)** is pressed.
35. HOLD - OFF (Knob)	Control provided for varying hold off time in the ratio 1:10

36. X-POS (Knob)	Controls horizontal position of trace.
37. TRIG. AC/DC/HF/LF/LINE (Lever switch + LED)	Selects internal trigger coupling mode to AC, DC, HF, LF, or LINE. LED glows if sweep is triggered.
38. I / II (PB switch)	Switch in out position selects the triggering of CH.I switch when pressed selects the triggering of CH.II.
39. ALT (PB switch)	Switch when pressed two signals of different frequencies and shapes are triggered simultaneously.
40. EXT (PB switch)	Switch when pressed selects External triggering. (Trigger signal via TRIG. INP **41.**) Switch when in out position, selects internal triggering.
41. TRIG. INP (BNC connector)	Input for external trigger signal.
42. OVERSCAN (LEDs)	In HM605, LED indicates when trace is out of screen on either side, top or bottom.
43. DELAY (Center knob)	In HM605, Continuous variable pot for adjustment of sweep delay time.
44. NORM/SEARCH/ (3 position slide sw + LED)	In HM605, Switch selects Delay mode of **DELAY** operation. NORM: Oscilloscope works in normal mode (LED OFF). SEARCH: Selects Delay position of signal (LED flashes). DELAY: Displays delayed signal (LED glows continuously).

OPERATING INSTRUCTIONS

1. GENERAL INFORMATION

The **HM605/HM605-B** is as easy to use as all other **SCIENTIFIC** oscilloscopes. It is also easy to operate. The logical arrangement of the controls allows anyone familiar with the operation of the instrument after a short time. However, experienced users are also advised to read through these instructions so that all functions are understood. Immediately after unpacking, the instrument should be checked for mechanical damage and loose parts in the interior. If there is transport damage, must be informed immediately. The instrument must then not be put into operation.

Check that the instrument is set to the correct mains/line voltage.

2. USE OF TILT HANDLE

To view the screen from the best angle, there are three different positions for setting up the instrument. If the instrument is set down on the floor after being carried, the handle remains automatically in the upright carrying position (A).

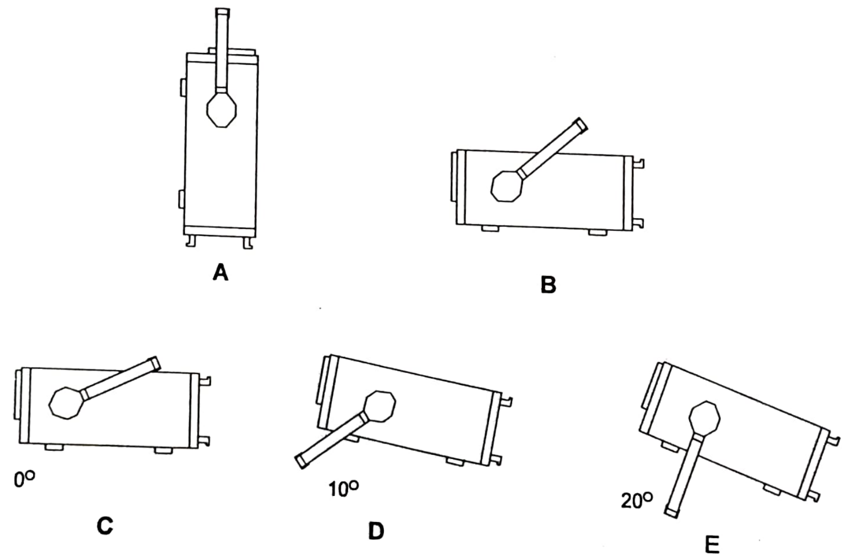


Fig. 1 Use of tilt handle

In order to place the instrument onto a horizontal surface, the handle should be turned to the upper side of the oscilloscope (C). For the D position 10° inclination, the handle should be turned in the opposite direction out of the carrying position until it locks in place automatically underneath the instrument. For the E position (20°) inclination, the handle should be pulled to release it from the D position and swing backwards until it locks once more.

The handle may also be set to position for horizontal carry by turning it to the upper side to lock in the B position. At the same time, the instrument must be moved upwards because otherwise the handle will jump back.

3. SAFETY

The case, chassis and all measuring terminals are connected to the protective earth contact of the inlet. The mains plug should only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord without a protective conductor.

Warning: *Any interruption of the protective conductor inside or outside the instrument or disconnection of the protective earth terminal is likely to make the instrument dangerous. Intentional interruption of the protective earth connection is prohibited. The mains/line plug should be inserted before connections are made to measuring circuits.*

Under certain conditions, 50 Hz hum voltage can occur in the measuring circuit due to the interconnection with other mains/line powered equipment or instruments. This can be avoided by using an isolation transformer between the mains/line outlet and the power plug of the instrument. When displaying waveforms where the "low level"side of the signal is at a high potential, even with the use of protective isolation transformer it should be noted that this potential is connected to the oscilloscope's case and other accessible metal parts. High voltages are dangerous. In this case, special safety precautions are to be taken.

Whenever it is likely that protection has been impaired, the instrument shall be made inoperative and be secured against any unintended operation. The protection is likely to be impaired if, for example, the instrument

- shows visible damage.
- fails to perform the intended measurements.
- has been subjected to prolonged storage under unfavorable conditions (e.g. in the open or in moist environments)
- has been subjected to severe transport stress (e.g. in poor packing).

4. OPERATING CONDITIONS

The instrument has been designed for indoor use. The permissible ambient temperature range during operation is 0°C ...+40°C. The permissible ambient temperature range of storage or transportation is - 40°C ...+ 70°C. The maximum operating altitude is up to 2200m (non-operating 15000m). The maximum relative humidity is upto 95%.

If condensed water exists in the instrument it should be acclimatized before switching ON. In some cases (e.g. extremely cold oscilloscope) two hours should be allowed before the instrument is put into operation. The instrument should be kept in a clean and dry room and must not be operated in explosive, corrosive, dusty, or moist environments. The oscilloscope can be operated in any position, but the convection cooling must not be impaired. **The ventilation holes should not be covered.** For continuous operation the instrument should be used in the horizontal position, preferably tilted upwards, resting on the tilt handle.

The specifications stating tolerances are only valid if the instrument has warmed up for 30 minutes at an ambient temperature between +15°C and +30°C. Values not stating tolerances are typical for an average instrument.

5. MAINTENANCE

Various important properties of the oscilloscope should be carefully checked at certain intervals. Only in this way it is largely certain that all signals are displayed with the accuracy on which the technical data are based. The exterior of the oscilloscope should be cleaned regularly with a dusting brush. Dirt, which is difficult to remove on the casing and handle, the plastic and aluminum parts, can be removed with a moistened cloth (99% water + 1% mild detergent). Spirit or washing benzene can be used to remove greasy dirt. The screen may be cleaned with water or washing benzene (but not with spirit (alcohol) or solvents). It must then be wiped with a dry clean lint-free cloth. Under no circumstances may the cleaning fluid get into the instrument. The use of other cleaning agents can attack the plastic and paint surfaces.

6. SWITCHING ON AND PRELIMINARY CHECKS.

Before connecting power to the oscilloscope, the following simple procedure should be performed.

- Check that instrument is set to correct mains/ line voltage.
- Check all pushbutton switches are in out position.
- Rotate all variable controls with dotted caps i.e. timebase variable control, hold-off, CH.I and CH.II variable controls, fully clockwise to their CAL position.
- Set all other controls with dots to their mid range position.
- AT/NORM control should be kept in AT position, i.e. switch in out position.
- Trigger coupling should be kept to AC position.
- Input coupling switches for CH.I and CH.II should be kept to GD position.

6.1 CONNECTION TO MAINS SUPPLY

This oscilloscope works on 220V or 240V, ±10%, 50 Hz, AC single-phase mains supply. At the time of delivery the instrument is set to 220V line voltage. It can be switched to 240V line by turning the toggle switch located at the rear side of the oscilloscope.

- Switch on the oscilloscope by pressing red **POWER** pushbutton.
- A yellow LED will glow to indicate that instrument is ON. The trace displaying one base line should be visible after a short warm up time of 10 seconds.
- Adjust INTENS (intensity) and FOCUS (sharpness) of the trace for optimum results.
- The oscilloscope is now ready for use. If only a spot appears (CAUTION - CRT phosphor can be damaged) reduce the intensity and check that X-Y pushbutton is in out position.

6.2 TRACE ROTATION

In spite of Mu-metal shielding of the CRT, effects of the earth's magnetic field on the horizontal trace position cannot be completely avoided. This is dependent upon the orientation of the oscilloscope on the place of work. A centered trace may not align exactly with the horizontal center line of the graticule. A few degrees of misalignment can be corrected by a potentiometer accessible through an opening on the front panel marked **TR.**

7. SIGNAL DISPLAYS

7.1 GENERAL

With HM605/HM605-B, practically all repeating signals with the frequency spectrum below 60MHz can be examined.
Operating problems may sometimes occur when composite signals are to be displayed, especially if they do not contain any level components and a repetition frequency, which is suitable for triggering. This occurs for example with bursts. To obtain a stable triggering display in these cases, use of NORM triggering, timebase variable control and/or HOLD OFF control is recommended.
Video signals are relatively easy to trigger. When investigating these signals at frame rate, the TRIG. coupling switch should be set to LF position (Low Pass Filter).
For optional operation as DC or AC voltage amplifier, each channel is provided with a DC-AC input coupling switch. The DC position should only be used with an attenuator probe, or at very low frequencies, or if the measurement of the DC Voltage content of the signal is absolutely necessary.
When investigating very low frequency pulses, the flat tops may be sloping with AC coupling. In this case DC operation is preferred, provided the signal is not superimposed on a too high DC voltage level. Other wise a capacitor of adequate value must be connected to the input of the vertical amplifier (with DC Coupling). This capacitor must have a sufficiently high breakdown rating. DC is also recommended for the display of logic and pulse signals, particularly if the pulse duty factor changes during operation. DC voltages can only be measured in the DC position of the input coupling switch.

When investigating low voltages, the location of the ground connection on the test circuit can be critical. This should be as close as possible to the measuring point. If this is not done serious signal distortions may result from spurious currents (HF or other) through the ground leads or chassis parts. This also applies to the ground leads of the attenuator probes, which ideally should be as short and thick as possible.

Hum or interference appearing on the measuring circuit (especially when a small deflection coefficient is used) could be caused by multiple grounding, as equalizing currents flow in the screening of the measuring cables.

CAUTION

When connecting unknown signals to the oscilloscope input, always set the DC-AC input coupling switch to AC and the VOLTS/DIV. switch to 20V/div. position.

7.2 CONNECTION OF TEST SIGNAL

The signal to be displayed should be connected to the vertical input of the oscilloscope by means of a shielded test cable. The use of these shielded cables is recommended for relatively low frequencies (upto approx. 50 KHz). For higher frequencies and when the signal source is of low impedance, a cable with characteristic impedance (usually 50 Ω) or probes is recommended. When investigating square or pulse waveforms, a resistor equal to the characteristic impedance of the cable must also be connected across the cable directly at the Y input of the oscilloscope. When using a 50 Ω cable, a 50 Ω through termination should be used.

If a ×10-attenuator probe is used, no termination is necessary. When using such probes even the high impedance sources are slightly loaded. If the voltage loss due to the attenuation of the probe can be compensated by higher amplitude setting on the **HM605/HM605-B**, the probe should always be used. **All attenuator probes must be compensated in conjunction with the oscilloscope's Y input.** Set the input coupling switch to DC. With AC Coupling, the attenuation is frequency dependent and the displayed pulses can show ramp-off. Furthermore, DC voltage contents are suppressed but charge the input coupling capacitor of the oscilloscope. This has a maximum rating of 500V only (DC+Peak AC). For suppressing DC Voltages, a capacitor of adequate value and voltage rating may be connected in series with the probe tip (e.g. for ripple measurement).

7.3 PROBE COMPENSATION AND USE

To display an undistorted waveform on an oscilloscope, the probe must be matched exactly to the input impedance of the Y amplifier. **HM605/HM605-B** generates a square wave signal for this purpose with very short rise time (5 ns) at 1 kHz frequency. The square wave signal can be taken from the two concentric sockets beneath the screen. One socket supplies 0.2 V_{pp} ±1% for ×10 attenuator probes, the other 2Vpp ± 1 % for ×100 attenuator probes. These voltages correspond in each case to a screen amplitude of 4 div., provided the input attenuator switch of the **HM605/HM605-B** is set to the deflection coefficient 5 mV/div.

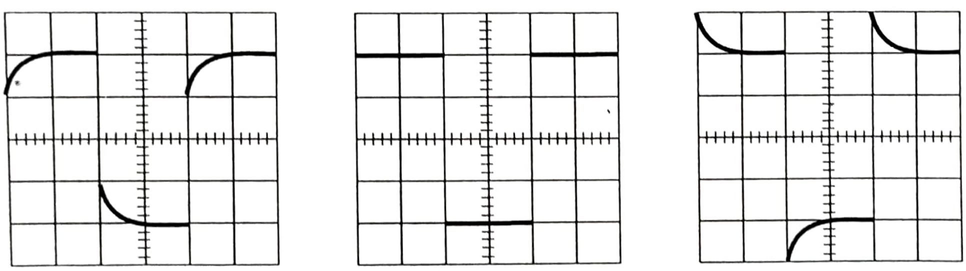


Fig. 2 1kHz compensation

The C-trimmer adjustment compensates the capacitive loading of the oscilloscope input (approx. 25 pF for the **HM605/HM605-B**). By this adjustment, the capacitive division assumes the same ratio as the ohmic voltage divider, to ensure the same division ratio for high and low frequencies. The same voltage attenuation is then ensured at high and low frequencies as for direct voltage (For 1:1 probes or switchable probes set to 1:1, this compensation is neither necessary nor possible). The trace line must be parallel with the horizontal graticule lines for accurate probe adjustment.
Connect the 10:1 or 100:1 probe to the input of the channel, for which it is to be adjusted and don't mix up the probes later (always use that particular probe with the same channel). Set input coupling to DC, input attenuator to 5 mV/div. and TIME/DIV. switch to 0.2 ms/div. (variable controls in calibration position CAL). Insert the probe tip (without spring hook) into the calibrator output socket (For ×10 probe in 0.2V socket, ×100 in 2V socket).

Two cycles are displayed on the screen. The compensation trimmer must now be adjusted. The location of the compensation trimmer can be found in the probe information sheet. Adjust the trimmer with the insulation screwdriver provided, until the tops of the square wave signal are exactly parallel to the horizontal graticule lines (see 1 KHz diagram). The signal height should then be 4 div. ± 0.16 div. (= 4%(oscilloscope 3% and probe 1%)). The signal edges are invisible during this adjustment.

8. VERTICAL AXIS.

8.1 MODES OF CHANNEL OPERATION

HM605/HM605-B can display signals via two channels in the following modes.

Single channel I	- All switches in out position.
Single channel II	- CH I/II switch pressed.
Dual channel I and II (Alt)	- Only DUAL switch pressed. Two traces of CH.I and CH.II are displayed alternately.
Dual channel I and II (Chop)	- DUAL & ADD switches pressed. Two traces of CH.I and CH.II are displayed simultaneously.
Algebraic sum CH I+CH II	- Only ADD switch pressed.
Algebraic diff. CH II-CH I	- CH I Invert switch is also pressed along with ADD switch.
X-Y	- All switches in out position, X-Y switch pressed, X-signal via CH.II.

8.2 OVERSCAN INDICATOR

In HM605, this indicating facility shows any overscanning of the usable screen dimensions in the vertical direction, if the base line or signal portions are not within the graticule. The indication is achieved by two LEDs, marked **OVERSCAN** that are located in the centre between the attenuators. If one of the LEDs illuminates without an input signal, this means that the Y position control of the respective channel is not adjusted properly. Since each LED correlates with one out of both possible directions, it can be seen, in which direction the trace has left the screen.

8.3 AMPLITUDE MEASUREMENTS

The scientific **HM605/HM605-B** is designed for accurate measurement of direct signals from 2mV to 500V. The value of the signal amplitude can be measured in div. (physical height). This reading relative factor is indicated by the **VOLTS/DIV.** switch setting. During calibrated measurements , the amplitude variable control has to be set at cal position. The attenuation factor of the probe has to be accounted for.

8.3.1 DC MEASUREMENTS

For DC measurements a single trace line is required. The timebase and trigger controls have no effect on the actual measurement. For DC measurements set the respective channel's input coupling switch to DC. Bring the trace to the reference line of the graticule. When DC voltage is applied, the trace will move up or down according to applied DC voltage, using ground as reference. The trace displacement can be measured in div.

8.3.2 HIGH VOLTAGE MEASUREMENTS

For DC measurements upto 160 Vpp the selector switch must be set to DC. AC measurements can be made with the selector switch set to AC. The total value (DC + Peak AC) of the signal must not exceed ±500V. With X10 attenuator probe voltages upto 600 V can be evaluated.

REFERENCE LINE

With **Y-POS.** control (input coupling to **GD**) it is possible to see a horizontal graticule line as **reference line for ground potential** before the measurement. It can lie below or above the horizontal central line according to whether positive and/or negative deviations from the ground potential are to be measured. Certain switchable ×10/×1 attenuator probes also have a built- in ground reference switch position.

8.3.3 DIFFERENTIAL MEASUREMENTS

Note For this two identical probes are required.

Caution: Remove ground clips from both probes.

Measurements can be made in the following way

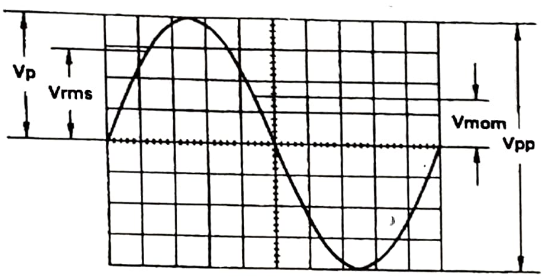
- Connect probes to CH.I and CH.II inputs.
- Press INVERT I and ADD pushbutton switches.
- Ensure CH.I/II and DUAL pushbuttons are released.
- Set attenuator switches of CH.I and CH.II to 20V/div. and input selector switches to AC.
- Connect both probes across the circuit component where the signal is to be measured.
- Adjust oscilloscope controls for optimal display, ensuring that both amplitude switches are set to equal ranges.
- For DC differential measurements both channel input selector switches should be set to DC.
- If trace moves up CH.II input is positive.
- If trace moves down CH.I input is negative.

8.3.3 AC MEASUREMENTS

In general, AC voltage values normally refer to the rms value. However, the oscilloscope gives peak-to peak voltages. If a sinusoidal waveform, displayed on the oscilloscope screen, is to be converted into an effective (rms) value, the resulting peak-to-peak value must be divided by $2\times\sqrt{2} = 2.83$. For converting this value to rms value the following formula is to be used.

$$\boxed{V_{rms} = V_{pp} / 2\sqrt{2}}$$

The relationships between the different voltage values are shown in fig 3.



V_{rms} = effective value;
V_p = simple peak or crest value;
V_{pp} = peak-to-peak value;
V_{mom} = momentary value.

Fig. 3 Voltage value of a sine curve

For exact amplitude measurements, the Variable control on the attenuator switch must be set to its calibrated position CAL. When turning the variable control anticlockwise, the sensitivity will be decreased by a factor of 2.5(approx.). **Therefore every intermediate value is possible within the 1-2-5 sequence.**

The minimum signal voltage, which must be applied at the Y input for a display of 1 div., is approximately **2mVpp**. This is achieved with the attenuator control set at 5mV/div., its variable control in the CAL. position and 2mV switch pressed. With attenuator control set at 20V/div., 2mV switch in out position and its variable control turned fully anticlockwise, sensitivity becomes 50V. The **deflection coefficients** on the input attenuators are indicated in **mV/div.** or **V/div.** (Peak-to-Peak value).

The magnitude of the applied voltage is ascertained by multiplying the selected deflection coefficient by the vertical display height in div. If **an attenuator probe × 10** is used, a further multiplication by a factor of 10 is required to ascertain the correct voltage Value.

With direct connection to the Vertical input, **signals up to 160 V_{pp}** may be displayed (attenuator set **to 20 V/div.,** variable control to cal position).

VOLTAGE VALUES OF A SINE CURVE

With the designations

H = display height in div. (cm).

U = signal voltage in V_{pp} at the Vertical input.

D = deflection coefficient in V/div. at attenuator switch

U = D.H

H = U / D

D = U / H

However, these three values are not freely selectable. They have to be within the following limits (trigger threshold accuracy of reading).

H between 0.5 and 8 div., if possible 3.2 to 8 div.,

U between 2mV_{pp} and 160 V_{pp},

D between 2mV/div. and 20 V/div. in 1-2-5 sequence.

If the applied signal is superimposed on a DC (direct voltage) level, the total value (DC + peak value of the alternating voltage) of the signal across the Y-input must not exceed ± 500 V.

TOTAL VALUE OF INPUT VOLTAGE

The dotted line shows a voltage alternating at zero volt level. When superimposed a DC level, the addition of the positive peak and the DC voltage results in the max voltage (DC + AC peak).

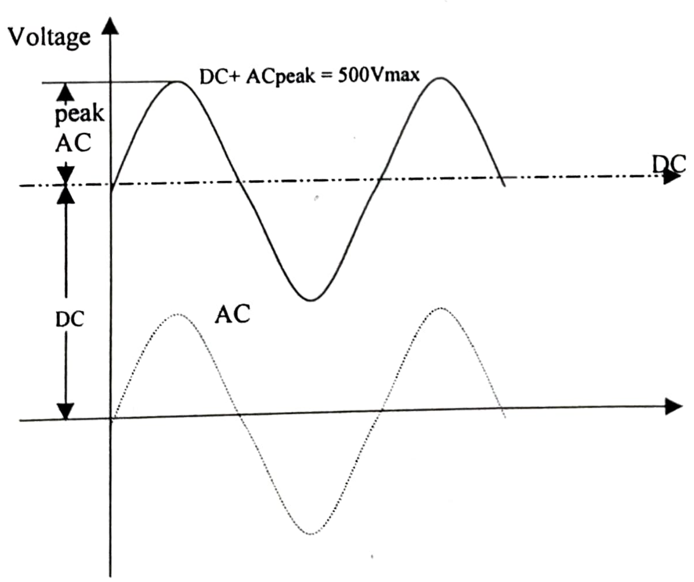


Fig.4

9. HORIZONTAL AXIS

9.1 TIME MEASUREMENTS

As a rule, most signals to be displayed are periodically repeating processes, also called periods. The number of periods per second is the repetition frequency. Depending on the time base setting of the **TIME/DIV.** switch, one or several signal periods or only part of a period can be displayed. The time coefficients are stated in s/cm, ms/cm and µs/cm on the TIME/DIV. switch. The scale is accordingly divided into three fields There are 23 time coefficient ranges of the **HM605/HM605-B**, from 0.05 µs/cm to 1 s/cm.

The duration of a signal period or a part of it is determined by multiplying the relevant time (horizontal distance in div.) by the time coefficient setting on the TIME/DIV. switch. The variable time control (identified with dotted knob cap) must be in its calibrated position CAL. (dot pointing horizontally to the right).

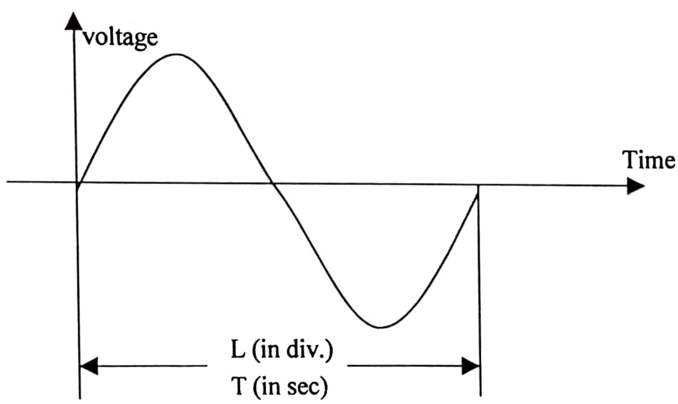


Fig.5 Time and frequency measurement

With the designations
L = displayed wave length in cm of one period.
T = time in seconds for one period.
F = recurrence frequency in Hz of the signals.
T_c = time coefficient in s/cm on timebase switch and the relation F = 1/T, the following equations can be stated:

$$T = Tc \times L \qquad L = T / T_c \qquad T_c = T / L$$

$$F = 1 / (L \times T_c) \qquad L = 1 / (F \times T_c) \qquad T_c = 1 / (L \times F)$$

With X-MAG. ×10 pushbutton pressed, the T_c value must be divided by 10.
If the time is relatively short as compared with the complete signal period, an expanded time scale should always be applied (X-MAG. ×10 button pressed). In this case, the ascertained time values have to be divided by 10. The time interval of interest can be shifted to the screen center using the X-POS. control.

9.2 PHASE DIFFERENCE MEASUREMENT IN DUAL MODE

Phase difference between two input signals of the same frequency and shape can be measured very simply on the screen in Dual mode. Both base lines should be set in the center, with the Y-POS. control knobs of both channels before the measurement. The time base should be triggered by the reference signal (phase position 0). The other signal can then have a leading or lagging phase angle. In alternate triggering condition, phase difference measurement is not possible.

DUAL Alternate mode should be selected for frequencies ≥ 1 kHz & the chop mode is more suitable for frequencies less than 1kHz (less flickering). For greatest accuracy, adjust not more than one period and approximately the same height of both signals on the screen. The variable controls for amplitude and time base and the LEVEL knob can also be used for this adjustment - without influence on the result. With sinusoidal signals, observe the zero (crossover point) transitions; the sine peaks are less accurate. If a sine signal is noticeably distorted by even harmonics, or if an offset DC voltage is present, AC coupling is recommended for both channels. If it is a question of pulses of the same shape, read off at steep edges.

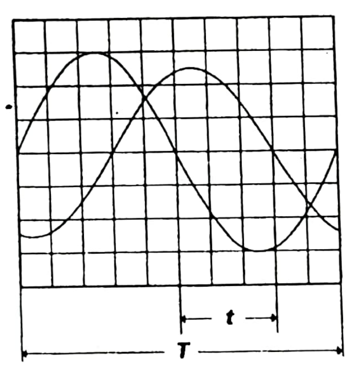


Fig.6 Phase difference measurement

Phase difference measurement in DUAL mode

t = horizontal spacing of the zero transitions in div.

T= horizontal spacing for one period in div.

In the example illustrated, t = 3 div. and T = 10 div.

The phase difference in degrees is calculated from

$$\phi = \frac{t}{T} .360^\circ = \frac{3}{10} .360^\circ = 108^\circ, \text{ or expressed in arc radians}$$

$$\phi = 2\pi \times \frac{t}{T} = 2\pi \times \frac{3}{10} = 1.885 \text{ radian}$$

Relatively small phase angles at not too high frequencies can be measured more accurately in the X-Y mode with Lissajous figures.

In this

t_{tot} is the total measured risetime,
t_{osc} is the risetime of the oscilloscope amplifier (approx.5.8 ns. for 60MHz oscilloscope), and
t_p is the risetime of the probe (e.g. = 2 ns).

If t_{tot} is greater than 100 ns, then t_{tot} can be taken as the risetime of the pulse and calculation is unnecessary. Calculation of the example in the figure above results in a signal rise time.

$$t_r = \sqrt{11^2 - 5.8^2 - 2^2}$$

The measurement of the rise or fall time is not limited to the trace dimensions shown in the above figure. It is only particularly simple in this way. In principle it is possible to measure in any display position and at any signal amplitude. It is only important that the full height of the signal edge of interest is visible in its full length at not too great steepness and that the horizontal distance at 10% and 90% of the amplitude is measured. If the edge shows rounding or overshooting, the 100% should not be related to the peak values but to the mean pulse heights. Breaks of peaks (glitches) next to the edge are also not taken into account. With very severe transient distortions, the rise and fall time measurement has little sense.

For amplifiers with approximately constant group delay (therefore good pulse transmission performance) the following numerical relationship between rise time t_r (in ns) and bandwidth BW (in MHz) applies.

$$t_r = \frac{350}{BW} \quad \text{or} \quad BW = \frac{350}{t_r}$$

9.4 SWEEP DELAY

9.4.1 General

During the normal time base operation, the trigger signal starts the sweep, i.e. the time base sweep signal will begin at exactly the same instant as the trigger signal is applied. The new HM203M's sweep delay facility enables the sweep to be started at selected delay times after the trigger signal has been applied. The time ranges from 0.1s to 100ms, with its fine control to 1 s.

The sweep delay facility therefore makes it possible to start the sweep at particularly any point of the waveform. The period, which follows the start of this sweep, can then be expanded by an increase of time base speed. From a **4s per div.** time base range downward to slower sweep speeds, an expansion of at least 1000 times is possible. With timebase speeds faster than 5 s/ div. the maximum expansion decreases proportionally. By an extreme increase in the expansion, the delay brightness decreases and trace focus may change. When the expansion is very large, the signal displayed may have a tendency to jitter. This may be caused by even slight changes in signal frequency.

The sweep delay facility has three controls, which are located in the timebase section of the front panel.

These are :

DELAY: Time selector, this switch has seven positions ranging from 0.1µs to100ms. Used for coarse selection of delay times.

DELAY VAR: This fine control is used for fine time delay adjustment depending on the setting of the coarse position switch.

NORM-SEARCH - DELAY: This switch selects both delay mode.

NORM: In this position the delay circuit is switched off and the complete waveform under investigation will be displayed.

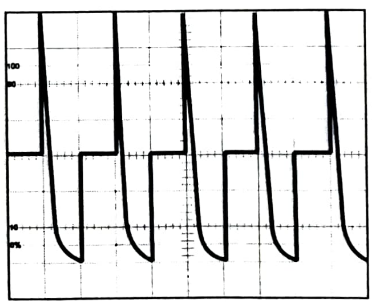
SEARCH: In this position, the CRT display will show the amount of delay, i.e. blank the trace on the left of CRT screen. Using the **DELAY** switch and the **DELAY VAR,** the delay can be adjusted to select a particular point of the displayed signal or predetermined delay time.The delay time is then the distance from the extreme left of the graticule to the beginning of the trace and is dependent on the time base setting. The **DELAY** indicator LED will blink in **SEARCH** mode.

DELAY: In this position the display is delayed by the time determined during **SEARCH** mode. Adjustment of the delay time (fine or coarse) will have the effect of moving the signal but the part of the signal seen on the CRT screen will keep the same time coefficients as shown on the time base switch. Another effect is that the displayed signal will move with the adjustment of the delay fine control. This can be regarded as the graticule moving along the trace. The **DELAY** indicator LED will illuminate continuously in **DELAY** mode.

9.4.2 OPERATION OF DELAY FACILITY

NORMAL MODE

1. With no signal applied or channel input coupling switch set to **GD**, adjust the **X-POS** control so that the trace is in the centre of the graticule. Ensure that **DELAY** switch is set to the **NORM** mode and adjust oscilloscope to display one to five basic periods of the signal under investigation.
2. Set **DELAY** mode controls (fine and coarse) fully counter clockwise.
3. Check that **X MAG x10** switch is not pressed. **HOLD-OFF** control and **TIME BASE VAR** control set to calibrated position.
4. Check that trigger **LEVEL** control is adjusted to ensure stable triggering. The TRIG. LED should be illuminated.



MODE	:	**NORM.**
TIME/DIV	:	**0.5ms./div.**
LED	:	**OFF**

DISPATCH PROCEDURE FOR SERVICE

Should it become necessary to send back the instrument to factory please observe the following procedure.

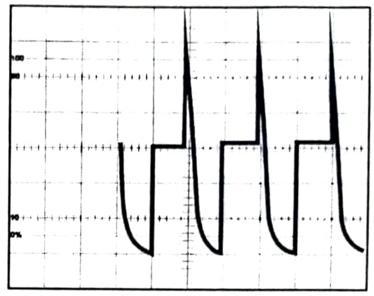
(1) Before dispatching the instrument please write to us giving fully details of the fault noticed.

(2) After receipt of your letter our repairs dept. will advise you whether it is necessary to send the instrument back to us for repairs or the adjustment is possible in your premises.

(3) Dispatch the instrument (Only on receipt of our advise) securely packed in original packing duly insured and freight paid alongwith accessories and a copy of the details of defects noticed to us at our factory address)

SEARCH MODE

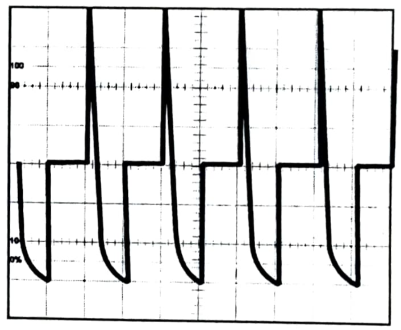
1. Set **DELAY** switch to **SEARCH** position. The **DELAY LED** indicator will flash.
2. Increase **DELAY COARSE** and **VARIABLE** control for requirement delay time. The start of the trace will move to right of graticule. The amount of shift indicates the delay time setting. If trace disappears then the delay time setting is too high.
3. The **X- POS** control should not be adjusted. Precise adjustment of the delay time is made with the **DELAY VAR** control. This can then be calculated from the timebase switch setting.



MODE : SEARCH
TIME/DIV : O.5ms./div.
LED : Blinking

DELAY MODE

1. Set mode switch to **DELAY** position.
   The **DELAY LED** should illuminate constantly.
2. The trace will now start in the same position as for normal display. The signal position can be adjusted by the **DELAY VAR** control.



MODE : DELAY
TIME/DIV : O.5ms./div.
LED : ON

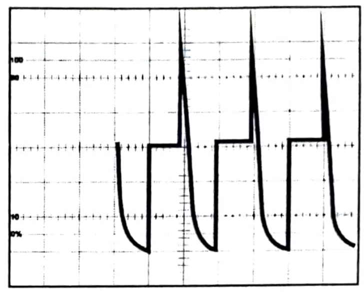
9.4.3 EXPANSION OF SIGNAL

1. In the **DELAY** mode, the required part of the signal can be displayed by adjusting the **DELAY VAR** control.
2. Increase the timebase sweep speed to expand the displayed signals required. The **TIMEBASE VAR** control and the **X-MAG × 10** facilities may have to be used.
3. If the signal leaves the CRT screen, the **DELAY VAR** control requires readjustment. This control can be adjusted to enable any point of the signal to be displayed.

   In the example shown in the figure above, it can be seen that an expansion of x 10 was obtained by increasing the timebase sweep speed from 0.5 ms/div. to be 50µs/div. The precise measurement for the displayed portion of the waveform is possible. This was found to be 250µs by multiplication of the horizontal length in div. by the timebase time coefficient. The Time base VAR control must always be set at calibrated position, when accurate measurements are to be made.

SEARCH MODE

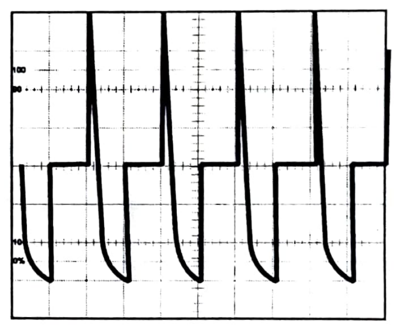
1. Set **DELAY** switch to **SEARCH** position. The **DELAY LED** indicator will flash.
2. Increase **DELAY COARSE** and **VARIABLE** control for requirement delay time. The start of the trace will move to right of graticule. The amount of shift indicates the delay time setting. If trace disappears then the delay time setting is too high.
3. The **X- POS** control should not be adjusted. Precise adjustment of the delay time is made with the **DELAY VAR** control. This can then be calculated from the timebase switch setting.



MODE : SEARCH
TIME/DIV : O.5ms./div.
LED : Blinking

DELAY MODE

1. Set mode switch to **DELAY** position.
   The **DELAY LED** should illuminate constantly.
2. The trace will now start in the same position as for normal display. The signal position can be adjusted by the **DELAY VAR** control.



MODE : DELAY
TIME/DIV : O.5ms./div.
LED : ON

9.4.3 EXPANSION OF SIGNAL

1. In the **DELAY** mode, the required part of the signal can be displayed by adjusting the **DELAY VAR** control.
2. Increase the timebase sweep speed to expand the displayed signals required. The **TIMEBASE VAR** control and the **X-MAG × 10** facilities may have to be used.
3. If the signal leaves the CRT screen, the **DELAY VAR** control requires readjustment. This control can be adjusted to enable any point of the signal to be displayed.

   In the example shown in the figure above, it can be seen that an expansion of x 10 was obtained by increasing the timebase sweep speed from 0.5 ms/div. to be 50μs/div. The precise measurement for the displayed portion of the waveform is possible. This was found to be 250μs by multiplication of the horizontal length in div. by the timebase time coefficient. The Time base VAR control must always be set at calibrated position, when accurate measurements are to be made.

the X field marked **X-Y** must be pressed. In X-Y mode, timebase is inactive. The signal applied at input of CH.II, front panel marking **CH.II (X)** causes X deflection. The calibration of the X signal during X-Y operations is determined by the setting of the channel II input attenuator and variable control. This means that the sensitivity ranges and input impedances are identical for both the X and Y axes. However, for X-position alteration the **X-POS.** control knob must be used (as Y-POS.II control knob becomes inactive). It is important to note that the X-MAG. ×10 facility, normally used for expanding the sweep should not be used in the X-Y mode. It should also be noted that the bandwidth of the X amplifier is approximately 5 MHz (-3dB), and therefore an increase in phase difference between both axes is noticeable from 50 KHz onwards. The Y-Input signal can be inverted by using the INVERT facility.

Lissajous figures can be displayed in the X-Y mode for certain measuring tasks.

- Comparing two signals of different frequency or bringing one frequency up to the frequency of the other signal. This also applies for whole number multiples or fractions of the one signal frequency.
- Phase comparison between two signals of the same frequency.

10.1 PHASE COMPARISON WITH LISSAJOUS FIGURE

The following diagrams shows two sine signals of the same frequency and amplitude with different phase angles.

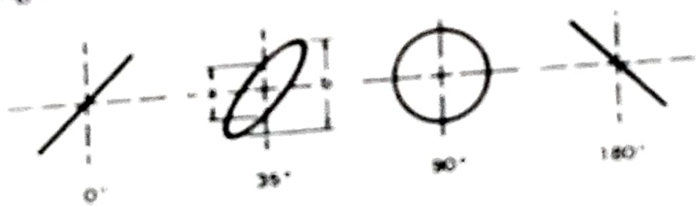


Fig. 8 Phase comparison lisajeous figures

Calculation of the phase angle or the phase shift between the X and Y input voltages (after measuring the distances a and b on the screen) is quite simple with the following formula and a pocket calculator with trigonometric functions and besides independent of both deflecting amplitudes on the screen.

$$\sin \phi = a/b$$

$$\cos \phi = \sqrt{1-\left(\frac{a}{b}\right)^2}$$

$$\phi = \arcsin (a/b)$$

The following must be noted here :

- Because of the periodic nature of the trigonometric functions, the calculation should be limited to angles ≤ 90°. However here is the advantage of the method.
- Do not use a too high test frequency. The phase shift of the two X and Y amplifiers of the **HM605/HM605-B** in the X-Y mode can exceed an angle 3°, above 100 KHz.
- It cannot be seen as a matter of course from the screen display if the test voltage leads or legs the reference voltage. A CR network before the test voltage input of the oscilloscope can help here. The 1 MΩ input resistance can equally serve as R here, so that only a suitable capacitor C needs to be connected in series. If the aperture width of the ellipse is increased (compared with C short-circuited) then the test voltage leads the reference voltage and vice versa. This applies only in the region up to 90° phase shift. There fore C should be sufficiently large and produce only a relatively small just observable phase shift.

If both input voltages are missing or fall in the X-Y mode, a very bright light dot is displayed on the screen. This dot can burn the phosphor at a too high INTENS setting which causeseither a lasting loss of brightness, or in the extreme case, complete destruction of the phosphor at this point.

11. TRIGGERING

A signal can be displayed only if the timebase is running or triggered. To produce a stationary display, time base must be synchronous with the test signal. Triggering can be performed by using the test signal itself (internal triggering) or by an externally supplied but synchronous signal voltage (external triggering).

The trigger voltage should have certain minimum amplitude. This value is called the **trigger threshold.** It is measured with a sine signal. When the trigger voltage is taken internally from the test signal, the trigger threshold can be stated as vertical display height in div., through which the time base generator starts, the display becomes stable, and the trigger LED lights.

The internal trigger threshold of the **HM605/HM605-B** is given as 0.5 div. When the trigger voltage is externally supplied, it can be measured in V_{pp} at the TRIG.INP. socket. Normally, the trigger threshold may be exceeded up to a maximum factor of 20.

11.1 TRIGGERING MODES

The **HM605/HM605-B** has two trigger modes, which are characterized as the following.

11.1.1 AUTO (Peak value trigger)

If the **AT/ NORM.** pushbutton in the X field is in the out position i.e. **AT;** the sweep generator is running without test signal or external trigger voltage. A base line is always displayed even without

a signal applied. This trigger mode is therefore called Automatic Triggering. Operation of the scope needs only correct amplitude and time base settings, for constantly visible trace. A **LEVEL** adjustment is neither necessary nor possible with automatic triggering. This simple **AT** mode is recommended for all uncomplicated measuring tasks. However, automatic triggering is also the appropriate operation mode for the "entry" into difficult measuring problems e.g. when the test Signal is unknown relating to amplitude, frequency or shape.

Presetting of all parameters is possible with automatic triggering; the change to normal triggering can follow thereafter.

The automatic triggering works above 10 Hz up to at least 20 MHz. The failure of the automatic triggering at frequencies below 10 Hz is abrupt. However, it cannot be recognized by the TRIG. LED this may still be blinking. Breakdown of triggering is best recognizable at the left screen edge (the start of the trace in differing display height).

The automatic triggering follows immediately all variations or fluctuations of the test signal above 10 Hz. However, if the pulse duty factor of a square-wave signal changes so much that one part of the square-wave reduces to a needle pulse, switching over to normal triggering and using the LEVEL control can become necessary. With automatic triggering the trigger point lies approx. in the zero voltage crossing. The time interval, required for the time base start, can be too short at a steep zero crossing of the needle pulse. Then normal triggering should be used.

Automatic triggering is practicable with internal and external trigger voltage.

11.1.2 NORMAL TRIGGERING

With normal triggering (AT/NORM. button pressed) and **LEVEL** adjustment, the sweep can be started by signals within the frequency range selected by the TRIG. coupling switch. In the absence of the adequate trigger signal or when the trigger control (particularly the **LEVEL** control) is misadjusted, no trace is visible, i.e. the screen is blanked completely.

While using the internal normal triggering mode, it is possible to trigger at any amplitude point of a signal edge, even with very complex signal shapes, by adjusting the **LEVEL** Control. Its adjusting range is directly dependent on the display height, which should be atleast 10 mm. If it is smaller than 1 div. the LEVEL adjustment needs to the operated with a sensitive touch. In the external normal triggering mode the same applies to approx. $0.5V_{pp}$ external Trigger voltage amplitude.

Other measures used for triggering of very complex signals are, the use of the time base variable control and **HOLD-OFF** time control, hereinafter mentioned.

11.2 TRIGGER SLOPE (+/-)

The trigger point can be placed alternatively on a rising or falling edge of the test signal. This is valid with automatic and with normal triggering. The selected slope is set with the +/- button. The plus sign (+/- button released) means an edge, which is coming from a negative potential and rising to a positive potential. This has nothing to do with zero or ground potential and absolute voltage value. The positive slope may also lie in a negative part of a signal. A falling Edge (minus sign) triggers, when the +/- button is pressed.

However, with normal triggering, the trigger point may be varied within certain limits on the chosen edge using the LEVEL control. The slope direction is always related to the input signal and non-inverted display.

11.3 TRIGGER COUPLING

The coupling mode and accordingly the frequency range of the trigger signal can be changed using the **TRIG.** selector switch. However, this is possible only with the TV SEP switch in OFF position.

AC: Trigger range 10 Hz to 100 MHz

This is the most frequently used trigger mode. The trigger threshold is increasing below 10Hz.

DC: Trigger range DC to 100 MHz.

DC triggering is recommended if the signal is to be triggered with quite slow processes or if pulse signals with constantly changing pulse duly factors have to be displayed. Always work with normal triggering and LEVEL adjustment. Otherwise there is the possibility in the AT position (automatic triggering) that the trigger point may change or that triggering may not occur with signals without zero crossing(e.g. with DC offset) The balance of the corresponding channel input should then be corrected (see "DC balance adjustment procedure). Sometimes triggering is easier with AC input coupling, because the signal then has its average value exactly at the oscilloscope's ground potential.

HF: Trigger range 1.5 kHz to 100 MHz (high -pass filter)

The HF position is suitable for all radio- frequency signals. DC fluctuations and low frequency excess noise of the trigger voltage are suppressed, giving a stable display. The trigger threshold increases below 1.5 KHz. It is useful for frequencies above 80 MHz.

LF: Trigger range DC to 1 KHz (low pass filter)

The LF position is often more suited for low- frequency signals than DC position, because the (white) noise in the trigger voltage is strongly suppressed. So jitter or double triggering of complex signals is avoided or at least reduced, in particular with very low input voltages. The trigger threshold increases above 1 kHz. LF position is specially suited to trigger video signals at frame frequency. It can also be applied to all signals under 1 kHz.

Line : A part of a secondary winding voltage of the power transformer is used as mains/line

frequency trigger signal (50 to 60 Hz) in the LINE TRIG. position of the TRIG. selector switch. This trigger mode is independent of amplitude and frequency of the Y signal and is recommended for all mains/line synchronous signals. This also applies within certain limits to - whole number multiples or fractions of the line frequency. Line triggering can also be useful to display signals below the trigger threshold (less than 0.5div). It is therefore particularly suitable for measuring small ripple voltages of mains/line rectifiers or stray magnetic field in a circuit.

Magnetic leakage (e.g. from a power transformer) can be investigated for direction and amplitude using a search or pick-up coil. The coil should be wound on a small former with a maximum no. of turns of a thin lacquered wire and connected to a BNC connector (of scope input) via a shielded cable. Between cable and BNC center conductor a resistor of at least 100 Ω should be series connected (RF decoupling). Often it is advisable to statically shield the surface of the coil. However, no shorted turns are permissible. Maximum, minimum and direction to the magnetic source are detectable at the measuring point by turning and shifting the coil.

11.4 ALTERNATE TRIGGERING

With alternate triggering it is possible to trigger two signals from different frequency sources (asynchronous). In this case the oscilloscope must be operated in DUAL alternate mode with internal triggering and each input must be of sufficient height to enable trigger. To avoid trigger problems due to different DC voltage components, AC input coupling for both channels is recommended.

Phase difference measurement is not possible in this trigger mode as the trigger level and slope settings are equal for both signals. If signals are applied with a high frequency ratio (difference), the trace intensity then reduces, if the timebase is set to smaller time coefficients (faster sweep).

11.5 EXTERNAL TRIGGERIG

This mode is selected when **EXT.** switch is pressed. Pressing the **EXT.** button disconnects the internal triggering and the timebase can be triggered externally by applying a min. of 0.1Vpp voltage signal at **TRIG.INP.** socket. This Ext. Trigger voltage may have completely different form, from the test signal voltage, but it must be in synchronism with the test signal. Triggering is even possible - in certain limits- with whole number multiples or fractions of the test frequency, but only in locked phase relation. The maximum input voltage that can be applied at the input is **100V(DC + peak AC).**

11.6 TRIGGER INDICATOR

An **'LED ON'** condition (to the left of the TRIG. switch) indicates that the sweep generator is triggered. This is valid with automatic and with normal triggering. By observing the trigger LED, sensitive trigger level adjustment is possible when normal triggering is used, particularly at very low signal frequencies. The indication pulses are of only 100 ms duration. Thus for fast signals the LED appears to glow continuously, for low repetition rate signals, the LED flashes at the repetition rate (or at a display of several signal periods), not only at the start of the sweep at the left screen edge, but also at each signal period.

11.7 SINGLE

A single shot triggering facility enables the timebase to sweep the CRT only once. This is used when a single process or event is to be displayed or photographed. To operate the oscilloscope in the single mode, press the **SINGLE** and then the **RESET** pushbutton. A glowing LED indicates that the oscilloscope is **ready** to accept an input signal. Whenever the signal comes, it is displayed once only. The LED turns off. To prepare the oscilloscope for the next single event press reset pushbutton. It is advised to use **NORMAL** mode of triggering with low amplitude (high sensitivity) or low frequency signals. The setting of the level control amplitude and timebase should be determined before single sweep is used.

11.8 TRIGGERING COMPLEX SIGNALS

11.8.1 HOLD-OFF TIME ADJUSTMENT

If it is found that a trigger point cannot be located on extremely complex signals even after repeated and careful adjustment of the LEVEL control in the normal triggering mode. A stable display may often be obtained using the **HOLD OFF** control (in the X-field). This facility varies the hold off time between two-sweep periods approx. up to the ratio 10: 1. Pulses or other signal waveforms appearing during this period cannot trigger the timebase.

Particularly with burst signals or aperiodic pulse trains of the same amplitude, the start of the sweep can be delayed until the optimum or required time.

11.8.2 FUNCTION OF VARIABLE HOLD-OFF CONTROL

A very noisy signal or a signal with a higher interfering frequency is at times double displayed. It is possible that LEVEL adjustment only controls the mutual phase shift, but notthe double display. The stable single display of the signal, required for evaluation, is easily obtainable by expanding the hold off time until one signal is displayed. To do this, the **HOLD-OFF** knob is slowly turned to the right, until one signal is displayed.

A double display is possible with certain pulse signals, where the pulses alternately show a small difference of the peak amplitudes. Only a very exact TRIG. LEVEL adjustment makes a single display possible. The use of the **HOLD- OFF** knob simplifies the right adjustment.

After specific use, the **HOLD-OFF** control should be set to its calibration position (fully ccw), otherwise the brightness of the display is reduced drastically. The function of **HOLD-OFF** is shown in the above figures.

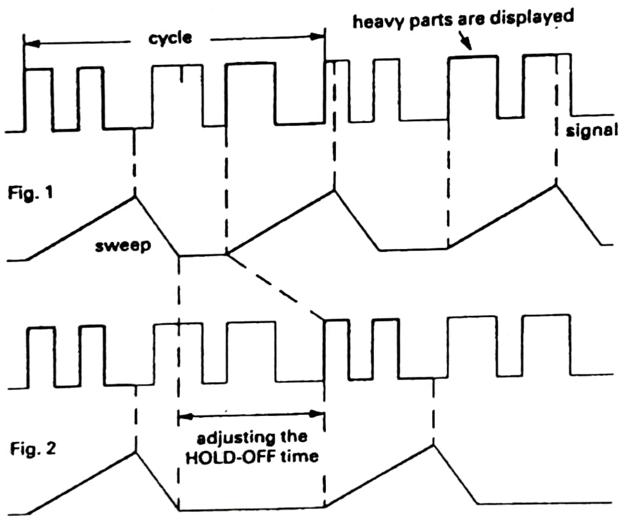


Fig.10

Fig. 10 shows a case where the HOLD-OFF knobs is in the x1 position and various different waveforms are overlapped on the screen, making the signal observation unsuccessful.
Fig. 11 shows a case where only the desired parts of the signal are stable displayed.
A double display is possible with certain, pulse signal. Where the pulses alternately show a small difference of the peak amplitudes. Only a very exact LEVEL adjustment makes a single display possible. The use of the HOLD-OFF knob simplifies the right adjustment.
After specific use the HOLD OFF control should be reset into its calibration detent, otherwise the brightness of the display is reduced drastically.

12. Z MODULATION

This enables the trace to be switched from light to dark, depending on the applied modulating signal voltage. The intensity of the beam cannot be varied by external signal ; it can only be switched ON and OFF. The signal should be applied directly to the input marked **Z** on the rear side of the instrument. Checking the Z-modulation facility is possible using a signal generator (max. 5Vpp, 600Ω). The amplitude of this voltage determines the light dark ratio. High TTL level (positive logic) gives unblanking (i.e. bright) and low level gives blanking(i.e. dark). No higher voltages than +5 Volt are permitted. A signal generator, which produces negative signals relative to ground, is unsuitable. A signal applied at the Z-modulation socket must not contain DC offset voltage.

Without a modulating generator, the function of the Z modulation can be checked simply by short-circuiting the Z-modulation socket with ground, then the baseline should be blanked fully.

13. SAWTOOTH OUTPUT

A BNC socket at the rear side of the oscilloscope marked with a sawtooth waveform can be used to obtain a sample signal from the oscilloscope's internal timebase. The output waveform is approx. 5 V_{pp} and varies in frequency depending on the setting of the timebase switch. The connected load to this socket must be greater than 10 K Ω.

14. Y OUTPUT

The Y deflection signal, which is applied, to the CRT's Y plates is available at the BNC socket marked 'Y' located at the rear side of the instrument. The Y output would be the same signal as displayed on the CRT screen with a level of approx. 100 mV/div without 50Ω termination. With 50Ω termination this output voltage is reduced to 50 mV/div. The bandwidth is that of the instrument, but depends strongly on capacitive loads. Y output can be switched using the I/II trigger pushbutton to channel I or II.

15. GRATICULE ILLUMINATION

Graticule illumination is adjustable to two intensities.
At position 0 the lamps are switched OFF.
At position 1 the lamps are switched ON, but are dim.
At position 2 the lamps are bright.

16. COMPONENT TESTER

-GENERAL

The **HM605/HM605-B** has a built in electronic component tester (abbreviated CT), which is used for instant display of test pattern to indicate whether or not components are faulty. The CT can be used for quick checks of all semiconductors resistors, capacitors, and inductors.

Certain tests can also be made to integrated circuits. All these components can be tested in and out of circuit. Since this circuit operates with mains frequency (50 Hz) and a voltage of 8.5 V_{rms} max. (open circuit) the indicating range of the CT is limited to a range from 20 ohms to 4.7 K Below and above these values , the test pattern shows only short circuit or open circuit. For the interpretation of the displayed test pattern, these limits always should be borne in mind. However, most electronic components can normally be tested without any restriction.

-USING THE COMPONENT TESTER

The CT is switched ON by depressing the CT pushbutton. This makes the vertical preamplifier and the timebase generator inoperative. A shortened horizontal trace will be observed. It is not necessary to disconnect scope cables unless in circuit measurements are to be carried out in the CT mode, the only control which can be operated are INTENS FOCUS and X-POS. All other controls and setting have no influence on the test operation. For the component connections two simple test leads with 4 mm banana plugs are required. The test leads are connected to the insulated CT socket and the adjacent ground socket in the Y-Section. The component can be connected to the test either way round . After use, to return the oscilloscope to normal operation release the CT pushbutton.

***CAUTION** Do not test any component in live circuit remove all grounds, power and signals connected to the components under test. Set up component tester as stated above. Connected test leads across component to be tested. Observe oscilloscope display.*

-TEST PATTERN DISPLAYS

The figure shows typical test patterns displayed by the various components under test. It may be noted here that component testing is a two terminal check across that. It may show a healthy PN or NP junction. It is a qualitative test and does not indicate any quantity.

- Open circuit is indicated by straight horizontal line.
- Short circuit is shown by straight vertical line.
- A horizontal ellipse indicates high impedance or a relatively large capacitance or a relatively high inductance.
- A vertical ellipse indicated small impedance or a relatively large capacitance or a relatively small inductance.
- A slopping ellipse means that the component has a considerable ohmic resistance in addition to its reactance.