INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Mathematical tables/non-programmable scientific calculator.

Answer FIVE of the EIGHT questions in the answer booklet provided.
All questions carry equal marks.

Maximum marks for each part of a question are as shown.
Candidates should answer the questions in English.

Take: Free space wave velocity, \( C = 3 \times 10^8 \text{ m/s} \).
1. (a) Define each of the following with respect to pulse modulation systems:

(i) quantization noise;

(ii) Nyquist sampling rate. (2 marks)

(b) (i) A data transmission link consists of two four-input concentrators and a multiplexer. With the aid of a labelled block diagram, describe the operation of the link.

(ii) With the aid of a labelled diagram, describe the operation of a star network topology. (10 marks)

(c) An a.f. signal of $4 \sin 600 \pi t$ volts is transmitted using 8-bit Pulse Code Modulation (PCM). Determine the:

(i) Nyquist sampling rate;

(ii) quantization error voltage;

(iii) signal-to-quantization noise ratio. (8 marks)

2. (a) (i) List two losses that occur in optical fibres.

(ii) With the aid of a labelled diagram, describe the operation of a light emitting diode. (8 marks)

(b) An optical fibre has a core of refractive index of 1.72 and cladding whose refractive index is 1.48. If the signal wavelength is 0.66 $\mu$m and the core diameter is 4 $\mu$m, determine the:

(i) numerical aperture;

(ii) signal frequency;

(iii) number of modes that can be propagated. (6 marks)

(c) Table 1 shows data for an optical fibre.

(i) Plot the response curve.

(ii) Determine the:

(I) frequency of operation;

(II) spectrum of the fibre in wavelengths. (6 marks)
Table 1

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>400</th>
<th>800</th>
<th>900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output signal (μV)</td>
<td>-</td>
<td>9.5</td>
<td>22</td>
<td>38</td>
<td>45</td>
<td>36.5</td>
<td>18.5</td>
<td>11</td>
<td>5</td>
</tr>
</tbody>
</table>

3. (a) (i) List two errors associated with the very high frequency omirange (VOR) radio navigation aid.

(ii) Sketch the A scope radar display and explain its shape. (10 marks)

(b) Explain how marker beacons are used as navigation aids in instrument landing systems. (5 marks)

(c) A radar system, operating at 8 GHz over a bandwidth of 750 kHz, uses an amplifier with a noise figure of 9 dB and an antenna whose diameter is 2 m. If the antenna radiates 20 kW and the target cross-sectional area is 6 m², determine the radar range. (5 marks)

4. (a) (i) List three areas of application of a varactor diode.

(ii) Draw a labelled block diagram of a high-level amplitude modulation (AM) transmitter and describe its operation. (9 marks)

(b) An FM stereo encoder has a carrier wave of 19 kHz and a stereo signal sub-carrier of 38 kHz. If the a.f input signal ranges from 0 Hz to 15 kHz, draw a labelled spectral band for the composite signal. (3 marks)

(c) An AM system has a 20 kW carrier wave of amplitude 10 V and a modulating signal of amplitude 8 V.

(i) Sketch the AM waveform;

(ii) Determine the:

   (I) modulation index;
   (II) radiated power;
   (III) transmission efficiency. (8 marks)

5. (a) Define each of the following as applied to antennas:

(i) effective aperture;

(ii) front-to-back ratio. (2 marks)
(b) (i) With the aid of a labelled diagram, describe the operation of a horn-feed microwave antenna.

(ii) Figure 1 shows the polar diagrams of two different antennas. Explain, with reason(s), which antenna is suitable for:

(I) radiation of signals at 700 kHz;
(II) reception of TV signals. (9 marks)

Fig. 1

(c) A 5-element dipole end-fire array radiates 5 kW at 60 MHz towards a receiving antenna located 120 km away. If the path attenuation is 25 dB, determine the:

(i) power flux density at the receiving point;
(ii) power received by the antenna if its gain is 12 dB. (9 marks)

6. (a) (i) List two factors that determine the fidelity of a radio receiver.

(ii) With the aid of a labelled block diagram, describe the operation of an AM superheterodyne radio receiver. (10 marks)

(b) Table 2 shows data for a radio receiver tuned between 80 MHz and 120 MHz.

(i) plot the sensitivity response curve;
(ii) determine the:

(I) receiver sensitivity;
II) frequencies at which sensitivity is 27.5 $\mu$V. (6 marks)

Table 2

<table>
<thead>
<tr>
<th>Input signal ($\mu$V)</th>
<th>44</th>
<th>31.5</th>
<th>22.5</th>
<th>15</th>
<th>10</th>
<th>10.5</th>
<th>17</th>
<th>25</th>
<th>38.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (MHz)</td>
<td>80</td>
<td>85</td>
<td>90</td>
<td>95</td>
<td>100</td>
<td>105</td>
<td>110</td>
<td>115</td>
<td>120</td>
</tr>
</tbody>
</table>
(c) With the aid of a circuit diagram, describe the operation of a series i.f trap in a radio receiver.  

7. (a) Define each of the following with respect to satellite communication:

(i) perigee;  

(ii) angle of inclination.  

(b) (i) Explain “program tracking” as applied to an earth station antenna.  

(ii) With the aid of a labelled diagram, describe the operation of a tunnel diode amplifier.  

(c) A rectangular waveguide, having a plane separation of 4 cm, operates at 12 GHz when carrying the dominant mode. Determine the:

(i) cut-off wavelength;  

(ii) guide wavelength;  

(iii) group velocity;  

(iv) phase velocity.  

8. (a) (i) Define each of the following as applied to radar systems:

(I) 2nd return echoes;  

(II) maximum unambiguous range;  

(ii) With the aid of a labelled diagram, describe the plan-position indicator (PPI) radar display.  

(b) Figure 2 shows a line-pulser used in pulsed radar systems. Explain its operation.  

![Circuit Diagram]

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**Fig. 2**
(c) An MTI radar system operates at 4 GHz with a pulse repetition frequency of 900 pulses per second. Determine the lowest three blind speeds for the radar. (7 marks)