APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION

SECTION 1. DBM/DBA METER AND MEASURING TECHNIQUES

1. DBM/DBA VOLTMETERS. DBM/DBA Voltmeters are used to make frequency response measurements on telephone lines. Results obtained with these meters reflect the condition of a line as the telephone equipment sees it. By definition, OdBa is equal to -85 dBm at 1000 Hz. Whereas, dBm is a measure of power at all audio frequencies, dBa covers only a restricted band of audio frequencies corresponding to the response of the F1A telephone receiver. The dBa is useful in measuring noise on telephone lines because the line user is interested in only noise which can be heard on the F1A telephone receiver. There is another unit of noise measurement called the dBrn which corresponds to the frequency response curve of the 144 telephone receiver. The dBrn zero reference level is set at -90 dBm because it is the lowest noise level possible to measure, and it is desirable to have all dBrn measurements expressed as positive number values.

a. Net Loss Measurements. For net loss measurements, set up the test equipment according to the circuit shown in Figure 1-1.

The test equipment listed below is required for net loss measurements with type 1142 TELCO circuits.

(1) Audio Signal Generator (Hewlett-Packard 200AB or Equivalent)

(2) Two each DBM/DBA Meters

(3) H pad, 20 dB, 600 ohm, Figure 1-2

With the test equipment connected as shown in Figure 1-1, turn the first DBM/DBA meter to the Z-hi position and the second DBM/DBA meter to the Z-lo position. The attenuator of the first DBM/DBA will be set to the 0 dBm position; the attenuator of the second DBM/DBA meter will be set to the appropriate dBm value. Adjust the audio oscillator to feed a 1000 Hz signal into the pad at the level of +12 dBm as indicated by the first DBM/DBA meter. This is equivalent to -8 dBm into the line due to the 20 dB loss in the H pad. Read the receiver signal level directly in dBm at the remote end of the circuit by means of the second DBM/DBA meter, and record the value. The net transmission loss can be found by deducting the -8 dBm, 1000 Hz sending level from the 1000 Hz received level. Net loss measurements for 2002 Voice Grade leased circuits and test equipment requirements are almost identical to the 1142 leased circuit identified above. With the 2002 voice grade circuit, there is no requirement for the -20dB "H-pad". The audio oscillator is adjusted to provide a 0.0 dB signal level to the TELCO circuits. The test equipment will be connected in the same manner described above.

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

b. Frequency Response Measurements. The test equipment should be connected as described under "Net Loss Measurements" above. Adjust the oscillator for an output every hundred Hertz from 300 Hertz up to 3000 Hertz, with an input level of +12 dBm feeding into the H pad. When making frequency response measurements, noise is a potential source of error. If the noise alone is 12 dB or more below the level of the signal-plus-noise, this source of error may be neglected. It is accepted practice to use 1000 Hertz as the zero-reference point in voice band frequency response comparisons. The set of values obtained by subtracting the 1000 Hertz received level from the actual received level of all frequencies is used to plot the frequency response curve of the line under test. Record this set of values. For 2002 voice grade leased circuits, the frequency response measurements will be the same as identified above. The only difference is that the audio oscillator is adjusted to provide a 0.0 dB signal level to the demarc and there is no "H-pad" used.

c. Noise and Signal-to-Noise Ratio. The procedure for measuring noise and determining the signal-to-noise ratio consists of the six steps outlined below:

(1) With the equipment connected as shown in Figure 1-1, reduce the input to the pad to -5 dBm (-15 dBm into the line) and measure the received signal level for 2600, 2700, 2800, 2900, and 3000 Hz. Record the received levels.

(2) Turn off the signal generator at the sending end, and switch the DBM/DBA meter at the receiving end to the dBa scale. Note that the meter at the receiving end remains in the Z-lo position. No external line terminating resistor is required at the receiving end of the line.

(3) Adjust the DBM/DBA meter to successively more sensitive dBa ranges until the needle reads midway or higher on the dBa scale. Take an average reading of the noise. This reading is the noise in dBa. Record this value.

(4) To obtain the signal-to-noise ratio, the dBa value obtained in step 3 above must be converted to its equivalent weighted dBm value. This is done by algebraically adding -85 to the dBa value. Note that with the DBM/DBA meter, no correction factor is needed to compensate for the F1A filter insertion loss. For example: If +12 dBa is obtained in step 3, the equivalent weighted dBm value will be: (+12) + (-85) = -73 dBm.

(5) The signal-to-noise ratio for the frequency band between 300 and 2500 Hertz is the numerical difference between the weighted noise (in dBa) of step 4 and the lowest received level within this frequency range as recorded in the previous frequency response tests.

(6) To obtain the signal-to-noise ratio for the frequencies between 2600 and 3000 Hz, subtract the lowest received level from the weighted noise level (in dBm).

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

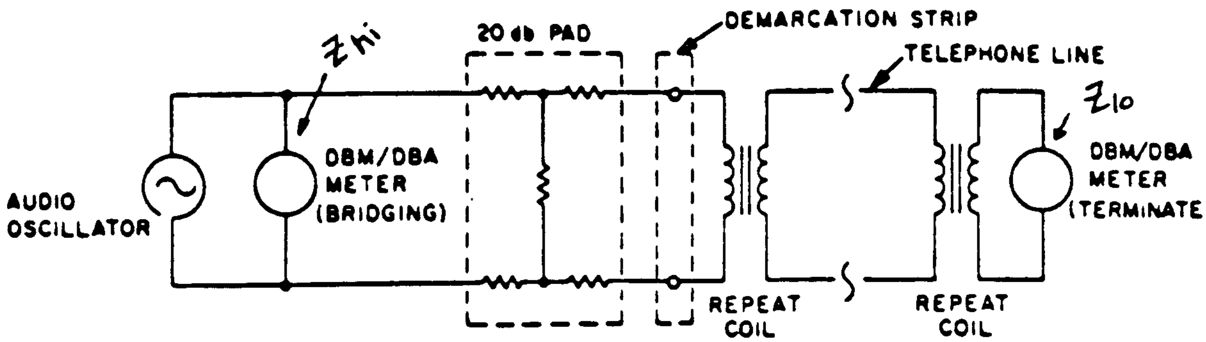


Figure 1-1. EQUIPMENT SETUP FOR SIGNAL-TO-NOISE RATIO

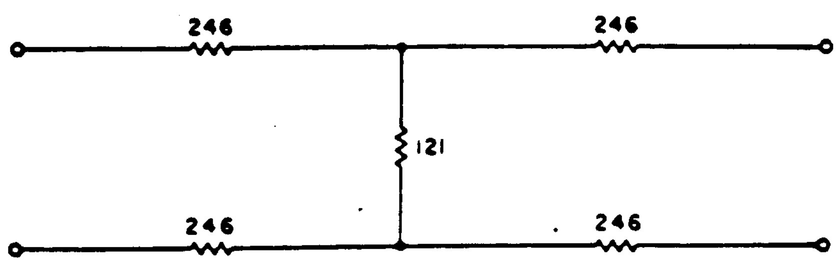


Figure 1-2. 20 dB PAD

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

GENERAL MEASURING TECHNIQUES

To determine the overall loss and frequency, response characteristics of a line, fixed level audio frequency tones in the voice-frequency range (300 to 3000 Hz) are applied, in progressive 100Hz steps, to the sending end of the control line. Measure and record the level of these tones at the receiving end of the control line with suitable test equipment. Refer the recorded values to a reference level established at 1000Hz and transcribe these values to a chart of suitable design to depict a graphic illustration of the overall loss and frequency response characteristics of the line. Refer to Figures 2-1 and 2-2 for the test arrangement to be used.

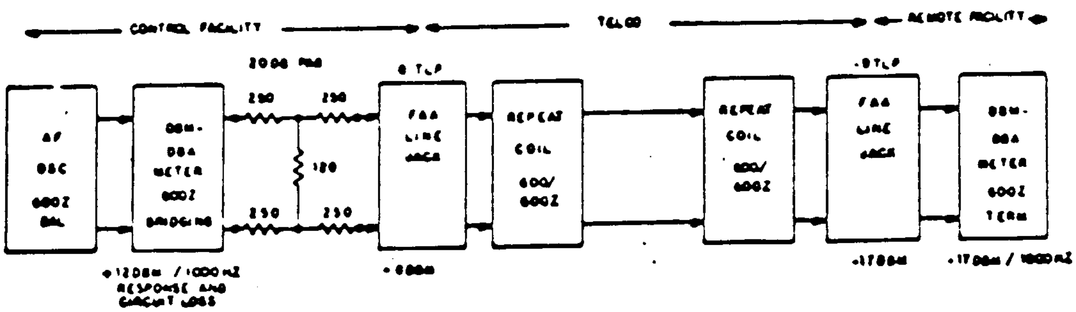


Figure 2-1. General Arrangement for Transmission Attenuation Measurements

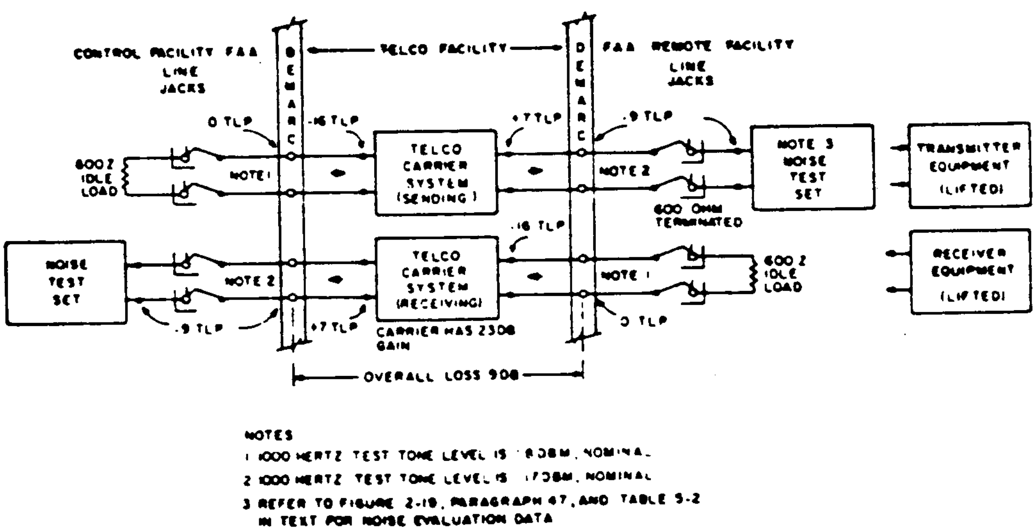


Figure 2-2. General Arrangement for Transmission Noise Measurements

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

SECTION 2. RADIO FREQUENCY POWER METERS

1. The radio frequency wattmeter used for evaluating and testing communications equipment within the FAA is the Bird Model 43 Wattmeter and VSWR Indicator, or equivalent. For this reason, only the Bird wattmeter will be discussed in this text (Figure 3).

a. The Bird Wattmeter and VSWR Indicator. The Thruline wattmeter is a portable unit contained in a die cast aluminum housing, with removable formed metal enclosure at the rear. The unit includes a leather carrying strap, four rubber bumper feet on the base, and four rubber bumpers on the back for use in standing or flat-lying positions. For further mechanical protection, the microammeter is shock mounted between a hollow rubber back-up ring and three stem bumpers on the front face of the meter. A slotted zero-adjustment screw is on the lower front face of the meter. Below the meter is the rectangular top face of the RF line section casting. The measuring element is inserted in the center.

A special cable, shielded against stray RF interference, connects the microammeter to the DC jack at the side of the line section and to the external jack on the upper righthand side of the housing. By means of this arrangement, the microammeter may also be connected to an accessory RF line section outside of the meter housing (Figure 4). This line section is an operating duplicate of that encased in the meter housing of the Model 43 unit. It differs only in that it has a special dust plug (held captive by a short length of anchored bead chain) and a non-magnetic sheet metal cover (used as a mounting bracket).

The DC jack assembly, on the side of the RF line section, has a by-pass capacitor nested inside which shunts across the meter circuit. This more fully protects meter readings against the adverse effect of any stray RF energy existent in the plug-in-element. The DC jack mounts a phosphor bronze spring finger. This opens into the measuring element socket through a lateral clearance hole in the line section. The finger has a small silver button, near its end, which mates with the contacts on the inserted element. The line section is a silver-plated brass casting, precision produced to provide unimpaired impedance of the RF coaxial line in which it is inserted. For additional mechanical support, the ends of the line section are machined to accurate size and nested in mating slots in the side wall of the housing. The RF connectors at each end are of a quick-change type, being fastened down by only the four screws of the respective mounting flanges. The housing does not interfere with any connector changes.

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

To make measurements, a cylindrically shaped plug-in element is inserted in the socket of the line section. A small catch in the upper right hand corner of the casting face presses on the shoulder of the plug-in element body, thereby maintaining the element in steady alignment with an assured bottom contact to provide the most consistent electrical operation. The plug-in element has its terminals on diametrically opposite sides of the body, so that pickup is made in

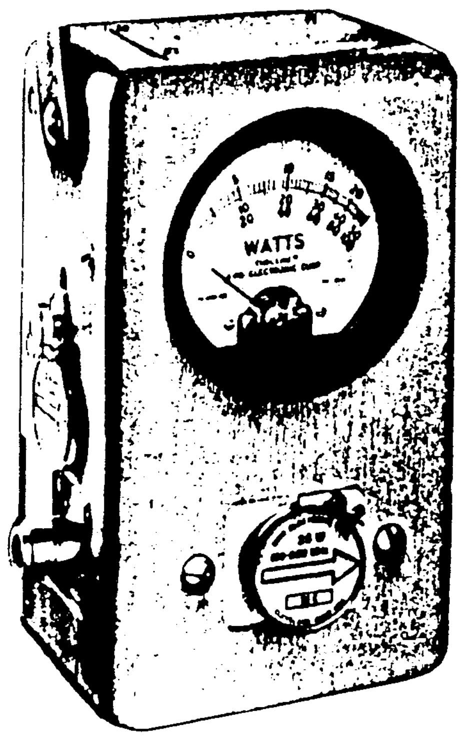
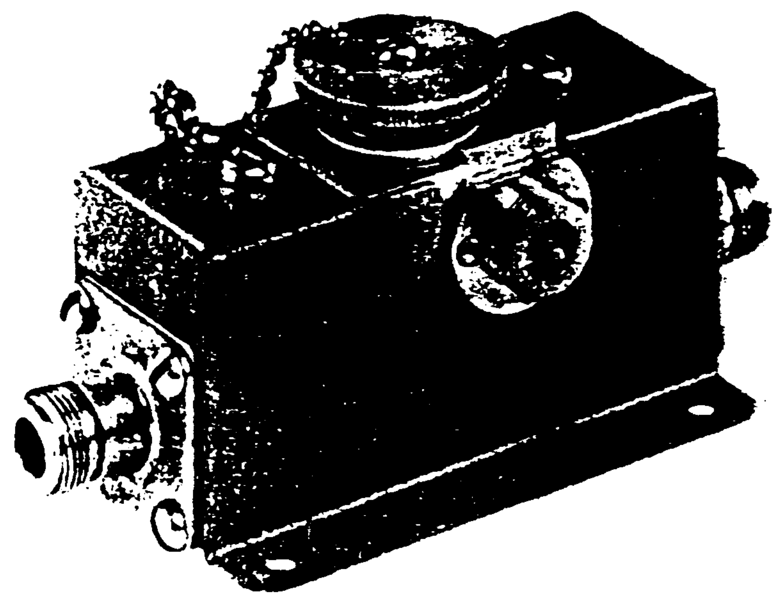


Figure 3. Bird Model 43 Wattmeter

ELECTRONIC TEST EQUIPMENT

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)
Figure 4. Bird Thru-Line



APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

either direction. The contacts on the plug-in element make connection with the DC pickup button only when the plug-in element is in the precise forward or reverse position. The small index pin on the element must be on the lower level of the casting face and against the transverse shoulder.

The meter scale, as described above, is read according to the full scale rating stamped on the cap of the plug-in measuring element.

(1) Applications.

(a) Power Measurements. The Model 43 Thruline wattmeter is a directional RF wattmeter, which measures power flow and load match in coaxial lines. It is for use with CW, AM, and FM transmitters, but is not for use on pulsed transmitters.

The Model 43 is designed for 50-ohm application. The insertion VSWR of this meter is considerably less than 1.05 (loss below 0.2dB) for frequencies up to 1000 MHz in a standard 50-ohm circuit. The meter is direct reading (30 mA DC full scale), expanded down-scale for easy reading. The fifty divisions are graduated at 25, 50, and 100 watts full scale. By adjustment of the decimal point, these graduations may be used for reading measurements of the scalar values for any plug-in elements that may be provided with this equipment.

Measurements are made by the insertion and operation of the plug-in elements previously mentioned.

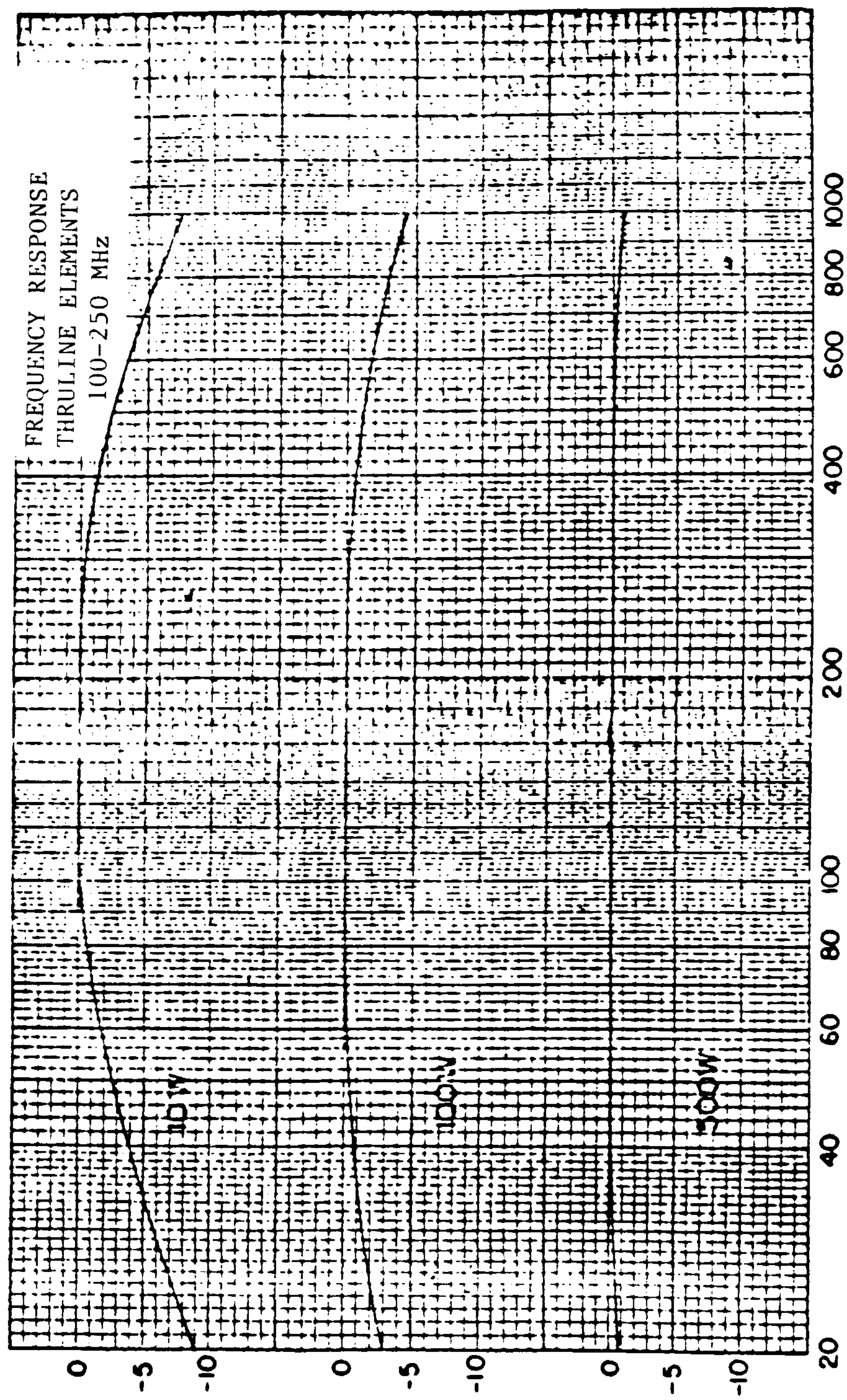
The elements determine the power range scale to be read on the meter, and the major markings (i.e., 50 W, 100 W, etc.) are the full scale power value for that element. Elements are also marked for frequency range. The transmitter frequency must be within the band of the element used.

See Figure 5 for frequency band flatness and performance of the elements outside of stated frequencies. Elements for additional ranges (power or frequency) may be ordered through the FAA supply system.

The arrow on a plug-in element indicates the sensitive direction, i.e., the direction of power flow which the meter will read. "Arrow" and "Reverse" are directional terms used in reference to the Thruline element and indicate, respectively, the sensitive and null directions of the element. Rotate the element to reverse the sensitive direction. "Forward" and "Reflected" are directional terms used in reference to the source-load circuit. Note that the transmitter may attach to either connector of the Thruline. It makes no difference which external RF connection is selected, since the elements are reversible and the RF circuit is symmetrical end for end. Before taking readings, be sure that the meter pointer has been properly zeroed under no-power conditions.

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

Figure 5. Wattmeter Element Chart



APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

The Thruline used with a Termaline resistor of proper power rating forms a highly useful absorption wattmeter. With arrow set toward the load, it is unnecessary to reverse the plug-in element because reflected power may be neglected.

In cases where readings are being made when the meter unit is connected to an auxiliary RF line section body, always remove any measuring element from the unused RF line section. Otherwise, the DC circuit will be unbalanced or shorted according to the arrow position of the other element, causing inaccurate or no reading on the meter.

(b) Voltage-Standing-Wave-Ratio Measurements. Power delivered to (and dissipated in) a load is given by:

Watts into load = (Forward power) - (Reverse power)

i.e., where appreciable power is reflected, as with an antenna, it is necessary to subtract reflected power from forward power to get load power. This correction is negligible (less than 1 percent) if the load is such as to have a VSWR of 1.2 or less. Good load resistors, such as Termalines, will show negligible or unreadable reflected power.

VSWR scales, and their attendant controls for setting the reference point, have been intentionally omitted from the Thru-line for two reasons: (1) To make something similar to a hypothetical DC voltohmmeter with control pots for the voltmeter multipliers creates unnecessary complexities. Even more complications arise when diodes at RF are involved. (2) Experience using the Thruline on transmitter tune-up, antenna matching, etc., i.e., on operating problems, shows that the power ratio, 0, is of small value compared to the VSWR. To determine the VSWR of a radio frequency transmission system, the forward power must be measured; then an accurate reading of the reverse power should be obtained. Using the charts furnished by the manufacturer in the wattmeter case or the charts in Figure 7 and 8 of this text, the VSWR can be determined with a minimum of time and calculations.

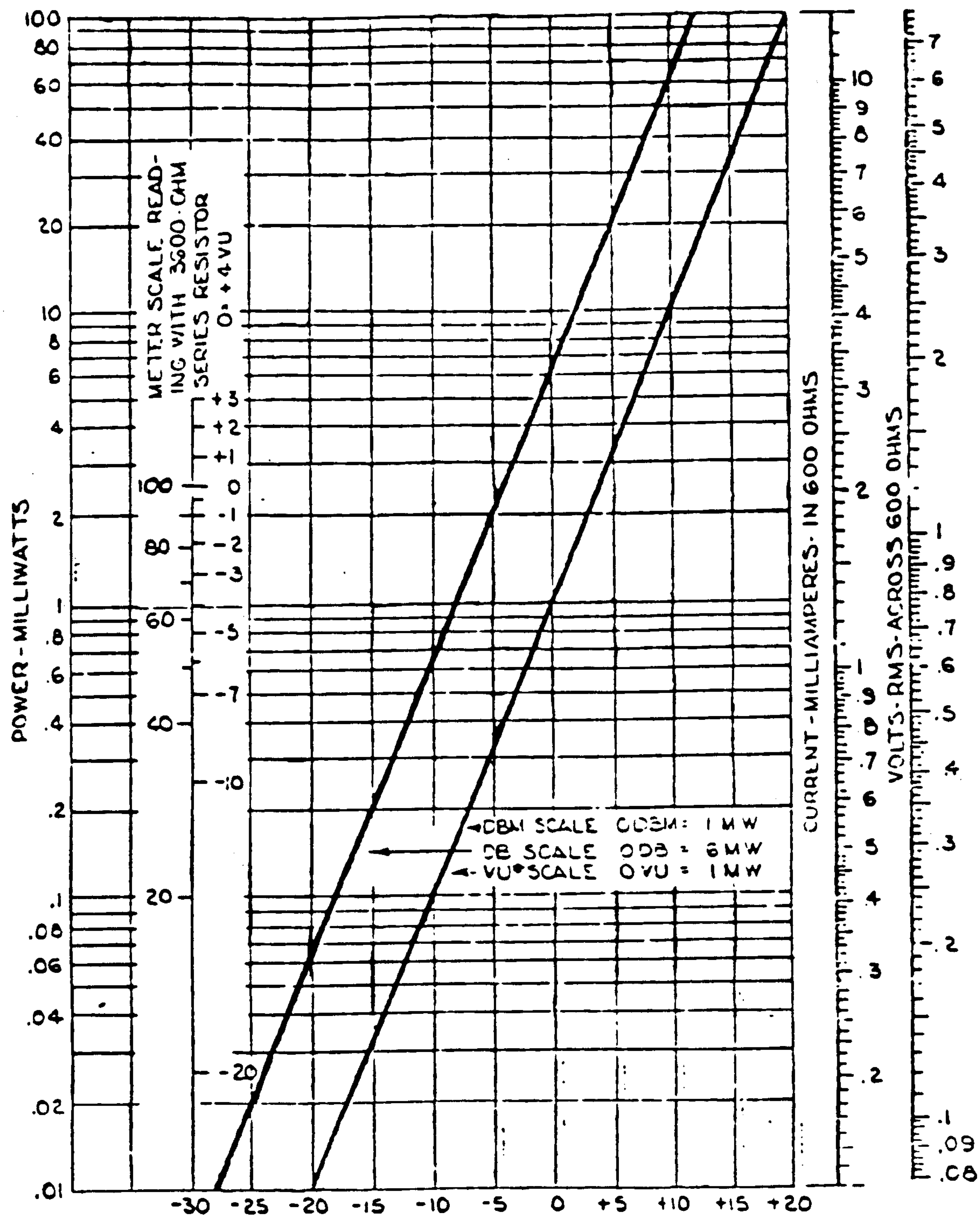
Example: The forward power read from a certain communications transmitter is 50 watts and the reverse power is measured at .09 watt.

Solution: On Figure 7, read .09 watt vertically on the Reverse Power-Watts scale, then read 50 watts forward power on the horizontal scale. Project these points to intersection and read the VSWR as 1.09.

The chart in Figure 8 is used the same way; however, it has provisions for larger values of reverse power.

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

Figure 6. dB-dBm-VU REFERENCE CHART



* THE SCALE READING IN VU WILL CORRESPOND TO DBM WITH REFERENCE TO ONE MILLIWATT ONLY IN THE CASE OF STEADY-STATE SINE WAVE VOLTAGES AT 1000 CYCLES.

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

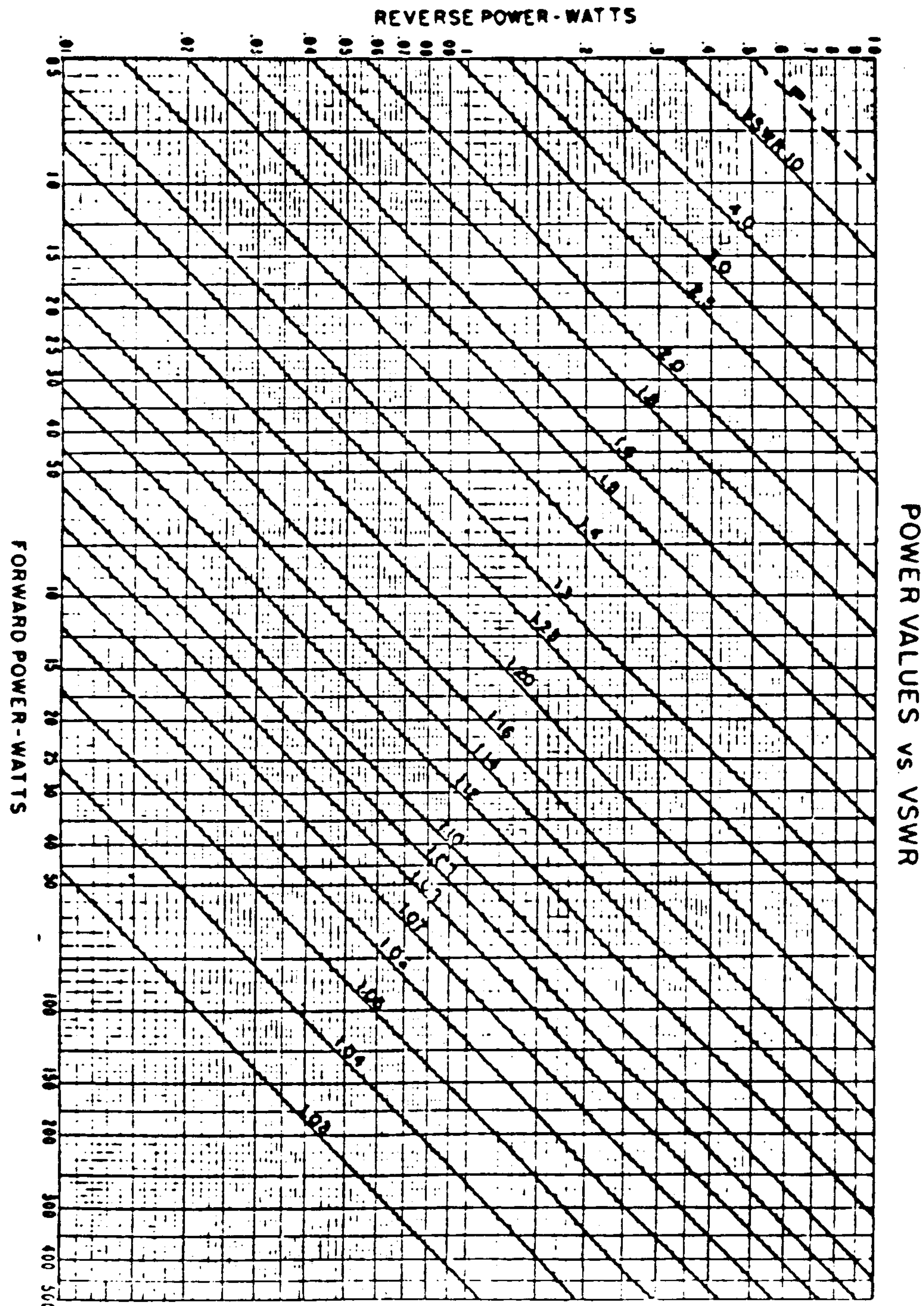


Figure 7. Low Reverse Power SWR

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

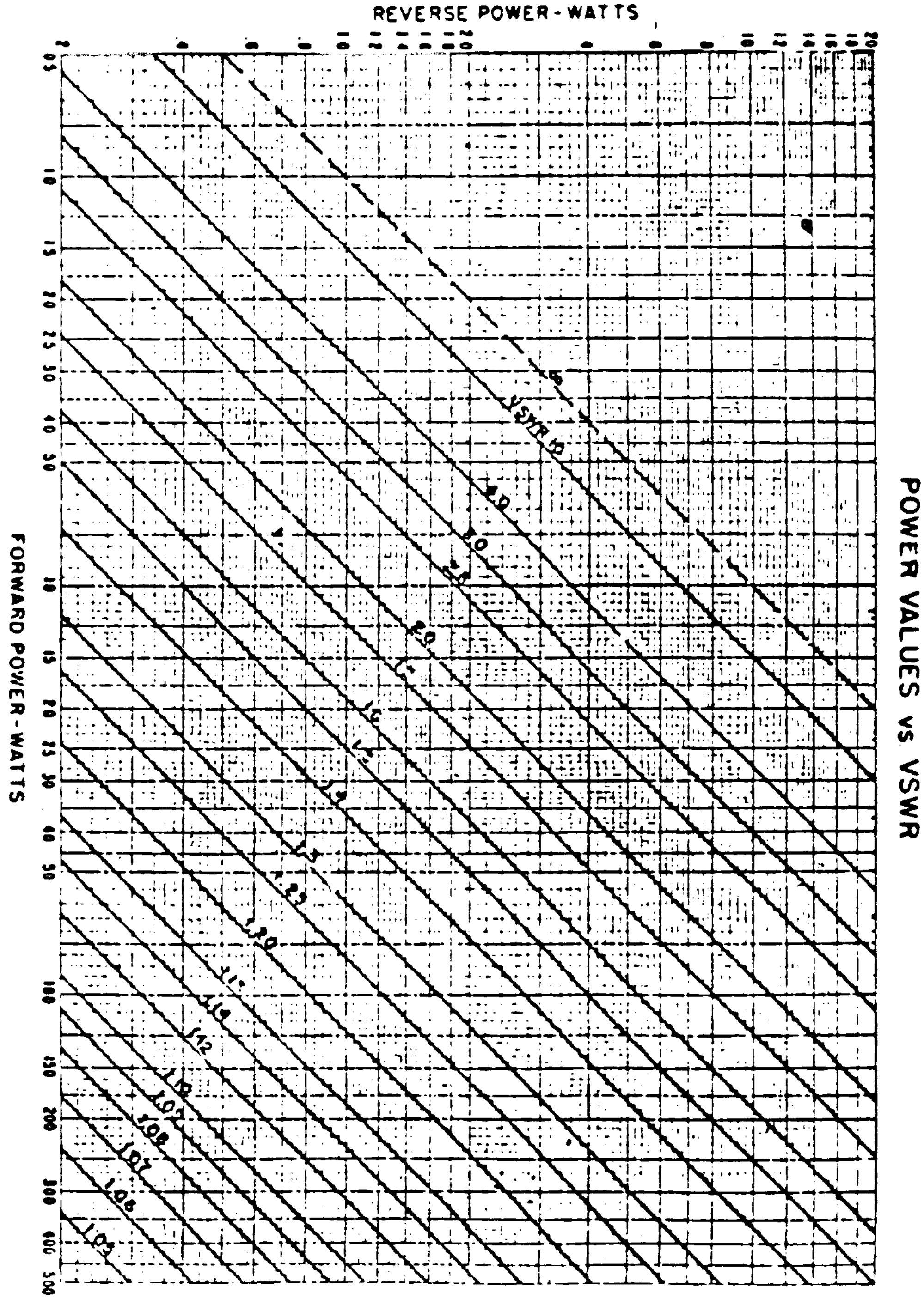


Figure 8. High Reverse Power SWR

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

The accuracy of measurements having low-reflected power may be extended by using two elements. In the example, the forward power could have been measured using a 100 watt element and the reverse power using a 1 watt element.

CAUTION: Do not rotate the smaller wattage element to the forward power position when making VSWR measurements. Inadvertent exposure of an element to too much forward power could destroy the element or meter movement.

(c) Evaluating Components of an RF Transmission System. The Thruline wattmeter is very useful for evaluating lines, coaxial relays, connectors, filters, and other components of a transmission system. Attenuation (power lost by heat in the line) as well as VSWR may be measured by inserting the unknown line between two Thrulines or between two RF bodies used with one meter and one set of elements. (End of line to be terminated in a load resistor.) This method applies also to insertion between the Thruline and a Termaline absorption wattmeter.

Very small values of attenuation require allowance for normal instrument errors. The correction may be determined by direct rigid connection of the Thrulines, or of the Thruline-Termaline combination, in cascade. Slight juggling of zero settings is permissible for convenience in eliminating computation, provided readings are being taken fairly well up scale.

(2) Limitations.

(a) Frequency Response. The plug-in elements have a very flat frequency response over a frequency ratio of more than 2-1/2 to one. This characteristic provides a practically flat response within the assigned frequency range for all the elements.

An illustrative set of curves for three elements of one of these frequency bands is shown in Figure 5. Notice that on the low-power element, the fall-off above and below the assigned frequency band is more pronounced than it is for the high-power element. This figure shows the characteristics of elements of 10 watts and above. Elements of lower than 10 watts will show greater fall-off. The degree of drop in response varies progressively less for each power level from low to high, with the average difference at approximately the mean power level.

Harmonics, or sub-harmonics, may be known to exist in the measured circuit (outside of the element frequency band). If so, a rough approximation of the response of the element to these harmonics may be made by the use of these curves. The frequency ordinate to be read on the graph will be obtained by proportioning the frequency of the element used with that of the one illustrated. Interpolation of the curve values will give an approximation of the extent that these harmonic signals are being measured by your element.

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

(b) Impedance Mismatch. There may be cases where it is necessary to use the Thruline on other than 50-ohm circuits. Within certain limitations, results may be obtained on 70-ohm lines, but this information will be more a matter of "match" or "percentage of reflected power" rather than one of accuracy of power indications.

Insertion of the Thruline places a 4-inch length of 50-ohm air line in the circuit, making the load on the transmitter effectively different from its original condition without the Thruline. For a power reflection factor under 10 percent and a frequency below 200 MHz, the 4-inch length mismatch is not too serious. But going any higher than these values, even if the transmitter is tuned up with the Thruline in place, the load impedance will be very different when it is removed.

The Thruline, of course, indicates zero reflection when the 50-ohm load at its load connector is purely resistive. An ideal condition, on a 70-ohm line on the load side of the Thruline, will show 3 percent reflected power; i.e., when the Thruline load is 70 ohms resistive, the VSWR in the 50-ohm Thruline is 70/50 (= 1.4). The Thruline can also show this same reflected percentage with 50/1.4 = 35.7 ohms pure resistive load, which could exist with 10 percent reflected power on the 70-ohm line (VSWR = 2 on the 70-ohm line). From this you can see that the 70-ohm line could have as much as 10 percent reflected power and VSWR =2 when the Thruline indicates 3 percent reflected power or VSWR = 1.4.

It should be especially remembered that with 70-ohm lines it is most important to get the reflected power indication and subtract if from the forward power, because of this factor being so much more critical here than with an intended 50-ohm line.

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

SECTION 3. COMMUNICATION ANTENNA INSTALLATION CRITERIA

1. ELEVATION AND SEPARATION. Because of the essentially "line of sight" propagation characteristics of very high and ultra high radio frequencies, and the distance involved in the communications conducted between FAA ground facilities and aircraft in flight, VHF and UHF antennas should be elevated as practicable over surrounding structures. Antenna support structures shall provide, wherever possible, a minimum separation of eight feet between antennas to reduce distortion of radiation patterns, interference, etc. Where adjacent channel frequencies differing by one megacycle or less are to be collocated at the same remote site, the associated transmitting antennas shall be mounted on structures separated by a minimum distance of 80 feet. At FSS antenna platform or tower cab roof installations where this requirement cannot be readily met, the associated antennas shall be located as far apart as possible so as to minimize potential interference problems.

2. ACCESSIBILITY. The mounting arrangements for antennas shall include, wherever possible, a practical and safe means for one employee working alone, to lower or dismount each antenna for maintenance service and repair.

3. STRUCTURAL MAINTENANCE OF ANTENNAS AND SUPPORTS. VHF and UHF antenna assemblies shall be properly mounted, fitted together with nuts, screws, etc., and drawn up tightly to reduce the failures caused by vibration due to weather conditions. Antennas shall present a properly treated and/or painted surface to the weather so that rust and corrosion are forestalled and the antennas present an acceptable appearance. Antenna insulators shall be free of cracks or other significant defects. Under no circumstances shall an antenna insulator be painted.

4. ANTENNA MARKINGS. A nameplate is usually supplied with each VHF and UHF antenna. Where such is not the case, a suitable identification shall be fabricated by permanently marking the type number and frequency range on a metal plate or other durable material and attaching it to the antenna.

5. LIGHTNING PROTECTION. Damage to air/ground communications equipment resulting from lightning strikes on the antenna has been reported in a few cases where no protective device was provided for the antenna. A low resistance path to ground shall be provided for all antenna masts as required by the National Electrical Code. An example of a path which may be provided is by the use of a copper wire with a cross section equal to at least AWG No. 6 connected to a ground system consisting of two or more rods (approximately 10-feet long) driven into the ground about 8 to 10 feet apart. These rods should be connected together with a suitable length of No. 6, or larger, copper wire to provide a wraparound of several turns on each rod. The ground wire from the antenna mast should be connected in the same manner, and both wires should be connected to the ground rod with solderless pressure type lugs to provide good electrical contact. Connection to the antenna

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

mast should also be made with a solderless pressure type lug and the metal under the lug should be thoroughly cleaned to ensure a low resistance path. The No. 6 copper wire should be a direct run from the antenna mast to the ground connection.

6. PROTECTION OF TRANSMISSION LINES. Coaxial lines within the building shall be routed overhead wherever practicable. Where it is necessary that coaxial transmission lines be laid over surfaces subject to foot traffic, or over abrupt edges, they shall be protected by metal ducts, conduits, or other suitable guards. Transmission lines shall be tailored to provide normal slack for weather effects. The coiling of unnecessary transmission line is not permitted. Bends shall be made on the longest radius practicable. Wherever possible, the minimum radius of a bend shall be not less than 10 times the cable diameter. Where distance between antenna and equipment room precludes running a single length of coaxial cable, and a junction between two lengths of cable must be made, RF coaxial connectors of the "N" or "HN" series should be used. Every effort should be made to protect such junctions from weather effects, wherever possible. Coaxial connectors and such junctions should be enclosed in weatherproof metal boxes which are easily accessible for service. The Hoffman Box is 20" x 20" x 6" and has a hinged cover.

When installed, all cables shall enter through the bottom of the box. At RCAG and similar installations, the box shall be mounted on the tower platform. At installations where cable transition occurs in a location other than on towers, the primary determining factor for locating the box shall be convenience of access.

7. MAXIMUM LENGTH OF COAXIAL TRANSMISSION LINES.

a. The lengths of coaxial transmission lines used with either VHF or UHF antennas shall be kept to a minimum consonant with good overall engineering judgment. In this connection, the location of antennas shall, where possible, be such as to permit minimum transmission line lengths to be used without sacrificing line-of-sight and coverage requirements.

b. Where the length of coaxial line required to connect the antenna to the receiving or transmitting equipment is 100 feet or more, RG-331/U (RG-333/U) or equal cable shall be used for the major portion of the line, whether used for VHF or UHF. Only in those cases where RG-331/U (RG-333/U) is not practicable, due to duct configuration or space limitations, and then only when supported by an engineering study, will RG-8/U (RG-213/U) or equal cable be permitted for the entire length of line. RG-331 and RG-333 coaxial cables should be used, if possible, in lieu of RG-17 or RG-218.

8. SUPPORT OF TRANSMISSION LINES. Transmission line runs shall be well supported along their entire length. Supports, either cable grips and/or clamps, shall be so located as to assure that cable weight is evenly distributed. Whenever possible, cables should be supported at intervals of about 10 feet.

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

9. COAXIAL CABLE CLAMPS. When the Kindorf "maple" clamps used on antenna towers require replacement, they should be replaced with porcelain cable supports. The porcelain supports are available at the FAA Depot and should be requisitioned as required. The description is as follows: NSN 5975-00-970-5166, support, porcelain insulator, for 1-inch diameter cable RG-331/U, complete with Everdur clamp and slotted head screw.

10. TRANSMISSION LINE MARKINGS. Each coaxial transmission line shall be suitably and permanently marked at the equipment end, and at the antenna end, to permit identification of each transmission line with the equipment and antenna.

11. OPERATING TWO AN/GRR-23 OR AN/GRR-24 RECEIVERS FROM COMMON ANTENNA.

a. Tune the two receivers using the tuning procedure indicated in Section 9, paragraph 9.5 of instruction book TI 6620.2A, Receiver, Radio AN/GRR-23 and AN/GRR-24. The frequencies of the two receivers must be separated by 1.0 MHz or more if they are VHF receivers, and 3.0 MHz or more if they are UHF receivers. Approximately 2.5 dB degradation in sensitivity can be expected with two receivers connected for operation from a common antenna.

b. Connect the two receivers as shown in Figure 3-2 of instruction book TI 6620.2A. The proper length of cable between the two receivers must be used. The cable length is determined by the frequency of the primary receiver. See Figure 3-3 or 3-4 of TI 6620.2A for the proper cable length. Length is to be measured to the end of the center pin of the coaxial line. Total length should include any adapters used when the cable is not terminated with type N connectors.

12. Multicouplers. The use of active antenna multicouplers to combine receivers on one antenna is also an acceptable practice. These units are available with a minimum of 4 ports to a maximum of 32 ports. Four and eight port units are used in the Southwest Region facilities. The multicouplers cover either the UHF or the VHF spectrum by use of an internal bandpass preselector filter. The multicoupler is designed to mount in a standard 19-inch relay rack.

APPENDIX 5. USEFUL COMMUNICATIONS INFORMATION (CONT'D)

Figure 9. Conversion Chart Modulation Level

Mod. %	dB	Mod. %	dB
10	-15.56	46	- 2.32
11	-14.74	47	- 2.14
12	-14.0	48	- 1.96
13	-13.48	49	- 1.76
14	-12.64	50	- 1.6
15	-12.4	51	- 1.42
16	-11.48	52	- 1.26
17	-10.96	53	- 1.08
18	-10.46	54	- .92
19	- 9.76	55	- .76
20	- 9.54	56	- .6
21	- 9.12	57	- .46
22	- 8.72	58	- .30
23	- 8.32	59	- .16
24	- 7.96	60	0.0
25	- 7.6	61	+ .16
26	- 7.26	62	+ .28
27	- 6.96	63	+ .44
28	- 6.64	64	+ .56
29	- 6.32	65	+ .70
30	- 6.2	66	+ .84
31	- 5.74	67	+ .96
32	- 5.48	68	+ 1.1
33	- 5.2	69	+ 1.22
34	- 4.94	70	+ 1.34
35	- 4.68	71	+ 1.44
36	- 4.44	72	+ 1.60
37	- 4.2	73	+ 1.72
38	- 3.98	74	+ 1.84
39	- 3.74	75	+ 1.94
40	- 3.52	76	+ 2.06
41	- 3.32	77	+ 2.16
42	- 3.10	78	+ 2.28
43	- 2.90	79	+ 2.40
44	- 2.7	80	+ 2.50
45	- 2.5		