The European School of Antennas
"*High-frequency techniques and Traveling-wave antennas*"

Solutions of the Exam (second part)

1. Why are traveling-wave antennas named so?

    a) Because the radiated field travels from the antenna to the receiver
    b) Because the antenna is moving in space
    c) Because the aperture illumination is established by a propagating wave
    d) Because they are always matched, so no standing wave is possible in the feeding line

2. What is the most typical radiative feature of a LWA?

    a) It is low profile
    b) It is wideband
    c) It is frequency scannable
    d) It is economic

3. What radiative characteristic is mainly determined by the phase constant β of a leaky wave?

    a) Pointing angle
    b) Beamwidth
    c) Bandwidth
    d) Cross-polarization level

4. What radiative characteristic is mainly determined by the attenuation constant α of a leaky wave?

    a) Pointing angle
    b) Beamwidth
    c) Bandwidth
    d) Cross-polarization level

5. What is the nature of a leaky mode in uniform structures made of ordinary (metallic and dielectric) materials?

    a) Proper
    b) Improper
    c) It may be both

6. Given the following non-uniform plane wave in a vacuum:

$$\boldsymbol{E}(x,z) = \boldsymbol{y}_0 e^{-j\beta\left[\sin\left(\vartheta_\beta\right)z+\cos\left(\vartheta_\beta\right)x\right]} e^{-\alpha\left[\sin\left(\vartheta_\alpha\right)z+\cos\left(\vartheta_\alpha\right)x\right]}$$

with $\beta = \frac{3}{2}\frac{\omega}{c}$, $\alpha = \frac{1}{2}\frac{\omega}{c}$, $\theta_\beta = 60°$, and $\theta_\alpha = 120°$, can this represent the field of a leaky wave in the vacuum region above a uniform 2D open waveguide? **NO** (it can immediately be seen that the phase and attenuation vectors are not orthogonal, thus this is not a solution of Helmholtz equation in vacuum)

7. How does a proper surface mode evolve below its cutoff frequency?

   a) Becomes a leaky complex mode
   b) Becomes real improper and then leaky complex
   c) Disappears
   d) Remains proper but evanescent longitudinally

8. May a leaky complex pole in a given grounded dielectric slab come arbitrarily close to the saddle point at $\theta = \pi/2$?

   a) Yes, at the cutoff frequency of the corresponding mode
   b) No, never
   c) It depends on the dielectric permittivity of the slab
   d) Yes for TE modes, no for TM modes

   (This question was perhaps formulated in a misleading way (all the students gave a wrong answer!). The instructors meant to consider the movement of a leaky (i.e., *complex*) pole by varying frequency: while a real improper pole approaches the saddle point at $\theta = \pi/2$ as the operating frequency approaches the cutoff frequency, a complex pole always remains at a finite distance from the saddle point).

9. In what spatial region does a leaky wave contribute to the excited field in a SDP representation?

   a) On the aperture plane only
   b) In a wedge-shaped region
   c) Everywhere in space
   d) In the far field

10. What is a possible mechanism to induce leakage in a bound mode of an open waveguide?

   a) Closing the waveguide
   b) Perturbing the symmetry of the structure
   c) Tapering longitudinally the aperture
   d) Adding a dissipative load

11. How is the antenna length chosen for a given $k_z = \beta - j\alpha$?

a) In order to achieve a desired efficiency
b) In order to avoid grating lobes
c) In order to avoid excitation of surface waves
d) It is fixed by the operating frequency

12. What happens in a uniform LWA made of ordinary media when frequency is increased (keeping all the other parameters fixed)?

a) The beam scans towards broadside
b) The beamwidth oscillates periodically
c) The beam scans towards endfire
d) The pointing angle remains approximately constant

13. How is a high directivity achieved in a substrate-superstrate planar structure?

a) By placing the source in a suitable location
b) By properly choosing the operating frequency
c) These antennas are never directive
d) By choosing the structure parameters in order to satisfy specific resonance conditions

14. From what type of leaky waves is the radiation pattern in the H plane mainly determined in 2D LWAs?

a) TM
b) TE
c) Both
d) It depends on the structure

15. Is it possible for a 2D LWA to radiate a pencil beam at broadside?

a) Yes, but the beamwidths in the principal planes are different
b) No
c) It depends on the specific structure
d) Yes, and the beamwidths in the principal planes are equal

16. How many leakage regimes exist in a microstrip line?

a) One
b) Two
c) Three
d) None

17. What is the nature of leaky modes in periodic structures?

a) Proper
b) Improper
c) It may be both

18. What is the spectral nature of the space harmonics in a Floquet leaky mode?

a) They are all improper
b) They are all proper
c) Only one is improper
d) It depends on the frequency and structure parameters

19. How many branch points are there in the dispersion equation of a periodic open structure?

a) Two, at $\pm k_0$
b) One, at k_0
c) An infinite number
d) It depends on the structure

20. What is an open stopband?

a) A frequency range in which a standing wave exists on a periodic structure
b) A frequency range around the frequency at which one spatial harmonic has a zero phase constant
c) A kind of open 2D waveguide
d) A leakage regime in the backward quadrant

21. What is the difference between uniform LWAs with isotropic media and 1D periodic LWAs in terms of scanning properties?

a) 1D periodic LWAs only scan in one quadrant
b) They have the same properties
c) Uniform LWAs only scan in one quadrant
d) 1D periodic LWAs can radiate at broadside

22. How is the scan in azimuth achieved in linear arrays of LWAs?

a) By varying frequency
b) By varying the phase shift
c) By applying a bias voltage
d) These arrays cannot be scanned in azimuth