Important Special Antennas Formulas PDF

Formulas
Examples
with Units

List of 34
Important Special Antennas Formulas

1) Array Antennas Formulas

1.1) Beam Width between First Null (BWFN) Broadside Array Formula

Evaluate Formula

Formula

$$BWFN = \frac{2 \cdot \lambda_b}{d \cdot N}$$

Example with Units

$$171.9064° = \frac{2 \cdot 90.01\,\text{m}}{10\,\text{m} \cdot 6}$$

1.2) Beam Width between First Null (BWFN) Endside Array Formula

Evaluate Formula

Formula

$$BW_{end} = 2 \cdot \sqrt{\frac{2 \cdot \lambda_b}{N \cdot d}}$$

Example with Units

$$198.4894° = 2 \cdot \sqrt{\frac{2 \cdot 90.01\,\text{m}}{6 \cdot 10\,\text{m}}}$$

1.3) Field Pattern of Broadside Array Formula

Evaluate Formula

Formula

$$E = \cos\left(\pi \cdot \frac{\cos\left(\Phi_s\right)}{2}\right)$$

Example with Units

$$0.9762 = \cos\left(3.1416 \cdot \frac{\cos\left(278°\right)}{2}\right)$$

2) Helical Antennas Formulas

2.1) Axial Ratio of Helical Antenna Formula

Evaluate Formula

Formula

$$AR = \frac{\left(2 \cdot n\right) + 1}{2 \cdot n}$$

Example

$$1.0832 = \frac{\left(2 \cdot 6.01\right) + 1}{2 \cdot 6.01}$$

2.2) Beam Width between First Null (BWFN) of Helical Antenna Formula

Evaluate Formula

Formula

$$BW_{fn} = 115 \cdot \frac{C_\lambda^{\frac{3}{2}}}{C \cdot \sqrt{S \cdot n}}$$

Example with Units

$$220.6484° = 115 \cdot \frac{0.8\,\text{m}^{\frac{3}{2}}}{1.467\,\text{m} \cdot \sqrt{35.3\,\text{m} \cdot 6.01}}$$

2.3) Gain of Helical Antenna Formula

Evaluate Formula

Formula

$$G_a = 11.8 + 10 \cdot \log10\left(C_\lambda^{\,2} \cdot n \cdot S \right)$$

Example with Units

$$33.1283\,\text{dB} = 11.8 + 10 \cdot \log10\left(0.8\,\text{m}^{\,2} \cdot 6.01 \cdot 35.3\,\text{m} \right)$$

2.4) Half-Power Beamwidth of Helical Antenna Formula

Evaluate Formula

Formula

$$B_{hp} = \frac{52}{C_\lambda \cdot \sqrt{n \cdot S}}$$

Example with Units

$$255.6886° = \frac{52}{0.8\,\text{m} \cdot \sqrt{6.01 \cdot 35.3\,\text{m}}}$$

2.5) Helix Circumference of Helical Antenna Formula

Evaluate Formula

Formula

$$C_\lambda = \frac{Z_h}{140}$$

Example with Units

$$0.8\,\text{m} = \frac{112\,\Omega}{140}$$

2.6) Input Impedance of Helical Antenna Formula

Evaluate Formula

Formula

$$Z_h = 140 \cdot C_\lambda$$

Example with Units

$$112\,\Omega = 140 \cdot 0.8\,\text{m}$$

2.7) Pitch Angle of Helical Antenna Formula

Evaluate Formula

Formula

$$\alpha = \arctan\left(\frac{S}{\pi \cdot H_d} \right)$$

Example with Units

$$48.3034° = \arctan\left(\frac{35.3\,\text{m}}{3.1416 \cdot 10.01\,\text{m}} \right)$$

3) Loop Antennas Formulas

3.1) Directivity of Large Loop Formula

Evaluate Formula

Formula

$$D = 4.25 \cdot \frac{a}{\lambda_a}$$

Example with Units

$$0.3777 = 4.25 \cdot \frac{8\,\text{m}^2}{90.011\,\text{m}}$$

3.2) Efficiency Factor of Loop Antenna Formula

Evaluate Formula

Formula

$$K = \frac{R_{small}}{R_{small} + R_L}$$

Example with Units

$$0.0256 = \frac{0.0118\,\Omega}{0.0118\,\Omega + 0.45\,\Omega}$$

3.3) Isotropic Radiation Intensity for Loop Antenna Formula

Evaluate Formula

Formula

$$U_{ir} = \frac{U_r}{A_g}$$

Example with Units

$$0.09\,\text{W/sr} = \frac{27.01\,\text{W/sr}}{300.01\,\text{dB}}$$

3.4) Quality Factor of Loop Antenna Formula

Evaluate Formula

Formula

$$Q = \frac{X_L}{2 \cdot \left(R_L + R_{small} \right)}$$

Example with Units

$$0.3573 = \frac{0.33\,\Omega}{2 \cdot \left(0.45\,\Omega + 0.0118\,\Omega \right)}$$

3.5) Radiation Resistance of Large Loop Formula

Evaluate Formula

Formula

$$R_{large} = 3720 \cdot \frac{a}{\lambda_a}$$

Example with Units

$$330.6263\,\Omega = 3720 \cdot \frac{8\,\text{m}^2}{90.011\,\text{m}}$$

3.6) Radiation Resistance of Small Loop Formula

Evaluate Formula

Formula

$$R_{small} = 31200 \cdot \frac{A^2}{\lambda_a^4}$$

Example with Units

$$0.0119\,\Omega = 31200 \cdot \frac{5\,\text{m}^{2\,2}}{90.011\,\text{m}^4}$$

3.7) Size of Small Loop Formula

Evaluate Formula

Formula

$$L = \frac{\lambda_a}{10}$$

Example with Units

$$9.0011\,\text{m} = \frac{90.011\,\text{m}}{10}$$

3.8) Terminal Resistance of Loop Antenna Formula

Evaluate Formula

Formula

$$R_t = R_L + R_{small}$$

Example with Units

$$0.4618\,\Omega = 0.45\,\Omega + 0.0118\,\Omega$$

4) Microstrip Antenna Formulas

4.1) Actual Length of Microstrip Patch Formula

Evaluate Formula

Formula

$$L_p = L_{eff} - 2 \cdot \Delta L$$

Example with Units

$$29.454\,\text{mm} = 30.90426103\,\text{mm} - 2 \cdot 0.7251475831\,\text{mm}$$

4.2) Effective Dielectric Constant of Substrate Formula

Evaluate Formula

Formula

$$E_{eff} = \frac{E_r + 1}{2} + \left(\frac{E_r - 1}{2}\right) \cdot \left(\frac{1}{\sqrt{1 + 12 \cdot \left(\frac{h}{W_p}\right)}}\right)$$

Example with Units

$$4.0901 = \frac{4.4 + 1}{2} + \left(\frac{4.4 - 1}{2}\right) \cdot \left(\frac{1}{\sqrt{1 + 12 \cdot \left(\frac{1.57\,\text{mm}}{38.01\,\text{mm}}\right)}}\right)$$

4.3) Effective Length of Patch Formula

Evaluate Formula

Formula

$$L_{eff} = \frac{[c]}{2 \cdot f_{res} \cdot \left(\sqrt{E_{eff}}\right)}$$

Example with Units

$$30.8827\,\text{mm} = \frac{3E{+}8\,\text{m/s}}{2 \cdot 2.4\,\text{GHz} \cdot \left(\sqrt{4.09005704}\right)}$$

4.4) Effective Radius of Circular Microstrip Patch Formula

Evaluate Formula

Formula

$$a_{eff} = a_c \cdot \left(1 + \left(\frac{2 \cdot h_o}{\pi \cdot a_c \cdot E_r}\right) \cdot \left(\ln\left(\frac{\pi \cdot a_c}{2 \cdot h_o} + 1.7726\right)\right)\right)^{0.5}$$

Example with Units

$$174.6228\,\text{cm} = 174.538\,\text{cm} \cdot \left(1 + \left(\frac{2 \cdot 0.157\,\text{cm}}{3.1416 \cdot 174.538\,\text{cm} \cdot 4.4}\right) \cdot \left(\ln\left(\frac{3.1416 \cdot 174.538\,\text{cm}}{2 \cdot 0.157\,\text{cm}} + 1.7726\right)\right)\right)^{0.5}$$

4.5) Height of Equilateral Triangular Patch Formula

Evaluate Formula

Formula

$$H = \sqrt{S_{tng}^{\,2} - \left(\frac{S_{tng}}{2}\right)^2}$$

Example with Units

$$34.4051\,\text{mm} = \sqrt{39.7276\,\text{mm}^{\,2} - \left(\frac{39.7276\,\text{mm}}{2}\right)^2}$$

4.6) Length Extention of Patch Formula

Evaluate Formula

Formula

$$\Delta L = 0.412 \cdot h \cdot \left(\frac{\left(E_{eff} + 0.3 \right) \cdot \left(\frac{W_p}{h} + 0.264 \right)}{\left(E_{eff} - 0.264 \right) \cdot \left(\frac{W_p}{h} + 0.8 \right)} \right)$$

Example with Units

$$0.7263\,\text{mm} = 0.412 \cdot 1.57\,\text{mm} \cdot \left(\frac{\left(4.09005704 + 0.3 \right) \cdot \left(\frac{38.01\,\text{mm}}{1.57\,\text{mm}} + 0.264 \right)}{\left(4.09005704 - 0.264 \right) \cdot \left(\frac{38.01\,\text{mm}}{1.57\,\text{mm}} + 0.8 \right)} \right)$$

4.7) Length of Ground Plate Formula

Evaluate Formula

Formula

$$L_{gnd} = 6 \cdot h + L_p$$

Example with Units

$$38.85\,\text{mm} = 6 \cdot 1.57\,\text{mm} + 29.43\,\text{mm}$$

4.8) Normalized Wavenumber Formula

Evaluate Formula

Formula

$$F_n = \frac{8.791 \cdot 10^9}{f_{res} \cdot \sqrt{E_r}}$$

Example with Units

$$1.7462 = \frac{8.791 \cdot 10^9}{2.4\,\text{GHz} \cdot \sqrt{4.4}}$$

4.9) Physical Radius of Circular Microstrip Patch Formula

Evaluate Formula

Formula

$$a_c = \frac{F_n}{\left(1 + \left(2 \cdot \frac{h_o}{\pi \cdot F_n \cdot E_r} \right) \cdot \left(\ln\left(\pi \cdot \frac{F_n}{2 \cdot h_o} + 1.7726 \right) \right) \right)^{\frac{1}{2}}}$$

Example with Units

$$174.538\,\text{cm} = \frac{1.746227005}{\left(1 + \left(2 \cdot \frac{0.157\,\text{cm}}{3.1416 \cdot 1.746227005 \cdot 4.4} \right) \cdot \left(\ln\left(3.1416 \cdot \frac{1.746227005}{2 \cdot 0.157\,\text{cm}} + 1.7726 \right) \right) \right)^{\frac{1}{2}}}$$

4.10) Radiation Resistance of Infinitesimal Dipole Formula

Evaluate Formula

Formula

$$R_{isd} = 80 \cdot \pi^2 \cdot \left(\frac{l_{isd}}{\lambda_{isd}} \right)^2$$

Example with Units

$$0.3159\,\Omega = 80 \cdot 3.1416^2 \cdot \left(\frac{0.0024987\,\text{m}}{0.12491352\,\text{m}} \right)^2$$

4.11) Resonating Frequency of Equilateral Triangular Patch Formula

Evaluate Formula

Formula

$$f_r = 2 \cdot \frac{[c]}{3 \cdot S_{tng} \cdot \sqrt{E_r}}$$

Example with Units

$$2.3983\,\text{GHz} = 2 \cdot \frac{3E{+}8\,\text{m/s}}{3 \cdot 39.7276\,\text{mm} \cdot \sqrt{4.4}}$$

4.12) Resonating Frequency of Microstrip Antenna Formula

Evaluate Formula

Formula

$$f_r = \frac{[c]}{2 \cdot L_{eff} \cdot \sqrt{E_{eff}}}$$

Example with Units

$$2.3983\,\text{GHz} = \frac{3E{+}8\,\text{m/s}}{2 \cdot 30.90426103\,\text{mm} \cdot \sqrt{4.09005704}}$$

4.13) Side Length of Equilateral Triangular Patch Formula

Evaluate Formula

Formula

$$S_{tng} = 2 \cdot \frac{[c]}{3 \cdot f_{res} \cdot \sqrt{E_r}}$$

Example with Units

$$39.7001\,\text{mm} = 2 \cdot \frac{3E{+}8\,\text{m/s}}{3 \cdot 2.4\,\text{GHz} \cdot \sqrt{4.4}}$$

4.14) Side Length of Hexagonal Patch Formula

Evaluate Formula

Formula

$$S_{hex} = \frac{\sqrt{2 \cdot \pi \cdot a_{eff}}}{\sqrt{5.1962}}$$

Example with Units

$$192.1471\,\text{mm} = \frac{\sqrt{2 \cdot 3.1416 \cdot 17.47378\,\text{cm}}}{\sqrt{5.1962}}$$

4.15) Width of Ground Plate Formula

Evaluate Formula

Formula

$$W_{gnd} = 6 \cdot h + W_p$$

Example with Units

$$47.43\,\text{mm} = 6 \cdot 1.57\,\text{mm} + 38.01\,\text{mm}$$

4.16) Width of Microstrip Patch Formula

Evaluate Formula

Formula

$$W_p = \frac{[c]}{2 \cdot f_{res} \cdot \left(\sqrt{\frac{E_r + 1}{2}}\right)}$$

Example with Units

$$38.01\,\text{mm} = \frac{3E{+}8\,\text{m/s}}{2 \cdot 2.4\,\text{GHz} \cdot \left(\sqrt{\frac{4.4 + 1}{2}}\right)}$$

Variables used in list of Special Antennas Formulas above

- **a** Area of Large Circular Loop *(Square Meter)*
- **A** Area of Small Circular Loop *(Square Meter)*
- a_c Actual Radius of Circular Microstrip Patch *(Centimeter)*
- a_{eff} Effective Radius of Circular Microstrip Patch *(Centimeter)*
- A_g Loop Antenna Gain *(Decibel)*
- **AR** Axial Ratio
- B_{hp} Half Power Beam Width *(Degree)*
- BW_{end} Beam Width between First Null Endside Array *(Degree)*
- BW_{fn} Helical Beam Width of First Null Broadside Array *(Degree)*
- **BWFN** Beam Width between First Null Broadside Array *(Degree)*
- **C** Operational Circumference *(Meter)*
- C_λ Helix Circumference *(Meter)*
- **d** Distance *(Meter)*
- **D** Directivity of Large Loop
- **E** Field Pattern
- E_{eff} Effective Dielectric Constant of Substrate
- E_r Dielectric Constant of Substrate
- F_n Normalized Wavenumber
- f_r Resonant Frequency *(Gigahertz)*
- f_{res} Frequency *(Gigahertz)*
- G_a Helical Antenna Gain *(Decibel)*
- **h** Thickness of the Substrate *(Millimeter)*
- **H** Height of Equilateral Triangular Patch *(Millimeter)*
- H_d Helix Diameter *(Meter)*
- h_o Thickness of Substrate Microstrip *(Centimeter)*
- **K** Efficiency Factor
- **L** Size of Small Loop *(Meter)*

Constants, Functions, Measurements used in list of Special Antennas Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- constant(s): **[c]**, 299792458.0 *Light speed in vacuum*
- Functions: **arctan**, arctan(Number) *Inverse trigonometric functions are usually accompanied by the prefix - arc. Mathematically, we represent arctan or the inverse tangent function as tan-1 x or arctan(x).*
- Functions: **cos**, cos(Angle) *Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.*
- Functions: **ctan**, ctan(Angle) *Cotangent is a trigonometric function that is defined as the ratio of the adjacent side to the opposite side in a right triangle.*
- Functions: **ln**, ln(Number) *The natural logarithm, also known as the logarithm to the base e, is the inverse function of the natural exponential function.*
- Functions: **log10**, log10(Number) *The common logarithm, also known as the base-10 logarithm or the decimal logarithm, is a mathematical function that is the inverse of the exponential function.*
- Functions: **sqrt**, sqrt(Number) *A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.*
- Functions: **tan**, tan(Angle) *The tangent of an angle is a trigonometric ratio of the length of the side opposite an angle to the length of the side adjacent to an angle in a right triangle.*
- Measurement: **Length** in Meter (m), Millimeter (mm), Centimeter (cm) *Length Unit Conversion*
- Measurement: **Area** in Square Meter (m²) *Area Unit Conversion*
- Measurement: **Angle** in Degree (°) *Angle Unit Conversion*

- L_{eff} Effective Length of Microstrip Patch *(Millimeter)*
- L_{gnd} Length of Ground Plate *(Millimeter)*
- l_{isd} Length of Infinitesimal Dipole *(Meter)*
- L_p Actual Length of Microstrip Patch *(Millimeter)*
- **n** Number of Turns of Helical Antenna
- **N** Number of Turns of Array Antenna
- **Q** Quality Factor
- R_{isd} Radiation Resistance of Infinitesimal Dipole *(Ohm)*
- R_L Loss Resistance *(Ohm)*
- R_{large} Radiation Resistance of Large Loop *(Ohm)*
- R_{small} Radiation Resistance of Small Loop *(Ohm)*
- R_t Terminal Resistance of Loop Antenna *(Ohm)*
- **S** Turn Spacing *(Meter)*
- S_{hex} Side Length of Hexagonal Patch *(Millimeter)*
- S_{tng} Side Length of Equilateral Triangular Patch *(Millimeter)*
- U_{ir} Isotropic Radiation Intensity of Loop Antenna *(Watt per Steradian)*
- U_r Radiation Intensity in Loop Antenna *(Watt per Steradian)*
- W_{gnd} Width of Ground Plate *(Millimeter)*
- W_p Width of Microstrip Patch *(Millimeter)*
- X_L Inductive Reactance *(Ohm)*
- Z_h Input Impedance *(Ohm)*
- α Pitch Angle *(Degree)*
- ΔL Length Extension of Microstrip Patch *(Millimeter)*
- λ_a Wavelength in Loop Antenna *(Meter)*
- λ_b Broad Side Array Wavelength *(Meter)*
- λ_{isd} Wavelength of Dipole *(Meter)*
- Φ_s Phase Shift *(Degree)*

- Measurement: **Frequency** in Gigahertz (GHz)
  Frequency Unit Conversion
- Measurement: **Electric Resistance** in Ohm (Ω)
  Electric Resistance Unit Conversion
- Measurement: **Wavelength** in Meter (m)
  Wavelength Unit Conversion
- Measurement: **Sound** in Decibel (dB)
  Sound Unit Conversion
- Measurement: **Radiant Intensity** in Watt per Steradian (W/sr)
  Radiant Intensity Unit Conversion

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