OSCILLOSCOPE BASICS

At Your Fingertips... Using the Philips Smart 'Scope family

PHILIPS

OSCILLOSCOPE BASICS AT YOUR FINGERTIPS... USING THE PHILIPS SMART 'SCOPE FAMILY

CONTENTS

MEET THE SMART 'SCOPE FAMILY

The Philips Smart 'Scope family is a complete, versatile, 60 MHz and 100 MHz oscilloscope system with a choice of standard transportable and rack-mounted units. All this plus an extensive range of system-oriented extras to provide exactly the configurations you need.
Options that will add extra functions, measuring convenience and greater mobility to your daily oscilloscope programmes. Brief details of the Philips Smart 'Scope family are included here for completeness together with a list of accessories. For further details please contact your local Fluke-Philips organisation.

Instruments:
60 MHz oscilloscope with single time-base
60 MHz oscilloscope with dual time-base
100 MHz oscilloscope with dual time-base
100 MHz oscilloscope, dual-time base with cursors

Options (Factory installed)
Rackmount
P7 Phosphor CRT
Y Output
Sweep and Gate output

Accessories:
IEEE-488 Interface for systems with IEEE controllers
All oscilloscope functions except potentiometer settings can be remotely controlled.
Front-panel memory back-up for storing one front-panel setting even if mains power is disconnected.
Oscilloscope adjustable stand.
Front cover
Oscilloscope camera
Video line selector
Accessory pouch
Battery pack
Oscilloscope trolley

Probes
100 MHz, 10:1, 1.5 m, modular with scale read-out
75 MHz, 10:1, 2.5 m, modular with scale read-out
300 MHz, 100:1, 1.5 m, modular
15 MHz, 1:1, 1.5 m, modular
15 MHz, 1:1, 2.5 m, modular
650 MHz, FET probe
AC current probe
Isolation amplifier.

LOGICAL LAYOUT... AS SIMPLE AS ZYX

The Smart Scope family of oscilloscopes chosen for this instruction manual have an ergonomically designed front panel layout that makes operating as easy as reading a book - a mainly left-to-right, top-to-bottom logical sequence of fingertip operations.

Even the front panel ZYX division into the three basic classification is simpler than it sounds.

After switch-on, no need to hunt for the trace - the press of an AUTOSET button (Green for GO) gives automatic settings of all scope parameters for the connected input signal.

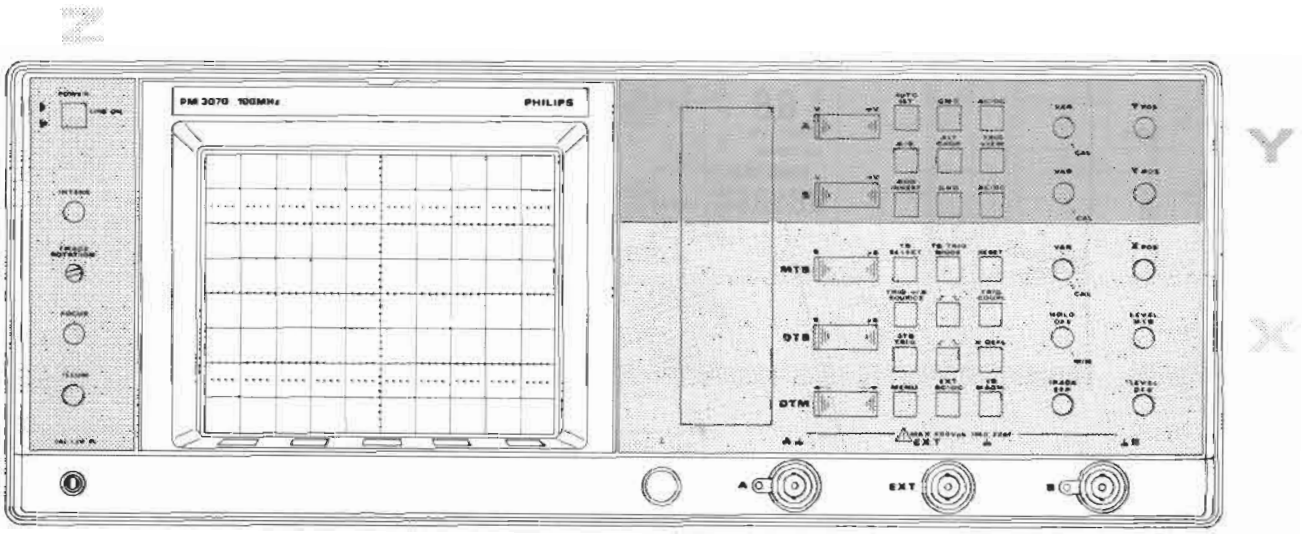
And optimum trace and spot quality is easily set by the left-hand Z controls INTENS and FOCUS.

Eyes right then for the vertical (Y) display parameter controls:

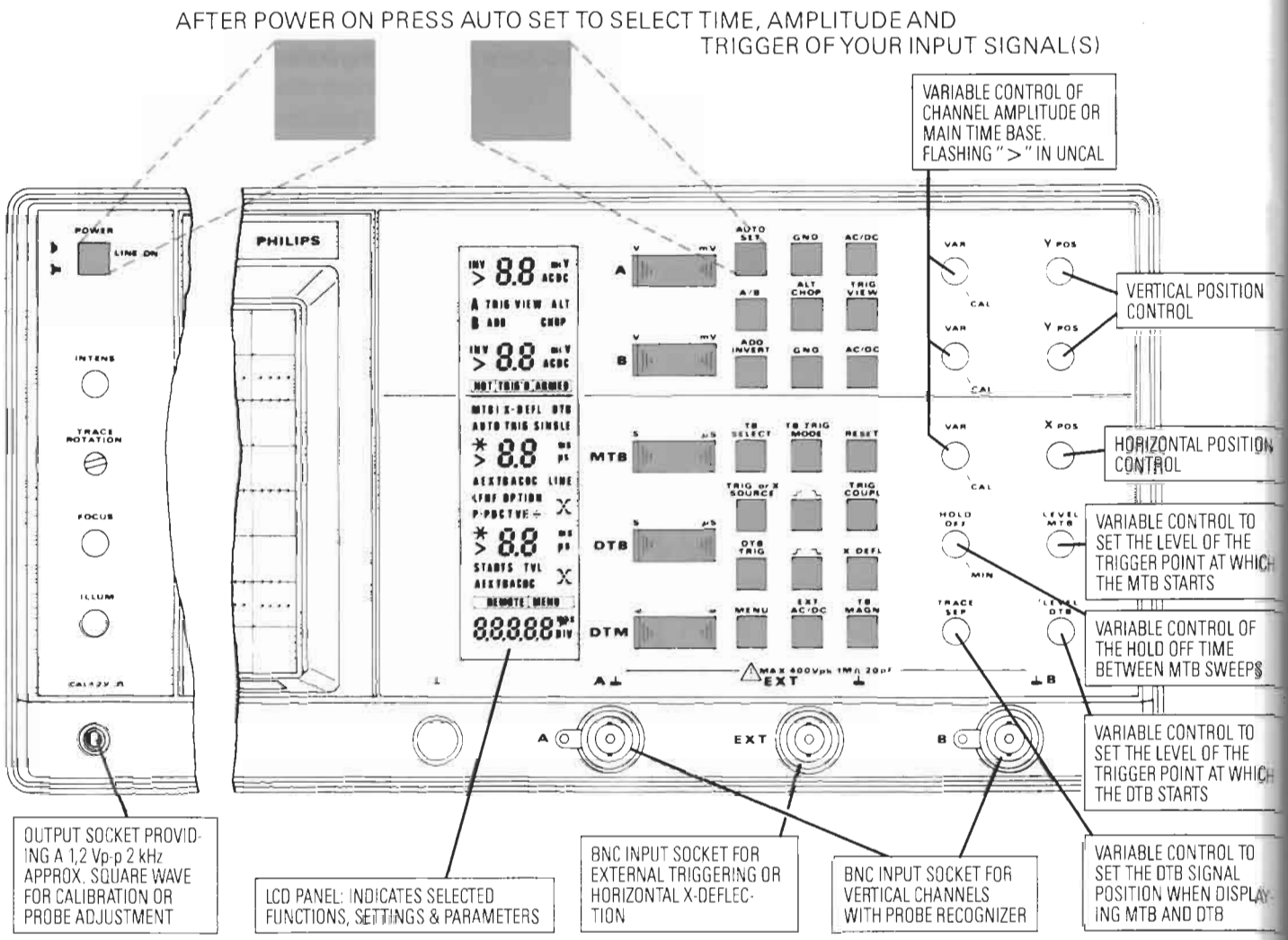
Up/Down rockers for vertical amplitude, function pushbuttons and Y position variable controls.

Finally, eyes down for the X-axis controls:

MTB, DTB rockers, X position variable controls, function pushbuttons and triggering controls.

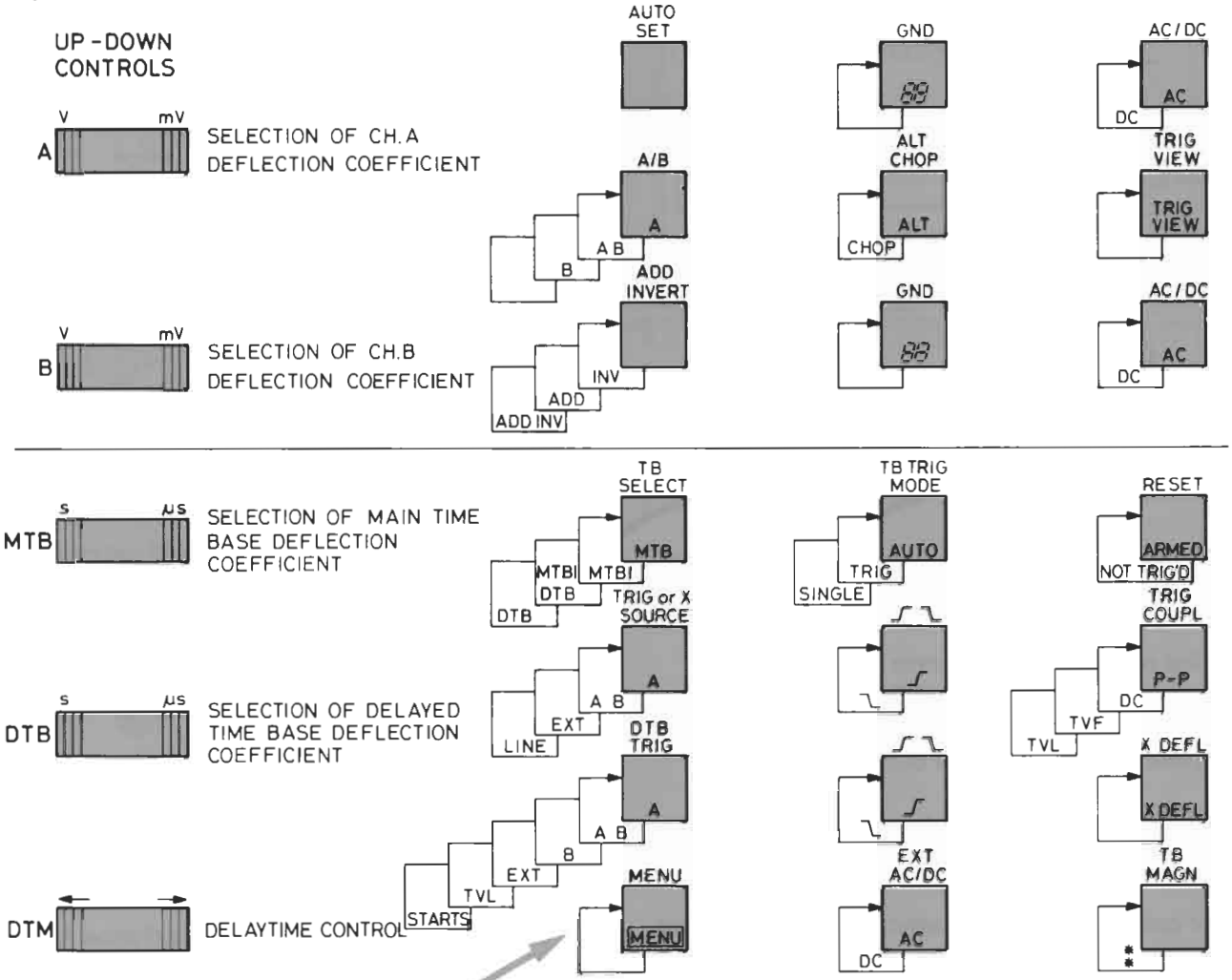


QUICK-OPERATING CHART



SOFTKEYS FOR SIMPLICITY

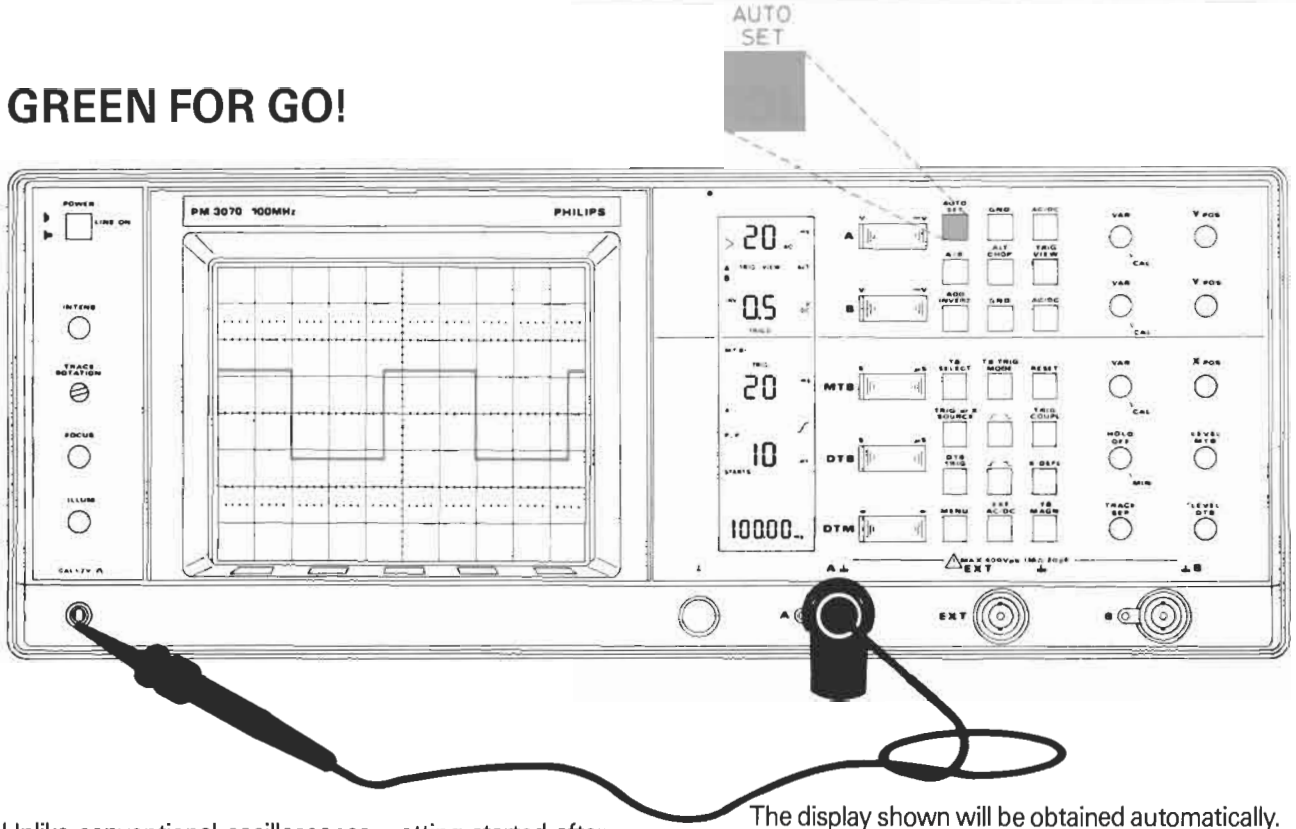
An in-depth view of the options behind the multi-function keys.



To look down the menu:

- Press MENU for learning mode.
- Press any softkey for an automatic in-depth view of its step functions.

GREEN FOR GO!



Unlike conventional oscilloscopes, getting started after switching on a Philips SMART SCOPE is easy:

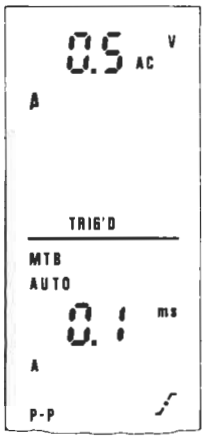
- first connect your signal under test, any signal;
- check the INTENS and Y POS controls are at "12 o'clock";
- press the green AUTOSET button.

Settings for amplitude, time-base and triggering are then brought into range.

For convenience, only the selected functions, channel, amplitude, time-base and triggering are displayed on the LCD panel - no more, no less!

For example, connect the CAL signal to channel A input;
- Press AUTOSET

The display shown will be obtained automatically. The LCD will indicate:



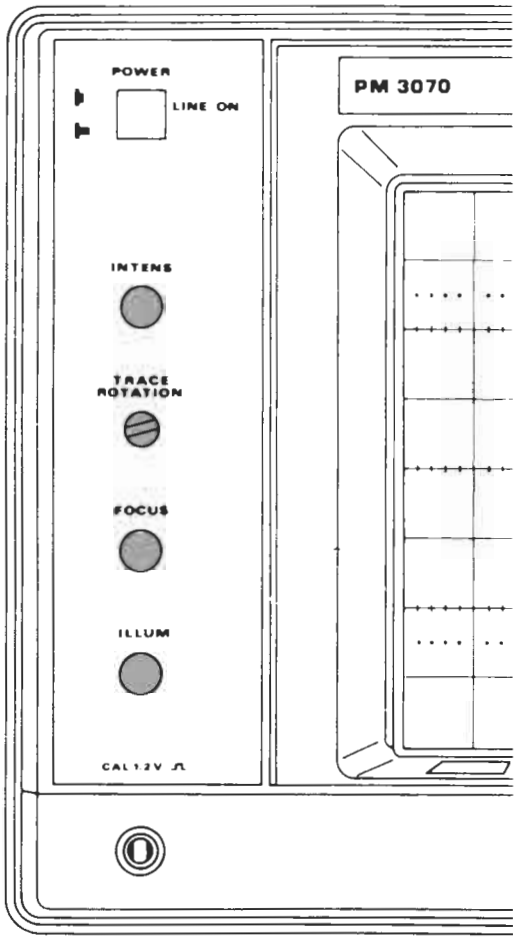
- Y ampl.setting 0.5V/div AC-coupled,
- channel A selected

- Triggered
- Main Time-base selected
- Automatic triggering
- MTB speed 0.1ms/div

- Trigger source:channel A
- triggers on +ve slope,
- pk-pk trigger coupling

The display shows that the CAL signal is a square-wave of 2 kHz, amplitude 1.2 V.

LOOKING ON THE BRIGHT SIDE (Z-AXIS)



On the left we have the controls that influence the display of the electron beam on the CRT. After initial adjusment they rarely need to be touched.

INTENS: controls the brightness of the displays

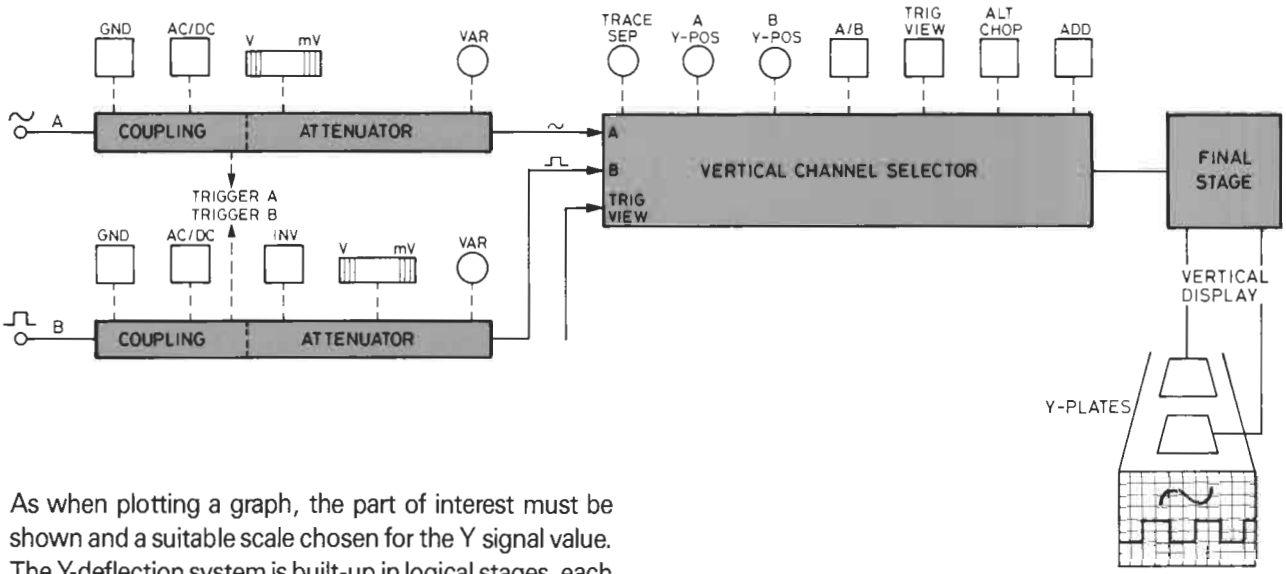
TRACE ROTATION: aligns the base-line of the signal with the horizontal graticule lines. This may vary with different locations due to the earth's magnetic field.

FOCUS: sets the sharpness of the trace

ILLUM: controls the illumination of the graticule.

The Z-MOD socket on the rear of the oscilloscope provides a useful input point to control the trace brightness with an external signal (see Extra Timing with Z-modulation, page 32).

SIGNAL INPUT CIRCUITS (Y-AXIS)



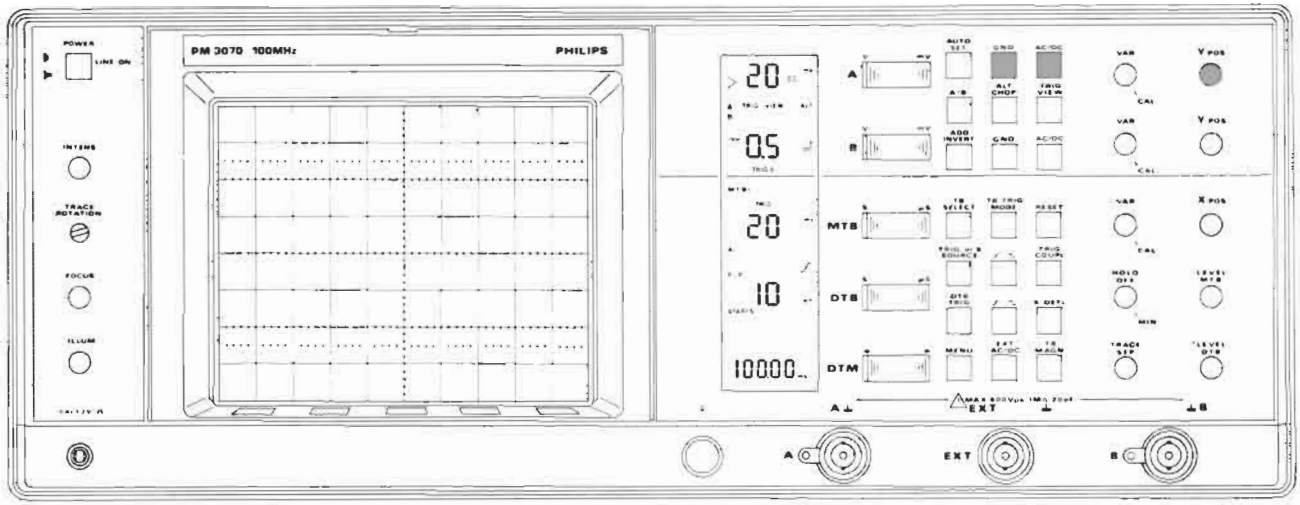
As when plotting a graph, the part of interest must be shown and a suitable scale chosen for the Y signal value. The Y-deflection system is built-up in logical stages, each performing a specific function.

The input signal is suitably coupled to the input attenuator which serves to calibrate it and bring its amplitude to a convenient viewing level.

The vertical channel selector chooses which channels shall be routed to the final amplifier and the Y deflection plates of the CRT: A, B, −B, A+B, A−B, TRIG VIEW or a combination of these.

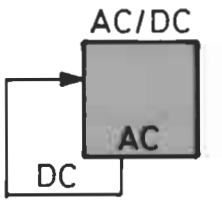
Note that the trigger pick-offs are before the INVERT and Y POS controls so that triggering is not influenced by them. Similarly, Y POS is independent of the INVERT button.

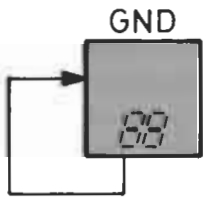
INPUT COUPLING



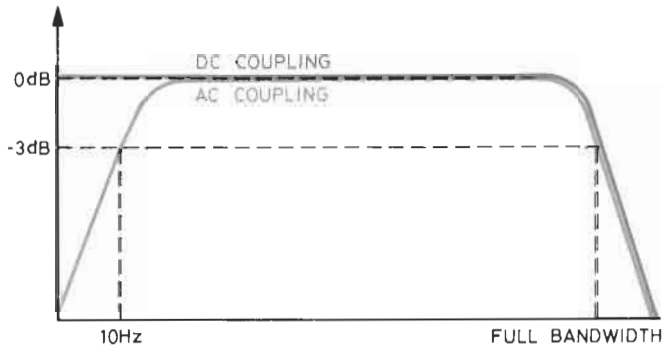
The function softkey AC/DC offers the choice of input coupling via a capacitor (AC) or direct (DC):

- **AC-coupling** blocks the DC component of a signal and is useful when an AC signal superimposed on a DC level needs to be observed; e.g. spikes on a 5 V TTL power supply. AC-coupling is automatically selected in AUTO SET.
  Remember, however that low frequencies are also attenuated by AC-coupling.
- **DC-coupling** allows both the DC and AC components of the signal to pass without attenuation. Therefore DC-coupling gives undistorted waveforms for the lower repetition rates.

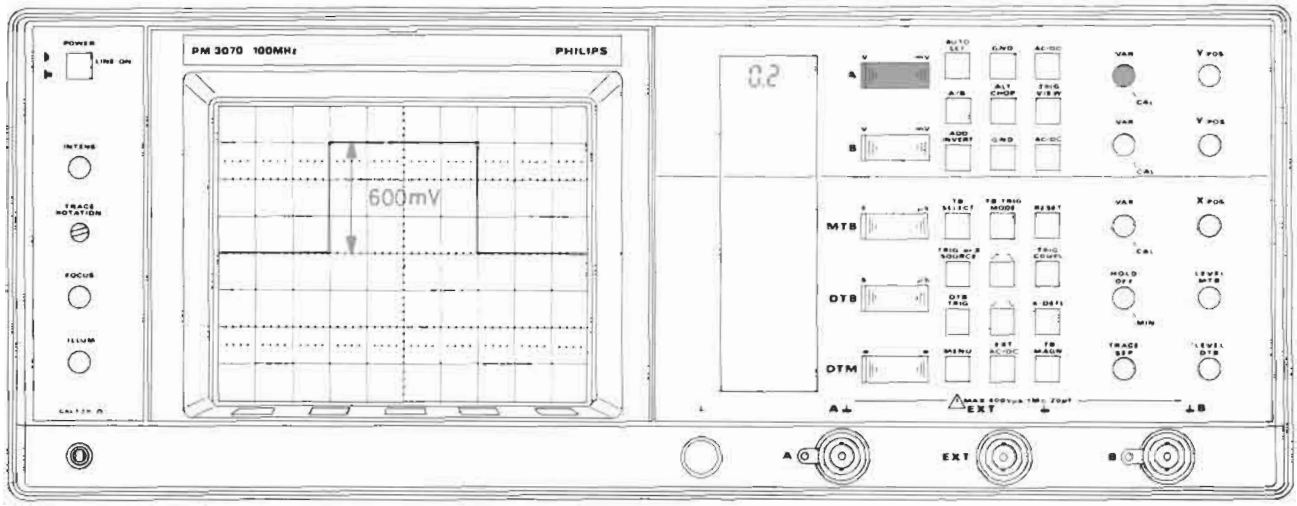




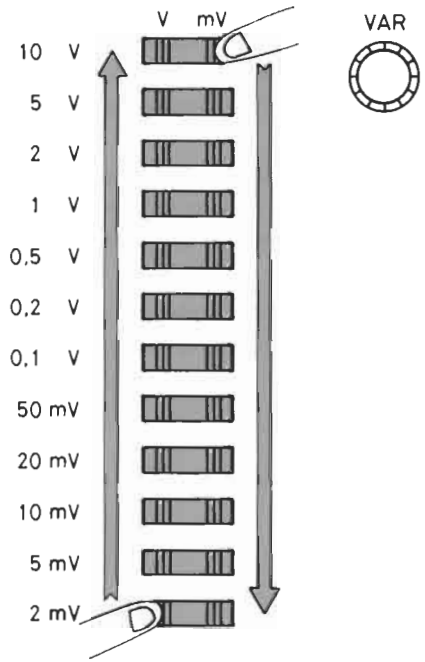
The **softkey GND** interrupts the connected signal and grounds the Y channel input to display the base line. This zero-line may then be set by the Y-POS control as a reference point for further displays.



AMPLITUDE ADJUSTMENT



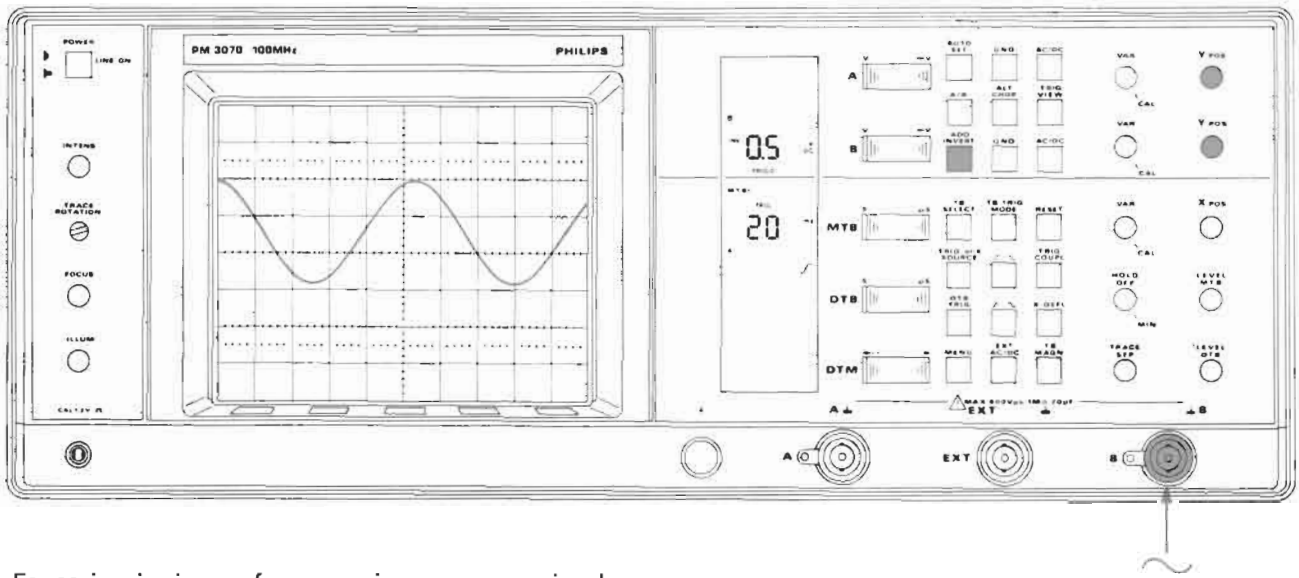
The conventional AMPL/DIV rotary switch has been superseded by fast, fingertip-action rocker control. Simply press left (V) for UP, right (mV) for DOWN.
The scale is from 2mV/div to 10 V per division in a 1-2-5 step series, with the selected range instantly displayed in the LCD.



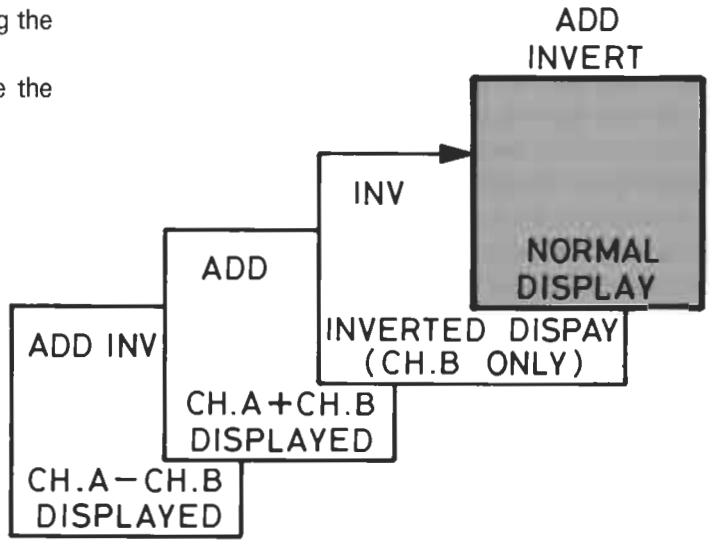
The VAR control gives a variable, fine adjustment between the 1-2-5 steps but **must be set to its clockwise CAL position for calibrated measurements.** A flashing ">" before the range value indicates that the VAR control is not in CAL position; i.e. it warns that the scale displayed is greater than (>) the range value indicated.

For example, in CAL position, when 0.2 V is displayed in the LCD, each division height represents a signal amplitude of 0.2 V (200 mV). So a pulse height of 600 mV occupies 3 divisions.
Note that with the VAR control turned anti-clockwise out of CAL, the same signal would occupy something less than 3 divisions.

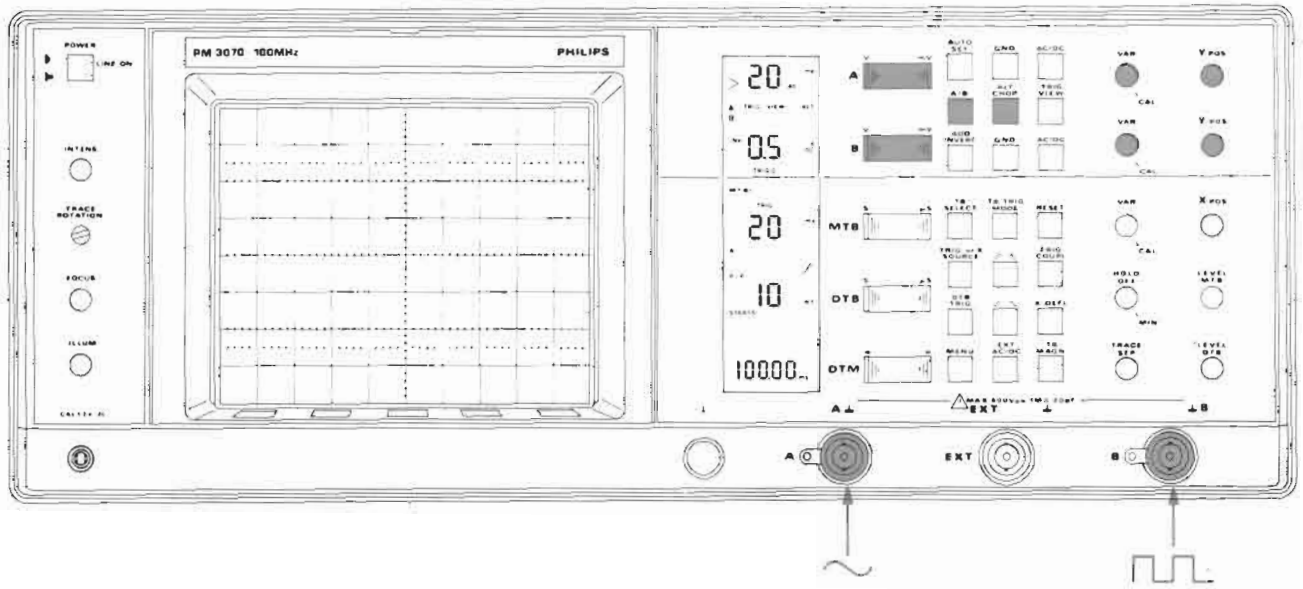
VERTICAL POSITIONING AND INVERTING



For easier viewing, or for comparison purposes, signals may be shifted up or down on the screen by using the Y POS control(s) on the upper right of the front panel.
Or even upside down (channel B only) by selecting the INVERT function of the **ADD/INVERT softkey.**
Note that inverting the signal does not influence the setting of the position.

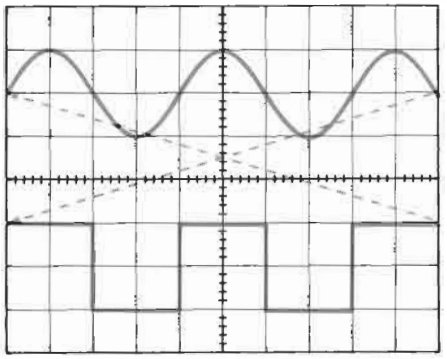


COMBINED OPERATIONS

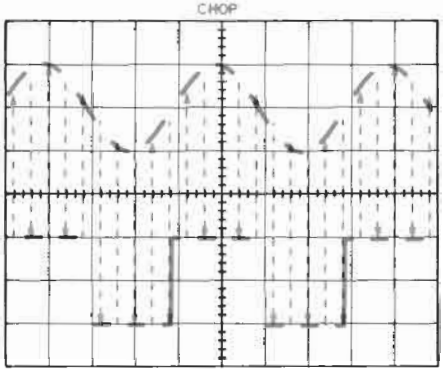


In the dual channel versions, both channels operate identically. The **A/B softkey** selects channel A, A and B or B.

The **ALT/CHOP softkey** selects the ALTernate or CHOPped mode for tracing two or more signals. In the ALT mode, the CRT beam alternately traces one signal sweep and then the other. At low repetitition rates this writing action can be seen, so ALT is mainly used for high-speed signals (about 0.1 ms/div and above).
In the CHOP mode, the beam chops from one signal to the other at a fast switching frequency and is therefore suitable for low-speed signals and the only possible mode for single-shot events.



CHOP



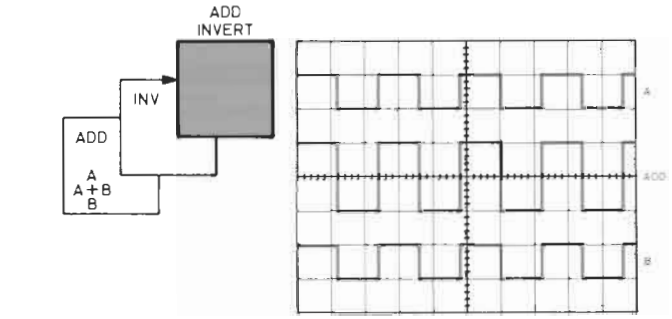
A+B, A−B AND TRIGGER VIEW

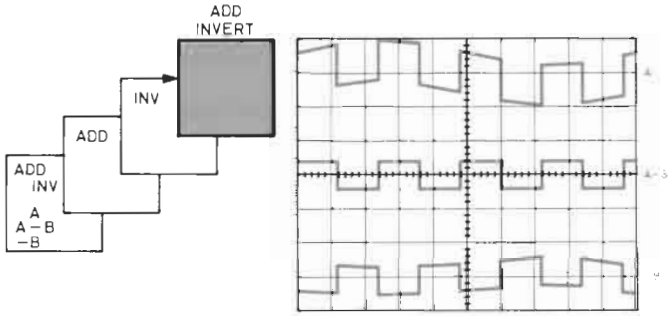
Signals added or subtracted

The **ADD/INVERT softkey** function enables algebraic combinations of the A and B signals to be displayed as a third signal. Its position is influenced by both the A and B position controls (Y POS).

A and B ADD in the LCD panel displays A, B and A+B.

A and B ADD INV in the LCD panel displays A, B and A−B.
This differential mode (A-B) is useful for rejecting common-mode signals. By measuring in differential mode, the common-mode signal present on one channel cancels out the common-mode signal on the other channel leaving the real signal visible on the display. A typical application of this is the elimination of hum.

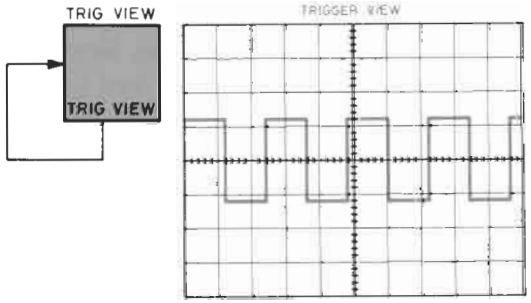




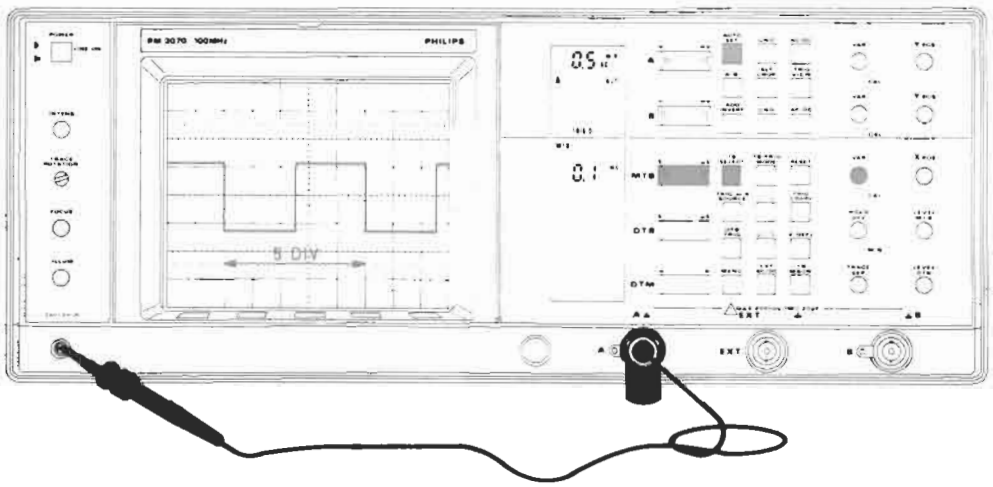
Displaying the trigger signal

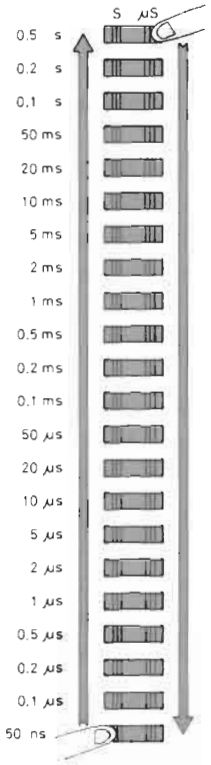
The **TRIG VIEW softkey** enables display of the actual signal used for triggering the instrument (see Trigger Modes, page 20). It shows the triggering conditions for the time-base.

TRIG VIEW may also be used as a third channel in addition to channels A and B. In this event, input is via the EXT socket and the **TRIG** or **X SOURCE softkey** function must be selected.



THE TIME SCALE (X-AXIS)





The horizontal time axis deflection coefficients of the display are set by a rocker control. For the moment we will consider the main time base (MTB). The scale is from 50 ns/div to 0.5 s/div in a 1-2-5 step series. Simply press left (s) for a slower time-base and press right (μs) for a faster time-base.

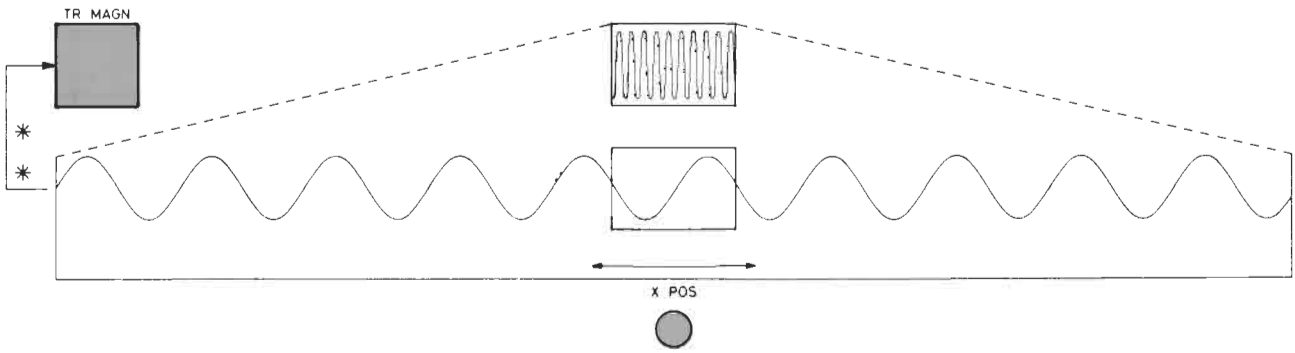
The VAR control gives a variable, fine adjustment between steps but **must be set to its clockwise CAL position for calibrated measurements.**
A flashing " > " before the range value warns that the VAR control is not in CAL position.

Example:
Connect the CAL signal to A and select AUTO SET to prove the method of calculating the period and frequency of a signal.
Ensure that the VAR control is fully clockwise at the CAL position.

The MTB scale setting in the LCD shows 0.1 ms and one complete square-wave occupies 5 divisions:
5 div x 0.1 ms/div = 0.5 ms
From this period the frequency of the square-wave is calculated as:
1/0.5 ms = 1000/0.5 = 2 kHz.

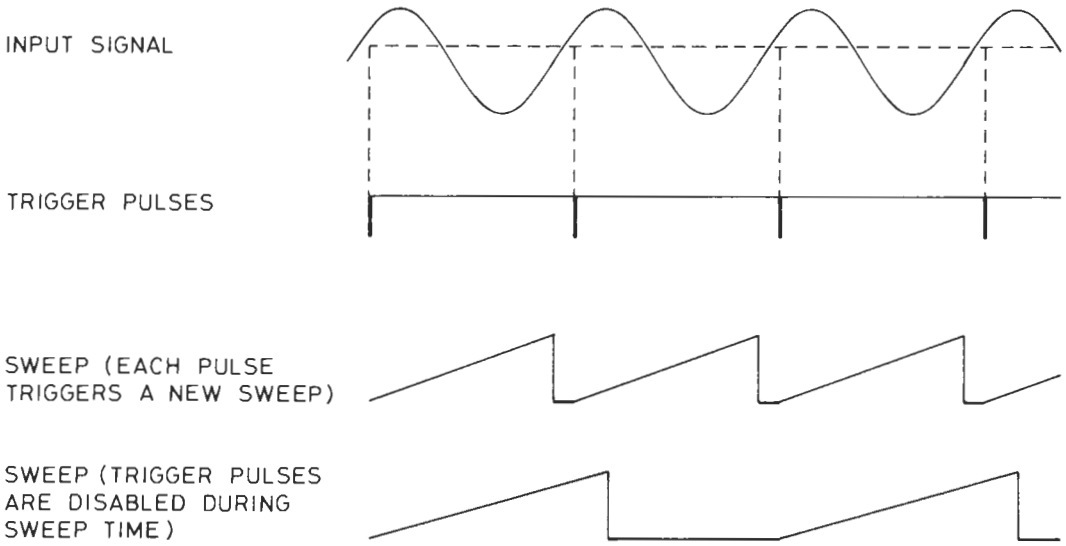
This method can be applied to determine the frequency of any waveform.

MAGNIFYING THE TIME SCALE



Pressing the **TB MAGN softkey** magnifies the X time-base by a factor of 10, indicated by a "*" in front of the new deflection factor shown in the LCD. For example, a 0.2 ms deflection reads *20 μs after pressing TB MAGN.
As shown, the signal is stretched out in the horizontal direction. The advantage of using TB MAGN over setting the time-scale to a faster setting with the rocker switch is that the viewing window' can now be moved along the original signal (now expanded in time) using the **X-POS control**. Every part of the original signal can, therefore, be seen in much greater detail.

GETTING A STABLE DISPLAY



About triggering

For repetitive signals, a stable, jitter-free display will only be obtained if each horizontal left-to-right sweep is started (triggered) at precisely the same point on the signal waveform.

A trigger pulse, usually a sample of the input signal, is used to start the time-base when the pulse crosses a certain pre-determined **level**, either on the signal's positive or negative **slope.**

At the end of each sweep, the trace is blanked and the spot is quickly brought back (the flyback). It will start the sweep again on receipt of a trigger pulse at exactly the same point as before.

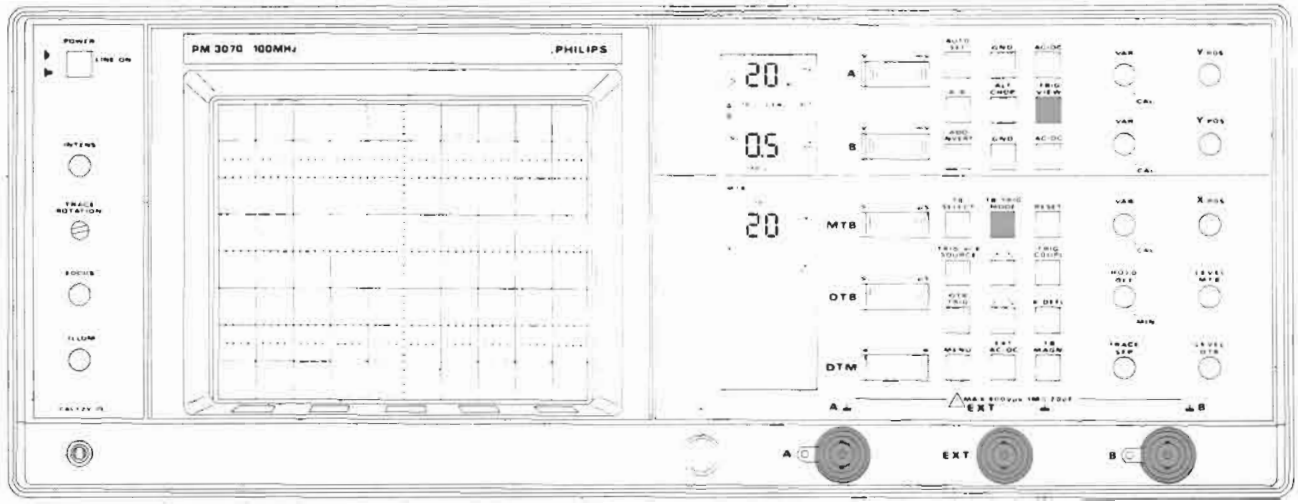
It is important that any trigger pulses that occur during the sweep or flyback should have no effect.

This situation is possible if several waveforms are displayed on the screen (see Hold-off, page 25).

Steps to successful triggering

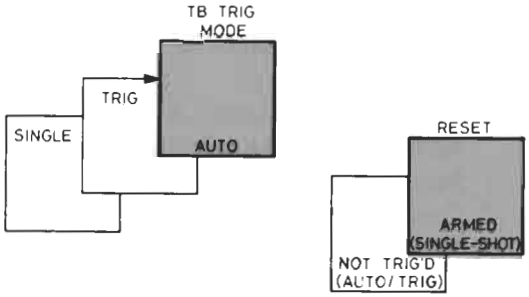
1. Select the trigger source:
   Either of the two input channels A or B, an external signal or a signal derived from the mains (see Trigger Source, page 22).
2. Select trigger coupling:
   Decide if the whole signal has to be passed (DC) or if it has to be filtered; i.e. pk-pk, TV Line or TV Frame pulses (see page 23).
3. Select trigger level and slope on the input signal at which the sweep should start (see Trigger Level and Slope, page 24):

MAIN TIME-BASE TRIGGER MODES

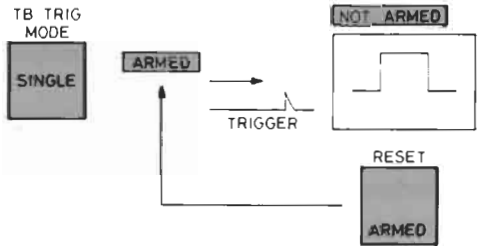


With AUTO SET selected, the MTB is free-running (AUTO) in the absence of trigger signals.

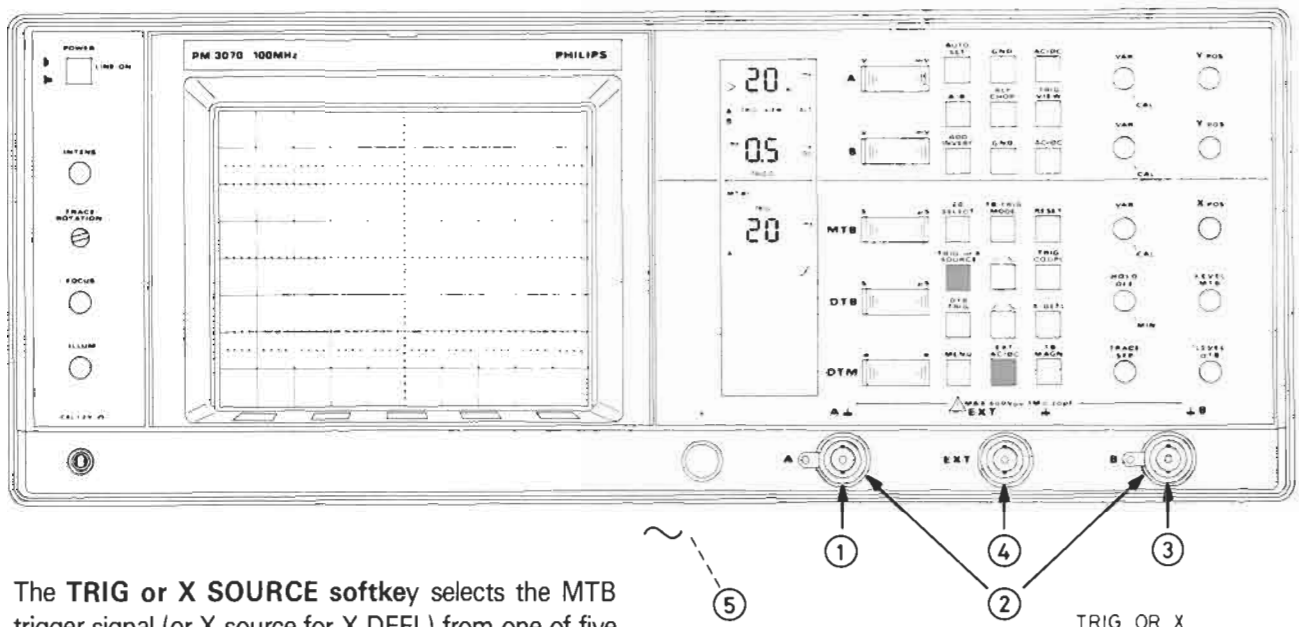
The **TB TRIG MODE softkey** can be used to select:
– AUTO mode: free-running. The connected signal is always displayed.
– TRIG mode: the MTB will only start on a suitable signal derived from a selected trigger source (A, B, EXT or LINE). Neither the MTB nor the DTB will run without trigger pulses. So when not triggered, the signal is not displayed.
– SINGLE mode: the MTB runs only once after the receipt of a trigger pulse.
The required trigger level can be set up beforehand in the TRIG VIEW mode.
ARMED is displayed until receipt of a trigger.
Press RESET softkey to re-arm (ARMED) circuit to await the next trigger pulse.



Capturing single events (SINGLE-SHOT)
First set-up as for repetitive waveforms.

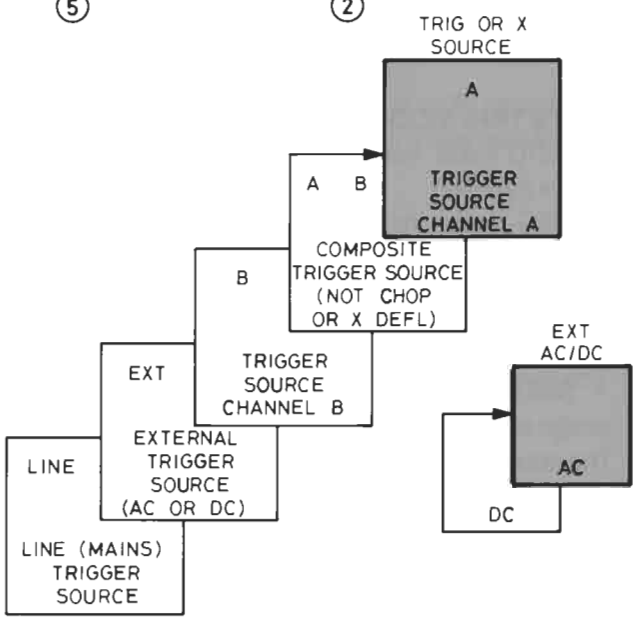


TRIGGER SOURCES



The **TRIG or X SOURCE softkey** selects the MTB trigger signal (or X source for X DEFL) from one of five sources:

1. Trigger source channel A. Two frequency related signals can be checked by triggering on the lower frequency signal of the two.
2. Composite triggering of channels A and channel B if they are not time- or frequency-related. With each ALT sweep the trigger signal is also switched to the other channel (composite not active for X DEFL or in CHOP mode).
3. Trigger source channel B.
4. An external trigger source **(EXT AC/DC softkey** selects the coupling mode). This offers the possibility to be used as a third channel.
5. A LINE trigger source derived from the internal mains supply. This is used for instance to detect whether line frequency interference is present in the signal that is being measured.



TRIGGER COUPLING

The TRIG COUPL softkey offers choice of trigger coupling:

P-P (peak-to-peak) triggering gives automatic ranging of the LEVEL control, the range being determined by the peak-to-peak value of the signal.

DC is the normal trigger coupling. All the signal including any DC component is passed.

TVF allows triggering at the slow TV Frame (Field) synchronising pulses; the LEVEL control is inoperative.

TVL allows triggering at the fast TV Line synchronising pulses; the LEVEL control is inoperative.

In addition, some oscilloscopes also have low frequency (LF) and high frequency (HF) reject filters.

Note that the ⌐¬ **softkey** selects:

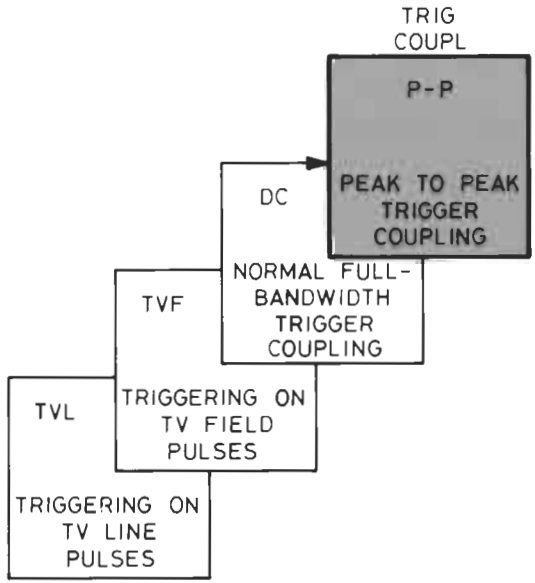
"+" (pos. video) or "−" (neg. video) if TVF, TVL or X DEFL are selected.

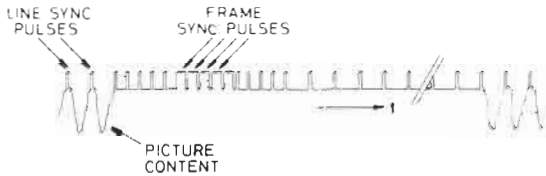
More about TV Triggering

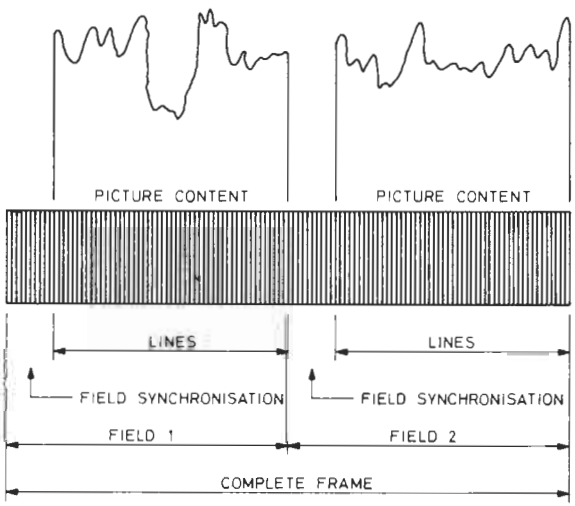
The relationship between TV Fields and TV Lines is shown. In either the TVF or TVL trigger modes the sync. pulses of the video signal are separated from the picture content and are used to derive the Field and Line trigger pulses.

All TV Field and Lines are displayed on the oscilloscope picture, i.e. they are written over each other. A single line may be selected for display by using the delayed time-base facility (see page 27).

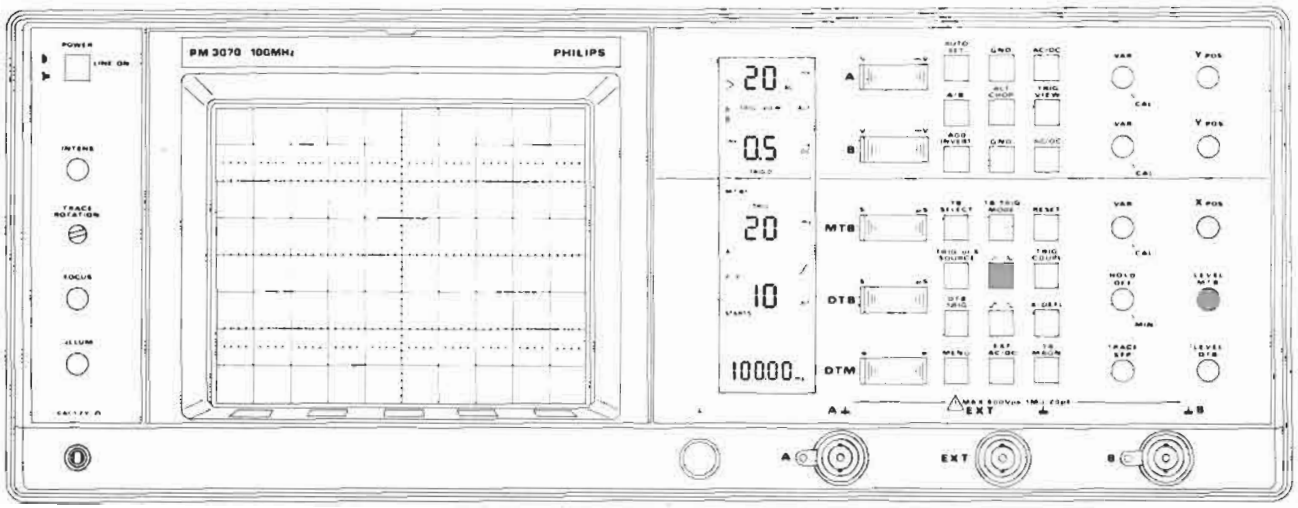
The two Field sync. pulses are necessary per frame because the lines are interlaced on television to give a more stable picture.







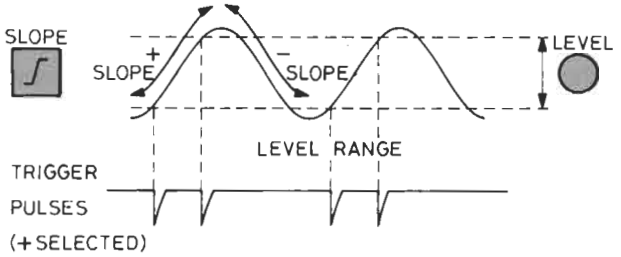
TRIGGER LEVEL AND SLOPE



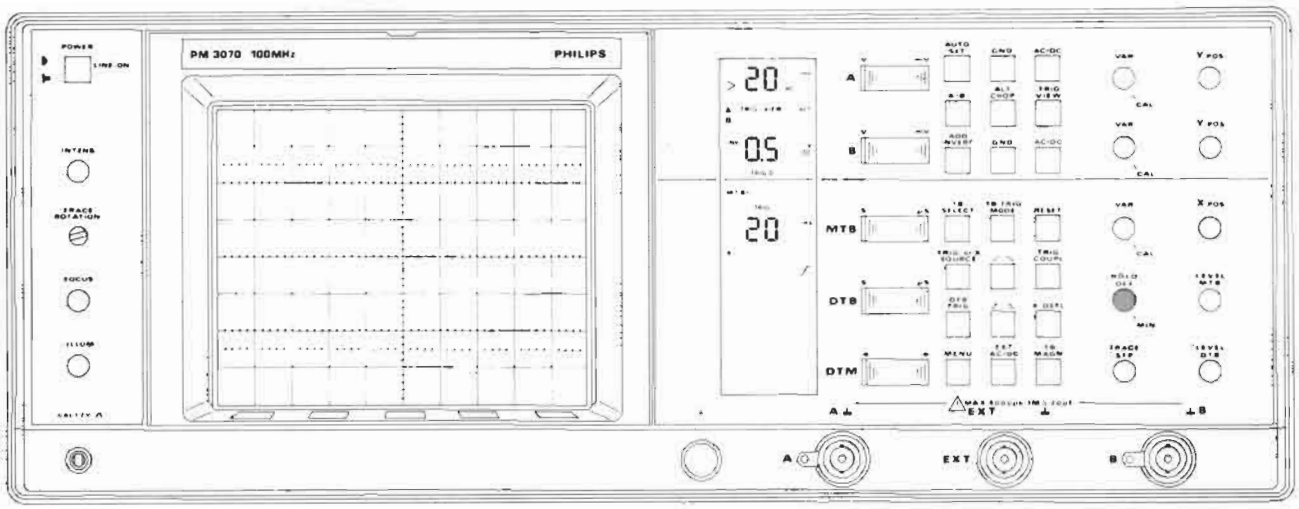
The rotary **LEVEL MTB control** allows the starting point of the main time-base display to be continuously adjusted over the signal waveform as shown.

The ⌐ ¬ **softkey** (SLOPE) can be used to choose either the positive-going slope (⌐) or the negative-going slope (¬) for triggering.

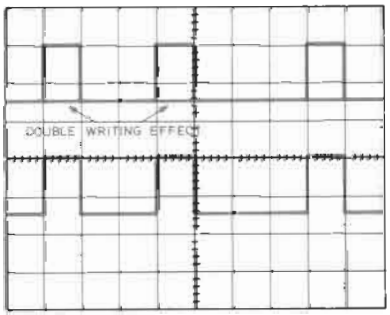
This softkey inverts X DEFL signals; it gives a "+" or "–" indication of video polarity when TVF, TVL or X DEFL are selected.



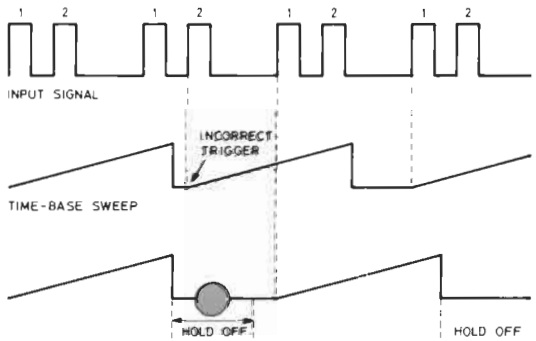
TRIGGER HOLD-OFF



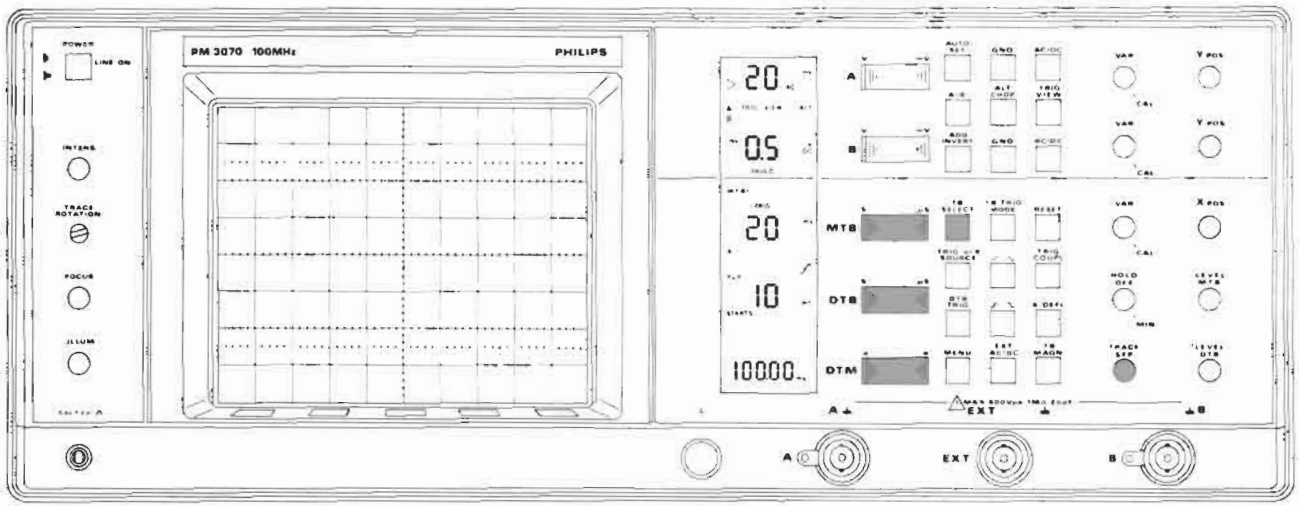
The HOLD OFF control is used to prevent trigger signals from interfering with the start of the sweep; i.e. it prevents triggers before the time-base sweep is complete, so eliminating the problem of "double-writing" when displaying multiple pulse signals. If double-writing occurs, the HOLD OFF control is adjusted from MIN until the overlap on the base-line disappears.



Example: The double pulse input signal means that the selected trigger signal sees the same conditions on the second pulse as the first and so starts the time-base too soon. The double-writing effect is seen as an extended base-line on the upper trace.
Adjusting the hold-off time will inhibit the trigger until it sees the first pulse again and over-writes it exactly, as in the lower trace.



CHOOSING TIME-BASES



So far we have concerned ourselves with the main time-base (MTB).

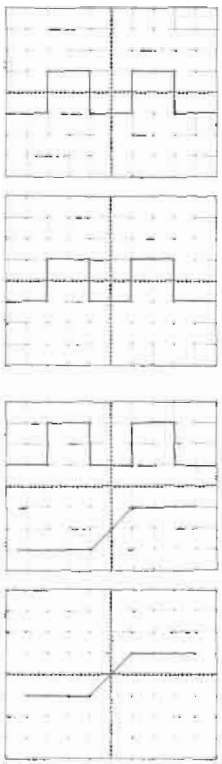
The **TB SELECT softkey** gives choice of four different horizontal display modes:

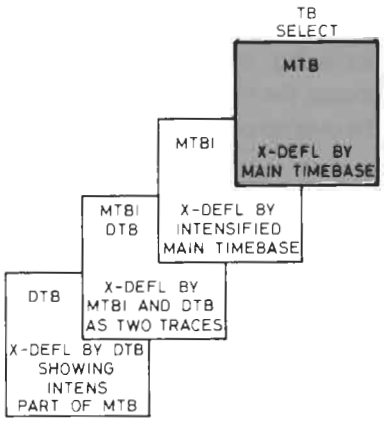
MTB - deflection by the main time-base.

MTBI - deflection by the intensified main time-base. This provides a method of locating any part of the signal that needs to be displayed by the delayed time-base.
The **DTM rocker** (Delay Time Multiplier) controls the delay time.

MTBI DTB - two traces: deflection by MTBI (intensified main time-base) and by DTB, the delayed intensified portion of the time-base.
TRACE SEP controls vertical shift of DTB trace.

DTB - deflection by the delayed time-base (the selected intensified part of the MTB).



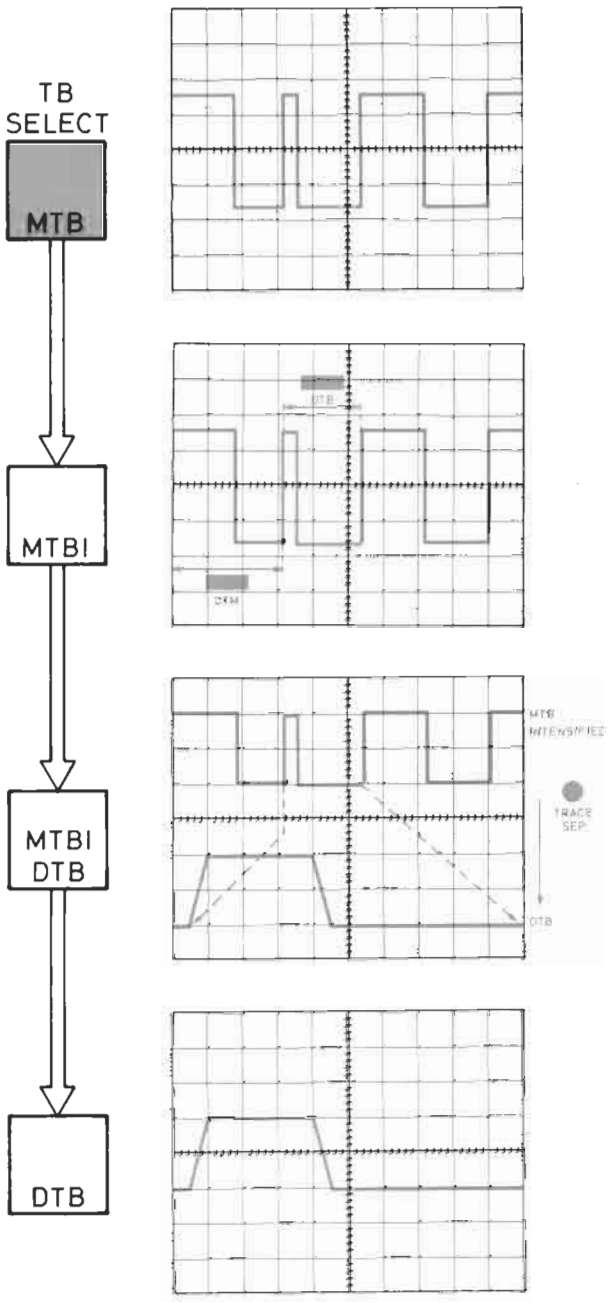


LOOKING FOR SIGNAL DETAIL

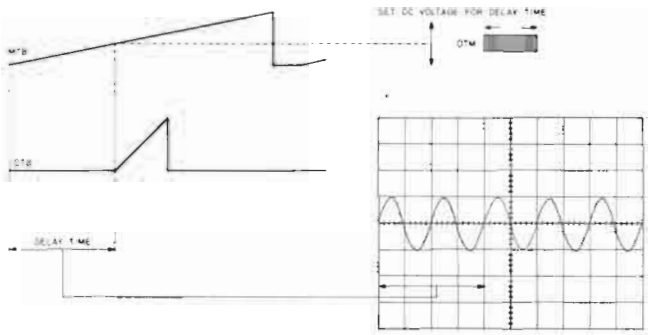
Searching for a particular part of a magnified signal can be difficult. The Main Time-Base Intensified (MTBI) facility offers a means of marking the area of interest on the main signal. The selected deflection coefficient of the Delayed Time-Base (DTB) will determine the length of the intensified part.
Its position is set by the **DTM (Delay Time Multiplier)**, which delays the start of the DTB to the selected value (shown in the LCD panel). The delayed time-base then automatically displays in detail the selected intensified part of the main time-base.

Example:

- Select AUTO SET and press the TB SELECT softkey to display MTBI.
- Set the length of the intensified part with the DTB rocker switch.
- Press DTM rocker switch to shift the intensified part to the signal area of interest.
- Press TB SELECT to display both time-bases (MTBI DTB).
- Use TRACE SEP rotary control to separate the traces.
- If necessary, use DTB rocker switch to adjust range.
- Press TB SELECT to display DTB only.

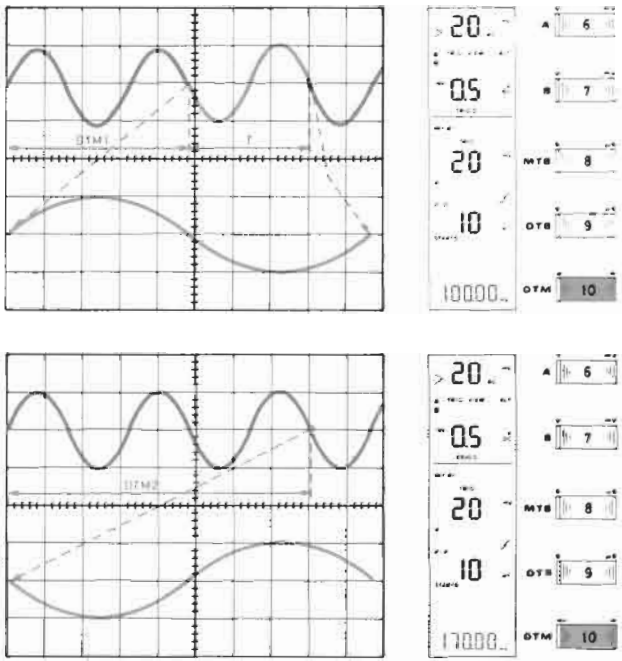


TIME MEASUREMENTS WITH THE DTB

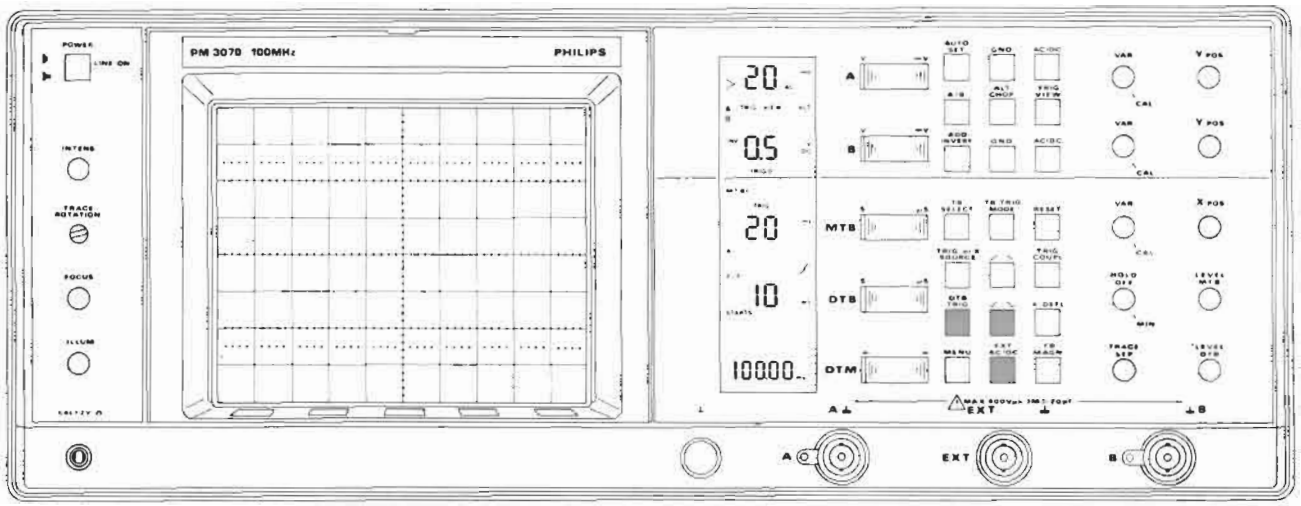


As stated, delay time can be read directly from the LCD. To measure an interval of time T, say a period of a displayed waveform, read off the start of the period, DTM1, then set the intensified starting point with the DTM rocker to the the end of the period and read off DTM2. The required T measurement is then given by DTM2-DTM1.
Example below:
170.00 - 100.00 = 70 ms.

As the DTB can be started anywhere along the MTB waveform (DTB control is electrically-coupled to the MTB up-down control), it provides a precise means of measuring time intervals. The DTM (Delay Time-base Multiplier) rocker control is used to step change the delay. The starting point is determined by comparing the MTB sweep voltage with an accurately controlled DC voltage, set-up by the DTM rocker control. At the point in the sweep where this adjusted DTM voltage is equal to the MTB value, the DTB starts as shown. The delay time can be read from the LCD display, which is time-related when the MTB is calibrated and when STARTS is selected as DTB trigger source. The LCD is division-related when the MTB is not calibrated or when DTB is in triggered position.

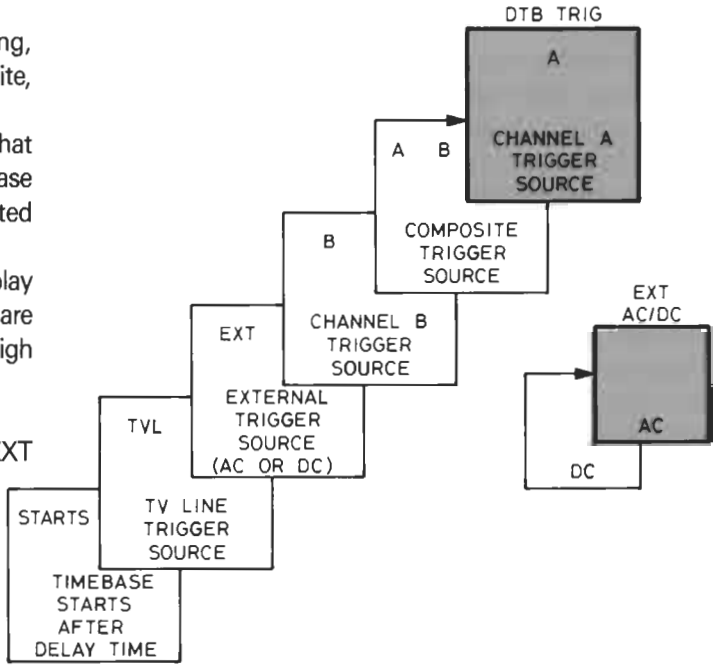


DELAYED TIME-BASE TRIGGERING

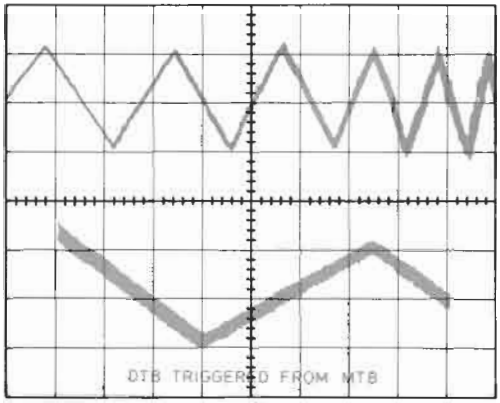


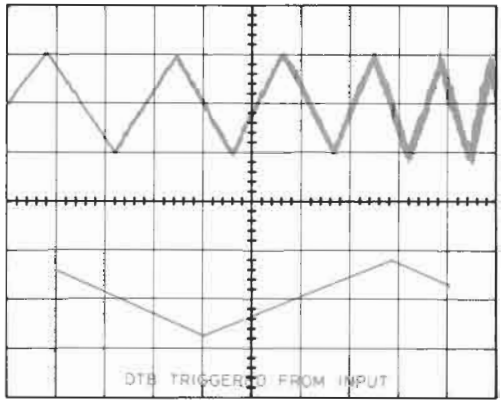
The DTB triggering is independent of the MTB triggering, but offers similar facilities: Channel A, composite, channel B, EXT, TVL.
There is also a "STARTS" trigger facility. This means that in the MTBI or DTB mode the delayed time-base generator starts immediately after the delay time selected on the DTM rocker control.
DTB triggering avoids (time) instability of the display (jitter), which may be present when short DTB times are used in relation with the MTB time/div to get high magnification.

Note that the EXT AC or EXT DC are selected by the EXT AC/DC softkey.



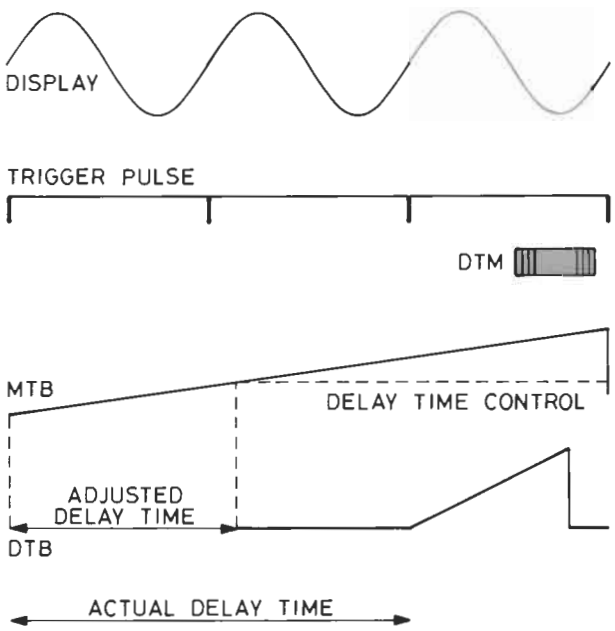
TRIGGER DELAY FOR JITTER-FREE DISPLAY



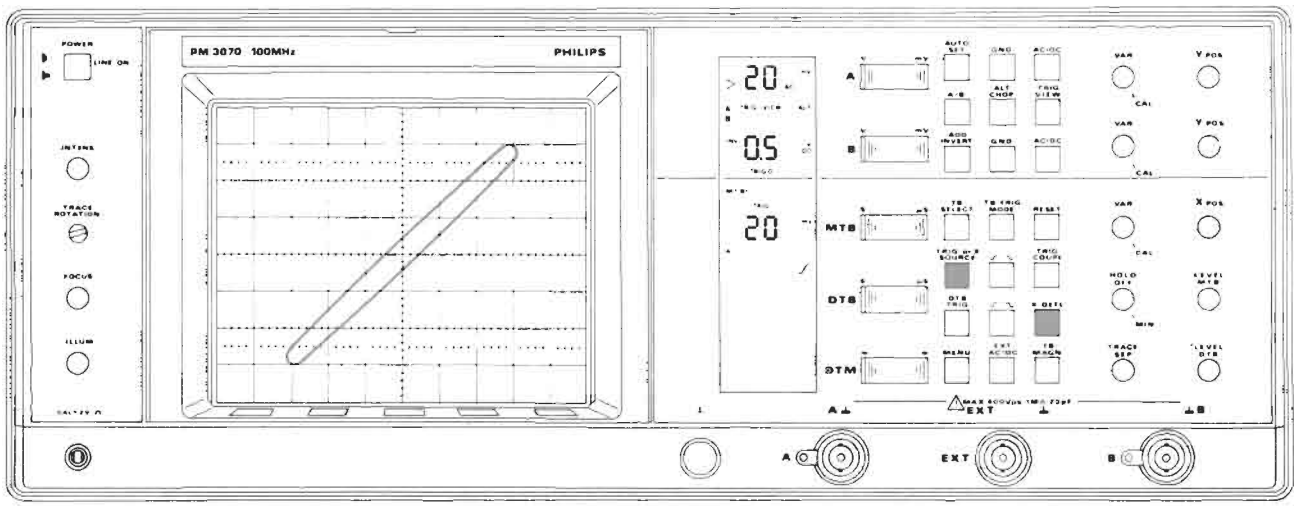


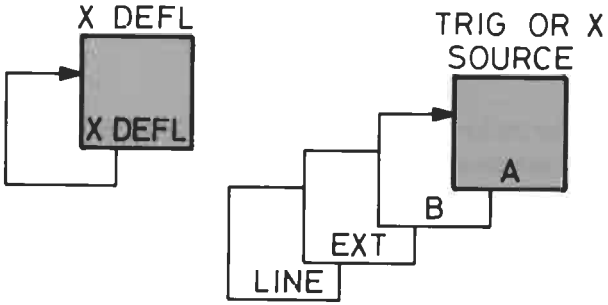
Some instability may be present in such input signals as long pulse trains, where the time between successive pulses is not constant. This could result in jitter when examing say a single pulse if the DTB is triggered by the MTB, because the trigger point is fixed; i.e. the DTB starts whether or not the starting point of the pulse under observation is present.

However, if the DTB is triggered independently from the input signal and not from the MTB, a stable display is obtained. Here the actual trigger delay consists of the adjusted delay time plus the time taken for the next trigger pulse to appear; i.e. the DTB waits for the signal.



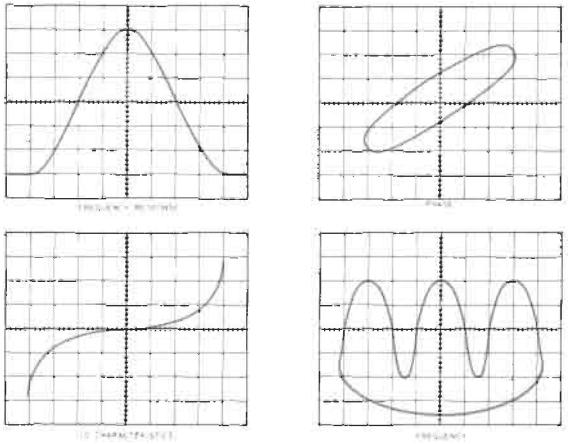
X-Y DISPLAYS (X DEFL)



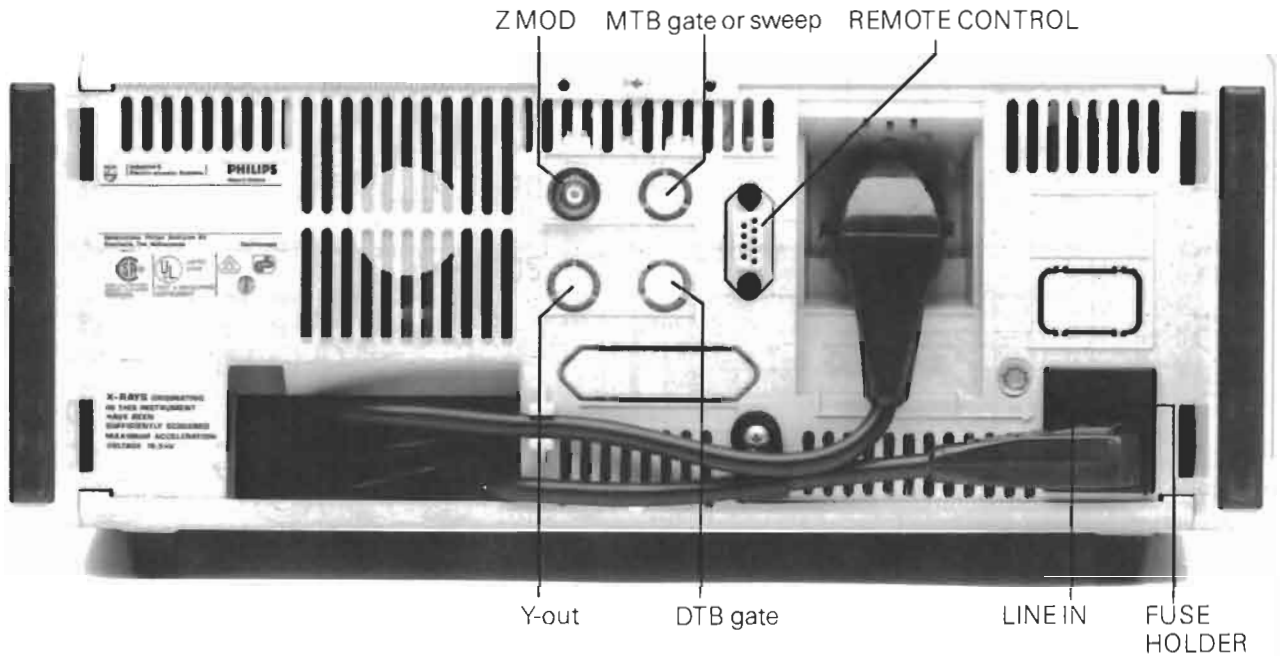


So far we have displayed signals as a function of time (the familiar Y-t graph).
However, the **X DEFL softkey** allows one signal to be displayed as a function of another.
The required X-axis signal is selected by the **TRIG or X SOURCE softkey** (A, B, EXT or LINE).
Channels A and B offer a wide range of sensitivities, whereas the EXT socket input has a fixed amplitude.

The X-Y mode has a wide range of applications, for example:
- amplitude vs. frequency of circuits and filters;
- output current vs. input voltage of semiconductors;
- Comparison of frequency or phase shift using Lissajous figures.



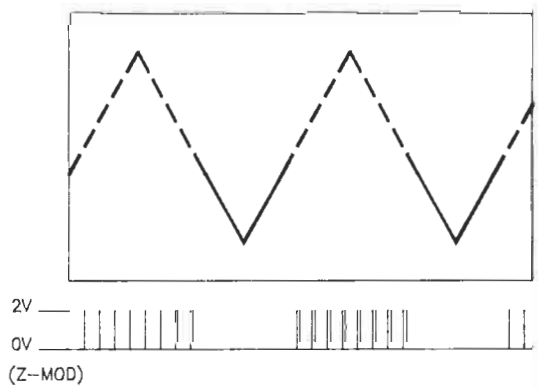
EXTRA TIMING WITH Z-MODULATION



After the forward sweep, the display is blanked during the flyback time so that there are no unwanted traces on the screen as the beam returns to the start position - for the same reason you take your pen off the writing paper between lines!

However, this beam on/off facility can also be usefully employed during the forward sweep to display markers on the trace, for example a clock signal, or a signal to suppress non-relevant sections of the trace.

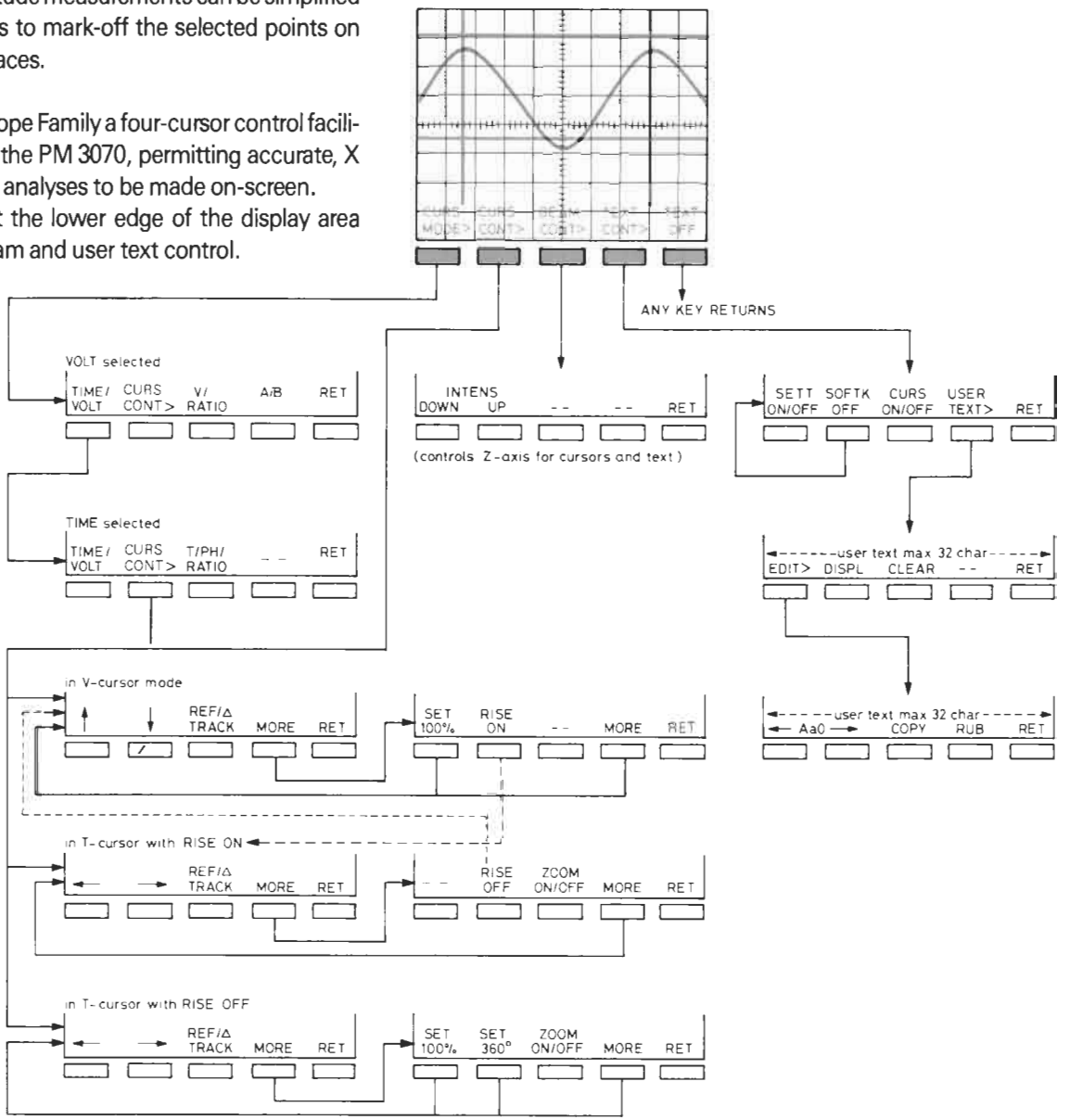
This is done by applying the required blanking signal to the Z-MOD BNC-input on the rear panel. The input is TTL-compatible. Blanking occurs when the signal exceeds 2 V.



EXTRA MEASURING FEATURES

Time and amplitude measurements can be simplified by using cursors to mark-off the selected points on the displayed traces.

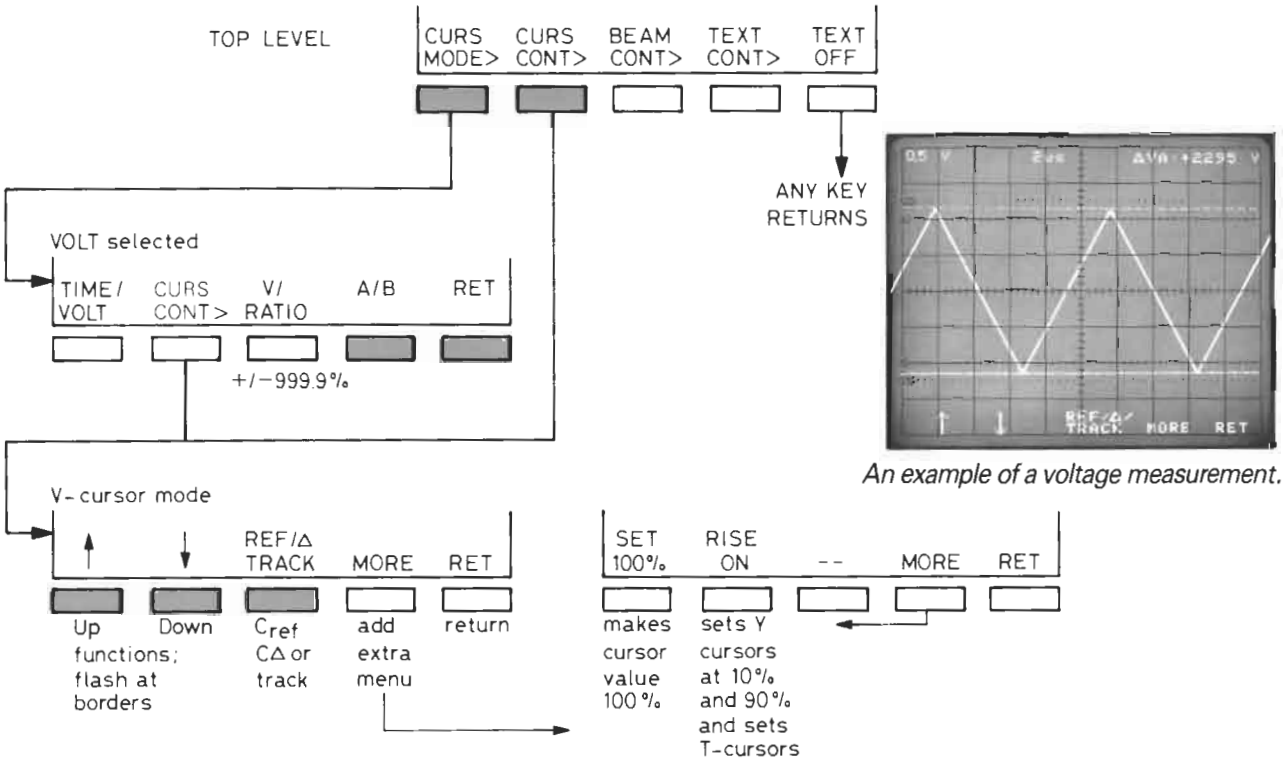
In the Smart Scope Family a four-cursor control facility is featured in the PM 3070, permitting accurate, X and Y error-free analyses to be made on-screen.
Five softkeys at the lower edge of the display area offer cursor, beam and user text control.



VOLTAGE CURSORS

The CURS MODE softkey gives a choice of VOLT or TIME cursors. The default position gives VOLT cursors. This is indicated and set in the submenu by 'VOLT' intensified. The readout can be chosen to be in volts or as a % ratio by selection of V/RATIO softkey. The A/B softkey determines the channel selected for the cursors. With the functions set, press RET to return to the top menu level.

The CURS CONT softkey controls and activates the special functions of the chosen cursor mode.
The Volt Cursor submenu.

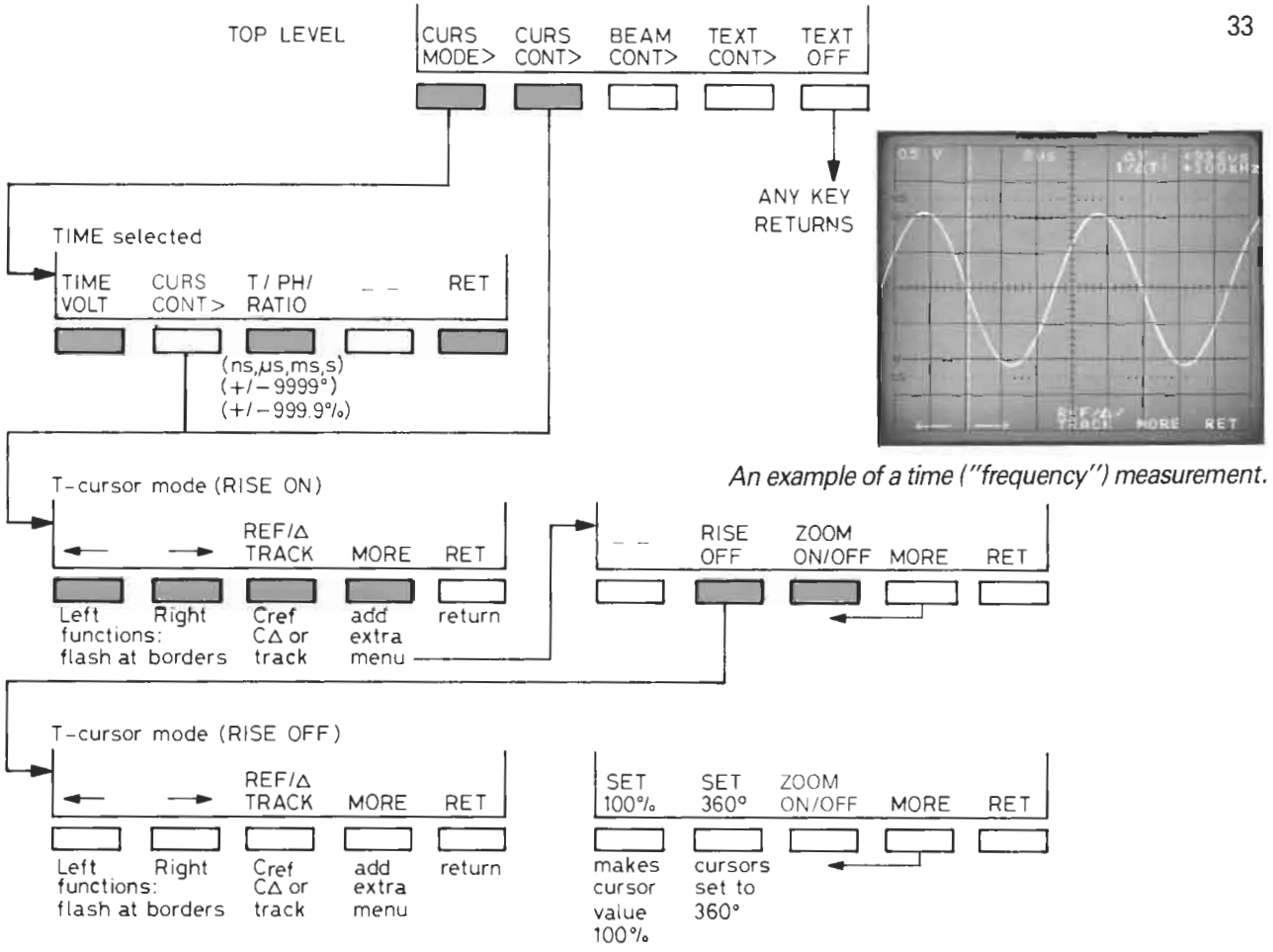


An example of a voltage measurement.

TIME CURSORS

The CURS MODE softkey gives a choice of VOLT or TIME cursors. Depress the softkey to indicate and set 'TIME' intensified. The readout can be chosen to be in time, phase or as a % ratio by selection of the T/PH/RATIO softkey.

The CURS CONT softkey controls and activates the special functions of the chosen cursor mode; the Time Cursor submenu.

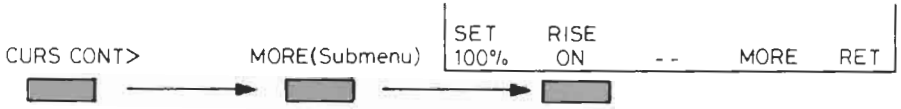


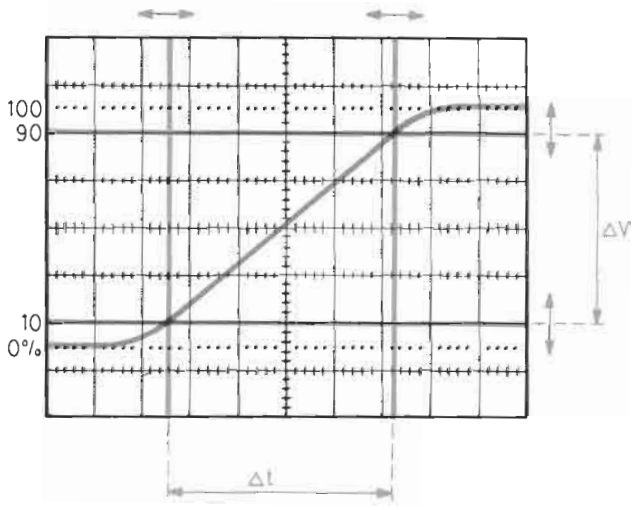
An example of a time ("frequency") measurement.

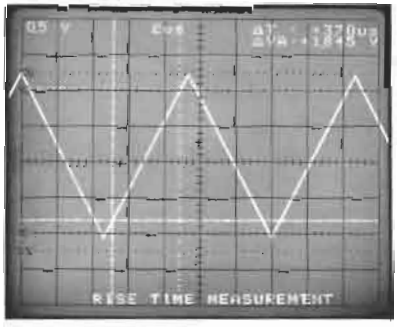
RISETIME FUNCTION (dV/dT)

The CURS CONT softkey controls and activates the special functions of the chosen cursor mode. After selecting V-cursors (CURS MODE) and having adjusted the cursors to the peak-peak values of your trace, to measure RISETIME, press submenu softkey MORE and select RISE ON.
When activated, this function:

- sets the Y-cursors at 10% and 90% of the old Y-cursor values.
- sets the T-cursor to give control by two extra cursors, which must be placed at the intersection of the trace and Y cursors.
- gives the dV, dT values in the readout.
- Risetime is dT at 10% and 90% of dVp-p







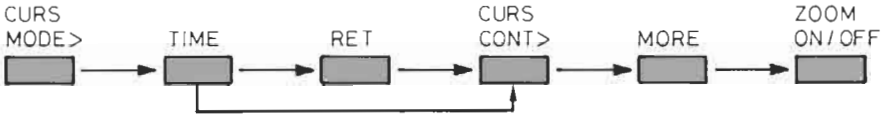
A rise time measurement.

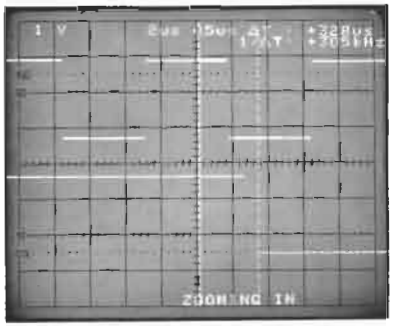
ZOOM FUNCTION

The CURS CONT softkey controls and activates the special functions of the chosen cursor mode. The ZOOM function is useful for taking a closer look at detail in the Time-cursor mode.
Selecting this softkey results in the following:

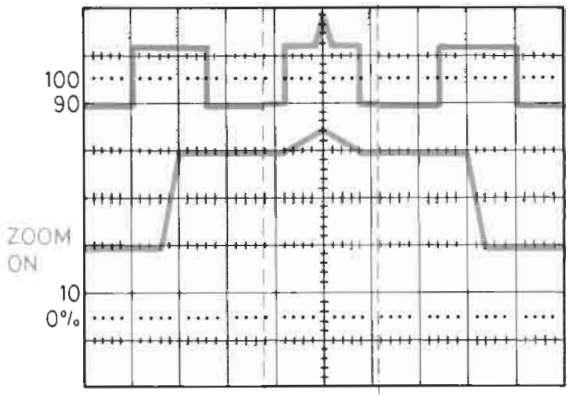
- the DTB is selected
- the DTM (delay time multiplier) control is set to the position of the first (reference) cursor.
- the DTB speed is set to the fastest position so that the two cursors fall in the intensified part of the MTB sweep.

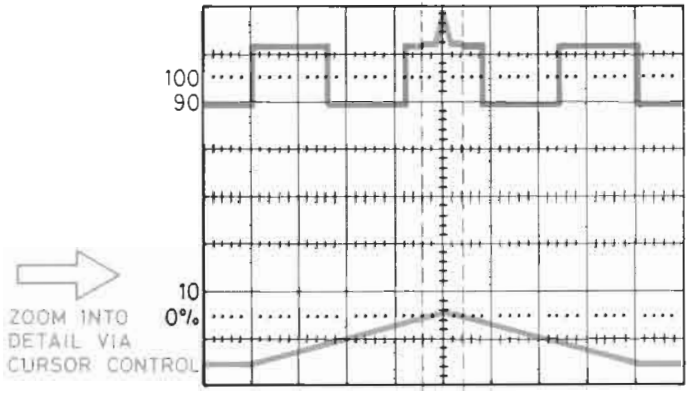
The cursors can then be set manually to zoom into the particular detail required.





Zooming in on a signal detail.





USER TEXT

The user text facility enables details to be added to a display for identification purposes or to include extra information. It is very useful when the oscilloscope forms part of a system; e.g. via the IEEE-bus. It enables the user to take screen photo's with on-screen comments.