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The NOTEBOOK

BOONTON RADIO CORPORATION · BOONTON, NEW JERSEY

Applications of the Signal Generator Calibrator

JAMES E. WACHTER, *Project Engineer*

Figure 1. Type 245-C Signal Generator Calibrator.

The Type 245 Signal Generator Calibrator, available in two models, is a portable, self-powered, precision instrument which may be used as a calibrated high-level rf voltmeter; a source of calibrated microvolt-level voltage of known impedance; and a calibrated percent AM meter. Being portable and furnishing its own power, the instrument is especially adaptable to correlating signal generators and receivers located considerable distances from one another, such as might be found in airline communications installations and general service depots. With its calibrated output voltages, the instrument is ideal for calibrating receivers, since it permits the use of almost any shielded signal source, regardless of output accuracy, obviating the need for elaborate test equipment. Used for calibrating signal generator output systems and for calibrating percent amplitude modulation, the Calibrator not only saves inspection time, but frees other test equipment for more profitable use elsewhere.

Description

A simplified block diagram of the Signal Generator Calibrator is shown in Figure 2. The two basic parts of the instrument, a non-frequency-sensitive rf voltmeter and a precision fixed attenuator, are combined in a rigid mechanical unit of coaxial construction, a cross section of which is shown in Figure 3. The coaxial unit, together with suitable switching, amplifying, and metering circuits are housed in a small, sloping-panel cabinet measuring 9 inches wide, 5 inches deep, and 5 inches high, and weighing only 5 pounds. All of the operating controls and a very sensitive meter are located symmetrically on the front panel. Power is supplied from internal mercury batteries.

Used as a high-level input voltmeter, the Calibrator operates as a 50-ohm monitor of the input voltage at the voltmeter diode, which, within the accuracy specifications of the instrument, is essentially the same as the voltage applied to the input cable. The instrument will read, directly, input rf voltages of 0.1, 0.05, and 0.025 volt.

When operated as a source of low-level voltage, the Signal Generator Calibrator must be supplied from an external source. The voltage applied to the instrument is monitored at the input to the coaxial attenuator and the low-level output from the attenuator appears in series with a 50-ohm impedance-matching resistor. The rf voltmeter is calibrated to indicate the output voltages of 20, 10, and 5 μv (245-C) or 2, 1, 0.5 μv (245-D) across a 50-ohm termination connected directly to the output jack of the Calibrator. The accessory Type 517-B Output Cable supplied with the Calibrator provides a 50-ohm terminating resistor followed by a 25-ohm impedance-matching resistor which raises the equivalent source impedance at the end of the cable to 50 ohms.

When using the Calibrator as a percent AM meter, it is necessary to perform an initial setup, using an unmodulated rf input signal to establish the % AM meter reference. This setup is performed with the Meter Function switch in the RF IN position. Once the reference is established, the instrument is switched to % AM and the voltmeter detects the same signal with modulation applied. The ac component of the voltmeter is amplified, detected, and indicated on the calibrated % AM meter scale.

A more complete description of the theory and design of the Signal Generator Calibrator is given in references 1, 2, and 3. Complete performance specifications are given in this article under "Specifications".

Calibrating Signal Generator Output

Calibrating the output of a signal generator is generally performed using

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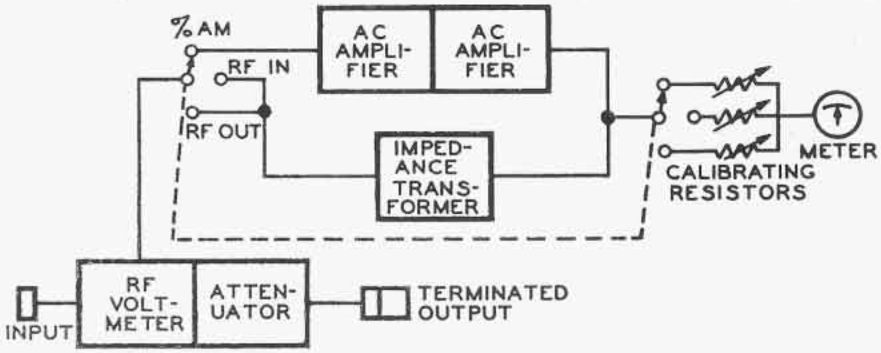

Figure 2. Signal Generator Calibrator System Block Diagram.

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a bolometer bridge. Most bolometer bridges are essentially high-level devices (of the order of 0.1 volt) and therefore can only be used to check the upper end of a piston type attenuator, meaning that the mechanical law of the attenuator must be relied upon for lower voltage levels.

Using the Calibrator, high-level voltages of 0.1, 0.05, and 0.05 volt can be read, directly, merely by changing ranges and adjusting the generator output to the appropriate calibration mark on the meter. If it is desired to calibrate voltages higher than 0.1 volt, it is only necessary to insert a precision pad of the appropriate attenuation between the generator output and the Calibrator input. For example, to calibrate a generator output of 0.2 volt, a pad of 6 db attenuation would be used, and the generator output level would be adjusted until the Calibrator indicated 0.1 volt.

Signal generator low-level output voltages can be calibrated using the Calibrator as a transfer device. The 245-C will calibrate, directly, the levels of 20, 10, and 5 microvolts and the 245-D will calibrate the levels of 2, 1, and 0.5 microvolts. Used in this manner, the Calibrator acts as a precision fixed attenuator of 80 db attenuation in the case of the 245-C and 100 db in the case of the 245-D.

The signal generator is connected to the Calibrator, with the Calibrator set to indicate output voltage, and the Calibrator output is connected to a receiver having a suitable signal-to-noise ratio and a means of indicating relative signal level. The generator output is then adjusted until the Calibrator indicates the desired output; for example, 2 μv. The receiver is tuned and peaked to this signal and the receiver output noted. The Calibrator is removed from the setup, and the signal generator, with its output set at minimum, is connected to the receiver. The generator output is increased until the receiver indicates the same signal level as previously noted. The generator is now delivering 2 μv (within specification tolerance) and its attenuator calibration can be checked accordingly.

Should it be desired to check the attenuator of a generator at lower levels than the Calibrator will provide (either 5 or 0.5 μv); this may be done using precision fixed attenuators between the Calibrator output and the receiver.

Exploring Law of Attenuation

A point of interest is the fact that the law of attenuation of a piston attenuator can be reasonably well explored using the Signal Generator Calibrator. The generator output is first checked at the maximum level and at levels of 6 db and 12 db below maximum using the Calibrator input voltmeter calibrations of 0.1, 0.05, and 0.025 volt. Then, the minimum calibrated output from the generator is checked using the Calibrator and a receiver. The checks at maximum and minimum output fix the overall calibration of the attenuator. If the measured attenuation at very low levels is less than is indicated by the attenuator dial calibration, it is an indication of rf leakage internal to the attenuator system; i.e., the attenuator is receiving power from other than the desired source, a variation in the attenuator bore diameter, or errors in the dial drive. The three high-level checks determine the linearity of the attenuator calibration, since it is in this high-level region, where the attenuator loop is near the mouth of the attenuator tube, that the law of the attenuator is generally violated by spurious modes of propagation.

Measuring Receiver Sensitivity

The Signal Generator Calibrator provides signal levels which are most often required for sensitivity measurements of both narrow and broad-band receivers: 2, 1, and 0.5 μv from the 245-D and 20, 10, and 5 μv from the 245-C. However, if levels lower than 0.5 μv are required for more sensitive receivers or for noise figure measurements, these can be obtained by associating the Calibrator with either a precision piston attenuator (for complete versatility) or with precision fixed attenuators. The lowest level of measurement attainable then is subject only to the limitation in shielding the receiver from the signal source.

Used in conjunction with a swept signal source, the Calibrator permits the dynamic checking of receiver sensitivity. The receiver, previously aligned with a high-level signal, is supplied with a calibrated low-level, swept signal from the Calibrator and the receiver sensitivity curve is observed as a visual display on an oscilloscope. This test requires the use of a well shielded sweep signal generator such as the BRC Type 240-A.

It should be noted here, that in receiver sensitivity measurements where the highest degree of accuracy is required it may be necessary to correct the Calibrator voltmeter indications for the output cable attenuation. If the output cable supplied with the Calibrator is used, it is advisable to apply this correction at frequencies above 500 mc. For any other cable used to connect the Calibrator to the receiver, the correction will depend upon the length and type of cable employed.

Calibrating Signal Generator Percent AM

Calibration of signal generator percent AM is generally performed using an equipment to heterodyne the signal generator carrier frequency down to some frequency acceptable to an oscilloscope and then sweeping the oscilloscope with the signal generator modulating frequency. The trapaziodal pattern thus obtained on the oscilloscope is a measure of the percent AM, subject, of course, to the interpretation of the observer.

With the Calibrator only two steps are required for percent AM calibration. First, a reference level is established on the Calibrator input range, using the unmodulated output of the signal. Then, with the Calibrator set on the % AM range, modulation is applied to the carrier and percent AM is read, directly, on the Calibrator % AM scale.

Distortion

It should be noted that the instrument is accurately calibrated for undistorted, sinusoidal modulation. The presence of distortion, therefore, introduces a corresponding error in the meter reading as indicated in Figure 4. It follows that with distortion present and the most accurate results required, it is necessary to know the kind and amount of distortion so that the meter reading may be corrected accordingly.

Carrier Shift

Another possible cause for error in the % AM indication would be a shift in carrier level due to the application of modulation. If percent AM calibrations are to be made under conditions of carrier shift, it may be desirable to recalibrate the % AM meter. For any reasonable linear carrier shift with modulation, this recalibration is easily accomplished using the internal % AM meter sensitivity control to adjust the meter to indicate correctly a known percent AM.

In this connection, it is interesting to note that the Calibrator may be used to detect gross shifts in carrier level caused by the application of modulation. When used in the RF IN position as an rf voltmeter, the meter indication for a modulated carrier will be somewhat greater than for the same level carrier without modulation. For a carrier level of 0.1 volt, for example, the meter indication is increased approximately 1/16 inch for 50% modulation. If, when modulation is applied, the meter reading does not increase about the expected amount, carrier shift is indicated. Should the meter read less with modulation applied, a considerable shift in carrier level would be indicated, indicating the presence of so-called "downward modulation" (positive peak clipping of the envelope).

Monitoring Transmitter Output

An antenna connected to the Calibrator input and placed in proximity to a transmitter antenna, or at some other point radiating power, would enable the Calibrator to indicate relative field strength when used in the RF IN position. If the input to the Calibrator were adjusted to the 0.1-volt reference level, the instrument could be used in the % AM position to indicate, directly, the percent AM present.

An improvement of this application would be the connection of a well shielded, sensitive receiver to the low-level output of the Calibrator to directly monitor the transmitter while in reasonable proximity to it.

Impedance Matching

It should be noted that for the best accuracy in the measurements described herein, as with most measurements involving the interconnection of instruments, the problem of matching impedances must be taken into account. Reference 4, covers this subject in some detail.

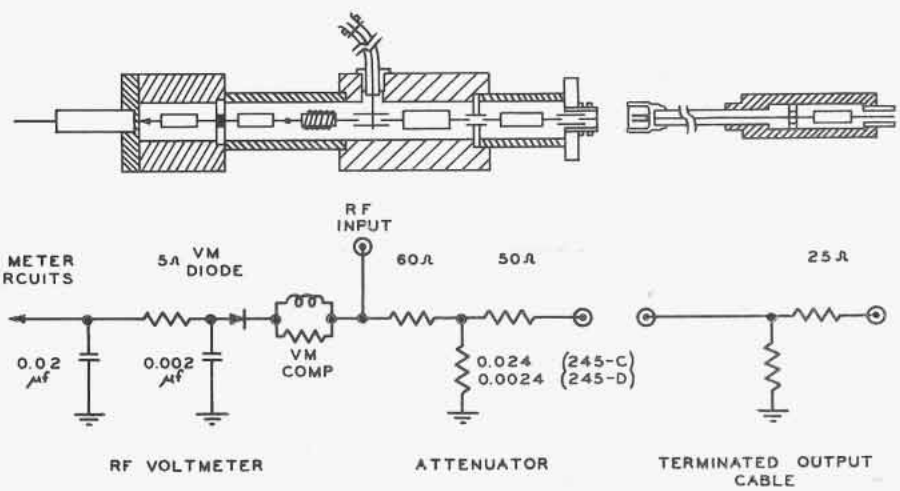


Figure 3. Coaxial Voltmeter-Attenuator Assembly and Output Cable.

Recalibration

The general design of the Signal Generator Calibrator is such that recalibration is seldom necessary. However, if recalibration becomes necessary, it is recommended that the instrument be returned to the factory for the most accurate calibration. If this is not convenient, field calibration of a lesser degree of accuracy may be performed.

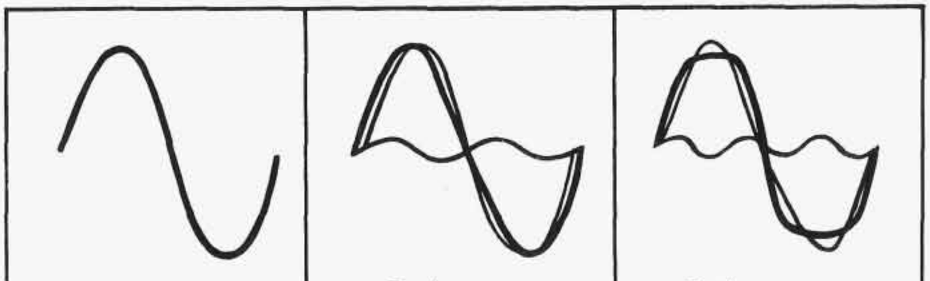
Input Voltmeter

Field recalibration of the input voltmeter may be accomplished using either of two methods. The first method involves the use of a 1000 cps source and a 60 µf additional bypassing capacitor. The bypass capacitor is connected at the voltmeter output at the end of the coaxial block. The 1000 cps should be of low distortion and the source should have an output impedance of 50 ohms. If the output impedance is not 50 ohms, an impedance matching pad should be used. The signal level should be monitored at the input to the Calibrator with an accurate ac voltmeter of high input impedance. Internal meter sensitivity controls are provided in the Calibrator to adjust the meter for correct indication of the three input voltages of 0.1, 0.05, and 0.025 volt

A second method for calibrating the input voltmeter is to compare the Calibrator voltmeter reading directly to the calibrated output of a known accurate signal generator having a piston type attenuator, such as the BRC Type 202-E or Type 225-A Signal Generators. These generators have a 50-ohm output impedance. If a generator with other than 50 ohms output impedance is used, a matching pad must be employed, and the attenuation of the pad must be taken into account when determining the input to the Calibrator as indicated by the signal generator attenuator calibration. The input signal is adjusted for 0.1, 0.05, and 0.025 volt and the internal sensitivity controls in the Calibrator are adjusted so that the Calibrator indicates these levels correctly. If a generator of dubious accuracy is used, the three levels can be established by calibrating the generator at the three levels, using a bolometer bridge.

% AM Meter

The % AM Meter can be recalibrated in much the same way as the rf voltmeter; i.e., by comparison with a known percent AM. As mentioned previously, it is desireable that the modulation be of low distortion and that there be no



FUNDAMENTAL	10% 2nd HARMONIC	10% 3rd HARMONIC
P.P.V. ERROR	+1.5%	−10
AVG. V. ERROR	0	+3.3 %
METER READING ERROR	−1.5%	+13.3%

***Figure 4.** Example of Error Caused by 10% Second and Third In-phase Harmonic Modulation Distortion.*

carrier shift with modulation. A suitable generator for this purpose is one such as the BRC Type 232-A. If only an uncalibrated AM source is available, it may be calibrated using the trapazoidal method. A convenient modulating frequency is 1000 cps and a good calibration point is 50%. Several points may be checked, if desired, and a compromise setting may be made for any slight error noted. With the modulated signal applied to the Calibrator, the internal % AM meter sensitivity control is adjusted so that the meter indicates the correct % AM.

Low-Level Output

When the Signal Generator is received from the factory, it is accurately calibrated. It would be advisable at this time to calibrate the high and low-level outputs of several signal generators and to record the information. This data would then serve as a convenient means for checking the calibration of the signal Generator Calibrator at some later date when there is reason to believe that its accuracy has deteriorated.

Field recalibration of the Calibrator low-level output (attenuation) can be performed easily by direct comparison to a signal generator having an accurately calibrated precision piston attenuator which has been standardized with a bolometer bridge. A sensitive receiver of good signal-to-noise ratio, with a means for indicating relative signal level, is required to monitor the low-level signals. The generator is connected to the receiver and a low-level signal of the order of 2 μv is applied. The receiver is tuned and peaked to this signal and the relative signal level indication noted. The generator is then disconnected from the receiver and the Calibrator (set for a 2 μv output) is inserted; the input cable connected to the generator and the terminated output cable connected to the receiver. The generator output is increased until the receiver indicates the same signal level as was previously indicated (2 μv), and the internal sensitivity control in the Calibrator is adjusted so that the Calibrator meter indicates the correct calibration. The same procedure would be used for the two lower levels of 1 μv and 0.5 μv utilizing the sensitivity controls provided for each level. This method is of greatest value when the generator has been previously checked by the Signal Generator Calibrator.

As mentioned previously, it is necessary to properly match impedances if the best accuracy is to be obtained. Also, it is advisable to use identical type and length cables when making comparison measurements.

Specifications

RADIO FREQUENCY MEASUREMENT CHARACTERISTICS

RF Range: 500 Kc. to 1000 Mc.
RF Voltage Measurement Levels:
Input: 0.025, 0.05, 0.1 Volts.
Output: 5, 10, 20 μv. (245-C).
0.5, 1, 2 μv. (245-D).
RF Voltage Accuracy:
Input: ±10% 500 Kc. to 500 Mc.*
±15% 500 Mc. to 1000 Mc.*
*When supplied from a 50 ohm nominal source, with a VSWR <2.
Output: ±10% 500 Kc. to 500 Mc.
±20% 500 Mc. to 1000 Mc.
RF Impedance:
Input: 50 ohms.
Output: 50 ohms.*
*At output jack on instrument and at output connector of Type 517-B Output Cable.
RF VSWR:
Input: ≤1.3 500 Kc. to 500 Mc.
≤1.6 500 Mc. to 1000 Mc.
Output: ≤1.05 500 Kc. to 100 Mc.*
≤1.07 100 Mc. to 500 Mc.*
≤1.1 500 Mc. to 1000 Mc.*
*At output connector of Type 517-B Output Cable.

AMPLITUDE MODULATION MEASUREMENT CHARACTERISTICS

AM Range: 10 to 100%.
AM Accuracy: ±10% 30 cps. to 15 Kc.*
±15% 20 cps. to 20 Kc.*
*Modulating frequency.
AM Frequency Range: 20 cps. to 20 Kc.
RF Input Requirements: 0.05 volts.

References

1. Gorss, C. G., "An RF Voltage Standard Supplies a Standard Signal at a Level of One Microvolt", BRC Notebook No. 5.
2. Gorss, C. G., "Calibration of an Instrument for Measuring Low-Level RF Voltages", BRC Notebook No. 14.
3. Poirier, R., "A Signal Generator Calibrator for RF Level and Percent AM"' BRC Notebook No. 21.
4. Moore, W. C., "Use of the RF Voltage Standard Type 245-A", BRC Notebook No. 7.

Measurement of Voltage Sensitive Capacitors

As evidenced by an ever-increasing rate of inquiries, there is a growing interest today in measuring the dynamic parameters of voltage sensitive diode capacitors at radio frequencies. Much information has appeared in the literature on these devices, so that it will suffice to say that these diodes, under certain biasing conditions, exhibit the characteristics of variable capacitors. Our particular interest in this matter is to indicate a means of measuring the equivalent series resistance, equivalent series capacitance, and of course, Q of these capacitors. The Type 250-A RX Meter, a completely self-contained RF bridge operating over a range from 500 kc to 250 mc, and completely described in issue number 2 of the Notebook, has been found ideally suited for this application and the purpose of this article is to outline a method for carrying out these measurements. Since the Q can be very easily found from the resistance and capacitance, and inasmuch as the equivalent series capacitance and equivalent parallel capacitance are approximately the same where the Q involved is 10 or greater, measurements can be simplified to the determination of the equivalent series resistance and equivalent capacitance.

Basic Technique

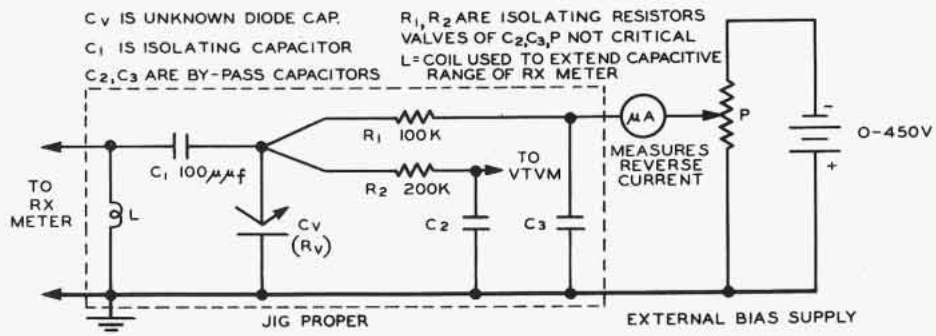
Basically the technique used in measuring these voltage sensitive diode capacitors is very similar to that employed with other circuits requiring a known and controlled amount of bias applied to the component under test. Methods of introducing biasing potentials and typical measuring circuits for the RX Meter have been discussed in issue number 6 of the Notebook. This article also illustrated a method for extending the capacitance range of the RX Meter beyond the direct-reading range of 20 $\mu\mu$f available on the instrument. Actually, then, the matter of measuring the voltage sensitive capacitive diode merely involves the introduction of the necessary bias to establish the proper operating point and a knowledge of the method used for extending the capacitive range of the RX Meter. This information, when properly applied will yield for frequencies below 20 mc, the equivalent parallel resistance and capacitance, which can then be converted to the Q of the circuit.

High-Frequency Technique

For measurements of these voltage sensitive variable capacitors at frequencies above approximately 20 mc, however, it became apparent that some modification of the low frequency techniques would have to be employed since the coils used at 50 mc or above would have inductances below 0.1 microhenries, and the 0.003 microhenry residual inductance of the bridge would now start to introduce errors and have an increasingly greater influence on the accuracy of the measurements as smaller coils were used for range extension.

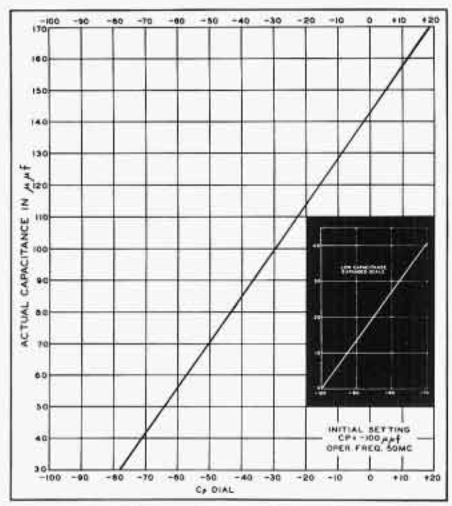
As a matter of background information, it might be interesting to note that a solution to this situation was approached in various ways. For example, an initial attempt was made to circumvent the use of a coil entirely, by first using a series capacitor in the order of 20 $\mu\mu$f, measuring it both for its capacitance and losses (including the jig), and converting these values to their series equivalents. By then adding the actual diode to be tested, similarly reading the entire circuit parameters and converting them to their series equivalent, an evaluation could be made of the diode by subtracting out the losses external to it. However, after some extensive study and evaluation of this method, it was decided that while it would yield a realistic value of capacity in most cases, the conversion and determination of the equivalent series resistance of the diode was not satisfactory.

Some thought was also given to the use of a quarter-wave-length line as a means of converting the capacitance of the diode to an inductive reactance, thereby extending the range automatically to an equivalent 100 $\mu\mu$f. However, this advantage was gained at the expense of various disadvantages; namely, each quarter-wave-length line would be suitable at only a given frequency, the values of resistance that could be meas-



Courtesy Pacific Semiconductors, Inc.

Figure 1. Typical circuit for measuring voltage sensitive capacitors at frequencies above approximately 20 mc.



Courtesy Pacific Semiconductors, Inc.

Figure 2. Calibration curve for C_P dial when measuring capacitances.

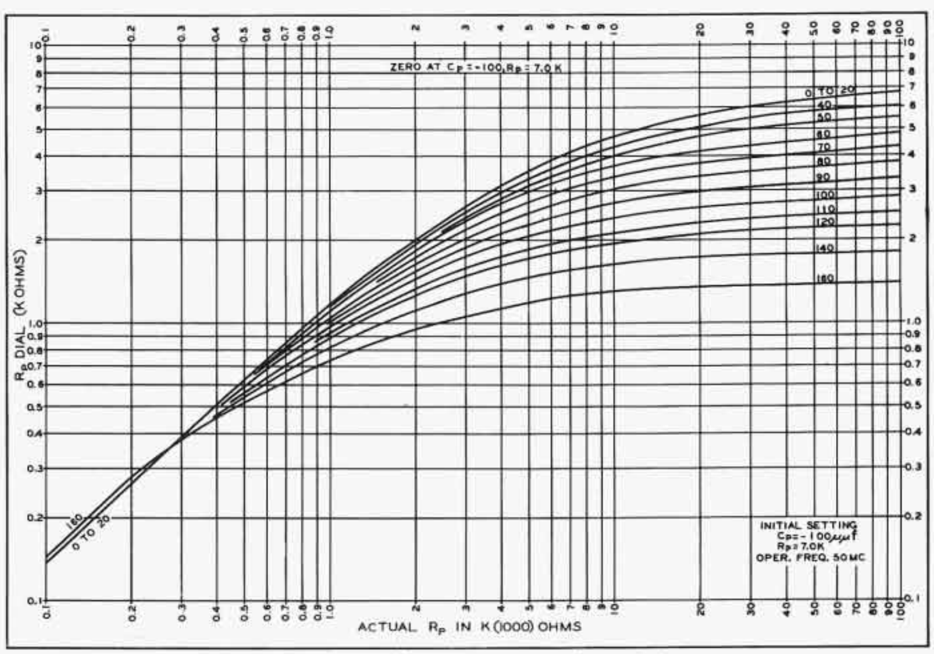
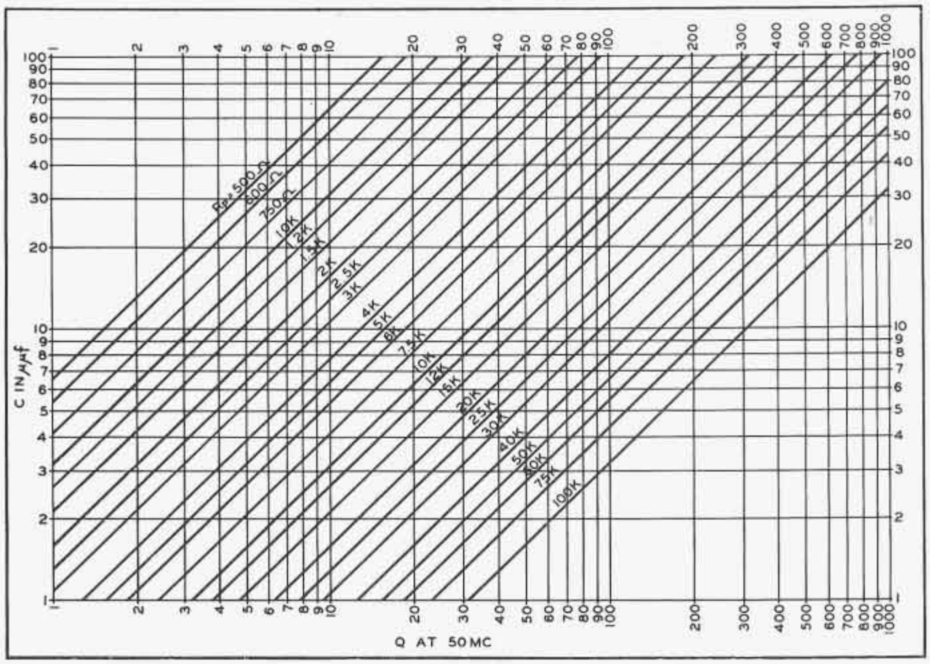


Figure 3. Calibration curves for the R_P dial.



Courtesy Pacific Semiconductors, Inc.

***Figure 4.* Typical family of curves for converting parallel resistance and capacitance to Q.**

ured in this manner were not high enough, and while this quarter-wave-length line, when coupled through a 515-A adapter did eliminate the residual inductance of the bridge, it did not help with the residuals that were added in the jig circuit at the other end of the cable. Some thought was also given to the use of a half-wave-length line but this was also discarded because of the frequency limitation and because it did not eliminate jig residuals.

With the abandonment of the above approaches, it became apparent that an ideal method would be one that would take into account; not only the residual inductance in the 250-A RX Meter, but also the various strays and residuals presented by the fixture or jig used with the diode capacitor. Figure 1 represents a typical circuit used for this measurement.

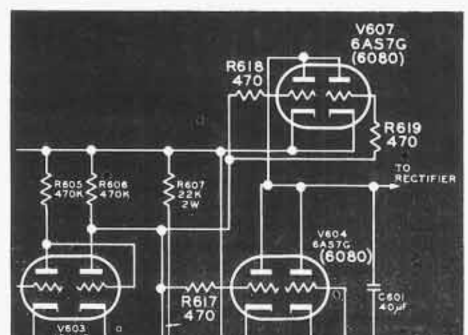
Essentially the method consists of using a coil having the necessary inductance to transpose the balance point of the bridge far enough to yield the desired capacitance, and then actually calibrating the C_p dial using various capacitors of predetermined values to obtain a correction curve to be used with the RX Meter at a given frequency. This curve is shown in Figure 2. Further, by using various values of capacitance in parallel with high quality resistors, whose resistance has been measured previously directly at the terminals of the RX Meter, at the calibration frequency, it is possible also to calibrate the R_p dial of the RX Meter to include the jig residuals. Such a calibration curve is shown in Figure 3. Using these calibration curves at a given frequency, it is now possible to measure the diode capacitor directly in the circuit as shown, and having the necessary calibration curves, the information is conveniently corrected to reflect the two parameters of the diode under test. From this information and using the curve shown as Figure 4, it is now possible to scale off the Q of the device. If so desired, the equivalent series resistance can also be determined from the corrected values of parallel capacitance and parallel resistance.

The author wishes to express his appreciation to Pacific Semiconductors, Inc., Culver City, California, for the invaluable help and data tendered.

Type 240-A Series Tube Modification

Frequent replacement of the 6AS7G regulator series tube on instruments received for repair, together with the fact that the plates of this tube were observed to glow excessively during inspection and testing operations at the factory, led to a quality control investigation of the Type 240-A Sweep Signal Generator power supply circuit. Tests revealed that due to circuit design changes and a change in the 5U4G rectifier tube furnished by our supplier, the 6AS7G series tube was being operated under overload conditions. To correct this condition, an additional regulator series tube with associated dropping resistors, has been incorporated into the 240-A power supply circuit.

Though the simplest circuit modification would be to add another 6AS7G tube, this was not possible in the case of instruments already in production, because the power supply chassis layout would not permit the addition of a 6AS7G tube. For this reason, the 6AS7G series tube in these instruments has been replaced by two smaller 6080 series tubes. In instruments produced in the future, however, the layout of the power supply chassis will be changed to accommodate two 6AS7G series tubes. A schematic diagram of the modified circuit is shown below. Components changed or added are identified in bold print.



Section of Type 240-A Power Supply Schematic

BRC WINS GOVERNOR'S SAFETY AWARD

On June 3, Governor Robert B. Meyner of New Jersey presented a governor's safety award to Boonton Radio Corporation for the remarkable

Governor Meyner Presents Governor's Safety Award to Dr. Downsbrough.

record of accumulating more than 1,820,000 man hours of work without a disabling accident. The last disabling accident at the plant occurred on April 15, 1952.

The governor's award is the highest given in a plant safety program sponsored by the Bureau of Engineering and Safety of the New Jersey Department of Labor and Safety. Since the inception of the safety program nine years ago, only nine companies in the state have received this award.

Presenting the award plaque to Dr. George A. Downsbrough, BRC president, the governor told employees:

"I congratulate all of you on this achievement. Over the course of this safety program, I have been accustomed to seeing this foremost of awards go, for the most part, to the giants among our industries. I am happy at this evidence that safety conciousness is by no means restricted to our bigger corporations."

Accepting the award, Dr. Downsbrough told the employees that the company was proud of this excellent safety record and urged that they not rest on their laurels but continue to be alert and safety conscious. On behalf of the employees, he presented the governor with an inscribed ashtray fashioned from a casting used on the Type 202 Signal Generator.

In a final note, the governor asked the employees to extend their good safety habits to the road and to their homes.

C. W. QUINN JOINS BRC FIELD ENGINEERING STAFF

Charles W. "Chuck" Quinn joined BRC as Sales Engineer in March of this year. Beginning his association with the company at this time afforded "Chuck" the opportunity to serve in the BRC booth at the IRE show where he was able to get first-hand information from our customers regarding their measurement problems. In more recent months, he has visited or otherwise been in touch with many of our customers along the east coast from the Metropolitan New York area south to the Metropolitan Washington area.

A native of New Jersey, "Chuck" served with the U.S. Navy from 1942 until 1946. He was graduated from Purdue University with a B.S. degree in Electrical Engineering in 1947. After graduation he accepted a position with Collins Radio Co., Cedar Rapids, Iowa where he was engaged in the development of receivers, frequency synthesizers, and fm transmitting equipment.

From October 1951 until he became associated with BRC, "Chuck" held engineering posts with Measurements Corporation, Boonton, N. J. During this time he gained additional experience in the development of noise meters, vacuum tube voltmeters, signal generators, and pulse generators.

"Chuck's" interests outside BRC lie in amateur radio (W2MMK) and photography. His more relaxing moments are spent in swimming and ice skating.

Considering his years of experience in the electronic measurement field, "Chuck" promises to be a valuable addition to the BRC engineering family.

Charles W. Quinn

If you are in the local area and have a measurement or applications problem, call or write "Chuck" at any time. Remember too, that BRC has Engineering Representatives throughout the U.S.A., in Canada, and overseas. A telephone call or letter is all that is required to put them at your service.

EDITOR'S NOTE

Q Meter Contest Winner

The Q of the problem coil displayed in the BRC exhibit at the IRE Show is 193. Winner of the Q Meter, with an estimate of 193, is Mr. Arno M. King of the Naval Research Laboratory in Washington, D. C.

In a letter to our General Manager, Mr. King confides that his recent, almost daily, use of the Q Meter prompted him to rule out such extreme estimates as 5 and 5,000 but from there on it was strictly a guessing game. "I have no secret procedures to offer," he writes, "and readily concede that only a very large element of luck could have placed me within 10% of the exact value, let alone the 1% tolerance which has been needed to win in the past."

Anyone who viewed the coil at the show will bear Mr. King out on this point. Our engineers contrived a series of various size coils, connected in a bridge-type configuration, which all but defied anything but educated guessing as to the value of Q. Yet, out of a total of 1200 entries, 11 persons, besides Mr. King, estimated within $\pm 1\%$ of the measured Q. These persons, whom we feel are deserving of honorable mention, are listed below:

Estimate

191 M. H. Brown, Rollan Electric Co. Chicago, Ill.

192 Art Ward, Livingston Electronics Essex Fells, N. J.

192.5 R. Lafferty, The Daven Co. Livingston, N. J.

192.7 C. R. Miller, Sperry Gyroscope Great Neck, N. Y.

193 Arno M. King, Naval Research Laboratory Washington 25, D. C.

195 Seymour S. West, Western Reserve University Cleveland, Ohio

195 C. E. Young, Naval Research Laboratory Washington 25, D. C.

195 Tom Crystal, 316 St. Paul St. Brookline, Mass.

195 Nick Lazar, Corning Glass Works Bradford, Pa.

195 S. Krevsky, USAS RDL Belmar, N. J.

195 Jerry Vogel, Marine Electric Corp. Brooklyn, N. Y.

195 B. Bedoian, ARMA Corp. Garden City, N. Y.

Mr. Arno M. King winner of the Q Meter contest.

The display coil was measured on a Type 260-A Q Meter in the BRC standards laboratory by our Quality Control Engineer. Several measurements were made resulting in a computed average Q of 193 and a computed average capacitance of $352 \mu\mu f$.

Mr. King, our winner, was born in Cleveland, Ohio. He attended Washburn University in Topeka, Kansas in 1939 then transferred to Bucknell University in Lewisburg, Pa., where he received a B. S. degree in 1943. Following graduation, he was employed by the Naval Research Laboratory, Washington, D. C. where he has spent all of his professional career working on problems associated with tracking radar. Currently, he is serving as Head of the Terminal Equipment Section of the Tracking Branch, Radar Division. In addition to being a member of the IRE, he holds memberships in Tau Beta Pi, Pi Mu Epsilon, Sigma Pi Sigma, and the Scientific Research Society of America.

Our congratulations to Mr. King and sincere thanks to all of our friends who visited with us at the show.

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