Key Equations:

1. $c = \lambda F \sqrt{\in}$

2. $\lambda = \dfrac{c}{F\sqrt{\in}}$

3. $F = \dfrac{c}{\lambda\sqrt{\in}}$

4. $T = \dfrac{1}{F}$

5. $\delta = \sqrt{\dfrac{1}{2\pi F \sigma \mu}}$

Microwave Transmission Lines:

6. Impedance inversion in a quarter-wavelength shorted stub: $\dfrac{Z}{Z_o} = \dfrac{Z_o}{Z_L}$

7. Characteristic impedance for a quarter-wavelength Q section: $Z_o = \sqrt{ZZ_L}$

8. VSWR:
   From incident voltage (Vi) and reflected voltage (Vr): $VSWR = \dfrac{V_i + V_r}{V_i - V_r}$

9. Length of a transmission line as a function of reflection transit time: $L_{meters} = \dfrac{c\upsilon T_d}{2}$

10. Impedance looking in to a transmission line:
    (a) ZL is not equal to Zo in a random-length lossy line: $Z = Z_o \dfrac{Z_L + Z_o \tan(\gamma l)}{Z_o + Z_L \tan(\gamma l)}$

    (b) Half-wavelength lossy lines: $Z_o = \dfrac{276}{\sqrt{\varepsilon}} \log \dfrac{2S}{d}$

11. Characteristic impedance of transmission lines:
    (a) Parallel line:
    $$Z_o = \frac{276}{\sqrt{\varepsilon}} \log \frac{2S}{d}$$
    (b) Coaxial line:
    $$Z_o = \frac{138}{\sqrt{\varepsilon}} \log \frac{D}{d}$$
    (c) Stripline:
    $$Z_o = \frac{377}{\sqrt{\varepsilon}} \frac{T}{W}$$

12. Transmission line impedance as a function of voltage and current: $Z_L = \dfrac{V_{inc} + V_{ref}}{I_{inc} + I_{ref}}$

13. Characteristic impedance of a lossy line: $\sqrt{\frac{R + j\omega L}{G + j\omega C}}$

14. Dielectric constant as a function of velocity: $\varepsilon = \frac{1}{\upsilon^2}$

15. Cutoff wavelength: $\lambda_c = \frac{2}{\sqrt{(m/a)^2 (n/b)^2}}$

16. Propagation constant as a function of frequency: $\beta = \omega\sqrt{\varepsilon\mu} \quad \sqrt{1 - \left(\frac{F_c}{F}\right)^2}$

Waveguides:

17. Group velocity in a waveguide: $V_g = c \sin a$

18. Relationship between frequency and free-space wavelength: $c = F\lambda_o$

19. Wavelength in a waveguide: $\lambda = \frac{V_p \lambda_o}{c}$

20. Cutoff wavelength: $\lambda = 2a$

21. Cutoff frequency: $F_c = \frac{C}{2a}$

22. Complex impedance: $Z = R \pm jX$

23. Normalized impedance: $Z = \frac{R \pm jX}{Z_o}$

24. Power reflection coefficient: $P_{pwr} = P^2$

25. VSWR as a function of reflection coefficient: $VSWR = \frac{1+P}{1-P}$

26. Return loss as a function of VSWR: $Loss_{ret} = 10\log(P_{pwr})$

27. General mode equation for resonant cavity: $F_r = \frac{c}{2(\mu\varepsilon)}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2 = \left(\frac{P}{d}\right)^2}$

28. Mode equation for air dielectric: $F_r = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2 = \left(\frac{P}{d}\right)^2}$

29. Quality factor Q of a resonant circuit: $Q_0 = \frac{2\pi\ U_s}{U_d}$

Microwave Antennas:

30. Shape factor: $SF = \frac{F2 - F1}{F_H - F_L}$

31. Q of a filter: $Q = \frac{F_c}{BW_{3dB}}$

32. Cutoff frequency of a waveguide feeding dish antenna: $f_{cutoff} = \frac{175{,}698}{d_{mm}}$

33. Gain of a parabolic dish antenna: $G = \frac{k(\pi D)^2}{\lambda^2}$

34. Focal length of parabolic dish antenna: $f = \frac{D^2}{16d}$

35. Antenna directivity as a function of power densities: $D = \frac{P_{\max}}{P_{av}}$

36. Directivity gain of an antenna: $G_d = \frac{4\pi P_a}{P_r}$

37. Power gain of an antenna: $G_p = \frac{4\pi P_a}{P_n}$

38. Relationship between directivity gain and power gain: $G_p = \frac{P_r G_d}{P_n}$

39. Gain of a horn radiator: $G = \frac{10A}{\lambda^2}$

40. Alternate notations for impedance in ac circuits: $Z = \sqrt{R^2 + \left(X_L - Xc^2\right)}$

41. Efficiency factor of an antenna comparing resistances: $k = \dfrac{R_r}{R_r + R_o}$

Microwave Transistors:

42. Power-frequency limit: $\dfrac{\sqrt{P_{\max} X_{co}}}{2\pi (l/\upsilon)} = \dfrac{E_{\max} V_s}{2\pi}$

43. Maximum gain: $G_{\max} = \sqrt{\dfrac{F_t}{F}} \dfrac{Z_o}{Z_{in}}$

Discrete Microwave Amplifiers:

44. Gain of a parametric amplifier: $G = f_i / f_s$

45. Noise in a parametric amplifier: $F_{noise} = \dfrac{R_a}{R1} + \dfrac{f_s}{f_i}$

46. Manley-Rowe relationship for parametric amplifiers: $\sum_{m,n} \dfrac{mP_{m,n}}{mf_p + nf_s} = 0$

47. Noise figure as a function of noise factor: $NF = 10 \log F_n$

48. Noise temperature as a function of noise factor: $T_e = (F_n - 1)T_0$

49. Noise temperature as a function of noise figure: $T_e = \left[anti \log\left(\dfrac{NF}{10}\right) - 1 \right] KT_0$

50. Total noise in a system: $P_{n(total)} = GKB(T_o + T_e)$

51. Noise factor of amplifiers in cascade: $F_n = F_1 + \dfrac{F_2 - 1}{G1} + \dfrac{F_3 - 1}{G1G2} + \text{K} + \dfrac{F_n - 1}{G1G2\,\text{K}\;G_{n-1}}$

52. Characteristic impedance required of a quarter-wave Q-section transformer:

$$Z_o = \sqrt{R_i \times R_o}$$

Hybrid and Monolithic Microwave Integrated Circuit Amplifiers:

53. Noise power: $P_n = KTB$

54. Noise factor as a function of SNR: $F_n = \frac{SNR_{in}}{SNR_{out}}$

55. Noise factor as a function of output noise power: $F_n = \frac{P_{no}}{KT_0BG}$

56. Component values in the LC version of the Wilkinson power divider:

$$R = 2Z_o$$

$$L = \frac{70.7}{2\pi F_o}$$

$$C = \frac{1}{2\pi 70.7 F_o}$$

57. Physical length of a quarter-wavelength coaxial cable section: $L = \frac{2952V}{F}$

58. Impedance required of a quarter-wavelength Q matching section: $Z'_o = \sqrt{Z_L Z_O}$

59. Characteristic impedance of a stripline section: $Z_o = 377\frac{h}{w\sqrt{\varepsilon}}$

60. Input/output impedance of MIC internal amplifier: $R_o = \sqrt{R_f \times R_e}$

61. Gain in MIC internal amplifier: $G_{dB} = 20 \log\left[\frac{R_f - R_e}{R_o = R_e}\right]$

62. Gain in a cascade amplifier: $G = G1 \times G2 \times G3 \times \mathsf{K} \times Gn$

63. Mismatch loss due to SWR in a single-stage amplifier: $ML = -10 \log\left[1 - \left(\frac{SWR-1}{SWR+1}\right)^2\right]$

64. Noise figure of a cascade amplifier: $NF_{total} = NF1 + \frac{NF2-1}{G1} + \frac{NF3-1}{G1G2} + \mathsf{K} + \frac{NFn-1}{G1G2Gn}$

Microwave Diodes:

65. Tunnel diode frequencies - self-resonant frequency: $F_s = \frac{1}{2\pi}\sqrt{\frac{1}{L_s C_j} - \frac{1}{(RC_j)^2}}$

Microwave Diode Generators:

66. Electron transit time in a Gunn diode: $T_t = \frac{L}{V_\delta}$

67. Operating frequency in the Gunn or transit-time mode: $F_o = \frac{V_{dom}}{L_{eff}}$

68. Criterion for LSA oscillation: $-G \geq G_o$

69. Output power from a Gunn diode: $P_o = n(MV_{th}L)(N_o eVA)$

Transmitters:

70. Output frequency of a multiplier: $F2 = N \times F1$

71. Friis's transmission equation: $\frac{P_r}{P_t} = \frac{G_t G_r \lambda^2}{(4\pi d)^2}$

72. Friis's equation in decibel form: $10 \log \frac{P_r}{P_t} = G_{t(dB)} + G_{r(dB)} + 10 \log\left(\frac{\lambda}{4\pi d}\right)^2$

73. Spreading loss in satellite communications: $L = 33\,dB + [20 \log (d_{km})] + [20 \log (F_{MHZ})]$

74. Total noise in system: $T_{total} = T_{eq(rcvr)} + T_{eq(ant)}$