1. Define Over sampling Ratio. [N/D-16]

In most cases 10-bit resolution is sufficient, but in some cases higher accuracy is desired. Special signal processing techniques can be used to improve the resolution of the measurement. By using a method called 'Oversampling and Decimation' higher resolution might be achieved, without using an external ADC.

2. Draw the block diagram of Delta Sigma Modulator injected with noise. [N/D-16]

![Block diagram of Delta – sigma Modulator](image-url)
3. What is meant by Localizer?

The localizer operates in the VHF band (108-110 MHz) and consists of a transmitter with an antenna system. The radiation of which has two lobes, one with a predominant modulation of 90 Hz and other with 150 Hz.

4. What are the types of Radar present in the Ground controlled approach systems?
- Surveillance radar element
- Precision approach radar
5. **What are the disadvantages of ILS?**
   - Provides a single approach path along the extended centre line of the runway.
   - It is site sensitive and subject to distortion and bending of the approach path due to site irregularities.

6. **What are the basic elements of a MLS system?**
   - Azimuth beam equipment
   - Elevation beam equipment
   - Distance measuring equipment
7. **What is meant by Doppler navigation?**
   It employs the Doppler Effect to determine the velocity of the craft in a frame of coordinates fixed with respect to the aircraft.

8. **Define Frequency Trackers**
   The frequency tracker locates the centre of the noise like Doppler spectrum and gives the output the pure signal of this frequency.
9. Define Inertial Navigation
   Inertial navigation is a system of dead reckoning navigation in which the instruments in the craft determines its accelerations and by successive integration, obtain its velocity and displacement.

10. What are the features of Navigation over earth?
    - The system of coordinated should be fixed with reference to earth.
    - The coordinate system most convenient for use is latitude and longitude.
    - Avery large gravitational fields is present at the surface of the earth.
11. What are the components of inertial navigation systems?

- Accelerometers
- Gyros and stabilized platforms

12. Define DECTRA

DECTRA is a Decca tracking and ranging. This is a long range hyperbolic navigational system working at a frequency of about 70 KHz. The system is designed to provide navigation information over a long route, particularly along the sea.
13. Define-CONSOL
It is a rotating beacon operating in the LF/MF band which employs a system of three antennas producing a multi lobed pattern which is switched to produce a number of equi signals as in the radio range.

14. Define-CONSOLAN
It is same as CONSOL except that a two antenna system is used instead of three antennas.
15. What are Marker Beacons?
These are Radio beacons which are intended to mark some salient points.

16. Define –SHORAN
Short Navigation System is a secondary radar system in which fix is obtained by the craft, which carries the interrogator, by simultaneously interrogating two ground beacons.
Decimation can be regarded as the discrete-time counterpart of sampling. Whereas in sampling we start with a continuous-time signal \( x(t) \) and convert it into a sequence of samples \( x[n] \), in decimation we start with a discrete-time signal \( x[n] \) and convert it into another discrete-time signal \( y[n] \), which consists of sub-samples of \( x[n] \). Thus, the formal definition of \( M \)-fold decimation, or down-sampling, is defined by Equation 9.1. In decimation, the sampling rate is reduced from \( F_s \) to \( F_s/M \) by discarding \( M-1 \) samples for every \( M \) samples in the original sequence.

\[
y[n] = y[nM] = \sum_{k} h(k) x[nM - k]
\]  

(9.1)

Figure 9.1: Block diagram notation of decimation, by a factor of \( M \).

The block diagram notation of the decimation process is depicted in Figure 9.1. An anti-aliasing digital filter precedes the down-sampler to prevent aliasing from occurring, due to the lower sampling rate. The subject of aliasing in decimated signals is covered in more detail in Section 9.4. In Figure 9.2 below, it illustrates the concept of 3-fold decimation i.e. \( M = 3 \). Here, the samples of \( x[n] \) corresponding to \( n = \ldots, -2, 1, 4, \ldots \) and \( n = \ldots, -1, 2, 5, \ldots \) are lost in the decimation process. In general, the samples of \( x[n] \) corresponding to \( n \neq kM \), where \( k \) is an integer, are discarded in \( M \)-fold decimation. In Figure 9.2 (b), it shows samples of the decimated signal \( y[n] \) spaced three times wider than the samples of \( x[n] \). This is not a coincidence. In real time, the decimated signal appears at a slower rate than that of the original signal by a factor of \( M \). If the sampling frequency of \( x[n] \) is \( F_s \), then that of \( y[n] \) is \( F_s/M \).

### 9.4.1 Decimation

The implications of aliasing caused by decimation are very similar to those in the case of sampling a continuous-time signal, in Section 1.3. In general, if the Fourier transform of a signal, \( X(\theta) \), occupies the entire bandwidth from \([0, \pi] \), then the Fourier transform of the decimated signal, \( X_{\text{down}}(\theta) \), will be aliased. This is due to the superposition of the \( M \) shifted and frequency-scaled transforms. This is illustrated in Figure 9.5 below, which shows the aliasing phenomenon for \( M = 3 \).
Figure 9.4: Interpolation of a discrete-time signal by a factor of 3.
4.5: Aliasing caused by decimation; (a) Fourier transform of the original signal; (b) After decimation filtering; (c) Fourier transform of the decimated signal.
2. With the help of necessary diagrams, explain delta sigma DAC. 

FIG. 1 (RELATED ART)

Delta Sigma DAC

FIG. 1 shows a conventional Delta-Sigma DAC for converting a 16-bit digital signal to an audible signal Vout. The Delta-Sigma technique is popular because it achieves high resolution and quality with effective hardware implementations. An interpolator 102 receives an n-bit digital signal at a first sampling rate, and performs an interpolation to generate an n-bit output signal at a second, higher sampling rate. A Delta-Sigma modulator 104 receives the output signal from the interpolator 102 and shapes the quantization noises therein, thereby generating a shaped signal as a substantially linear analog representation of the 16-bit digital signal within a pass band. A DAC 106 then converts the shaped signal to an analog form, and a filter 110 filters high frequency noises therein to output the audible signal Vout.
When powering up, a system clock (not shown) requires a period of transient time to settle, and the Delta-Sigma modulator 104 also takes time to converge to stability. Random digital signals may be generated during the period, and amplified by the DAC 106 to output glitch noise. In the filter 110, an inverter 120 is conventionally implemented to avoid power-up glitches. A logic high signal is input to the inverter 120 when powering up, thus the inverter 120 enters a high impedance (High-Z) mode that forms an equivalent open circuit for the output node A. In this way, the power-up glitches are not passed to the output of filter 110. When the Delta-Sigma modulator 104 completes initialization, a zero pattern is output, and the inverter 120 returns to normal mode from the High-Z mode, passing the zero pattern to the filter 110. The zero pattern does not generate audible sounds through the filter 110. Additionally, a reference voltage Vref for the operational amplifier OP1 is coupled to ground by a switch 112 according to the control signal #ctrl when powering up, and the filter 110 forms a unity gain buffer that is also capable of avoiding power-up glitches. The reference voltage Vref is typically cascaded to a large capacitor (not shown) to obtain higher SNR. When the inverter 120 returns from High-Z mode to normal mode, the control signal #ctrl simultaneously switches to a logic low, such that the reference voltage Vref gradually increases to its operating point according to the RC constant.

In FIG. 1, an alternative implementation provides an output switch 114 coupled to the output of the operational amplifier OP1. The output switch 114 as well as the switch 112, may be a NMOS. When powering up, a control signal #ctrl of logic high is sent to the output switch 114, coupling the audible signal Vout to ground. The power-up glitches output from the operational amplifier OP1 are thus instantly avoided.

The High-Z mode solution, however, cannot be applied to finite impulse response (FIR) based Delta-Sigma DACs or switched capacitor architectures. Additionally, the zero patterns generated from the Delta-Sigma modulator 104 may still render glitches since the duty cycle transient of the zero pattern is unpredictable for the filter 110. The output switch 114 may not effectively pull the audible signal Vout to ground because the operational amplifier OP1 may output a significantly large loading. An improved anti-glitch circuit is therefore desirable.
3. Explain in detail about Ground Controlled Approach System (GCA).

- GCA is a high precision radar system sited near the airport runway. With the help of this system controller on the ground can bring the aircraft into approach zone & then guide it along the path. The system consists of two radars one called surveillance radar element (SRE) & other called as precision approach radar (PAR). SRE is a search radar with a PPI display. As the SRE is not an essential part of the approach system. The following data relating to an early version of SRE may however be noted.

**Surveillance Radar Element**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength</td>
<td>10 cm</td>
</tr>
<tr>
<td>Peak power</td>
<td>80 kW</td>
</tr>
<tr>
<td>Pulse length</td>
<td>0.5 μ sec</td>
</tr>
<tr>
<td>Pulse repetition frequency</td>
<td>2000 pulses/sec.</td>
</tr>
<tr>
<td>Scan rate</td>
<td>30 rev/min.</td>
</tr>
<tr>
<td>Beam width in the horizontal plane</td>
<td>approx. 0.5°</td>
</tr>
</tbody>
</table>

The fan-shaped beam covers about 20° in the vertical plane.

**Precision Approach Radar:**

- This precision radar has a maximum range of about 15-20 km & scans the approach zone both in azimuth & elevation. The precise performance & display details depend to some extent on the manufacturer of the equipment. Radar has to scan a 20° azimuth sector & a 7° elevation sector to meet the operational requirements. For the accuracy we have two separate antennas are used one for azimuth & other for elevation scanning. By setting the power we can control the angle of scanning.

![Azimuthal coverage diagram](image)
Also the position of the PAR w.r.t runway is shown in the figure below.

- PAR precision depends upon precise determination of the beam position. The PAR uses the single radar transmitter which is connected alternately to the two antennas so two scans are interlaced.

Features of Position approach radar

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter power (peak)</td>
<td>50 kW</td>
</tr>
<tr>
<td>Frequency</td>
<td>9080 MHz</td>
</tr>
<tr>
<td>Pulse width</td>
<td>0.18 μsec</td>
</tr>
<tr>
<td>Pulse repetition frequency</td>
<td>3.825 kHz</td>
</tr>
<tr>
<td>Range discrimination</td>
<td>200 ft</td>
</tr>
<tr>
<td>Azimuth discrimination</td>
<td>0.6°</td>
</tr>
<tr>
<td>Elevation discrimination</td>
<td>0.6°</td>
</tr>
</tbody>
</table>

- For large coverage large antenna is used (13 ft * 1.625 ft). Two types of PAR used fixed and movable. For movable PAR antenna should be lighter than the fixed one. The data obtained by the PAR are displayed on two CRTs one displaying range & elevation angle & other displaying range & azimuth angle. The accuracy of PAR is such that at a distance of 1 mile it is possible to detect deviations of glide-slope as little as 8m.
4. **Explain in detail pulsed Doppler system.**

**Doppler Effect**

- Doppler radar directs a beam of electromagnetic waves towards the earth. Some of the energy re-radiated by the earth towards the aircraft is received & compared when the aircraft has a component of the velocity in the direction of the beam, the difference frequency called Doppler shift is nearly proportional to the velocity component. This is Doppler Effect.

**Beam Configuration:**

- Consider an aircraft flying over the earth, transmitting EM waves in a narrow beam making an angle $\Phi$ with the horizontal

![Diagram of Doppler Effect](image)

- If the aircraft is in level flight & the beam is directed in the vertical plane containing the forward velocity $V$ of the craft the component of the velocity in the direction of the beam is $V \cos \Phi$ & the Doppler shift is

$$\frac{2V \cos \Phi}{\lambda}$$

- But this is only one component of the shift is obtain in general three component is needed. Some of the configurations is shown in figure below
Track Stabilization
Components of DNS

- Pulsed Doppler radar may be one of the two types
- Incoherent type
- Coherent type

In incoherent operation the phase of radiation will change from pulse to pulse to obtain Doppler shift the pulses received from two opposite beams, which arrives at same time, are compared

Incoherent Pulsed Doppler system
• AFC of the local oscillator is necessary at these frequencies therefore a sample of transmitted signal is taken from a directional coupler & applied to the AFC circuit. Generally four beam configuration is used.
• Pulsed magnetron is used as the transmitter & this is switched to the beam pairs (1-3, 2-4) sequentially.
• A duplexer is used to permit common antenna for transmission & reception.
• Received signals is applied to a superheterodyne
• receiver, the output of this is Doppler frequency signal

**Coherent Pulsed Doppler system**

• Compare to incoherent in Coherent Doppler radar system employs a continuous wave oscillator & a pulsed power amplifier.
• Relatively low frequency generated by a quartz-crystal oscillator & stepped up by a chain of multipliers using step-recovery diodes or varactors.
• The local oscillator frequency is generated by heterodyning the oscillations at the transmission frequency with an oscillator at the intermediate frequency.

![Diagram of Coherent Pulsed Doppler system]

• The output of mixer is centred at the IF.
• The mixer & IF amplifier are followed by a coherent detector to which the other input is a reference frequency voltage.
• Reference frequency is obtained by mixing the IF with an offset oscillator output & taking the difference frequency output.
• By setting the offset oscillator both positive & negative Doppler shifts are obtained.
• This system is capable to detect sense of the velocity as well as the vertical velocity
• The only disadvantage of the coherent pulsed system is its greater complexity
• Another problem occurs at lower altitudes is that the transmitted pulse is received back before the next pulse is transmitted
• Solved by setting PRF

**Continuous Wave Doppler Radar**
• Separate transmitting & receiving antennas are required for preventing the transmitter output from entering the receiver

The Doppler difference frequency is obtained by direct heterodyning of the transmitted & received signals
• This is equivalent to having an IF of zero & is called homodyne reception
• The difference signal is amplified in an audio amplifier & applied to frequency tracker
• In homodyne operation the sense of the velocity can not be obtained
• Suffers from reflection from nearby objects, turbulent air, precipitation
• Generally used fixed antenna

**FM-CW Doppler Radar**
• Uses common antenna for Tx & Rx
• The received signal is mixed with sample of transmitted signal in balanced mixer & desired side band is filtered & applied to coherent mixer
• The output of filter is mixed with the $n$th harmonic of the FM oscillator in the
• coherent mixer output of which will be difference frequency
• After amplification the signal is fed to frequency tracker
• Sometimes uses separate antenna for Tx & Rx
• The sense information may be obtained

**Frequency Trackers**

• Locates the centre of the noise-like Doppler spectrum & gives pure signal of frequency
• Various configurations but most of them employ a tracking oscillator
• In this the spectrum is compared with local oscillator frequency & error signal is generated
• According to the error signal oscillator is driven & correct frequency tuned. Other is two filter tracker
• In this arrangement single filter is used but the oscillator frequency is switched by a square wave & takes on alternately two values which are separated by a spectrum width
- Oscillator output is mixed with the Doppler signal & pass through low pass filter & envelope detector.

- The output of the filter is square wave & applied to the phase detector where two signals compared & error signal is generated.

**Accuracy of DNS**

- The overall accuracy depends upon ground speed measurement & heading accuracy.
- Computational errors if Analog computers are used.
- 0.25% may be achieved if negligible computational error.

5. Explain in detail Instrumentation landing system.

**Basics of Landing**

- When visibility is good, whether in the day or at night, this operation is carried out by visual observation of the ground & landing lights.
- The landing is then performed under ‘Visual Flight Rules’ (VFR) conditions.
- Usually this is taken to indicate a horizontal visibility of 5 km or more & vertical visibility of 300 m. when these conditions are not satisfied, the landing is under ‘Instrument Flight Rules’ (IFR) conditions.
- Special arrangements are provided at airports to enable the aircraft to execute landings under bad visibility.
- So we have to provide information about its exact position in relation to desired path & horizontal & vertical positions.
- Two types:
  - ILS (Instrument Landing System) MLS
  - MLS (Microwave Landing System)
  - Ground Controlled Approach (GCA)
- GCA does not required any special navigational equipment only a communication set is needed in the aircraft.

**Instrument Landing System**

- The instrument landing system (ILS) comprises the units localizers, glide path (or glide slope) & marker beacons.
- The localizer defines a vertical equi – signal plane which passes over the centre line of the runway & the glide-slope.
- Three marker beacons are also installed at certain specified distances from the end of runway.

**Localizer**

- The localizer operates in the VHF band (108- 110 MHz) & consists of a transmitter with an antenna system.
- The radiation from the antenna system has two lobes one with a modulation of 90Hz & other with a modulation of 150Hz.
• The two signals are equal hence both the lobes are symmetrical to the runway.
• The antenna array by means of which this pattern is obtained consists seven or eight elements.

• Loop antenna is used in localizer and this entire antenna system is placed at the centre line of the runway and about a 300 m from the end of the runway.
• Total of 7 or 8 loops divided in formation of 3-1-3 or 3-2-3 the centre loop fed with carrier of 90Hz & 150Hz modulated wave.
• While one side loop is fed with side-band of 90Hz & 150Hz.
Glide-Slope System

- The principle of operation of the glide-slope currently in use, called null-type glide-slope is very similar to the localizer.
- This system operates in the band 339.3 -335 MHz band employs two antennas having a polar diagram as shown in figure.
- Here the larger lobe represents the radiation from the lower antenna & transmit the carrier & smaller lobes represents the radiation from the top antenna & having only side-band frequencies.

If the aircraft flies along the null, it receives the signal of lower antenna only & the two modulations are equal, giving an equi-signal course. The glide-slope equipment & antenna have to be sited away from the runway so that they do not constitute a hazard. The modifier array is used here for error correction so the pilot can easily make out the correct course.
Receiving Equipment:

- The receiver is typically a crystal controlled multi-channel receiver. Separate receivers are required for the localizer & the glide-slope because they operate in widely different bands. Receivers having very efficient automatic gain control this keep the output of the receiver constant when the input varies from 20μV to 100000μV. So the meter indication is perfect & ensure the correct path finding. It is important, both in the localizer & the glide-slope, that the courses are maintained correctly & the modulation levels preserved. To achieve this we have to detect the signal strength for this dipole antennas are fixed at certain specified points on & off course. Now the received signal is processed to find the modulation components & monitor the course alignment, width & clearance. If the certain condition is not satisfied then it enables the alarm circuit.

![Diagram](image)

- The output of receiver is applied to two filters which separate the 90Hz & 150Hz signals, each of which is rectified by a bridge rectifier. The outputs of rectifier are connected so as to give the difference between the rectified voltages & this is applied to the indicator coil. R1 is used to compensate for different losses in the two rectifiers & filters. Voltage across R3 is applied to a coil which operates the 'flag alarm'. Thermistor is used for temperature compensation. The indicator shown in figure consists of a meter with two centre-zero movements. Horizontal needle indicates deviation from the glide-path & the vertical needle indicates deviation from the localizer. FSD of the meter typically set at 150μA.
Course Sharpness & Width

- The sharpness & width of the course are dependent on the relative depths of modulation of the 90Hz & 150Hz signals.

- The total signal modulation is defined by the relation: \( M = \frac{(A+B)}{C} \) where \( M \) is total signal modulation, \( A \) & \( B \) are the amplitudes of the 150Hz & 90Hz signals respectively & \( C \) is the carrier amplitude. The difference in the depth of modulation (ddm) of the two signals is given by \( \frac{(A-B)}{C} \). Now the meter indicates when current is pass through the coil. If equi-signal course followed by the aircraft then indication is null. The sharpness & width of the course are dependent on the relative depths of modulation of the 90Hz & 150Hz signals. The total signal modulation is defined by the relation: \( M = \frac{(A+B)}{C} \) where \( M \) is total signal modulation, \( A \) & \( B \) are the amplitudes of the 150Hz & 90Hz signals respectively & \( C \) is the carrier amplitude. The difference in the depth of modulation (ddm) of the two signals is given by \( \frac{(A-B)}{C} \). Now the meter indicates when current is pass through the coil. If equi-signal course followed by the aircraft then indication is null.

Site effects in the ILS

- The localizer & glide-slope courses are affected by the nature of the site on which they are installed. The terrain type introduce error in equi-signal course. For the type of terrain if we restrict the radiation it would difficult for aircraft to achieve the right path. The power of radiation & site conditions must take into account while designing the system so capture effect can be avoided.

Marker Beacons

- The ILS employs three marker beacons. It gives an indication in the aircraft when it passes over them. All of them operate at 75 MHz & work with an antenna which gives a fan-shaped beam which is typically +/- 40° wide along the approach path & +/- 80° perpendicular to it. The outer marker(OM) is placed at 7km from the touchdown point of the runway. The radiation is modulated at 400Hz giving two dashes/sec. The second one called as middle marker (MM) is placed where the glide path is 200 ft which is generally about 1km from the touchdown point. The modulation is at 1300Hz with one dash every 2/3 sec. The last inner marker which is not used at all airports is placed where the glide-path is 100 ft above the ground. It is modulated at 3000Hz & transmits 6 dots/sec. In the aircraft a single receiver tuned to 75MHz is employed. The output is available as an audio signal & also actuates three lamps one for each marker beacon.