ANTENNAS • ANTENNA SYSTEMS
TRANSMISSION LINES

ANDREW

PARABOLIC ANTENNA SYSTEM COMPUTER and TRANSMISSION LINE & WAVEGUIDE SELECTOR

INSTRUCTIONS FOR ANDREW PARABOLIC ANTENNA SYSTEM COMPUTER

The ANDREW Parabolic Antenna System Computer is designed to calculate parabolic antenna radiation characteristics, performance of passive repeaters, free-space and tropospheric forward "Scatter" propagation attenuations, and thermal noise and equivalent noise input of receivers. With this computer, it is possible to calculate the complete system performance of a radio relay link.

1 PARABOLIC ANTENNA RADIATION PATTERN CHARACTERISTICS.
For a given frequency, set on the F scale, and diameter of a parabolic antenna, set on the D scale, the radiation pattern characteristics and the gain of the antenna may be found, respectively, on scales Θ and G.

EXAMPLE: F = 6 KMC and D = 4'. Set 6K on F scale over 4 on D scale. On the Θ scale, the approximate positions of the first and second side — lobe maxima are found to be respectively 4.8° and 7.2° (off main beam peak). The full width between the 3-db (½ power) points of the main beam is 2.85° and that between 1-db (80% power) points is 1.65° as indicated by the indices .5P and .8P. These figures are all based on a parabolic tapered illumination of the aperture, with the edges 10-db below the center. The antenna gain is found on the G scale over the appropriate aperture efficiency, (g scale). The arrow is at the EIA recommended figure of 55% efficiency. For this example, the gain is 35.1 db over isotropic.

2 FREE-SPACE PROPAGATION ATTENUATION.
For a given frequency on the F scale and distance between stations on M scale, the free-space attenuation between two assumed isotropic antennas is found on the A scale.

EXAMPLE: F = 6 KMC, M = 30 miles. Set 6K on F scale over 30 on M scale. The result on the A scale, opposite the arrow is 141.7 db. If 4' parabolic antennas, as above, are actually used at each of the stations, the signal attenuation is obtained by subtracting the combined gain of the two antennas from the isotropic attenuation figure. 141.7 db less 70.2 db gives a result of 71.5 db.

3 TROPOSPHERIC FORWARD "SCATTER" PROPAGATION ATTENUATION.
This is obtained by finding first the free-space attenuation and adding the additional "scatter" loss (median value) obtained from the S scale.

EXAMPLE: F = 6 KMC, M = 100 miles. From (2) above, A is found to be 152.1 db. The "scatter" loss is found on the S scale, opposite 100 miles on M scale, to be 60 db. The total "scatter" propagation attenuation is then S + A = 212.1 db.

4 THERMAL NOISE OF RECEIVER.
Thermal noise is KTB, where K is Boltzmann's constant, T is temperature (assumed to be 300° Kelvin) and B is receiver bandwidth.

EXAMPLE: B = 20 MC. Set KTB index on f scale over 20 MC on B scale, the thermal noise is indicated, on the N scale, by the arrow to be −130.8 dbw.

5 EQUIVALENT NOISE INPUT OF RECEIVER (ENI).
ENI may be obtained with known receiver noise factor (NF) and band width (B).

EXAMPLE: NF = 15 db. B = 20 MC.. Set 15 on NF scale over 20 MC on B scale. The arrow indicates ENI to be −115.7 dbw on N scale.
If noise factor (NF) is not readily available in early system planning, empirical factor $10(F)^{2/3}$, which is based on performance of commercially available crystal mixers, may be used. This is shown on f scale (Channel Frequency mc).

INSTRUCTIONS (Continued)

6 **ANTENNA SYSTEM CALCULATION.**

Problem: two stations are separated by 20 miles, to be operated at 6 KMC with a radiated power of 1 watt and a receiver bandwidth of 20 MC. If a carrier-to-noise ratio, (C/N) of 45 db is desired, what sizes of antennas are needed at these stations?

Solution: From procedure (2) above, A is found to be 138.2 db. From procedure (5) above, ENI is found to be −115.7 dbw. With a power of 1 watt, the received signal is −138.2 dbw, and is therefore 22.5 db below noise. For C/N = 45 db, the total antenna gain must be, G = A + ENI + C/N or 67.5 db. From procedure (1), it is found that, at this frequency, a 4' parabolic antenna gives 35.1 db gain. For this system, the minimum acceptable would be two 4', one at each end.

7 **PASSIVE REPEATER USING TWO PARABOLIC ANTENNAS.**

To transmit a microwave signal over a mountain, or produce a "dogleg" in a system, two parabolic antennas may be suitated back-to-back, one facing in each direction, and used as a passive repeater. The procedure is the same as (6) above, except that the propagation attenuation is the sum of the attenuations for the two sections of the link, and the total antenna gain needed should be equal to the sum of the gains of all four antennas, or more.

8 **PASSIVE REPEATER USING A FLAT REFLECTOR.**

In a "dogleg" system, a flat reflector may be used as a passive repeater. The system performance is calculated exactly as in (7) above, except for the gain of the reflector. Since the reflector receives and retransmits the microwave power its gain should be counted twice, as if it were two antennas back-to-back. If the reflector has a circular projected area, its gain is indicated by the index 100 instead of the arrow on the g scale; and the full width between the 3 db points of its radiation pattern is indicated by the *index O*. If the reflector has a square projected area, of dimension D times D, its gain is indicated by the *index S* on the g scale, and its 3 db full width is indicated by the *index U*. The index U is the full width between the ½ power points of the main beam of any uniformly illuminated linear array, of length D and at frequency F. For the gain of a reflector having a *rectangular* projected area, the dimension, D, of a *square* reflector with the same area should be used. The horizontal beam width, however, is calculated using the actual projected horizontal dimension.

INSTRUCTIONS FOR TRANSMISSION LINE & WAVEGUIDE SELECTOR

The characteristics of Andrew transmission lines and waveguides are listed, with provisions for determining the efficiency of a given length of line. The first column lists the nominal size of each type of transmission line, and the EIA or RG designation for waveguides, while the next column gives the Andrew part number for these lines.

Impedance Ohms is the transmission line characteristic impedance. O.D. *Inches* and *I.D. Inches* are the outer and inner diameters of the conductors of the coaxial lines, and the width and height of waveguides. AVERAGE POWER is the maximum CW carrier power for a VSWR of unity, with no modulation. For coaxial lines the average power is limited by heating, with an allowable inner conductor temperature rise of 62° C over a 40° C ambient. This corresponds to a 23° C rise in the outer, which is also the limiting factor in waveguide. *Peak power* is the maximum usable RF power based on voltage breakdown consideration with no allowance for modulation or VSWR, but including a safety factor of 2:1. *Frequency Range* is the usable operating frequency range of the transmission line or waveguide in kilo-megacycles. *Dielectric Support* indicates the type of insulation used for inner conductor supports in coaxial lines.

To find attenuation or average power capacity for any line at a given frequency, move the slider until the desired frequency is in the opening opposite frequency M.C. Read attenuation in db per 100 feet, or average power in KW for the line or waveguide in the upper part of the opening on the appropriate line.

To determine efficiency for a given length of line or waveguide:

1. Find attenuation for the line in db per 100 feet.
2. Adjust slider until the attenuation on the α scale is opposite the length of transmission line in feet on the L scale.
3. **Read percent efficiency on the E scale opposite the arrow.**

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