Pickett C19-T Microwave Transmission Slide Rule

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The C19-T was copyrighted by Pickett in 1965, and was designed to aid the solutions involving microwave transmission and communication systems. The instructions are on four 1 inch X 12 inch strips and I have scanned and enlarged them for easier reading (the C19-T with the instructions is uncommon, if not rare).[1]

Sections I, II, III, IV, V, VI, XIII, XIV, and XV are for microwave transmission; transmitter to receiver. I have some background in this, and examples are presented (you will have to refer to the various sections for the equations and slide rule operation); all results are within 0.2 dB (or dBm) of theoretical and 0.5% for non-dB solutions. The instructions for communication receiver and signal processing calculations are contained in sections VII, VIII, IX, X XI, and XII. The last four instruction pages have antenna/reflector gain curves, fixed-loss curves and tables, and echo distortion curves. Note; only the applicable sections are presented, so all sections are not present.

MICROWAVE TRANSMISSION EXAMPLES (See the instructions for C19-T operation)

Paths with Parabolic Transmitter and Receiver

I C19-T Definitions

Received Power, P_R =
(Transmitted Power [P_T]) – (Net Path Loss [NPL])
in dBm
NPL = L_P + Fixed Losses in dB
L_P = (Apparent Free - Space Loss [L_S]) –
(Antenna Gains [G_T and G_R]) in dB
Received Power, P_R = (Transmitted Power [P_T]) - (Net Path Loss [NPL]) in dBm
Received Power, P_R = (Transmitted Power, P_T) –
(L_P + Fixed Losses) in dBm
Received Power, P_R = (Transmitted Power [P_T]) + (Antenna Gains, G_P + G_R)
– (Free Space Loss [L_S] + Fixed Losses) in dBm

II Apparent Free-Space Loss, L_S in dB

f = 7.5 GHz;
Transmitter/Receiver Distance = 60 miles;
$L_S \approx$ 149.65 dB

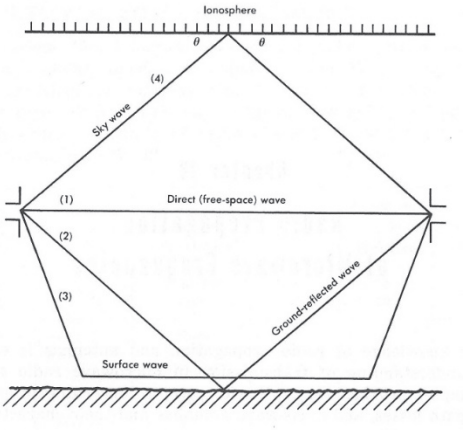


Figure 1. Transmitter and Receiver Antenna Configuration [1]

III Parabolic Far Field Antenna Gains, G_T and G_R in dB

Transmitter Diameter, D_T = Receiver Diameter, D_R = 15 feet, and f = 7.5 GHz

A) Antenna Efficiency, η = 55%;
$G_T = G_R \approx$ 48.5 dB

B) Efficiency other than 55%; η = 65%;
$G_T = G_R \approx$ 48.5 + 0.7 = 49.2 dB

The Far-Field distance, d_1 in miles, can be found from section IV with φ = 0° and AP = D^2.
$D_T = D_R$ = 15 feet; $d_1 \approx$ 0.65 miles

A Passive Reflector Gain, G_P in dB

f = 7.5 GHz, φ = 40°, H = 20 feet, W = 15 feet
(Area [AP] = 300 ft^2)
$G_P \approx$ 106.5 dB
Effective Antenna Area [AE] = 282 ft^2
B-scale Passive Far-Field Distance, d_i in miles[a]
$d_i \approx$ 0.812 miles

[a]Note; if the answer is above the right B scale index the A scale limits are 0.1/0.1/1 mile. If above the left B scale index the A scale limits are 1/10/100 miles.

IV Passive Reflector

V Net Path Loss — NPL and L_P

NPL = L_P + Fixed Losses in dB
Paths Without Passive Repeaters (see Figure 1);

P_T = 35 dBm
$L_P = LS - (G_T + G_R)$ dB
$L_P \approx 149.65 - (48.5 + 48.5) = 52.65$ dB
Net Path Loss, NPL = L_P + fixed losses ≈ 52.65 + fixed losses in dB
Received Power, P_R = (Transmitted Power, P_T) – (Net Path Loss [NPL]) in dBm
$P_R \approx 35 + 48.5 + 48.5 - 149.65 =$
- (17.65 + fixed losses) in dBm

The instructions are not useful for transmitter and receiver diameters other than 10 feet. To find the receiver power with a passive reflector use the following equation:

$P_R = P_T + G_T + G_R + G_T$ – (L_S from Transmitter to reflector + L_S from reflector to receive + fixed losses) in dBm

f = 7.5 GHz, $D_R = D_T$ = 15 feet, d_1 (from Transmitter to Passive Reflector = 60 miles), Passive Reflector H = 20 feet, W = 15 feet, $\varphi = 40^o$, d_2 (from Passive Reflector to Receiver) = 8 miles, and P_T = 35 dBm. We have solved for all but the Free-Space Loss for d_2 = 8 miles

$L_S (d_2) \approx 132.15$ dB
$P_R \approx 35 + 48.5 + 48.5 + 106.5 - (149.65 + 132.15 + \text{fixed losses}) =$ - (43.33 + fixed losses) in dBm

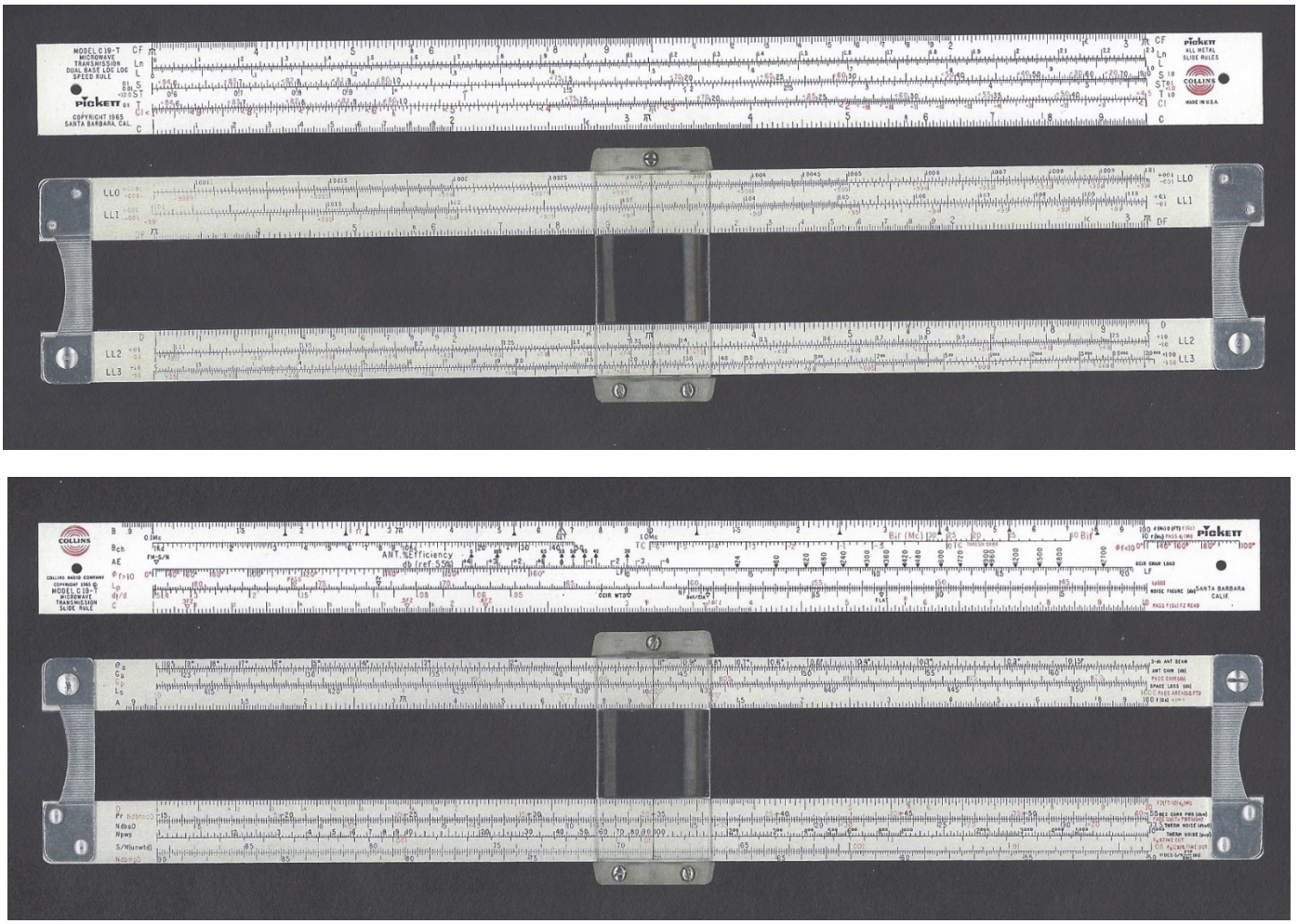


Figure 2. The Pickett C-19 (front and back)

XIII Wavelength in Free Space, λ in inches

For f = 7.5 GHz, $\lambda \approx 1.515$ inches
To determine the decimal point:
f(1 GHz to 11.808 GHz)); λ (11.808 inches to 1 inch)
f(11.808 GHz to 100GHz)); λ (1 inch to 0.11808 inches)

XIV Fresnel Zone clearance, R_f in feet

d = 60 miles, d_1 = 12 miles, f = 7.5 GHz, $R_f \approx 76.25$ feet
d_t = distance from antenna to obstruction = 12 miles
$h(K = 4/3)^b \approx 72$ feet; $h(K = 1) \approx 96$ feet; $h(K = 2/3) \approx 144$ feet

[b]Note; if the slide must be repositioned, the B scale limits are 1/10/100 feet; if not, the B scale limits are 100/1,000/100,000 feet.

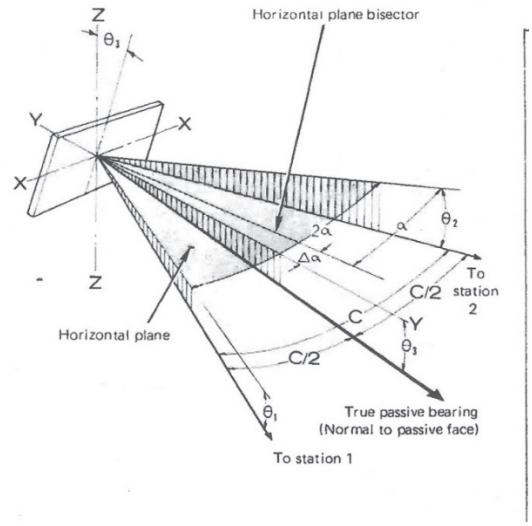


Figure 3. Passive Reflector; Stations 1 and 2 are Transmitter and Receiver; Note the angle C in the figure is our φ [2]

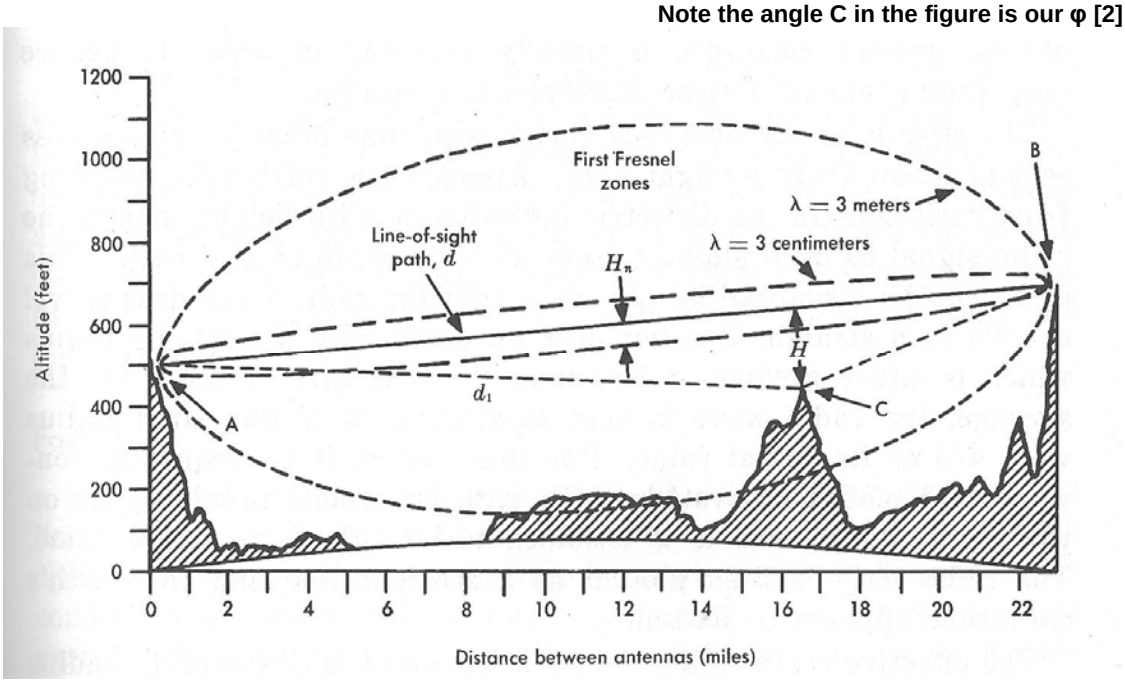
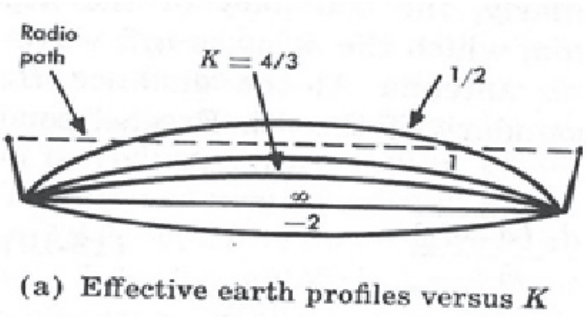


Figure 4. Fresnel Zone (H is our R_f) [1]

XV Earth Curvature



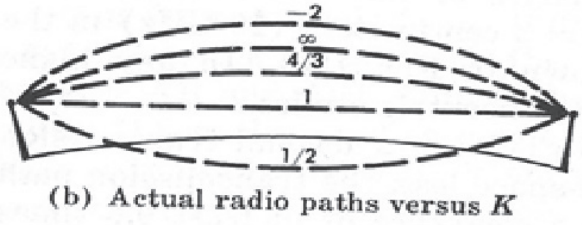


Figure 5. Earth Curvature and Antenna Height, h [1]

References

1. Bell Telephone Laboratories, *Transmission Systems for Communication*, 1964.
2. Passive Repeater Engineering, 1989. http://www.valmont.com/userfiles/file/specialty_structures/Catalog161A.pdf

Notes

1. JOS Plus indicates that supplemental material for this article is available at www.oughtred.org. This file contains the scanned C-19 slide rule instructions.