January 9, 1959

Mr. W. F. Goetter, Chairman IRE Subcommittee 27.4
Industrial Electronics Division
Technical Products Department
General Electric
Syracuse, New York

Dear Mr. Goetter:

Enclosed please find two (2) copies of a proposed standard for the measurement of transmitter cabinet radiation, which you recall I had agreed to write for our next meeting Jan.16, 1959.

I hope you find time to read this before our next meeting.

Very truly yours,

V. J. Mancino

1959

IRE 27.4 PROPOSED STANDARDS ON METHODS OF MEASUREMENT OF TRANSMITTER CABINET AND EXTERNAL WIRING RADIATION

6. Spurious Output due to Transmitter Cabinet and External Wiring Radiation.

6.1 General. The Spurious Output radiated from a transmitter which may consist of harmonic (or sub-harmonic) components may be measured by measuring the voltage induced in a receiving antenna with the use of a calibrated frequency-selective voltmeter or receiver.

6.2 Equipment required:

6.2.1 Pickup Device The radiated spurious output should be measured with a pickup device which is connected to a calibrated frequency-selective voltmeter or receiver by a matching impedance network or balum. This pickup device may be a rod or loop for frequencies below 25MC, a resonant dipole for frequencies from 25MC to 1000MC, and a horn antenna for frequencies above 1000MC. The pickup device must be calibrated over its useful frequency range so that it may be used to read open circuit voltage (antenna induced voltage.)

6.2.2 Interference-Free Area. The radiated spurious output shall be measured in an area sufficiently free from ambient interference and physical obstructions. It is desireable that the ambient interference level during testing be at least 6 db below the interference limits specified in the appropriate specifications. However, in the event that at the time of measurement the levels of ambient interference plus the interference of the item under test are not above the specified limit, such tested item shall be considered to comply with the specified requirements. In addition any frequency whose identify is definitely established such as a broadcast station is exempt from this requirement.

6.2.3 Variable Attenuator. A calibrated variable attenuator is needed to provide a means for adjusting the output indication level of the measuring instrument so as not to overload the frequency selective voltmeter or receiver. It may also be useful in checking for spurious responses.

6.2.4 Frequency-selective voltmeter or receiver. A frequency-selective voltmeter or receiver (may be more than one) which can tune to the carrier and any spurious output frequency of interest, is needed. If a receiver is used, it must have an output indicator. The receiver cabinet should incorporate good shielding techniques and the power lines should be well filtered.

6.2.5 Coaxial switches. Coaxial switches (or suitable means for changing connections) may be required to substitute the calibrated signal generator for the transmitter during calibration.

6.2.6 Measuring Equipment Enclosure. To prevent pickup of extraneous radiations during the measurements, the measuring equipment should (if necessary) be enclosed within a suitable shielded enclosure and the signal from the pickup device brought into the shielded enclosure through a well-shielded cable.

6.2.7 Calibrated Signal Generator. A calibrated signal generator (or generators) to cover the carrier frequency and any spurious frequencies of interest is needed.

6.2.8 Isolation pads, if needed.

6.3 Procedure

6.3.1 General

6.3.1.1 Distance of Pickup Device from Equipment Under Test. The distance between the pickup device and the equipment under test shall be as specified in the individual specification.

6.3.1.2 Measuring Instruments. The instruments used to perform the measurements shall be capable of peak and RMS Carrier measurements.

6.3.1.3 Broadband Interference Measurement. Broadband interference shall be measured by using an impulse generator with the substitution technique, or by calibrating the interference measuring instrument so that it reads directly in decibels above one microvolt per unit bandwidth. The peak detector function on the interference measuring instruments shall be used for broadband and pulsed cw measurements.

6.3.1.4 CW Interference Measurements. CW interference shall be measured by calibrating the interference measuring instrument so that it reads directly in decibels above one microvolt or by using a signal generator with a substitution technique.

6.3.1.5 Pulsed CW Interference Measurements. Pulsed cw shall be measured in accordance with the procedures used for broadband interference.

6.3.1.6 Bonding Measuring Instrument. Interference measuring instruments utilizing dipole antennas shall be bonded to the ground plane or shielded enclosure with the group clip on the power cord.

6.3.1.6.1 The counterpoise on rod antennas shall be bonded to the group plane with a strap of such length that the rod antenna can be positioned correctly. The strap shall be as wide as the counterpoise. This applies to rod antennas utilizing the interference measuring instrument as a counterpoise, and to rod antennas mounted on a separate counterpoise.

6.3.1.6.2 The interference measuring instruments shall be physically grounded with only one connection. If the copper strap is used, neither the ground clip, the ground terminals, nor the power supply shall be connected to ground.

6.3.1.7 Monitoring. The interference measuring instrument shall be monitored with a headset, loudspeaker, oscilloscope, or other indicating devices, during all measurements. Precaution shall be taken to insure that the monitoring does not influence the meter reading on the interference measuring equipment.

6.3.1.8 Test Frequencies. The interference measuring instrument shall be slowly tuned through each frequency octave and the frequencies at which maximum interference is obtained shall be selected as test frequencies. Test frequencies shall not be selected (prior to the interference test.) A minimum of three measurements shall be made in each frequency octave.

6.3.1.9 Arrangement. The general arrangement of equipment, interconnecting cable assemblies, and supporting structures shall be such as to simulate an actual installation insofar as practicable. Shielded leads or cables shall be used only where they will be so used in actual practice, except that shielded dummy antennas shall be used for receivers and transmitters.

6.3.1.10 Ground plane. A copper or brass ground plane, 0.01 inch thick minimum for copper, 0.025 inch thick minimum for brass, 12-square feet or more in area with a minimum width of 30 inches, shall be used in all cases where a shielded room is employed. The ground plane shall be bonded to the shielded room at intervals no greater than 3 feet and at both ends of the ground plane. For large equipment systems normally mounted on a metal test stand, the test stand may be considered part of the ground plane and bonded accordingly. When a shielded room is not used, the test sample may be placed on a solid support for operation. The support may be solid earth, steel, or iron flooring, metal bedplate, metal sheet-covered planking, or the like.

6.3.1.11 Bonding. Only the provisions included in the design of the equipment and specified in the installation directions shall be used to bond units, such as equipment case and mount, together. Where bonding straps are required to complete the test setup, as from support to screen room or mount to ground plane, the straps shall have a width-to-length ratio of 1 to 5, or greater, shall have a minimum thickness of 0.025 inches and shall be copper or brass metal straps, not braid. Such bond straps shall be attached by clean metal-to-metal contact.

6.3.1.12 Dummy Antennas. Any dummy antenna used shall have electrical characteristics which closely simulate those of the normal antenna, and should be shielded where possible. The dummy antenna shall be capable of handling the power required and shall contain any unusual components which are used in the

antenna (such as filters, crystal diodes, etc.). When the nominal antenna impedance is 50 ohms, a 50-ohm (±20 percent from 0.15-1000mc) dunny antenna shall be used.

6.3.1.13 Loads. The equipment under test shall be loaded with the full mechanical and electrical load, or equivalent, for which it is designed. This requirement specifically includes electrical loading of the contacts of mechanisms which are designed to control electrical loads even though such loads are physically separate from the equipment under test. Operation of voltage regulators and other circuits which operate intermittently is required. The loads used shall simulate the resistance, inductance, and capacitance of the actual load.

6.3.1.14 Antenna Orientation and Positioning in Shielded Enclosures. Those interference measuring instruments which use a rod antenna shall be so placed that the rod antenna is in a vertical position and the instrument panel or counterpoise is 6 inches below the level of the ground plane. The rod antenna shall be located at the point where maximum interference or susceptibility indications are obtained when it is moved along a line parallel with the edge of the ground plane. Those interference measuring instruments which use a resonant dipole antenna shall have the dipole positioned parallel with the front edge of the ground plane. Its height shall be 12 inches ± 1 inch above the level of the ground plane and its center shall be adjacent to the geometrical center of the units under test. The rod or the dipole antenna shall be located at the specified distance from the test sample. When the dimensions of the dipole or directive antenna become smaller than the test layout, the antenna shall be moved parallel to the edge of the ground plane to keep its sensitive elements adjacent to the point of maximum leakage or susceptibility. At frequencies from 25 up to and including 35 megacycles, the

measurements shall be taken with the dipole antenna adjusted to 35mc. The dipole antenna shall be adjusted to the proper length at all frequencies above 35mc.

6.3.1.15 Antenna Orientation and Positioning (Free Space). Those interference measuring instruments which use a rod antenna shall be so placed that the rod antenna is in a vertical position. Those interference measuring instruments which use a dipole antenna shall be so placed that the antenna is parallel with the test sample and on the same level as the midpoint of the test sample. The antenna shall be at the specified distance from the test sample. The antenna shall be located at a point around the perimeter of the test sample where maximum interference signal is received.

6.3.2 Standard Method. NOTE: The standard method is used when it is desired to obtain the absolute level of the radiated spurious response signal, without regard to the rated power output of the equipment under test. If the desired result is to be a measurement of the absolute field intensity one must make the measurement in the far field (at least two wave lengths away); this need not be followed, however, if one is measuring the absolute antenna induced voltage.

1. Connect the equipment as shown in Figure 1.
2. Operate the transmitter under test in its intended manner with its output connected to a dummy load.
3. Tune the frequency-selective voltmeter or receiver through the frequency range of interest with the variable attenuator adjusted for maximum sensitivity of the measuring circuit. When a spurious output is found, adjust the attenuator to obtain a suitable reference reading on the on the output indicator.

   CAUTION: In all frequency-selective voltmeters or receivers spurious responses may occur by:(1) desensitization of the receiver by the entry of a strong off-channel signal through the antenna input. (2) By the entry of a strong on-channel signal through the receiver case or power lines and by-passing its calibrated input attenuator. These responses must be known or determined for the particular device used.

In addition care must be taken to insure that the spurious signal being measured can be actually attributed to the equipment under test. This is easily determined by momentarily turning off the equipment under test.

4. If the frequency-selective voltmeter or receiver is of the type that can be calibrated internally, then calibrate it according to the recommended manufacturer's procedure and measure the spurious radiated signal.

5. If the substitution method is used then substitute the calibrated signal generator for the transmitter, adjust its output frequency to the spurious frequency, and operate it at a power output level which will enable the reference level of (3) to be obtained with variation of the variable attenuator.

6. The interference level in terms of open circuit antenna voltage is calculated as follows:

(a) CW Interference

Interference Level (antenna induced, DB above 1uV) = meter reading (or substituted signal generator reading) + cable loss + antenna factor.

(b) Broadband Interference

Interference Level (antenna induced, DB above 1 uV per MC) =

$$\frac{\text{meter reading(or substituted signal generator)+ cable loss + antenna factor}}{\text{impulse bandwidth}}$$

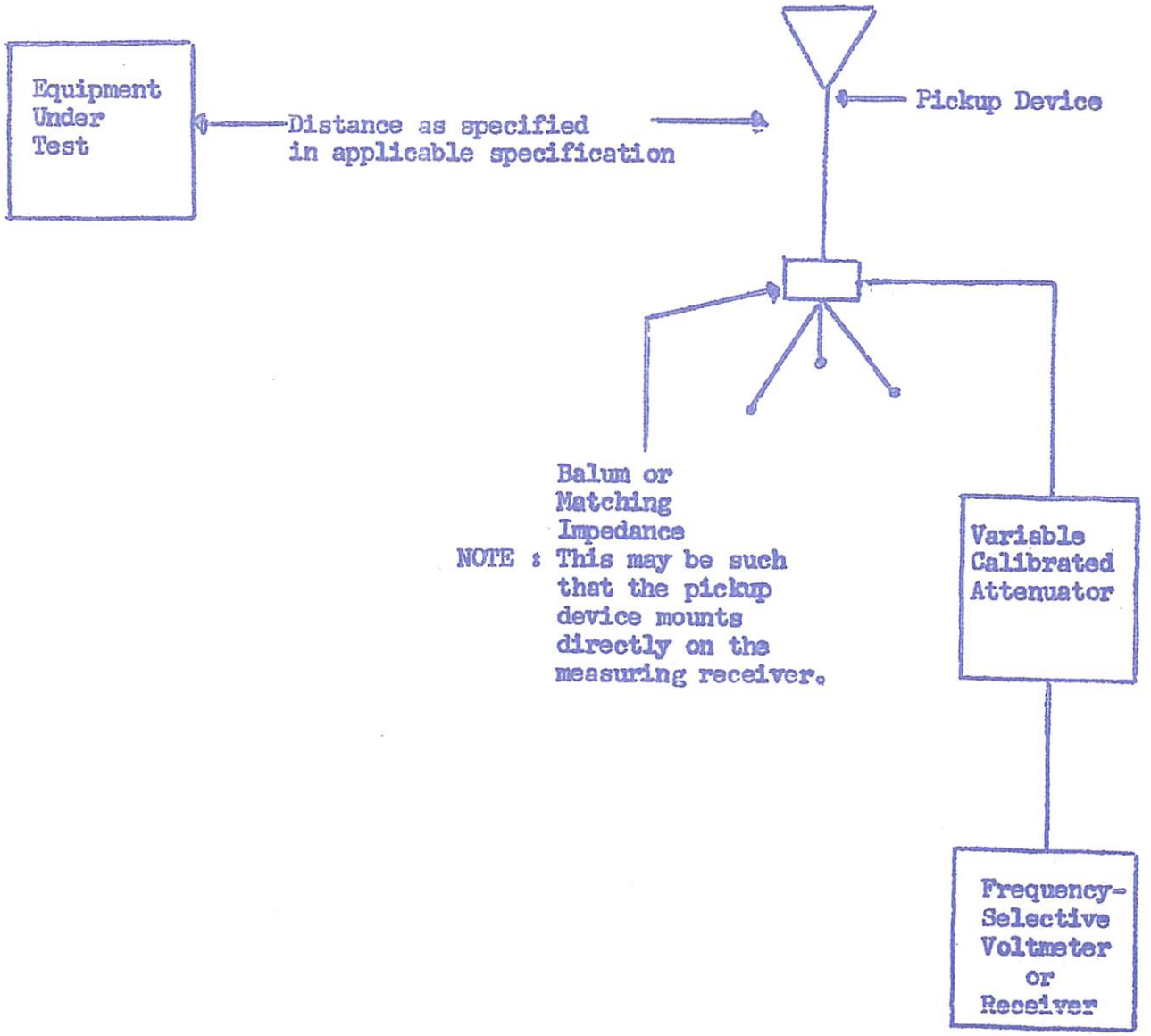
Equipment Under Test
Distance as specified in applicable specification
Pickup Device
Balum or Matching Impedance
NOTE : This may be such that the pickup device mounts directly on the measuring receiver.
Variable Calibrated Attenuator
Frequency-Selective Voltmeter or Receiver

FIGURE 1.

6.3.3 Alternate Method. NOTE: The alternate method is used when it is desired to obtain the radiated power of the spurious signal with respect to the rated power of the equipment under test.

1. Connect the equipment as shown in Figure 2. It should be noted that the points of measurement must be a distance of at least 10 wavelengths from the transmitter so that only the distant or radiation field is encountered by the measuring receiver.
2. Operate the transmitter under test in its intended manner with its output connected to a dummy load.
3. At a remote point tune the frequency-selective voltmeter or receiver through the frequency range of interest with the variable attenuator adjusted for maximum sensitivity of the measuring circuit. When a spurious output is found, adjust the attenuator to obtain a suitable reference reading on the output indicator.
4. The pickup device is rotated for maximum signal into the receiver and a reading is obtained.
5. De-energize the transmitter.
6. An RF signal generator or other suitable source of controlled oscillation is now used in conjunction with a dipole antenna to supply the substituted power. This equipment is located in the near vicinity of the transmitter. In particular, the dipole antenna is located at a distance no greater than 3 feet from the transmitter. Thus, essentially the same path is utilized for both transmitter power and the substituted power.
7. Energize the RF signal generator and tune to the preset frequency on the receiver obtained in (4).
8. Rotate both antennas for maximum signal into the receiver, the receiver antenna being rotated first.

9. Adjust the level of the signal generator to give the same reading at the receiver which was noted in (4).

10. To determine the substituted power, the input impedanc e to the generator antenna must be known. The radiated power of the spurious signal relative to the peak transmitter power in watts can now be calculated by the formula:

$$DB = 10 \log \frac{P \text{ Transmitter}}{P \text{ Substituted}}$$

11. Sample Calculation:

Frequency	110.5MC
Distance	155. Feet
Generator uV into antenna	160,000 uV
Receiver uV at antenna	14 uV
Power of Transmitter	2000 watts peak

a) Substituted Power at the Generator:

$$\text{Power} = \frac{V^2}{R} = \frac{(.16)^2}{50} = 0.000511 \text{ watts}$$

b) Relative Radiation Power of Spurious Signal:

$$DB = -10 \log \frac{P \text{ Transmitter}}{P \text{ Substituted Power}}$$

$$DB = -20 \log \frac{2000}{0.000511} = -10 \log 3.92 \times 10^6$$

$$DB = -65.9 \text{ DB}$$

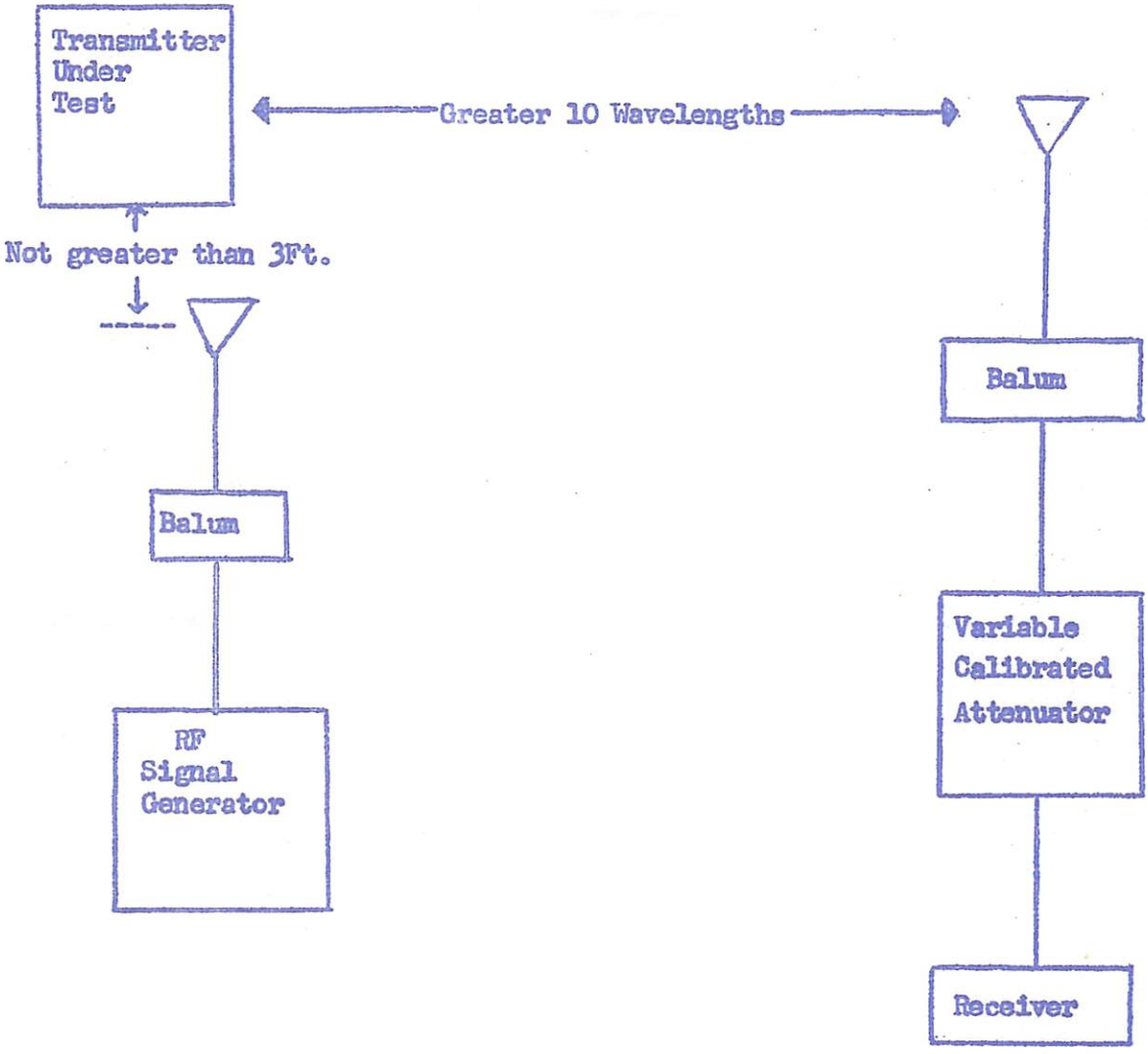
Transmitter Under Test
Greater 10 Wavelengths
Not greater than 3Ft.
Balum
RF Signal Generator
Balum
Variable Calibrated Attenuator
Receiver

FIGURE 2.