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RF and Antenna Engineering (CT 425)

2nd In-Semester Examination

Closed Books and Closed Notes Examination

Date: 20 October 2022 **Time: 8:30 to 10:30 am**

Answer all questions.

1. (a) Define noise factor (F) in terms of the signal-to-noise ratio at the input and signal-to-noise ratio at the output of an amplifier. If the gain of the amplifier is G and the bandwidth is B_n and the noise factor is F, what is the available output noise power? What is the relationship between noise factor F and noise figure of an amplifier? Where k is Boltzmann's constant. (5 marks)

$$F = \frac{\text{available } S/N \text{ power ratio at the input}}{\text{available } S/N \text{ power ratio at the output}} \qquad (4.13.2)$$

(2 marks)

$$P_{no} = FGkT_oB_n \qquad (4.13.4)$$

(2 marks)

$$\text{noise figure} = (F)\ \text{dB} = 10 \log F \qquad (4.13.5)$$

(1 mark)

(b) For amplifiers in cascade, G_i and Fi are gain and noise factor of i_{th} amplifier, respectively. Define Friis's formula for overall noise factor F. Where i vary from 1 to n. To maintain the overall noise figure as low as possible, what are the requirements regarding F_1 and G_1? (5 marks)

Pages 139 to 141 for explanation. (1 mark)

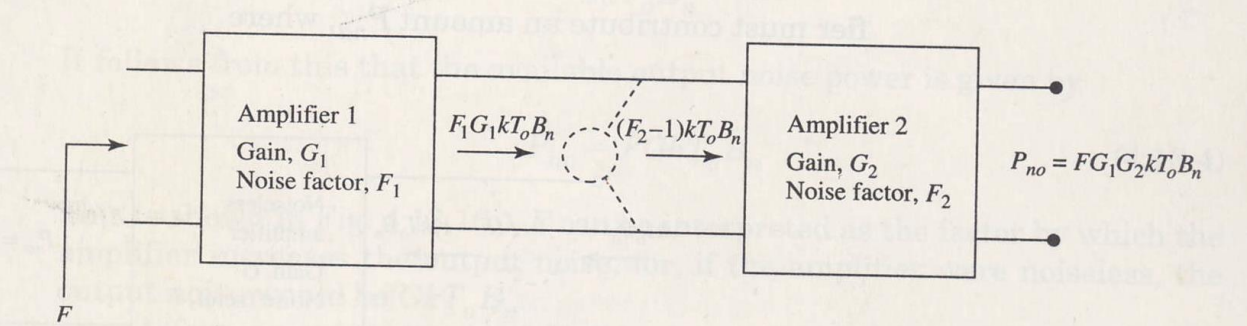


Figure 4.15.1 Noise factor of two amplifiers in cascade.

(1.5 marks)

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \cdots \qquad (4.15.5)$$

(1.5 marks)

For low F, G_1 should be as large as possible part and F_1 as small as possible. (1 mark)

(c) A mixer stage has a noise figure of 20 dB, and this is preceded by an amplifier that has a noise figure of 9 dB and an available power gain of 15 dB. Calculate the overall noise figure referred to input. (4 marks)

Example on 4.15.1 on page 141 and 142 (4 marks)

(d) What is the relationship between noise factor F and equivalent input noise temperature T_e of an amplifier? (3 marks)

$$T_e = (F - 1)T_o \qquad (4.18.3)$$

(3 marks)

(e) For a lossy network, what is the relationship between F and L? Where L is the loss factor. (3 marks)

F = L (3 marks)

2. (a) What are the two types of impedance matching in transmission line theory? Z_G and Z_L are complex impedances of source and load. For conjucate matching, what is relationship between Z_G and Z_L? (4 mark)

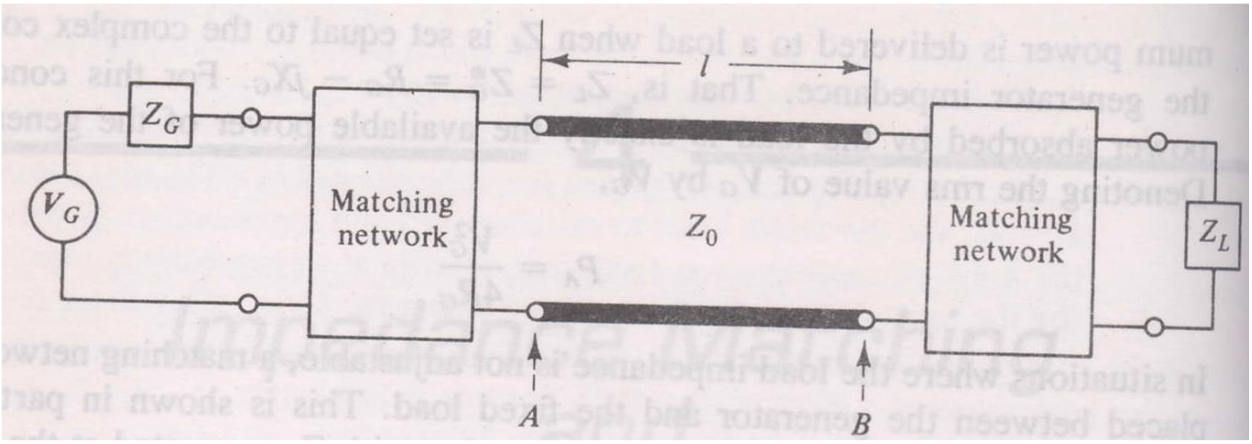
Pages 118 and 119

Types of impedance matching.
Conjugate Matching: The matching of a load impedance to a generator for maximum transfer of power. (1.5 marks)

Zo Matching: The matching of a load impedance to a transmission line eliminate wave reflections at the load. (1.5 marks)

$Z_L = Z_G^*$ (1 mark)

(b) For a transmission line of characteristic impedance (Z_o) and length l, Z_G as well as Z_L are not equal to Z_o. To get matched transmission line system, draw a suitable figure to show locations of matching networks. (5 marks)



(5 marks)

(c) For matching of load of a transmission line with a quarter-wave transformer, what are the two parameters which are calculated by the Smith chart? (4 marks)

(a) The point, nearest to the load, at which a quarter-wave transformer may be inserted to provide correct matching
(b) The Z_0' of the transmission line to be used for the transformer

For (a) 2 marks and (b) 2 marks

(d) For matching of load of a transmission line with a short-circuited stub, what are the two parameters which are calculated by the Smith chart? (4 marks)

Stub length (2 marks) and Distance to stub (2 marks)

(e) In solving matching problems using Smith chart, it may be required to find load admittance from load impedance. If load impedance is plotted on Smith chart used as impedance chart, give steps to find load admittance on the Smith chart? λ is the wavelength. (3 marks)

Draw VSWR circle. (1 mark)
Find point on VSWR circle opposite to impedance point at $\lambda/4$ (1 mark)
Treat Smith chart as admittance chart (1 mark)

Following questions 3 and 4 are of descriptive nature. Marks are only deducted if you have not answered definitions or figures. All defination or figures are of equal marks.

3. (a) Briefly describe all types of antennas with the aid of figures. (10 marks)

(b) Define radiation pattern, directive gain (dBi), directive gain (dBd), HPBW, FNBW, bandwidth and polarization of an antenna. (10 marks)

4. (a) Define 3 field regions of an antenna with the aid of a figure. If D is the largest dimension of an antenna, what are R_1 and R_2 which are boundaries of different regions. λ is the wavelength. (8 marks)

(b) Define omnidirectional antenna, isotropic antenna, directive antenna, E-plane pattern of antenna and H-plane pattern of an antenna. (7 marks)

(c) In radiation pattern of an antenna, define radiation lobe, major lobe, minor lobe, side lobe and back lobe (5 marks)