APPENDIX H

REFERENCES

1. Telecommunications E-I Practices, U.S. Army, CCTM 105-50.
2. Telecommunications Performance Standards USAF TO-31Z-10-1.
3. Tropospheric Scatter Transmission, Proc IEEE, Vol. 48.
4. Microwave Radio Relay Systems, USAF TO-31R5-1-9.
5. DCS E-I Standards Manual, DCAC 330-175-1.
6. DCA Cost Manual, DCAC 600-60-1.
7. DCS Applications Engineering Manual, DCAC 370-185-1.
8. Radar Relay and Troposcatter Equipment, RADC-TN-60-249.
9. Radio Communications System Planning, USAF AFM-100-23.
10. C-E Facility and System Planning, USAF AFM-100-17.
11. Electrical Communications Systems, Radio U.S. Army, TM-11-486-6.
12. Engineering Considerations For Microwave Communications Systems, Lenkurt, 1970.
13. Transmission Loss Predictions for Tropo Scatter Communications Circuits, NBS Tech Note 101, Vol. I and Vol. II.
14. Planning and Engineering Radio Link Paths, Siemens and Halski.
15. Wideband Subsystem Engineering Reference Book, Vol. IIB, USAF AFCCDD-TN-60-50.
16. Propagation Reliability in LOS & Tropo Scatter Links, ITT-CSI.
17. Microwave System Planning, USAF TO-31R5-1-12.
18. Tropo Scatter - LOS System Planning, EMR.
19. Reference Data For Radio Engineers, 5th Edition, ITT.
20. Microwave Path Surveys and Site Selection, Raytheon.
21. Passive Repeater Systems Engineering Manual, SM-300, MSC-Denver.
22. Microwave Antenna Heights For Coastal Areas, Lenkurt.
23. Military Communications Systems Technical Standards, MIL-STD-188C.
24. Microwave Engineers Technical & Buyers Guide, 1970 Edition.
25. Microflect Passive Repeater Engineering Manual 161, Microflect Co. Inc., 1962.
26. EIA Standards, RS-173, RS-222A.
27. Site Survey Manual for Communications Facilities, DCAC 160-1.
28. Tactical Communications-Electronics Planning, USAF AFM-100-37.
29. Radio Propagation Fundamentals, Ballington K., Bell Sys. Tech Journal 1957, Vol. 36, P. 593, (Antenna Engineering Handbook, H. Jasik McGraw-Hill,1961).
30. Communication System Engineering Handbook, Hamsher McGraw-Hill, 1967.
31. Some Aspects of FM Design for LOS Microwave and Tropo Systems, R. L. Marks, RADC, Griffiss AFB, 1965.
32. Path Calculation for TV Microwave Relay Systems, Raytheon, 1957.
33. Transmission Systems for Communication, Bell Tel. Labs., Revised Third Edition, 1965.
34. Electromagnetic Waves and Radiating Systems, E. Jordan, Prentice-Hall, 1950.
35. The Base Electronic System Engineering Plan, NAVELEX 0572.

36. IEEE Overall Communication System Planning, Vols. I, II, III, ITT Communication Sys. Inc., 1964.
37. Radio Relay-Communication by Microwaves, Bell System, 1964.
38. Reference Data for Satellite Communications Earth Terminals, ITT/Defense Communications Division, 1968.
39. Report on Short Term Propagation Study at 7000MC, Microwave Division, Motorola Inc., 1959.
40. Passive Repeaters for Microwave Relay System, Raytheon, 1957.
41. Microwave Path Surveying by Optical Methods, Raytheon, 1957.
42. Polarization Considerations on Microwave System Planning, Raytheon, 1957.
43. Determination of Microwave Path Reflection Points, Raytheon, 1957.
44. Signal to Noise Calculations for TV Microwave Relay Systems, Raytheon, 1957.
45. Atmospheric Scattering and Attenuation of Radio Wave (Line of Sight and Scatter Paths), R. E. Gray, 1967.
46. Obtaining Microwave Towers from Standard Packages, Microflect Co. Inc., 1969.
47. FCC Rules and Regulations, Part 17, Construction, Marking and Lighting of Antenna Structures; 1968.
48. Passive Repeater Installations Can Reduce Microwave System Costs, Microflect Co. Inc., 1967.
49. Determining Microwave Antenna Heights for Coastal Areas, Lenkurt Electric Co., 1964.
50. Noise Performance in Industrial Microwave Systems, Lenkurt Electric Co., 1964.
51. Microwave Radio Systems Antenna Feed, Engineering, Installation and Evaluation; GT&E, 1969.
52. Principles of Modems, CSI, 1966.

GLOSSARY

The following are the definitions of the more commonly used microwave terms. Note that figure Glossary - 2 is a tabulation of microwave terms and equations.

Antenna (Gain). The ratio of the maximum radiation intensity in a given direction to the maximum radiation intensity produced in the same direction from a reference (isotropic) antenna with the same power input.

Antenna (Isotropic). A hypothetical antenna which radiates or receives equally in all directions. It can represent convenient reference antennas for expressing directional properties of actual antennas.

Antenna (Parabolic). An antenna consisting of a radiating element (dipole or horn) and a reflector in the general shape of a parabola to concentrate the energy into a narrow beam.

Attenuation. A general term used to denote a decrease in magnitude of current, voltage, or power of a signal in transmission from one point to another. It may be expressed as a ratio or, by extension of terms, in decibels (dB).

Attenuation Constant. For a traveling wave at a given frequency, the real component of the propagation constant; the relative rate of exponential decrease of amplitude of a field component (voltage or current) in the direction of propagation expressed in nepers or dB per unit length.

Azimuth. Direction, specified in degrees clockwise from north. Thus, due west would be 270^{o} azimuth.

Bandpass Filter. A circuit that allows certain frequencies to pass and reduces in amplitude all frequencies above and below the bandpass region. The power level applied to a filter is very important. Excessively high levels can completely negate the operation of the filter. (Filter rated as having a given loss at a specified frequency-deviation outside pass band.)

Bandwidth. The range of frequencies of a device within which performance with respect to some characteristic conforms to a specified standard. General practice is to specify bandwidth at half-power (3-dB) points.

Baseband. The sum of the frequencies that make up a composite multiplex signal. In the process of modulation, the frequency band occupied by the aggregate of the transmitter signals when first used to modulate the carrier. The term is commonly applied to cases where the ratio of the upper to the lower limit of the frequency band is large compared to unity.

Beam. The focusing of electromagnetic energy into space as radiated from a directional antenna.

Bend, E Plane. A bend in a waveguide in the plane of the electric field. Commonly called an "easy" bend.

Bend, H Plane. A bend in a waveguide in the plane of the magnetic field. Commonly called a "hard" bend.

Bolometer. A barretter, thermistor, or any other instrument using the temperature coefficient of resistivity to measure power. It contains an element, the resistance of which changes as a result of heating by RF power.

Channel (RF). That portion of the frequency spectrum that is assigned to a particular transmitter or receiver.

Choke Joint. A connector between two sections of transmission line in which the gap between the sections is built out to form a series-branching transmission line carrying a standing wave, in which contact is at or near a current minimum.

Coaxial Line. A transmission line where one conductor completely surrounds the other, the two being coaxial and separated by a dielectric or dielectric spacers. Such a line has no external field and no susceptibility to external fields from other sources.

Coupler, Directional. A transmission coupling device for separately sampling (through a known coupling loss for measuring purposes) either the forward (incident) or the backward (reflected wave in a transmission line. Similarly, it may be used to excite in the transmission line either a forward or backward wave. (See figure Glossary - 1.)

Crosstalk. The phenomenon in which a signal transmitted on one circuit or channel of a transmission system is detectable in another circuit or channel.

Cutoff Frequency (Waveguide). The lowest frequency at which energy will propagate in some particular mode without attenuation.

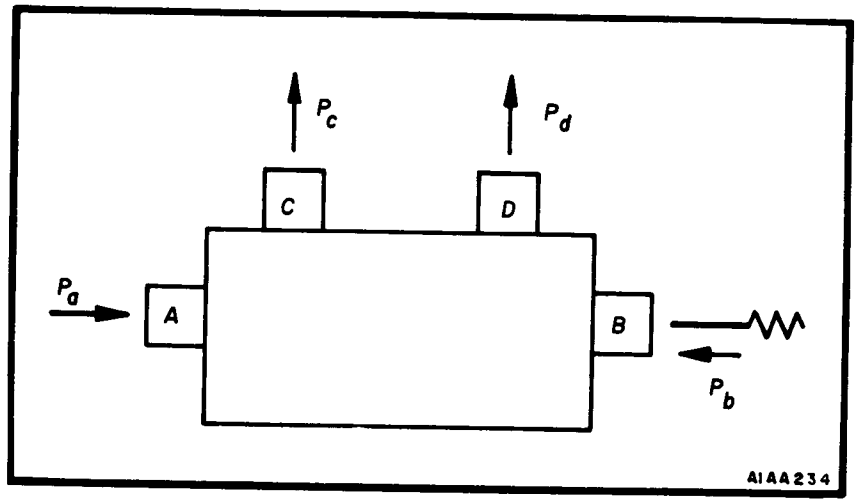
Cutoff Frequency of Amplifier. The highest and the lowest frequencies at which amplifier gain begins to decrease sharply.

Cutoff Frequency of Filter. The frequency at which the filter attenuates applied frequencies by a stated amount.

Cutoff Wavelength. The ratio of the velocity of electromagnetic waves in free space to the cutoff frequency.

Diffraction. The phenomenon produced when waves pass the edge of an opaque body, in which the wave appears to be deflected, producing fringes of parallel waves.

Diplexer. A device that permits an antenna system to be used simultaneously or separately by multiple transmitters operating on different frequencies. Not a duplexer.



GL-1. Power Flow in Directional Coupler

Directional Coupler. see Coupler, Directional.

Duplexer. A device which permits a transmitter and a receiver to operate on a single transmission line or antenna. It effects a mismatch in the receiver section of the transmission line when the transmitter is operating and restores matching in this section when the transmitter is quiescent. (Not a diplexer.)

Equalization. The process of obtaining a flat frequency response over a frequency band.

Equalizer. A device that corrects for the nonlinear response of an electrical circuit.

Four-Wire Circuit. A two-way sending and receiving circuit which uses an individual pair of wires to carry transmitted intelligence in one direction and received intelligence in the opposite direction. This method provides the highest grade circuits, but requires twice as many pairs of wire as 2-wire operation, in which sending and receiving are accomplished over a single pair of wires.

Frequency Division Multiplex (FDM). A method of deriving two or more simultaneous, continuous channels from a medium connecting two points by assigning separate portions of the available frequency spectrum to the several channels. (Each signal channel modulates a separate subcarrier.)

Frequency Modulation (FM). The form of modulation in which the instantaneous frequency of a sine wave carrier is caused to depart from the carrier frequency by an amount proportional to the instantaneous value of the modulating signal.

Frequency Shift Keying (FSK). A method of transmitting the mark and space portions of a teletype (TTY) signal by shifting the carrier frequency a fixed amount. It is characterized by continuity of phase during the transition from one signaling condition to another.

Fresnel Zone. The cigar-shaped zone (or region) between an antenna and the Fraunhofer region, the center of which is the direct beam path between a microwave transmitting and receiving antenna. If the antenna has a well-defined aperture D in a given aspect, the Fresnel zone in that aspect is commonly taken to extend a distance $2D^2/\lambda$ in that aspect, where λ = wavelength. The total distance from any point on the first fresnel zone to the transmitting and receiving antenna is one-half wave length longer than the direct path.

High Pass Filter. A filter that allows all frequencies above a certain (cutoff) frequency to pass with very little attenuation and attenuates all frequencies below that frequency.

Horizontal Polarization. A radio wave in which the electrostatic field (E vector) is in a horizontal plane. The transmitting antenna will be horizontal, and the receiving antenna should also be in this plane.

Impedance, Characteristic (of a rectangular wave-guide). A pure resistance, whose magnitude is dependent on the dimensions of the cross-section of the guide and on the medium in which the wave is transmitted, but is independent of frequency. For the dominant (TE_{10}) mode at any specific frequency above cut-off frequency, it is the ratio of the square of the rms voltage between midpoints of the two conductor-faces normal to the electric vector to the total power flowing when the guide is match-terminated. For modes other than TE_{10}, the impedance must be derived from analysis of the particular geometric structure of the guide relative to the specific frequency.

Impedance, Characteristic (of a two-conductor transmission line). The square root of the product of the inductance per unit length and the capacitance per unit length. For a traveling, transverse electromagnetic wave, the ratio of the complex voltage between the conductors to the complex current on the conductors in the same transverse plane, with the sign so chosen that the real part is positive.

Impedance, Normalized. The impedance of a system divided by the characteristic impedance.

Incident Power or Signal. Power from the generator transmitted to the load.

Ionosphere. That part of the outer atmosphere (25 or more miles above the earth) where ions and free electrons are normally present in quantities sufficient to affect radio-wave propagation. It is divided into several regions or layers which can absorb or reflect electromagnetic radiation.

Isolator, Ferrite. A device which allows RF energy to pass through in one direction with very little loss; RF power in the reverse direction is greatly attenuated.

Junction Hybrid. A waveguide arrangement with four branches which has the property that energy can be transferred from any one branch into only two of the remaining three branches.

Line of Sight (LOS). An optical path between two points.

Lobe. One of the three-dimensional sections of the radiation pattern of a directional antenna bounded by one or two cones of nulls. (The size, shape, and relative power are dependent on antenna characteristics.) The lobe containing the direction of maximum radiation or reception is called the major lobe; all other lobes are called minor lobes.

Loss, Mismatch (reflection loss). The ratio, in dB, of the incident power to the difference between incident power and reflected power; a measure of the loss caused by reflection.

Lower Sideband. The difference-frequency produced by the combination of the carrier and the modulating frequencies when amplitude-modulation is used.

Low Pass Filter. A circuit that allows all frequencies below a certain (cutoff) frequency to pass with very little attenuation and attenuates all frequencies above the cutoff frequency.

Matched Termination (Waveguide). A termination producing no reflected wave at any transverse section of the waveguide; i.e., the real power is totally absorbed by the termination. (To achieve this, the termination must present a purely resistive load equal in magnitude to the characteristic impedance of the associated waveguide.)

Microstrip. A microwave transmission component using a single conductor supported above a ground plane.

Microwave Region. That portion of the electromagnetic spectrum lying between the far infra-red and the conventional RF portions - commonly regarded as extending from 1 MHz (30 cm) to 300 kMHz (1mm).

Mode (of transmission propagation). The mode of propagation of electromagnetic waves through waveguide is described by the configurations of electric (E) and magnetic (H) fields existing in a plane perpendicular to the waveguide axis. These modes are further identified by double-subscripts that indicate the electric- and magnetic-field distribution in half-cycles along the x- and the y-axis, respectively, of the waveguide. The modes are: TE (transverse-electric) waves; TM (transverse-magnetic) waves; and TEM (transverse-electromagnetic) waves. A typical mode-designation might be $TE_{1,0}$, which indicates a TE mode with one half-cycle of E-field along the x-axis, and zero half-cycles along the y-axis.

Modem. A contraction of "modulator-demodulator," for a device which performs both functions. It is mounted in a single panel and usually has some circuits which are common to both functions.

Multipath Effect. The condition produced when a radio signal transmitted from a point is received at a distant station as two separate signals varying slightly in phase (time) due to their traveling over paths of different length.

Multiplex. A method to provide more than one communications channel on a single-carrier circuit.

Profile Chart. Vertical cross-sectional drawing of the terrain between two microwave stations showing distance between stations, location, and elevation of obstructions, etc.

Propagation Constant. A transmission characteristic of a line which indicates the effect of the line on the wave being transmitted along the line. It is a complex quantity having a real term, the attenuation constant and an imaginary term, the phase constant. 1. Per unit length of a uniform line, it is the natural logarithm of the ratio of the current at a point of the line, to the current at a second point, at unit distance from the first point along the line in the direction of transmission, when the line is infinite in length, or is terminated in its characteristic impedance. 2. Per section of a periodic line, it is natural logarithm of the ratio of the current entering a section, to the current leaving the same section, when the periodic line is infinite in length, or is terminated in its iterative impedance. 3. Of an electric transducer, it is the natural logarithm of the ratio of the current entering the transducer, to the current leaving the transducer, when the transducer is terminated in its iterative impedance.

Radiation Pattern. A polar graphical representation displaying the relative intensity of radiation from an antenna in any direction.

Reflected Power or Signal. Power flowing from the lead back to the generator.

Reflection Coefficient. The vector ratio of the electric field associated with the reflected wave to that associated with the incident wave.

Reflectometer. A system so arranged to measure the incidental and reflected voltages and indicate their ratio.

Reflector (Passive). A flat surface placed at an angle in the beam path of a signal to change its direction.

Refraction. The change in direction of propagation of a wave front due to its passing obliquely from one medium into another of different density.

Resonator, Cavity. A region enclosed by conducting walls, within which resonant fields may be excited and whose frequency is determined by the geometry of the enclosure.

Sidebands. Two bands of frequencies, one above and one below the carrier frequency, produced as a result of modulation of a carrier. The upper sideband contains the frequencies that are the sums of the carrier and modulated frequencies. The lower sideband contains the eifference of these frequencies.

Simple Sideband Suppressed Carrier Modulation (SSB). A type of amplitude modulation in which the carrier and one sideband are eliminated before the RF signal is transmitted.

Slotted Section. A length of waveguide, in the wall of which is cut a non-radiating slot (used for standing wave measurements).

Smith Diagram. A diagram with polar co-ordinates, developed to aid in the solution of transmission-line and waveguide problems.

Subcarrier. A carrier that is modulated and in turn modulates a second carrier.

Telemetering. The process of transmitting intelligence of a type that is normally read on meters or gauges to a remote point and producing the desired information at that point.

Thermistor. A resistance element made of a semi-conducting material which exhibits a high negative temperature coefficient of resistivity.

Time Division Multiplex (TDM). A method of deriving several channels from a given frequency spectrum, by assigning discrete time intervals in sequence to the different channels. During a given time interval the entire available frequency spectrum can be used by the channel to which it is assigned. In general, TDM systems use pulse transmission. The multiplex pulse train may be considered to be the interleaved pulse trains of the individual channels. The individual channel pulses may be modulated either in an analog or a digital manner.

UHF. Ultra-high frequency, the band of frequencies between 300 and 3000 mHz.

Upper Sideband. The frequency produced from the sum of the carrier and the modulating frequencies when amplitude-modulation is used.

VHF. Very high frequency, the band of frequencies between 30 and 300 mHz.

Voltage Standing-Wave Ratio (VSWR). The ratio of the amplitude of the electric field or voltage at a voltage minimum to that at an adjacent maximum in a stationary-wave system, as in a waveguide, coaxial cable, or other transmission line.

Wave, Dominant. The guided wave having the lowest cutoff frequency; the only wave which will carry energy when excitation is between the lowest cutoff frequency and the next higher frequency of a waveguide.

Waveguide Tee. A junction used to connect a branch section of waveguide in series or parallel with the main transmission line.

Waveguide Tuner. An adjustable device added to a waveguide to effect an impedance transformation.

Waveguide Wavelength. For a traveling plane wave of a given frequency, the distance along the waveguide between points at which a field component (or the voltage or current) differs in phase by two radians.

Wave, Transverse Electric (TE Wave). In a homogeneous isotropic medium, an electromagnetic wave in which the electric field vectors are everywhere perpendicular to the direction of propagation.

Wave, Transverse Electromagnetic (TEM Wave). In a homogeneous isotropic medium, an electromagnetic wave in which both the electric and magnetic field vectors are everywhere perpendicular to the direction of propagation.

Wave, Transverse Magnetic (TM Wave). In a homogeneous isotropic medium, an electromagnetic wave in which the magnetic field vector is everywhere perpendicular to the direction of propagation.

Wave, TE_{mm} (In Rectangular Waveguide). The transverse electric wave for which m is the number of half-period variations of the electric field along the longer transverse dimension and n is the number of half-period variations of the electric field along the shorter transverse dimension.

Wave, TM_{mm} (In Rectangular Waveguide). The transverse magnetic wave for which m is the number of half-period variations of the magnetic field along the longer transverse dimension, and n is the number of half-period variations of the magnetic field along the shorter transverse dimensions.

Wavemeter, Absorption. A device using the characteristics of a resonator which cause it to absorb maximum energy at its resonant frequency when loosely coupled to a source.

MICROWAVE TERMS AND EQUATIONS

α	Attenuation
α_o	Attenuation of air filled copper transmission line = 0.35×10^{-9} nepers/meter = 0.3×10^{-5} db/kilometer
Γ	coefficient of reflection = -1 for short circuit = $+1$ for open circuit = 0 for matched load
δ	skin depth
ϵ	Dielectric constant
ϵ_o	Dielectric constant for air
λ	Wavelength
λ_g	Guide wavelength
λ_c	Cutoff wavelength
μ	Permeability
μ_o	Permeability of air = $4\pi \times 10^{-7}$henries/meter
K	Coupling coefficient
ρ	Resistivity = 1.74×10^{-8} ohm-meters for copper
σ	Electrical conductivity
κ_o	Permittivity of air = 8.854×10^{-12} farad/meter
v	Velocity of propagation
v_o	Velocity of propagation in air = 2.998×10^8 centimeter/second = 2.998×10^8 meters/second = 186,280 miles/second = 11.808×10^9 inches/second
ϕ	Phase angle
β	Phase constant
Z_0	Characteristic impedance = 376.7 ohms for free space = 120π
D	Directivity
P	Power
V	Voltage
I	Current
R	Resistance
C	Capacitance
G	Conductance
B	Susceptance
X	Reactance
Y	Admittance
L	Inductance
f	Frequency
ω	Angular frequency = $2\pi f$
Q	Figure of Merit of a resonator = $2\pi \frac{\text{energy stored}}{\text{energy dissipated per cycle}} = \frac{\Delta f}{f_o}$
H	Magnetic vector
E	Electric vector
a	Broad waveguide dimension
b	Narrow waveguide dimension
z	Direction of propagation
n	Mode designation (for TE_{10} m = 1, n = 0)
m	Mode designation (for TE_{10} m = 1, n = 0)
VSWR	Voltage Standing Wave Ratio
PSWR	Power Standing Wave Ratio

Wavelength in meters $\lambda_m = \frac{300,000}{f \text{ in kilocycles}} = \frac{300}{f \text{ in megacycles}}$

Wavelength in centimeters $\lambda_{cm} = \frac{30,000,000}{f \text{ in kilocycles}} = \frac{30,000}{f \text{ in megacycles}}$

Wavelength in inches $\lambda_{in} = \frac{11,808,000}{f \text{ in kilocycles}} = \frac{11,808}{f \text{ in megacycles}}$

$$\delta = \frac{1}{2\pi}\sqrt{\frac{4\pi\rho\lambda_{meters}}{\mu c_{meters}}}$$

$$Z_o = (\mu_o/\kappa_o)^{1/2}$$

$$db = 10 \log\frac{P_1}{P_2} = 20 \log\frac{V_1}{V_2} = 20 \log\frac{I_1}{I_2}$$

$$\lambda = \frac{v}{f} \qquad Z_o = \sqrt{\frac{\mu}{\kappa}}$$

In a lossless medium of dielectric constant ϵ

$$v = \frac{v_o}{\sqrt{\epsilon}}$$

$$\lambda = \frac{v_o}{f\sqrt{\epsilon}} \qquad Z_o = \sqrt{\frac{\mu_o}{\kappa_o\epsilon}} = \frac{120\pi}{\sqrt{\epsilon}}$$

$$|\Gamma| = \sqrt{\frac{P_{reflected}}{P_{incident}}} = \frac{VSWR - 1}{VSWR + 1}$$

$$\therefore VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

$$\% \text{ Power reflected} = \left(\frac{VSWR - 1}{VSWR + 1}\right)^2 .100$$

$$PSWR = (VSWR)^2$$

For waveguides

$$(\lambda_{mn})_c = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}}$$

$$\beta_{mn} = \frac{2\pi}{\lambda}\sqrt{\epsilon - \left[\frac{\lambda}{(\lambda_{mn})_c}\right]^2} = \frac{2\pi}{\lambda_q}$$

$$\lambda_g = \frac{\lambda}{\sqrt{\epsilon - \left[\frac{\lambda}{(\lambda_{nm})_c}\right]^2}}$$

For TE_{10} in air filled waveguide

$$\lambda_g = \frac{\lambda}{\sqrt{1 - \left(\frac{\lambda}{2a}\right)^2}}$$

$$\lambda_c = 2a$$

$$\alpha = \frac{4\alpha_o A}{a}\left(\frac{a}{2b} + \frac{\lambda^2}{\lambda_c^2}\right) \quad \text{where } A = \frac{\sqrt{c_1/\lambda}}{\sqrt{1 - (\lambda/\lambda_c)^2}}$$

A termination is connected to terminal B, and a signal P_a is applied to terminal A. P_a will flow through the device and be reflected by the termination resulting in P_b and a standing wave. A small portion of the input signal P_a is extracted at terminal C, unaffected by the reflection from the termination and

AIAA 235(A)

GL-2. Microwave Terms and Equations (Sheet 1 of 2)

proportional to the magnitude of the input signal. A similar portion of the reflected signal P_b is extracted at terminal D, proportional to the magnitude of the reflected signal and vanishing when the termination is adjusted for unity VSWR.

Coupling —

The ratio of power supplied to the power output at the auxiliary line output.

$$\text{Coupling (db)} = 10 \text{ Log } \frac{P_a}{P_c} = 10 \text{ Log } \frac{P_b}{P_d}$$

Directivity —

A measure of the discrimination of a directional coupler between waves traveling in two directions in the main line. It is measured as the ratio of the two power outputs from an auxiliary line when a given amount of power is successively applied to each terminal of the main line.

$$\text{when } P_b = 0, \text{ Directivity (db)} = 10 \text{ Log } \frac{P_c}{P_d}$$

Formulas —

The directional coupler is employed to measure the magnitude of the reflection coefficient by measuring the magnitude of the direct and reflected voltages.

$$K = \frac{E_r}{E_d}$$

where

K = magnitude of reflection coefficient
E_r = magnitude of reflected voltage
E_d = magnitude of direct voltage

The resultant VSWR, return loss, and mismatch loss, may be computed as follows:

$$\text{VSWR} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

$$\text{Return Loss (db)} = 10 \text{ Log } \frac{1}{K^2}$$

$$\text{Mismatch Loss (db)} = 10 \text{ Log } \frac{1}{1 - K^2}$$

Down Converters —

THEORY: A down converter is a crystal holder with two RF inputs. A local oscillator signal of known frequency is applied to one input, the RF signal to the other. The two signals are mixed in the nonlinear crystal. The result of the mixing is to produce, among other frequencies, the difference frequency between the RF and LO (local oscillator) signals at the IF output. The mixer thus converts an RF signal to a much lower frequency IF signal which is more conveniently amplified and otherwise handled.

DESIGN: The schematic circuit of the XR mixers is shown in Figure 100.

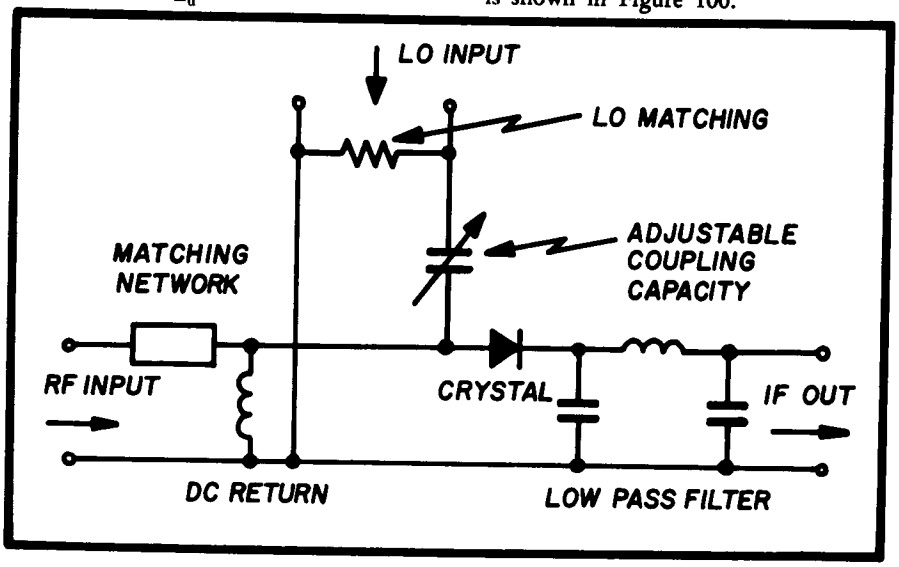


Figure 100. Down Converter

AIAA235(8)

GL-2. Microwave Terms and Equations (Sheet 2 of 2)

☆ U. S. GOVERNMENT PRINTING OFFICE: 1972 O - 469-434