BASIC MEASUREMENTS

In this section of the manual basic procedures for making measurements on various devices are described.
Some examples and exceptions are also indicated.

NOTE:
The tests in the following pages are merely examples. Select the parameters in all the tests carefully for your specific device. Exceeding the limit values, as indicated in the component data sheet, may be destructive to the device. Especially the various breakdown voltage tests can be destructive.

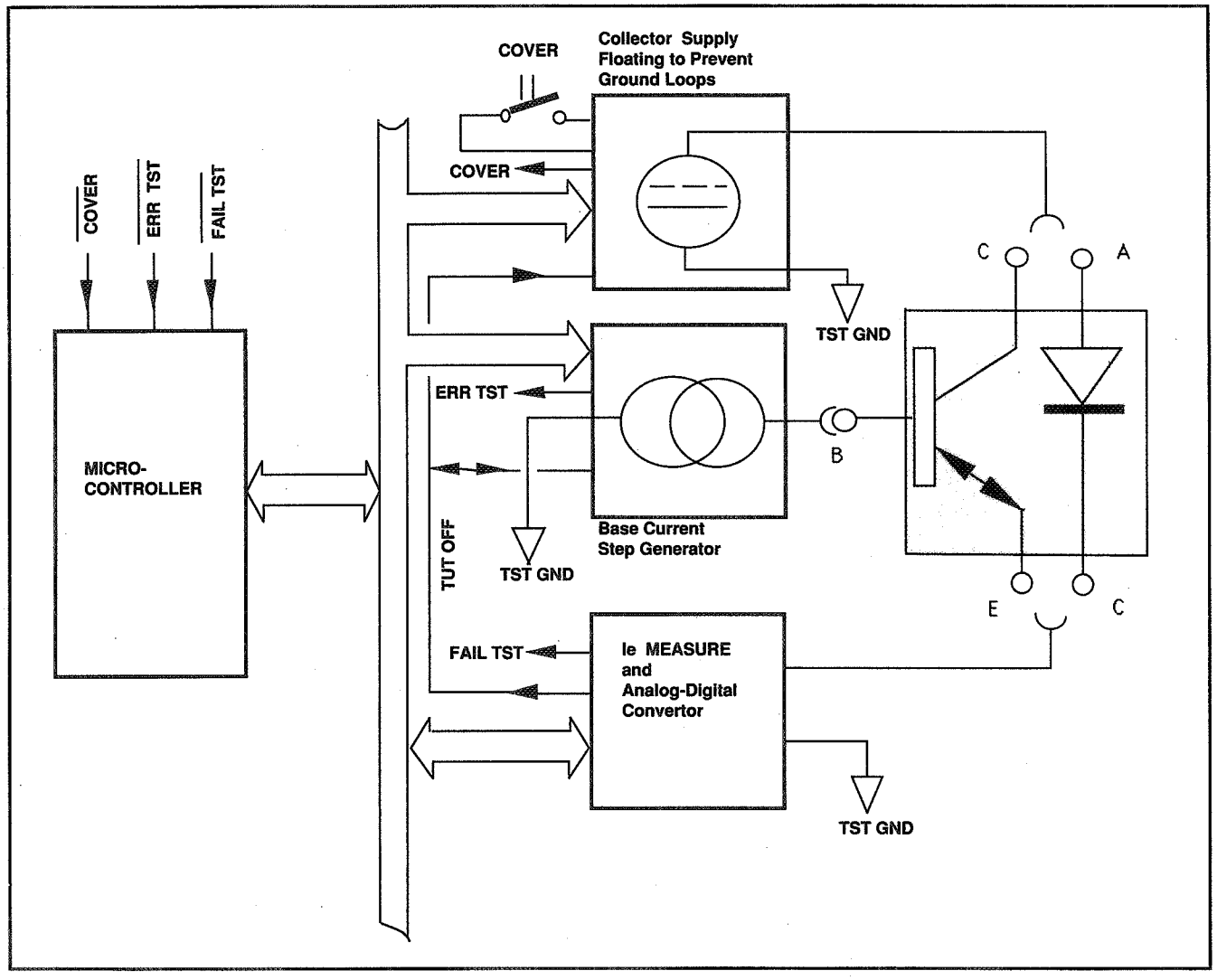


Fig. 3-1 Block diagram 571 Curve Tracer.

TRANSISTOR MEASUREMENTS

A NPN transistor, type 2N2219, is used in the following examples. (A type 2N3904 provides similar results.)
Put the transistor in the appropriate socket with the leads in the correct contact, as indicated on the front panel.

Press MENU and select the appropriate type and parameters on the menu page. In this example an NPN type is used, but a PNP (2N3906) provides similar results.
Pressing START will result in a set of Vce - Ic curves (Fig. 3-3) that gives a general indication of the transistor's performance.

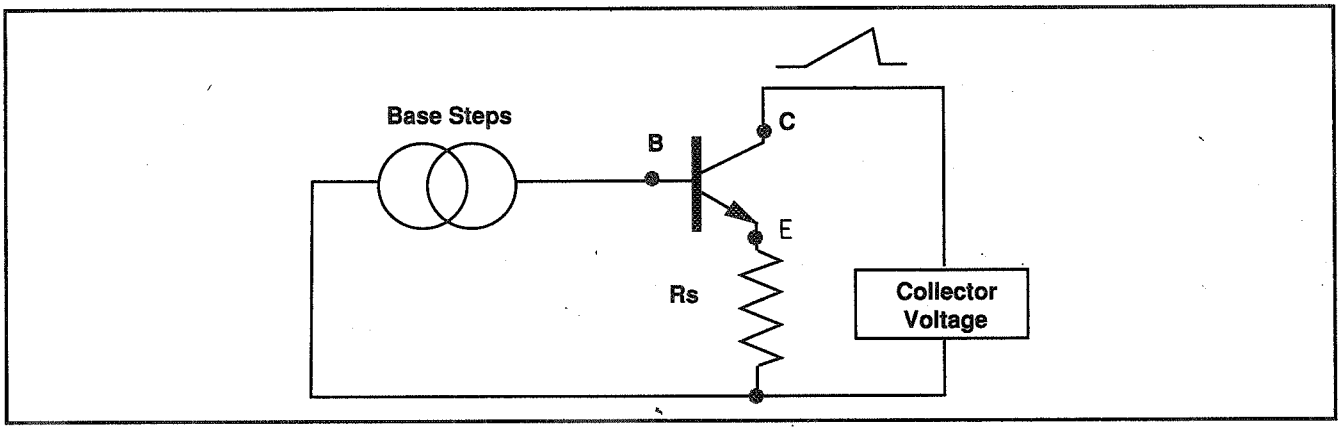


Fig. 3-2 Transistor Connection diagram.

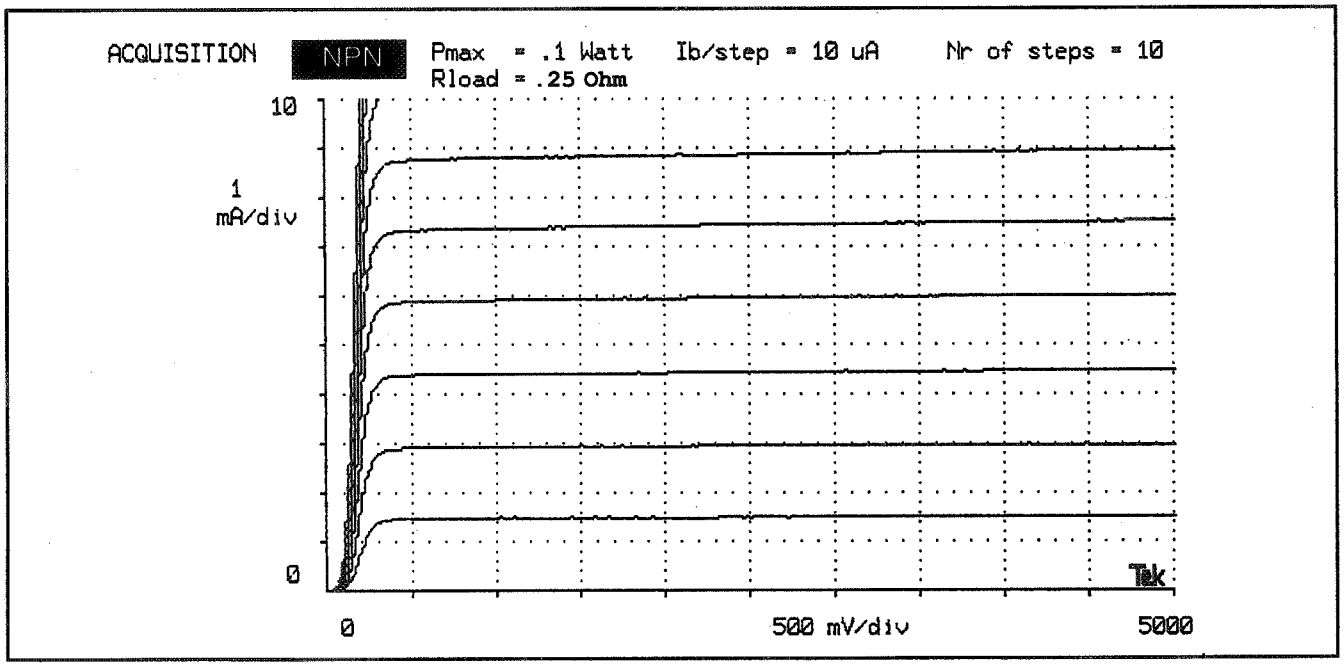


Fig. 3-3 Vce - Ic curves (NPN transistor).

SATURATION voltage [Vce (sat)].

Press MENU to return to the menu page.
Change Vce max. to 0.5 V, Ib/step to 50 µA/step, and select Rload 10 Ohm using the arrow keys.
Pressing START results in a set of curves in the saturation region of the transistor. Saturation voltages at a given current can be examined. (Fig. 3-4)

For closer readout of the saturation voltage press CURSOR and direct the active cursor to the required position. The position of the cursor is shown at the left of the graticule.

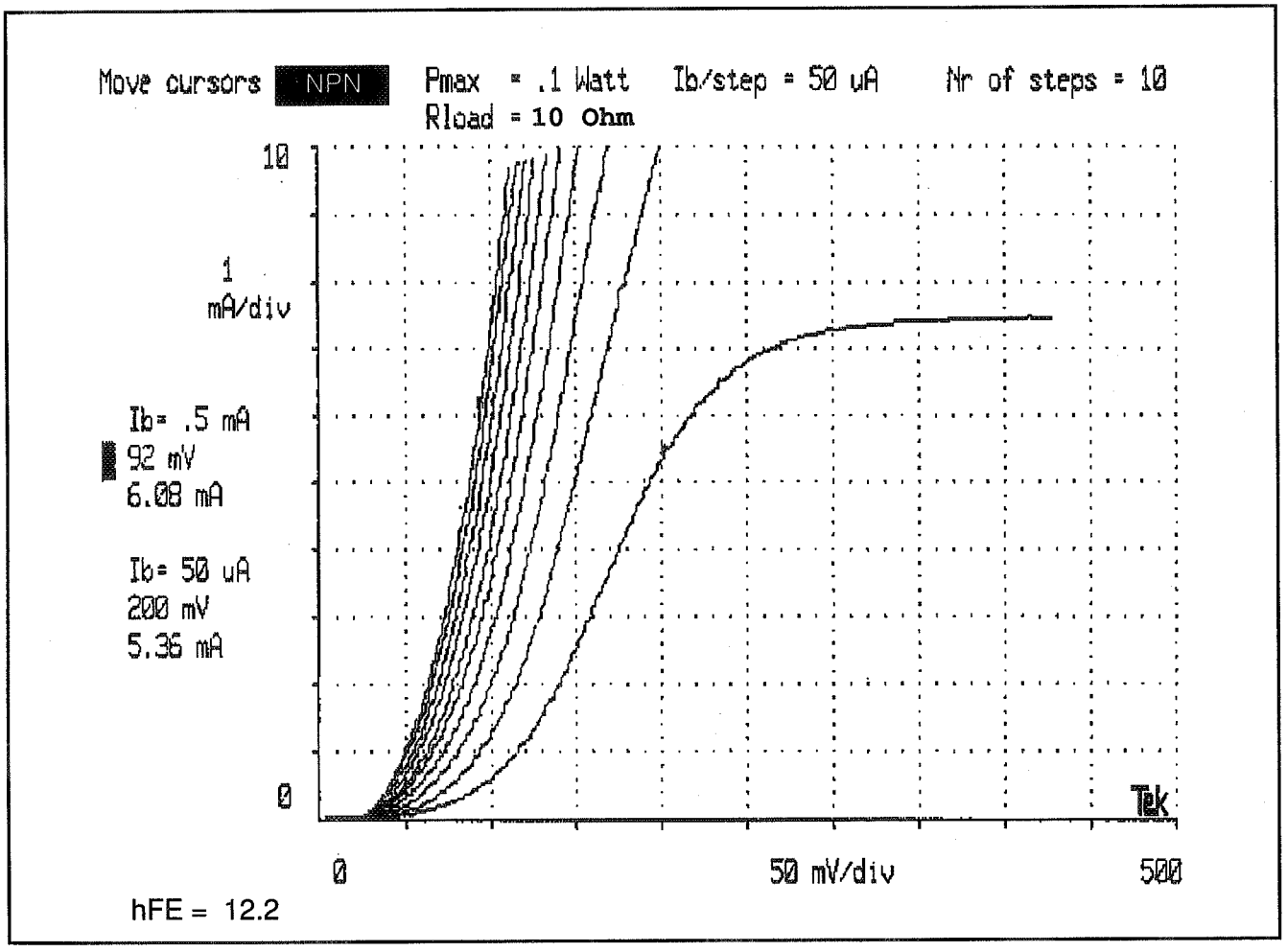


Fig. 3-4 Transistor Saturation area.

TRANSISTOR BREAKDOWN voltages

Generally, a breakdown of a reverse biased PN junction is the transition from a state of high dynamic resistance to a state of lower dynamic resistance for increasing magnitude of reverse current. The following types breakdown voltages are commonly used :

- V_{CEO} - Collector-to-emitter breakdown voltage, with base open.
- V_{CES} - Collector-to-emitter breakdown voltage, with base short circuited to emitter.
- V_{CBO} - Collector-to-base breakdown voltage, with emitter open.
- V_{EBO} - Emitter-to-base breakdown voltage, with collector open.

As an example of a transistor breakdown voltage, a set of curves on the 571 shows the Collector-Emittor break down voltages as a function of Ib in Fig. 3-5.

Press MENU to return to the menu page.
Select by using the arrow keys.:

Vce max.	100 V,
Ic max	10 mA,
Ib/step	5 µA,
Pmax	0.5 Watt

Press START. Notice that the collector-base breakdown voltage is at about 60 Volt at a given current. (Fig. 3-5)

NOTE:

Select the parameters carefully!! If not, this test can be destructive to the device. Refer to the component data sheet for more information.
Press the STOP button as soon as the current rises and the breakdown starts, to prevent damage to the device.

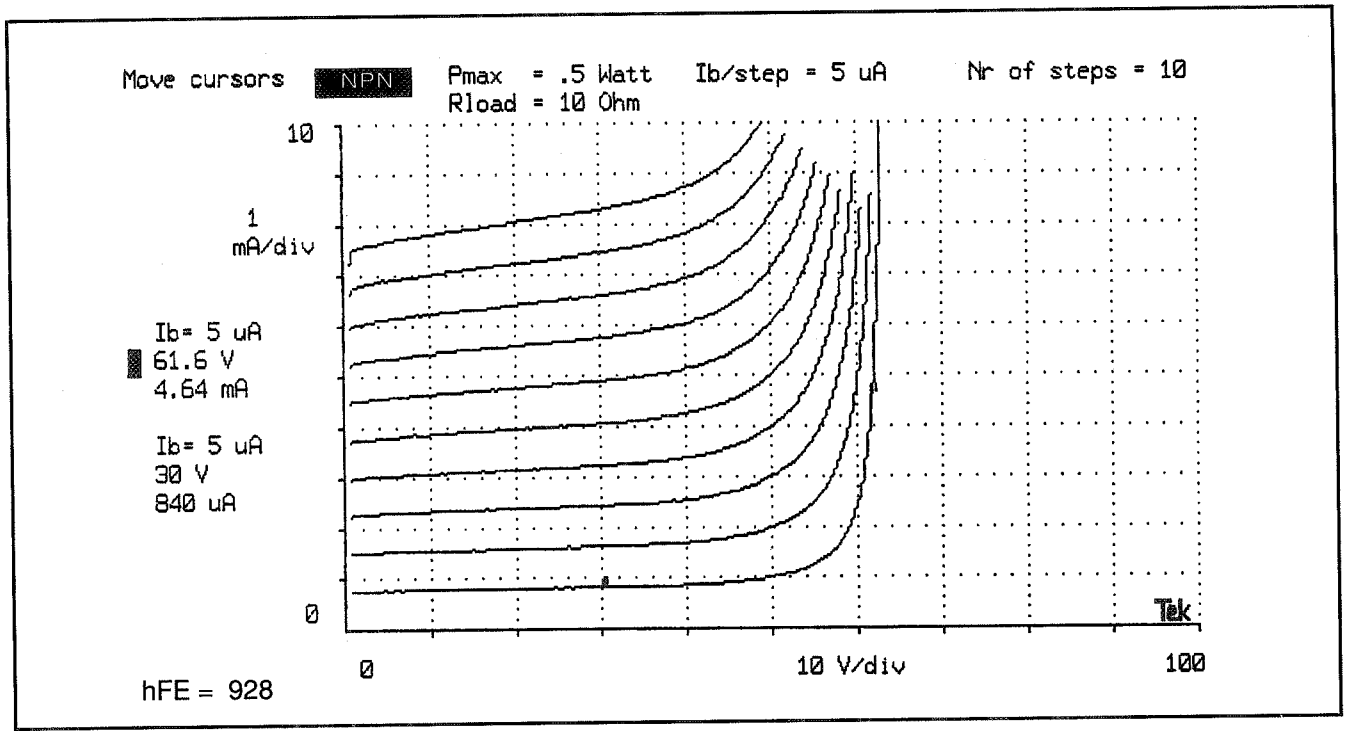


Fig. 3-5 Collector-base breakdown voltage curve.

TEMPERATURE DRIFT.

Press MENU to return to the menu page.
Select by using the arrow keys:

Function	acquisition continuous,
Vce max	20 V,
Ic max	100 mA,
Ib/step	200 µA,
Steps	3,
Pmax	2 Watt

Press START and watch the curves grow until they look like Fig. 3-6.
Press STOP to interrupt the acquisition.

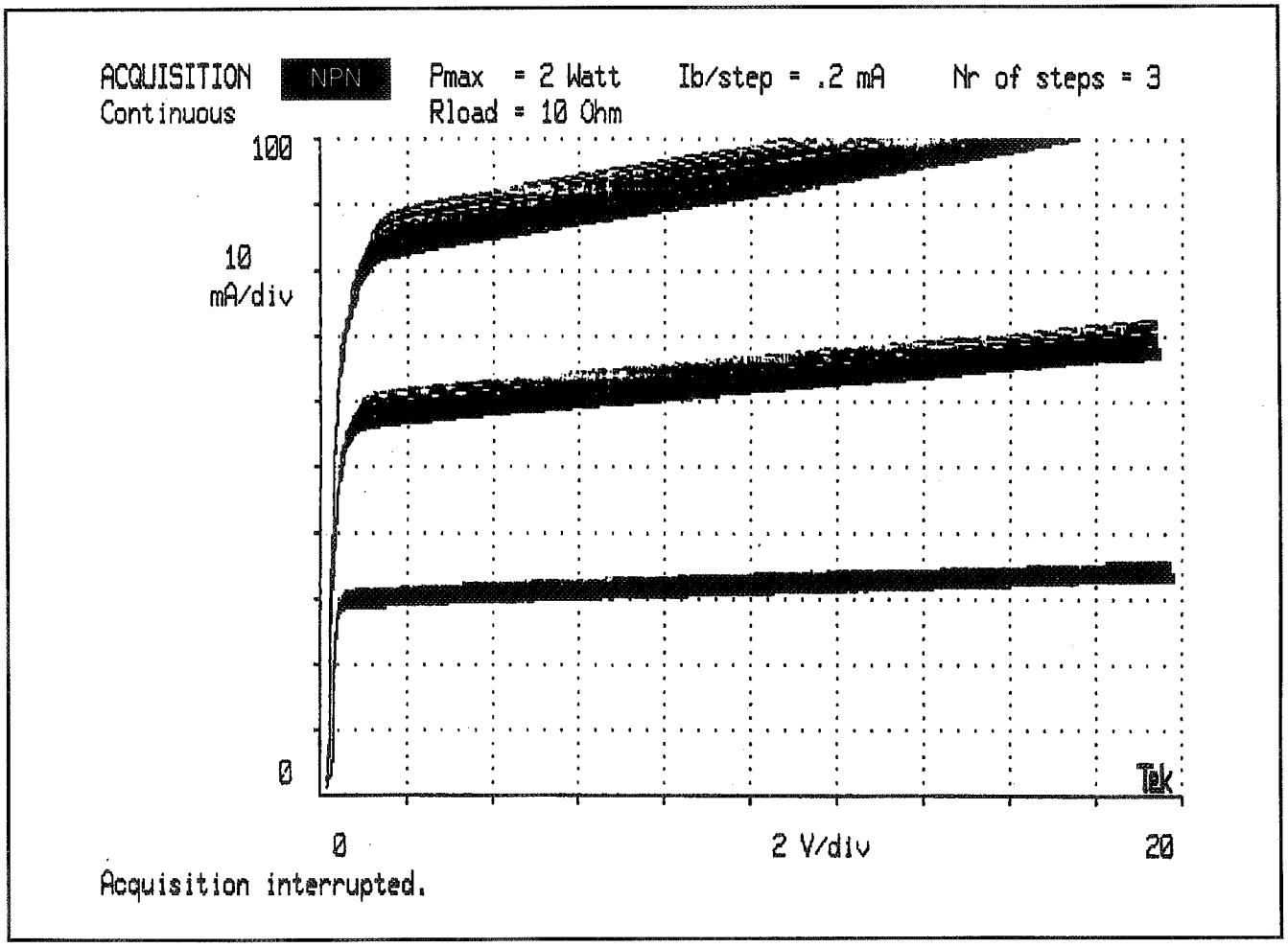


Fig. 3-6 Temperature drift curves.

LOADLINE measurement.

Press MENU to return to the menu page.
Select by using the arrow keys:

Function	acquisition,
Vce max	2 V,
Ic max	2 mA,
Ib/step	1 µA,
Steps	10,
Rload	1 kΩ,
Pmax	100 W

Press START . The curves will end along the loadline representing a load of 1 kΩ. (Fig. 3-7)

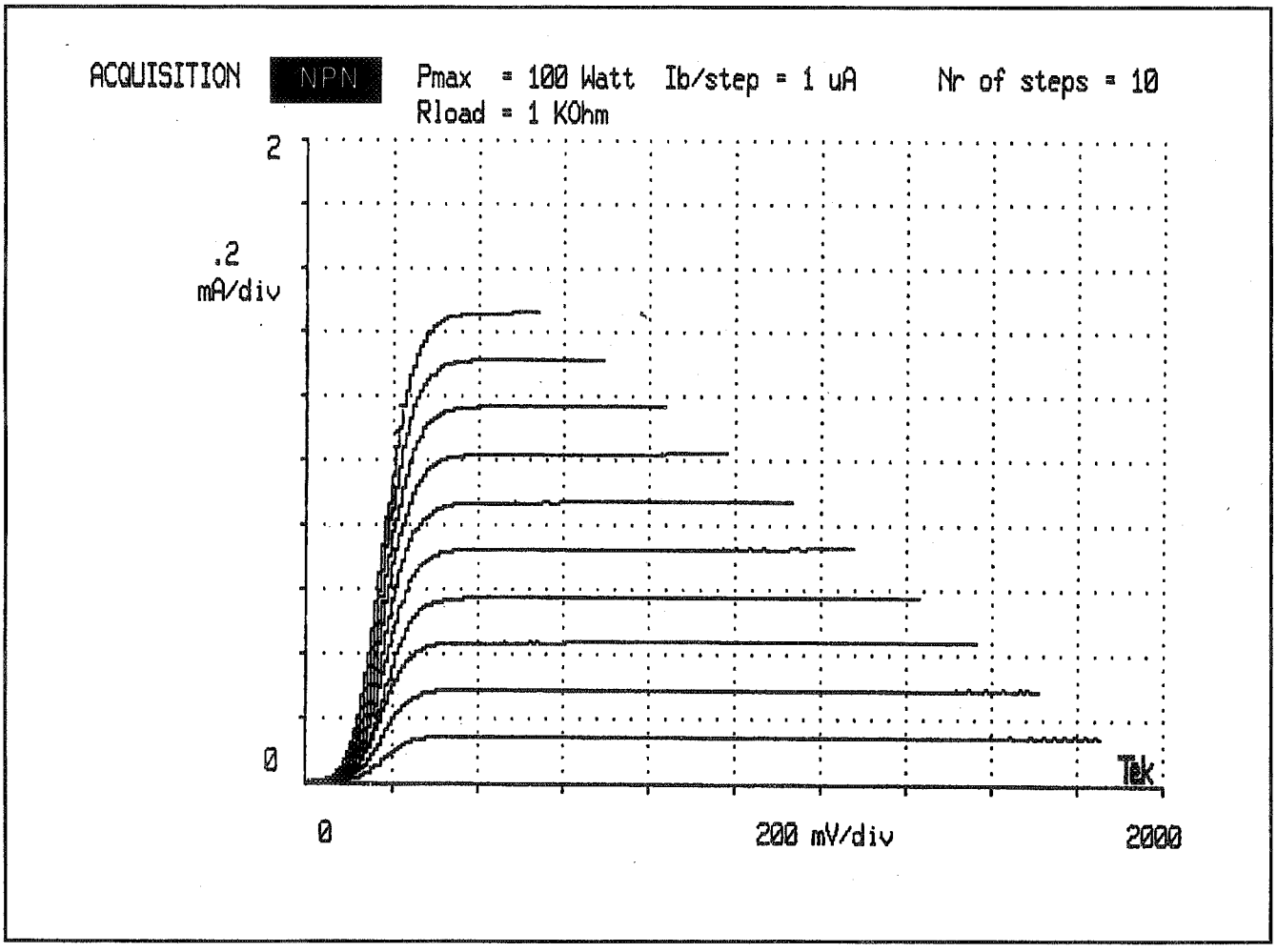


Fig. 3-7 Loadline.

POWERLIMIT measurement.

Press MENU to return to the menu page.
Select by using the arrow keys:

Function	acquisition,
Vce max .	50 V, (remember the cover!)
ic max .	20 mA,
Ib/step	10 µA,
Steps	10,
Rload	0.25 Ω,
Pmax	0.1 Watt.

Press START and notice the curves end along a hyperbola. (Fig. 3-8)

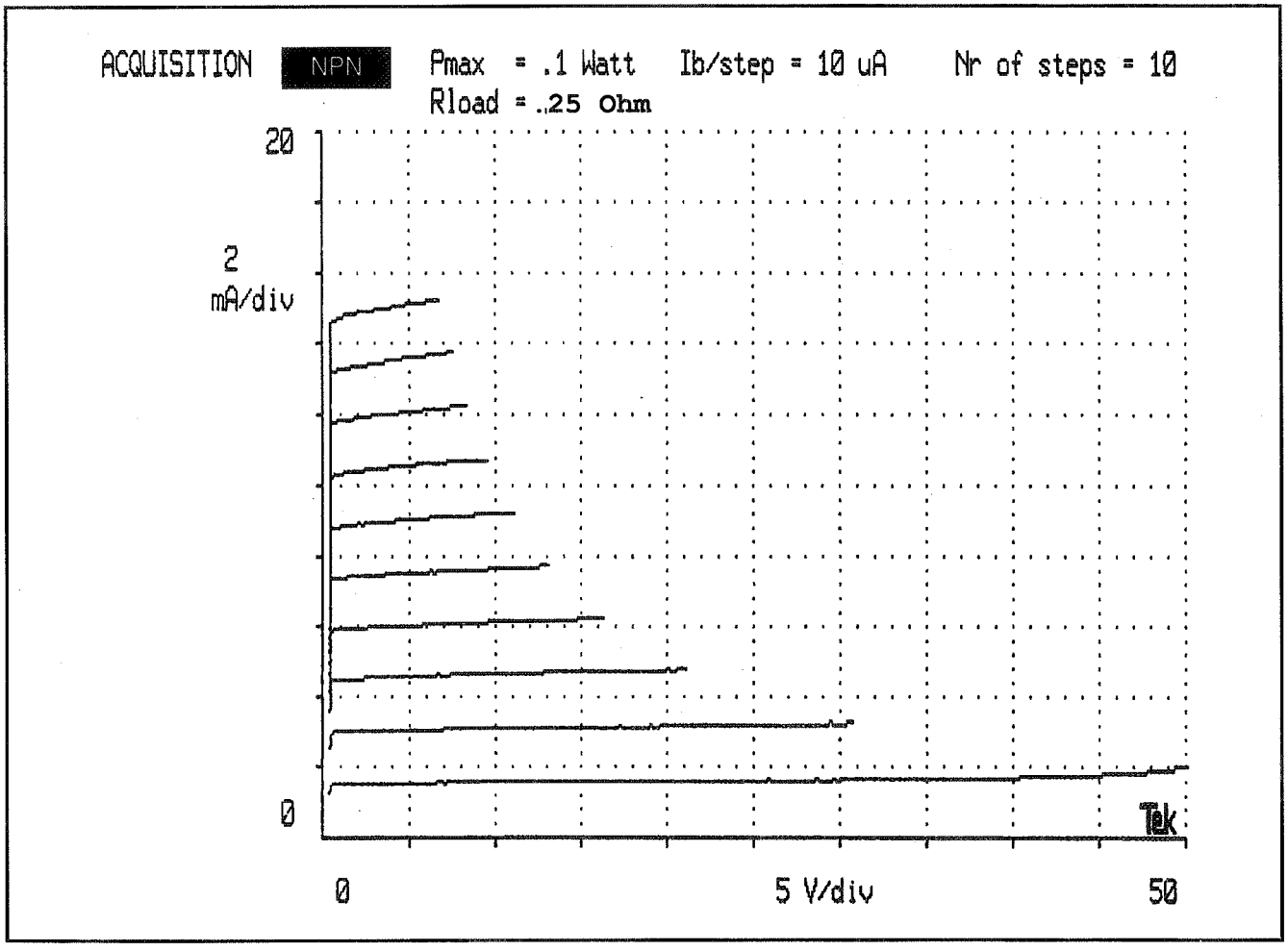


Fig. 3-8 Power curve.

H - PARAMETER measurements. [hFE, hfe, hoe]

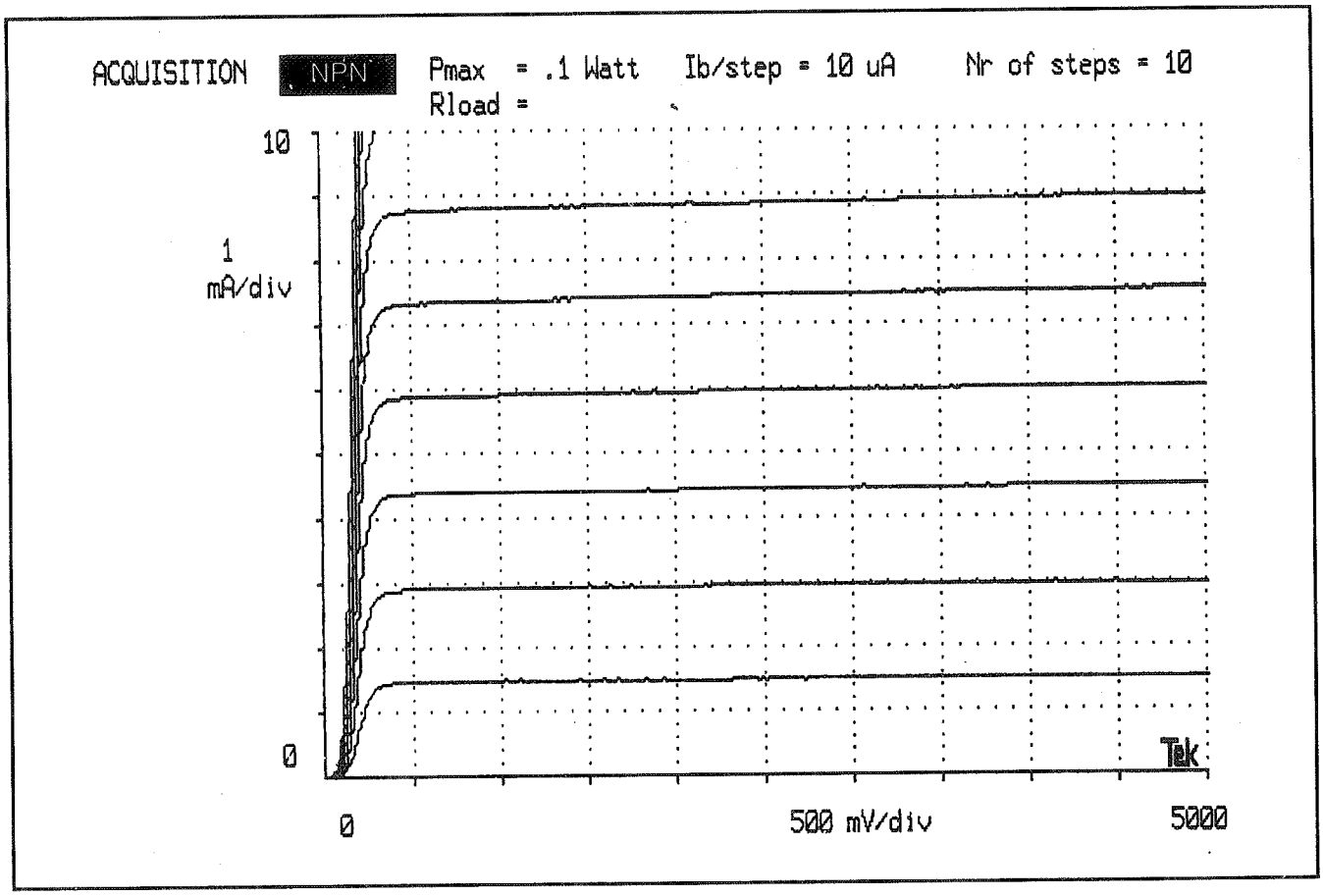
Static h-parameter measurement (h_{FE}).

h_{FE} - Create the curves according to the default settings, as indicated at the Vce - Ic test. (See figure below). Press CURSOR and notice the cursors appear in the middle of the lowest curve. The h_{FE} at the position of the blinking cursor is printed in the lower left corner of the display. The cursor can be moved by the horizontal arrow keys along the curve. After the arrow key is released, the h_{FE} is updated for the new cursor location.

Small signal h-parameter measurements (h_{fe}, h_{oe}).

h_{fe} - Move one cursor to a specific position, for instance the highest curve at 4 V. Press CURSOR to swap the activity and move the other cursor to the same voltage, one curve below. ΔIc divided by ΔIb gives the hfe under these specified conditions of collector current and collector voltage.

h_{oe} - Move both cursors to the same curve (with the vertical arrow keys). One for instance at 2 V , the other at 4 V. Δ Ic divided by ΔVce gives the hoe under these specified conditions of collector current and collector voltage.



Collector-Emitter Breakdown Voltage measurement [V ceo(br)]

Remove the base lead of the DUT from the socket. (For a PNP device, interchange the emitter and collector leads also.)
Press MENU to return to the menu page.
Select by using the arrow keys:

Type	DIODE
Va max .	100 V,
Ia max	1 mA,
Rload	1 kΩ
Pmax	0.1 Watt

Press START and observe a curve as in fig. 3-9.

NOTE:
Your picture may not look as clean as this example, try another Rload or other Ia max for better results.

Testing Vces has the same procedure, only the base lead of the DUT must be connected to the same contact as the emitter. For most devices Vces is above 100 V which is beyond the range of the 571.

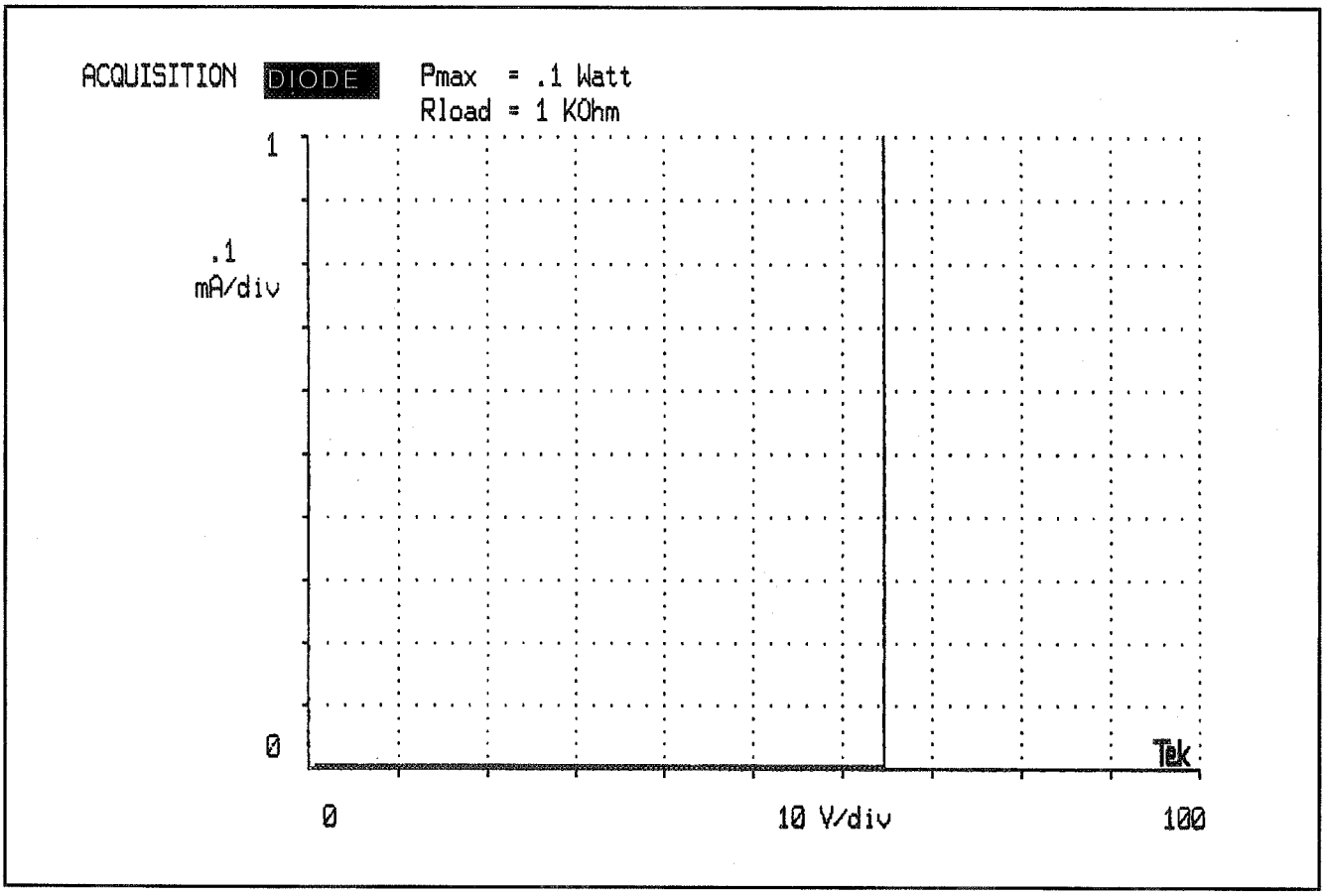


Fig. 3-9 Vceo curve.

FIELD EFFECT TRANSISTOR MEASUREMENTS

For this example a JFET type 2N4416 is used. (See Fig. 3-10 for proper connections.)
Connect the DUT in the appropriate socket on the front panel.
Go to the menu page and select:

Function	acquisition,
Type	N-FET,
Vds max.	10 V,
Id max .	20 mA,
Vg/step	200 mV,
Offset	–1.200 V,
Steps	10 ,
Rload	0.25 Ω,
Pmax .	0.1 W.

Press START and observe a set of curves as in Fig. 3-11.

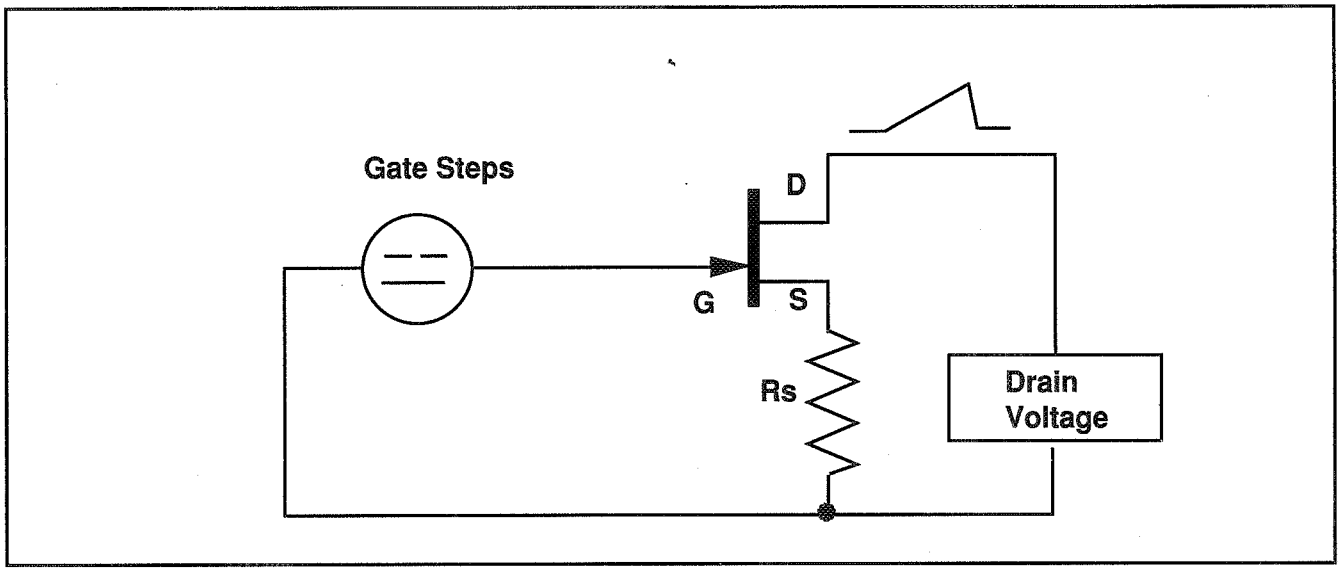


Fig. 3-10 FET Connection diagram.

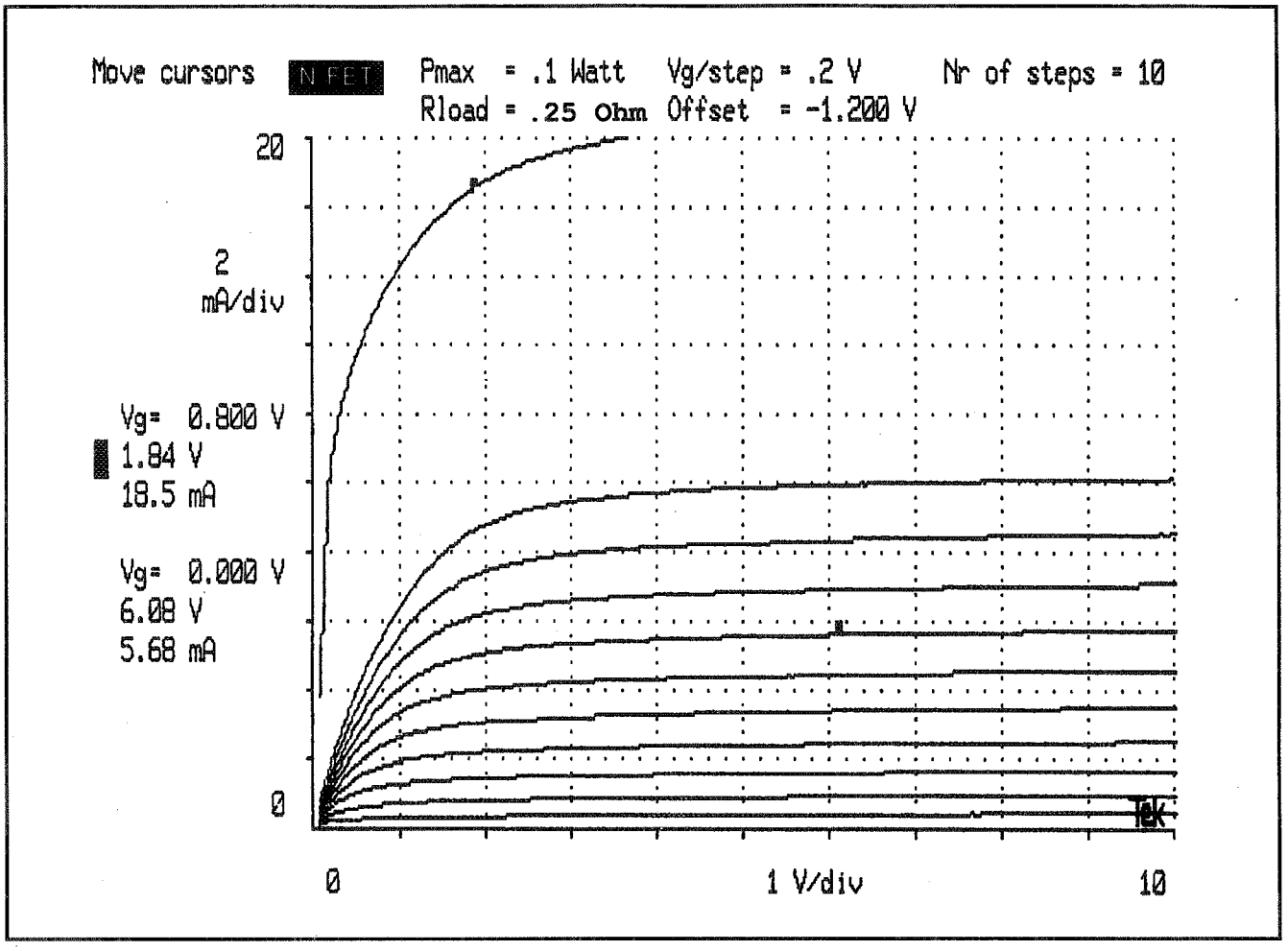


Fig. 3-11 JFET curves in depletion and enhancement mode.

The curves above the curve Vg = 0 V in Fig. 3-11 represent the enhancement mode, the curves below Vg = 0 V represent the depletion mode.
Notice the highest curve at Vg = 800 mV. At that drive voltage, the FET has the electrical properties of a good conductor.
In addition, at a drive voltage above about 600 mV the gate-channel diode opens so the gate current is changing from substantial zero to a few mA. (The driving source is a voltage source!)

This effect only happens with J-fet's. Usually, J-fet's are driven in depletion mode.
MOS-FET's can be driven as well in enhancement mode as in depletion mode, depending of the type and purpose.

DRAIN BREAKDOWN voltage.

Press MENU to return to the menu page.
Select by using the arrow keys:

Vds	100 V,
Id max.	10 mA,
Vg/step	0.2 V,
Offset	–1.400 V.

Press START and notice the Drain breakdown at about 60 V. (See Fig. 3-12)

There is another breakdown voltage: The gate-source breakdown. This is a destructive test so we will not discuss it here.

NOTE:
Select your parameters carefully!! If not, this test may be destructive to the device. Refer to your component data sheet.
Press STOP as soon as the current rises, and the break down starts, to prevent damage to the device.

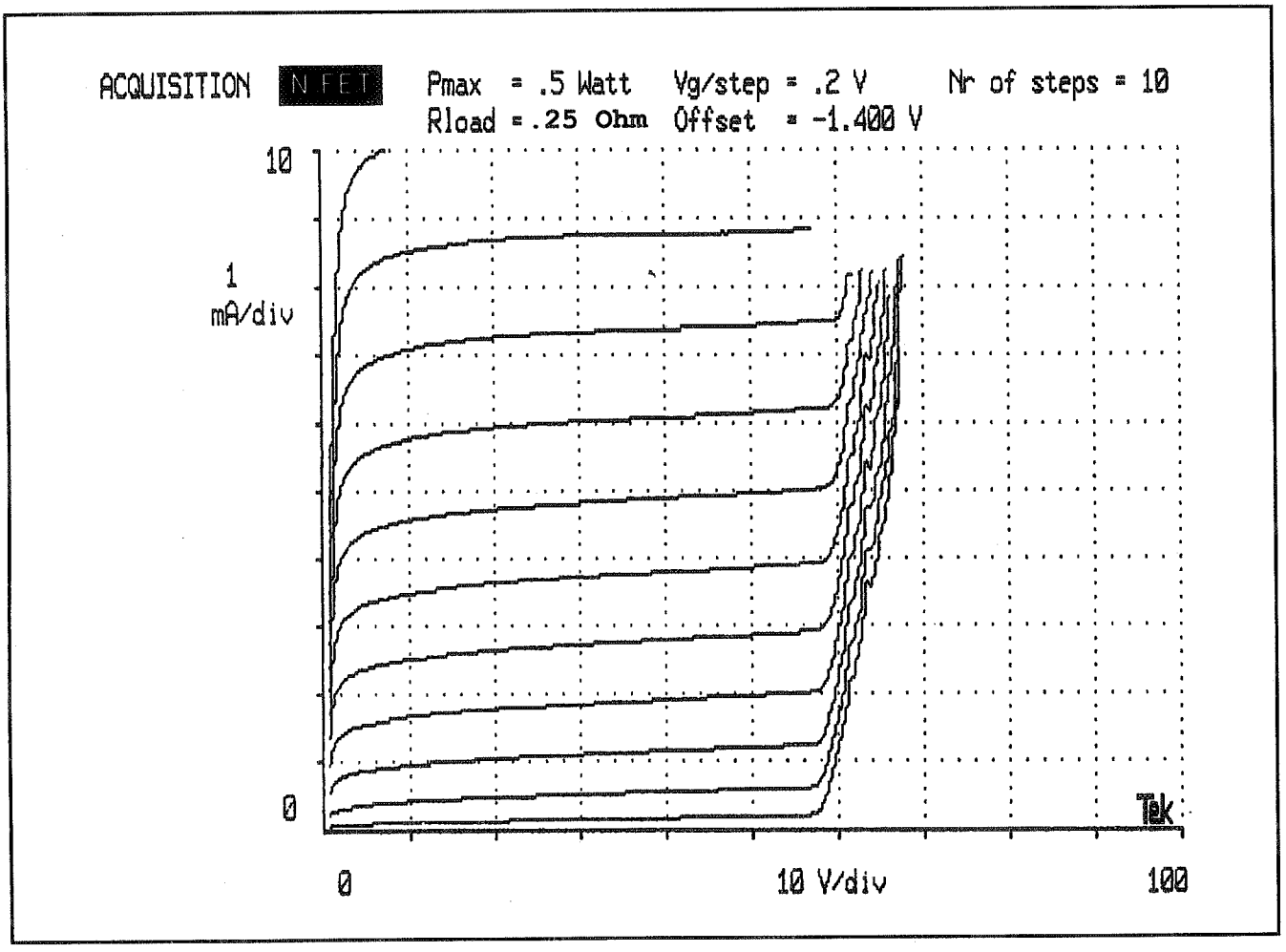


Fig. 3-12 Drain breakdown voltage curves.

PINCH OFF voltage.

Press MENU and select by using the arrow keys:

Vds max.	5 V,
Id max .	0.05 mA,
Vg/step	0.1 V,
Offset	– 2.150 V,
Rload	100 Ω

Press START. This will result in a picture of the pinch off region of the DUT. (Fig. 3-13)
Using the cursors, you can determine exactly at which curve the DUT starts to conduct. By changing the offset voltage, the pinch off voltage can be measured within 25 mV.

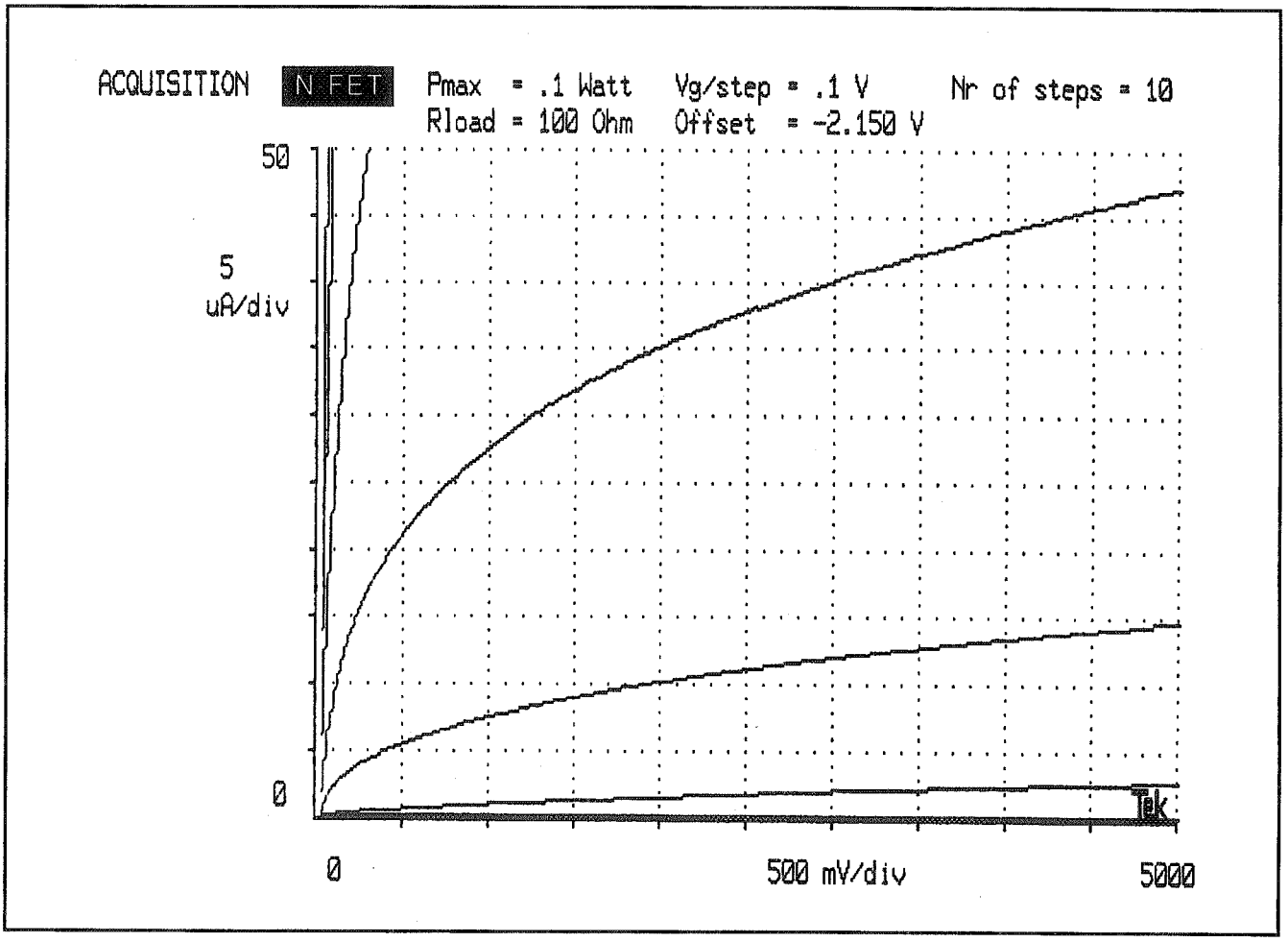


Fig. 3-13 Pinch off voltage curves.

DIODE MEASUREMENTS

FORWARD voltage.

Connect a diode in the diode socket on the front panel in forward direction.
Press MENU and select by using the arrow keys:

Type	diode,
Va max.	1 V,
Ia max.	1 mA,
Rload	100 Ω

Press START. This results in a curve as in Fig. 3-14.
To calculate Ri: Press CURSOR and direct the 2 cursors to any position you like.
Ri = ΔVa divided by ΔIa.
Press STOP to leave the cursor utility.

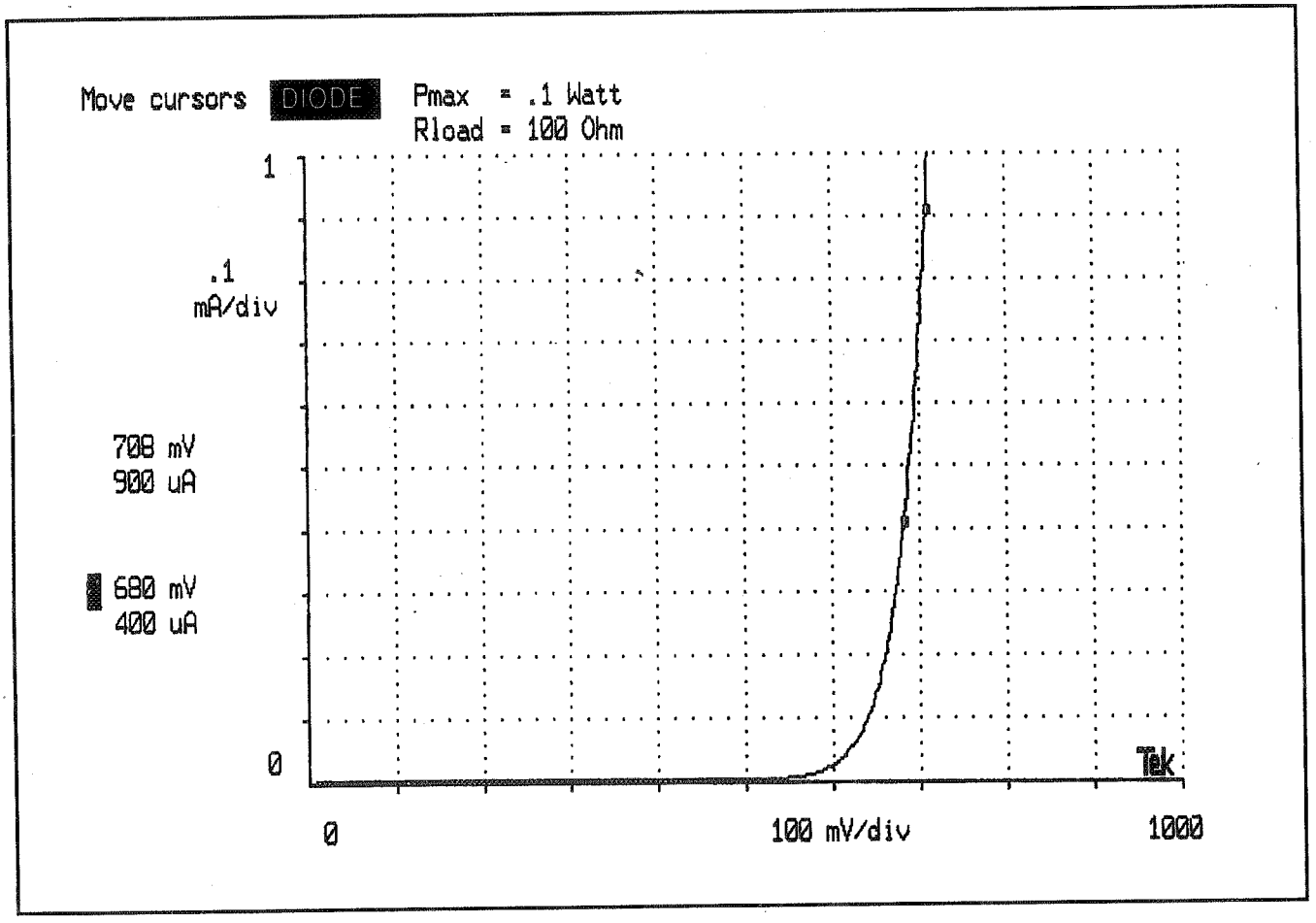


Fig. 3-14 Diode curve in forward direction.

REVERSED voltage.

Connect a zener diode in the diode socket in reversed direction. Change Va max. with the right arrow key to the appropriate value for the zener diode.
Press START.
After acquisition press STORE.

To measure the forward characteristic of the zener diode, connect the zener in forward direction.
Press START.
On one picture, the forward characteristic as well as the zener characteristic are presented. (Fig. 3-15)

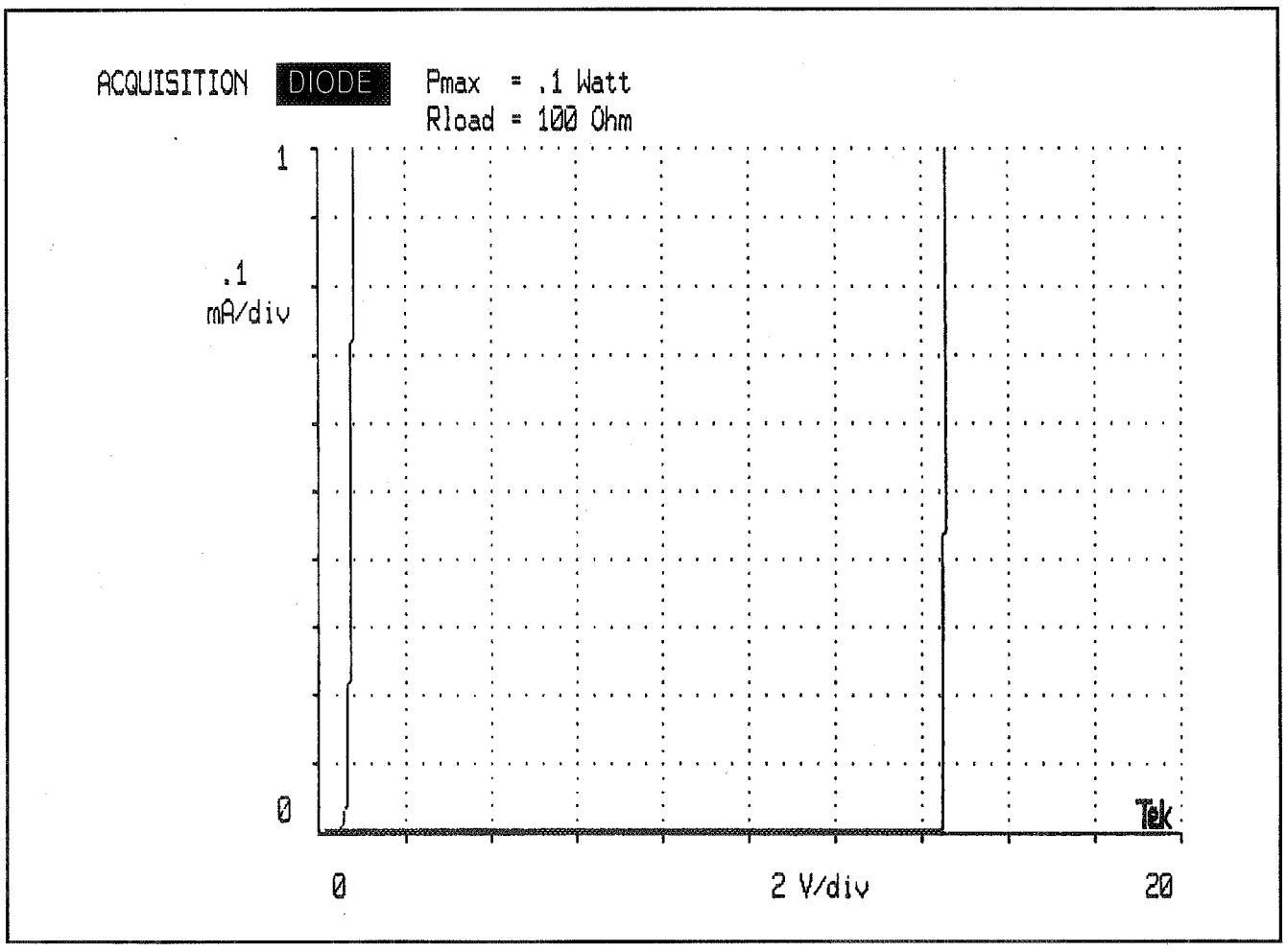


Fig. 3-15 Zener diode curve in forward and reversed direction.

THYRISTOR MEASUREMENTS

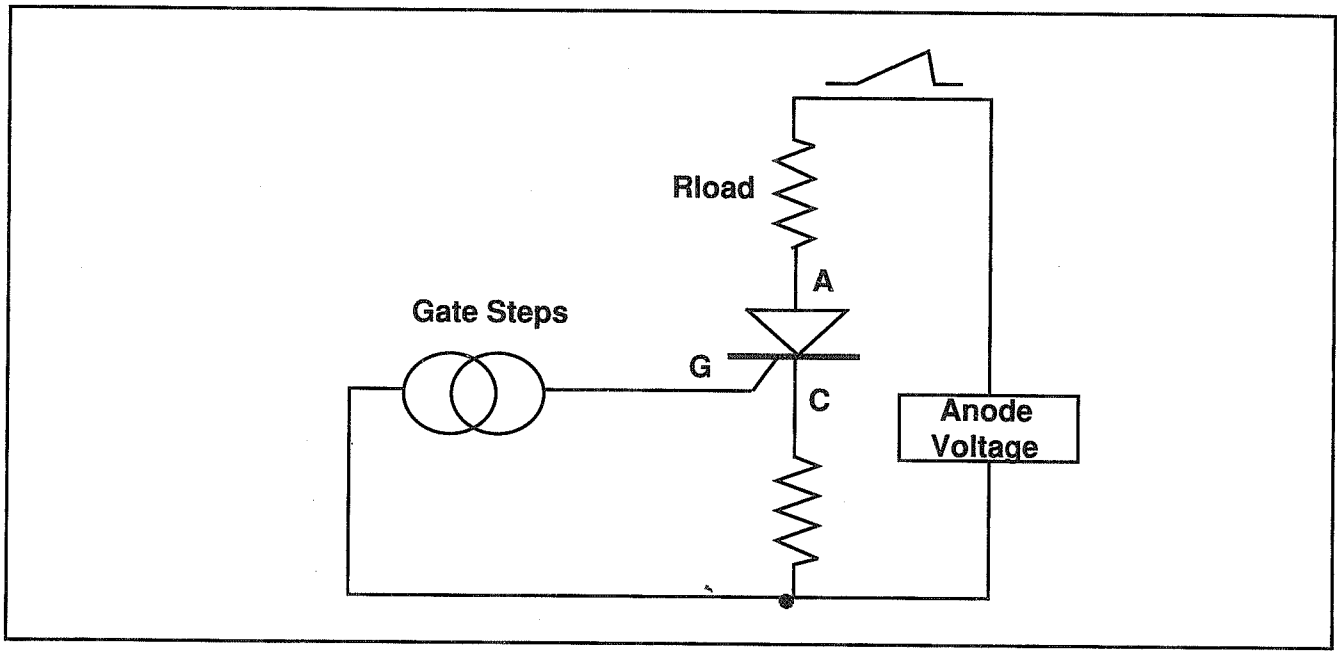


Fig. 3-16 Thyristor connection diagram.

Thyristors are tested the same way as NPN transistors, but a minimum Rload of 100 Ohm is required (See Fig. 3-16).
The 571 is performing this Rload selection automatically if an S.C.R. is selected. This measurement is executed with a BT151 type.
The 571 does not show vectors with negative ΔVxx.
Use the cursor utility to determine the range of the curve.

Select by using the arrow keys:

Type	SCR
Va max.	20 V
Ia max.	20 mA
Ig/step	0.2 mA
Steps	10
Rload	1 kΩ
Pmax.	0.1 W

Press START and notice a curve as in Fig. 3-17.

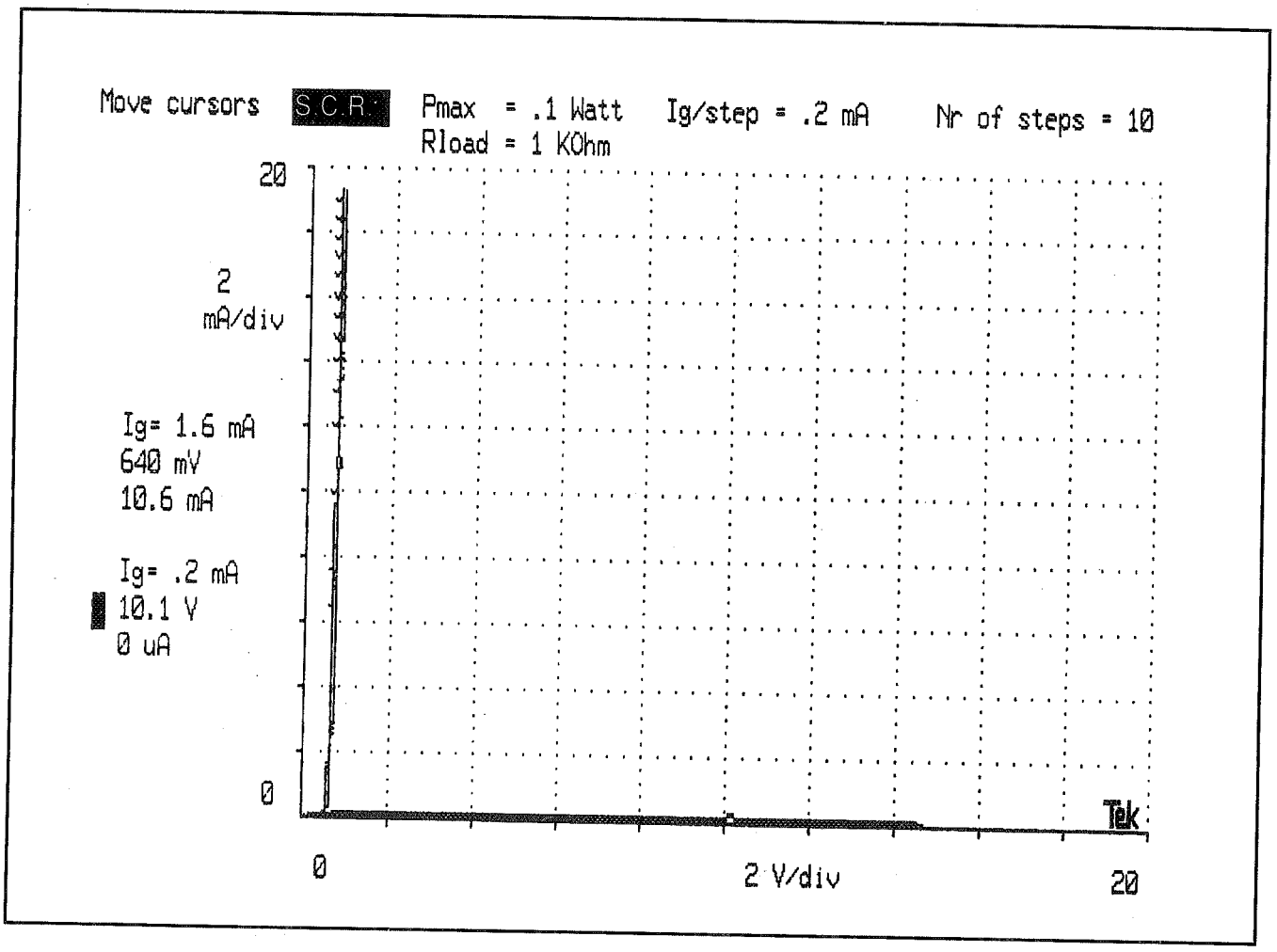


Fig. 3-17 Thyristor curves.

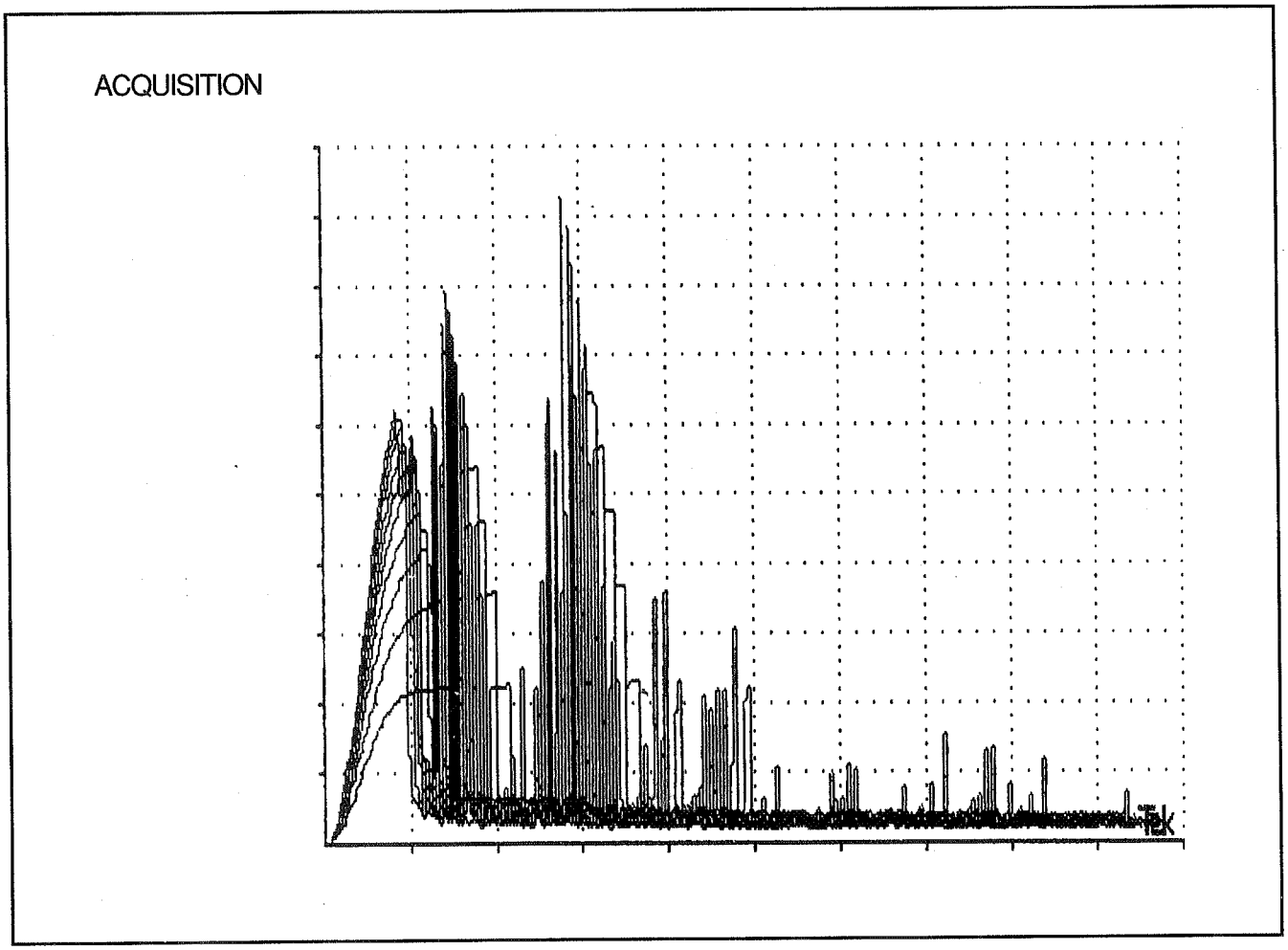


Fig. 3-18 Thermal protection curve.

A note for all measurements

Precautions have been taken inside the 571 to prevent oscillations inside the DUT.
Nevertheless it may happen that some special high frequency devices still have a tendency to oscillate. This can be noticed by a noisy display or the Hfe decreasing very suddenly in the curves. Adding a small capacitor (15 pF) between emitter and base, or a 1000 pF capacitor between collector and base of the DUT, in the same socket, will eliminate the oscillations.

Figures as shown may differ depending on types used. The 571 has a hardware overcurrent protection and a thermal protection. Trying to test a shortcircuit according to the parameters in Fig. 3-18 causes the internal thermal protection circuit to activate after a few seconds, resulting in the meaningless picture like Fig. 3-18 is.

⚠ Terminate the test quickly !

COMPARE MODE

The compare mode is intended to compare devices to a reference device (see page 2-6).
During a compare session two sets of curves will be displayed on the screen.
The high lighted curve is the reference; it will be retrieved from the memory each time an acquisition in compare mode is initiated. The second set of curves is in normal intensity. This is the set of curves of the device under test. The compare mode allows the comparison of :

1. Diodes to diodes
2. S.C.R.'s to S.C.R.'s.
3. Bipolar transistors of the same type (NPN or PNP)
4. Bipolar transistors of the complementary type (NPN to PNP and PNP to NPN)
5. FET's of the same type (P-FET's or N-FET's)
6. FET's of the complementary type (P-FET's to N-FET's and N-FET's to P-FET's)

For example :

Select : COMPARE mode,
NPN and
the desired test parameters.

Hook up a NPN transistor in the appropriate socket and press <START>.
After the acquisition the curves are stored as the reference.
Hook up another NPN transistor and press <START>.
Two sets of curves reflecting the two transistors are displayed.
Now hook up a PNP transistor and press the <UP> or <DOWN> button.
Before the acquisition starts, the absolute values of the test parameters are not altered, but ALL the polarities are inverted and the acquisition starts.

The reference device type is displayed below the word 'COMPARE' upper left on the screen, and the type of the device under test is displayed inverse in the top line on the screen.

During a compare session it is not possible to change scale factors. The scale factors used to sample the reference are also used to sample the devices under test.

The prompt bar at the bottom of the screen indicates the keys that are valid and how they affect the 571.

MAINTENANCE

General

This section of the manual provides information on recalibration of the instrument, on the verification procedure, the procedure for protection of information that is saved in the EEROM, and also general maintenance information of the 571 Curve Tracer.

To assure proper operation, execute the verification procedure of the instrument every 6 months or after 1000 hours of use, whichever occurs first.

Adjustments of internal circuits to specified accuracy, and / or calibration check should be performed at the factory or a Tektronix Service Center.
Before returning the instrument for any servicing, please contact your nearest Tektronix Service Center.

WARNING

To avoid fire hazard, use only the fuse of correct type, voltage rating, and current rating as specified on the instrument and in fuse replacing instructions.

VERIFICATION PROCEDURE

The 571 has a build in verification program, that is accessible to the user.
The test provides test patterns for the monitor, checks on the performance of the frontpanel keys, the hardware protection circuitry and the overall accuracy of the 571 analog hardware.
To test the accuracy of the hardware, a digital multimeter (for example a Tektronix DM 504 or DM 511) is required to do some external checks on the build in reference sources. This ensures the traceability of the references.
The 571 verification program offers these references on the testsockets during the verification test.
To start the verification test use the following procedure:

- Switch off the 571.
- Set the slide switch NORM/TEST on the rear panel to "TEST".
- Switch on the 571.
- The 571 starts testing successively the video part, the front panel keys, the EEROM and the references.
- Examine the patterns and follow the instructions on the screen..

Note:
If the slide switch on the rear is used by switching from "NORM" to "TEST" or "TEST" to "NORM", while the 571 is on, the software gets confused. An error message " `Contact your local Tek service office` " is being printed. Reset the 571 by switching the power off and on again.

- **Video Test**

The 571 displays a test pattern for checking CRT deflection linearity.
After evaluation of the deflection system, press any key to get the next test pattern. This allows checking the video attributes and the focus of the monitor. Again, press any key to get the next test pattern.

- **Front Panel Keys**

Any time a key is pressed, the corresponding word on the screen changes to inverse video.
The sequence of pressing a key is not essential. The keys may be pressed more than once.
As soon as all the keys, including the protect cover switch, have been activated at least once, the 571 goes on to the next test.

- **EEROM (Electrical Erasable Read Only Memory) test.**

The 571 checks the EEROM function.
Press any key to continue.

- **References.**

In this test the next two reference values are checked:

1. The 571 prompts for the collector voltage. Check the collector voltage according to the message on the screen with a DMM (connected to the banana jacks marked "E" and "C" on the front). "E" is the low output, "C" is the high output.

2. The 571 generates a current of 10 mA. When the 571 asks for it, connect the DMM in current mode between the banana jacks "E" and "B" on the frontpanel. "E" sinks the current, "B" sources the current.

- **Verification Test**

After the last instructions on the screen have been executed, the 571 indicates a complete selftest, using the two values you just verified, as its references.
The 571 prints the progress of the test procedure on the screen.
As soon as a test fails the 571 prints on the screen for instance:

```
TEST # 2 . 7 positive . XX
FAILED; READ YY EXPECTED ZZ +/- Z
```

The first number (the '2') indicates which part of the analog hardware was under test (also printed at top of the screen).
The second number (the '7') indicates which range of that part was under test.

XX is the sub test number. (Usually the stimulus that was written at the base drive or the collector supply digital to analog convertor (DAC)).
YY is the value that was read by the analog to digital convertor (ADC).
ZZ is the value that was expected.
Z is the tolerance in counts (1 count out of 250 full scale means 0.4%).

When the 571 detects an error it stops execution of the subsequent checks. If no errors are detected, the 571 displays " *** UNIT OK ! *** ".

After completing the verification test, switch off the 571, set the slide switch back to NORMAL, switch the 571 on again and resume the normal operation. If any of the tests fails, please contact your nearest local Tektronix Service Center for repair and/or calibration.

EEROM PROTECTION UTILITY

In section 2, page 2-7, the application of the EEROM was explained as part of the menu.
The write protect utility was not discussed there because it may be wise to restrict this information to just a few people who are authorized to make changes in the protected programs of the EEROM.

To activate the write protection, use the following procedure:

- Save all the menu settings you wish to have saved in the EEROM as described in section 2.
- Switch-off the 571. (Don't worry, the EEROM is non volatile, so all settings are save.)
- Press both the UP and DOWN arrow keys at the same time.
- Keep the keys pressed, while switching-on the 571 until the menu appears on the screen.

During power up initialization the write protect attribute will be stored in the EEROM. It will remain there until it is removed, (after de-activating the write protection) no matter how often the 571 is switched on and off.

To de-activate the write protection, use the following procedure:

- Switch-off the 571.
- Press both the LEFT and RIGHT arrow keys at the same time.
- Keep the arrow keys pressed while switching-on the 571, until the menu appears on the screen.

During power up initialization the 571 removes the write protect attribute from the EEROM.

CLEANING INSTRUCTIONS

This instrument should be cleaned as often as operation conditions require. Accumulation of dirt on components may act as an insulating blanket and prevents efficient heat dissipation that can cause overheating and component breakdown.
Use a non-residue type of cleaner; preferable isopropyl alcohol or denatured ethyl alcohol.
Before using any other type of cleaner consult your Tektronix Service Center or representative.

Exterior : Loose dust accumulated on the front can be removed by a soft cloth or a small brush.
Dirt that remains on the front can be removed with a soft cloth dampened with a mild detergent and water solution.

CAUTION

Do not use abrasive cleaners !!

Interior : It is recommended that in cleaning the interior, the accumulated dust be first blown off with dry low pressure air, then use a soft brush to remove any remaining dust.

CAUTION

This instrument contains electrical components that are susceptible to damage from static discharge. Discharge the static voltage from your body by wearing an approved wrist strap and pad connection while cleaning the interior of the instrument !!