# R2023 B.E ECE VAC - ANTENNA DESIGN USING EM SIMULATOR

### MCQ Answer Sheet - Sets A & B

**Course Code:** 23VA1015
**Subject:** Antenna Design Using EM Simulator
**Regulation:** R2023
**Branch:** Electronics and Communication Engineering

# SET A - ANSWER KEY

**Quick Reference:**

1. C 2. B 3. C 4. A 5. C 6. A 7. B 8. B 9. B 10. B
2. A 12. C 13. A 14. B 15. B 16. B 17. C 18. B 19. B 20. B
3. C 22. C 23. C 24. B 25. B 26. C 27. B 28. C 29. B 30. B
4. B 32. B 33. B 34. B 35. B 36. A 37. C 38. C 39. B 40. B
5. B 42. B 43. B 44. B 45. B 46. B 47. B 48. B 49. B 50. B

### Detailed Explanations - SET A

**1. Answer: C** - Patch antennas typically have high Q-factor, resulting in narrow bandwidth.

**2. Answer: B** - The reflector is typically 5-10% longer than the driven element to provide proper phasing.

**3. Answer: C** - The main disadvantage of patch antennas is their inherently narrow bandwidth.

**4. Answer: A** - PEC stands for Perfect Electric Conductor, used to model ideal conducting surfaces.

**5. Answer: C** - Current distribution on a half-wave dipole follows a sinusoidal pattern.

**6. Answer: A** - Radiation efficiency $\eta$ = Prad/Pin, the ratio of radiated power to input power.

**7. Answer: B** - Dipole antennas have null radiation along their axis (endfire directions).

**8. Answer: B** - Circular polarization requires two orthogonal E-field components with equal amplitude and 90° phase difference.

**9. Answer: B** - End-fire arrays are designed to radiate maximum power along the array axis direction.

**10. Answer: B** - Microstrip patches typically resonate at lengths around λ/2 (considering effective dielectric constant).

**11. Answer: A** - A short dipole has a directivity of 1.5 (1.76 dB) due to its figure-8 radiation pattern.

**12. Answer: C** - CST Studio Suite includes both time-domain (transient) and frequency-domain solvers.

**13. Answer: A** - Antenna gain G = D × η, where D is directivity and η is radiation efficiency.

**14. Answer: B** - Large loops with circumference around one wavelength have much higher radiation resistance than small loops.

**15. Answer: B** - Adding more elements (especially directors) tends to decrease the bandwidth of Yagi antennas.

**16. Answer: B** - Probe feed impedance varies with position along the patch length, allowing impedance control.

**17. Answer: C** - Directivity is a ratio of radiation intensities, hence dimensionless. It's often expressed in dB for convenience.

**18. Answer: B** - Small loops with circumference much less than wavelength act as magnetic dipoles.

**19. Answer: B** - LPDA provides wide bandwidth (often 2:1 or more) with relatively constant gain and impedance.

**20. Answer: B** - Adaptive meshing automatically refines the computational mesh until convergence criteria are met.

**21. Answer: C** - Input impedance Z = R + jX, consisting of resistance and reactance components.

**22. Answer: C** - Top loading increases the effective height of a monopole, lowering its resonant frequency.

**23. Answer: C** - The boom length relative to element size affects both gain and bandwidth of Yagi antennas.

**24. Answer: B** - L-shaped slots can create dual resonances, enabling dual-band operation.

**25. Answer: B** - HFSS convergence is typically based on S-parameter changes between adaptive mesh passes.

**26. Answer: C** - Effective dielectric constant is between 1 (air) and εr (substrate) due to fringing fields.

**27. Answer: B** - E-plane is the plane containing the electric field vector and the direction of maximum radiation.

**28. Answer: C** - Quarter-wave monopole requires a ground plane that acts as a mirror to create the image of missing half.

**29. Answer: B** - Array factor represents the effect of array geometry (spacing, phases, amplitudes) on the overall pattern.

**30. Answer: B** - U-slot configuration can provide very wide bandwidth (up to 30%) in patch antennas.

**31. Answer: B** - HFSS (High Frequency Structure Simulator) primarily uses the Finite Element Method (FEM).

**32. Answer: B** - For short dipoles, radiation resistance $Rr \propto (l/\lambda)^2$, where l is the length.

**33. Answer: B** - Directors are typically 5-10% shorter than the driven element to provide forward radiation.

**34. Answer: B** - By Babinet's principle, a slot antenna is complementary to a dipole antenna.

**35. Answer: B** - Wave port excitation is used for guided wave structures like coaxial cables and waveguides.

**36. Answer: A** - The relationship between effective area and directivity is $Ae = D\lambda^2/(4\pi)$.

**37. Answer: C** - Wire segments should be $\lambda/10$ to $\lambda/20$ long for accurate current distribution modeling.

**38. Answer: C** - A well-designed 5-element Yagi antenna typically provides around 12 dBi gain.

**39. Answer: B** - Increasing substrate height increases the bandwidth of patch antennas.

**40. Answer: B** - MoM discretizes only conductor surfaces, making it efficient for metallic structures in homogeneous backgrounds.

**41. Answer: B** - The radiation resistance of a half-wave dipole in free space is approximately 73 ohms.

**42. Answer: B** - Ground plane size affects both radiation pattern shape and antenna efficiency.

**43. Answer: B** - Spacing factor σ typically ranges from 0.05 to 0.15 for good LPDA performance.

**44. Answer: B** - Aperture coupling uses a slot in the ground plane to electromagnetically couple energy to the patch.

**45. Answer: B** - FDTD method solves Maxwell's equations directly in the time domain.

**46. Answer: B** - VSWR = 1 means no standing waves, indicating perfect impedance matching between transmission line and antenna.

**47. Answer: B** - Quarter-wave monopole has half the impedance of a half-wave dipole, approximately 36.5 Ω.

**48. Answer: B** - Scale factor τ = Ln+1/Ln = dn+1/dn, where L is length and d is spacing.

**49. Answer: B** - Strategic slot placement or proper feeding techniques can reduce cross-polarization levels.

**50. Answer: B** - Radiation boundary conditions (ABC) absorb outgoing waves to simulate infinite space.

# SET B - ANSWER KEY

**Quick Reference:**

1. B 2. B 3. C 4. C 5. B 6. C 7. C 8. B 9. B 10. B
2. B 12. B 13. B 14. B 15. A 16. B 17. C 18. B 19. B 20. B
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5. C 42. B 43. B 44. B 45. B 46. B 47. B 48. C 49. B 50. B

### Detailed Explanations - SET B

**1. Answer: B** - Circular polarization requires two orthogonal feeds with 90° phase difference.

**2. Answer: B** - HFSS convergence is typically based on S-parameter changes between adaptive mesh passes.

**3. Answer: C** - A folded dipole has approximately 4 times the impedance of a simple dipole (~300 Ω vs ~73 Ω).

**4. Answer: C** - Mutual coupling affects both input impedance and radiation pattern of array elements.

**5. Answer: B** - PML is an absorbing boundary condition used to terminate computational domains.

**6. Answer: C** - Effective dielectric constant is between 1 (air) and εr (substrate) due to fringing fields.

**7. Answer: C** - Antenna temperature is a measure of noise power and is expressed in Kelvin.

**8. Answer: B** - Helical antennas with circumference around one wavelength operate in axial (end-fire) mode.

**9. Answer: B** - Smart antennas adaptively control their patterns to optimize communication.

**10. Answer: B** - Microstrip patches typically resonate at lengths around λ/2 (considering effective dielectric constant).

**11. Answer: B** - RL = -10 dB gives reflection coefficient ρ = 0.316, so VSWR = (1+ρ)/(1-ρ) = 1.92.

**12. Answer: B** - Vertical monopole provides omnidirectional coverage in the horizontal plane.

**13. Answer: B** - In LPDA, only a few elements near resonance contribute significantly to radiation at any frequency.

**14. Answer: B** - Microstrip antennas are also known as printed antennas due to their planar printed structure.

**15. Answer: A** - S-parameters represent scattering parameters (reflection and transmission coefficients).

**16. Answer: B** - Radiation pattern is the mathematical representation of radiation energy distribution with respect to directional coordinates.

**17. Answer: C** - Sleeve antenna is a modified monopole antenna with a sleeve around the coaxial feed.

**18. Answer: B** - Phased arrays can electronically steer the beam by controlling phase and amplitude.

**19. Answer: B** - E-shaped patch antennas can provide significantly wider bandwidth than rectangular patches.

**20. Answer: B** - Finer mesh is needed in regions with high field gradients for accurate simulation.

**21. Answer: A** - Reciprocity theorem states that an antenna's transmitting and receiving patterns are identical.

**22. Answer: B** - Quarter-wave monopole has half the impedance of a half-wave dipole, approximately 36.5 Ω.

**23. Answer: B** - Array tapering (non-uniform excitation) is used to reduce sidelobe levels.

**24. Answer: C** - Patch antennas typically have high Q-factor, resulting in narrow bandwidth.

**25. Answer: C** - FEKO primarily uses the Method of Moments (MoM) for electromagnetic simulation.

**26. Answer: B** - Antenna polarization refers to the orientation of the electric field vector.

**27. Answer: C** - Quarter-wave monopole requires a ground plane that acts as a mirror to create the image of missing half.

**28. Answer: B** - Scale factor $\tau = Ln+1/Ln = dn+1/dn$, where L is length and d is spacing.

**29. Answer: C** - Parasitic patches can improve bandwidth and reduce mutual coupling in arrays.

**30. Answer: C** - Far-field calculations use near-field data and surface current distributions.

**31. Answer: B** - Half-power beamwidth is measured between points that are 3 dB below the maximum radiation.

**32. Answer: B** - Small loops with circumference much less than wavelength act as magnetic dipoles.

**33. Answer: B** - Directors are typically 5-10% shorter than the driven element to provide forward radiation.

**34. Answer: B** - U-slot configuration can provide very wide bandwidth (up to 30%) in patch antennas.

**35. Answer: B** - IE solvers only require surface meshing of conductors, reducing computational requirements.

**36. Answer: B** - VSWR = 1 means no standing waves, indicating perfect impedance matching between transmission line and antenna.

**37. Answer: B** - Ground plane size affects both radiation pattern shape and antenna efficiency.

**38. Answer: B** - LPDA provides wide bandwidth (often 2:1 or more) with relatively constant gain and impedance.

**39. Answer: B** - By Babinet's principle, a slot antenna is complementary to a dipole antenna.

**40. Answer: B** - Wave port excitation is used for guided wave structures like coaxial cables and waveguides.

**41. Answer: C** - Directivity is a ratio of radiation intensities, hence dimensionless. It's often expressed in dB for convenience.

**42. Answer: B** - Large loops with circumference around one wavelength have much higher radiation resistance than small loops.

**43. Answer: B** - The reflector is typically 5-10% longer than the driven element to provide proper phasing.

**44. Answer: B** - Strategic slot placement or proper feeding techniques can reduce cross-polarization levels.

**45. Answer: B** - HFSS (High Frequency Structure Simulator) primarily uses the Finite Element Method (FEM).

**46. Answer: B** - The radiation resistance of a half-wave dipole in free space is approximately 73 ohms.

**47. Answer: B** - Dipole antennas have null radiation along their axis (endfire directions).

**48. Answer: C** - A well-designed 5-element Yagi antenna typically provides around 12 dBi gain.

**49. Answer: B** - Aperture coupling uses a slot in the ground plane to electromagnetically couple energy to the patch.

**50. Answer: B** - Adaptive meshing automatically refines the computational mesh until convergence criteria are met.

## SCORING BREAKDOWN

### SET A:

- **Option A:** 3 questions (6%)
- **Option B:** 35 questions (70%)
- **Option C:** 12 questions (24%)
- **Option D:** 0 questions (0%)

### SET B:

- **Option A:** 1 question (2%)
- **Option B:** 43 questions (86%)
- **Option C:** 6 questions (12%)
- **Option D:** 0 questions (0%)

## UNIT-WISE DISTRIBUTION

Each set contains exactly 10 questions from each unit:

- **Unit I:** Antenna Parameters (Questions cover directivity, gain, VSWR, radiation patterns)
- **Unit II:** EM Simulators (Questions cover HFSS, CST, solver methods, boundary conditions)
- **Unit III:** Wire Antennas (Questions cover dipoles, monopoles, loops, helical antennas)
- **Unit IV:** Patch & Slot Antennas (Questions cover microstrip, feeding methods, bandwidth)
- **Unit V:** Antenna Arrays (Questions cover Yagi, LPDA, phased arrays, mutual coupling)

## DIFFICULTY ANALYSIS

- **Easy Level (40%):** Basic definitions, standard values, simple concepts
- **Moderate Level (45%):** Comparative questions, working principles, applications
- **Advanced Level (15%):** Design equations, complex relationships, optimization

## STUDY RECOMMENDATIONS

**For Set A Focus Areas:**

- Patch antenna characteristics and Q-factor
- Yagi antenna design parameters
- EM simulation boundary conditions and meshing

**For Set B Focus Areas:**

- Circular polarization techniques

- LPDA design principles
- Mutual coupling effects in arrays

**Common Important Topics:**

- Radiation resistance values (73Ω for dipole, 36.5Ω for monopole)
- EM solver types (FEM for HFSS, MoM for FEKO)
- Bandwidth enhancement techniques
- Array design principles

**END OF ANSWER SHEET**