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Design of a UHF Q Meter

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With the intensive development presently going on in the ultra-high frequency area of the frequency spectrum, the need for a Q Meter capable of measurements in this frequency range has become evident. It was inevitable that the task of designing such an instrument would be undertaken by Boonton Radio Corporation, pioneer in the field of Q Meter design.

Q Meters presently in use are limited to measurements at frequencies below 300 Mc. This limitation is due mainly to certain design characteristics inherent in these instruments which have precluded the possibility of their use at UHF; namely, the injection resistance does not remain constant, resulting in poor calibration at higher frequencies; high series inductance is introduced into the measuring circuit at higher frequencies; and the oscillator design is not suited to UHF operation.

This article describes how these and other design problems were solved by the BRC Engineering Department during the course of the development of the new UHF Q Meter Type 280-A (Figures 1 and 2), an instrument which measures Q from 10 to 25,000 over a frequency range of 210 to 610 Mc.

Direct Reading, Self-Correcting Q Capacitor

The key to the development of the UHF Q Meter lay in the design of the Q capacitor, for without a workable Q capacitor, a UHF Q Meter would not be practical. A concept of a true reading capacitance was selected for the Q capacitor design in the UHF Q Meter.

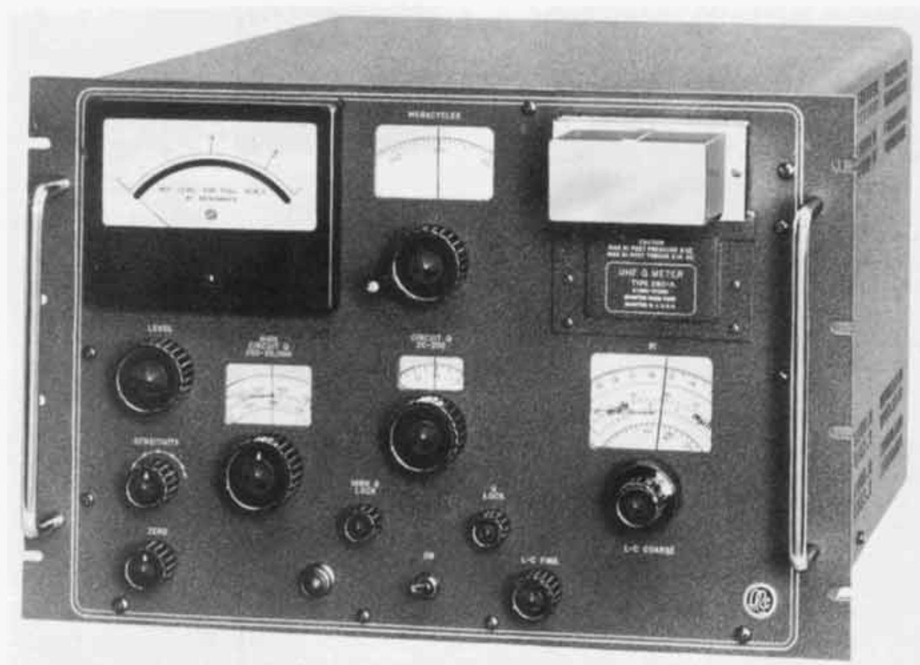

Figure 1. UHF Q Meter Type 280-A

If a capacitor (C) has a series inductance (L), which is characteristic of all capacitors, the equivalent capacitance (C_{eq}) is given by the equation:

$$C_{eq} = C \times \frac{1}{1-\omega^2 LC}, \text{ where } \omega =$$

operating frequency times 2π.

In the usual case L may vary with C. For example, in a butterfly-type capacitor, L and C vary in the same direction. In certain other type structures, such as the capacitor structure used in the BRC Type 190-A high-frequency Q Meter, L is almost constant.

As an interesting possibility, assume that L will vary inversely with C, so that L times C is a constant. This is equivalent to the series resonant frequency being constant, and independent of capacitance. Then, at a given frequency, C_{eq} would be equal to a constant times C, and the error (difference between C_{eq} and C) would be a constant percentage; this percentage being a function of frequency only.

In this case, if the readout scale for C were made logarithmic, a simple single motion of the readout index would produce a constant percentage correction in the C readout, and the system would provide a true capacitance reading at any frequency level.

Construction of the Q Capacitor

Having established the fact that series L times C should be a constant and that the law of variation of capacitance should be logarithmic, a practical way of constructing such a device had to be found. With high Q as an objective, sliding contacts were ruled out because

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they are known to introduce unwanted and unpredictable variable resistance. A logical solution was a two-stator capacitor with insulated movable plates meshing both stators. The plate material would need to be of highest conductivity and the unit would have to be small and well shielded to prevent radiation loss. The constant series resonant frequency of the capacitor should be at least twice the maximum frequency of use.

Using the relationship that the equivalent high frequency capacitance equals the low frequency capacitance times the factor $\frac{1}{1-\left(\frac{F}{F_c}\right)^2}$ (derived from previous equation), where F equals the operating frequency and F_c equals the constant series resonant frequency of the unit, the correction factor is 1.33 (when $F/F_c = 1/2$). This correction factor is quite high compared with the anticipated accuracy of $\pm$ 5%.

The constant L times C product suggested a capacitor with an average internal path length which would decrease as the capacitance was increased. The two most likely motions to accomplish a varying capacitance are rotation and translation, with translation being defined as motion in a straight line, and rotation as the angular movement of a shaft about its axis. Translation was chosen for our purpose because it allowed the plate area to be moved toward the capacitor terminals at the same time that the capacitance is increased.

From the start it was obvious that binding posts, as we know them, would introduce too much inductance for the high resonant frequencies anticipated. Therefore, the plane of reference concept was adopted, with the two capacitor stators presenting a common plane surface, separated by an air gap. The stator surfaces would be tapped for terminal screws which would be used for connection of the components to be measured. However, the calibrated capacitance would appear at the reference plane only,

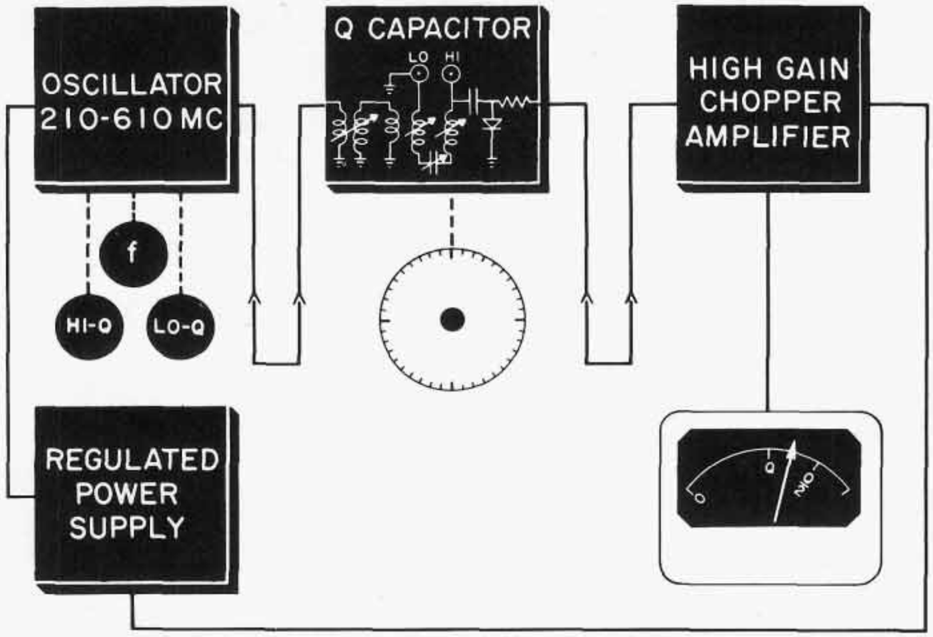

Figure 2. Block Diagram — UHF Q Meter

These design requirements were met in the Q capacitor structure shown in Figure 3. The translator plates approach from the bottom allowing the effective path from the plane of reference to the capacitor to be advanced at the same time that the capacitance is increased. The curve on the rear section of the translator plates is designed to give the translator plates the logarithmic capacitance variation required. The plane of reference is slanted 20° to allow the translator to approach the plane of reference as closely as possible. This tilting device maintains the approach distance to a point where the inductance is kept low, and at the same time provides a heavier stator section for attachment of components.

To give the reader some idea of the size of the capacitor structure in the instrument, the total width of the plane of reference is only 0.5 inch, and the air gap between the high stator and the ground stator is only 0.020 inch.

The electrical requirements of the capacitor were translated into mechanical dimensions by considering the structure to be a series of transmission lines of various impedance levels. The structure was then analyzed as a series of three transmission lines, one butted on to the next, with an open end and with a constant total length. The shaped translator plates approach from the bottom (Figure 3) out of the rectangular ground stator which is large enough to contain the entire translator, except for two small support tabs. The resulting self-resonant frequency is around 2000 Mc, or higher than the two-to-one requirement previously mentioned. The distance from the translator to the front terminals varies at approximately the proper ratio. The stators are wedge shaped to provide a larger section for the terminal screws and to give additional support to the structure. The entire unit is well shielded to prevent spurious resonant structures.

Linear ball bushings are used to support the translator plates so that there is virtually no play in the translator plates as they are moved toward the plane of reference.

L-C Dial Correction

The reason previously given for designing a capacitor with constant L

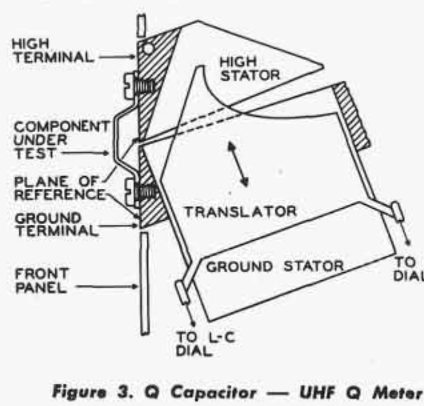

Figure 3. Q Capacitor — UHF Q Meter

times C, and for providing logarithmic capacitance variation was that the dial would be correctable by a constant percentage at any given operating frequency, and that this percentage would be equivalent to a given angular rotation of the readout hairline with respect to the capacitance scale. This is accomplished in the UHF Q Meter by pivoting the readout hairline for the capacitance dial on the same center as the capacitance dial. The hairline is rotated as a function of the frequency dial rotation by means of cam devices designed in accordance with the previously mentioned correction formulae. Readout of effective RF capacitance is therefore automatically accomplished with the tuning of the oscillator.

As an aid to computation, a concentric spiral logarithmic inductance dial is pivoted on the same shaft as the capacitance dial. The spiral inductance dial and the capacitance dial are held together by means of a friction disk. For each operating frequency used, there is an alignment of these two dials which results in the inductance scale reading that inductance which will resonate with the effective capacitance. The mechanics of driving the translating capacitor from a rotary shaft motion are accomplished by a conventional rack and pinion drive which is spring loaded to prevent backlash.

Circuit Coupling

Input is inductively coupled to one side of the high stator and output is capacitively coupled to the opposite side of the high stator, with the high stator serving as a shield between the two. The output is a voltage probe and the input is a current probe.

In order that the input coupling is only as much as is needed to give suitable output on the voltage probe for a wide range of circuit Q conditions, the input coupling has been made variable. Output from the oscillator is terminated in the movable probe of a cut-off type piston attenuator. The movable probe is a 50-ohm termination, resulting in a low standing wave ratio on the oscillator output line. A small loop at the end of the attenuator tube couples to a 50-ohm line which in turn enters the Q capacitor enclosure. This line is shorted near the front terminals of the Q capacitor with a small loop which couples to the Q circuit. The entire 50-ohm line is very short and nearly lossless and resonates at approximately 1400 Mc. Therefore, if the attenuator piston is decoupled, negligible loss is injected into the Q circuit. The advantage of this scheme is that for low Q circuits, where loss is less important and high injection level is needed, the piston is closely coupled; and for high Q circuits, where low injection level is required, the piston with its resistive component is decoupled from the Q circuit.

The voltage probe consists of a 1N82 diode coupled very loosely by a capacitive probe to the high stator. This diode looks like 4500 ohms in parallel with 0.5 pf capacitance. Voltage from the Q circuit is divided by a very small coupling capacitor providing a voltage ratio of 25 to 2, and resulting in a resistance ratio of 156 to 1. The diode appears across the Q circuit as roughly 0.7 megohms, limiting the Q of the Q capacitor to somewhat over 3,500. This value is considerably higher than the Q of small components suitable for measurement at the Q capacitor terminals.

Oscillator

In order to circumvent the previously mentioned problems associated with measuring resonant rise in the UHF range, a different principle of Q measurement has been employed in the UHF Q Meter. This principle is derived from the well known relationship that Q is equal to the frequency of resonance divided by the bandwidth from 3db point to 3db point on the resonance curve. This relationship is extremely accurate for values of 10 and above.

A number of automatic methods for sweeping this bandwidth to provide an automatic Q readout were considered, but it is likely that these methods would complicate the instrument and render it less accurate and reliable. It was decided, therefore, that the most direct approach to this type of Q measurement would be by manual, mechanical tuning of the oscillator. If this mechanical tuning were properly coupled to a dial, the dial itself could be made to readout Q directly. The oscillator frequency in this case would be an exceptional function of shaft rotation, and a given angular rotation of the oscillator shaft would be the same percentage of the oscillator frequency, regardless of the shaft position. The oscillator vernier would be calibrated in Q, starting at infinity and progressing down the Q range.

To measure Q with this system, an operator would start a measurement with the vernier dial reading ∞ at one 3db point and then tune through resonance, stopping at the other 3db point (Figure 4). The dial could be made to read Q directly. This system is simple and straightforward and a modulation system is not required. Use is made of basic mechanical elements which are necessary in an oscillator in any case, and the only additional requirement imposed on the design is that the oscillator vernier be somewhat refined and calibrated in Q. The indicator is a simple square-law diode detector, free of complex demodulator circuitry. This represents a Q measurement broken down into its fundamental essentials.

The oscillator frequency, as a function of shaft rotation, is very important in reading Q accuracy. The law must follow the general form: $f = Ae^{K\theta}$, if the Q dial calibration is to be accurate. Therefore, the oscillator structure should be repeatable. Two forms are apparent in which the frequency is controlled chiefly by mechanical parts: one employs tuned transmission lines and the other is a "butterfly" type construction. Both types employ a rigid mechanical resonator, but because the transmission line oscillator would tend to be noisy and cause frequency jumping over small motions, the "butterfly" type was chosen for this application.

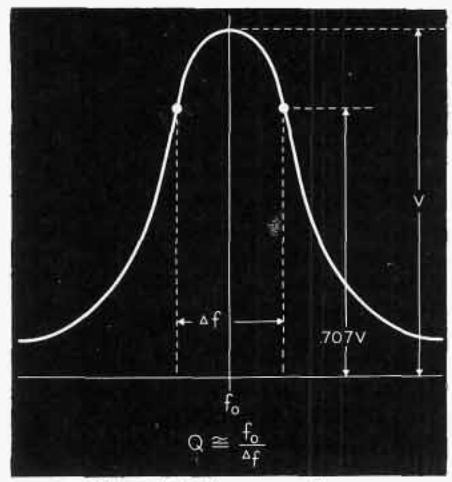

Figure 4. Q Resonance Curve

Vernier Tuning System

Q can be measured by means of a gear reduction system on the oscillator shaft up to a point: however, when the motion of the gear drive is reduced to its most infinitesimal increment, this motion becomes erratic. This could be expected for the measurement of high circuit Q values. To avoid this problem, an independent vernier was devised for the measurement of Q values beginning at 200. Basically, this fine vernier is achieved by rotating the entire butterfly stator by a micrometer driven torsion spring system, with the rotor shaft held fixed. The system is shown schematically in Figure 5. The disk represents the stator support and the four lines marked "S" are spring-tempered beryllium copper. These springs are stiff in a radial direction but permit rotation when the micrometer is advanced. The micrometer screw provides the precise uniform motion required. The springs flex elastically, in exact relationship to the micrometer motion, so there is no lost motion or backlash in the system.

The oscillator main drive is a double-ended shaft driven at right angles by a precision worm. Both vernier drives have a lock and a clutch between the shafts and the dials which are operated by means of front panel controls.

Oscillator Output System

In order to insure sufficient isolation between the test circuit and the oscillator, the oscillator output should be high. For the existing voltmeter sensitivity 0.1 watt would be sufficient for most cases. Because of the losses which may occur in makeshift external resonator couplers, it was decided that the oscillator output should be close to 1 watt RF. This output is just high enough for most requirements, without sacrificing stability.

The oscillator tube is a GENELEX DET22, with dc power handling capabilities of 10 watts. It is a planar type tube, and therefore has a very high series resonant frequency, assuring consistency of oscillator design and consequently uniformity of the law of frequency variation as a function of rotation ($f = Ae^{K\theta}$) from unit to unit. Ideally, a plot of θ versus the log of frequency should be a straight line with a slope which is the same for all instruments. This slope is held within $\pm$ 15% of nominal for all instruments at all points on the curve from 210 to 610 Mc. Operating conditions of the butterfly oscillator tend to vary considerably across the band. In order to keep the power level in the oscillator tube reasonably constant, a constant current pentode is connected in the cathode return of the tube. This holds the current change within reasonable limits without a large series dc drop. The oscillator has been carefully designed to eliminate spurious parasitic resonances which might cause the output amplitude or frequency to change at a rapid rate and thereby affect the accuracy of the measurement.

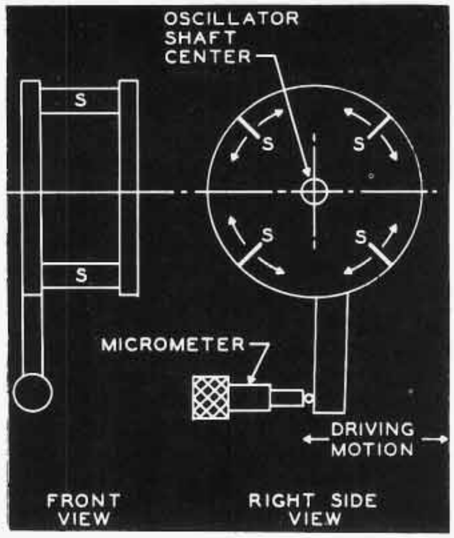

Figure 5. High Q Vernier Tuning System

Mechanical Design Parameters

Mechanical design parameters were derived from existing formulae for butterfly resonators. These parameters did not accurately elevate the inductance in the minimum capacitance condition, when the rotating plates fill the open area. The final shape of the capacitor plates was arrived at by first designing from the best known formulae, and then correcting this shape on the basis of data taken from this structure.

With nearly 10 watts being lost in the plate structure of the oscillator tube, it was necessary to provide excellent heat conduction from the plate to the general mass of metal in the stator, where it could be dissipated by radiation. The plate mount itself is a solid copper casting soldered fast to the butterfly stator. Ventilation around the outside of the oscillator is maintained at a relatively high level by the use of adequate clearance between the oscillator and other units in the instrument, and by means of perforations in the instrument cabinet.

Voltmeter System

The output from the diode probe is approximately 20 microvolts dc when the resonant peak voltage is 0.025 volts rms. In order to work with this low voltage level, a high-gain dc amplifier was necessary. A photo-conductive chopper amplifier circuit,[1] is used. This device employs light-sensitive resistance elements. Light is interrupted periodically by a mask rotated by a synchronous motor. Sharply tuned filters are used to remove noise and synchronous detection is used to better the efficiency of recovery. This unit can be operated on a 50-cycle power source by merely changing a plug-in filter unit.

[1] This circuit is similar to that which is used in the H-P 425A dc voltmeter.

Five steps of sensitivity have been provided by means of a front panel switch. The switch has five positions which equally divide the sensitivity ranging between 25 millivolts RF and 250 millivolts RF fullscale. Each step is approximately 3 to 1 dc sensitivity. Since the detector is square law, a 100 to 1 dc range represents a 10 to 1 RF level range. The switch steps, therefore, are roughly 5db.

If the Q to be measured is high and the test voltage is not critical, the least sensitive range would be used because the fluctuation noise is least and the response time of the voltmeter is shorter. At the higher sensitivities, the time of response is somewhat longer and zero fluctuation noise is noticeable. For very low Q devices, where it might not be possible to develop 0.25 volt across the resonator, maximum sensitivity would be used.

Provisions for Measurement of External Resonators

The coaxial cable which connects the oscillator to the Q capacitor and the cable which connects the dc voltmeter to the Q capacitor are jumpered at the rear of the instrument to allow for connection of external resonating devices. A suitable inductive probe connected to the oscillator output, to present a reasonable 50-ohm termination, could be used to lightly couple to the circuit under test and a small shunt diode could be used for the pickup. In this manner the external resonator would simulate, very closely, the internal resonator, and its Q and resonant frequency could be determined readily.

This application represents a remarkable advance in the Q Meter art. Previously, the Q Meter could only resonate on its terminals and therefore presented to these external resonating devices a non-reducible minimum shunt capacitance. With the UHF Q Meter the devices can be measured without significantly adding capacitance and changing the internal impedance of the external resonating device. In this respect, it would be well to point out that the UHF Q Meter has a lower minimum capacitance at its terminals (only 4 pf) than the previous Q Meters in any frequency range.

A more detailed discussion of external resonator measurements will be given in Notebook Number 28.

Power Supply

A 300-volt, electronically regulated power supply furnishes all of the power for the oscillator and the dc voltmeter circuit. Power voltages for the voltmeter are supplied through dropping resistors. Two regulated filament dc power supplies are required: one for the oscillator which has common cathode and heater connections, and the other for the constant-current pentode and low-level stages in the dc voltmeter. These dc supplies are transistor regulated with a dc Zener diode reference. Two 6.3-volt ac supplies are provided for noncritical filament and bulb lighting.

Conclusion

Development of the UHF Q Meter Type 280-A has brought about a number of significant advances to the Q Meter measurement art. First, it has made possible the direct reading, without correction, of Q, inductance, and capacitance. Second, the frequency range for Q measurements has been extended to 610 Mc. Third, the resonant voltage has been lowered from approximately several volts, which was a function of Q, to 0.025 volts, which is constant for a measurement; opening the field for measurement of semiconductor devices and other non-linear impedances. Finally, a unique means has been provided for measuring the Q of external resonators with Q's up to 25,000, with negligible circuit loss due to the measurement.

Specifications

RADIO FREQUENCY CHARACTERISTICS

RF Range: 210 to 610 MC
RF Accuracy: ±3%
RF Calibration: Increments of approximately 1%
RF Monitor Output: 10 mv. minimum into 50 ohms*
* at frequency monitoring jack

Q MEASUREMENT CHARACTERISTICS

Q Range:
Total Range: 10 to 25,000*
High Range: 200 to 25,000*
Low Range: 10 to 200
* 10 to approx. 2,000 employing internal resonating capacitor
Q Accuracy: ± 20% of indicated Q
Q Calibration:
High Q Scale: Increments of 1-5% up to 2,000
Low Q Scale: Increments of 3-5%

INDUCTANCE MEASUREMENT CHARACTERISTICS

L Range: 2.5 to 146 mμh*
* actual range depends upon measuring frequency
L Accuracy: ± 11 to 15%*
* accuracy depends upon resonating capacitance
L Calibration: Increments of approx. 5%

RESONATING CAPACITOR CHARACTERISTICS

Capacitor Range: 4 to 25 μμf
Capacitor Accuracy: ± (5% + 0.2 μμf)
Capacitor Calibration: 0.05 μμf increments, 4-5 μμf
0.1 μμf increments, 5-15 μμf
0.2 μμf increments, 15-25 μμf

MEASUREMENT VOLTAGE LEVEL

RF Levels: 25, 40, 80, 140, 250 mv. nominal*
* across measuring terminals

PHYSICAL CHARACTERISTICS

Mounting: Cabinet for bench use; by removal of end covers, suitable for 19" rack mounting
Finish: Gray wrinkle, engraved panel (other finishes available on special order)
Dimensions: Height: 12-7/32" Width: 19" Depth: 17"
Weight: Net: 72 lbs.

POWER REQUIREMENTS

280-A: 105-125/210-250 volts, 60 cps, 140 watts
280-AP: 105-125/210-250 volts, 50 cps, 140 watts

A VHF Telemetering Signal Generator System

WILLARD J. CERNEY, *Sales Engineer*

The Type 202-G FM-AM Signal Generator and the Type 207-G Univerter (Figure 1) were designed specifically for measuring the performance of telemetering systems and equipment.[1] With a frequency range of 195 to 270 Mc, the 202-G Signal Generator is ideally suited for checking telemetering receivers since this frequency range completely blankets the recently extended 215 to 260 Mc telemetry band. The 207-G is a unity gain frequency converter which is used in conjunction with the 202-G to provide additional frequency coverage of 0.1 to 55 Mc in the intermediate frequency range.[2]

Description of the Type 202-G

A functional block diagram of the Type 202-G FM-AM Signal Generator is shown in Figure 2. The instrument consists essentially of an oscillator, a reactance modulator for FM, a pair of frequency doublers, an audio oscillator, a regulated power supply, an output network, and associated monitoring meters.

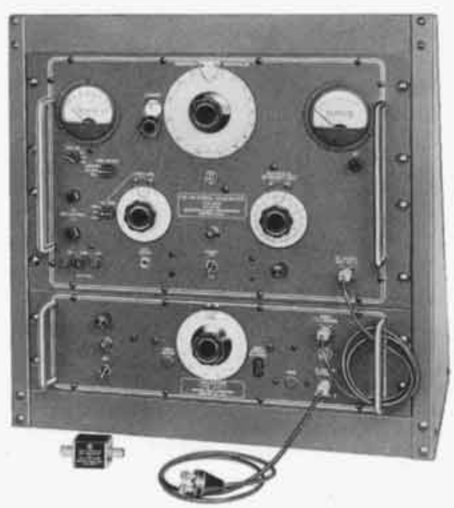

Figure 1. Rack Mounted View of 202-G and 207-G

When a voltage is applied to the grid of the reactance tube, a proportional shift in frequency is accomplished. This modulating voltage is applied to the FM terminals and coupled through a network to the grid of the reactance tube. The band pass of this network is 30 cps to 200 kc. Modulating voltage may be selected internally from any one of seven standard RDB subcarrier frequencies, or from any suitable external oscillator capable of furnishing frequencies in the range of 30 cps to 200 kc. AM may be obtained by means of a front panel internal modulation switch which places the audio signal on the screen grid of the second doubler tube. Simultaneous AM and FM may also be obtained by using an external oscillator.

The RF unit in this instrument is mounted on a rugged aluminum casting and is thoroughly shielded. This results in excellent stability, low leakage, and reliability.

The instrument is designed for bench use or for installation in a standard 19-inch rack. All of the operating controls

1. H. J. Lang, "A Telemetering FM-AM Signal Generator," BRC Notebook Number 21, Spring, 1959.
2. The 207-G may also be used to extend the frequency ranges of the Types 202-D and 202-F Signal Generators.

are arranged in convenient functional order on the front panel. All calibrated controls are direct reading.

Description of the Type 207-G

A functional block diagram of the Type 207-G Univerter is shown in Figure 3. The instrument consists essentially of a mixer, a local oscillator with a nominal center frequency of 195 Mc, two broad-band amplifiers, an output stage, and a power supply. Input from the 202-G Signal Generator is fed into the mixer from which is subtracted the output frequency of the local oscillator. The resulting difference signal is then separated by filtering and amplified. The second stage amplifier drives the output stage which is a cathode follower used to provide a suitable source impedance. Like the 202-G, the 207-G may be operated on a bench or installed in a standard 19-inch rack. All operating controls are located on the front panel.

Interconnection of Types 202-G and 207-G

The frequency range of the 202-G Signal Generator may be extended to provide intermediate frequencies of 0.1 to 55 Mc by interconnecting the instrument with the 207-G with the output and patching cables furnished with the instruments, as shown in Figure 1. The Type 501-B Output Cable is connected to the 207-G unity gain output and the Type 502-B Patching Cable is connected between the 202-G output and the 207-G input. These connections reproduce the FM and AM characteristics of the 202-G at the 207-G output.

A Type 509-B Attenuator is supplied with the 207-G for use in cases where the signal level required is low compared to the constant noise level of the 207-G. Used at the output of the 207-G, the 20-db pad attenuates both the signal level and constant noise level. This permits the use of a higher input signal from the 202-G thus improving the signal-to-noise ratio.

Applications

The Type 202-G Signal Generator and Type 207-G Univerter, when used together, provide a signal generator system especially suited for measuring performance and aligning VHF telemetering equipment. Some of the major applications of this system are listed below.

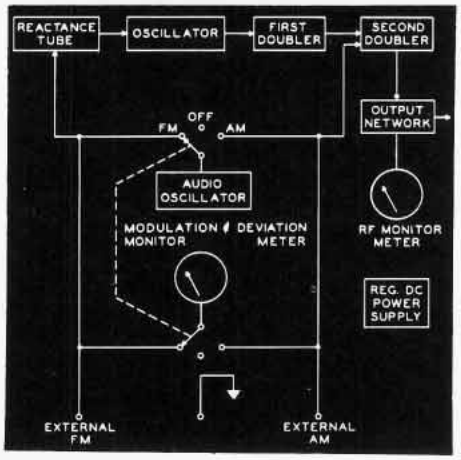

Figure 2. Block Diagram — Type 202-G

1. *Receiver Alignment* — The system may be used to check and align IF and RF amplifiers and local oscillators. Tracking may also be checked in cases where VFO equipment is used. RF checks are performed with the 202-G and IF checks are performed with the 207-G and 202-G interconnected.

2. *Receiver Bandwidth Measurements*— The calibrated output system in the 202-G makes the instrument a convenient tool for performing normal bandwidth measurements. These measurements are made by first disabling the AGC in the receiver and then determining the half-power points on the response curve. Through the use of a precision backlash-free gear train, approximately 2,200 vernier logging divisions are provided to aid in making frequency measurements. Each logging division changes the output frequency approximately 34 kc. The minimum bandwidth that can be measured without use of the 207-G is determined by the required accuracy of the bandwidth measurement. For example, if the required accuracy of the measurement is approximately 10%, then the minimum bandwidth directly readable from the 202-G would be 350 kc. If the bandwidth is narrower or requires greater accuracy, it will be necessary to measure the bandwidth of the IF amplifiers at intermediate frequencies, using the calibrated dial on the 207-G. This technique is usually acceptable, since the IF amplifiers generally control the overall bandwidth of the receiver.

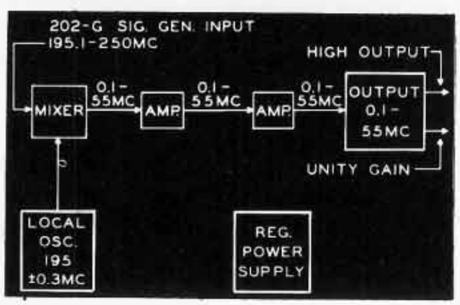

Figure 3. Block Diagram — Type 207-G

3. *Receiver Sensitivity Measurements*— To fully analyze FM receiver performance, three measurements must be made. These are maximum sensitivity, quieting sensitivity, and deviation sensitivity. The 202-G provides a calibrated output of 0.1 μv to 0.2 volt which is ideally suited for these measurements. Maximum sensitivity is generally defined as the minimum amount of a specified carrier with a standard modulation that will produce a standard output with all controls set for maximum gain. In modern telemetering systems, it is not uncommon to have receivers with sensitivities of 0.5 μv or better. Quieting sensitivity is usually specified as the minimum unmodulated carrier signal required to reduce the output noise by a specified amount below the output with standard test modulation. A typical receiver required 3 μv to attain 20 db and 5.5 μv to attain 30 db of quieting. A deviation sensitivity test is the measurement that characterizes the discriminator. This measurement is generally accomplished by having a specified carrier level, with minimum deviation, produce a standard test output signal at the discriminator with all controls set for maximum gain.

4. *Receiver AGC Characteristics* — Generally the telemetering receiver detects fluctuating RF signals from the telemetering transmitter due to the relative motion between the receiver and transmitter. Because of the motion problem, good AGC response and control are necessary to insure reliable reception. The fact that the 202-G has a continuously calibrated RF signal output which can be continuously varied, makes this instrument particularly suited for measuring the AGC level and response. The AGC level is determined by feeding a predetermined RF level into the receiver and measuring the amount of dc level in the AGC circuit. Normally, AGC time response is checked using a low-frequency square wave to amplitude modulate an RF source of a predetermined level and observing the rise time of the AGC voltage on an oscillograph or oscilloscope.

5. *Recovered Audio Distortion* — The

signal generator system may be used to measure distortion on recovered audio in TCM (tone code modulation), PM (phase modulation), and other overall systems. This determination would normally be made with a distortion analyzer, such as the H-P 330B, connected to the output of the receiver under test.

6. *Pulse Response Check* — Occasionally in PAM (pulse amplitude modulation), PCM (pulse code modulation), and PDM (pulse deviation modulation) types of modulation it is important to know the overall pulse response of a receiver. If excessive delay, rise time, fall time, and overshoot occurs with the recovered data, the overall data handling capability of a system is adversely affected. The pulse response check is accomplished by using a square-wave generator to modulate the 202-G and observing the output pulse on a good oscilloscope.

7. *System Performance Check* — By modulating the 202-G with an external subcarrier generator, the overall performance of a complete data system may be checked. A check of the system can also be made to determine system reliability versus signal and modulation level. The modulating signal may also be recorded and compared with the recovered data.

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James F. McCann

We at BRC are proud of our association with Instrument Associates, Inc. and salute them for their continuing record of faithful service to our many customers in the New England area.

275-A As A Bias Supply for Making Transistor Measurements on the RX Meter

The 275-A Transistor Test Set not only provides a highly accurate source of measurement for $\propto_0$, β_0, and h_{ib}, but can be used to furnish I_E and V_{CB} bias for measurements on the RX Meter. The power supplies in the 275-A are ideal for this purpose because they are continuously variable, well regulated, and easily reversed. In addition, both I_E and V_{CB} are monitored with an accurate meter and the voltages are readily accessible from the front panel test terminals.

When operating the 275-A in this manner, it is advisable to remove the 1000-cps signal superimposed on the E and B terminals, as this signal may cause an indefinite null on the RX Meter. The signal is easily removed by connecting a suitable capacitor; e.g., 30 μf with a minimum working voltage of 15 vdc, across the E and B test terminals, and setting the $\propto$-h_{ib}-β Selector to the .9 — 1.0 $\propto$ range. The positive terminal of the capacitor must be connected to the B terminal on the 275-A when the NPN-PNP switch is in the NPN position, and to the E terminal when the NPN-PNP switch is in the PNP position.

A detailed discussion of a method for determining transistor parameters using the Transistor Test Set Type 275-A and the RX Meter Type 250-A is presented in Notebook Number 26.

ARVA, INC. NEW BRC SALES REPRESENTATIVES

Boonton Radio Corporation is pleased to announce the appointment of ARVA, Inc. as sales representatives for BRC in the states of Alaska, Washington, Oregon, Idaho, and Montana, and the Western Canadian Provinces of British Columbia, Alberta, Saskatchewan, and Manitoba. Headquarters of ARVA, Inc. is located in Seattle, Washington. Other sales offices are located in Spokane, Portland, and Vancouver, D. C. Canada.

EDITOR'S NOTE

Hewlett-Packard S. A. Appointed European Distributor for BRC Products

In order to further improve our service to our many European customers, BRC, effective July 1, 1960, appointed Hewlett-Packard S. A. Rue Du Vieux Billard No. 1 Geneva, Switzerland, exclusive sales coordinator and distributor for our products in the following countries: Austria, Belgium, Denmark, Finland, France, Western Germany, Greece, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Yugoslavia, and United Kingdom. Under their direction, qualified Engineering representatives have been established in each of these countries to provide local application engineering, order processing, and repair services.

BRC products are now available for immediate delivery from HPSA's "duty-free" warehouse in Basel, Switzerland with one minimum uniform surcharge added to the U. S. catalog price to cover shipping and handling costs. Bulk air shipments to the Basel warehouse are made periodically from our plant in Boonton, New Jersey thereby eliminating expensive export packing charges and, by consolidation, actually reducing the shipping and handling charges on individual items.

Bill Doolittle, Managing Director HPSA

For more than a decade, BRC has intensively trained its domestic Sales Representatives through frequent Sales Seminars at our factory in Boonton, New Jersey but, because of the long distances involved, it has not always been possible for a majority of our European representatives to regularly participate in this program. Under our new arrangement with HPSA, special training seminars are now scheduled in Geneva, Switzerland, exclusively for our European staff. Representatives from our factory will make available to all of our European customers the very latest application engineering data on both new and established products. The first of these seminars will be held in April, at which time BRC will be represented by Harry J. Lang, Sales Manager.

Import control regulations in many European countries have made it difficult or even impossible for potential BRC customers to receive demonstrations of BRC instruments. To overcome this problem, HPSA has equipped a specially constructed Mobile Demonstration Laboratory, outfitted with many of the newest BRC instruments, to make on-the-spot demonstrations in any part of Europe.

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