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Transistor Current Gain Determination With The Transistor Test Set And The RX Meter

CHARLES W. QUINN, *Sales Engineer*

This article presents a discussion of a method for determining transistor parameters β, β_o, h_{ie}, h_{ib}, f_β, f_T, and Kf_α, using the Transistor Test Set Type 275-A and the RX Meter Type 250-A, together with a step-by-step procedure and an example employing this method. Equations are also included for determining parameters t_r, t_f, and Gm_t. Terms used throughout the discussion are defined below.

Definition of Terms

- β — (h_{fe}) Small-signal, short-circuit current gain, common emitter configuration. β will be used in preference to h_{fe} in order to simplify subscripts.
- $|\beta_o|$ — Same as β above except that the frequency involved is well below cutoff for transistors with negligible phase shift at 1 kilocycle in the common base configuration ($f_\alpha \geqq 500$ kc).
- h_{ie} — Small-signal ac input impedance, common emitter configuration, output short circuited (h_{11e}).
- h_{ib} — Small-signal ac input impedance, common base configuration, output short circuited (h_{11b}).
- f_β — β cut-off frequency. The frequency at which $|\beta|$ is -3db down from $|\beta_o|$, ($.707|\beta_o|$).
- f_T — The frequency at which $|\beta|$ equals unity or zero db. This is also the transistor gain bandwidth product.[1, 8]
- K — K is the base grading factor.[1]
- α — (h_{fb}) Small-signal, short-circuit current gain, common base configuration.
- f_α — f_α is the α (h_{fb}) cut-off frequency where $|\alpha|$ is -3db down from $|\alpha_o|$.
- α_o — Same as α above except that the frequency involved is well below cutoff for transistors with negligible phase shift at 1 kilocycle in the common base configuration.
- f — Any arbitrarily chosen frequency of measurement.
- t_r — Transistor rise time of the saturated common emitter switch.[4]
- t_f — Transistor fall time of the saturated common emitter switch.[4]
- Gm_t — Transistor transconductance, grounded emitter $\equiv \dfrac{\delta_{ic}}{\delta V_{be}}$.
- P — Ratio of $|\beta_o|/|\beta|$.
- S — Ratio f/f_β.

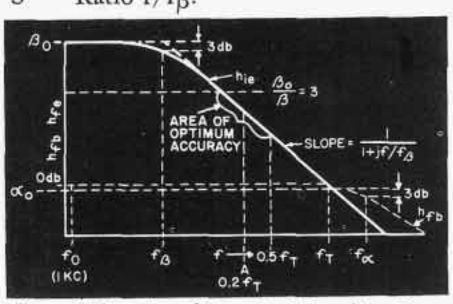

Figure 1. Location of Important Transistor Parameters on Relative Frequency and Amplitude Basis.

Method for Determining Parameters

The method used for determining transistor parameters β, β_o, h_{ie}, h_{ib}, f_β, f_T, and Kf_α, is based on the theory that β (h_{fe}) follows, to a very close approximation, the classical 6db-per-octave slope as a function of frequency (Figure 1).[2, 3] This is true for all transistors that are currently in production. This characteristic is expressed by the equation:

$$\beta = \frac{1}{1 + j\dfrac{f}{f_\beta}} |\beta_o|. \qquad (1)$$

Actually, this method requires but three simple measurements; $|\beta_o|$ on the 275-A Transistor Test Set and h_{ie} and h_{ib} on the 250-A RX Meter. These measurements are then used to characterize many low and medium-power transistors in the frequency range of 1 kc to well above 1 kmc. $|\beta|$ is computed from the two two-terminal RX Meter measurements and compared to $|\beta_o|$ which is read directly on the Transistor Test Set. The ratio of $|\beta_o|/|\beta|$ is then used in conjunction with the curve in Figure 2 to determine the various other parameters.

Two jigs are required for use in making the RX Meter measurements. Schematic diagrams of these jigs are shown in Figure 3A and C on page 3 of Notebook number 19. A suggested design for the jig is shown in Figure 5. It is recommended that the RX Meter measurements be made at a frequency (f) of approximately $0.2f_T$.

Figure 1 shows, graphically, the location of the important parameters on a relative frequency and amplitude basis. Point A ($0.2f_T$) on the straight-line section of the curve is the center of the area recommended for optimum accuracy when making high-frequency RX Meter measurements. A more detailed discussion of accuracy will be undertaken later in the article. It can also be seen in Figure 1 that f_α is always greater than f_T. It has been shown that f_α does not always adhere to a 6db-per-octave slope.[2]

Procedure for Determining Parameters

The following is a step-by-step procedure for determining transistor parameters in accordance with the method discussed in the previous paragraphs. The data obtained may be conveniently recorded on a data sheet (Figure 3) as a part of the procedure.

Determination of β

1. Measure the R_p and C_p values cor-

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responding to h_{ib} and h_{ie} directly on the RX Meter and record these values in column 1 on the data sheet.

2. Convert C_p into X_p ($-C_p$ corresponds to $-jX_p$), using the equation $X_p = \frac{1}{2\pi f C_p}$, and enter the values for R_p and X_p in column 2.

3. Convert the data in column 2 to rectangular coordinates, the series impedance. This conversion can be made by means of the series-parallel conversion chart in the 250-A instruction book and BRC Catalogs L and L-1, or by means of the equations given below. If the conversion chart is used, select a convenient multiplying factor to obtain a location of sufficient resolution on the chart.

General Equations:

$$X_s = -\frac{X_p Q^2}{1 + Q^2}$$

$$R_s = \frac{R_p}{1 + Q^2}$$

$$Q = \frac{R_p}{X_p}$$

Equations for Q less than 0.1:

$$X_s = -\frac{{R_p}^2}{X_p}$$

$$R_p = R_s$$

Equations for Q more than 10:

$$R_s = \frac{{X_p}^2}{R_p}$$

$$X_s = -X_p$$

Enter the data in column 3 on the data sheet.

4. Compute β using the data from column 3 and the equation:[5,6,7]

$$\beta = \frac{h_{ie} - h_{ib}}{h_{ib}} = \frac{R + jX}{R_1 + jX_1} \text{ or}$$

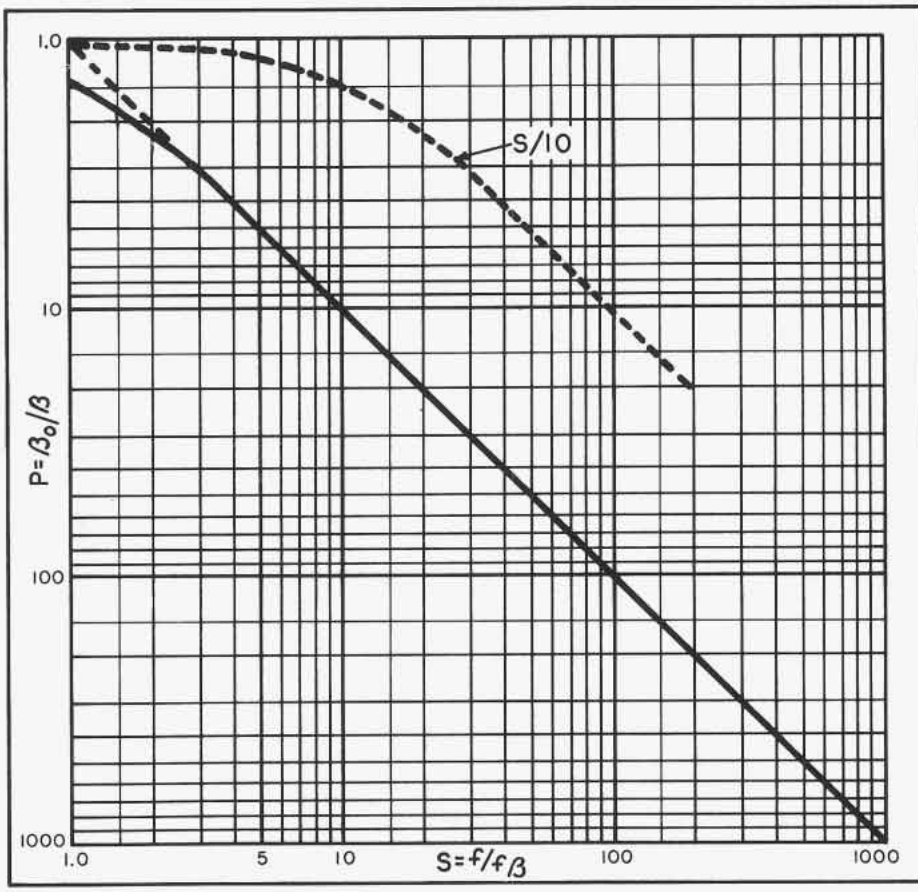

Figure 2. Nomograph for Determining Transistor Parameters

the real and imaginary terms of the numerator divided by the real and imaginary terms of the denominator. Enter this data in column 4.

5. Compute the magnitude of β as follows:

$$|\beta| = \sqrt{\frac{R^2 + X^2}{R_1^2 + X_1^2}}$$

Enter the data in column 5.

6. Measure $|\beta_o|$ and $|\alpha_o|$ directly on the 275-A. Enter these values in columns 6A and 6B.

7. Determine the ratio of the data in column 6A to the data in column 5:

$$\frac{|\beta_o|_{275}}{|\beta\ |_{250}} = \frac{|\beta_o|}{|\beta\ |} = P.$$

Enter this ratio in column 7.

8. Locate the ratio of $|\beta_o|/|\beta|$ (P) of column 7 on the vertical axis in Figure 2 and proceed horizontally to intersect the curve. Drop a line vertically and read $\frac{f}{f\beta} = S$ on the horizontal axis. Enter this in column 8.

9. Compute $f\beta = \frac{f}{S}$ and enter this in column 9.

Determination of f_T

10. Locate the value $|\beta_o|$, recorded in column 6, on the vertical axis of the curve in Figure 2 and proceed horizontally to the curve. Project this point vertically to the horizontal axis and read S. Compute f_T using the equation: $f_T = Sf\beta = \beta_o f\beta$.[3] If $|\beta|$ falls on the 6db-per-octave slope ($P \geqq 3$), $f_T = |\beta| f$. Enter the data in column 10.

Determination of β at a frequency (f) other than that used in the initial 250-A measurement

11. Determine the ratio of $f/f\beta = S$ and locate this point on the horizontal axis of the curve in Figure 2. Proceed vertically to the curve and read the ratio $P = (|\beta_o|/|\beta f|)$ on the vertical scale. Compute $|\beta| = |\beta_o|/P$ and enter this data in column 11.

Determination of f_α and K

12. f_α may be computed using the following general equation:

$$f_\alpha = \frac{f_\beta\,(1+\beta_o)}{K} \cong \frac{f_\beta\,\beta_o}{K}.$$

In some instances, specifically in the case of a transistor with a 6db-per-octave common base current gain cutoff, K is unity and the equation in (12) becomes: $f_\alpha = f_\beta\,(1+\beta_o)$. If either K or f_α are known, the other may be computed. $Kf_\alpha = f_\beta\,(1+\beta_o)$ and can be computed from the data in columns 1 and 9 of the data sheet. To check an assumed value of one variable, the equation $f_T = \alpha_o K f_\alpha$, may be used.[2] K is a function of the manufacturing process and may be from 0.4 to 1.0. However, K does not vary appreciably from transistor to transistor of the same manufacturing process, having a value of 0.822 for uniform impurity density. The value drops further for accelerating "built-in" fields or "drift" transistors.

Example

The method and step-by-step procedure described above are used in the following example to measure and compute parameters f_β, f_T, β, and Kf_α, for a typical transistor. Data obtained from these measurements and computations is recorded on the data sheet in Figure 3.

Specifications:

β_o = 15

f_T = 45 mc (estimated)

Conditions:

f = $0.2f_T$ = 9.0 mc

f_o = 1000 cps

V_{CB} = 6 v

I_E = 1.0 ma.

Step 1. h_{ie} and h_{ib} are measured on the 250-A in terms of R_p and C_p, and the values are recorded in column 1 on the data sheet.

Step 2. The C_p reading is converted to X_p; ($X_p = \frac{1}{2\pi fc}$) and R_p and X_p are recorded in column 2.

Step 3. The data in column 2 is converted to rectangular coordinates, series impedance, by means of a series-parallel conversion chart or the following computations.

h_{ib}

Computing Q:

$$Q = \frac{R_p}{X_p} = \frac{100}{7.5K} = 0.0133$$

Using equations for Q less than 0.1:

$$X_s = -\frac{R_p^2}{X_p} = -\frac{10{,}000}{7{,}500} = -j1.3$$

$$R_s = R_p = 100$$

$$h_{ib} = 100 - j1.3.$$

h_{ie}

Computing Q:

$$Q = \frac{R_p}{X_p} = \frac{2.2K}{1.1K} = 2$$

Using equations for Q between 0.1 and 10:

$$X_s = -X_p \frac{Q^2}{1+Q^2}$$

$$X_s = -1.1K \times 4/5 = -j880$$

$$R_s = \frac{R_p}{1+Q^2} = \frac{2.2K}{5} = 440$$

$$h_{ie} = 440 - j880$$

This data is recorded in column 3.

Step 4. Rectangular coordinate, series impedance β is computed using the data in column 3 as follows:

$$\beta = \frac{h_{ie} - h_{ib}}{h_{ib}}$$

$$\beta = \frac{440 - j880 - 100 + j1.3}{100 - j1.3}$$

Subtracting R terms and j terms separately:

$$\beta = \frac{340 - j879}{100 - j1.3} = \frac{R - jX}{R_1 - jX_1}$$

This data is entered in column 4.

Step. 5. Compute the magnitude of β as follows:

$$|\beta| = \sqrt{\frac{R^2 + X^2}{R_1^2 + X_1^2}}$$

$$|\beta| = \sqrt{\frac{340^2 + 879^2}{100^2 + 1.3^2}}$$

$$|\beta| = \sqrt{\frac{888{,}200}{10{,}000}} = 9.4$$

This data is recorded in column 5.

Step 6. β_o and α_o are measured directly on the 275-A and recorded in column 6.

Step 7. The ratio P is determined as follows:

$$P = \frac{\beta_o}{\beta} = \frac{20}{9.4} = 2.13.$$

This ratio is recorded in column 7.

Step 8. The ratio P is located on the curve in Figure 2 and S is determined to be 1.95. Record S in column 8.

Step 9. f_β is computed as follows:

$$f_\beta = \frac{f_s}{s} = \frac{9}{1.95} = 4.6\text{ mc}$$

and is recorded in column 9.

Step 10. f_T is determined as follows:

$f_T = Sf_\beta$ or $\beta_o f_\beta$

$f_T = 20 \times 4.6 = 92$ mc

and is entered in column 10. Note that $f_T = \beta f$ cannot be used in this case because $P = |\beta_o|/|\beta|$ is less than 3. Note also, that f_T is 92 mc or considerably higher than the 45 mc estimated under "Conditions."

Step 11. $|\beta|$ is determined at 50 mc as follows:

$$S = \frac{f}{f_\beta} = \frac{50}{4.5} = 10.5.$$

S(10.5) is then located on the horizontal axis in Figure 2, and proceeding from this point, vertically, to the curve, P is read on the curve. Then, $|\beta| = \frac{|\beta_o|}{P} = \frac{20}{10.5} = 1.8$. β is recorded in column 11.

	1	2	3	4	5	6		7	8	9	10	11	12
	R_p C_p	R_p X_p	RECT. Z R_s X_s	β RECT.	β POLAR	(A) β_o	(B) α_o	P	S	f_β	f_T	β 50MC	Kf_α
h_{ib}	100+2.3	100+j7.5K	100−j1.3	340−j879 / 100−j1.3	9.4	20	0.9515	2.13	1.95	4.6	92MC	1.8	115MC
h_{ie}	2.2K+16	2.2K+j1.1K	440−j880										

Figure 3. Data Sheet

Step 12. Kf_α or f_α is determined as follows:
$Kf_\alpha = f_\beta(1+\beta_o) = 4.5 \times 21 = 95$ mc
Record Kf_α in column 12.

This indicates that K must be known to determine f_α or vice versa. If the base layer of this transistor is the uniform impurity type, K = 0.822. Then,

$$f_\alpha = \frac{4.5 \times 21}{0.822} = 115 \text{ mc.}$$

Determining Parameters h_{ie}, t_r, t_f, Gm_t, h_{ic}, and h_{fc}

Transistor parameters h_{ie}, h_{ic} and h_{fc} may be readily calculated from direct measurements of α, β, and h_{ib} on the Transistor Test Set:[9]

$$h_{ie} = h_{ic} = \frac{h_{ib}}{(1\text{-}\alpha)\ (1\text{-}h_{rb}) + h_{ob}\, h_{ib}} \qquad (2)$$

Since, typically, $h_{rb} << 1$, $(1\text{-}h_{rb}) \approx 1$, and $h_{ob}\, h_{rb} << 1$, under small-signal, low-frequency conditions, equation (2) may be reduced to equation (3) which results in an error of 10% for $\alpha = 0.99$ and decreases with a decrease in α:

$$h_{ie} = h_{ic} \approx \frac{h_{ib}}{1\text{-}\alpha} \approx h_{ib}\,(1+\beta) \quad (3)$$

$$h_{fc} = \frac{h_{rb}\text{-}1}{(1\text{-}\alpha)\ (1\text{-}h_{rb}) + h_{ob}\, h_{ib}} \quad (4)$$

Under the assumptions and within the limits of error set forth for equation (3), equation (4) may be similarly reduced to equation (5):

$$h_{fc} \approx \frac{1}{1\text{-}\alpha} \approx -(1+\beta) \qquad (5)$$

Additional parameters t_r, t_f, (Figure 4) and Gm_t may be determined as follows.[4]

t_r

$$\text{Rise time } (t_r) \cong 0.8 \frac{I_C\,(\text{sat.})}{I_B\, 2\pi f_T} \qquad (6)$$

$$\frac{I_C}{I_B} = \beta_{DC} \text{ at operating current range.}$$

t_f

$$t_f \cong 0.8 \frac{\beta_C \text{ off}}{2\pi\, f_T} \qquad (7)$$

"β_C off" is the turn-off circuit β, using the circuit in Figure 4, and can be measured on the 275-A by adjusting to the proper dc bias point.[4]

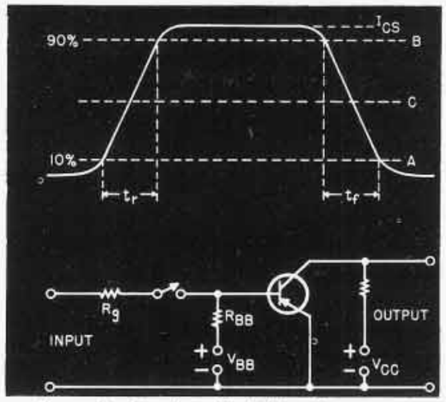

Figure 4. Transistor Switching Parameters

*Gm_t**

$$Gm_t = \frac{\beta_o}{h_{ie}} \qquad (8)$$

$$h_{ie} = h_{ib}\,(1+|\beta_o|) \qquad (3)$$

$$Gm_t = \frac{|\beta_o|}{h_{ib}\,(1+|\beta_o|)} \cong \frac{1}{h_{ib}} \qquad (9)$$

h_{ib} can be measured directly on the 275-A.

Gm_t is derived as follows:

$$Gm_t = \frac{\delta_{ie}}{\delta V_{be}} =$$

$$\frac{\delta_{ie}}{\delta_{ib}} \times \frac{\delta_{ib}}{\delta V_{be}} = \frac{\dfrac{\delta_{ie}}{\delta_{ib}}}{\dfrac{\delta V_{be}}{\delta_{ib}}}$$

$$\text{Since } \beta = \frac{\delta_{ie}}{\delta_{ib}} \text{ and } h_{ie} = \frac{\delta V_{be}}{\delta_{ib}},$$

$$Gm_t = \frac{\beta}{h_{ie}}.$$

An example of the procedure for determining t_r, t_f, and Gm_t will not be included in this discussion.

Accuracy and Limitations

It is obvious from the equations presented in the foregoing procedure, that the accuracy of $|\beta_o|$ is of prime importance, since all of the parameters; f_β, f_T, t_r, t_f, β, and Kf_α are based on the ratio $P = |\beta_o|/|\beta|$. If the accuracy of $|\beta_o|$ can be made to exceed the accuracy of all other measurements, the overall accuracy will be improved accordingly.

**Pointed out by H. Thanos, RCA, Somerville, N. J.*

This is the case when the measurements are made on the 275-A Transistor Test Set, where the accuracy of $|\beta_o|$ is $(0.6 + 30/\beta)\%$ or usually less than 2%. The ratio $P = |\beta_o|/|\beta|$ is employed to take care of the possibility that the measured β at $0.2f_T$ (as per the published specifications or estimate) falls above the 6db-per-octave slope, and to preclude the need for an additional measurement. This actually happened in the example given above. For optimum accuracy, the ratio P should be greater than 3 and f should not exceed 0.5 f_T for the average transistor.

The accuracy of the high-frequency β (h_{fe}) measurements is dependent upon the RX Meter accuracy equations (See pages 10 and 11 of the 250-A instruction book.) and the relationship:

$$h_{fe} = \frac{h_{ie} - h_{ib}}{h_{ib}}.$$

For most values of h_{ib}, which is usually resistive, 3% accuracy is about average. For h_{ie} 5% accuracy can be expected. Generally, accuracies better than 10% can be expected for h_{fe}. Since the h_{ie} and h_{ib} real and imaginary terms are in quadrature, potential errors in R_p and C_p are not directly additive, but are a function RMS of the respective errors.

The above discussion of this procedure also considers some of the limitation imposed by the original assumption that β (h_{fe}) adheres strictly to the 6db-per-octave fall off common to R-C filters.

Another important consideration involves the design of the jigs for the RX Meter measurements. Good high-frequency techniques and practice must be followed to achieve the accuracies mentioned. Figure 5 suggests a jig design to minimize most of the problems encountered. It is also possible to "calibrate out" RX Meter and jig residuals by means of the technique described on page 4 of Notebook number 22, when making measurements above 20 mc.

The accuracy of t_r and t_f is affected by the variation of $|\beta|$ as a function of the current range over which the transistor is to be operated. Improved accuracy can be obtained if $|\beta_o|$ readings are taken at points approximating A, B, and C in Figure 6, and the results are averaged. If it is found that the bias current for $|\beta_o|$ average is such that h_{ib} is below the range of the RX Meter, a convenient bias current can be used and f_T can be corrected by the ratio of $|\beta_o|$ at the current of the RX Meter measurement to $|\beta_o|$ average. If $|\beta_o|$ proves to be

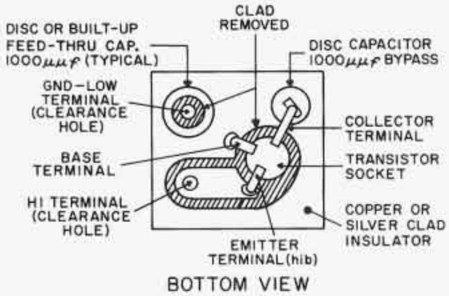

Figure 5. Suggested Design for a VHF h parameter Jig for Measuring Transistor Parameters on the RX Meter

quite constant as a function of bias conditions, which is the case for well designed switching units, corrections are not necessary and accuracies better than 20% can be expected.

Still another step may be taken if accuracies greater than those already mentioned are desired. If the frequency characteristics of the transistor are such that when $S = f/f_\beta = 0.1$, f is 500 kc or greater, a $|\beta_o|$ measurement may be made on the RX Meter at 500 kc. The $|\beta_o|$ measurements on both instruments (250-A and 275-A) can then be compared and a correction factor computed. See the broken-line curve in Figure 2. This correction, applied to subsequent β measurements on the 250-A, will yield improved accuracies.

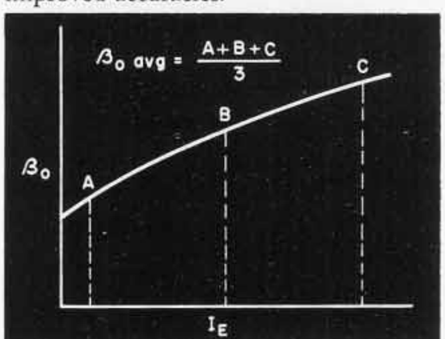

Figure 6. Typical β_o versus I_E curve for Determining β_o Average

Conclusion

We have shown that a transistor current gain characteristic can be readily determined for the common emitter configuration using the 275-A Transistor Test Set and the 250-A RX Meter. Since RF measurements, with this procedure, are made at $0.2f_T$, devices with f_T's up to 1.25 kmc can be accommodated.

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Diode Measurements on the Transistor Test Set Type 275-A

WILLARD J. CERNEY, *Sales Engineer*

There are many instances in diode applications when it is desirable to know the AC impedance of the diode as well as the DC resistance. A few examples of these applications are:

1. When a diode is used as a limiter or clipper.
2. When a Zener diode is used as a voltage regulator and the AC impedance is of importance.
3. When diodes are used in the design of power supply circuits. Here, knowing the AC impedance of diodes will be of value in designing ripple suppression and low-frequency coupling networks.

The terms and expressions used in this article are defined in Figure 1.

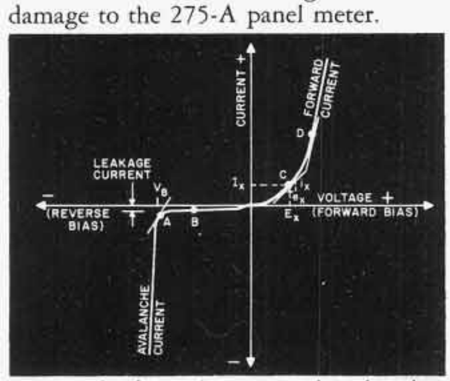
Typical values for a 1N1522 diode at points A, B, C, and D on the diode curve in Figure 1, are given in the table below.

Point	*Volts*	*DC Res.* $= \frac{E_x}{I_x}$	*AC Res.* $= \frac{e_x}{i_x}$
A	−8.2	820	0.2
B	−6	1200	6100
C	+1	20	1
D	+2	18	0.5

The Transistor Test Set Type 275-A may be used to measure the DC forward resistance and the forward biased AC resistance of all diodes, directly and simply, within the current and impedance ranges of the instrument (0 to 100 MA. and 0.3 to 3000 ohms). Some of the high-current diodes may also be measured using external equipment. In addition, the 275-A may be used to measure the DC breakdown voltage and resistance and the AC resistance of Zener or Regulator diodes at any point.

MEASUREMENT PROCEDURE

A step-by-step procedure for making diode measurements on the 275-A is given below. Before a diode is connected across the terminals of the 275-A, the controls should be set up in accordance with the initial set up procedure to prevent damage to the instrument or the diode under test. All of the measurements must be limited to 100 milliamperes unless external equipment is used. Care should be taken not to short the E and C terminals as this might result in damage to the 275-A panel meter.



V_B = Avalanche region, commonly referred to as the voltage breakdown or Zener point. Actually the exact voltage and current points are defined arbitrarily.

DC Resistance = Resistance at any point on curve = $\frac{E_x}{I_x}$ as shown above.

AC Resistance = Impedance at any point on curve = $\frac{\Delta E}{\Delta I}$ or $\frac{e_x}{i_x}$ as shown above.

Figure 1. Diode Curve

Initial Set Up Procedure

1. Set the α-h_{ib}-β Selector to the h_{ib} position.
2. Set the SET-CHECK-MIN switch to the SET position.
3. Set the Meter switch to the V_{CB} position.
4. Turn the V_{CB} Volts Range Selector and the V_{CB} control fully counterclock-

wise; i.e., $V_{CB} = 0$.
5. Set the Meter switch to the I_E position.

Forward Biased Measurements (All Diodes)

To measure DC forward resistance and AC resistance when forward biased, set up the instrument controls in accordance with the initial set up procedure then proceed as follows:
1. Connect the diode to be measured between terminals E and B on the 275-A.
2. Set the I_E controls for the desired biasing current.
3. Set the SET-CHECK-MIN switch to the CHECK position and the NPN-PNP switch to the position that gives the highest reading on the panel meter.
4. Connect an external DC VTVM (such as the HP 412A) across the diode under test.
5. Set the SET-CHECK-MIN switch to the MIN position and read the VTVM and I_E. The DC forward resistance equals the VTVM reading divided by the I_E reading.
6. Set the Meter switch to the MIN position and adjust the h_{ib} dial for a null meter reading.
7. The h_{ib} reading is the small signal forward biased AC resistance.

Reversed Biased Measurements (Zener or Regulator Diodes)

If the breakdown voltage of the Zener or Regulator diode to be measured is less than 6 volts DC, perform the following procedure in addition to the procedure for the forward biased measurements.
1. Set the Meter switch to the I_E position.
2. Set the I_E controls for the desired biasing current.
3. Set the NPN-PNP switch to the position opposite to that used in step 3 in the forward biased measurement procedure.
4. Read the external VTVM and I_E.
5. The DC breakdown resistance equals the VTVM reading divided by the I_E reading.
6. Set the Meter switch to the MIN position and adjust the h_{ib} dial for a null meter reading.
7. The h_{ib} reading is the breakdown or operating AC resistance.

If the breakdown voltage of the Zener or Regulator diode is greater than 6 volts DC, perform the following procedure in addition to the procedure for forward biased measurements.
1. Set the SET-CHECK-MIN switch to the SET position.
2. Change the diode connection from the B terminal to the C terminal on the 275-A. Do not disturb the connection at the E terminal.
3. Set the Meter switch to the I_E position.
4. Set the I_E controls for the desired biasing current.
5. Set the NPN-PNP switch to the position opposite to that used in step 3 in the forward biased measurement procedure.
6. Set the SET-CHECK-MIN switch to the MIN position.
7. If the I_E reading on the panel meter increases, turn the V_{CB} control clockwise until the meter indicates the desired biasing current.
8. Read the external VTVM and I_E.
9. The DC breakdown resistance equals the VTVM reading divided by the I_E reading.
10. Set the Meter switch to the MIN position and adjust the h_{ib} dial for a null meter reading.
11. The h_{ib} reading is the breakdown or operating AC resistance.

Measurements Above 100 MA.

To measure diodes above 100 milliamperes on the 275-A, proceed as follows:
1. Connect an external power supply as shown in Figure 5 on page 10 of the 275-A instruction book. The resistance of the supply should be high (constant current) so that it does not shunt down the diode impedance.

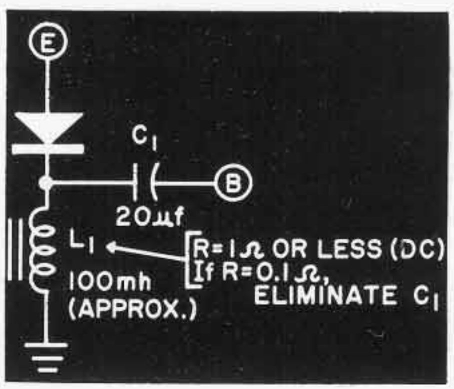
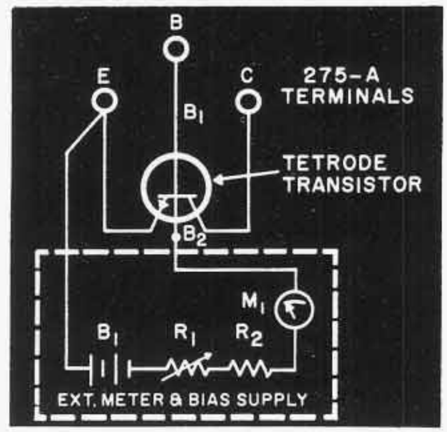


Figure 2. Connections for Measuring Diodes Above 100 MA.

2. Connect the diode to be tested and the choke to the 275-A terminals as shown in Figure 2.
3. Follow the procedure for forward biased measurements.

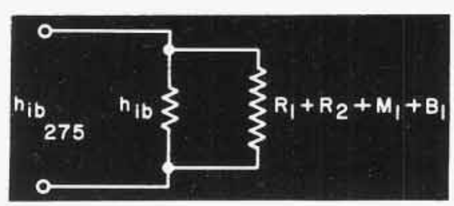
Measuring Tetrode Transistors on the 275-A

Tetrode transistors can be conveniently and directly measured on the Transistor Test Set Type 275-A with the same accuracies specified for standard triode units, by employing a simple external meter and bias supply. The correct connections for this measurement are shown in the figure below. After the connections are made to the 275-A, the I_E, V_{CB}, and I_{B2} in the external bias supply are set to the desired values and the 275-A is operated in the normal manner to measure α, β, and h_{ib}.



Connections for Measuring Tetrode Transistors on the 275-A

In making these measurements, the following notes should be observed:
1. The external bias supply impedance should be very large with respect to h_{ib}, in order to reduce the loading effect of the bias supply on the h_{ib} reading.
2. B_1, R_1, R_2, and M_1 in the figure should be selected to give the desired current range and at the same time provide the very large impedance required per Note 1. If it is not possible to select values of R_1 and R_2 that are much larger than h_{ib}, the effect of the external components may be determined by calculation as follows:



Equivalent Circuit

$$h_{ib275} = \frac{h_{ib}\,(R_1 + R_2 + M_1 + B_1)}{h_{ib} + (R_1 + R_2 + M_1 + B_1)}$$

Solving for h_{ib}:

$$h_{ib} = \frac{h_{ib\,275}\,(R_1 + R_2 + M_1 + B_1)}{(R_1 + R_2 + M_1 + B_1) - h_{ib\,275}}$$

Note: B_1 and M_1 can usually be chosen to be negligible compared to R_1 and R_2.

Typical measurements for a 3N36 tetrode transistor are:

$V_{CB1} = 5V$
$I_E = 1.5MA.$
$I_{B2} = 0.91MA.$
$h_{fe} = 12$
$h_{fb} = 0.9227$
$h_{ib} = 28$ ohms

Typical values for external bias used in the above measurements are:

$R_1 = 10K$ ohms
$R_2 = 2.2K$ ohms
$M_1 = 0\text{-}2MA.$
$B_1 = 2V$

MEET OUR REPRESENTATIVES

VAN GROOS COMPANY

The Van Groos Company was formed in 1945 by J. C. Van Groos and presently operates with headquarters in Woodland Hills, California and a branch office in Los Altos.

"Van" grew up with the West Coast electronics business. He began his engineering career at the University of California. Later on he was Maintenance Engineer for the McClatchey Broadcasting Chain and prior to World War II he entered the sales engineering field in California. During the latter part of the War, he was in charge of ground electronic equipment at all Naval Air Stations.

J. C. Van Groos

Since its inception, the credo of the Van Groos Company has been complete service to the customer, and to implement this customer service concept. Van conceived the idea of a mobile demonstrator to meet the needs of the dynamic electronic industry in California.

In 1956 a 30-foot Flexible bus was converted into a mobile demonstrator known as "Groosvagen". During the first year this mobile unit was used to demonstrate to more than 15,000 engineers in the California area. The "Groosvagen" was so effective, in fact, that in 1958 the Van Groos Company put into service another mobile demonstrator known as "Groosvagen II". This unit was bigger and better with such added features as a mobile telephone, air conditioning, and a self-contained generator, and proved to be more popular than ever with the West Coast engineers. Van advises, in fact, that it has been difficult to keep up with the demand for mobile demonstrations.

Since the beginning of 1960 an air conditioned service and calibration laboratory, under the supervision of Mr. Vic Howard, has been in operation at the Van Groos Company's Woodland Hills office. This new facility has been added to provide local repair service on all instruments with emphasis on minimum down-time for the customer.

Interior of the Van Groos Mobile Demonstrator "Groosvagen II'

During his career Van has been an active member of the IRE and is currently a senior member. Two years ago he founded and served as Chairman of the San Fernando Sub-Section which now has 1500 members. He also has been an Amateur Radio enthusiast since 1930 and is holder of Radio Amateur License W6GFY.

The Van Groos Company has built its success in the electronic test equipment field by emphasizing service combined with integrity. We at BRC proudly salute the Van Groos Company for their faithful service to our many valued customers throughout California.

SERVICE NOTE

Modification of Type 265-A Q Comparator for Improved Stability

Beginning with Q Comparator Type 265-A, Serial No. 70, an auxiliary mounting bracket has been added to the plug-in Type 520-A Oscillator Inductors to provide a more rigid mounting for the inductor when it is plugged into the oscillator circuit on the Detector Unit. The new bracket securely clamps the 520-A inductor to the top of the Detector Unit cover so that it cannot shift in its socket with vibration from the capacitor drive motor. Some customers had advised BRC that this vibration would often cause a shift in oscillator frequency noticeable as a shift in the CRT display on the Indicator Unit.

In order to provide a means whereby this feature could be incorporated into equipment already in the field, a special field modification kit has been prepared and distributed to our representatives and in some cases, directly to our customers. If there are any owners of Q Comparators with serial numbers below 70 who have not received this modification kit, they may be obtained by calling or writing BRC.

The New Type 520-A Oscillator Inductor Mounting Bracket

EDITOR'S NOTE
Q Meter Winner

Many Notebook readers have written to the Notebook inquiring about the winning estimate in the Q Meter Contest held last March at the IRE show. We announced the name of the winner in our Spring issue, but neglected to give his estimate. Mr. Byers' estimate was 394.

Mr. Byers informed us in a letter that he was both pleased and greatly surprised when he heard the news of his winning the contest. "I frequently use both your models 160-A and 190-A in working with coils for signal generators," he writes, "but your contest coils usually bear little resemblence to coils with which I am familiar."

It is odd that Mr. Byers should make this comment, because we have received similar complaints from other contest hopefuls. Be assured that we have passed these complaints along to the Engineers responsible for the design of the contest coils. Each year, however, the coils become more and more incredible. Apparently they have become obsessed with their fiendish task.

William F. Byers

Mr. Byers, our contest winner, was graduated from Ohio State University with a BS in Electrical Engineering in 1943. After teaching at the University for a brief period, he joined the General Radio Company and has been with that Company ever since, engaged in the design and development of special purpose and standard signal generators, frequency modulation equipment, and broadcast monitoring equipment.

Mr. Byers is a member of the Institute of Radio Engineers and the American Radio Relay League, and is holder of Amateur Radio Station License WINXM.

Our congratulations again to Mr. Byers. We are sure that he will make good use of the Q Meter.

BRC APPOINTS NEW SALES REPRESENTATIVES

Boonton Radio Corporation is pleased to announce the appointment of the George H. Sample Company and the S. Sterling Company as sales representatives. The George H. Sample Company will be our exclusive representative in Australia with its headquarters in Melbourne. The S. Sterling Company will be our exclusive representative in Michigan, West Virginia, and sections of Ohio and Pennsylvania, with its main offices in Detroit.

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LOS ANGELES, California
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Telephone: EMpire 4-3057
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Telephone: WHitecliff 8-7266

ST. PAUL 14, Minnesota
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842 Raymond Avenue
Telephone: MIdway 6-7881
TWX: ST P 1181

SYRACUSE, New York
E. A. OSSMANN & ASSOC., INC.
2363 James Street
Telephone: HEmpstead 7-8446
TWX: SS 355

TORONTO, Ontario, Canada
BAYLY ENGINEERING, LTD.
Hunt Street
Ajax, Ontario, Canada
Telephone: AJax 118
(Toronto) EMpire 2-3741

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