SPRING, 1962

NUMBER 31

The NOTEBOOK

BOONTON RADIO CORPORATION · BOONTON, NEW JERSEY

DESIGN OF AN IMPROVED FM-AM SIGNAL GENERATOR

ARTHUR N. OATIS, *Development Engineer*

The age of missiles and satellites has suddenly created a need for communications and data transmission systems which impose tight requirements on FM receivers. For example, FM telemetering systems have squeezed more and more carrier frequencies into their band, and each carrier is required to contain more information per unit time than has been needed in the past. These considerations alone imply that FM receivers for telemetering purposes be capable of handling higher modulation frequencies than they have in the past and, at the same time, provide for isolation of the more closely spaced subcarriers. It is important that the modulated carriers in such systems be free of extraneous sidebands in order to minimize crosstalk between adjacent subcarriers. Hence, the transmitters used in these systems are apt to have a highly linear FM characteristic (frequency vs. voltage characteristic). In the world of FM signals for home entertainment too, the importance of FM linearity is stronger than ever, now that we are faced with the closely spaced (L+R) and (L—R) stereo channels.[1] The 202H and 202J FM signal generators are intended to assist engineers and technicians associated with the function and/or development of such communication systems.

In view of the above considerations,

YOU WILL FIND . . .

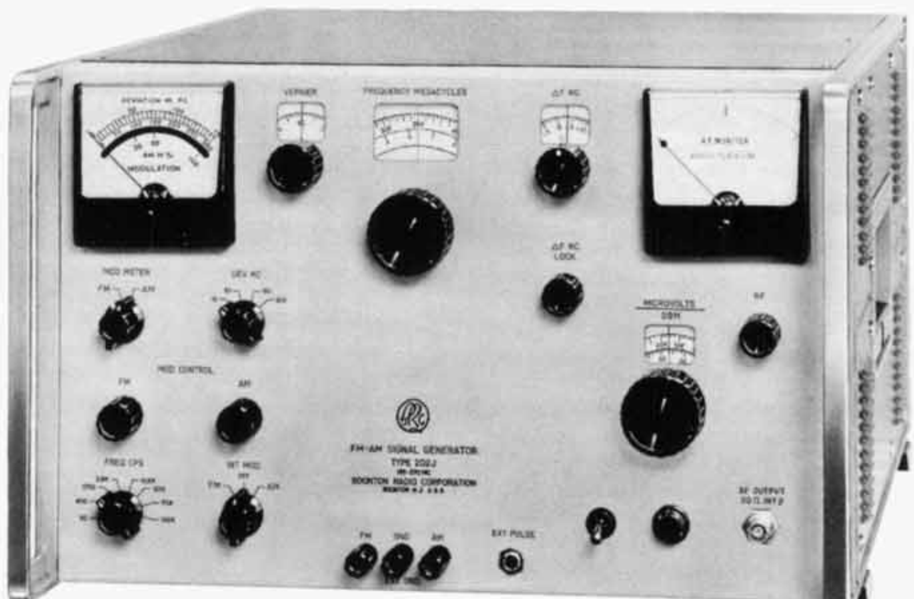


Figure 1. Type 202J Signal Generator

BRC decided to concentrate its design effort on obtaining a linear modulation characteristic. Readers familiar with the 202E and 202G, which these new instruments replace, are aware that these instruments have an exceptionally stable FM characteristic. Since the 202 line has been much admired for this characteristic by communications engineers for nearly fifteen years, it was decided to build on the same basic design rather than to embark on a new idea. Hence, the RF portion of the instrument, in block form, remains unchanged. Figures 2 and 3 show the 202H and 202J, respectively, in block form.

FM Linearity

By giving routine, but careful, attention to the oscillator and reactance tube circuits (described under design Considerations for the Oscillator and Modulator), a linearity of 1½% (equivalent to ¾% total harmonic distortion) at 150 kc deviation for the 202J was achieved. At 300 kc deviation, the FM linearity is 5%. The 202H FM characteristic yields a demodulated output with less than 1% THD at 75 kc deviation. At 100 Mc carrier and 75 kc deviation, the 202H introduces ½% THD.

All of the above numbers are specified limits, and typical performance is consistently better.

Electronic Vernier Tuning

A new system of electronic vernier tuning has been incorporated into both

THE BRC NOTEBOOK is published four times a year by the Boonton Radio Corporation. It is mailed free of charge to scientists, engineers and other interested persons in the communications and electronics fields. The contents may be reprinted only with written permission from the editor. Your comments and suggestions are welcome, and should be addressed to: Editor, THE BRC NOTEBOOK, Boonton Radio Corporation, Boonton, N. J.

the new 202H and 202J to permit relatively small calibrated changes in output frequency. This system operates by applying dc voltage to the grid of the reactance tube through a precision potentiometer. The total range of the control is ±40kc. The calibrated dial covers the range of ±30kc in 1kc increments and may be slipped against the potentiometer shaft by operating a dial lock mechanism. A jack is also provided for inserting external dc voltage for use in connection with an external X-Y plotter or frequency control system.

Microphonics and Vibration

Potentially, vibration and sound are two of the main sources of disturbance in low deviation measurements. Design of the 202H and J is aimed at alleviating this problem. Figure 4 shows the mounting of an RF unit in the 202J and H. The unit is supported by four vibration absorbing mounts. Bellows-type, flexible couplings isolate the shafts of the main tuning capacitor and of the attenuator's piston from the front panel. The net result is that the FM sensitivity of the 202H and J to acoustic or mechanical impulses, applied to the front panel or to the mounting hardware, is five times less than that of the 202E and G. Thus, the short-term frequency stability is much improved in all but the most quiet environments.

Automatic Level Set

The modern tubes used in the amplifier and doublers of the RF unit provide enough reserve RF power output to operate a level control circuit. The output meter remains within ±2% of the "red line" setting (for 0.2 volts maximum output) across the frequency band.

Power Supply

The new generators contain regulated dc power supplies (both plate and filament) for all tubes in the RF unit. As a result of these regulated supplies the residual FM at line frequency in the 202J is less than half as much as it is in the 202G.

In order that the entire instrument be contained in a single package without excessive heating of the RF unit by the power supplies, all active components of the power supplies are semiconductors.

There are three basic improvements in the 202H over the 202E supply.

1. The power supply and signal generator are contained in a single cabinet.
2. Both supplies are more stable (by a factor of 5), with respect to line voltage fluctuations, than are their counterparts in the 202E.
3. The 202H power supply contains neither a ballast tube nor a VR tube, both of which components are vulnerable.

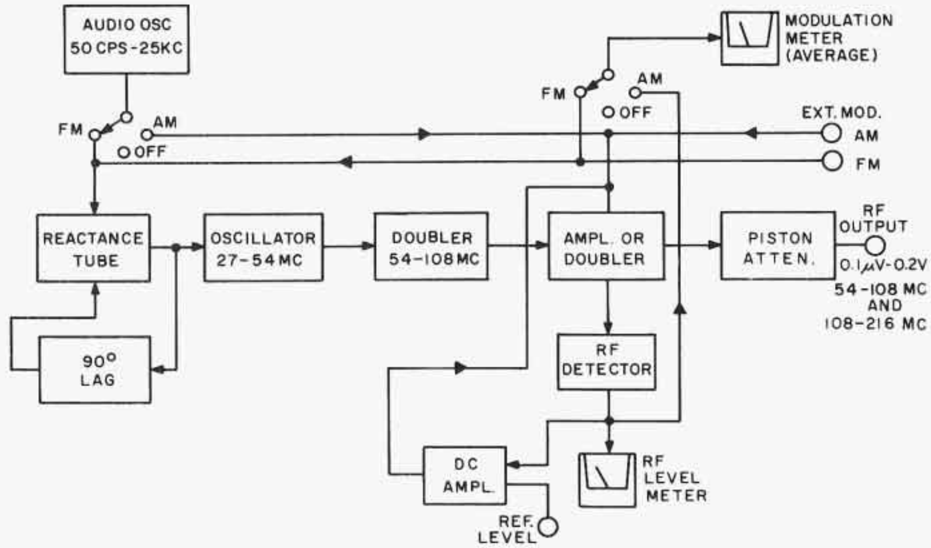


Figure 2. Block Diagram of Type 202H

FM Bandwidth of 202J

A need for wide bandwidth arises particularly in PCM telemetering systems. The maximum IRIG Telemetering standard bit rate is 330kc in the VHF band, and the receiver IF bandwidth requirement for this bit rate is about 500 kc. Hence, the bandwidth of an FM Signal Generator for checking a receiver's ability to handle such signals should be more than 500 kc. The 202J has a 1 mc FM bandwidth.

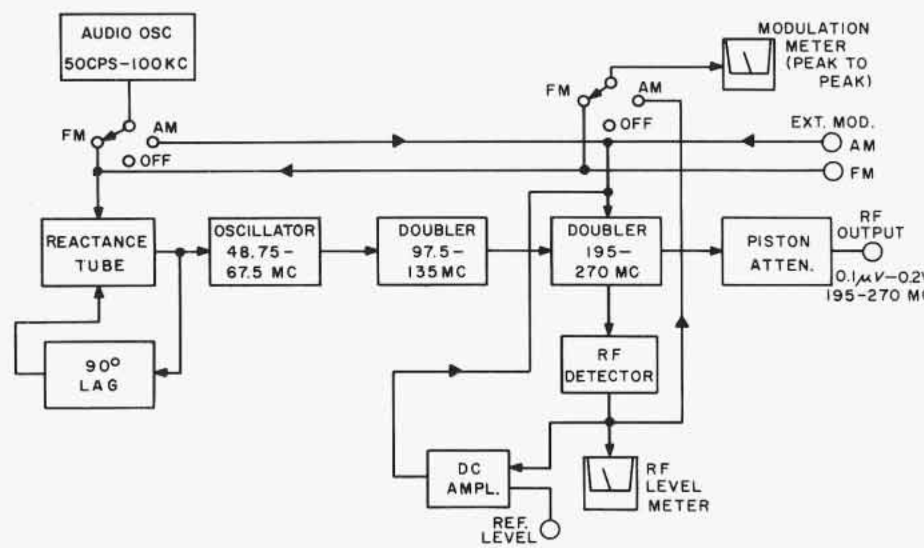


Figure 3. Block Diagram of Type 202J

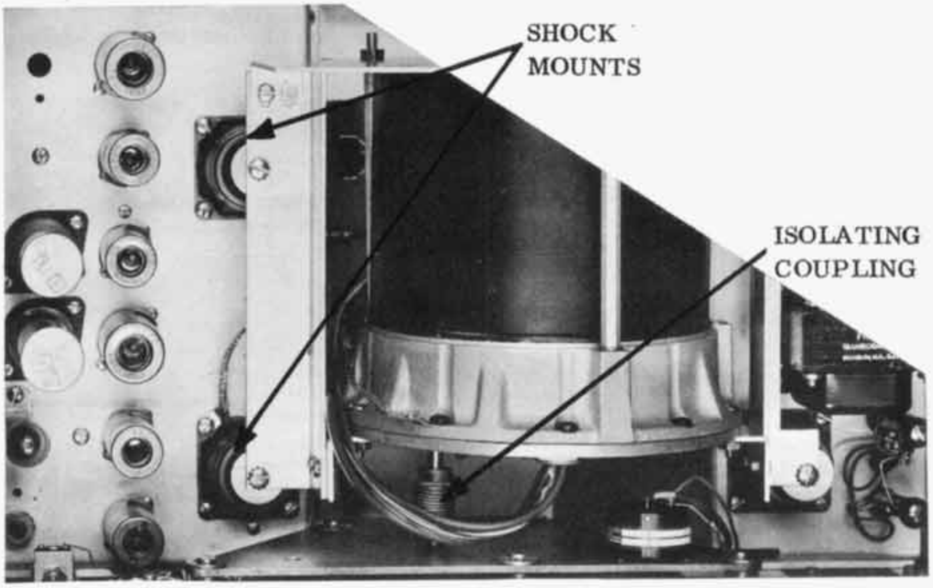


Figure 4. Type 202J — Top View

Peak Reading Modulation Meter Circuit for 202J

The modulation meter circuit is entirely new for the 202J. It reads the peak-to-peak deviation for all modulation waveforms which do not have important frequency components outside the pass band of 10 cps to 1 mc. The circuit consists of a two-stage, feedback amplifier, followed by a peak-to-peak voltmeter circuit.

The 202H has the same kind of averaging meter circuit as the 202E it replaces, with two exceptions: the diodes in the 202H meter circuit are more stable, and the dependence of the meter reading stability on diode stability has been reduced by amplifying the signals to be measured before metering them.

In order to ensure a net gain in overall meter accuracy, the amplifier has been heavily stabilized by negative feedback.

Design Considerations for the Oscillator and Modulator

The basic BRC 202 frequency modulator is now, as it always has been, a reactance tube with a bridged-T phase shift network. One of the merits of this type of network is that it allows relatively little variation of deviation sensitivity with carrier frequency. The small variation in FM sensitivity is diminished by ganging one of the passive elements in the phase shift network to the tuning capacitor in the oscillator. An analysis of the action of the bridged-T and other phase shift networks used with reactance tube frequency modulators has been given by M. Crosby and D. Hill.[2] Within this framework, the improved FM linearity in the 202H and J has been achieved with no loss of constancy of FM sensitivity or carrier frequency stability.

In the process of developing an FM oscillator, one must be sure that, at every frequency in the tuning band, the oscillator operates at a frequency fairly close to resonance of the LC circuit. If, at some frequency in the band, the oscillator departs from this frequency, then the impedance of the LC circuit contains an equivalent parallel reactance at that frequency. Of course, this kind of action does not prevent us from frequency modulating the oscillator, but it does result in rather violent changes in FM sensitivity at some points in the band.

Occasionally one finds a carrier frequency close enough to a point of discontinuity to be traversed in the modulation cycle. We still modulate the inductance of the LC circuit as planned, but the departure of operating frequency from resonance is now varying during the cycle. This is not the kind of behavior one would care to make allowances for. Therefore, great pains were taken to design the oscillator-reactance tube combintaion such that these effects were minimized. The oscillator was loaded as lightly as practicable by the phase shift network, for example.

In the interest of FM linearity, the oscillator level is rather low so that its phase shifted output cannot drive the reactance tube outside of its linear region.

Tube type 6688 was chosen for the reactance tube and doubler stages, primarily because of its high stability and high trans-conductance. It has the added merit of low input conductance in the VHF band.

New Packaging

Both of these new signal generators are packaged in a restyled cabinet which can be readily rack-mounted. The front panel RF output jack can also be readily installed in a mounting hole, provided in the rear cabinet panel, for rack-mounted applications. Convenient carrying handles are provided on the sides of the cabinet in addition to the standard rack handles integral with the side frame castings.

Specifications

The following specifications apply to both the Types 202J and 202H, unless otherwise indicated.

RADIO FREQUENCY CHARACTERISTICS

RF Range: 195-270 MC (202J) 54-216 MC (202H)
No. Bands: 1 (202J) 2 (202H)
Band Ranges: 195-270 MC (202J) 54-108 MC, 108-216 MC (202H)

RF Accuracy:
Main Dial: ±0.5%*
Electronic Vernier: ±(10% +1 KC)*
*after one hour warm-up

RF Calibration:
Main Dial: Increments of 0.5 MC (202J and 54-108 MC on 202H)
Increments of 1.0 MC (108-216 MC on 202H)
Mechanical Vernier: 2200 divisions through range (202J)
2300 divisions through range (202H)
Electronic Vernier: Increments of 1 KC over ±30 KC range*
*total range ±40 KC; provision for slipping dial to place "0" at a specific frequency

RF Stability:
0.02% per hour* (202J)
0.01% per hour* (202H)
*after two hour warm-up

RF Output:
Range: 0.1 μv to 0.2 volts*
*across external 50 ohm load at panel jack
Accuracy: ±10%, 0.1 μv to 50 K μv
±20%, 50 K μv to 0.2 volts
Auto Level Set: holds RF monitor meter to "red line" over band
Impedance: 50 ohms
VSWR: 1.2
Spurious Output: All spurious RF output voltages are at least 25 db below desired fundamental on 202J (30 db on 202H)

RF Leakage: Sufficiently low to permit measurements at 0.1 μv

AMPLITUDE MODULATION CHARACTERISTICS

AM Range:
Internal: 0-50%
External: 0-100%
AM Accuracy: ±10% at 30% and 50% AM
AM Calibration: 30, 50, 100%
AM Distortion: 5% at 30%
8% at 50%
20% at 100%
AM Fidelity: ±1 db, 30 cps to 200 KC

FREQUENCY MODULATION CHARACTERISTICS

FM Range:
Internal: 0-300 KC in 4 ranges (202J)
0-250 KC in 4 ranges (202H)
External: 0-300 KC in 4 ranges (202J)
0-250 KC in 4 ranges (202H)
FM Accuracy: ±5% of full-scale*
*indication proportional to peak-to-peak (202J) and sine-wave (202H) of modulating waveform

FM Calibration:

202J

0-15 KC in increments of 0.5 KC
0-30 KC in increments of 1 KC
0-150 KC in increments of 5 KC
0-300 KC in increments of 10 KC

202H

0-7.5 KC in increments of 0.5 KC
0-25 KC in increments of 1 KC
0-75 KC in increments of 5 KC
0-250 KC in increments of 10 KC

FM Non-Linearity*: 1.5% at 150 KC, 5% at 300 KC (202J)
*"least squares" departure from straight line passing through origin

FM Distortion: 0.5% at 75 KC (100 MC and 400 cps modulation only)
(202H) 1% at 75 KC (54-216 MC)
10% at 240 KC (54-216 MC)

FM Bandwidth: ±3 db, 3 cps to 1 MC (202J)

FM Fidelity: ±1 db, 5 cps to 500 KC (202J)
±1 db 5 cps to 200 KC (202H)

Spurious FM: Total RMS spurious FM from 60 cps power source is at least 60 db below 150 KC (202J)

Signal-to-noise Ratio: 60 db below 10 KC (202H)

Microphonism: Extremely low; shock-mounted RF unit

External FM Requirements: 1 volt RMS into 100K ohms for 150 KC deviation

PULSE MODULATION CHARACTERISTICS

PM Source: External
PM Rise Time: 0.25 μsec
PM Fall Time: 0.8 μsec

MODULATING OSCILLATOR CHARACTERISTICS

OSC Frequency:

202J		202H	
50 cps	10.5 KC	50 cps	7.5 KC
400 cps	30 KC	400 cps	10 KC
1730 cps	70 KC	1000 cps	15 KC
3900 cps	100 KC	3000 cps	25 KC

OSC Accuracy: ±5%
OSC Distortion: 0.5%
OSC External Output:
30 volts approx. at external FM posts
30 volts approx. at external AM posts

ACCESSORIES

Furnished: Type 502-B Patching Cable
Available: Type 207-G Univerter (202J)
Type 207-E Univerter (202H)
Type 501-B Output Cable
Type 504-A Adapter
Type 505-B Attenuator
Type 506-B Patching Cable
Type 507-B Adapter
Type 508-B Adapter
Type 509-B Attenuator
Type 510-B Attenuator
Type 514-B Output Cable
Type 517-B Output Cable

TUBE COMPLEMENT

Tubes	Transistors	Diodes	Zener Diodes
3—6688	1—2N1008	2—1N660	6—G31A-7H
1—6AF4	1—2N1136B	2—1N1763	1—G31H-56L
1—6AW8	1—2N1136	4—1N1764	1—G31G-7H
3—6AU6	2—2N1379	2—1N1581	2—G31A-12H
1—6BK7		1—S1029	1—G31G-47L
1—6AQ5			
1—12AU7			
1—6DJ8			

PHYSICAL CHARACTERISTICS

Mounting: Cabinet for bench use; readily adaptable for 19" rack mounting
Finish: Gray engraved panel; green cabinet (other finishes available on special order)
Dimensions: Height: 10⅜" Width: 16¾" Depth: 18⅜"
Weight: Net: 45 lbs.

POWER REQUIREMENTS

105-125/210-250 volts, 50-60 cps, 100 watts

References

1. John P. Van Duyne, "A Modulator for the New FM Stereo System," BRC Notebook Number 30.
2. M. G. Crosby and D. M. Hill, "Design of FM Signal Generator," Electronics, Nov., 1946, pages 96-101.

EXTERNAL OR "IN CIRCUIT" MEASUREMENTS ON THE UHF Q METER

CHARLES W. QUINN, *Sales Engineer*

Detailed information about the design and theory of operation of the UHF Q Meter Type 280-A is given in Notebook Number 27. Conventional applications are covered in detail in Notebook Number 28. An article concerning calibration of the instrument appears in Notebook Number 29. This article will deal specifically with the "unconventional" external or "in circuit" applications.

Basic Theory of Measurement

Briefly, the UHF Q Meter utilizes the bandwidth relationship $Q = \frac{f_o}{\triangle f}$ (for $Q \geqq 10$) to determine Q, as shown in Figure 1. A resonance indicating meter is used to determine the peak of the resonance curve and to resolve the half-power (.707V) points. This means that the UHF Q Meter reads Q in terms of frequency; the frequency being determined by the ability of the instrument to measure a *relative* amplitude change of 3db. The absolute value of V in Figure 1 is of no consequence and may

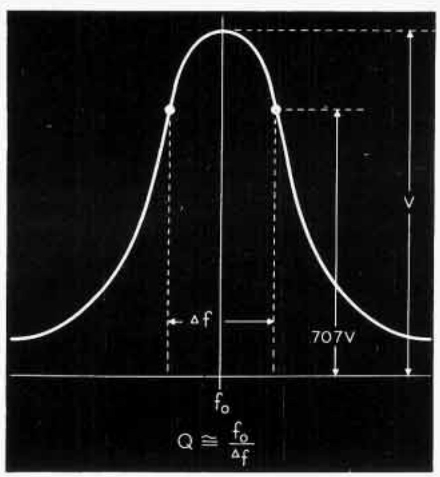


Figure 1. Q Resonance Curve

vary over a few decades (depending on the coupling of the probes and gain) without affecting the ability of the instrument to read *circuit Q.*

Type 580-A Probe Kit

In order to provide a convenient means of coupling into the external resonators or circuits, BRC has designed a probe kit (Type 580-A) which is suitable for many external measurements. The kit consists essentially of an injection probe and a detection probe, designed for coupling the external circuits to the output of the oscillator and the input to the chopper amplifier in the 280-A. For external measurements, the Q capacitor and associated coupling circuits in the UHF Q Meter are disconnected at the rear of the instrument and the injection and detection probes, furnished with the probe kit, are connected in their place. A basic block diagram of the UHF Q Meter, connected for external measurements, is shown in Figure 2.

Methods of Coupling to Test Circuits

Before discussing some of the techniques for "in circuit" measurements, it would be well to point out two basic requirements which should be met by the external circuit to be measured. First, the circuit must be resonant in the fre-

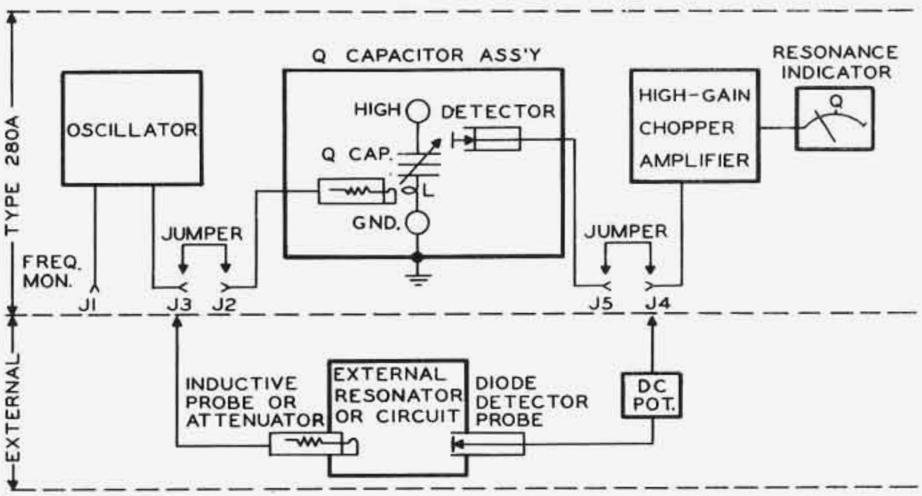


Figure 2. Block Diagram of UHF Q Meter Showing Connections For External Measurements

quency range of the 280-A (210 to 610 Mc). Secondly, the Q of the circuit must range from 10 to 25,000.

Figure 3A shows a typical amplifier configurtaion with a tuned coaxial resonator used as a plate load. This circuit may be measured using both the injection and detection probes in the Type 580-A Probe Kit, since it has access holes large enough for insertion of both probes. A preselector resonator could be similarly measured.

Figure 3B demonstrates another technique where an existing or "built in" loop is use for injection into the circuit to be measured and the 580-A detection probe is inserted into an access hole. In this case, care must be taken that the 280-A oscillator load does not exceed a 1.2 VSWR, referred to 50 ohms.

In Figure 3C the 580-A Probe Kit is not used. Existing or "built in" injection and detection circuits are connected directly to the 280-A oscillator and chopper amplifier circuits. When using this technique, the law of the detector used must be evaluated and taken into account. This may be accomplished by connecting a signal generator to the detector and using the variable attenuator in the signal generator to set up the 3db point on the 280-A resonance indicating meter. A precision 3db attenuator, connected in series with the signal generator, may be used for a more precise check of the detector.

Figure 3D illustrates still another technique for measuring an external circuit. The 280-A oscillator is connected to a tube input circuit, which may be "hot" or "cold", and the detection probe is connected at the output connector. This type connection is especially de-

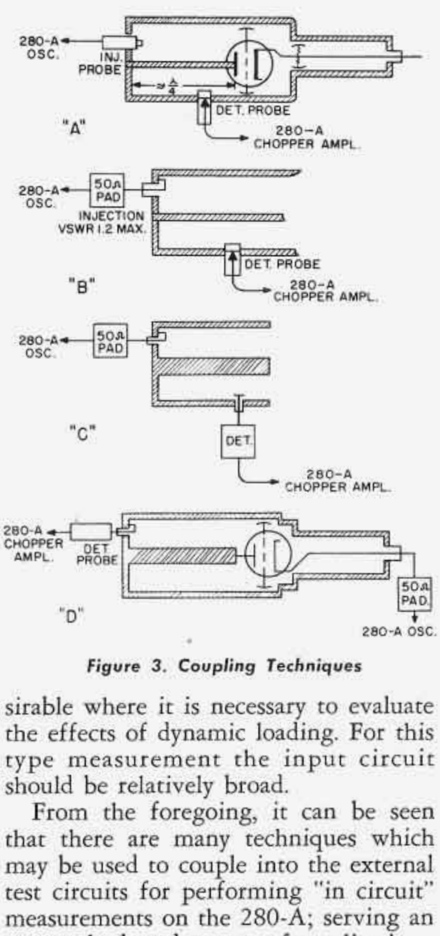


Figure 3. Coupling Techniques

sirable where it is necessary to evaluate the effects of dynamic loading. For this type measurement the input circuit should be relatively broad.

From the foregoing, it can be seen that there are many techniques which may be used to couple into the external test circuits for performing "in circuit" measurements on the 280-A; serving an extremely broad range of applications.

Resonator Measurements

The configurations of resonators in the frequency range of the 280-A are varied. A few of these configurations are shown in Figure 4. When performing resonator measurements it should be remembered that the resonators should be coupled to the 280-A at points which provide optimum coupling, wtih minimum loading by the 280-A. Basically, magnetic coupling is optimum at the Voltage Node point, or point of maximum current; i.e., the low Z point. Detection is optimum at the Current Node point or the point of maximum voltage; i.e., the high Z point (Figure 4).

Test Circuit Loading

Minimum loading is accomplished with the detector coupled as "loosely" as practical. The injection circuit, on the other hand, may be coupled much "tighter" without loading. The extent of loading can be evaluated by making a series of Q measurements at different sensitivity levels and probe spacings. Higher Q readings are indicative of negligible loading. The measurement should, therefore, be made at the minimum sensitivity level at which negligible loading occurs.

Extension of L Range

It is interesting to note that external measurements permit the inductance range of the 280-A to be extended beyond the specified 2.5 to 146 mμh range of the internal resonating capacitor. Referring to Figure 4G, if C were known, and could be adjusted to a value less than 4 pf (the minimum capacitance of the 280-A Q capacitor), the inductance range of the instrument could be extended to as much as 2 μh. This may be accomplished using a high quality, small variable capacitor with a range of approximately 0.2 to 3 pf and a Q of 200 or more. The 580-A probes are connected as shown in Figure 2 for external measurements. Either of the following techniques may then be used. The capacitance required to resonate the inductor could be estimated and the variable capacitor set for this value, using the calibrated Q capacitor. C_1 and Q_1 would then be measured. Then, with the coil and capacitor placed approximately as shown in Figure 4G, the resonant frequency and circuit Q (Q_c) would be determined. The inductance of the coil would then be computed for the measurement frequency using the following equations:

$$L = \frac{1}{\omega^2 C_1} \qquad Q = \frac{Q_1 Q_c}{Q_1 - Q_c}.$$

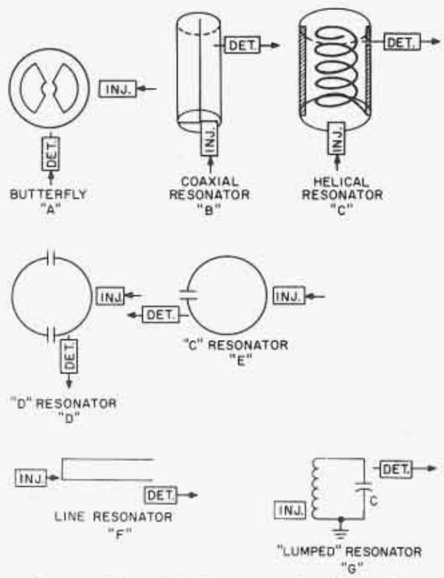


Figure 4. Typical Resonator Configurations

Another technique for extending the inductance range of the 280-A involves adjusting the variable capacitor until the desired resonant frequency is indicated by the 280-A. Circuit Q (Q_c) is then measured. The variable capacitance (C) and Q are then measured on the 280-A and the above equations are used to determine L and Q.

Test Circuit Shielding

When small or unshielded resonators are to be measured, it is often desirable to make use of shielding to minimize "hand capacitance" and radiation effects. This shielding may be in the form of a "work box" with built in supports for the 580-A probes, as shown in Figure 5. A setup of this type would be useful for evaluating the inductor mentioned in the previous paragraph.

External Resonators as Jigs and Fixtures

Resonators, in various forms, have applications in many fields. The "D" resonator (Figure 4D), because of its peculiar magnetic field, is used in the investigation of molecular resonances in the field of basic research to improve our understanding of materials. "C" type resonators could be used for the measurement of dielectrics where the specimen is inserted into the gap that forms the resonating capacitance. Helical resonators are used to investigate the effects of ionization of gases in the ion propulsion field. The helical resonator will also be useful in the evaluation of micro-

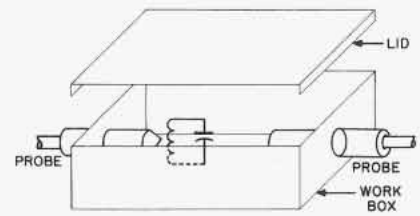


Figure 5. "Work Box" used as Shield for Resonator Measurements

wave varactors, diodes, and other semiconductors, where capacitance values are low and Q values are high.

The reentrant cavity or coaxial resonator is probably one of the most versatile resonators, since its performance can be readily calculated. It can serve as a fixture for evaluating dielectrics (Figure 6A) or magnetics (Figure 6B) in the frequency range of the 280-A (210 to 610 Mc).

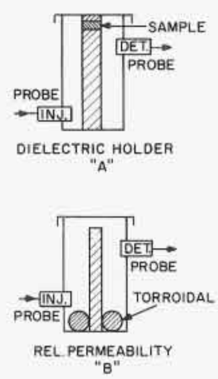


Figure 6.

Measurements Under Simulated Environmental Conditions

The coaxial and other type resonators may be used with the 580-A Probe Kit to provide thermal isolation between the specimen and the instrument. This would be of special interest to research and development people involved with temperature measurements.

Extension Probes for Small or Limited Access Resonators

The 580-A Probe Kit utilizes a telescoping sleeve principle. The outside diameter of the inner sleeve is 0.430 inch. The outside diameter of the outer sleeve is 0.500 inch. These diameters may be too large for some special applications, either because of the physical size or the effect this size would have on the circuit under test. For high Q circuits (100 or more), this situation can be remedied by fabricating extensions for the probes, similar to the samples shown in Figure 7A. This would permit measurements where the diameter of the access holes would be limited only by the diameter of the coaxial cable used.

Note that the length of these probe extensions must be such that their resonant frequency is well above the resonant frequency of the resonator being measured. Resonance of the probes may be checked by bringing them close to each other, with the external resonator removed, and sweeping the frequency through the point of measurement. If the probe extensions are functioning properly, no sharp slope in output indications should be observed.

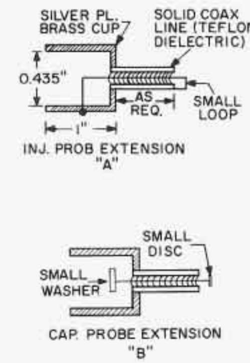


Figure 7. Examples of Probe Extensions

Conclusion

An attempt has been made here to point up some of the techniques which could be used for performing external measurements of circuits and resonators with the Type 280-A UHF Q Meter. Doubtless there are many applications which have not been touched upon or that should be expanded upon. It is our intension to delve more into dielectric measurements, low and high temperature techniques, semi-conductor measurements, and magnetics, in future Notebook articles. In the meantime, we here at BRC would appreciate hearing from any of our customers who have measurement problems in this area or who have evolved new measurement techniques which could be applied to this versatile instrument.

■ ■ ■ ■

■ ■

SERVICE NOTE

Modification of Type 250-A for Reduced Signal Level and Increased Sensitivity

Reducing Signal Level

An improved method has been devised for reducing the signal level at the terminals of the Type 250-A RX Meter for special applications where a low signal level is required. In the past, the signal level was lowered by inserting a 100K ohm potentiometer in the signal oscillator plate supply, as described on pages 16 through 18 of the 250-A instruction manual. This provided a means for varying the oscillator plate voltage, thus reducing the signal oscillator output level. This system works satisfactorily for the most part, but occasionally a plate voltage will be selected which will "shut-off" the oscillator.

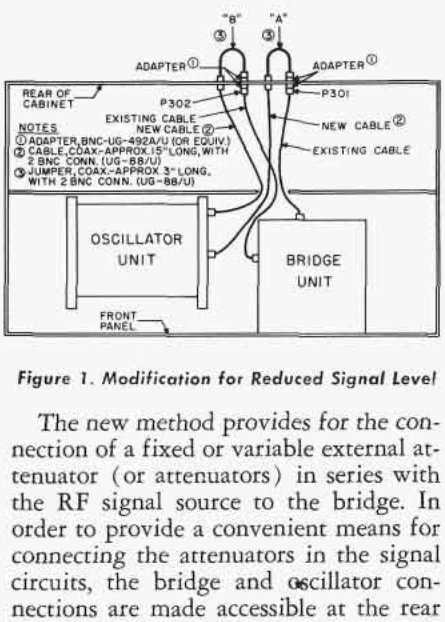


Figure 1. Modification for Reduced Signal Level

The new method provides for the connection of a fixed or variable external attenuator (or attenuators) in series with the RF signal source to the bridge. In order to provide a convenient means for connecting the attenuators in the signal circuits, the bridge and oscillator connections are made accessible at the rear of the instrument cabinet. These connections are jumpered for normal operation. For special applications, the jumpers are removed and replaced with fixed or variable attenuators. In most cases, the attenuator is connected in place of jumper "A" (Figure 1). In some instances, because of mixing in the test component, it would be desirable to attenuate both signals.

The modification, together with a list of the parts required, is shown in Figure 1.

Increasing Sensitivity

When the signal level to the bridge is reduced for special applications, as described above, increased detector sensitivity is often desirable. The sensitivity of the 250-A may be significantly increased by modifying the instrument as shown in Figure 2.[1] The signal from IF amplifier V202 (6AG5) is connected to a jack at the rear of the 250-A cabinet. A VTVM, connected to this jack, amplifies the signal and serves as a null indicator which has improved sensitivity over the null indicator on the front panel of the 250-A. This improves the resolution of the C_p and R_p dials and also results in improved resolution of the R_p or X_p parameter which is occasionally the minor impedance in a measurement. (Minor impedance is defined as that impedance which contributes least to the amplitude and phase of the current in an RF circuit.)

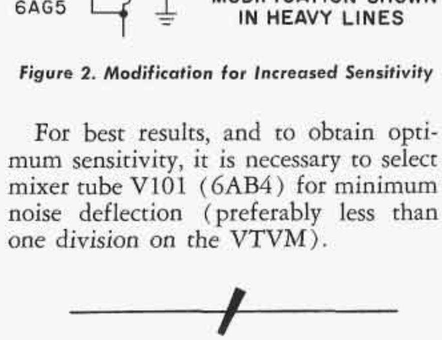


Figure 2. Modification for Increased Sensitivity

For best results, and to obtain optimum sensitivity, it is necessary to select mixer tube V101 (6AB4) for minimum noise deflection (preferably less than one division on the VTVM).

[1]This modification was suggested by H. Thanos of R.C.A., Somerville, N. J.

BRC DEDICATES NEW PLANT

Friday, October 20, 1961 was a perfect day for the dedication of the new BRC plant. Nestled in the Rockaway Valley, against a backdrop of high hills ablaze with autumn-painted trees, the new plant was the center of scenic splendor.

On hand for the dedication ceremony were BRC employees; friends and business associates of BRC; members of the local, county, and state government; and executives from the Hewlett-Packard (BRC's parent company) family.

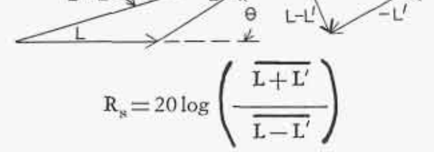
The dedication ceremony was presided over by Dr. George Downsbrough. President of BRC. Guest speaker was Mr. David Packard, President of Hewlett-Packard. Mr. A. R. Post, Chief, Bureau of Commerce for the State of New Jersey, delivered a message of congratulations from the Governor of New Jersey.

A "ribbon-cutting" ceremony was held at the main entrance to the new plant, with cutting honors going to Mr. John Vandermark, Mayor of Rockaway Township.

Mr. John Vandermark, Mayor of Rockaway Township, N. J., cuts ribbon to officially open the new BRC plant as Dr. George A. Downsbrough and Mr. David Packard look on.

CORRECTION

The vector diagram and accompanying equation in Figure 2 of the article entitled, "A Modulator for the New FM Stereo System," published in Notebook Number 30, are not correct. The correct diagram and equation are given below.



$$R_s = 20 \log \left(\frac{\overline{L+L'}}{\overline{L-L'}} \right)$$

EDITOR'S NOTE

BRC to Show Four New Instruments at IRE

(VISIT BOOTHS 3101-3102)

This year, at the IRE show, BRC will show four new instruments: the new Types 202-H and 202-J FM-AM Signal Generators, the new Type 230-A Signal Generator Power Amplifier, and the new Type 219-A FM Stereo Modulator.

The Type 202-H signal generator covers the frequency range of 54 to 216 Mc and replaces the Type 202-E. The 202-J blankets the 195 to 270 Mc telemetering range and replaces the 202-G. Improvements in these instruments include: improved FM linearity, automatic RF level set, electronic vernier tuning, increased FM modulation bandwidth, improved FM deviation metering, reduced FM microphonism, a completely solid-state power supply, and a completely redesigned cabinet.

The 230-A Signal Generator Power Amplifier provides a means of increasing the RF power output of conventional signal generators up to 4 watts or +6 dbw (14 volts rms into 50 ohms), in the frequency range of 10 to 500 Mc.

The 219-A FM Stereo Modulator provides the stereo modulation outputs, as specified in FCC Docket 13506, suitable for modulating FM signal generators, such as the BRC Type 202-E or 202-H.

A "Guess the Q" contest, which seems to have become traditional with BRC, will be a feature at the BRC booth again this year. Our engineers have been hard at work devising a "guess-defying" Q circuit that should be a delight and a challenge to booth visitors.

Visit booths numbers 3101 and 3102. See and hear more about our new instruments, and have the BRC engineers on duty help you with your test instrument application problems.

Photograph taken at a previous IRE show demonstrates that the BRC "mystery coils" put all of the Q contest entrants in a pensive mood.

Engineering Representatives

ALBUQUERQUE, New Mexico
NEELY ENTERPRISES
6501 Lomas Blvd., N.E.
Telephone: 255-5586
TWX: AQ-172

ATLANTA, Georgia
BIVINS & CALDWELL, INC.
3110 Maple Drive, N.E.
Tel. Atlanta, Georgia 233-1141
TWX: AT 987

BINGHAMTON, New York
E. A. OSSMANN & ASSOC., INC.
149 Front Street
Vestal, New York
Telephone: STillwell 5-0296
TWX: ENDICOTT NY 84

BOONTON, New Jersey
BOONTON RADIO CORPORATION
P.O. Box 390
Telephone: OAkwood 7-6400
TWX: ROCKAWAY NJ 866

BOSTON, Massachusetts
INSTRUMENT ASSOCIATES
30 Park Avenue
Arlington, Mass.
Telephone: MIssion 8-2922
TWX: ARL MASS 253

CHICAGO 45, Illinois
CROSSLEY ASSOC., INC.
2501 W. Peterson Ave.
Telephone: BRoadway 5-1600
TWX: CG508

CLEVELAND 24, Ohio
S. STERLING COMPANY
5827 Mayfield Road
Telephone: HIllcrest 2-8080
TWX: CV 372

DALLAS 9, Texas
EARL LIPSCOMB ASSOCIATES
3605 Inwood Road
Telephone: FLeetwood 7-1881
TWX: DL 411

DAYTON 19, Ohio
CROSSLEY ASSOC., INC.
2801 Far Hills Avenue
Telephone: AXminster 9-3594
TWX: DY 306

DENVER 10, Colorado
LAHANA & COMPANY
1886 South Broadway
Telephone: PEarl 3-3791
TWX: DN 676

DETROIT 35, Michigan
S. STERLING COMPANY
15310 W. McNichols Rd.
Telephone: BRoadway 3-2900
TWX: DE 1141

EL PASO, Texas
EARL LIPSCOMB ASSOCIATES
720 North Stanton Street
Telephone: KEystone 2-7281

HARTFORD, Connecticut
INSTRUMENT ASSOCIATES
734 Asylum Avenue
Telephone: CHapel 6-5686
TWX: HF 266

HIGH POINT, North Carolina
BIVINS & CALDWELL, INC.
1923 North Main Street
Telephone: High Point 882-6873
TWX: HIGH POINT NC 454

HOUSTON 5, Texas
EARL LIPSCOMB ASSOCIATES
3825 Richmond Avenue
Telephone: MOhawk 7-2407
TWX: HO 967

HUNTSVILLE, Alabama
BIVINS & CALDWELL, INC.
Telephone: 534-5733
(Direct line to Atlanta)

INDIANAPOLIS 5, Indiana
CROSSLEY ASSOC., INC.
3919 Meadows Drive
Telephone: LIberty 6-4891
TWX: IP 545

LAS CRUCES, New Mexico
NEELY ENTERPRISES
114 South Water Street
Telephone: 526-2486
TWX: LAS CRUCES NM 5851

LOS ANGELES, California
NEELY ENTERPRISES
3939 Lankershim Blvd.
North Hollywood, California
Telephone: TRiangle 7-1282
TWX: N-HOL 7133

ORLANDO, Florida
BIVINS & CALDWELL, INC.
P.O. Box 6941
601 N. Fern Creek Drive
Telephone: CHerry 1-1091
TWX: OR 7026

OTTAWA 4, Ontario, Canada
BAYLY ENGINEERING, LTD.
80 Argyle Ave.
Telephone: CEntral 2-9821

PHOENIX, Arizona
NEELY ENTERPRISES
641 East Missouri Avenue
Telephone: CRestwood 4-5431
TWX: PX 483

PITTSBURGH 27, Pennsylvania
S. STERLING COMPANY
4232 Brownsville Road
Telephone: TUxedo 4-5515

PORTLAND 9, Oregon
ARVA, INC.
1238 N.W. Glisen Street
Telephone: CApital 2-7337

RICHMOND 30, Virginia
BIVINS & CALDWELL, INC.
1219 High Point Avenue
Telephone: ELgin 5-7931
TWX: RH 586

ROCHESTER 25, New York
E. A. OSSMANN & ASSOC., INC.
830 Linden Avenue
Telephone: LUdlow 6-4940
TWX: RO 189

SACRAMENTO, California
NEELY ENTERPRISES
1317 Fifteenth Street
Telephone: GIlbert 2-8901
TWX: SC 124

SALT LAKE CITY 15, Utah
LAHANA & COMPANY
1482 Major Street
Telephone: HUnter 6-8166
TWX: SU 586

SAN DIEGO, California
NEELY ENTERPRISES
1055 Shafter Street
Telephone: ACademy 3-8103
TWX: SD 6315

SAN FRANCISCO, California
NEELY ENTERPRISES
501 Laurel Street
San Carlos, California
Telephone: LYtell 1-2626
TWX: S CAR-BEL 94

SEATTLE 9, Washington
ARVA, INC.
1320 Prospect Street
Telephone: MAin 2-0177

SPOKANE 10, Washington
ARVA, INC.
East 127 Augusta Avenue
Telephone: FAirfax 5-2557

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

SYRACUSE, New York
E. A. OSSMAN & ASSOCIATES, INC.
P. O. Box 128
101 Pickard Drive
Telephone: GLenview 4-2462
TWX: SS 355

TORONTO, Ontario, Canada
BAYLY ENGINEERING, LTD.
Hunt Street, Ajax, Ontario, Canada
Telephone: Ajax, WHitehall 2-1020
(Toronto) 925-2126

TUSCON, Arizona
NEELY ENTERPRISES
232 South Tuscon Blvd.
Telephone: MAin 3-2564
TWX: TS 5981

VANCOUVER 9, B. C. Canada
ARVA, INC.
1624 West 3rd Avenue
Telephone: REgent 6-6377

BOONTON RADIO CORPORATION

Printed in U.S.A.