CHAPTER

7.3

NOISE

1. The power spectral density of a bandpass white noise $n(t)$ is $\mathcal{N}/2$ as shown in fig.P.7.3.1. the value of $\overline{n^2}$ is

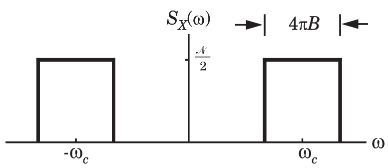

Fig. P7.3.1

(A) $\mathcal{N}B$ (B $2\mathcal{N}B$

(C) $2\pi\mathcal{N}B$ (D) $\dfrac{\mathcal{N}B}{\pi}$

2. In a receiver the input signal is 100 μV, while the internal noise at the input is 10 μV. With amplification the output signal is 2 V, while the output noise is 0.4 V. The noise figure of receiver is

(A) 2 (B) 0.5

(C) 0.2 (D) None of the above

3. A receiver is operated at a temperature of 300 K. The transistor used in the receiver have an average output resistance of 1 kΩ. The Johnson noise voltage for a receiver with a bandwidth of 200 kHz is

(A) 1.8 μV (B) 8.4 μV

(C) 4.3 μV (D) 12.6 μV

4. A resistor $R = 1$ kΩ is maintained at 17°C. The rms noise voltage generated in a bandwidth of 10 kHz is

(A) 16×10^{-14} V (B) 0.4 μ V

(C) 4 μ V (D) 16×10^{-18} V

5. A mixer stage has a noise figure of 20 dB. This mixer stage is preceded by an amplifier which has a noise figure of 9 dB and an available power gain of 15 dB. The overall noise figure referred to the input is

(A) 11.07 B) 18.23

(C) 56.48 (D) 97.38

6. A system has three stage cascaded amplifier each stage having a power gain of 10 dB and noise figure of 6 dB. the overall noise figure is

(A) 1.38 (B) 6.8

(C) 4.33 (D) 10.43

7. A signal process $m(t)$ is mixed with a channel noise $n(t)$. The power spectral density are as follows

$$S_m(\omega) = \frac{6}{9+\omega^2},\ S_n(\omega) = 6$$

The optimum Wiener-Hopf filter is

(A) $\dfrac{\omega^2+9}{\omega^2+10}$ (B) $\dfrac{1}{\omega^2+10}$

(C) $\dfrac{\omega^2+10}{\omega^2+9}$ (D) None of the above

Statement for Question 8-9

A sonar echo system on a sub marine transmits a random noise $n(t)$ to determine the distance to another targeted submarine. Distance R is given by $v\tau_R/2$ where v is the speed of the sound wave in water and τ_R is the time it takes the reflected version of $n(t)$ to return. Assume that $n(t)$ is a sample function of an ergodic random process $N(t)$ and T is very large.

8. The V will be

(A) $2R_{NN}(\tau_R - \tau_T)$ (B) $R_{NN}(\tau_R - 2\tau_T)$

(C) $R_{NN}(\tau_R - \tau_T)$ (D) $\frac{1}{2}R_{NN}(\tau_R - \tau_T)$

9. What value of the delay τ_T will cause v to be maximum ?

(A) τ_R (B) $2\tau_R$

(C) $3\tau_R$ (D) None of the above

10. Two resistor with resistance R_1 and R_2 are connected in parallel and have Physical temperatures T_1 and T_2 respectively. The effective noise temperature T_s of an equivalent resistor is

(A) $\frac{T_1R_1 + T_2R_2}{R_1 + R_2}$ (B) $\frac{T_1R_1 + T_2R_1}{R_1 + R_2}$

(C) $\frac{T_1T_2(R_1 + R_2)^2}{(T_1 + T_2)R_1R_2}$ (D) $\frac{(T_1 + T_2)R_1R_2}{T_1 + T_2(R_1 + R_2)^2}$

Statement for Question 11-12 :

An amplifier has a standard spot noise figure $F_0 = 6.31$ (8.0 dB). The amplifier, that is used to amplify the output of an antenna have antenna temperature of $T_a = 180$ K

11. The effective input noise temperature of this amplifier is

(A) 2520 K (B) 2120 K

(C) 2710 K (D) 1540 K

12. The operating spot noise figure is

(A) 3.2 dB (B) 6.4 dB

(C) 9.8 dB (D) 11.9 dB

13. An amplifier has three stages for which $T_{e1} = 200$ K (first stage), $T_{e2} = 450$ K, and $T_{e3} = 1000$K (last stage). If the available power gain of the second stage is 5, what gain must the first stage have to guarantee an effective input noise temperature of 250 K ?

(A) 10 (B) 13

(C) 16 (D) 19

Statement for Question 14-16

An amplifier has an operating spot noise figure of 10 dB when driven by a source of effective noise temperature 225 K.

14. The standard spot noise figure of amplifier is

(A) 4 dB (B) 5 dB

(C) 7 dB (D) 9 dB

15. If a matched attenuator with a loss of 3.2 dB is placed between the source and the amplifier's input, what is the operating spot noise figure of the attenuator amplifier cascade if the attenuator's physical temperature is 290 K ?

(A) 9 dB (B) 10.4 dB

(C) 11.3 dB (D) 13.3 dB

16. In previous question what is the standard spot noise figure of the cascade ?

(A) 10.3 dB (B) 12.2 dB

(C) 14.9 dB (D) 17.6 dB

17. Omega Electronics sells a microwave receiver (A) having an operating spot noise figure of 10 dB when driven by a source with effective noise temperature 130 K Digilink (B) sells a receiver with a standard spot noise figure of 6 dB. Microtronics (C) sells a receiver with standard spot noise figure of 8 dB when driven by a source with effective noise temperature 190 K. The best receiver to purchase is

(A) A (B) B

(C) C (D) all are equal

Statement for Question 18-20 :

An amplifier has three stages for which $T_{e1} = 150$ K (first stage), $T_{e2} = 350$ K, and $T_{e3} = 600$ K (output stage). Available power gain of the first stage is 10 and overall input effective noise temperature is 190 K

18. The available power gain of the second stage is

(A) 12 (B) 14

(C) 16 (D) 18

19. The cascade's standard spot noise figure is

(A) 1.3 dB (B) 2.2 dB

(C) 4.3 dB (D) 5.3 dB

20. What is the cascade's operating spot noise figure when used with a source of noise temperature T_s = 50 K

(A) 1.34 dB (B) 3.96 dB

(C) 6.81 dB (D) None of the above.

21. Three network are cascaded. Available power gains are $G_1 = 8$, $G_2 = 6$ and $G_3 = 20$. Respective input effective spot noise temperature are $T_{e1} = 40$ K, $T_{e2} = 100$ K and $T_{e3} = 180$ K.

(A) 58.33 K (B) 69.41 K

(C) 83.90 K (D) 98.39 K

22. Three identical amplifier, each having a spot effective input noise temperature of 125 K and available power G are cascaded. The overall spot effective input noise temperature of the cascade is 155 K. The G is

(A) 3 (B) 5

(C) 7 (D) 9

23. Three amplifier that may be connected in any order in a cascade are defined as follows:

Amplifier	Effective Input Noise Temperature	Available Power Gain
A	110 K	4
B	120 K	6
C	150 K	12

The sequence of connection that will give the lowest overall effective input noise temperature for the cascade is

(A) ABC (B) CBA

(C) ACB (D) BAC

24. What is the maximum average effective input noise temperature that an amplifier can have if its average standard noise figure is to not exceed 1.7 ?

(A) 203 K (B) 215 K

(C) 235 K (D) 255 K

25. An amplifier has an average standard noise figure of 2.0 dB and an average operating noise figure of 6.5 dB when used with a source of average effective source temperature $\overline{T_s}$. The $\overline{T_s}$ is

(A) 156.32 K (B) 100.81 K

(C) 48.93 K (D) None of the above

Statement for Question

An antenna with average noise temperature 60 K connects to a receiver through various microwave elements that can be modeled as an impedance matched attenuator with an overall loss of 2.4 dB and a physical temperatures of 275 K. The overall system noise temperature of the receiver $\overline{T}_{sys} = 820$ K.

26. The average effective input noise temperature of the receiver is

(A) 420.5 K (B) 320.5 K

(C) 220.5 K (D) 10.5 K

27. The average operating noise figure of the attenuator-receiver cascade is

(A) 13.67 d (B) 11.4 dB

(C) 1.4 dB (D) 1.367 dB

28. If receiver has an available power gain of 110 dB and a noise bandwidth of 10 MHz, the available output noise power of receiver is

(A) 6.5 mW (B) 8.9 mW

(C) 10.3 mV (D) 11.4 mV

29. If antenna attenuator cascade is considered as a noise source, its average effective noise temperature is

(A) 63 K (B) 149 K

(C) 263 K (D) 249 K

Statement for question 30-32 :

An amplifier when used with a source of average noise temperature 60 K, has an average operating noise figure of 5.

30. The $\overline{T}_e$ is

(A) 70 K (B) 110 K

(C) 149 K (D) 240 K

31. If the amplifier is sold to engineering public, the noise figure that would be quoted in a catalog is

(A) 0.46 (B) 0.94

(C) 1.83 (D) 2.93

32. What average operating noise figure results when the amplifier is used with an antenna of temperature 30 K ?

(A) 9.54 dB (B) 10.96 dB

(C) 11.23 dB (D) 12.96 dB

33. An engineer of RS communication purchase an amplifier with average operating noise figure of 1.8 when used with a 60 Ω broadband source having average source temperature of 80 K. When used with a different 60 Ω source the average operating noise figure is 1.25. The average noise temperature of the source is

(A) 125 K (B) 156 K

(C) 256 K (D) 292 K

34. The $\overline{T}_e$ for unit 1 and 2 unit are, respectively

(A) 126.4 K and 256.9 K

(B) 256.9 K and 126.4 K

(C) 527.8 K and 864.2 K

(D) 864.2 K and 527.8 K

35. The excess noise power of unit 1 and unit 2 are respectively

(A) 15.4 nW and 27.1 nW

(B) 23.8 nW and 21.1 nW

(C) 23.8 nW and 27.1 nW

(D) 15.4 nW and 21.1 nW

36. Consider following statement

S_1 : If the source noise temperature $\overline{T}_s$ is very small, unit-2 is the best to purchase

S_2 : If the source noise temperature $\overline{T}_s$ is very small unit - 1 is the best to purchase.

correct statement is

(A) S_1 (B) S_2

(C) both S_1 and S_2 (D) None

37. A source has an effective noise temperature of $T_s(\omega) = \frac{800}{100+\omega^2}$ and feeds an amplifier that has an available power gain of $G_a(\omega) = \left(\frac{8}{10+j\omega}\right)^2$. The $\overline{T}_s$ for this source is

(A) 10 K (B) 20 K

(C) 30 K (D) 40 K

38. A system have an impulse response

$$h = \begin{cases} e^{-Wt} & e < t \\ 0 & t < 0 \end{cases}$$

where W is a real positive constant. White noise with power density 5w/Hz is applied to this system. The mean-squared value of response is

(A) $1/W$ (B) $2.5/W$

(C) $4.5/W$ (D) $6/W$

39. White noise, for which $R_{XX}(\tau) = 10^{-2}8(\tau)$ is applied to a network with impulse response $h(t) = 4(t)3 - te^{-4t}$ The network's output noise power in a 1 Ω resistor is

(A) 0.15 mW (B) 0.35 mW

(C) 0.55 mW (D) 0.95 mW

40. White noise with power density $N_0/2 = 6(10^{-6})$ W/Hz is applied to an ideal fitter (gain= 1) with bandwidth W (rad/sec). For output's average noise power to be 15 W, the W must be

(A) $2.5\pi(10^{-6})$ (B) $-2.5\pi(10^{6})$

(C) $4.5\pi(10^{-2})$ (D) $4.5\pi(10^{6})$

41. An ideal filter with a mid-band power gain of 8 and bandwidth of 4 rad/s has noise $X(t)$ at its input with power spectrum $(F(2) = 0.9773)$

$$\rho_{XX}(\omega) = \left(\frac{50}{\sqrt{8\pi}}\right)e^{-\frac{\omega^2}{8}}$$

The noise power at the network's output is

(A) $\frac{164}{\pi}$ (B) $\frac{343}{\pi}$

(C) $\frac{211}{\pi}$ (D) $\frac{191}{\pi}$

42. A system has the power transfer function

$$|H(\omega)|^2 = \frac{1}{1+\left(\frac{\omega}{W}\right)^4}$$

where W is a real positive constant. The noise bandwidth of the system is

(A) $\frac{\pi W}{2\sqrt{2}}$ (B) $\frac{\pi W}{\sqrt{2}}$

(C) $\frac{\pi W}{2}$ (D) None of the above

43. White noise with power density $\mathcal{N}_0/2$ is applied to a low pass network for which $|H(0)| = 2$. It has a noise bandwidth of 2 MHz. If the average output noise power is 8.1 W in a 1 Ω resistor, the $\mathcal{N}_0$ is

(A) 6.25×10^{8} W/Hz (B) 6.25×10^{-8} W/Hz

(C) 1.25×10^{8} W/Hz (D) 1.25×10^{-8} W/Hz

Statement for Question 44-46 :

An amplifier has a narrow bandwidth of 1 kHz and standard spot noise figure of 3.8 at its frequency of operation. The amplifier's available output noise power is 0.1 mW when its input is connected to a radio receiving antenna having an antenna temperature of 80 K.

44. The amplifier's input effective noise temperature T_e is

(A) 812 K (B) 600 K

(C) 421 K (D) 321 K

45. Its operating spot noise figure F_{op} is

(A) 5.16 (B) 7.98

(C) 11.15 (D) 16.23

46. Its available power gain G_a is

(A) 2×10^{12} (B) 4×10^{12}

(C) 8×10^{12} (D) 11×10^{12}

SOLUTION

1. (B) $\overline{n^2} = 2\int_{f_c+B}^{f_c+B} \frac{\mathcal{N}}{2} df = 2\mathcal{N}B$

2. (A) $\text{NF} = \frac{S_i/N_i}{S_o/N_o} = \frac{100/10}{2/0.4} = 2$

3. (A) $v_n^2 = 4kTBR$

$= 4 \times 1.38 \times 10^{-23} \times 300 \times 200 \times 10^3 \times 10^3 = 3.3 \times 10^{-12}$

$v_{nrms} = 1.8\mu \text{ V}$

4. (B) $\overline{v_n^2} = 4kTBR, \quad T = (273+17)K = 290 \text{ K},$

$R = 1000\Omega, \ B = 10^4 \text{ Hz}, \ k = 1.38 \times 10^{-23} \text{ J/K}$

$\overline{v_n^2} = 4 \times 1.38 \times 10^{-23} \times 290 \times 10^3 \times 10^4 = 16 \times 10^{-14} \ V^2$

$v_{nrms} = 0.4\mu \text{ V}$

5. (A) $F_1 = 9$ dB = 7.94, $F_2 = 20$ dB = 100

$A_1 = 15$ dB = 31.62,

$$F = F_1 + \frac{F_2 - 1}{A} = 7.94 + \frac{100-1}{31.62} = 11.07$$

6. (C) Gain of each stage $A_1 = A_2 = A_3 = 10$ dB

Noise figure of each stage

$F_1 = F_2 = F_3 = 6$ dB or $F_1 = F_2 = F_3 = 4$ db

$$F = F_1 + \frac{F_2 - 1}{A_1} + \frac{F_3 - 1}{A_1 A_2} = 4 + \frac{4-1}{10} + \frac{4-1}{100} = 4.33$$

7. (B) $H_{op}(\omega) = \frac{S_m(\omega)}{S_m(\omega) + S_m(\omega)} = \frac{\frac{6}{9+\omega^2}}{\frac{6}{9+\omega^2} + 6} = \frac{1}{10+\omega^2}$

8. (C) $V = \frac{1}{2T}\int_{-T}^{T} n(t-\tau_T)n(t-\tau_R)dt$

Since T is very large

$$V = \lim_{T\to\infty}\frac{1}{2T}\int_{-T}^{T} n(t-\tau_T)n(t-\tau_R)dt = A[n(t-\tau_T)n(t-\tau_R)]$$

Since $N(t)$ is ergodic, $V \approx R_{NN}(\tau_R - \tau_T)$

9. (A) Because $|R_{NN}(\tau)| \le R_{NN}(0)$ for any auto correlation function, V will be maximum if $\tau_R = \tau_T$

10. (B) Use the current form of equivalent circuit

$i_n^2 = i_1^2 + i_2^2 = \frac{2kT_1 d\omega}{\pi R_1} + \frac{2kT_2 d\omega}{\pi R_2}$ where $i_n^2 = \frac{2kT_s d\omega}{\pi R}$,

Thus $T_s = \left(\frac{T_1}{R_1} + \frac{T_2}{R_2}\right)R = \frac{T_1 R_2 + T_2 R_1}{R_1 + R_2}$

11. (D) $T_e = T_0(F_0 - 1) = 290(6.31 - 1) = 1539.9$ K

12. (C) $F_{op} = 1 + \dfrac{T_e}{T_a} = 1 + \dfrac{1540}{180} = 9.56$ or 9.8 dB

13. (B) $T_e = 250 = T_{e1} + \dfrac{T_{e2}}{G_1} + \dfrac{T_{e3}}{G_2}$

$250 = 200 + \dfrac{450}{G_1} + \dfrac{1000}{5G_2}$ or $G_1 = 13$

14. (D) $F_0 = 1 + \dfrac{T_s}{T_0}(F_{op} - 1) = 1 + \dfrac{225}{290}(10 - 1)$

$= 7.98$ or 9.0 dB

15. (D) Here $L = 2.089$ or 3.2 dB, $T_L = 290$ K

$T_e = T_{e1} + \dfrac{T_{e2}}{G_1} = T_L(L-1) + \dfrac{T_0(F_0 - 1)}{1/L}$

$= 290[(2.089 - 1) + (2.089)(7.98 - 1)] = 4544.4$ K

$F_{op} = 1 + \dfrac{4544.4}{225} = 21.2$ or 13.3 dB

16. (B) $F_0 = 1 + \dfrac{4544.4}{290} = 16.67$ or 12.2 dB

17. (B) For A: $F_{op} = 10$(or 10 dB) when $T_s = 130$ K

$T_{eA} = 130(10 - 1) = 1170$ K

For B: $F_o = 3.98$(or 6 dB) when $T_s = 290$ K

$T_{eB} = 290(3.98 - 1) = 364.2$ K

For C: $F_o = 6.3$(or 8 dB) when $T_s = 190$ K

$T_{eC} = 190(6.3 - 1) = 1007$ K, (B) is better as T_{eB} is less.

18. (A) $T_e = T_{e1} + \dfrac{T_{e1}}{G_1} + \dfrac{T_{e3}}{G_1 G_2}$

$G_2 = \dfrac{T_{e3}}{G_1(T_e - T_{e1} - \frac{T_{e2}}{G_1})} = \dfrac{600}{10(190 - 150 - \frac{350}{10})} = 12$

19. (B) $F_0 = 1 + \dfrac{T_e}{T_0} = 1 + \dfrac{190}{290} = 1.655$ or 2.19 dB

20. (C) $F_{op} = 1 + \dfrac{T_e}{T_s} = 1 + \dfrac{190}{50} = 4.8$ or 6.81 dB

21. (A) $T_e = T_{e1} + \dfrac{T_{e2}}{G_1} + \dfrac{T_{e3}}{G_1 G_2} = 40 + \dfrac{100}{8} + \dfrac{280}{8(6)} = 58.33$ K

22. (B) $T_e = T_{e1} + \dfrac{T_{e2}}{G_1} + \dfrac{T_{e3}}{G_1 G_2} = T_{e1}\left[1 + \dfrac{1}{G} + \dfrac{1}{G^2}\right]$

or $(T_{e1} - T_e)G^2 + T_{e1}G + T_{e1} = 0$

$(125 - 155)G^2 + 125G + 125 = 0$

$6G^2 - 25G - 25 = 0$ or $G = 5$

23. (A) Sequence T_e

ABC$110 + \dfrac{120}{4} + \dfrac{150}{4(6)} = 146.25$

ACB$110 + \dfrac{150}{4} + \dfrac{120}{4(12)} = 150.00$

BAC $120 + \dfrac{110}{6} + \dfrac{150}{6(4)} = 144.583 \leftarrow$ Best

CBA$150 + \dfrac{120}{12} + \dfrac{110}{(12)(6)} = 161.528$

24. (A) $\overline{T}_e = T_0(\overline{F} - 1) \le 290(1.7 - 1) = 203$ K

25. (D) Here $\overline{F}_0 \approx 1.585$ (or 2.0 dB) and $\overline{F}_{OP} \approx 4.467$ (or 6.5 dB)

$\overline{T}_s = \dfrac{T_0(\overline{F}_0 - 1)}{\overline{F}_{op} - 1} = \dfrac{290(1.585 - 1)}{4.467 - 1} = 48.93$ K

26. (B) Here $T_a = 60$ K, $L = 1.738$ (or 2.4 dB), $T_L = 275$ K and $\overline{T}_{sys} = 820$ K. We know that

$\overline{T}_R = \dfrac{[\overline{T}_{sys} - T_a - T_L(L-1)]}{L} = \dfrac{820 - 60 - 275(1.738 - 1)}{1.738}$

$= 320.5$ K

27. (B) $\overline{F}_{op} = 1 + \dfrac{\overline{T}_e}{\overline{T}_s} = 1 + \dfrac{\overline{T}_{sys} - T_a}{\overline{T}_s} = 1 + \dfrac{820 - 60}{60}$

$= 13.67$ or 11.4 dB

28. (A) Here $G_R(\omega_0) = 10^{11}$ (or 110 dB)

and $W_{PV} = 2\pi(10^7)$ Hz

$N_{clo} = \dfrac{k\overline{T}_{sys}G_R(\omega)W_n}{2\pi L} = \dfrac{1.38(10^{-23})(820)(10^{11})(10^7)}{1.738}$

$= 651.110^{-5}$ or 6.51 mW

29. (C) $dN_{ao} = k[T_a + T_L(L-1)]\dfrac{d\omega}{2\pi} = kT_s\dfrac{d\omega}{2\pi}$

Thus $T_s = T_a + T_L(L-1)$

$= 60 + 275(1.738 - 1) = 263$ K

30. (D) $\overline{T}_e = \overline{T}_s(\overline{F}_{op} - 1) = 60(5 - 1) = 240$ K

31. (C) $\overline{F}_o = 1 + \dfrac{\overline{T}_e}{290} = 1 + \dfrac{240}{290} = 1.8276$

32. (A) $\overline{F}_{op} = 1 + \dfrac{\overline{T}_e}{\overline{T}_s} = 1 + \dfrac{240}{30} = 9$ or 9.54 dB