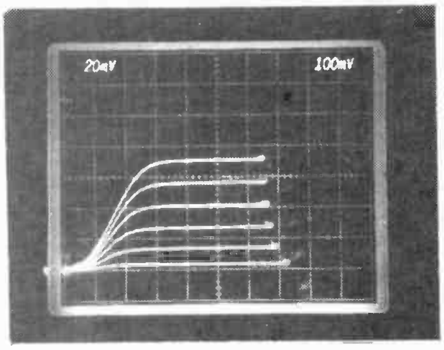
CURVE TRACER

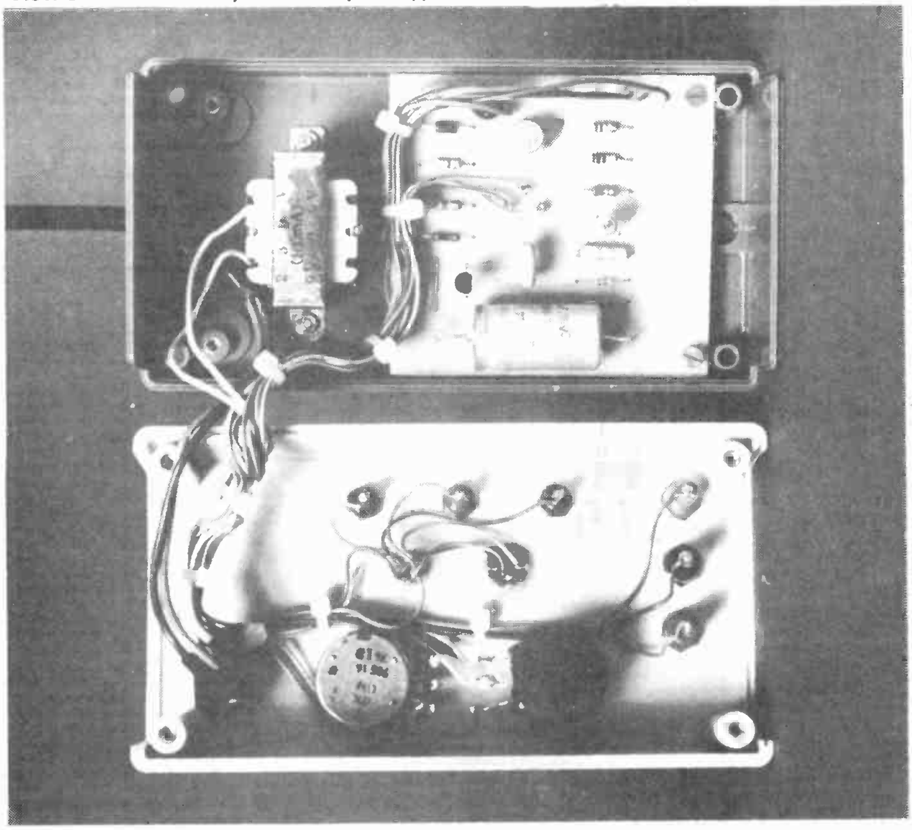


Display the dynamic characteristics of a variety of semi conductor devices with out curve tracer. Design by J. H. Adams.

THE CURVES INVOLVED in this design are not unfortunately those of the Bardots and Welchs of this world but curves that, to some, are just as interesting. The design will allow the dynamic voltage-current characteristics of diodes and transistors to be displayed on the screen of a DC 'scope capable of taking an external X input.

The performance of the unit will not be up to that of a commercial machine but considering such commercial designs are priced in the thousand pound range while our design could be built for around five pounds, we're not doing too badly.

View of the internal layout of the prototype version



Construction of the curve tracer is straightforward. Mount all the components on the PCB according to the overlay. The interal layout of our prototype is shown in the photographs. The unit is mains powered and a battery supply is not suitable for this circuit.

Initially try the curve tracer with a high gain nrn transistor, a BC108 will be ideal. Connect it to one of the tracer's sockets and connect the unit to the 'scope. Set the Y gain on the 'scope at maximum and set up the maximum required level of collector voltage by adjusting RV1. RV2 will control the number of steps displayed on the screen. The X sensitivity of the 'scope should be 1V per division.

The performance of the unit is degraded by the slight drop in the DC potential on C1 during the 10mS sweep and the slight effect of the 100R sampling resistor, in that its volt drop is included in the observed collector potential. However as stated above the unit will give a good indication of the dynamic performance of a wide range of semiconductor devices (as the photograph shows) at a price that is a fraction of similar commercial equipment.

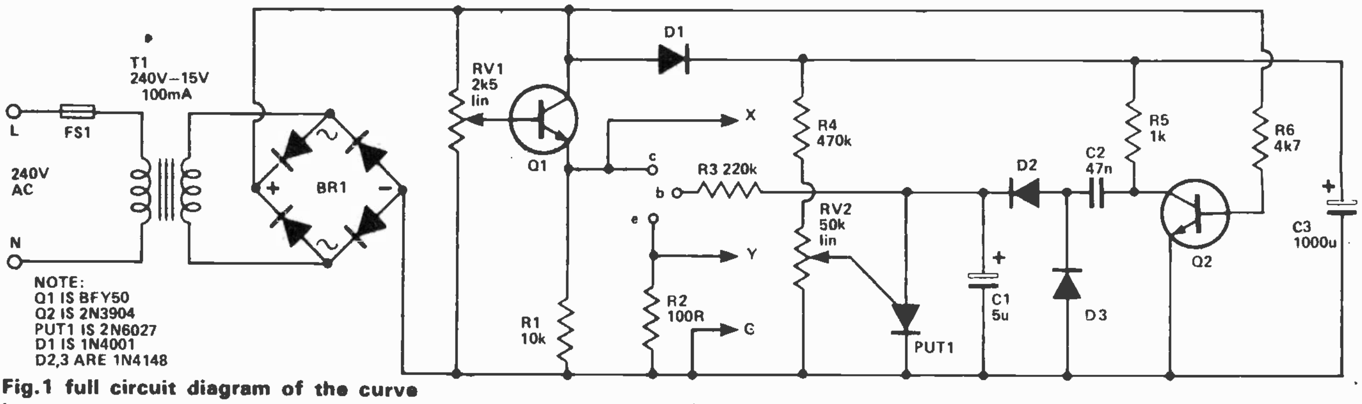


Fig.1 full circuit diagram of the curve tracer.

HOW IT WORKS

The principles of the full circuit can perhaps be best explained by consideration of a simpler form of the circuit. Figs. 2 and 3 show circuits for investigating the dynamic characteristics of a diode and transistor (at fixed base current) respectively.

The 'diode circuit' will, unless an inverter is available, produce a trace that will appear upside down.

Operation of this circuit is quite straight forward. RV1 allows the peak value of the AC supply to be adjusted. This is then applied to the device under test via a current limiting resistor as well as to the X input of the 'scope. The current flow in the device at any time is proportional to the voltage developed across a low value sampling resistor in the current path. This voltage is fed to the Y input of the scope.

The simple transistor tester functions in much the same way. RV1 allows the base current to be adjusted within the range 10aA to 100aA.

The characteristics of an N-Channel FET (2N3819) may also be examined with this basic building block. The output characteristics are displayed for a gate voltage selected by RV1. Transfer characteristics (gate voltage vs. Drain Current) may be shown by transferring lead X to the gate terminal and mining the 1000μF capacitor to the 15V supply (observing the change in polarity).

Moving now to the full circuit of Fig 1 that allows a far more informative display providing, as it does, simultaneous displays of the characteristic curves for several equally spaced values of base current.

The circuit operates as follows. Every 10 ms the collector supply swings up and back over a half cycle of the full-wave rectified supply. At the end of each half cycle, there is a short period during which the supply potential is below about 0.6 V, and during this time, Q3 turns off, sending a pulse from its collector into the charge store C1 C2 D3 D2. Each pulse increases the potential in C1 by approximately 0.2 V. This would go on until the potential on C1 was 20 V were it not for Q2, the little known and much mis-described programmable unijunction transistor, PUT. This device is the semiconductor version of a neon lamp, insulating up to a certain p.d. and conductiong heavily at potentials above this breakdown value, but with the added advantage in that, through a third terminal, this breakdown potential is programmable over quite a wide range. Varying this control potential through the setting of VR2 sets the number of steps that will occur before the potential on C1 is great enough to make Q2 fire, reducing the capacitor's potential to approximately 0.6 V and so re-starting the sweep sequence.

The tracer can hardly be expected to match all the performance of a commercial curve tracer, the prices of which range into thousands of pounds. There are errors, due to the slight droop in d.c. potential on C1, and hence in base current, during the 10ms sweep, and due to the slight effect of the 100R sampling resistor, in that its volt drop is included in the observed collector potential, but as can be seen, these are quite insignificant as regards the final display. The only problem which may arise is the appearance of Radio 4 on the current axis (seen as a thickening of the trace). This is easily cured by placing a 10n disc capacitor across the actual Y-inputs of the oscilloscope.

A suitable transistor for the device under test is any reasonably high gain npn transistor, e.g. BC108. VR1 controls the maximum collector voltage, whilst VR2 sets the number of sweeps displayed. With the values given, the difference in base current between one step and the next is approximately given by:

$$\frac{1}{5R}\ \mu\text{A, where } R \text{ is in megohms.}$$

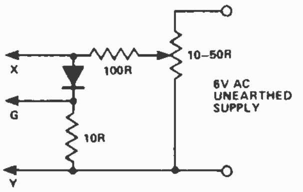


Fig.2 simple diode tester

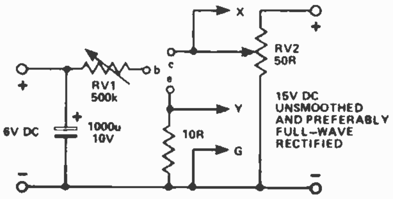


Fig.3 fixed current transistor tester

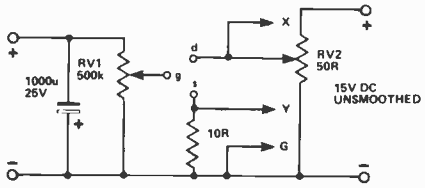
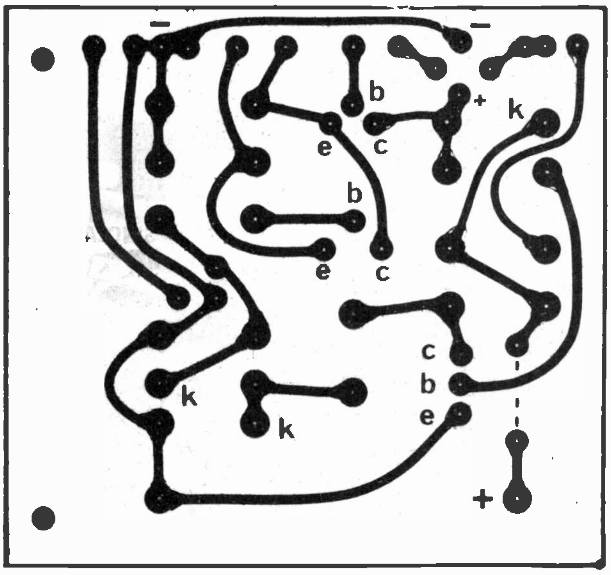


Fig.4 circuit for investigating FET transfer characteristics.



PARTS LIST

RESISTORS

R1	10k
R2	100R
R3	220k
R4	470k
R5	1k0
R6	4k7

CAPACITORS

C1	5u0 25 V electrolytic
C2	47n polyester
C3	1 000 25 V electrolytic

SEMICONDUCTORS

Q1	BFY50
Q2	2N3904
PUT1	2N6027
D1	1N4001
D2,3	1N4148
BR1	0.9A 400V

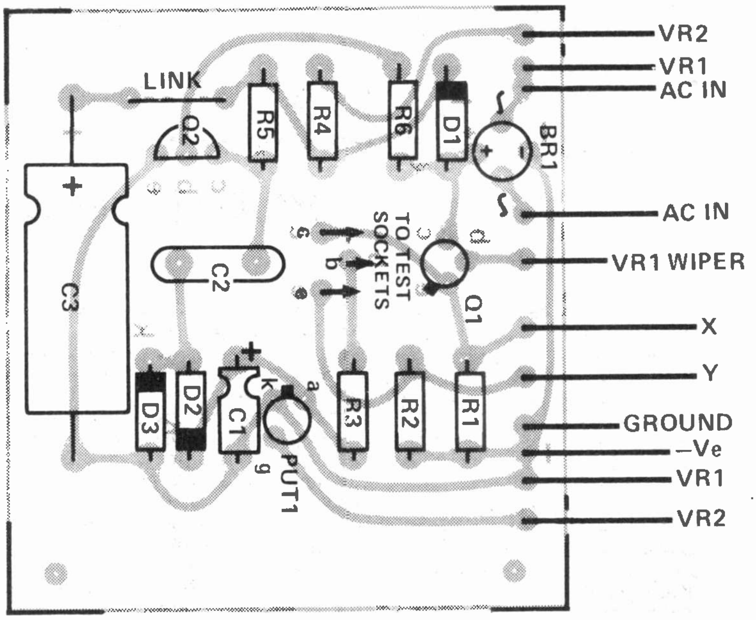
POTENTIOMETERS

RV1	2k5 1in
RV2	50k 1in

MISCELLANEOUS
PCB as pattern, case to suit, sockets, knobs, cable, etc.

BUYLINES

The components used in this project should in the main, be generally available — the only component likely to cause problems is the PUT, but this should be available from the larger mail order outlets.



7400 TTL	
7400	.10
7401	.12
7402	.12
7403	.12
7404	.10
7406	.27
7406	.12
7409	.13
7410	.12
7411	.21
7412	.21
7413	.24
7471	.64
7416	.26
7417	.33
7420	.12
7426	.24
7427	.24
7430	.12
7432	.23
7433	.50
7437	.23
7438	.23
7440	.16
7441	.50
7442	.38
7443	.85
7445	.67
7446	.67
7447	.59
7448	.48
7450	.16
7451	.16
7453	.16
7454	.16
7460	.16
7470	.36
7472	.32
7473	.21
7474	.26
7475	.29
7476	.31
7483	.68
7485	.84
7486	.25
7489	1.95
7490	.38
7491	.62
7482	.42
7493	.29
7495	.51
7496	.67
74104	.48
74105	.48
74107	.27
74109	.45
74121	.29
74122	.47
74123	.38
74141	.71

74151	.58
74154	1.00
74156	.60
74157	.54
74160	1.04
74162	.80
74163	1.18
74164	.87
74165	.93
74175	.67
74176	.84
74180	.86
74190	1.04
74192	.98
74193	.98
74194	.86
74196	.86
74197	.86
74198	1.41
74 LS TTL	
74LS00	.18
74LS01	.18
74LS02	.18
74LS04	.19
74LS05	.21
74LS08	.21
74LS09	.21
74LS10	.21
74LS11	.21
74LS14	1.10
74LS20	.18
74LS21	.21
74LS32	.24
74LS37	.26
74LS38	.29
74LS40	.25
74LS42	.54
74LS51	.29
74LS74	.32
74LS86	.33
74LS90	.86
74LS93	.86
74LS107	.34
74LS112	1.00
74LS123	.85
74LS124	2.20
74LS151	.95
74LS153	.64
74LS157	.64
74LS164	1.14
74LS175	1.05
74LS193	1.33
74LS194	2.06
74S TTL	
74S00	.36
74S04	.26
74S05	.38
74S08	.38
74S10	.38
74S11	.38

74S22	.38
74L37	.38
74S51	.26
74S64	.20
74S74	.38
74S112	.66
74S124	3.25
MICRO's MEMORIES	
74S186	2.40
1702A	3.99
2706	7.96
2102-1	1.22
2114	10.53
8080A	7.02
8251	7.06
LINEAR	
LM380-14	.80
LM3900	.48
LM741-8	.21
NE555	.29
NE556	.71
NE565	1.14
NE506	1.43
NE567	1.62
REGULATORS	
7805	.80
7812	.80
7905	1.39
7912	1.39
LM309	.86
LM723	.38
TRANSISTORS	
AC128	.23
AC176	.23
BC107	.10
BC108	.10
BC109	.10
BC177	.18
BC178	.18
BC179	.18
BC184	.15
BC187	.32
BC477	.24
BC478	.24
BC479	.24
BD131	.54
BD132	.54
BFY50	.23
BFY51	.23
BFY52	.23
BSY95A	.17
OC71	.20
OC72	.36
DC200	.45
TIP 2955	.85
TIP 3055	.68
TIS43	.33
ZTX300	.17

ZTX500	.18
2N3053	.20
2N2054	.57
2N3055	.57
2N3702	.12
2N3704	.12
2N3819	.29
DIODES	
BAX13	.05
1N914	.05
1N4148	.05
1N4151	.04
1N4001	.06
1N4002	.06
1N4003	.08
1N4004	.10
1N4005	.11
1N4005	.11
1N4007	.12
1N4500	.16
1N4504	.21
ELECTROLYTICS UF/V	
.47/100	.08
1/63	.08
2.2/63	.08
3.3/63	.08
4.7/35	.08
4.7/63	.08
10/16	.08
10/35	.08
10/63	.09
22/16	.08
22/35	.10
22/63	.12
33/16	.08
33/35	.11
33/63	.13
47/16	.09
47/35	.12
47/63	.15
100/16	.11
100/35	.13
100/63	.24
220/16	.12
220/25	.17
330/16	.18
330/35	.31
470/6V3	.14
470/16	.18
470/35	.38
1000/16	.30
1000/25	.48
2200/16	.54

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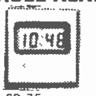

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