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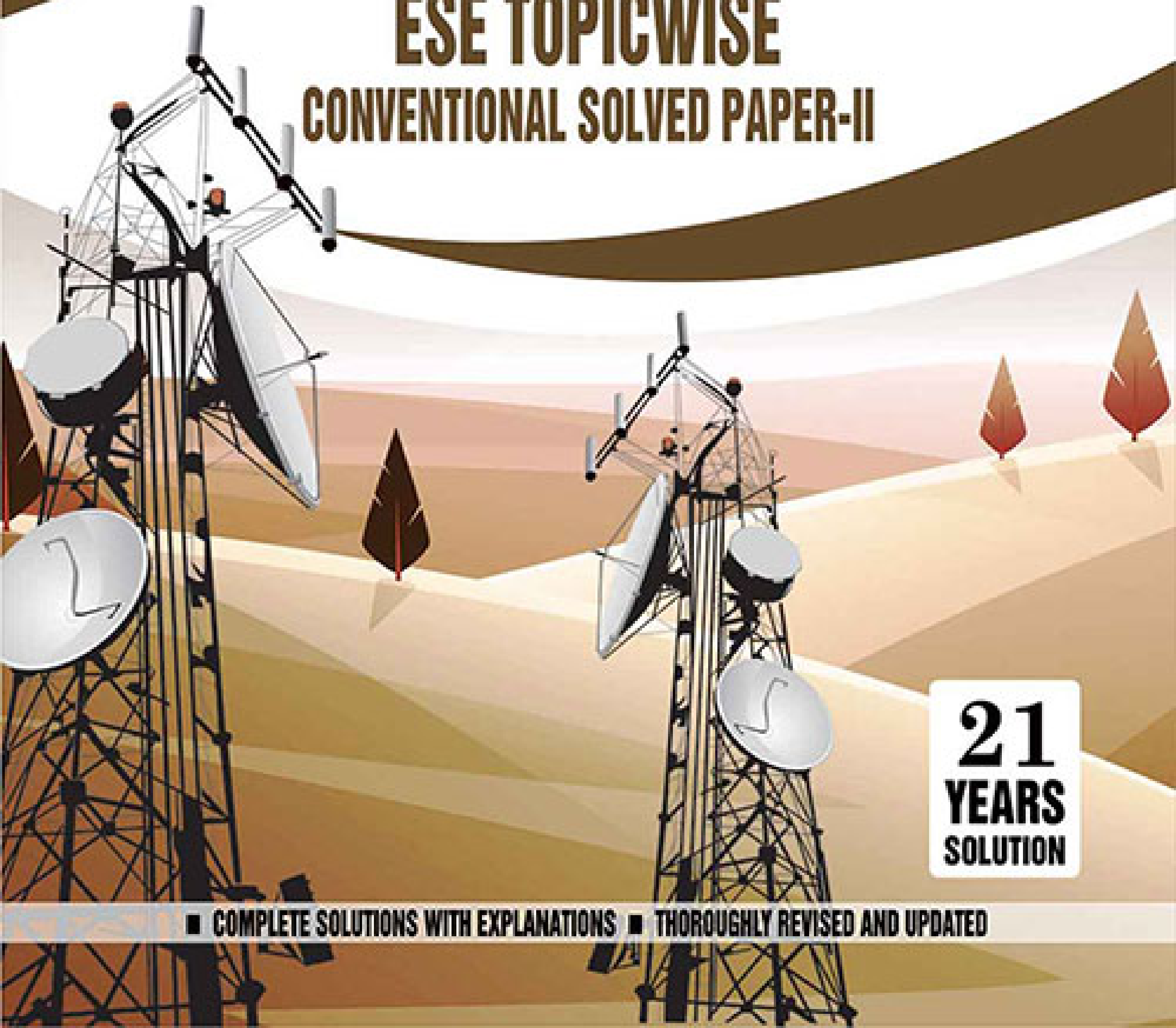
CONVENTIONAL SOLVED PAPER-II



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- COMPLETE SOLUTIONS WITH EXPLANATIONS
- THOROUGHLY REVISED AND UPDATED

ELECTRONICS & COMMUNICATION ENGINEERING

ESE TOPICWISE

CONVENTIONAL SOLVED PAPER-II

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Office: F-126, (Lower Basement), Katwaria Sarai, New Delhi-110 016

Phone: 011-2652 2064 ▪ **Mobile:** 81309 09220, 97118 53908

Email: info@iesmasterpublications.com, info@iesmaster.org

Web: iesmasterpublications.com, iesmaster.org

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F-126, (Lower Basement), Katwaria Sarai, New Delhi-110016

Phone : 011-26522064, **Mobile :** 8130909220, 9711853908

E-mail : info@iesmasterpublications.com, info@iesmaster.org

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PREFACE

Engineering Services Exam (ESE) is one of most coveted exams written by engineering students aspiring for reputed posts in the various departments of the Government of India. ESE is conducted by the Union Public Services Commission (UPSC), and therefore the standards to clear this exam too are very high. To clear the ESE, a candidate needs to clear three stages – ESE Prelims, ESE Mains and Personality Test.

It is not mere hard work that helps a student succeed in an examination like ESE that witnesses lakhs of aspirants competing neck to neck to move one step closer to their dream job. It is hard work along with smart work that allows an ESE aspirant to fulfil his dream.

After detailed interaction with students preparing for ESE, IES Master has come up with this book which is a one-stop solution for engineering students aspiring to crack this most prestigious engineering exam. The book includes previous years' solved conventional questions segregated Topicwise along with detailed explanation. This book will also help ESE aspirants get an idea about the pattern and weightage of questions asked in ESE.

IES Master feels immense pride in bringing out this book with utmost care to build upon the exam preparedness of a student up to the UPSC standards. The credit for flawless preparation of this book goes to the entire team of IES Master Publication. Teachers, students, and professional engineers are welcome to share their suggestions to make this book more valuable.

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UNIT 1

ANALOG AND DIGITAL COMMUNICATION SYSTEM

SYLLABUS

Random signals, noise, probability theory, information theory; Analog versus digital communication & applications; Systems-AM, FM, transmitters/receivers, theory/practice/standards, SNR comparison, Digital communication basics: Sampling, qunatizing, coding, PCM, DPCM, multiplexing-audio/video; Digital modulation: ASK, FSK, PSK: Multiple access: TDMA, FDMA, CDMA; Optical communication: fibre optics, theory, practice/standards.

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Chapter 1

Random Variables and Noise

Q–1: ***A two stage amplifier has the following parameters :***

	First stage	***Second stage***
Voltage gain	***12***	***20***
Input resistance	***500 ohms***	***80 K ohms***
Equivalent Noise Resistance	***1500 ohms***	***10 K ohms***
Output Resistance	***25 K ohms***	***1 M ohms***

Calculate :

(i) ***the equivalent noise resistance of the two stage amplifier;***

(ii) ***the noise figure of the amplifier if it is driven by a generator with output impedance 50 ohms.*** ***[15 Marks ESE–1998]***

Sol. Given :

The voltage gain of first stage = A_1 = 12

The voltage gain of second stage = A_2 = 20

Input resistance for first stage, $R_{i1} = 500\,\Omega$

Input resistance for second stage, R_{i2} = 10 K

Now, $R_1 = R_{i1} + R_{n1}$

[Noise resistance is in series with input resistance]

$$R_1 = 1500 + 500$$

$$R_1 = 2000\Omega$$

Also, $R_2 = (R_{01} \,||\, R_{i2}) + R_{n2}$

[output resistance of first stage is parallel to input resistance of 2^{nd} stage] + [equivalent noise resistance of 2^{nd} stage]

$$R_2 = (25K \,||\, 80K) + 10K$$

$$R_2 = \left(\frac{25 \times 80}{105} + 10\right)K$$

$$R_2 = 29.04 \text{ K}$$

Again, $R_3 = R_{02} = 1M\Omega = 1000K\Omega$

Now, equivalent input noise resistance is given as

$$R_{eq} = R_1 + \frac{R_2}{A_1^2} + \frac{R_3}{A_1^2 A_2^2}$$

$$= 2000 + \frac{29.04 \times 10^3}{(12)^2} + \frac{10^6}{(12)^2 \times (20)^2}$$

$$= 2000 + \frac{29040}{144} + \frac{1000}{144 \times 4}$$

$$R_{eq} = 2219.1\Omega$$

Noise figure given by,

$$F = 1 + \left(\frac{R_{eq}^1}{R_a}\right) \quad ...(1)$$

When

$$R_{eq}^1 = R_{eq} - R_{i1} = (2219.1 - 500) = 1719.1\Omega$$

R_a = output resistance of generator = 50Ω

Hence from (1),

$$F = 1 + \frac{1719.1}{50} = 35.38$$

$$F = 35.38 \text{ or } 15.48 \text{ dB} \quad [F \text{ in dB} = 10\log_{10} F]$$

Q–2: ***Show that the input-to-output SNR gain of a matched filter depends on the product of the input signal duration and the noise bandwidth.*** ***[10 Marks ESE–2002]***

Sol. Impulse response of matched filter is

$$h(t) = S^*(T - t)$$

$$T = \text{Time period of } s(t)$$

Noise power at output of the filter is given as

$$P_n = \frac{\eta}{2}\int_{-\infty}^{\infty} |H(f)|^2 df$$

where $\frac{\eta}{2}$ = Noise power spectral density at output filter.

Now

$$|S_0(T)|^2 = \left|\int_{-\infty}^{\infty} H(f) S_i(f).e^{-2\pi fT} df\right|^2$$

∴ Signal to noise ratio at the output is given as

$$(SNR)_{o/p} = \frac{\left|\int_{-\infty}^{\infty} H(f) S_i(f) e^{-j2\pi fT} df\right|^2}{\left(\frac{\eta}{2}\right)\int_{-\infty}^{\infty} |H(f)|^2 df}$$

∵ $\int_{-\infty}^{\infty} \left|S_i(f)^2\right| df = E = \text{Energy of the signal}$

∴

$$(SNR)_{o/p} \le \frac{2E}{\eta}$$

$$(SNR)_{o/p}\Big|_{max} = \left(\frac{2E}{\eta}\right) \quad ...(i)$$

Now the input signal to noise ratio is given as

$$S_i = \frac{1}{T}\int_0^T S_i^2(t) dt = \left(\frac{E}{T}\right)$$

$$N_i = \left(\frac{\eta}{2}\right)(2B) = (\eta.B) \quad [B = \text{Noise bandwidth}]$$

$$(SNR)_i = \frac{S_i}{N_i} = \left(\frac{E}{\eta BT}\right) \quad ...(ii)$$

Now from (i) and (ii)

$$\frac{(SNR)_{o/p}}{(SNR)_{i/p}} = \frac{2E}{\eta} \times \frac{\eta BT}{E} = 2BT$$

$$\therefore \quad \frac{(SNR)_{o/p}}{(SNR)_{i/p}} = 2BT$$

Q–3: ***An amplifier has a noise figure of 4 dB, a bandwidth of 500 kHz and an input resistance of 50Ω. Calculate the input signal voltage needed to yield an output SNR = 1 when the amplifier is connected to a signal source of 50Ω at 290 K.*** ***[8 Marks ESE–2006]***

Sol. Given that for amplifier

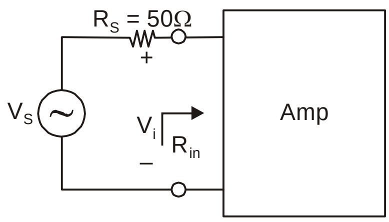
$$\text{Noise figure} = (F_n)_{dB} = 4dB$$

$$\text{Bandwidth} = B_n = 5000 \text{ kHz}$$

and,

$$(SNR)_0 = \frac{S_0}{N_0} = 1$$

$$R_{in} = 50\Omega$$



Let S_i be the input signal power and N_i be input noise power then,

$$S_i = \frac{(V_i)^2}{R_{in}}$$

or

$$S_i = \frac{1}{R_{in}}\left(\frac{R_{in}}{R_{in}+R_s}\right)^2 V_s^2$$

$$= \frac{1}{50} \times \left(\frac{50}{50+50}\right)^2 .V_s^2 = \left(\frac{V_s^2}{200}\right)$$

$$\therefore \quad V_s = \sqrt{S_i \times 200} \quad ...(i)$$

Since

$$\text{Noise figure} = F_n = \frac{(SNR)_{in}}{(SNR)_{out}} = \frac{(SNR)_i}{1} = (SNR)_i = \frac{S_i}{N_i}$$

$$\therefore \quad S_i = F_n \times N_i$$

$$= F_n \times KT_0 B_n \quad ...(ii)$$

Where K = Boltzman's constant = 1.38×10^{-23}

B_n = Receiver bandwidth = 500×10^3 Hz

T_o = Temperature = 290 K

$$\because \quad (F_n)_{dB} = 10\log_{10}(F_n)$$

or

$$4 = 10\log_{10}(F_n)$$

or

$$F_n = (10)^{0.4} = 2.512$$

Hence from eq. (ii)

$$S_i = 2.512 \times 1.38 \times 10^{-23} \times 290 \times 500 \times 10^3$$

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IES MASTER PUBLICATION
F-126 (Lower Basement), Katwaria Sarai, New Delhi-110016
Phone : 011 26522064, **Mobile :** 97 1185 3908
E-mail : info@iesmasterpublications.com, info@iesmaster.org
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