

VALVES - 2x 6BL8 900mA  
 1x 6BX6 300mA  
 1x 12AT7 300mA

## CIRCUIT FOR A SIMPLE OSCILLOSCOPE

*A simple, non-critical, reasonably compact, and relatively inexpensive design for an oscilloscope is described. It is suitable for television receiver servicing and (in conjunction with a high-gain pre-amplifier of limited bandwidth) for audio work. The Mullard low-voltage instrument tube type DG7-32 is used.*

### DESIGN CONSIDERATIONS

The basic consideration in the production of the oscilloscope was that a minimum of special components should be used, so that the television service engineer, for whom the instrument was particularly designed, should be able to build it 'off the shelf' and without any considerable outlay apart from the cost of the cathode ray tube.

In view of the present interest in audio amplifiers, a high-gain pre-amplifier of limited bandwidth has been designed as an accessory in the form of a small probe.

Conventional chassis and wiring methods are used. No attempt has been made to reduce the dimensions of the instrument unduly, as ease of construction is of greater importance than compactness in the design of an amateur-built instrument.

### SPECIFICATION

#### Y Amplifier

	Direct input	Probe $\times 10$	Pre-amplifier	
Input resistance	1	10	0.5	M $\Omega$
Input capacitance	20	10	10	pF
Maximum sensitivity*	100	1000	1	mV/cm
Maximum signal input*	30	300	3	V
Frequency response (to 3dB)	2c/s to 2.5Mc/s		5c/s to 20kc/s	

\*See operating notes (page 36)

#### Timebase

Frequency range	20c/s to 20kc/s, in five ranges
Sweep width	2cm to 8cm, continuously variable
Flyback suppression	operates on all ranges
Synchronisation	is internal, external, or 50c/s

#### Calibrator

50c/s voltages of 50, 10, 1.0 and 0.1V peak-to-peak to enable the gain control settings to be checked.

#### Display

The cathode ray tube used is a Mullard DG7-32, which has a 7cm screen with a green, medium-persistence phosphor. The tube is designed to operate at low anode voltages, and in this instrument is run at 400V. The final anode is operated above earth potential, but the construction of the tube prevents distortion of the trace when the tube face-plate is touched. A mumetal c.r.t. shield should be used.

#### Valve Complement

Five Mullard valves and two germanium diodes are used in the oscilloscope. They are:

V1	EZ80	Power supply
V2, V3	2 $\times$ ECF80	Y amplifier
V4	ECC81	Timebase and sync amplifier
V5	EF80	Timebase oscillator
D1, D2	2 $\times$ OA81	

In addition, the high-gain probe unit uses one EF86.

#### Dimensions

The size of the prototype instrument is 11in.  $\times$  5in.  $\times$  7in., and it weighs 7lb. The attenuator probe is 1in. in diameter and 3in. long, and the high-gain probe measures 4in.  $\times$  2 $\frac{1}{2}$ in.  $\times$  1 $\frac{1}{2}$ in.

*This article is based on a report prepared by L. S. Brown of the Mullard Applications Research Laboratory. The circuit has been developed from a design originated by W. D. Minjon of Philips, Eindhoven.*

*Full constructional details, checking procedures, and operating instructions will be published elsewhere in due course.*



## CIRCUIT DESCRIPTION

The circuit of the oscilloscope, with a high-impedance attenuator probe input, is shown in Fig. 1.

### Power Supplies

All supplies are obtained from a single transformer, which must be capable of supplying 250–0–250V at 40mA, 6.3V at 2A, and 6.3V at 0.3A. In the prototype the transformer used is a Partridge type H250/40 with flying leads.

A full-wave rectifier V1 (EZ80) supplies an h.t. voltage of about +310V, which feeds the Y amplifier, the timebase, and the final anode of the c.r.t.; while a half-wave metal rectifier MR1 provides a supply of –300V for the c.r.t.

The heaters of all the valves are fed from the 6.3V 2A winding, one side of which is earthed. (In the prototype transformer this winding has a centre tap which is not used, and which must be suitably insulated.) The 6.3V 1A winding is used to supply the 300mA heater of the c.r.t., and has one side connected to the cathode of the c.r.t.

### Y Amplifier

The Y amplifier built into the oscilloscope makes use of two valves, V2 and V3 (2×ECF80). The triode section of the first valve is connected as a cathode follower, its grid being connected to a panel socket into which is plugged either an input attenuator probe, a plain lead, or a high-gain pre-amplifier probe. The output of this cathode follower is coupled via an electrolytic capacitor C8 (25 $\mu$ F) to a potentiometer RV16 (10k $\Omega$ ) which provides a continuously variable gain control. The slider of the potentiometer is connected to the grid of the pentode section of V2, whose anode is coupled by C10 (0.1 $\mu$ F) and R19 (1M $\Omega$ ) to the grid of the pentode section of V3.

These two pentodes provide a gain of about 60 times, with a bandwidth of 2.5Mc/s. This response is obtained without the use of inductors. Some frequency compensation is obtained by means of the cathode by-pass capacitors C9 and C11 (220pF), which are effective only at high frequencies.

The output at the anode of the pentode section of V3 is coupled through C12 (0.05 $\mu$ F) to the grid of the triode section. This triode operates as a 'concertina' phase splitter to produce symmetrical deflecting signals for the tube deflector plates. The triode is grid current biased by R22 (10M $\Omega$ ). The paraphase outputs, from anode and cathode, are coupled to the c.r.t. Y plates by C13 and C14 (0.25 $\mu$ F). The leak resistors

R25 and R26 (4.7M $\Omega$ ) are returned to the final anode supply of the c.r.t. to prevent astigmatism.

An output is also taken from the cathode follower section of V2, via an isolating resistor R27 (10k $\Omega$ ) to a panel socket which may be used to provide a synchronising signal for the timebase. Since it is ahead of the gain control RV16, variation of this control will not affect the synchronisation of the trace on the tube.

### Timebase

The timebase generator uses a single pentode V5 (EF80) in a Miller-transitron circuit, while a double triode V4 (ECC81) is used as a sync amplifier and as a paraphase amplifier for the sawtooth sweep.

### Sweep Speed

The sweep speed is determined by the time constant of RV40 (2M $\Omega$ ) and R41 (390k $\Omega$ ) in series, and one of the capacitors C23 (0.1 $\mu$ F), C24 (0.02 $\mu$ F), C25 (0.005 $\mu$ F), C26 (1200pF), or C27 (300pF). These capacitors are selected by S2b, the coarse frequency control, while RV40 is continuously variable to provide a fine frequency control. The values of RV40 and R41 are chosen to give some overlap between the various ranges selected by S2b.

S2a selects a suitable value of screen-to-suppressor coupling capacitor for each sweep speed range. These values are chosen to give a sawtooth of about 150V amplitude at the anode of V5. The ratio of sweep to flyback time then obtained is greater than 5 : 1 on all ranges and for all settings of RV40.

### Sweep Amplitude

The anode load of the timebase generator consists of a potentiometer RV39 (25k $\Omega$ ) in series with a fixed resistor R38 (4.7k $\Omega$ ). The potentiometer forms a continuously variable sweep amplitude control. Its slider feeds one of the X plates of the c.r.t. via C31 (0.25 $\mu$ F). The connection from the anode of V5 to RV39 should be screened.

The other X plate is fed via C32 (0.25 $\mu$ F) from the anode of V4b, which is connected as an a.c. coupled see-saw phase inverter, and is grid current biased by R43 (10M $\Omega$ ).

### Flyback Suppression

A negative pulse, obtained from the screen of the Miller-transitron valve V5, is limited by D2 (OA81), and the resulting flat-topped wave which is developed across R36 is fed to the grid of the c.r.t. to suppress the flyback of the sweep.

**Shift Controls**

The basic design does not include X and Y shift controls. Fig. 2 shows how they can be included if required. It will be seen that, if such controls are used, R25, R26, R45, and R46 (all reduced to 3.9MΩ) are returned to their sliders. The mean deflector-plate potential is still maintained at final anode potential, since the final anode is now connected to the junction of R8 and R9.

**Sync Amplifier**

Synchronising signals, obtained internally from the Y amplifier, or from the mains, or externally, are fed to the grid of V4a, the sync amplifier. The valve is operated at zero bias and produces at its anode an amplified and limited version of the signal. This is d.c. restored to earth by D1 (OA81) and is then fed as a positive-going signal, in series with the suppressor resistor R34 (100kΩ) of the Miller-transitron valve V5.

**Calibration**

50c/s voltages derived from the mains transformer, with peak-to-peak amplitudes of 50V, 10V, 1V, and 0.1V, are brought out to panel sockets to enable the gain of the Y amplifier to be checked.

**High-Impedance Input Attenuator**

This consists of R11 (10MΩ) and C6 (0.3 to 3pF) in a screened box. It introduces an attenuation of 10 times, and gives an input resistance of 10MΩ.

**High-Gain Probe**

The high-gain probe consists of an EF86 in a conventional circuit (Fig. 3). It gives a gain of 100 times over a range from 5c/s to 20kc/s when connected to the oscilloscope by two feet of 75Ω television type screened coaxial cable. A switched ×10 attenuator is incorporated. The maximum signal input to the probe is 0.3V with the 1mV/cm attenuator setting, and 3V with the 10mV/cm setting.

Supplies for the pre-amplifier are taken from the main circuit.

**OPERATION AND PERFORMANCE**

**Input Circuits**

For general purposes an unscreened input lead plugged into the input terminal is satisfactory. The instrument then presents a load of 1MΩ in parallel with about 20pF to the circuit which is being examined. The maximum sensitivity is 100mV/cm.

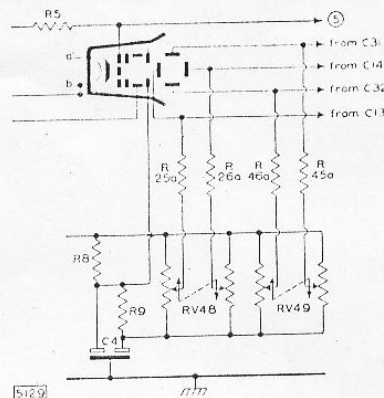


FIG. 2—MODIFICATION TO PROVIDE SHIFT CONTROLS R25a, 26a, 45a, and 46a are substituted for R25, 26, 45, and 46 of Fig. 1

and the maximum signal input which can be handled without distortion is about 30V.

When a screened lead is necessary to avoid the effects of stray pick-up, particularly from the line timebase of a receiver, there will be greater capacitive loading of the circuit under examination. The sensitivity and maximum input will remain as above.

**High-Impedance Attenuator**

Where either a higher input impedance or a greater signal-handling capacity is needed, the simple lead is replaced by the high impedance attenuator probe R11, C6. This presents to the circuit under test a load of 10MΩ in parallel with 10pF. It gives a maximum sensitivity of 1V/cm, and accepts a maximum input of 300V without distortion.

This probe should always be used when investigating circuits which include impedances higher than 100kΩ. It is useful for television receiver servicing, where a sensitivity better than 1V/cm is rarely needed.

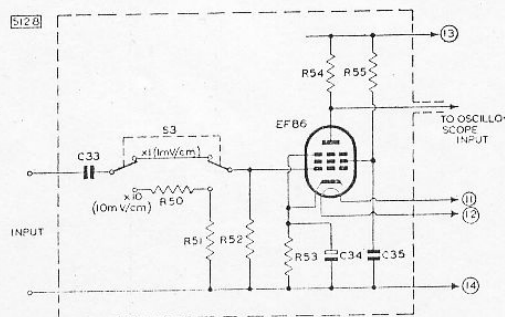


FIG. 3—HIGH-GAIN PROBE

### High-Gain Probe

With any of the above input arrangements the oscilloscope has an overall frequency response range from 2c/s to 2.5Mc/s. The high-gain pre-amplifier probe, however, is designed specifically for low level audio frequency investigation, and has a bandwidth of 5c/s to 20kc/s only.

With the attenuator switch at  $\times 1$  the maximum sensitivity of the oscilloscope is 1mV/cm, and the maximum signal which can be handled without distortion is 300mV (using the oscilloscope Y gain control). With the attenuator switch at  $\times 10$  the maximum sensitivity is 10mV/cm and the maximum signal is 3V. For examination of signal levels higher than this in audio amplifiers either an unshielded input lead or the high impedance attenuator probe can be used.

### Synchronisation

For most purposes the trace requires to be synchronised to the output of the Y amplifier, and the 'sync ext' and 'sync int' sockets are linked. For some purposes, notably the examination of television receiver video waveforms at frame frequency, the 'sync ext' socket may be linked to the socket marked '50c/s'. Alternatively, a signal derived from the sync separator or some other suitable portion of the receiver may be fed directly to the socket marked 'sync ext'. The impedance at this socket is approximately  $1M\Omega$  in parallel with 10pF. The synchronisation of the trace is not affected by variation of the 'Y gain' control.

### Calibration

Voltages of 50, 10, 1.0, and 0.1V peak-to-peak are provided. They may be used to set the gain control of the instrument to a known sensitivity, hence voltages can be measured from the trace. For example, when the high-input impedance probe is connected to the socket marked 50V, the trace height is say 1.5cm. If, when the probe is now connected to the grid of the line output valve of a television receiver, a trace of amplitude 4.2cm is obtained, then the peak-to-peak voltage at this electrode is

$$\frac{50 \times 4.2}{1.5} = 140V.$$

In receiver servicing the amplitude of a waveform is often of equal importance with its shape. The oscilloscope provides a means of observing both.

### Hum

Since the oscilloscope is designed primarily for television receiver servicing, it is not possible to connect its chassis permanently to earth. Hence either the earth lead on the probe, or a separate wire from the oscilloscope earth socket, must always be connected to the earth of the circuit being tested.

When an a.c./d.c. receiver is being examined, care should be taken to ensure, wherever possible, that the receiver chassis is connected to the neutral side of the mains. In addition to reducing the possibility of hum pick-up, this also helps to ensure the safety of the service engineer.

## PARTS LIST

### Capacitors

C1	Electrolytic	32	$\mu F$	350V	C18	Paper	0.01	$\mu F$	350V
C2	Electrolytic	16	$\mu F$	350V	C19	Silver-Mica	2200	pF	350V
C3	Electrolytic	25+25	$\mu F$	300V	C20	Silver-Mica	560	pF	350V
C4	Electrolytic	25+25	$\mu F$	300V	C21	Silver-Mica	150	pF	350V
C5	Electrolytic	16	$\mu F$	350V	C22	Paper	0.1	$\mu F$	350V
C6*	Trimmer	0.3 to 3	pF	500V	C23	Paper	0.1	$\mu F$	350V
C7	Paper	0.1	$\mu F$	500V	C24	Paper	0.02	$\mu F$	350V
C8	Electrolytic	25	$\mu F$	50V	C25	Paper	0.005	$\mu F$	350V
C9	Ceramic	220	pF	350V	C26	Silver-Mica	1200	pF	350V
C10	Paper	0.1	$\mu F$	350V	C27	Silver-Mica	300	pF	350V
C11	Ceramic	220	pF	350V	C28	Ceramic	33	pF	350V
C12	Paper	0.05	$\mu F$	350V	C29	Paper	0.05	$\mu F$	350V
C13	Paper	0.25	$\mu F$	350V	C30	Ceramic	33	pF	350V
C14	Paper	0.25	$\mu F$	350V	C31	Paper	0.25	$\mu F$	350V
C15	Silver-Mica	1800	pF	350V	C32	Paper	0.25	$\mu F$	350V
C16	Paper	0.01	$\mu F$	350V	C33§	Paper	0.1	$\mu F$	350V
C17	Paper	0.05	$\mu F$	350V	C34§	Electrolytic	100	$\mu F$	6V
					C35§	Paper	0.1	$\mu F$	350V

\* High-impedance input attenuator  
 § High-gain probe

Resistors

R1	150 kΩ	1W	R28	390 Ω	1/2W
R2	22 kΩ	1/2W	R29	470 Ω	1/2W
RV3	50 kΩ	1W linear	R30	47 Ω	1/2W
RV4	100 kΩ	1W linear	R31	2 × 10 Ω	2 × 1/2W in parallel
R5	270 kΩ	1/2W	R32	1 MΩ	1/2W
R6	2.2kΩ	1/2W	R33	82 kΩ	1/2W
R7	2.2kΩ	1/2W	R33a	10 kΩ	1/2W
R8	2 × 8.2kΩ	2 - 2W in parallel	R34	100 kΩ	1/2W
R9	8.2kΩ	2W	R35	27 kΩ	1/2W
R10	100 kΩ	1/2W	R36	10 kΩ	1/2W
R11*	10 MΩ	1/2W	R37	10 kΩ	1/2W
R12	1.2MΩ	1/2W	R38	4.7kΩ	1/2W
R13	1.0MΩ	1/2W	RV39	25 kΩ	1W linear
R14	330 Ω	1/2W	RV40	2 MΩ	1W linear
R15	10 kΩ	1/2W	R41	390 kΩ	1/2W
RV16	10 kΩ	1W linear	R42	1 MΩ	1/2W
R17	220 Ω	1/2W	R43	10 MΩ	1/2W
R18	5.6kΩ	1/2W	R44	1.2MΩ	1/2W
R19	1 MΩ	1/2W	R45	4.7MΩ	1/2W
R20	270 Ω	1/2W	R45a†	3.9MΩ	1/2W
R21	5.6kΩ	1/2W	R46	4.7MΩ	1/2W
R22	10 MΩ	1/2W	R46a†	3.9MΩ	1/2W
R23	10 kΩ	1/2W	R47	100 kΩ	1/2W
R24	10 kΩ	1/2W	RV48†	2 × 2 MΩ	two-gang, linear
R25	4.7MΩ	1/2W	RV49†	2 × 2 MΩ	two-gang, linear
R25a†	3.9MΩ	1/2W	R50§	470 kΩ	1/2W
R26	4.7MΩ	1/2W	R51§	47 kΩ	1/2W
R26a†	3.9MΩ	1/2W	R52§	470 kΩ	1/2W
R27	10 kΩ	1/2W	R53§	1.5kΩ	1/2W
			R54§	120 kΩ	1/2W
			R55§	470 kΩ	1/2W

\*High-impedance input attenuator †Shift control circuit §High-gain probe

Potentiometers are ± 20% tolerance; all other resistors are ± 10%

The metal rectifier MR1 may be any suitable type

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The value of the resistor shown as R3 in Fig. 1 should read 27kΩ, not, as indicated, 2.7kΩ.