THE USE OF OSCILLOSCOPES FOR TV WAVEFORMS

INTRODUCTION

You probably think you know how to use an oscilloscope. Don't worry this practical isn't about simply using an oscilloscope. It is concerned particularly with the display, interpretation and measurement of T.V. waveforms. In order to understand why the display takes on a particular form it is necessary to know how parts of the oscilloscope work. The practical will also teach you something of the workings of the scope therefore, as well as its use.

You will be left very much to your own devices during the practical. To help you monitor progress there are questions throughout the text. Answers to these, together with summaries of the points covered, will be found at the end of the work sheet. If you cannot answer the question, or your answer and/or observation differs from the answer given, then consult your supervisor for help.

The practical is designed to last 2 sessions, with each session on a different scope. The division between the two parts is not rigidly defined however, and after section 5 has been completed you can continue on the second scope. You should certainly aim to reach section 6 by the end of the first session. For revision purposes all points covered up to section 6 can be checked on either oscilloscope, only section 7 needing the more advanced instrument.

1. EQUIPMENT PROVIDED

Philips PM3215 Oscilloscope
Philips PM3262 Oscilloscope or similar
Timebase Chassis
x10 Probe
Dummy Jackfields
Wander leads
Video leads and terminations

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2. BASIC THEORY

Figure 1 represents a simple oscilloscope block diagram.

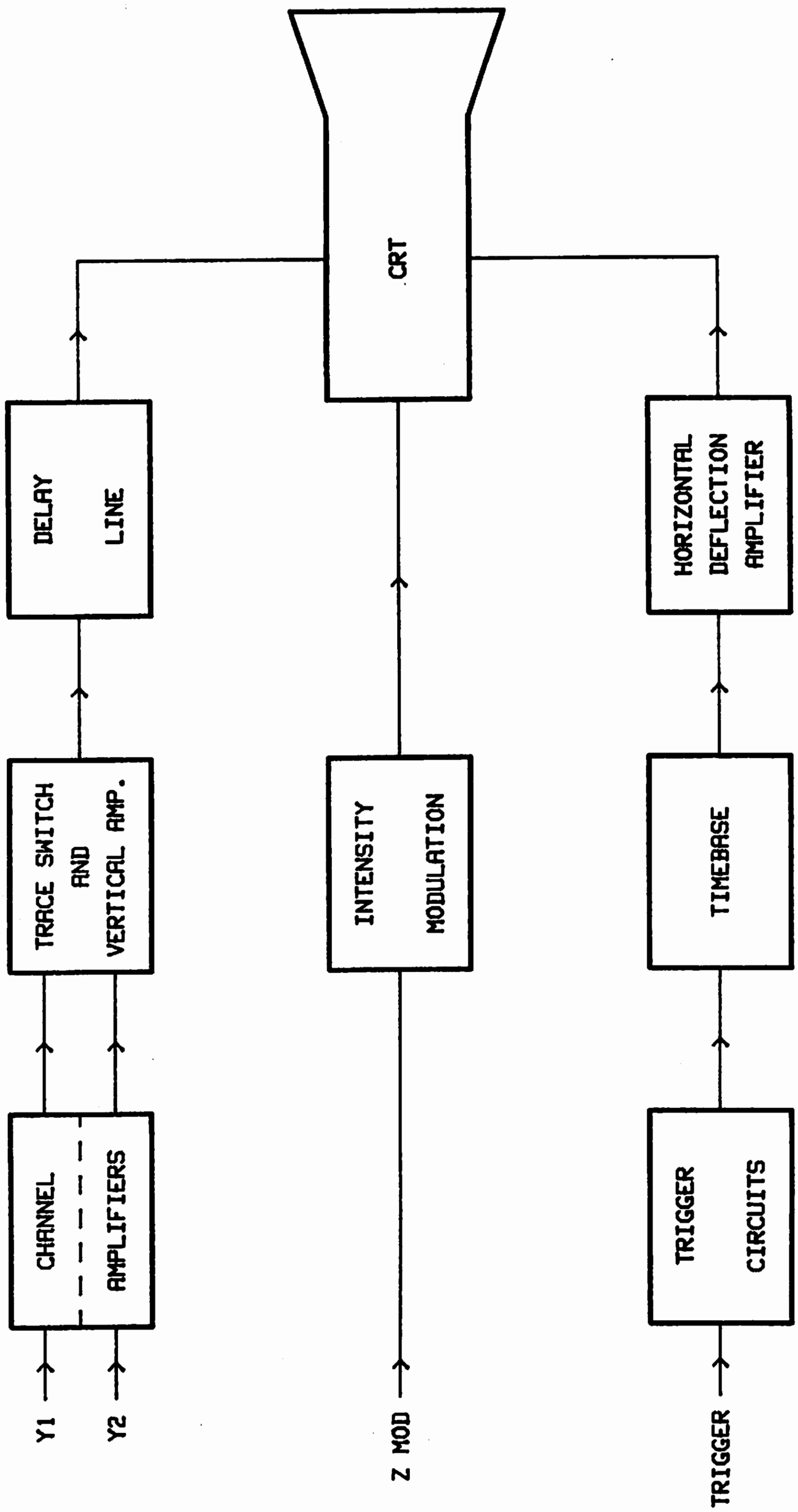


Fig 1. Simple Oscilloscope Block Diagram.

The oscilloscope can be broken down into four components:

CRT Display
Horizontal Deflection
Trigger Circuit
Vertical Deflection

The CRT display block contains the tube and its associated circuitry. The X and Y deflection plates are driven from the horizontal and vertical deflection systems respectively. Beam blanking and/or intensity modulation facilities will almost certainly be provided.

The horizontal deflection system contains the amplifiers which raise the horizontal deflection signal level to that required by the X plates. By far the major component of the horizontal deflection system is the timebase, which provides the linear horizontal sweep signal.

The trigger circuits afford the means whereby the horizontal sweep can be synchronised to some external stimulus. It determines the source of the trigger information, the sensitivity, and just what aspect of the external signal is to be used - e.g. dc level, line sync pulses etc.

The amplifiers in the vertical deflection system amplify the (typically) small input signal to the high level demanded by the plates. Input attenuators cope with a wide range of input levels. An electronic switch will almost certainly be included to enable the vertical deflection to be shared between two or more inputs.

This practical basically follows the block diagram as described above, concentrating on each part of the scope in turn. The final part of the experiment is concerned with the use of scopes which have dual timebase facilities.

3. CRT DISPLAYS X - Y PLOTTING

This part examines the basic display and X - Y deflection systems.

Disconnect any input leads. Locate the vertical mode buttons and select channel A only. Study the horizontal deflection controls and select external X deflection on the timebase control, and EXT on the Trigger /X Deflection Selector. Also select DC on the trigger selector. Centre the horizontal and vertical shift controls and turn up the intensity to a reasonable but not excessive level. If all has gone well you should see a spot somewhere near the centre of the screen. (If you cannot see a spot re-check the above. If still no spot then help!.....).

The shift controls can be used to move the spot anywhere on (and sometimes off!!) the display. The deflection system essentially amplifies the difference between the input signal and a dc derived from the shift control. See figure 2.

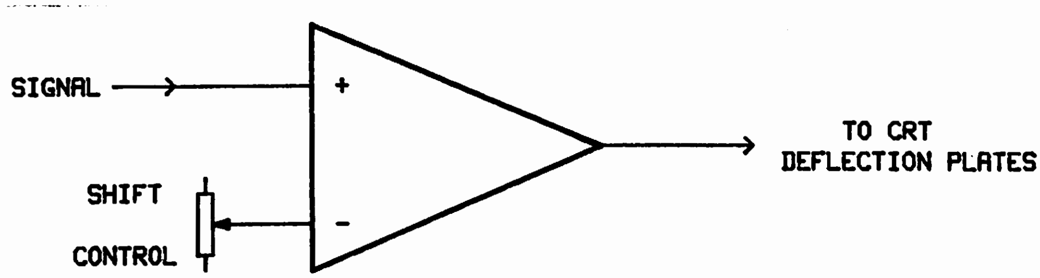


Fig 2. Basic Deflection System.

The horizontal and vertical deflections can thus be likened to the X and Y axes of a graph, and display the instantaneous amplitude relationship between the horizontal and vertical input signals.

Q 3.1 What common television monitoring unit uses an oscilloscope display in a simple X - Y plot mode?

Q 3.2 What signals are fed to the X and Y inputs of such a unit?

Using a simple wander lead, (not a probe), connect the calibration square wave ouput to channel A input. Adjust the input attenuator to produce a reasonable size of display.

Q 3.3 What is displayed on the CRT?

Q 3.4 Explain.

N.B. If the display is not vertical check that EXT has been selected on the X deflection selector.

Few applications are encountered however where a direct display of the amplitude relationship of two signals is required. Most displays show the form of the signal as observed over a finite period of time.

3.1 Why Two Y Inputs?

Once the means of displaying the form of a signal over a period of time is provided a whole new range of operations is possible. It is extremely useful if, as well as displaying a signal over a period of time, it can be compared with a second. In order to achieve this the vertical deflection system is time shared between the two inputs. An electronic switch connects each input in turn to the display. In its simplest operation the switch is operated by a very high frequency square wave which is unrelated to the input signals. This display mode is called CHOP. Section 6 covering the vertical deflection will examine dual trace operation in more detail.

4. HORIZONTAL DEFLECTION

In order to display the form of a signal related to time one of the display axes must vary as a function of time. Conventionally the horizontal deflection is time related. As deflection is proportional to the input signal voltage it follows that a voltage which varies as a predictable function of time is required. This is best provided by a linear voltage ramp, and is generated by the timebase.

4.1 Simple Timebase Circuit

In this part of the practical a simple timebase will be built-up from its component parts. The experiment chassis contains those elements essential to any timebase.

The first use of the chassis demonstrates the relationship between position and horizontal deflection voltage. Remove all leads from the chassis and connect the ramp CRO output to the X deflection input. Select slow speed operation. The meter on the chassis now indicates the deflection voltage relative to its centre screen value. Hold down the ramp reset button and adjust the oscilloscope X shift to position the spot on the left hand side of the screen. Release the reset button and observe the relationship between the deflection voltage and position.

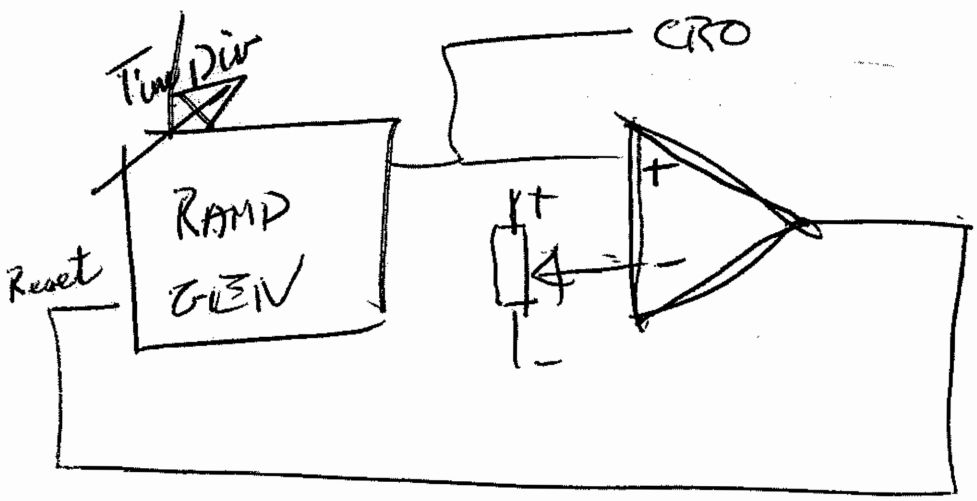
Adjust the time/div control on the chassis and re-start the ramp generator with the reset button.

Q 4.1 How is the deflection voltage amplitude for a given deflection related to the sweep rate?

This is an important factor in the operation of the timebase. It means that the capacitor charging current can be varied to change the rate of the ramp without worrying about its amplitude. Once the ramp has reached a level sufficient to deflect the trace to the right hand side of the display the ramp can be stopped and reset ready for the next sweep.

Q 4.2 How can the timebase tell when the right hand side has been reached?

You should now be in a position to construct, using the chassis, a simple free running timebase. Do this and check that it operates as you expect. Sketch the circuit in the space provided below.



Try also using the timebase on its fast speed setting - a conventional straight line sweep should be seen. (The deflection volt meter is disabled in the fast mode).

4.2 Synchronising The Timebase

If the timebase is to enable a study to be made of the amplitude-time characteristics of a signal the sweep rate must be related to the signal being investigated. This implies synchronisation of the sweep with the repetition rate of the signal under test.

Connect the staircase signal output from the chassis to channel A of the scope. This is a staircase at about television line frequency. Try and display one cycle of it using your simple time base.

Q 4.3 Apart from the difficulty of obtaining a steady trace, what display imperfections can you see?

FLY BACK

This point will be covered in a later section.

In order to synchronise the timebase its cycle of operation must be stopped at some point. A trigger pulse derived from the signal being investigated is then used to restart the cycle. (This is different to most T.V. receivers where a phase locked loop is used for the horizontal deflection).

Q 4.4 At which point in the timebase cycle should operation be stopped?

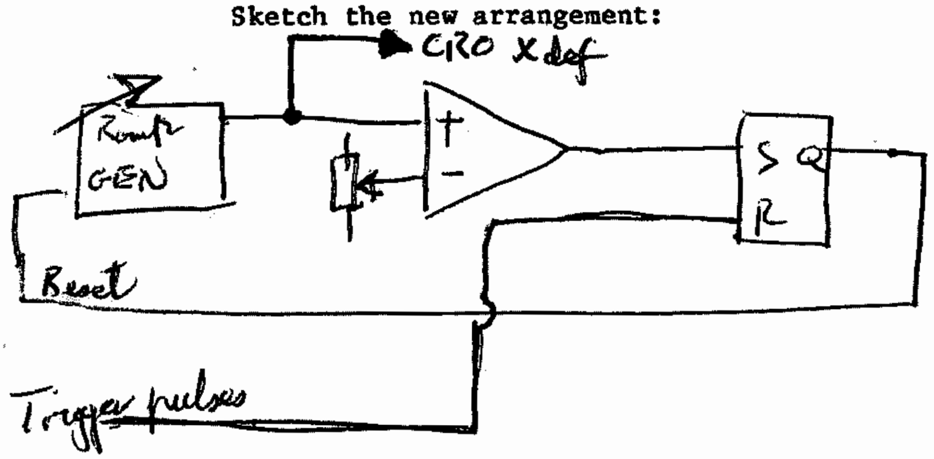
Just after flyback

Q 4.5 Why?

Soas it is ready to start trace after trigger

A simple bistable may be used in order to synchronise the timebase to a feed of trigger pulses. Modify your arrangement of section 4.1 to include the bistable provided. You should now be able to synchronise your timebase to the reference trigger pulses, and so display a stable staircase waveform. (Note that the bistable and monostable on the experiment chassis are triggered by positive going edges).

Sketch the new arrangement:



Q 4.6 Is the synchronisation reliable at all settings of the time/div control. Where do any problems occur?

Your circuit arrangment is based on the assumption that as soon as the bistable is reset the timebase is ready to make a new sweep. This is not the case however as the timing circuits have to be discharged to their starting conditions. This will take a finite time, and is generally a fixed percentage of the forward sweep time.

If the bistable is set by a new trigger pulse before flyback is complete the capacitor will start to charge again but from it's present voltage, which would cause the sweep to start from anywhere in the horizontal axis.

To overcome this most timebases include a hold-off circuit which disables the trigger pulse path for a short period after the bistable is set. On some oscilloscopes the hold-off time is variable, and can be used to "block out" unwanted trigger pulses. (e.g. a line rate sweep that is triggered every other line).

Q 4.7 What determines the minimum hold-off time?

Time to discharge C in Ramp Gen

Reconnect your circuit to include the hold-off monostable, and set the hold-off control to minimum.

Q 4.8 Can you now reliably synchronise the timebase at all time/div settings?

YES

Obtain a locked, one line display of the staircase. Increase the delay introduced by the hold-off circuit.

Q 4.9 Describe precisely the effects observed as the hold-off delay is increased.

Trace gets dimmer

Q 4.10 Explain why this happens.

its waiting for a longer holdoff time i.e. display is dimmer.

4.3 Timebase Outputs

You can now use the oscilloscope to examine the waveforms associated with the simple timebase. Connect a feed of the reference pulses to the X deflection input of the scope. Turn the range switch to 10μs/div and select AUTO trigger mode. The scope should once again display a locked staircase, this time under the control of its own timebase.

Use the dual trace facility in the chop mode to investigate the relationship between the various timebase waveforms. Try the affect of varying the time/div and hold-off controls in the simple timebase.

Q 4.11 Is the defect that you observed in question 4.3 still apparent now that the internal timebase is in use?

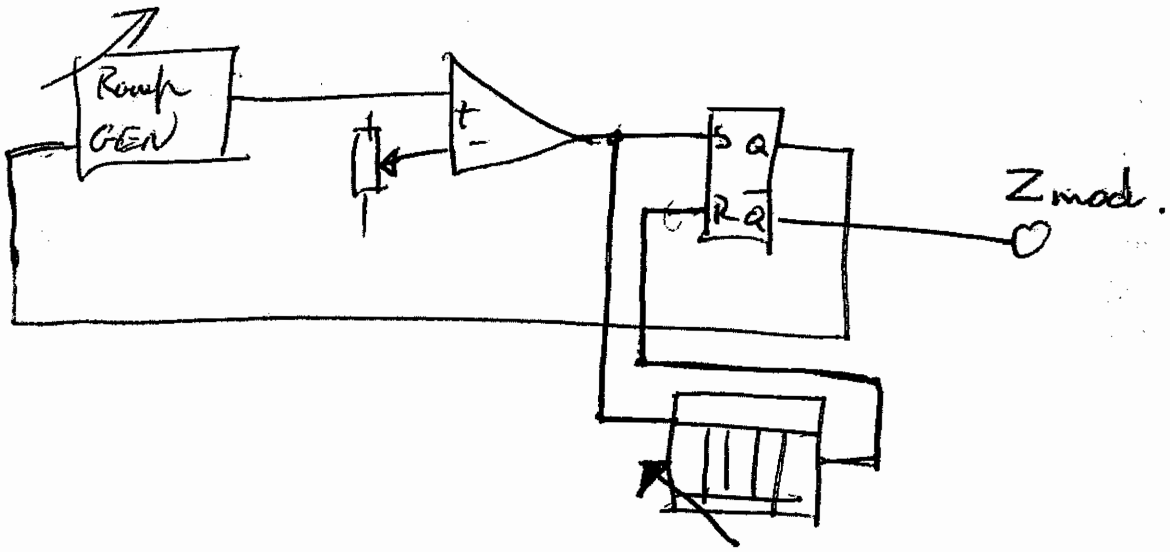
Q 4.12 How is the ramp reset signal of the simple timebase related to the ramp output?

It always occurs at some point -

This signal is generally made available as a GATE output. The scope also uses it internally to unblank the CRT when the ramp is in its forward sweep mode. Return the oscilloscope to its "external X" mode, using the simple timebase to provide the horizontal sweep. Use a suitable bistable output to feed the "Z MOD" input (on the rear) and note the improvement in the display.

Q 4.13 What pulse polarity is needed to blank the display? -ve

Sketch the final circuit of your timebase.



Return to the internal timebase in its AUTO mode.

5. TRIGGER CIRCUITS

So far a suitable pulse has been available to set directly the bistable controlling the ramp generator. Rarely will this be the case in practice. Some method of deriving the trigger pulse from the waveform under investigation is needed.

5.1 DC Triggering

The simplest solution is to detect when the input waveform reaches a predetermined voltage level. This can be done by means of a voltage comparator. The output is differentiated and used to set the bistable. If the reference input to the comparator is variable then the trigger point may be adjusted to suit particular requirements. This is the basis of the trigger level control. Figure 3 illustrates this.

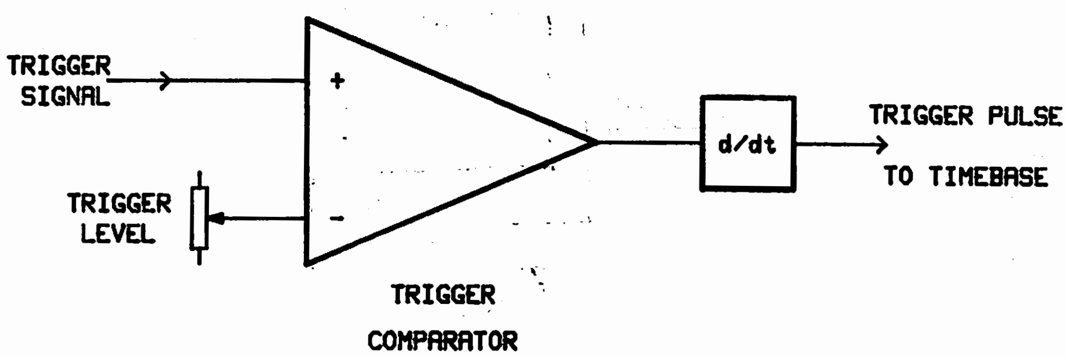


Fig 3. Simple Trigger Signal Generator.

Select DC trigger mode on the trigger selection. Adjust the trigger level control for a stable waveform display.

5.1.1 Internal DC triggering

The scope could just as easily derive its trigger pulse from the vertical deflection amplifier as from the external reference. Connect the reference oscillator square wave output to channel A input. Select A on the trigger source. Again it should be possible to adjust the trigger level for a stable trace.

Q 5.1 What happens to the display if the trigger slope (push button) is changed?

It will trigger on the -ve slope instead.

Q 5.2 With reference to figure 3 suggest how this control might operate.

Detect +ve or -ve edges.

Now connect the staircase to channel A and select positive slope. Observe the effect on the trigger position of changing the trigger level setting. With the trigger circuit dc coupled the timebase is always triggered by an absolute dc level. If the trigger signal is derived internally this is equivalent to saying that the trigger point, as set by the trigger level control, corresponds to a particular graticule line, and not a particular point on the signal. Whatever point on the signal coincides with the predetermined graticule line will trigger the scope.

Q 5.3 Without changing the amplitude of the display what other control could therefore affect the triggering?

Select COMPosite trigger source. (Both A and B buttons pressed). This picks the trigger signal after the electronic switch and will allow you to demonstrate the effect. Try it again with A only selected.

5.2 AC Triggering

Most operations will call for the timebase to be triggered by the same level of the waveform, irrespective of its present position, or dc level. A capacitor may be switched into circuit to block the dc component. This is shown in figure 4.

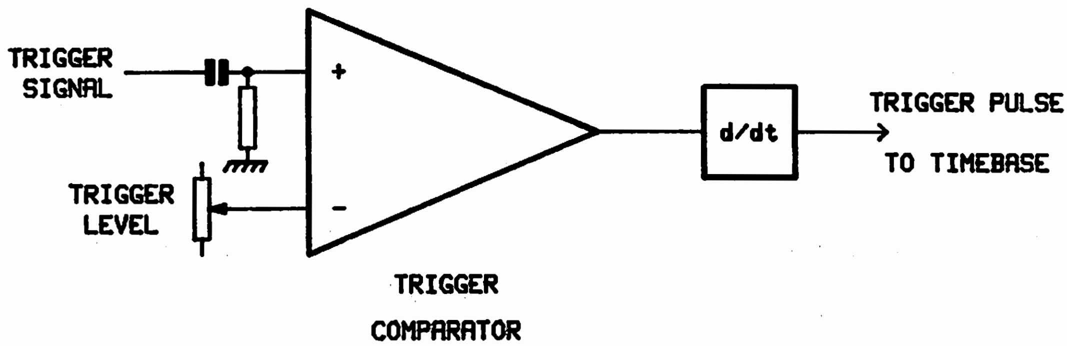


Fig 4. Trigger Circuit With AC Coupling.

5.3 Auto Mode

A variation on AC triggering is the AUTO mode. In this case the triggering level is often fixed as shown in figure 5.

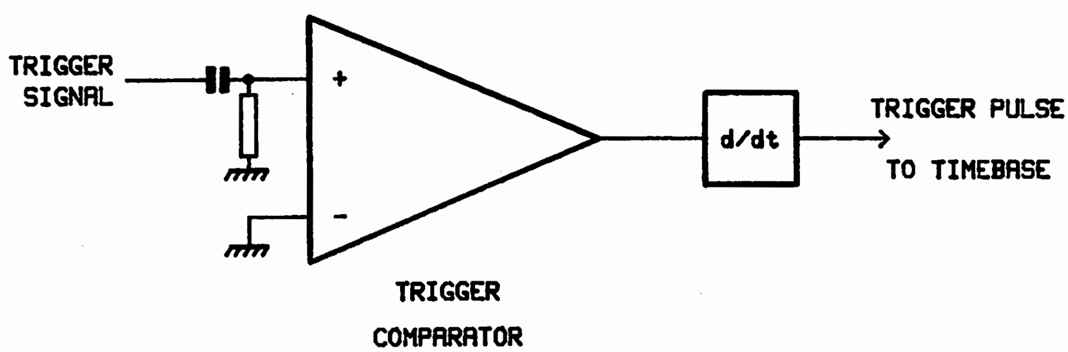


Fig 5. Auto Trigger Mode.

Q 5.4 What point on the input signal generates the trigger pulse?

Select AUTO mode and confirm that a stable trace is obtained with both trigger slope polarities.

Connect a feed of test card to channel A.

Q 5.5 Can you obtain a stable trace in the Auto mode?

YES

Q 5.6 Why?

JUST BECAUSE (Zero Crossing)

Remove the signal input to the scope completely.

Q 5.7 What happens to the trace in the Auto mode?

KEEPS GOING

Q 5.8 In AC and DC mode?

NO

Q 5.9 Does the circuit of figure 5 represent the only modification needed for Auto working? Explain your answer.

This is often achieved by introducing a measure of hf instability into the trigger comparator. Alternatively a small amount of 50 Hz is superimposed onto the trigger signal.

5.4 T.V. Triggering

Earlier you found out that Auto triggering with a complex T.V. waveform was impossible. Reconnect the test card to channel A and try again, this time using AC and DC trigger modes. It may be possible to obtain a reasonable trigger point, but often the presence of a burst makes this difficult.

Many scopes now include a sync separator to extract syncs from a video signal.

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Select TV mode.

Q 5.10 What effect does the trigger level control have?

NONE

Q 5.11 Does the trigger slope button have the expected effect in the T.V. mode?

YES

Q 5.12 Suggest what it does determine.

INVERTS i/p to trigger + passes thru sync seperator

Q 5.13 Does the scope include line and field sync separators? If so how are they selected? YES / By the timebase

Adjust the time/div control to obtain a display of exactly one line duration. Adjust the hold-off control to minimum (clockwise).

Q 5.14 How many lines per picture are displayed in this condition?

Q 5.15 Explain your answer.

Adjust the time/div control for a display of just less than one line duration.

Q 5.16 What happens as the display period is reduced?

Display goes dim

Q 5.17 Why?

Its waiting for the next sync pulse which is 2 lines away.

With the scope in this condition observe the effect of increasing the hold-off time.

5.5 Other trigger modes

AC, DC, Auto and TV are the trigger modes most commonly encountered. On some scopes you might just find a few others. HF REJect and LF REJect are the most common.

Q 5.18 Suggest uses for these two modes.

The experiment can now be continued on the more advanced oscilloscope if required. Use it in the MAIN T.B. mode and make sure that the delay T.B. is switched OFF on the TIME/DIV control.

6. VERTICAL DEFLECTION

The vertical deflection system breaks down into three areas. Those circuits associated with individual channels, e.g. attenuators, gain and shift controls; the trace switching and trigger selection circuitry and finally the CRT drive stages.

6.1 Channel Facilities

The circuit functions of each channel may be represented by figure 6.

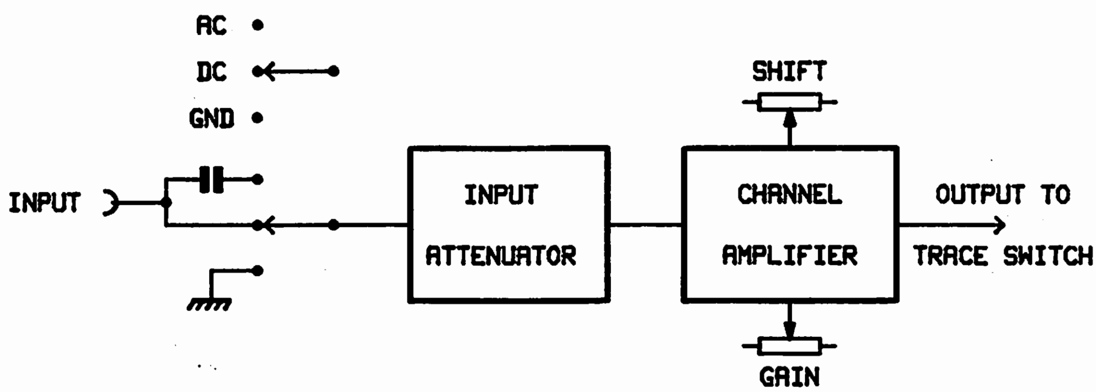

Fig 6. Vertical Deflection - Channel Functions.

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The AC-DC-Ground Switch allows the scope to monitor relatively small signals superimposed on large dc levels. Many scopes have a limit on this dc however, often it may be as low as 200 volts. The ground switch allows a clean reference to be determined prior to dc voltage measurement.

Q 6.1 What problems might arise if AC is used with a tv waveform?

The vertical amplifier is usually constructed as an amplifier of fixed gain, sufficient to cope with the smallest signal to be measured. It determines the performance of the vertical system particularly sensitivity, band width and rise time. Some scopes have x5 or even x10 gain switching - these should be used with caution, the band width may well plummet if they are used. NEVER use a x10 switch to compensate for the loss through a x10 probe - it defeats the object of using the probe in the first place.

The variable gain control allows the display height to be adjusted to some convenient value. Make sure it's calibrated before making measurements. The gain control also allows the channel gains to be matched for differential measurements.

6.1.1 Input Attenuator

The attenuator allows the scope to handle a range of signal levels. It generally consists of a number of fixed attenuators usually x1, x2, and x5. These are used in conjunction with ones of x10, x100, and x1000 to build up a wide range attenuator, often covering sensitivities from 2mV to 50V per division.

A basic attenuator for x10 is shown in figure 7.

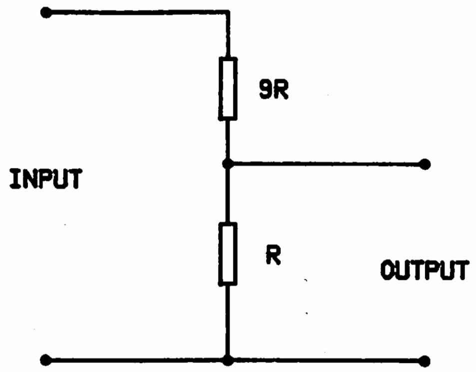


Fig 7. Basic x10 Attenuator

The load placed on such an attenuator will not be purely resistive. Stray capacitance will load the attenuator and reduce the band width as shown in figure 8.

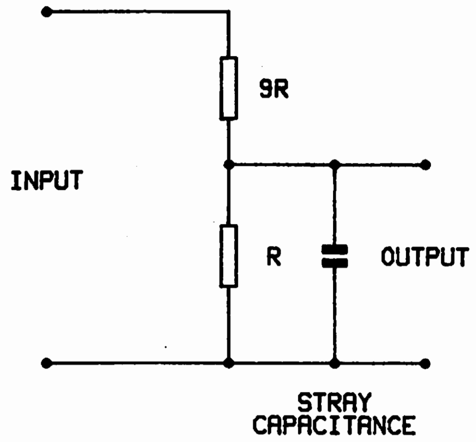


Fig 8. Attenuator With Stray Capacitance.

Q6.2 Modify figure 8 to improve it's hf response. Show any values.

To ensure correct matching all the attenuators are standardised to a particular resistance - shunt capacitance figure. Where necessary padding capacitors are connected in parallel with the input to match this. Often the scope front panel will state the values of capacitance and resistance.

Q 6.3 What are the input characteristics of this scope?

Q 6.4 What is the practical significance of this combination?

Television signals are often monitored in one of two ways. Accurately terminated 75Ω feeds may be used, in which case the scope input impedance can be ignored. Often check monitoring is carried out using open wander leads on a jackfield or unit front panel. To prevent the monitoring from upsetting the circuit operation the monitor points are "stood off" with, typically, 1k resistors.

Connect the feed of test card to the scope, terminate it in 75Ω, and measure its burst amplitude. Now connect the test card feed to the dummy jackfield and monitor it on the scope using an open wander lead. (Earth the dummy jackfield to the scope using another open wire lead).

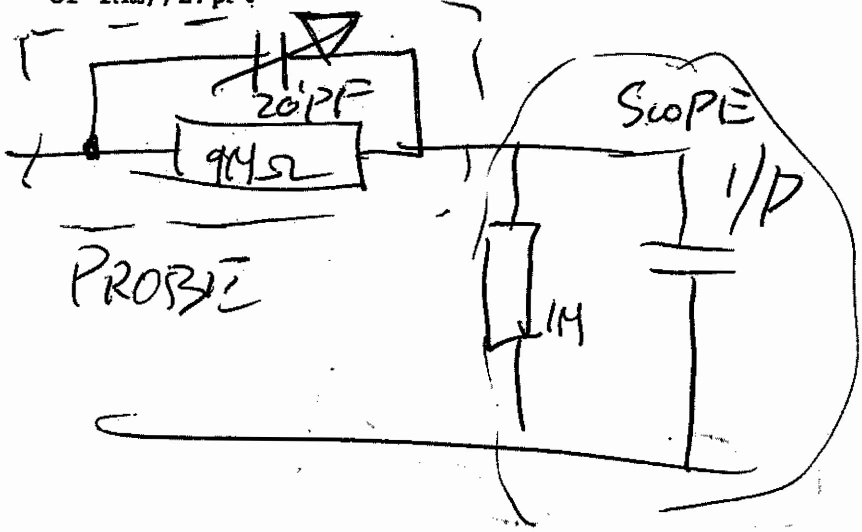
Q 6.5 Calculate the expected loss at subcarrier frequency due to the scope input impedance loading a 1k monitor point.

Does this agree with your measured value? Suggest reasons for any difference.

6.1.2 Probes

In many applications this input impedance is a limiting factor. Often however the full sensitivity of the scope will not be required. The x10 probe capitalises on this by increasing input impedance at the expense of sensitivity. It is basically a x10 attenuator feeding a load of 1MΩ in parallel with the shunt capacitance of the scope input and cable stray capacitance.

Q 6.6 Sketch the circuit of a x10 probe for use with an input impedance of 1MΩ//27pF.



The probe you have just sketched is only suitable for a load of 1MΩ//27pF. Most scopes are standardized to 1M, but rarely to a particular capacitance value.

Q 6.7 How can the probe be constructed to cope with different input capacitances?

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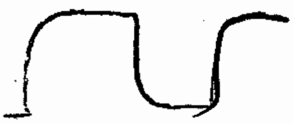
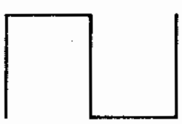
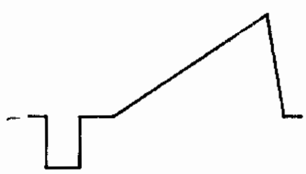
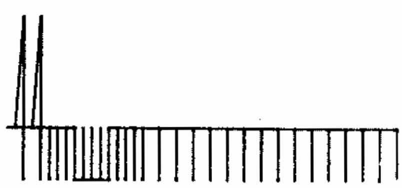
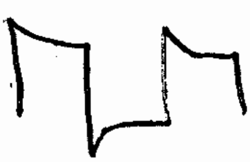
This requires a method of setting up the probe for use with a particular scope. That used employs a square wave at about 1kHz. When the probe is correctly set up the square wave will have flat tops and square edges. Under compensated the square wave will show hf loss, over compensated hf boost.

Use the probe to display the calibration square wave and adjust it to achieve, in turn, conditions of correct, under - and over compensation.
For each condition use the probe to monitor a field of sawtooth terminated by the dummy jackfield.

Sketch the relevant parts of the waveform as indicated by the following table.

PROBE	1kHz SQUARE WAVE	LINE SAWTOOTH LINE RATE	LINE SAWTOOTH FIELD RATE
UNDER-COMPENSATED			
CORRECTLY ADJUSTED			
OVER-COMPENSATED			

You have been warned!!!

Monitor the square wave and change the attenuator setting.

Q 6.8 Does the compensation change?

Q 6.9 What is happening if the answer to answer 6.8 is yes?

6.2 Trace Switching

At the start of this practical the concept of time sharing the vertical deflection system was mentioned. This was done using an electronic switch, operating at a very high frequency.

The mode was called CHOP.

Another mode is called ALT (alternate). In this case the switch is controlled by a bistable triggered at the end of each timebase sweep.

The difference between the two modes is that in CHOP many small elements of both channels are displayed on each horizontal sweep. In ALTERNATE each channel is displayed on every other horizontal sweep. In both cases the persistance of vision combined with that of the phospor provides the viewer with continuous traces of both channels. (Assuming the chopping square wave is unrelated to either channel).

Connect sawtooth and test card signals to the two inputs of the scope. Trigger the scope in the TV mode from channel A. Compare the the use of ALT and CHOP over as wide a range of time/div settings as possible.

Q 6.10 Is there a limit to the use of either mode?

YES

6.3 Trigger Selection

Closely associated with trace switching is the selection of trigger signals. So far the only selection has been between internally and externally derived signals.

Q 6.11 What are the three possible sources of internal trigger signals?

The individual channel triggers are selected by the A and B buttons. Note that the trigger pulses are picked off before the shift controls on these scopes. Pressing both buttons selects the trigger after the trace switch. This is used in conjunction with alternate mode working and triggers the timebase from the channel about to be displayed.

Q 6.12 If such a trigger mode were selected what would happen to the timing relationship of the displayed signals?

They would both be the same

Try it and see!!

Q 6.13 When would such a trigger mode be useful, if not essential?

Two different time related signals

Q 6.14 What might the scope trigger from if the same trigger selection were made in CHOP mode?

Trigger off chopp freq.

(This can be demonstrated on the PM 3215 scope but not the PM 3262.)

In order to avoid seeing the trace switching from one channel to the other (the response time of the switch is limited) the display is blanked whilst the switch takes place. If this were not done a chopped display could look very fuzzy.

6.3.1 Trigger Delays

Connect a feed of the calibration square wave to an input of the scope. Trigger internally from this signal. Expand the display. It should now be possible to examine the leading edge of the square wave signal in detail.

Q 6.15 Given that there must be some delay in the triggering circuits what must be done to the vertical signal after the trigger signal has been picked off?

Delayed a bit

Q 6.16 How is this related to the timebase speed setting?

6.4 ADD Mode

One other mode encountered is that called ADD. (or SUM, or A+B). In this mode the output of the two channels is summed and then passed to the vertical deflection system. Probably it is most useful when one channel is inverted, consequently it now performs as a differential amplifier.

Obviously the differential mode will only work correctly if both channel amplifier gains are identical.

Q 6.17 How can you most easily set the gains for equality?

Apply to same signal + invert and adjust for zero display

Set the two channels for equal gain and then display the difference between two signals - e.g. sawtooth and test card.

At this point you must move on to the more elaborate oscilloscope.

7. WHY DOES THE OSCILLOSCOPE NEED TWO TIMEBASES?

The main reason for the inclusion of a second timebase is that it enables the trace to be effectively expanded in a controlled manner. This allows small parts of a complex waveform to be examined in detail. It also permits accurate time measurements to be made.

The display could be expanded by increasing the gain to the X amplifier. For small expansions (x10) this is reasonable but consider a 1000X expansion. The shift control would be unacceptably coarse as the trace length would be a 1000 screen diameters! What sort of accuracy would you care to place on such displays? - very little!

One common factor generally emerges when trace expansion is required - the position of the area to be expanded can be predicted. An example is the selection of one line from a television field.

Q 7.1 Suggest a technique whereby a single line could be selected from a television field.

Digital methods are fine if an incremental system is acceptable. Expansion techniques are not the sole province of television line strobing however. Often it may be necessary to view part of a complex digital bitstream, or even a small part of a television line - e.g. the pulse from a pulse and bar signal. This means that an anologue delay is required.

Connect a feed of sawtooth to one channel and trigger from it. Select AC or DC positive slope triggering. Vary the trigger level and note what happens - the timing of the trigger point relative to the input signal is changed. The sawtooth signal combined with the comparator in the trigger circuit forms a simple voltage controlled delay.

Imagine taking the timebase ramp and applying it to one input of a voltage comparator. If the other input to the comparator is a dc set to cover exactly the amplitude range of the ramp, a voltage controlled delay is produced. The comparator output will change state at a point during the sweep as determined by the voltage setting. This is shown in figure 9.

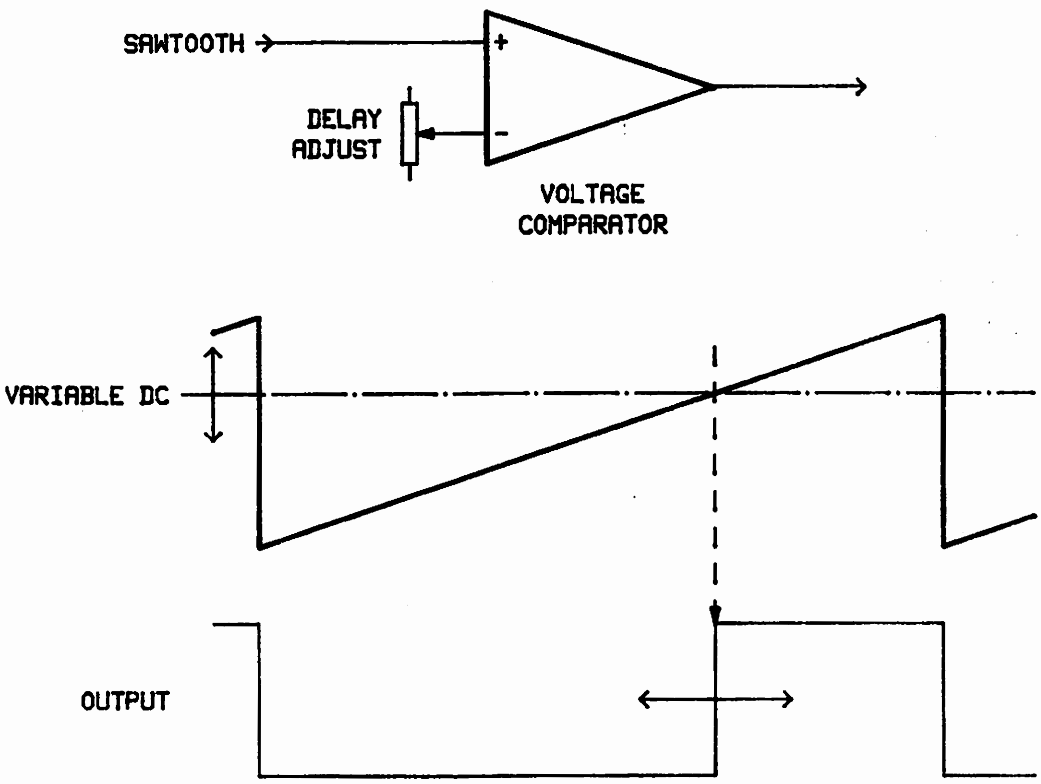


Fig 9. Use Of Ramp And Comparator To Provide A Voltage Controlled Delay.

If the timebase were set for one sweep in 20ms (e.g. 2ms/div) then a delay adjustable from 0 to 20ms is available. The delay time control is generally an accurately calibrated 10 turn potentiometer, and is referred to as the delay time multiplier. This could be used to find any point of the television field. Once the desired point is reached the comparator output can trigger a second, faster ramp generator. If its output were used to provide the horizontal deflection rather than the 20ms ramp, that small part of the field would be displayed. See figure 10

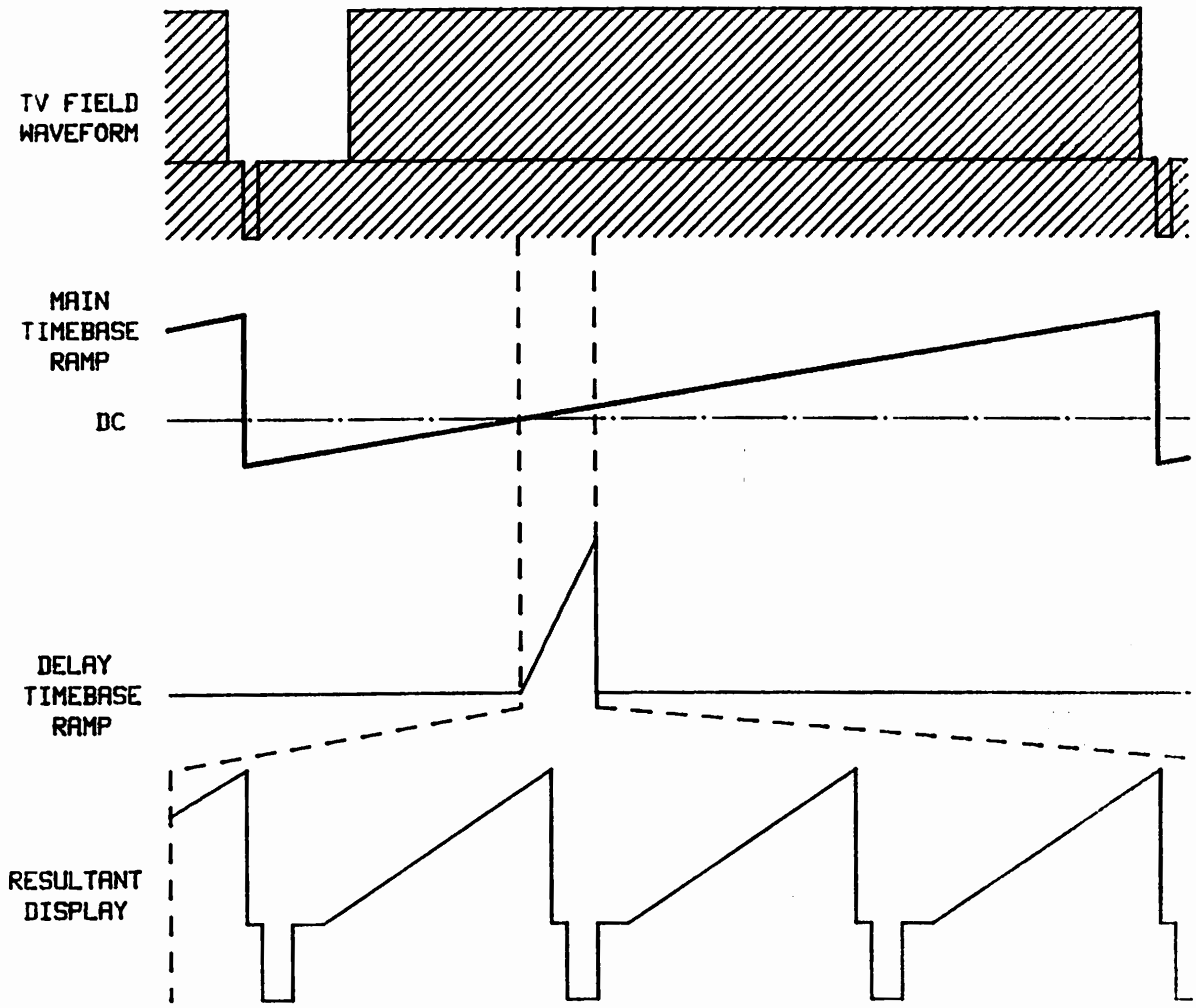


Fig 10. Expanded Display Using The Delay Timebase.

Q 7.2 If the main timebase is set to 2ms/div and the second to 50µs/div what is the effective scale length (in divisions) of the display?

7.1 How Do You Know Where You Are?

If the display length is effectively very long, and only one small area is being examined, it is not always easy to find the right place. Gradually increasing the delay until the desired point is reached is not only tedious but fraught. It is surprisingly easy to miss the bit you want! What is needed is a means of locating the part of the waveform required before expanding the display.

Remember the gate waveform?

Q 7.3 How could the gate waveform from the second timebase help in the location of the part of the waveform required?

Connect a feed of test card to channel A of the scope. Externally trigger the MAIN time base from field drive and set the DELAYED TB trigger selector to MAIN T.B. With MAIN TB mode selected set the scope to display one field of the test card waveform. Set the DELAYED timebase to 20μs/div.

A small portion of the waveform should now appear brighter than the rest. If it does not try adjusting the intensity control, and also check that the delay time multiplier is not on its end stop. If still no joy then help! Use the delay time multiplier to position this area over the letter box portion of the test card waveform.

Change the display mode to DELAY TIMEBASE. Those few lines which were highlighted are now displayed on the screen.

Q 7.4 Measure the horizontal duration of the black portion of the letter box.

7.2 Accurate Positioning

Say only one line is to be displayed. This means a delay timebase sweep speed of around 10μs/div. Try it. Notice how critical the adjustment of the delay time multiplier has become, and the problems of obtaining a steady trace. This is because the delay timebase is triggered immediately the main sawtooth reaches the level set by the delay time multiplier.

Q 7.5 Given a main timebase sweep rate of 2ms/div what is the apparent resolution accuracy (in percent) of the delay time multiplier if the display can apparently be positioned to within 1μs.

BEWARE OF FALSE IMPRESSIONS OF ACCURACY IN YOUR MEASUREMENTS!

This problem can be eased by arranging for the delay timebase to be triggered by an external reference. In this case line syncs are an obvious answer. In such a mode the delay timebase is not triggered until the next external trigger pulse after the delay period set by the delay time multiplier.

Connect the feed of syncs to the delay timebase trigger input and select EXT trigger. Adjust the trigger level as necessary and a stable line rate display should result. Now try the effect of varying the delay time multiplier. The delay timebase could equally well be triggered internally - try it and see.

Q 7.6 Use the delay facility to display a line of the lowest frequency grating and measure its frequency. What is it?

7.3 Accurate Time Measurement

So far the emphasis has been on making an accurate measurement of a short time interval somewhere in the much longer time period of the waveform. What if a much longer period is to be measured?

Remember that the delay time multiplier gives a delay adjustable from 0 to the sweep time of the main timebase. Notice that it has a vernier scale.

Q 7.7 With the main timebase set at 2ms/div what time delay corresponds to 1 fine multiplier division?

Q 7.8 What then does each coarse multiplier division correspond to?

This calibration can be used to measure time intervals accurately. Let's find out how long the white letter box is from top left to bottom right hand corners. Return the delay timebase to its continuously variable delay mode. Adjust the delay time multiplier to display the first line of the letter box. Position the leading edge of the letter box against a convenient graticule reference. Note the reading on the multiplier.

Now find the last line of the letter box and position its trailing edge against the same graticule reference. Note the new multiplier reading. Subtract the first from the second, multiply by the main time base setting and there you are.

Q 7.9 What is your measured letter box duration?

Try it again using the delay timebase in its triggered mode.

Q 7.10 Do you still get the same answer? - Explain.

7.4 Different Delay Periods

Not all measurements using a delay timebase are of lines from a television field. It may well be that a part of every line has to be examined, e.g. the pulse from a pulse and bar waveform. Trigger the main timebase at line rate and try picking out parts of the line.

7.5 Other Timebase Combinations

Some scopes have the facility for combining both timebase sweeps on one display. This is useful if a small part of the waveform is to be examined whilst still viewing the whole cycle. The MIXED mode on some scopes uses the main sweep up to the delay point, and then switches to the delay timebase after that. The LHS of the display is shown normally and the RHS expanded. Another possibility, found on this Phillips scope, is the ALTernate timebase mode. Here each timebase is used in turn for alternate sweeps of the display, thus superimposing both normal and expanded displays on the same screen. Try the other modes for yourself.

7.6 Television Field Display

Connect test card to the A channel of the oscilloscope, select A channel only and set up the main timebase to display slightly less than one field (e.g. main timebase set to 1ms/div). Go to the free - running delay mode and examine a few lines from the field.

Q 7.11 What has happened to the apparent line rate?

Q 7.12 Why is this?

To avoid the problem in such a case one of the fields has to be removed. This can be done in two ways. Ground channel B input and select ALT mode.

Q 7.13 What happens to the display? Explain your answer.

Q 7.14 Why does CHOP not produce the same result?

The other method relies on the inherent trigger delays of the scope. Select channel A only. Try adjusting the MAIN TB variable time/div control. Note the effect of increasing it.

Q 7.15 Explain the effect of increasing the time/div control.

Q 7.16 How could you display both fields without the apparent doubling of the frequency?

8. REVISION

Before finishing the experiment make sure you are familiar with all the main controls, their functions and normal settings. Make sure you can get a trace on the scope irrespective of the starting conditions (other than duff instruments!). There is a check list below if you have forgotten.

9. GETTING STARTED

1 SWITCH ON!

2 GROUND ALL INPUTS

3 CENTRE ALL SHIFT CONTROLS

4 SELECT 1ms/Div

5 SELECT MAIN (or A) TIMEBASE

6 SELECT REPetitive TIMEBASE MODE

7 SELECT AUTO TRIGGERING

8 TURN UP INTENSITY

9 Proceed as normal!!

OSCILLOSCOPES

APPENDIX

10. SUMMARIES

2.1 An oscilloscope consists of a CRT display, horizontal and vertical deflection systems and a trigger circuit.

3.1 The CRT and basic deflection systems form an X - Y plotting instrument.

3.2 A vectorscope is only an X - Y plotter fed with u and v signals.

3.3 The vertical deflection system may be time shared between two or more channels.

4.1 A voltage ramp provides the basic horizontal deflection signal.

4.2 A given deflection voltage always corresponds to a fixed point on the screen.

4.3 A voltage comparator can detect when the sweep has reached the RHS.

4.4 The timebase can be synchronised by stopping the sweep after flyback.

4.5 The basic synchronising element is a bistable set by trigger pulses and reset by the voltage comparator detecting the RHS voltage.

4.6 Triggering is difficult if the timebase repetion rate is very close to that of the trigger pulses.

4.7 A hold-off circuit overcomes this.

4.8 The gate output signifies that the timebase is running. It can be used to unblank the display.

5.1 The simplest triggering method is to detect a particular dc level in the input signal.

5.2 Varying the reference dc level provides the basis of a trigger level control.

5.3 Anything effecting the dc level of the trigger signal will effect the triggering.

5.4 A blocking capacitor will permit triggering from the signal, irrespective of dc level.

5.5 In the AUTO mode the trigger level is fixed at the mean level of the signal.

5.6 The timebase also runs continuously in the AUTO mode.

5.7 A sync separator may be used to provide TV triggering. It is often switched to line or field by the timebase controls.

5.8 In TV mode the slope control selects the video signal polarity.

5.9 HF and LF reject modes may be encountered.

6.1 The vertical deflection system is basically an attenuator followed by an amplifier of preset gain.

6.2 The AC coupling time constant might distort TV waveforms.

6.3 The input attenuator is designed to provide a constant input impedence.

6.4 The input capacitor may load external circuits.

6.5 The x10 probe minimizes the circuit loading at the expense of sensitivity.

6.6 The probe compensating capacitor is adjustable to cope with different scope inputs.

6.7 The probe must be properly compensated. A 1kHz square wave is best for this.

6.8 CHOP mode switches between the two inputs many times during one sweep.

6.9 In ALTERNATE each input is displayed every other sweep.

6.10 Flicker prohibits the use of ALT at low sweep rates.

6.11 Internally derived triggers may come from before or after the trace switch.

6.12 Triggering after the trace switch enables unrelated signals to be displayed but destroys time relationships.

6.13 The Y signal is delayed to compensate for the trigger circuit delays.

6.14 Adding the channels with one inverted provides a simple differential facility.

7.1 The use of two timebases effectively expands the display in a controlled fashion.

7.2 Line counting techniques could be used for picking lines out of a field.

7.3 A ramp and comparator form a simple delay circuit.

7.4 The timebase ramp could be used for the delay circuit.

7.5 A second timebase, triggered from the delay circuit, will display a selected small part of the waveform.

7.6 The delayed gate waveform can be used as a bright-up.

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7.7 Fast delay sweep speeds make positioning difficult. Triggering the delay timebase overcomes this.

7.8 The delay time multiplier enables accurate measurements to be made over long time intervals.

7.9 MIXED and ALT timebase modes enable normal and expanded displays to be combined.

11 ANSWERS TO QUESTIONS

3.1 A Vectorscope.

3.2 u and v respectively.

3.3 Two dots vertically above each other.

3.4 The square wave has a very fast risetime.

4.1 It isn't.

4.2 Use a voltage comparator to determine when the desired deflection voltage has been reached.

4.3 The flyback is visible.

4.4 After flyback.

4.5 So that the trigger signal will initiate the next sweep with minimum delay.

4.6 No, when the sweep time is close to the period of the signal or a multiple of it.

4.7 The flyback time of the timebase.

4.8 Yes.

4.9 No change until a certain point is reached whereupon the trace gets dimmer.

4.10 The timebase is now responding to only every other trigger pulse, or less.

4.11 No.

4.12 The reset signal is low when the timebase is sweeping.

4.13 Negative.

5.1 Trigger from the other edge of the pulse.

5.2 Reverses the trigger comparator inputs.

5.3 Vertical Shift.

5.4 The mean level.

5.5 No.

5.6 The timing of the signal corresponding to the mean level is not the same on all lines.

5.7 Reverts to a horizontal line.

5.8 Disappears.

5.9 No. Some means of causing the timebase to run in the absence of trigger pulses is needed.

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5.10 None.

5.11 No.

5.12 Video polarity.

5.13 Yes - by the coarse time/div control.

5.14 312 approximately.

5.15 Due to the flyback delay the timebase misses every other trigger pulse.

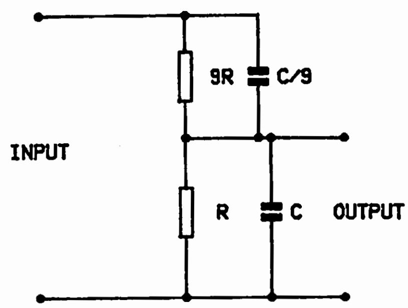
5.16 Trace gets brighter.

5.17 As less of the line is displayed more time is available for flyback. The timebase can then trigger from every line.

5.18 Reducing the effect on the triggering of noise and low frequency distortions respectively.

6.1 Low frequency distortion (field tilt) could occur.

6.2

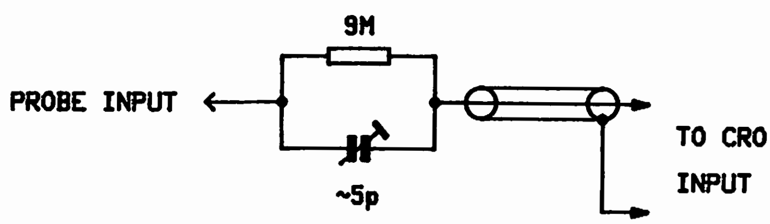


6.3 1MΩ//20pF.

6.4 The input impedance will be much lower than 1MΩ at high frequencies.

6.5 Approx. 13%. No, stray capacitance increases the loading.

6.6



(Don't forget the cable!)

6.7 Make the capacitor variable.

6.8 It shouldn't.

6.9 Input shunt capacitance is changing.

6.10 Alternate is unusable at low sweep speeds because of flicker.

6.11 Either channel, or after the trace switch.

6.12 It would be destroyed.

6.13 When displaying two signals of different frequencies.

6.14 The Chopping Square wave.

6.15 Must also be delayed.

6.16 Independant. It depends on the delay of the trigger circuits.

6.17 Connect the same signal to both inputs and adjust the gains for a straight line display.

7.1 Use a counter reset by picture (or field) pulses.

7.2 400.

7.3 Use it to "bright up" the display.

7.4 6μS

7.5 0.005%!!

7.6 1.5MHz.

7.7 20μs.

7.8 2ms, or more simply each coarse graticule division.

7.9 2.22mS

7.10 Probably not. Could be up to one line out due to the delay before the delay timebase triggers.

7.11 It has doubled.

7.12 The timebase is triggered from field pulses. These are offset by half a line on alternate fields.

7.13 Half the "line" pulses are removed. The trace switching bistable only displays every other field from each channel.

7.14 Chop is not a sweep-by-sweep change of inputs as is Alternate.

7.15 When the sweep time approaches 20ms the timebase will miss the next trigger pulse and so display every other field cf Q 5.14.

7.16 Use the delay timebase in its triggered mode.

M.B. Tancock/CR/OSCILLOS

15th April 1983