I. Basic Path Equations

A. $P_r = P_t \cdot NPL$

Where: P_r = Absolute received r-f signal level at input to the preselector filter (dbm)

P_t = Minimum r-f transmitter output power at output of Tx filter (dbm)

NPL = Net path loss (dB)

B. $NPL = L_{bs} + L_{ml} - G_{ts} + L_{ts} + G_{rs} + L_{rs}$

Where: L_{bs} = Sum of apparent free space losses (L$_p$) in db

L_{ml} = Sum of fixed losses (L$_f$) in db

L_{ts} = Path installation and maintenance margin (dB) (normally 1 db)

G_{ts} = Sum of all antenna gains (G$_p$) in db

$L_{rs} = L_{ts}$; $G_{rs} = G_{ts}$

II. Apparent Free Space Loss — L_p

(Relative to isotropic radiation)

$L_p = 96.58 + 20 \log d + 20 \log f$

Where: d = distance in miles

f = frequency in Gc

Slide Rule: Set $\frac{d}{f}$ arrow on D scale to nominal r-f frequency of path on A scale. Move hairline to path distance on D scale. Read apparent free space loss above on L_p scale.

III. For-Field Parabolic Antenna Gain, G_p and 3-db Beamwidth, θ_p

(Relative to isotropic radiation)

For VSWR, efficient antennas (apparent illumination of aperture with edges 10-db below the center of the primary pattern).

$G_p = 7.5 + 20 \log D + 20 \log f = 44.23 + 20 \log D_f$

Where: D = diameter of antenna in feet

f = frequency in Gc

Slide Rule: Set $\frac{D}{f}$ arrow on D scale to nominal r-f frequency of path on A scale. Move hairline to antenna diameter on D scale. Read for-field antenna gain for 10-db efficient antenna above on G_p scale and average of E and H plane 3-db beamwidths on θ_p scale.

(Note 1—For antenna gain relative to a ½ wave dipole, subtract 2.15 db from reading on G_p scale).
(Note 2—Standard parabolic antennas above 10-gc exhibit typical efficiencies lower than 55%).

B. For antenna efficiencies other than 55%:

$AG_{dbi} = 2.6 + 10 \log \frac{E}{100}$

Slide Rule: Set hairline to nominal r-f frequency of path on A scale. Move slide so that antenna efficiency on AE scale is under hairline. Move hairline to antenna diameter on D scale. Read for-field antenna gain above on G_p scale and average of E and H planes 3-db beamwidths on θ_p scale.

IV. For-Field Passive Repeater Gain — G_{rp}

(Relative to isotropic radiation)

$G_{rp} = 22.20 + 20 \log \frac{D}{f} + \phi_{db}$) + 40 log f

Where: ϕ = Area of passive repeater to square feet

ϕ = Included angle of passive formed by two legs of path in degrees.

Slide Rule: With the end index of the slide set to the effective area of the passive on D scale (as in the preceding calculation $10\phi_{db}$ set hairline to f in Gc on the D scale. Move if another arc D scale under hairline. $10\phi_{db}$ in miles exceeds reading on A scale opposite the end index of D scale, passive repeater is in far field.

V. Net Path Loss — NPL and L_{ts}

$NPL = -L_p + L_f + L_{ts}$

Paths without passives:

$L_p = 81.58 + 20 \log d - 20 \log f = -20 \log D_f - 20 \log \frac{D}{f}$

Paths with passive repeaters:

$L_p = 135.81 + 20 \log d + 20 \log d - 20 \log \text{ cos } \frac{\phi}{2} A_p$

$- 40 \log f - 40 \log D$

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Where: d = path or longer leg distance in miles

d_1 = shorter leg distance in miles

f = frequency in Gc

D = antenna diameter in feet (55% efficiency)

cos $\frac{\phi}{2} A_p$ = effective area of passive

A. For paths without passives:

Slide Rule: Set hairline to path distance in miles on A scale. Move ↑ in Gc on D scale under hairline if antenna scale are used move hairline to antenna diameter or feet on D scale. If passive repeater is used, set hairline to path distance in miles on the antenna diameter on D scale. Under hairline, read L_p Or for a predetermined L_p move hairline to L_p. Read on A scale the maximum product of antenna diameter, or if antennas are equal on ups, read on D scale the maximum diameter of antennas. For Net Path Loss, add fixed losses (L_f) and margin loss (L_m) to L_p

B. For paths with a passive repeater:

Slide Rule: Set hairline to path distance in miles on A scale. Move ↑ in Gc on D scale under hairline if antenna scale are used move hairline to antenna diameter or feet on D scale. If passive repeater is used, set hairline to path distance in miles on the antenna diameter on D scale. Under hairline, read L_p Or for a predetermined L_p move hairline to L_p. Read on A scale the maximum product of antenna diameters, or if antennas are equal on ups, read on D scale the maximum diameter of antennas. For Net Path Loss, add fixed losses (L_f) and margin loss (L_m) to L_p

VI. Received Carrier Power, P_r

$P_r = NPL \cdot P_t$

Where: P_t = minimum transmitter output power in dbm

Slide Rule: Set hairline to P_t power in dbm on B_{rpm} scale and move NPL in db on L_p scale under hairline. Move hairline to P_r marker on L_p scale, and read P_r below in dbm.

VII. Path Margins

A. For approximate fade margins in 3:1 for FCMR S3B systems to a noise level of 12 dnc2

Slide Rule: Set hairline to received carrier power in dbm on P scale. Move receiver noise figure in db on NF scale under hairline. Set hairline to highest channel or sole frequency in mc on B scale. For 25-mc receiver r-f bandwidth, under hairline read threshold correction in db on CT scale and reduce FMR (margin) reading on B_{rpm} scale under hairline by this correction to obtain the approximate fade margin in db. For channel frequencies lower than a 7G correction of 6 db better indicated on 6 on TC scale and reduce FMR (margin) reading on B_{rpm} scale under hairline by 6 db. Read fade margin on FMR scale under hairline.

B. To determine Thermal Noise in FCMR-S3B systems:

For 3:1 in channel bandwidths

$N_{thmr} = N_t - F_t - 20 \log \frac{f_c}{f_m} - 34.05$

Where: F_t = Receiver carrier power in dbm

N_t = Receiver Noise Figure

f_c/f_m = Channel deviation for channel CCITT.

f_c = Frequency of Channel

f_m = Assumed to be 250* (Below)

Slide Rule: As in fade margin calculations, set hairline to received carrier power in dbm on P scale, and move receiver noise figure in db on NF scale under hairline. (1) For channel bandwidths of 1:1 in and CCITT, channel deviations of 200 to 4000, set hairline to channel frequency in mc on B scale. Under hairline read channel deviation in db on CT scale. (2) For channel bandwidths of 1:1 in and CCITT, channel deviations other than 200 to 4000, set hairline to f/2 mc on B scale, and move the FMR CCITT, channel deviation in mc on B scale under hairline. Then set hairline to channel frequency in mc on B scale and read thermal noise. (3) For channel bandwidths of 2.2 kc and the a given peak r-f deviation, set hairline to 2200 channel bandwidth and move peak r-f deviation in mc on B scale under hairline. Read thermal noise in db on CT scale. (4) For channel bandwidths of 1:1 in and CCITT, channel deviations other than 200 to 4000, set hairline to channel frequency in mc on B scale and read peak r-f deviation in mc above on B scale. For channel bandwidths of 2.2 kc and CCITT, channel deviations other than 200 to 4000, slide A and B scales. Set hairline to the number of channels in 2200 channel loading scale and move C2 mc on B scale under hairline. Then set hairline to the new CCITT, channel deviation in mc on B scale, and read peak r-f deviation in mc above on B scale.

VIII. Video Signal/Noise, $\frac{PTP}{RMS}$

Video S/N $\frac{PTP}{RMS}$ (rms) = 105.17 = $P_r - N_t + 20 \log \Delta f$

Video S/N $\frac{PTP}{RMS}$ (rms) = 118.17 = $P_r - N_t + 20 \log \Delta f$

Where: P_r = Received carrier power in dbm

N_t = Receiver noise figure in db

Δf = peak r-f deviation in mc

Assumptions: Repetitive is 280* Kohler, video bandwidth is tested to 4.5 mc, and the weighting network improvement is 13 db.

Slide Rule: Set hairline to received carrier power in dbm on P_r scale, and move receiver noise figure in db on NF scale under hairline. For peak r-f deviations of 4 mc, set hairline to $\frac{PTP}{RMS}$ marker and read unweighted video S/N on S/N scale, or set hairline to $\frac{PTP}{RMS}$ marker and read weighted

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IX. FSMR-S3B Circuit Noise and Signal/Noise

Noise in a multiplex channel on a microwave system in picowatts, psophometric weighting, can be determined as follows:

$N = 3N_t + N_{ts} + N_{rs} + N_{ts} (N_{rs} + N_{ts}) + 3N_{mm} + 3N_{ts}$

$+ N_{ts} + N_{mm}$

Where: $3N_t$ = sum of noise thermal noise of each path of system at highest channel of sole frequency

N_{ts} = Number of baseband r-f terminal pairs in tandem-path system

N_{rs} = Number of tandem repeaters

N_{mm} = Radio intermodulation noise in calculated slot

N_{ts} = Radio baseband intrinsic noise in calculated slot

$3N_{mm}$ = sum of intermodulation noise noises of each antenna feeder line of all tandem paths in system.

$3N_{ts}$ = sum of r-f interference noise for each path of system.

N_{rs} = Noise contribution of baseband coupling and baseband amplifier equipment.

N_{mm} = Noise contribution of multiplex equipment.

Slide Rule: Set hairline to arithmetic sum of system noise sources in dbrnc2 on appropriate scale. Move hairline to N_{mm} scale. Read noise in dbnc2. Fill weighting in N_{mm} scale. For diversity systems, reduce N_{mm} reading by 1 db for minimum diversity improvement.

A. Conversion of Noise Units for Flat Noise Across 3.1 kc Bandwidth:

$N_{dbnc2} = 5.5 + 10 \log PWP$

$S/N = 82 - N_{dbnc2}$(dB avg)

N_{dbnc2}(average avg) = N_{dbnc2} - 5.5

(Note — 5.5 db conversion is commonly rounded off to 5 db)

$S/N = 88.5 - N_{dbnc2}$

$S/N = 90 - 0NR$ — NLR

Where: 0NR = noise power ratio

0NR = bandwidth ratio — baseband modulation bandwidth / audio bandwidth

NLR = CCIR noise level ratio — 1:1 = 0 log N for N ≥ 240 channels — 1:1 = 4 log N for N < 240 channels

Slide Rule: Read NLR on LT scale for number of channels on CCIR channel loading scale.

B. To determine Thermal Noise in FSMR-S3B systems:

For 3:1 in channel bandwidths

$N_{thmr} = N_t - F_t - 20 \log \frac{f_c}{f_m} - 34.05$

Where: F_t = Receiver carrier power in dbm

N_t = Receiver Noise Figure

f_c/f_m = Channel deviation for channel CCITT.

f_c = Frequency of Channel

f_m = Assumed to be 250* Below)

Slide Rule: As in fade margin calculations, set hairline to received carrier power in dbm on P scale, and move receiver noise figure in db on NF scale under hairline. (1) For channel bandwidths of 1:1 in and CCITT, channel deviations of 200 to 4000, set hairline to channel frequency in mc on B scale. Under hairline read channel deviation in db on CT scale. (2) For channel bandwidths of 1:1 in and CCITT, channel deviations other than 200 to 4000, set hairline to f/2 mc on B scale, and move the FMR CCITT, channel deviation in mc on B scale under hairline. Then set hairline to channel frequency in mc on B scale and read thermal noise. (3) For channel bandwidths of 2.2 kc and the a given peak r-f deviation, set hairline to 2200 channel bandwidth and move peak r-f deviation in mc on B scale under hairline. Read thermal noise in db on CT scale. (4) For channel bandwidths of 1:1 in and CCITT, channel deviations other than 200 to 4000, set hairline to channel frequency in mc on B scale and read peak r-f deviation in mc above on B scale. For channel bandwidths of 2.2 kc and CCITT, channel deviations other than 200 to 4000, slide A and B scales. Set hairline to the number of channels in 2200 channel loading scale and move C2 mc on B scale under hairline. Then set hairline to the new CCITT, channel deviation in mc on B scale, and read peak r-f deviation in mc above on B scale.

X. Video Signal/Noise, $\frac{PTP}{RMS}$

Video S/N $\frac{PTP}{RMS}$ (std) = 105.17 = $P_r - N_t + 20 \log \Delta f$

Video S/N $\frac{PTP}{RMS}$ (std) = 118.17 = $P_r - N_t + 20 \log \Delta f$

Where: P_r = Received carrier power in dbm

N_t = Receiver noise figure in db

Δf = peak r-f deviation in mc

Assumptions: Repetitive is 280* Kohler, video bandwidth is tested to 4.5 mc, and the weighting network improvement is 13 db.

Slide Rule: Set hairline to received carrier power in dbm on P_r scale, and move receiver noise figure in db on NF scale under hairline. For peak r-f deviations of 4 mc, set hairline to $\frac{PTP}{RMS}$ marker and read unweighted video S/N on S/N scale, or set hairline to $\frac{PTP}{RMS}$ marker and read weighted

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video S/N on V — S/N scale. These readings must be corrected for baseband noise contributions. Note the picowatts under hairline on N_{mm} scale. Set hairline to L/N baseband noise level (L/N is about 22 db when ur 60 db flat) and add the picowatts under hairline on N_{mm} scale to the picowatts previously noted. Set hairline to the new picowatts sum on N_{mm} scale and read corrected video S/N on V-S/N scale. For peak r-f deviations other than 4-mc, set hairline to $\frac{PTP}{RMS}$ marker, and move peak r-f deviation in mc on D scale under hairline. Then set hairline to $\frac{PTP}{RMS}$ marker and read video S/N on V-S/N scale.

XI. 15-Ga FM Program Channel Signal/Noise

S/N = 164.91 + P_r - 20 log $\frac{\Delta f}{f}$

Where: S/N = signal/noise in db at 15-Ga FM program channel without emphasis using CITC audio deviation of ±75 kc, set including back-to-back program channel noise.

P_r = Received carrier power in dbm

N_t = Receiver noise figure

Δf = Program channel subcarrier peak deviation of microwave at mc (usually ½ of video peak deviation)

f_m = Frequency in mc of program channel subcarrier

Slide Rule: Set hairline to received carrier power in dbm on P_r scale and move receiver noise figure on NF scale under hairline. Set hairline to program channel subcarrier frequency in mc on B scale. Under hairline read channel deviation in db on CT scale. Add to this reading the constant 164.91 db. Add 22 db to this reading for standard 25-mc second pre-emphasis improvement. This answer must be corrected for BW noise and back-to-back program channel noise which places a limit at 40 S/N of approximately 55 db. Add to the above reading the 40 S/N correction (from the S/N calculated value (including emphasis improvement) and the S/N limit value. Convert the sum of the picowatts on N_{mm} scale back to S/N on the 0db S/N scale for corrected program channel signal/noise.

XII. Wavelength in Free Space

$\lambda = \frac{11.808}{f}$

Where: λ = Wavelength in inches

f = frequency in gc

Slide Rule: Set hairline to λ marker on B scale. Move f in gc on C scale under hairline and read wavelength in inches on D scale under index of slide.

XIII. Fresnel Zone

$R_1 = 72.1 \sqrt{\frac{d_1 (d - d_1)}{fd}}$

Where: R_1 = radius of first Fresnel Zone in feet

d = total path length in miles

d_1 = shortest distance from end of path to obstruction in miles

f = frequency in gc

Slide Rule: Set hairline to path length in miles on A scale, and move frequency in gc on B scale under hairline. Set hairline to $\frac{d_1}{d}$ marker for 1st Fresnel Zone radius, to $\frac{0.57 d_1}{d}$ marker for 0.6 first Fresnel Zone radius, to "U" marker for 0.5 first Fresnel Zone radius, to $\frac{0.3 d_1}{d}$ marker for 0.3 first Fresnel Zone radius, to "U" marker for 0.1 first Fresnel Zone radius. Read R_1 in feet on D scale under hairline and read wavelength in inches on D scale under index of slide.

XIV. Earth Curvature

$h = \frac{2 Nd_1}{3.2}$

Where: h = elevation of terminal antenna in feet required above obstacle elevation for line-of-sight clearance of earth curvature determined by tangential ray at obstacle

d_1 = distance in miles from terminal to obstacle.

N = earth radius factor (normally calculations are made for N = 1 and 4/3 first Fresnel Zone radius)

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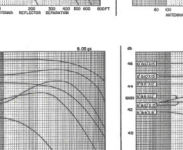
Fixed Losses

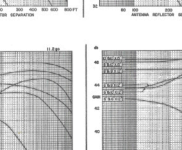
¼" Coaxial Air Dielectric-Flexible — 1.5 db per 100' at 2 gc

1¾" Coaxial Air Dielectric-Flexible — 1.1 db per 100' at 2 gc

Flexible rectangular waveguide (Multiply equivalent rigid rectangular losses in db by 3.

	30-Ga gc	15-Ga gc	10-Ga gc	10-Ga gc
Rectangular waveguide WR-75 loss per 100'	5.7 db	1.6 db	0.8 db	0.4 db
Rotax waveguide CW-107 loss per 100'	3.6 db	1.1 db	1.2 db	—
	3.7 db/gc		4 - 6 gc	10 - 12 gc
4 & 6 Foot Radome Loss	3.4 db		0.55 db	1.2 db
8 Foot Radome Loss	8.4 db		0.60 db	1.2 db
10 Foot Radome Loss	8.0 db		0.8 db	1.2 db
Aperture Radome Loss for Directed Antennas	0.1 db		0.1 db	0.2 db
Circulator Forward Loss Between Ports	0.5 db		0.5 db	0.5 db





FSM-S3B NOISE MEASUREMENT FREQUENCIES

No. of Channels	Band Limits High Pass	Low Pass	In Band Data Lowest	Center	Highest
24	12 kc	200 kc	60 kc	30 kc	305 kc
60	12 kc	252 kc	60 kc	155 kc	245 kc
60	60 kc	300 kc	300 kc	305 kc	295 kc
120	60 kc	552 kc	300 kc	315 kc	534 kc
240	60 kc	1,052 kc	300 kc	554 kc	1,052 kc
300	60 kc	1,300 kc	300 kc	554 kc	1,240 kc
600	60 kc	2,600 kc*	300 kc	1,240 kc	2,600 kc
960	60 kc	4,028 kc	300 kc	2,430 kc	3,890 kc
960	315 kc	4,188 kc	534 kc	2,430 kc	3,890 kc
1,200	315 kc	5,556 kc	534 kc	3,890 kc	5,340 kc
1,800	315 kc	8,256 kc	534 kc	3,890 kc	8,002 kc
2,700	315 kc	12,000 kc	534 kc	3,890 kc	12,130 kc

*Note — Highest modulation frequency for 600 channels is 2540 kc in CCITT systems and 2700 kc in WECO 1-600 systems.

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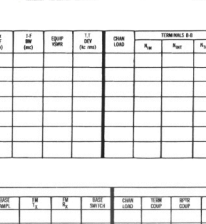
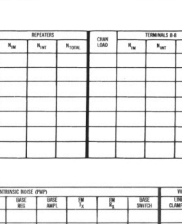
Echo Distortion

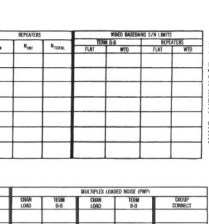
Echo distortion curves are in db. S/N that weighted and noise, dbnC. To convert for other footer losses, use weegrade loss chart to determine differences in footer loss from the weegrade used in the curve (multiply by two to allow for complete travel of echo signal). If the footer loss is lower, add this difference from the echo noise of the curve. If the footer loss is higher, subtract this difference from the echo noise of curves.

Echo curves are based on antenna and equipment VSWR's of 1.1:1. For other VSWR's, add or subtract the following corrections:

	1.05:1	1.05:1	2:1
Equipment VSWR	1.05:1	1.05:1	2:1
Antenna VSWR	1.1:1	1.15:1	1.15:1
Correction Factor	−4 db	−3 db	+22 db







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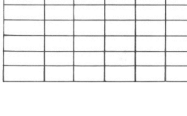

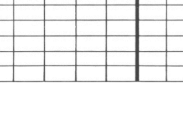

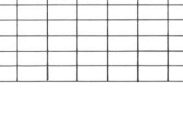

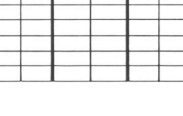

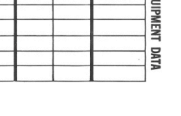

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SUPPLIER	EQUIP. TYPE	FREQ. BAND (Gc)	% OUT PWR (dbm)	% FREQ. STAB %	fo MC (db)	LF BW (mc)	EQUIP VSWR	LT DEV (%-mc)	CHAN LOAD	TERMINALS B-B N_{dB}	N_{dbC}	REPEATERS N_{dB}	N_{dbC}	N_{TOTAL}	CHAN LOAD	TERMINALS B-B N_{dB}	N_{dbC}	REPEATERS N_{dB}	N_{dbC}	N_{TOTAL}	VIDEO BASEBAND S/N (-MRTS) TERM B-B FLAT	WTD	REPEATERS FLAT	WTD

SUPPLIER	CHAN LOAD	TERM COUP	REPTR COUP	TERM BAND (Gc)	SAMPLE REG	SAMPLE AMPL	FM f_c	FM f_d	DIST SWITCH	CHAN LOAD	TERM COUP	REPTR COUP	CCIR BANDS	SAMPLE REG	SAMPLE AMPL	FM f_c	FM f_d	DIST SWITCH	CHAN LOAD	TERM COUP	REPTR COUP	CCIR BANDS	SAMPLE REG	SAMPLE AMPL	FM f_c	FM f_d	DIST SWITCH	CHAN LOAD	TERM B-B	GROUP CONNECT