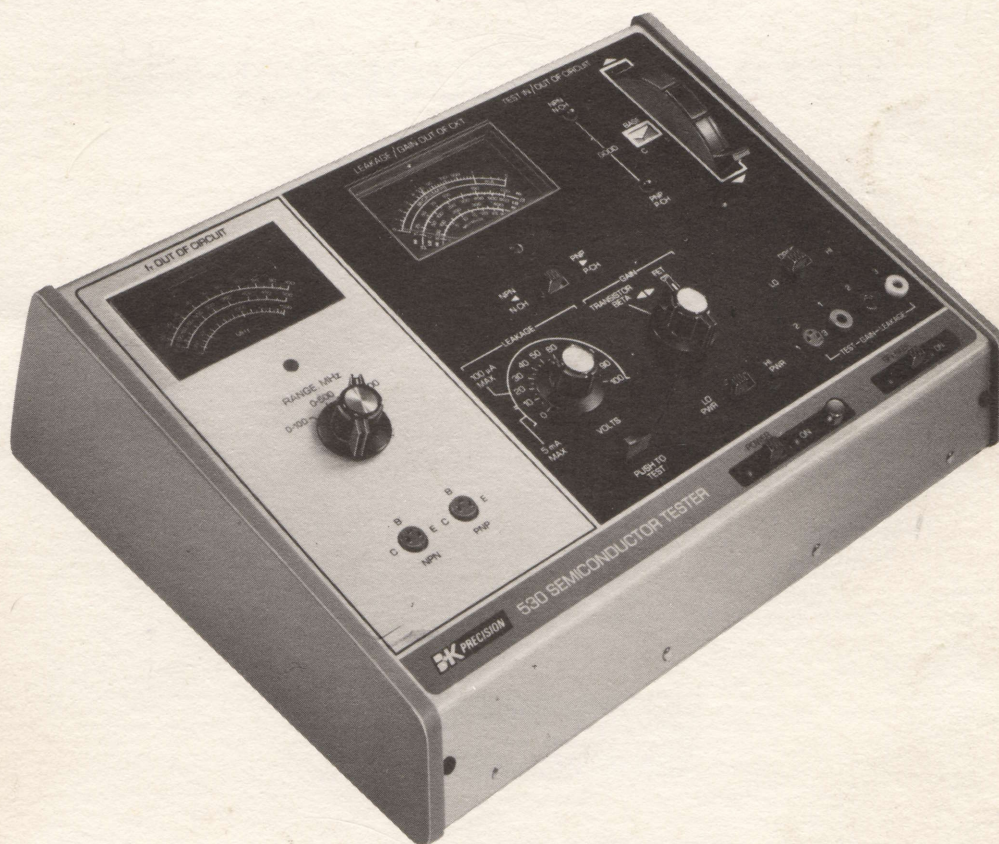


INSTRUCTION MANUAL

BK PRECISION

530

Semiconductor Tester



BK PRECISION

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PRICE \$5.00

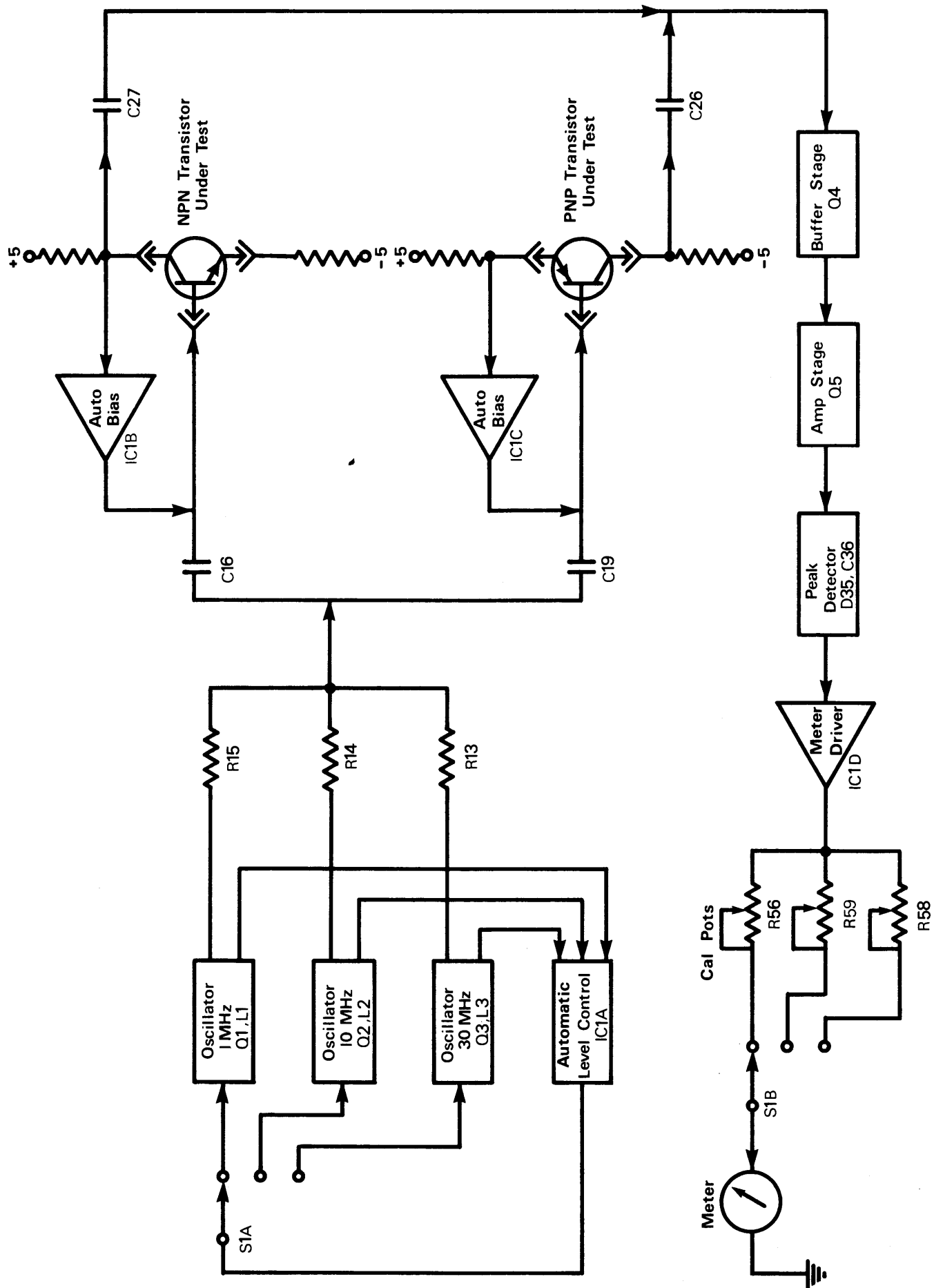


Fig. 7. Block diagram, fr test circuitry.

superimposes the 4.7V pulsating gate-to-source voltage.

The integrated drain pulses are amplified to feed the METER DRIVER which in turn drives the LEAKAGE/GAIN OUT-OF-CIRCUIT meter. The dynamic high transconductance parameter of the FET is read on the Hi g_m scale.

E. f_T Circuitry

The 530 f_T circuitry measures the gain-bandwidth product of bipolar transistors. This high frequency characteristic of transistors is measured on three separate frequency levels, which correspond to the three switch positions and the three meter scales. For a closer look at the f_T circuitry, refer to Fig. 7 and the schematic.

Three tuned oscillators generate three f_T base frequencies: 1, 10 and 30 MHz. An AUTOMATIC LEVEL CONTROL provides feedback to the oscillators to regulate the outputs to a fixed level. The signal output of the oscillator in use is fed through a resistor and a coupling capacitor to the base of the transistor under test.

An AUTO BIAS circuit senses the collector current of the transistor under test and automatically varies the base drive for 10 mA collector current.

The amplified collector signal is fed through a coupling capacitor to a current-to-voltage converter BUFFER STAGE. The buffer signal drives the transistor AMPLIFIER STAGE. The amplified signal is rectified in the PEAK DETECTOR and the DC voltage level is fed to the METER DRIVER, which in turn drives the meter for the f_T value on the range used.

NOTES

f_T EXPLANATION

f_T is one method used to measure and define the high-frequency characteristics of a transistor. Each individual transistor has a low-frequency current gain. This current gain is constant from DC up to some frequency determined by the transistor characteristics. This is the transistor cut-off frequency (f_c) and is defined as the frequency at which the current gain is reduced 3 dB (.707 times the low-frequency current gain). At frequencies greater than the cut-off frequency, the current gain decreases at a rate of 6 dB per octave. (The current gain is divided by 2 each time the frequency is doubled). This is illustrated in Fig. 15 for transistor A at frequencies greater than 1 MHz where the slope is negative. The highest frequency at which the transistor can actually provide current gain is the frequency at which the current gain has decreased to a value of one. Therefore, let us call this frequency f_T, according to the following definition:

DEFINITION OF f_T

f_T is the frequency at which the current gain of the transistor is equal to one, with the transistor in the common emitter mode and the collector shorted (AC) to the emitter.

The above description of current gain versus frequency characteristics of a transistor can be represented by the following mathematical equation:

$$\beta = \frac{\beta_0}{1 + j \frac{f}{f_c}} = \frac{\beta_0}{1 + \frac{f^2}{f_c^2}}$$

β = current gain f = frequency
 β_0 = low frequency current gain. f_c = cut-off frequency

Therefore, at frequencies much less than cut-off frequency:

$$\beta = \frac{\beta_0}{1} = \beta_0$$

At frequencies much greater than the cut-off frequency:

$$\beta = \frac{\beta_0}{\frac{f}{f_c}} = \frac{\beta_0 \times f_c}{f}$$

$$\beta \times f = \beta_0 \times f_c$$

Let $\beta = 1$, where f_T is defined

$$1 \times f = \beta_0 \times f_c = f_T$$

Thus, from definition, f_T is the frequency at which current gain is one, or unity, and the above equation shows that f_T is equal to the product of the low frequency current gain times the cut-off frequency.

Fig. 15 shows three examples of transistor current gain versus frequency characteristics. It is interesting to observe that the low frequency current gain of transistor B is less than that of transistor A, but transistor A has a lower cut-off frequency than transistor B; therefore, the f_T of both transistors can be the same although the cut-off frequencies of the transistors are different.

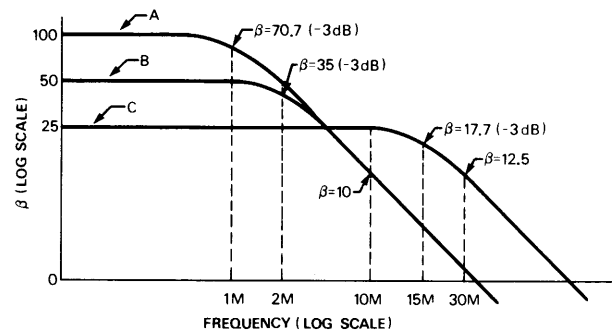


Fig. 15. β versus frequency for transistors A, B and C.

Transistor A $f_T = \beta_0 \times f_c = 100 \times 1 \text{ MHz} = 100 \text{ MHz}$

Transistor B $f_T = \beta_0 \times f_c = 50 \times 2 \text{ MHz} = 100 \text{ MHz}$

Another example is transistor C which has a low-frequency current gain that is less than the other two transistors, but, because of its high cut-off frequency, its f_T is greater than that of the other two transistors.

Transistor C $f_T = \beta_0 \times f_c = 25 \times 15 \text{ MHz} = 375 \text{ MHz}$

Taken from a previous equation, when the frequency is much greater than the cut-off frequency:

$$f_T = \beta \times f = \beta_0 \times f_c \text{ when } f \gg f_c$$

Thus, a practical method for measuring f_T is to measure the current gain at a frequency greater than the cut-off frequency, and then multiply current gain times frequency. This method is used in the Model 530 for three different test frequencies as follows:

Scale = 0 - 100 MHz:

Test frequency = 1 MHz.

1 MHz is used for low-frequency transistors and the current gain is measured up to 100 which provides a maximum f_T of 100 MHz.

$$f_T \text{ max.} = 100 \times 1 \text{ MHz} = 100 \text{ MHz}$$

Scale = 0 - 500 MHz:

Test frequency = 10 MHz.

10 MHz is used for medium-frequency transistors and the current gain is measured up to 50 which provides a maximum f_T of 500 MHz.

$$f_T \text{ max.} = 50 \times 10 \text{ MHz} = 500 \text{ MHz}$$

Scale = 0 - 1500 MHz

Test frequency = 30 MHz.

30 MHz is used for higher-frequency transistors and the current gain is measured up to 50 which provides a maximum f_T of 1500 MHz.

$$f_T \text{ max.} = 50 \times 30 \text{ MHz} = 1500 \text{ MHz}$$

For practical reasons, there are minimum meter deflections that must be met for each scale in order to provide an accurate f_T measurement. These minimum meter deflections are as follows:

SCALE	MINIMUM
0 - 100 MHz	5 MHz
0 - 500 MHz	50 MHz
0 - 1500 MHz	300 MHz

If the minimum meter deflection cannot be obtained, change to the next lower scale.

As an example, the three transistors in Fig. 15 would display the following reading on each scale:

Transistor	0 - 100	0 - 500	0 - 1500	f_T
A	71	100	100 (no good)	100
B	50	100	100 (no good)	100
C	25	250	375	375

Thus, the most accurate value for f_T is the largest absolute value obtained from any scale provided that the minimum meter deflection values are exceeded on the scale giving the greatest f_T value.

Since the collector bias current is one of the most important variables for determining f_T , the Model 530 provides an automatic bias of 10 ma for collector current, because many signal transistors provide the highest f_T at this current. An example of f_T versus collector current and bias voltage is shown in Fig. 16. V_{CE} is usually between 5 volts and 10 volts for most f_T measurements. The Model 530 provides a nominal 8 volts V_{CE} for measuring f_T . Therefore, the measured value of f_T is valid at these

parameter values within the accuracy stated in the specifications.

It should be remembered that there are many variables involved in measuring f_T and that changes in the test parameters can change the f_T reading. The fact that the f_T reading accuracy applies only at the specified test parameters does not mean that the test cannot be used to evaluate devices to be used under other operating conditions. Reference to Fig. 16 shows that by use of the curve family information shown, the performance at other operating conditions can be predicted. Even without this information, the relative high-frequency performance of transistors can be determined.

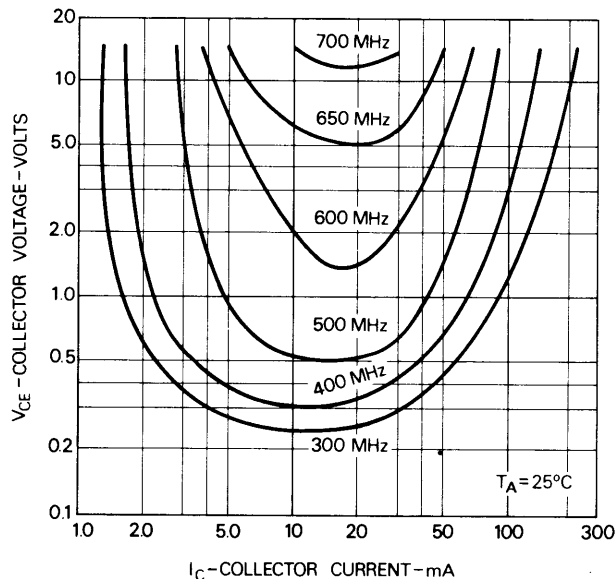


Fig. 16. Constant f_T curves for collector-emitter voltage vs. collector current (bipolar transistors).