S-26.3361 Millimeterwave Engineering

Examination 6.5.2009, at 9–12, S1

Maximum points of part A 3×6 = 18
Maximum points of part B 3×10 = 30

Part A, at 9:00–10:15
Use of literature is **not** allowed

1. Explain the following terms:
   a) finline
   b) corrugated horn
   c) bolometer mixer

2. The Gaussian beam is one of the fundamental concepts of quasi-optics. Discuss the Gaussian beam. For example, what it is, what kind of properties it has, why it is so important, how it is generated?

3. A millimeter wave receiver is to be installed on a small satellite. Discuss the different possibilities how to provide the local oscillator power if the receiver frequency is a) 100 GHz and b) 1000 GHz.

You may start with part B already at 10:00 if you wish.

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Part B, at 10:15–12:00
Use of literature is allowed

1. The 16-dB beam width of a Gaussian beam is 14 degrees according to Fig. 1. The frequency of operation is 200 GHz.

   a) What is the radius of the waist of the beam, w_0?
   b) How large portion of the radiated power is outside this -16 dB beam?
   c) A thin lens is placed 50 mm from the waist. What should be the focal length of the lens, so that a waist formed on the other side of the lens is also at a distance 50 mm from the lens?

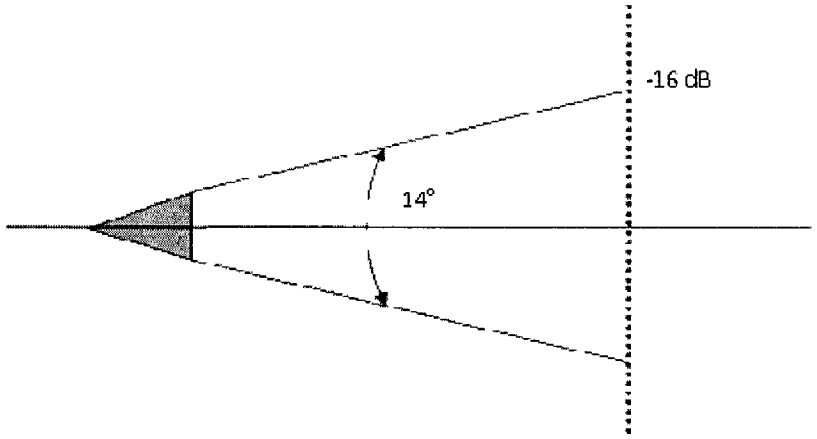

Figure 1: Observed power of Gaussian beam from Problem 1

2. A weather radar is operating at 94 GHz. The transmitted power P_T = 100 mW, the diameter of the parabolic reflector antenna D = 1.0 m, and sensitivity of the radar receiver is -80 dBm.
   Consider an object with radar cross section $\sigma = 10\ m^2$.

   a) What is the maximum range R_{max} of the radar, if the weather is clear and humidity close to zero (in this case, you can assume that the atmospheric losses are negligible).
   b) How much is this maximum range reduced, if the relative humidity is 75%?

3. For a receiver operating at 1200 GHz we need a rectangular waveguide operating at the lowest-order waveguide mode. What are the dimensions of the waveguide? Choose the dimensions so that 1200 GHz is in the center of the frequency band of the used waveguide mode. What is the attenuation (in dB) of a 3 cm long piece of copper waveguide (conductivity of copper is 58×10^6 S/m)? What instructions would you give to the manufacturer of such a waveguide with respect to the surface smoothness?