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A Q Comparator

JAMES E. WACHTER, *Project Engineer*

It would be difficult to imagine that any industry has expanded more than the electronic industry during the past decade. The production of television receivers, electronic control devices, computors, and many other electronic devices has soared during this time. With this increased production of electronic devices came ever increasing demands for enormous quantities of electronic components including coils, capacitors, resistors, and these components wired in combination. This brought about the inevitable need for faster methods of producing these components.

Developers went to work on the problem and today the fruits of their labor are evident in the numerous automatic production machines which are standard equipment in the plants of many of the electronic component manufacturers. These same manufacturers are producing thousands of coils, capacitors, and resistors daily. Productionwise the challenge has been met.

Reports from some of the electronic components manufacturers indicate, however, that not all is well. It appears that, in some areas, instrumentation for checking these components against manufacturer's tolerances has not kept pace. Today, manufacturers are interested in getting trend and reject information from the inspection operation back to the production operation as quickly as possible to keep production within design tolerances and to keep rejects to a minimum. This cannot be done with available instruments.

This article describes and delves somewhat into the design principles of an instrument which will meet present day requirements for a fast and accurate means for determining relative Q, inductance, capacitance, and resistance. The instrument, BRC's Type 265-A Q Comparator, is now in production.

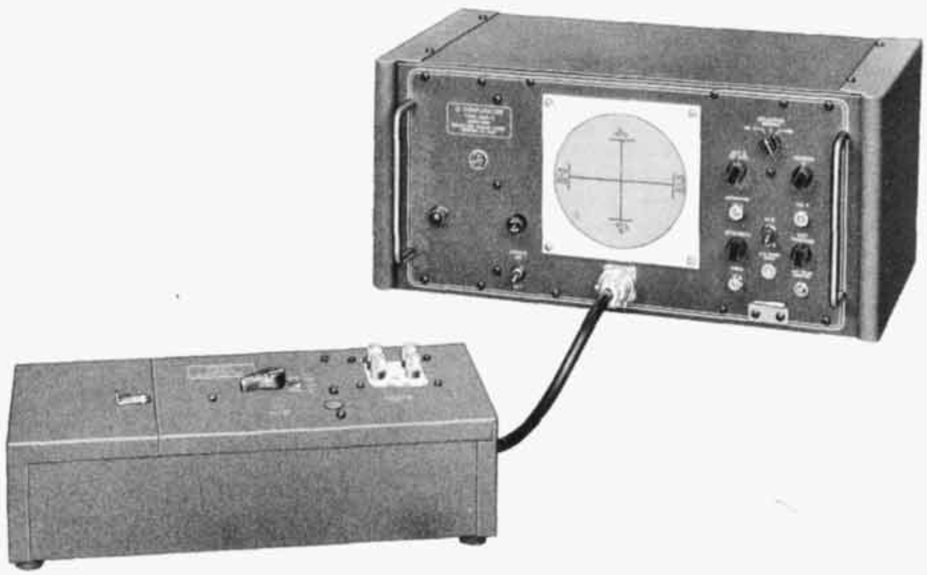

Figure 1. Two-unit design of the Type 265-A Q Comparator puts the test circuit portion of the instrument at the front of the test position where it is needed, and the indicator portion at the rear of the test position, out of the way but within easy view.

GENERAL DESCRIPTION

The Q Comparator is comprised essentially of a swept-frequency oscillator, Q meter-type measuring circuit with detector, vertical amplifier, differentiator, spot generator, horizontal amplifier with blanking circuit, cathode-ray tube, and power supply, (Figure 2). The swept-frequency oscillator and measuring circuit are assembled into a relatively small unit which is cable-and-plug connected to the main unit containing the cathode-ray tube and remaining circuitry. With this arrangement, the portion of the instrument on which the test connections are made can be used at the front of an inspection bench, taking up no more space than most inspection gauges or fixtures, while the main indicator portion of the instrument is placed at the rear of the bench or rack mounted off the bench altogether, out of the working area, (See Figure 1).

The initial set up of the Q Comparator is performed by a test engineer or other suitably skilled person, using a standard component having the characteristics that are desired in the production components. The set-up procedure, which will be explained later, results in a dot at the center of the CRT when the standard component is connected to the Q Comparator test circuit. Following this set up, comparatively unskilled personnel can rapidly check production components by simply connecting them to the test circuit and observing the position of the dot on the CRT. These are no tuning operations to be performed and no meter readings to be evaluated.

Any dot which does not appear at

YOU WILL FIND . . .

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the center of the CRT indicates that the component under test is different than the standard. Deviation along the vertical axis shows a change in Q and deviation along the horizontal axis shows a change in L (inductance) or C (capacitance). It becomes apparent that any desired limit conditions could be grease penciled on the CRT, and any dot falling outside these boundaries would then indicate a reject component. In addition to performing this "go — no-go" function, the instrument will supply trend information quickly so that in many cases production can be altered before rejects occur.

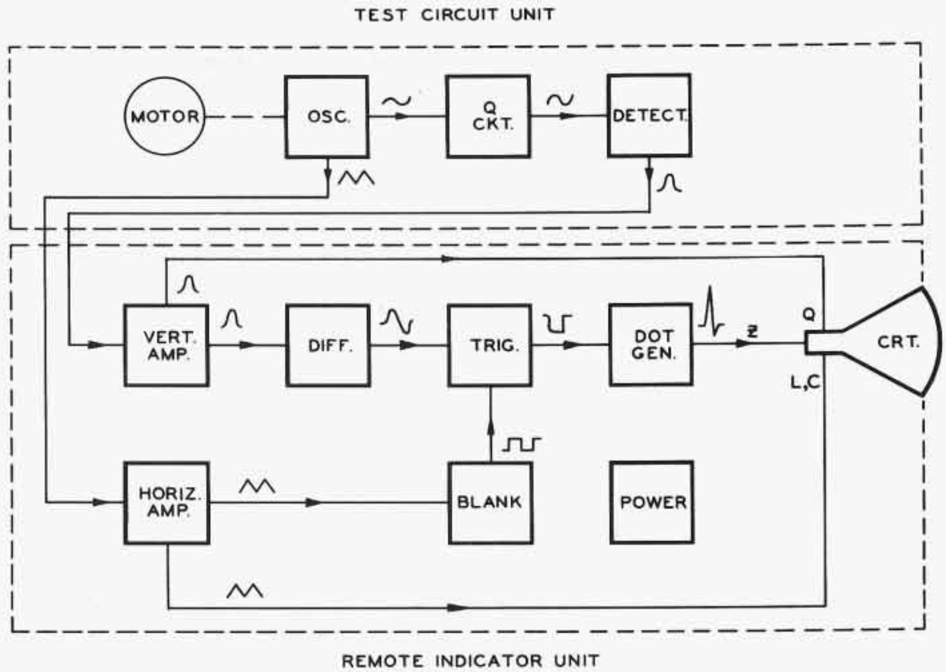

Figure 2. Q Comparator Block Diagram

SET-UP PROCEDURE

The standard component is connected to the Q Comparator test circuit, which is a basic Q-meter resonant circuit containing an injection impedance and resonating capacitor. With the oscillator tuning capacitor motor turned off, the capacitor is set to its center frequency position by means of a detent in its shaft. An oscillator coil covering the desired test frequency is selected and plugged into the oscillator circuit and tuned to the desired frequency by means of its calibrated adjustment screw. The capacitor detent is released and the motor actuated. By means of a switch, either of two sweep widths may be selected; ±25% or ±5% of the center capacitance in the oscillator circuit. It is simpler to use the wider sweep during the set up and then reduce it later if desired.

The adjustments made thus far are performed on the test circuit unit. The remaining adjustments concern the CRT display. The intensity is turned up and a fixed dc voltage is applied to the vertical deflection amplifiers by means of a function selector switch. Under this condition, a horizontal trace appears on the CRT. The trace is vertically and horizontally centered on the CRT by adjusting the vertical and horizontal deflection voltages respectively. The length of the trace, corresponding to the sweep width, is set to the desired size by varying the gain of the horizontal amplifier. The Q calibration of the CRT is made by varying the gain of the vertical amplifier. With the foregoing procedures completed, the function selector switch is put in the test position and the resonating capacitor (in the test circuit) is tuned for resonance.

Either of two resonating capacitors may be used, depending upon whether a high or low value of capacitance is required. Resonance will be indicated on the CRT by the appearance of a resonance curve or a portion of a resonance curve. The RF level of the oscillator is adjusted so as to raise or lower the peak of the resonance curve to the vertical center of the CRT. The resonating capacitor is finely tuned to locate the peak at the horizontal center of the CRT.

Adjustment of the "Dot Position" control will cause an intensified dot to appear on the resonance curve and to be moved across the peak of the curve. The dot is positioned at the highest point of the resonance curve; i.e., the center of the CRT (Figure 3). A "Hi Q - Low Q" switch permits the "Dot Position" control to function properly under either high or low-Q conditions. With the dot in position, the intensity of the display is reduced with the "Intensity" control until the resonance curve disappears and only the dot remains. The "Astigmatism" and "Focus" controls are adjusted for the sharpest and most symmetrical dot. The Q Comparator is now ready for use.

DESIGN TECHNIQUES
Oscillator and Sweep Generator

The oscillator is a simple one operating in the 200-kc to 70-mc range and consisting of a cross-connected 12AU7 double triode. Electrically the oscillator section is quite conventional. The tuning arrangements of the oscillator on the other hand are somewhat unconventional.

Tuning for center frequency is accomplished by means of variable inductances in the oscillator tank circuit, while the variable (swept) tuning is accomplished by a motor-driven capacitor. With this system, the ratio of the capacitance variation to the total average capacitance is independent of the coils used, and the same relative reactance variation can be obtained for any center frequency. The output of the oscillator is coupled via a loop to the injection impedance of the test circuit detector. Amplitude is controlled by varying the plate voltage of the oscillator tube.

Simultaneously with providing a swept frequency, one section of the motor-driven capacitor serves to generate a sawtooth voltage for the horizontal sweep (corresponding to the X axis on the cathode-ray tube) which is always in synchronism with the instantaneous frequency deviation.

Detector

In addition to the detector itself, the detector section contains the test circuit which is a Q-meter arrangement with a two-section tuning capacitor for high and low frequencies. The detector proper is an "infinite impedance" type (cathode follower). A 12AU7 double triode is used for this purpose with one of the tube sections being used for compensation of heater voltage changes.

Vertical Amplifier

The vertical amplifier consists of two cascaded differential dc amplifiers. DC amplification is required in order to keep the base line (corresponding to a no-input signal) in place so that the height of the resonance curve can be measured from this base for any position or width of the resonance peak. The differential amplifiers provide a simple means for balancing level variations caused by heater voltage changes, and depressing the base line so that only the peaks of the resonance curves show on the CRT screen.

A voltage divider stabilized with a neon lamp provides a means for setting up and checking the vertical amplification at the input of the vertical amplifier. The amplification of the vertical channel can be adjusted by varying the amount of negative feedback in the first stage.

The vertical amplifier also delivers the input signal to the differentiator.

Differentiator and Trigger

The differentiator-trigger circuit, consisting of a feedback-pentode differentiator between two cathode followers, provides a trigger pulse for the dot generator at the precise moment of the resonance curve peak. The differentiator produces first and second derivatives of the resonance curve which, in turn, are used to anticipate the peak of the resonance curve to allow for circuit delays.

In addition to acting as a source of feedback voltage to the differentiator proper, the second cathode follower drives the input amplifier to the trigger circuit. A minimum number of coupling capacitors have been used in the circuit in order to keep down any charging effects.

The trigger circuit comprises two cascaded modified "Schmitt" triggers and are essentially overdriven amplifiers delivering a well defined voltage step of constant amplitude at the moment the input voltage reaches a predetermined level.

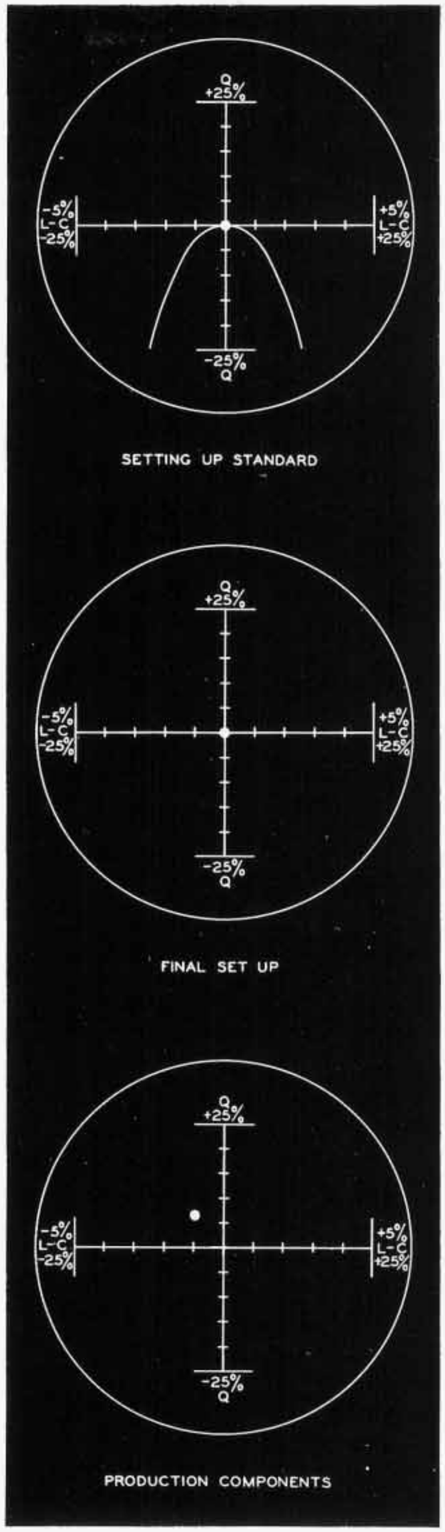

Figure 3. Q Comparator CRT Displays

Spot Generator

The step voltage from the trigger is differentiated and serves to initiate the final brightening pulse. This pulse is generated in a monostable multivibrator. In order to obtain a pulse of high amplitude and very short duration without excessive power consumption, high value load resistors are used and feedback and coupling capacitors of the multivibrator consist of the distributed and tube capacitances.

Horizontal Amplifier

A small sawtooth voltage is obtained from an RC network containing a rotating capacitor and amplified to a sufficient level to cover the entire CRT screen. Filters isolate the sawtooth generation from the oscillator. The first two stages of this amplifier are conventional RC-coupled triodes, with time constants that keep the sawtooth from deteriorating in shape. The final stage is a differential amplifier which provides a push-pull output and an easy means for centering the trace on the CRT screen.

One of the sawtooth outputs is differentiated into a square wave and used for actuating the blanking circuit. Blanking is necessary because of the slight nonlinearity of the sweep voltage which produces two resonance peaks side-by-side on the CRT screen. Eliminating the brightened dot from one of these results in the display becoming single-valued.

Cathode-Ray Tube

A cathode-ray tube is used as the display element, with the X axis horizontal and the Q axis vertical. The type 5ABP1, a 5-inch post-deflection accelerator tube, was chosen for this purpose because it requires the simplest amplifying and power supply circuitry.

The tube is operated with its cathode at —1700 volts, the deflection system at a few hundred volts positive, and the post accelerator at +1700 volts. An astigmatism control is required in addition to the usual focus and brightness controls, in order to provide a brightened dot that is reasonably small (about 1 mm) and circular. The brightness of the dot is considerably higher than would be used in a line display.

A magnetic shield isolates the CRT from the transformers and chokes in the power supply and from the driving motor in the oscillator and sweep generator sections.

Power Supply

The power supply supplies all of the voltages required by the Q Comparator. Certain of these voltage lines are stabilized with voltage regulator tubes because they feed stages sensitive to dc level changes. In some instances tubes will occasionally have their cathodes operating at close to +150 volts or −150 volts. In these cases only tubes with high permissible heater-cathode voltage ratings have been employed. This eliminates the need for separate filament windings.

Because of the number of tubes used in the instrument, some drawing relatively heavy currents during short intervals (pulses), thorough filtering is employed in the power supply in addition to sectionwise decoupling.

CONCLUSION

In the Type 265-A Q Comparator, BRC believes it has developed an instrument which will be invaluable to manufacturers of electronic components. The comparator provides comparison measurements of relative Q, inductance, and capacitance easily and accurately. Since these measurements require merely the visual inspection of a dot on a cathode-ray tube screen, the instrument can be operated by unskilled personnel once it is set up.

BRC customers interested in the Q Comparator may obtain information from one of the BRC representatives listed on page 8 of the Notebook. Also, the instrument will be on display in the BRC booth at the IRE show in New York City during March 24 through 27.

Remote Measurements with the RX Meter Employing Half-Wavelength Lines

ROBERT POIRIER, *Development Engineer*

Previous Notebook articles, Fall 1954, issue number 3, page 7 and Summer 1956 issue number 10, page 5 broached the subject of measuring impedances which are necessarily located some distance from an RX Meter but connected to the RX Meter through a constant impedance transmission line. The procedures to be described in the present article while not necessarily limited to constant impedance transmission line circuits will be restricted thereto because of the great simplification in data processing which results from the use of constant impedance transmission lines. It is the purpose of the present article to carefully consider the use of half-wavelength transmission lines of constant characteristic impedance, Z_o for remote impedance measurements with the Type 250-A RX Meter. The viewpoint is toward establishing simple procedures for interpreting the RX Meter readings through either lossless or lossy transmission lines to an unknown terminal impedance via the Smith Chart.

Transmission Line Equations

The equation which relates input impedance, Z_i to the characteristic impedance Z_o of a transmission line and the load resistance Z_l is given for the general case by

$$Z_i = Z_o \frac{Z_l \cosh \gamma l + Z_o \sinh \gamma l}{Z_o \cosh \gamma l + Z_l \sinh \gamma l} \quad (1)$$

where the complex propagation constant

$$\gamma = \sqrt{(R + j\omega L)\,(G + j\omega C)}, \quad (2)$$

for the distributed series resistance, R; inductance, L; shunt conductance, G; and capacitance, C per unit length. Some special cases are considered as follows:

For $Z_l = Z_o$

$$Z_i = Z_o$$

for any distance l between the load impedance and the measuring point.

When $Z_l = \infty$ $\quad \left(\frac{Z_o}{Z_l} = 0\right)$

as in the case of an open circuit terminal

$$Z_p = Z_o \frac{\cosh \gamma l}{\sinh \gamma l} = \frac{Z_o}{\tanh \gamma l} \quad (3)$$

and when $Z_l = 0$ as in the case of a short circuit terminal

$$Z_s = Z_o \tanh \gamma l \; . \quad (4)$$

By manipulating equations (3) and (4) we have

$$Z_o = \sqrt{Z_p\, Z_s} \quad (5)$$

and

$$\tanh \gamma l = \sqrt{\frac{Z_s}{Z_p}} \; . \quad (6)$$

In this article we are primarily concerned with half-wavelength lines for which Z_p and Z_s are pure resistances, R_p and R_s respectively. Also from (5) and (6)

$$\tanh \gamma l = \frac{Z_o}{R_p} \quad (7)$$

and separating γ into $\alpha + j\beta$ we have for ½ wavelength lines

$$\tanh 2\alpha l = \frac{2R_p\, Z_o}{R_p^2 + Z_o^2} \quad (8)$$

and

$$\tan 2\beta l = 0 \quad (9)$$

Equation (8) may be written as

$$\alpha l = \tfrac{1}{2} \tanh^{-1} \frac{2\, R_p\, Z_o}{R_p^2 + Z_o^2}$$

which for $R_p \geq 5Z_o$ reduces to

$$\alpha l \approx \frac{Z_o}{R_p} \text{ neper} \quad \text{or} \quad 8.69 \frac{Z_o}{R_p} \text{ db} \; .$$

Equation (8) relates the input resistance, R_p measured at integral half-wavelength distances from the open or short circuited end of a Z_o characteristic impedance transmission line to the total transmission loss αl of the length, l transmission line. We note that for lossless lines $(\alpha l = 0)$ R_p may be either 0 or ∞ but for transmission loss in excess of 20db R_p approaches Z_o for either open- or short circuited terminals or any termination in between open or short. Equation (8) is plotted in Figure 1 for the open and short circuit limits and from these a family of curves is generated to show the effect of transmission loss in db on the measured resistance of various resistive terminations separated from the measuring point by integral half wavelengths of transmission line. The characteristic impedance, Z_o of the transmission line has been assumed 50 ohms for this illustration.

The Smith Chart

The Smith Chart is a family of solutions contained within a unit circle for the transmission line equations in terms of the series orthogonal components and may be interpreted for R + jX of impedance or G + jβ of admittance. The polar coordinates of the unit circle are reflection coefficient, ρ and line length, βl in terms of wavelength. The maximum radius of the unit circle therefore corresponds to a reflection coefficient of 1 and the center to a reflection coefficient of 0. This is related to VSWR as

$$\text{VSWR} = \frac{1+\rho}{1-\rho}$$

So far as the series components of impedance or admittance are concerned, one-half wavelength of βl corresponds to a complete cycle and to 360° or one full turn around the chart. Smith Charts are available with the orthogonal coordinates calibrated in resistance and reactance for 50 ohm characteristic impedance, conductance and susceptance for 20 millimho characteristic admittance, or normalized impedance or admittance coordinates;

$$\frac{R}{Z_o}, \pm\frac{jX}{Z_o}, \frac{G}{Y_o}, \text{ and } \pm\frac{jB}{Y_o}$$

Usually included on the Smith Charts are the radially scaled parameters; reflection coefficient and loss, standing wave ratio and transmission loss.

For the purpose of illustrating the effect of transmission loss on Smith Chart plots, Figure 2 shows a normalized coordinate Smith Chart with 1db steps of transmission loss drawn as concentric circles. The intersection of these circles with the resistance/conductance axis corresponds, in Figure 1, to the intersections of the open and short circuit curves with whole integers of db and shows (as in Figure 1) the effect of transmission loss on the measured resistance of open or short circuit terminals at integral half-wavelength intervals in 1db steps.

Consider for example an open circuit termination. This corresponds in impedance coordinates to the extreme right end of the resistance axis and in admittance coordinates to the extreme left end of the admittance axis. An integral number of half wavelengths removed from the termination along a transmission line corresponds in the lossless case to the same integral number of clockwise revolutions around the Smith Chart, at constant radius, where the open circuit termination still appears as an open circuit. But for an integral number of half wavelengths and with 1db removed from the termination, the impedance or admittance locus spirals clockwise toward the center of the chart for the number of complete revolutions corresponding the number of half-wavelength line lengths to the circle representing 1 db transmission loss. In this case, we read from Figure 2 for the open circuit termination; R = 8.7Z_o ohms (435 ohms for Z_o = 50 ohms) or G = 0.115Y_o millimhos, or from Figure 1; R = 435 ohms.

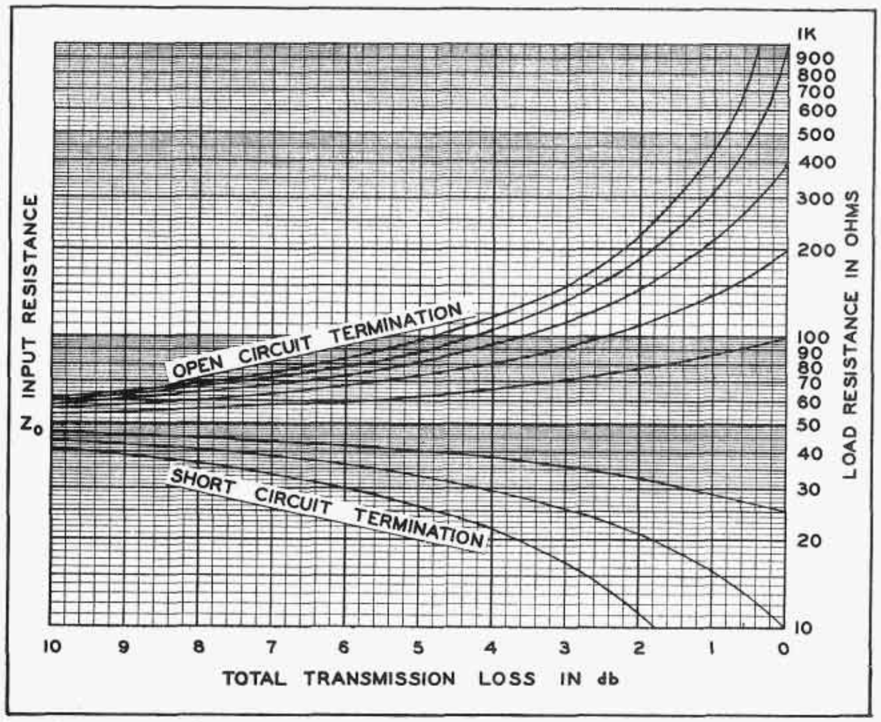

Figure 1. Apparent change of load resistance versus line loss in db when viewed from positions located an integral number of half-wavelengths from the termination.

Measurement Procedure

The basic operations associated with remote impedance measurements employing the RX Meter are outlined as follows:

1. Establish a length of uniform characteristic impedance transmission line between the RX Meter and the measuring point to be exactly an integral number of half wavelengths by providing an open circuit termination exactly at the location where the impedance to be measured will be located. Adjust the line length and/or the measuring frequency so that the RX Meter, appropriately tuned and balanced, reads a resistance; $R_p > Z_o$ and $C_p = 0$. For 50-ohm coax it is expedient to use the Coax Adapter Kit Type 515-A for connecting to the RX Meter. Record R_p. The effective parallel resistance thus obtained for an open-circuited line may be located on Figure 1 or a Smith Chart to determine the total transmission loss between the RX Meter and the open circuit. Record the total transmission loss. As an example, if the RX Meter reads R_p = 1,000 ohms C_p = 0 from Figure 1 or Figure 2, the total transmission loss is 0.4db.

In setting up the proper length transmission line it is preferable to avoid the use of a multiplicity of patch cords and/or constant impedance adjustable lines which are not exactly constant impedance. The reason for this is that adjustable lines and cable connectors (the latter especially when carelessly assembled and/or not kept clear of grease, dirt and the little brass chips and flakes of silver plate which tend to accumulate) produce discontinuities which cause changes in VSWR independently of the VSWR changes due to transmission loss. The operator in this case is faced with the choices of attempting to account for all discontinuities, eliminating them, or neglecting them.

2. Connect the impedance to be measured at the end of the transmission line in place of the open circuit. Rebalance the RX Meter and read and record R_p and C_p. Since the RX Meter

reads out parallel components it is convenient to convert the reading to normalized admittance coordinates,

$$G = \frac{1000}{Y_o R_p} \text{ and } B = \frac{j1000\omega C_p}{Y_o}$$

per unit millimho and locate the coordinates on a Smith Chart.

3. Consider a radius line drawn from the center of the Smith Chart through the located admittance. Since the transmission line has been established exactly an integral number of half wavelengths, the actual admittance at the end of line must be somewhere on this radius, there being no net change in βl for integral numbers of half wavelengths. For lossless or reflectionless transmission the admittance at the end of the line is the same as measured at the input end of the line. For lossy transmission with reflection the VSWR on the line will be increasing toward the load. The actual load admittance may be evaluated by adding the total transmission loss, previously determined, to the measured admittance along the radius vector away from the center of the Smith Chart. That is to say, the total transmission loss in db is added along the radial transmission loss scale in db away from the center of the Smith Chart, which is the direction for approaching the load to locate the point on the chart denoting the admittance (or impedance) of the load proper.

Examples

To illustrate step 3, above, let us suppose that the transmission loss of a given cable of one-half-wavelength 50-ohms characteristic impedance has been found to be 0.4db according to step 1, and that an RX Meter has indicated $R_p = 170$ ohms $C_p = 0$ for the termination and line. This may be plotted directly either as normalized conductance or normalized resistance since the series components are the same as the parallel components for pure resistance. On Figure 2 this data is plotted as conductance

$$G = \frac{1000}{20 \times 170} = 0.294$$

per unit millimho. Scaling 0.4db along the conductance axis away from the center from $0.294 \pm j0$ we find $0.25 \pm j0$ per unit millimho or 200 ohms for the termination. This result can also be obtained from Figure 1 which is plotted for pure resistance

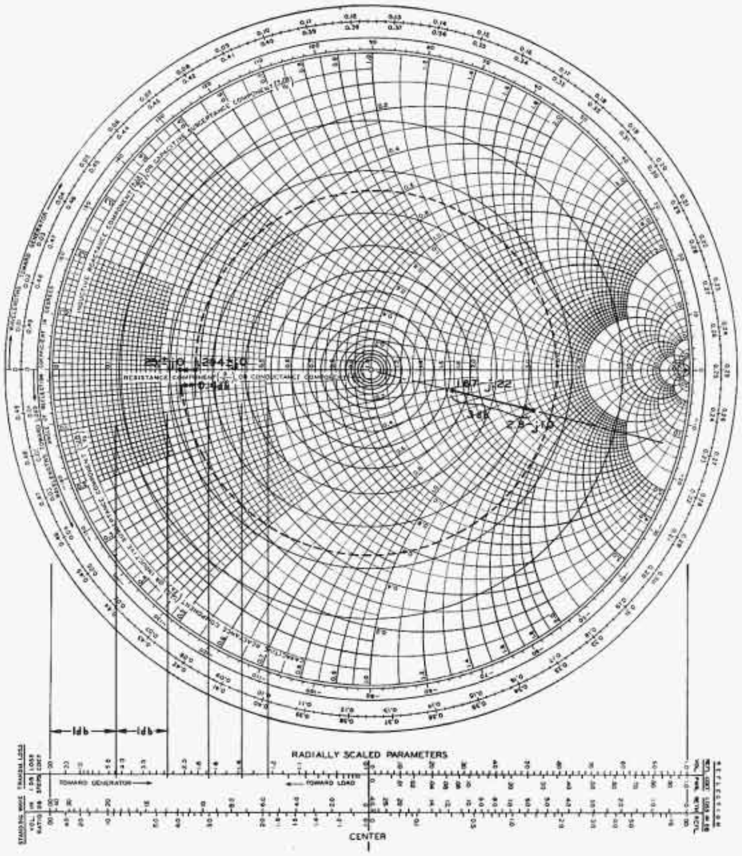

Figure 2. Smith Chart illustrating transmission loss.

terminations. The entire admittance locus for any point on the transmission line is shown on Figure 2 as a dashed line spiral of one revolution for the one half wavelength total line length.

A second example is considered as follows:

In this case, step 1 for 50-ohm coax reveals $R_p = 150$ ohms $C_p = 0$. From Figure 1 or Figure 2 the total transmission loss is 3 db. Step 2 reveals $R_p = 30$ ohms C_p — 7.0 $\mu\mu$f at 100 mc. Converting to normalized admittance coordinates

$$G = \frac{50}{30} = 1.67 \text{ and } B = -j\,50\,\omega$$

$C_p = -j0.22$. This point is located on the chart and a radial line through this point extended 3db away from center locates $2.8 - j1.0$ per unit admittance at the termination or

$$R_p = \frac{50}{2.8} = 17.9 \text{ ohms}$$

and $C_p = -31.8\mu\mu f$. For the purpose of simplifying the figure, the spiral admittance locus, mainly a matter of academic interest, was omitted in this example. Moreover, to plot the locus it is necessary to know the length of the line in wavelengths which was not given as data.

Some Aspects of Balanced Line Measurements

The foregoing procedures are essentially applicable for either unbalanced coaxial transmission line or dual balanced transmission lines such as "twin lead"; directly so when the balanced to unbalanced transition known as a balun is omitted and the two wires of the balanced line are connected directly to the Hi and Lo binding posts of the RX Meter. This procedure is subject to error resulting from unbalanced capacitance effects at the binding posts which may be minimized by leading the balanced line vertically away from the bridge. If a balun is employed a multiplying factor of 4 is required in going from unbalanced to balanced impedance and from balanced to unbalanced admittance. If the transmission line includes both balanced and unbalanced sections the balanced and unbalanced sections may be any length each, provided that the total transmission length is an integral number of half wavelengths and that the characteristic impedance of the balanced section is exactly 4 times the characteristic impedance of the unbalanced section. The total transmission loss is evaluated, as previously, by measuring R_p for the open circuited integral half-wavelength transmission line, locating R_p on the Smith Chart, and measuring attenuation on the db scale between $R = \infty$ and R_p. If the balanced to unbalanced characteristic impedance ratio is not exactly 4:1 then the two sections must be each adjusted to exactly an integral number of half wavelengths and the total transmission loss may be evaluated as previously.

Generally, measurements made with balanced lines are more subject to error than unbalanced coaxial. Primarily these errors result from discontinuities in Z_0 caused by unmatched cable connectors and the close proximity of the balanced sections to conducting objects. Here again, the choices are to account for all discontinuities, eliminate them or neglect them.

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New Wings for BRC

EDSON W. BEATTY, *BRC Pilot*

Over six years ago, BRC entered the business aviation field with the purchase of a Beechcraft Bonanza Aircraft for executive transportation. Recently we replaced this single-engine plane with a multi-engine Cessna 310, shown in the photograph. Because BRC is located on the fringe of Metropolitan New York, an area offering three major airports and fourteen domestic airlines, one would presume that we should have very little use for a business aircraft. Quite the opposite is true: we find the airplane to be extremely useful for handling our business transportation problems.

BRC's new Cessna 310 shown at the Morristown Municipal airport where it is based.

There are many advantages of owning and operating our own business aircraft; the most apparent being the time saved and the fact that we are not bound by firm schedules. For example, in order to travel via commercial airlines, an executive must depart from his office at least 2 hours before the scheduled departure time. Using the company aircraft, he can be in the air and on his way in 45 minutes. Since he sets his own departure time, he can tend to those "last minute details" before leaving. Also, with this type of operation, we are not limited to airline-served cities, but may use the facilities of most of the military and civil airports located throughout the country.

Our new Cessna 310 may be briefly described as a multi-engine, five-place, low-wing monoplane with retractable tricycle landing gear. At a distance in flight it resembles a jet aircraft. This allusion probably stems from the large wing-tip fuel tanks (each holds 50 gallons of fuel). The engines are a reciprocating type, consisting of two six-cylinder horizontally-opposed engines developing 240 HP each. The fuel tanks, together with the relatively short 25-foot length over-all and 36-foot wing span add greatly to the inflight stability of the aircraft. The 310 is aerodynamically clean in design, offering very low drag resistance. This reduction in drag resistance is accomplished mostly by good engine and cowling design. Each powerplant is installed in a 21-inch deep cowling which is an airfoil section contributing lift to the wing area. The powerplant accessories are completely duplicated on each engine so that in the event of a complete engine failure in either unit the generator output of only one is lost. The output of the other generator is more than ample to operate the electrical system and accessories of the plane.

At full load, the 310 will cruise at a speed of 205 MPH and climb at a rate of 1700 feet per minute near sea-level. It has a range of 875 miles and a service ceiling of 20,000 feet. The gross weight is 4600 pounds and the useful load is 1750 pounds.

Navigation and communication are no problem to the pilot because the BRC plane is amply equipped with the following impressive list of navigation and communication equipment.

ADF Receiver
VHF Navigation Receiver
VHF Communications Transceiver
VHF Standby Transmitter
ILS Glide Slope Receiver
Marker Beacon Receiver
Audio Amplifier

If we seem as enthusiastic about our airplane as a child with a new toy, it is because the aircraft has become an important part of our business operation. A recent business trip made by company executives typifies the ground that can be covered with this type of travel. The BRC group enplaned for a mid-morning departure from Morristown, New Jersey and arrived for a luncheon business meeting in Cleveland. They departed in mid-afternoon, arriving in Chicago late that same afternoon for meetings and dinner. After dinner, they left for Omaha, where they remained overnight. Departing the next morning, they arrived in Denver in time for noon appointments. We doubt that such a schedule could be maintained utilizing public transportation facilities.

ANOTHER Q METER CONTEST

In 1955, and again in 1957, BRC awarded Type 160-A Q Meters to lucky persons who visited the BRC booth at the IRE shows held in New York City in March of those years. The first award was determined by means of a drawing of registration cards filled out by guests at the BRC booth. In 1957 a new twist was added when guests were invited to estimate the Q of a specially wound coil exhibited at the booth, the person guessing closest to the actual measured Q being awarded the Q Meter.

The latter contest stimulated so much interest at the show last year that BRC has decided to sponsor a similar contest this year. A factory reconditioned 160-A Q Meter will be awarded again to the person whose Q estimate is closest to the measured Q of the "mystery" coil. Be assured that the coil will be as weird in shape and dimension as the fiendish minds of the BRC engineers can make it. See the coil, together with the Q Meter, at the IRE show in New

York City during March 24 through 27 and judge for yourself.

Contest rules will be the same as they were last year. The person who submits the Q estimate which is the closest to the actual Q of the coil, as measured by the BRC quality control engineer in the company standards laboratory, will be declared the contest winner. In case of a tie, a drawing will be made to decide the winner.

If you have some measuring problem, drop around to booths 3101 and 3102 at the show, we look forward to serving you. Maybe you will win a Q Meter for your trouble.

Norman L. Riemenschneider

BRC FIELD ENGINEERING STAFF

Pacing the growth of the electronic industry in the various geographical areas of the Country, we have endeavored to provide a staff of capable, well-trained field engineers to serve our customers in each territory. Below you will find a complete listing of our local field offices where, through a simple local telephone call, complete engineering assistance on the application of our instruments may be obtained. In addition, we maintain a field engineering group at our factory in Boonton, New Jersey to serve the local areas and also to assist our representatives in special applications. Our present home office staff includes Norman L. Riemenschneider and George P. McCasland, and we thought we would take this opportunity to introduce these engineers to you.

"Norm" joined BRC in 1953 as Sales Engineer and has concentrated on serving customers in the Metropolitan New York and Philadelphia areas. He received his B.S. in Electrical Engineering from Newark College of Engineering in 1943 and, drawing upon his 17 years of experience in the electronic industry, augmented by amateur radio experience dating back to 1938, has developed a wealth of valuable application information that has continually saved countless time and effort for our many customers.

"George" joined BRC just this past January and promises to be a welcome addition to our staff. He received his B.S. in Electrical Engineering from the University of Virginia in 1952 and his M.S. in Industrial Management from M.I.T. in 1954. With 3 years of experience in electronic systems development and amateur radio experience dating back to 1947, he is well qualified to assist our customers in the solution of their measurement problems. George will be responsible for serving our customers in the Metropolitan Baltimore and Washington areas.

If you're attending the I.R.E. Show, why not drop by at Booth Numbers 3101-2 and let Norm and George know of your instrumentation problems? A telephone call to our plant, at any time, will place these engineers at your service.

George P. McCasland

Engineering Representatives

ATLANTA, Georgia
BIVINS & CALDWELL
3133 Maple Drive, N.E.
Telephone: CEdar 3-7522
TWX: AT 987

BINGHAMTON, New York
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Intervale Road
Telephone: DEerfield 4-3200
TWX: BOONTON NJ 866

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KEystone 2-7281

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Telephone: CHerry 1-1091

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TWX: RO 189

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TWX: ST P 1181

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308 Merritt Avenue
Telephone: HOward 9-3825

TORONTO, Ontario, Canada
BAYLY ENGINEERING, LTD.
First Street
Ajax, Ontario, Canada
Telephone: Ajax 118
(Toronto) EMpire 8-6866

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