Q56. Write notes on system losses in radar system.

Nov./Dec.-15, Set-4, Q2(a)

(or)

What are the various system losses in radar system? Explain in detail.

Nov./Dec.-14, Set-2, Q2(b)

(or)

Describe the various system losses in radar system.

Nov./Dec.-14, Set-4, Q2(b)

(or)

Explain the various types of system losses in the radar systems.

Dec.-13, Set-4, Q2(b) M[5]

Explain the various system losses in a radar.

Oct./Nov.-17, Set-3, Q3(a)

(or)

What type of losses may exist in radar system? Explain in detail.

Ans: Nov.-16, Set-1, Q3

System Losses

The important factor which is omitted from the simple radar equation was system losses. These losses occur throughout the radar system and reduces the signal-to-noise ratio at the receiver output. The system losses are broadly divided into two types,

1. Predictable losses which include beam-shape loss, collapsing loss and plumbing loss.
2. Unpredictable losses which include limiting loss, operator loss, field degradation and stradding loss.

Plumbing Loss

At all times a finite loss is associated with the transmission lines used to join the transmitter and the antenna. At lower radar frequencies the loss associated with the transmission line is extremely small, unless its length is very lengthy. The attenuation caused by plumbing losses is taken into consideration at higher radar frequencies. Apart from this additional losses arise due to each bend or connection in the line and the antenna rotary joint. The attenuation caused by the connector losses varies relying upon the quality of connection. If the connection is poor then large attenuation is caused. The loss to be inserted in the radar equation is two times the one-way loss, because same transmission line is employed for transmission and reception.

When the signal passes through the duplexer, it suffers attenuation. The insertion loss is more, when the isolation required from the duplexer on transmission is more. The loss which is introduced, when the component (duplexer) is inserted into the transmission line is called insertion loss.

Beam-shape Loss

The loss which is added to the radar equation to account for the fact that the maximum gain is employed in the radar equation rather than a gain that changes pulse to pulse is known as Beam-shape loss. Then, the beam-shape loss relative to a radar that integrates all n pulses with an antenna gain corresponding to the maximum gain at the beam center is given by,

$$\text{Beam-shape loss} = \frac{n}{1+2\sum_{k=1}^{(n-1)/2} \exp(-5.55k^2/n_B^2)}$$

Where,

n_B – Number of pulses received within the half power beamwidth, θ_B.

n – Total number of integrated pulses.

A beam shaped in one plane has the loss shown in above expression. The maximum signal received does not correspond to the signal from the beam center, when the target passes through any point (other than center) of the pencil beam. The factor by which beam-shape loss is reduced, is the squares of the ratio of maximum antenna gain at which pulses were transmitted to the antenna gain at beam center.

The scanning loss can be taken as 1.6 dB for one-coordinate fan beam scanning and 3.2 dB for two-coordinate scanning, when there are a large number of pulses per beamwidth integrated.

Collapsing Loss

The added loss caused by the integration of additional noise samples together with the required signal-to-noise pulses is known as collapsing loss. Mostly these losses arise in displays, which collapse the range information i.e., C-scope that show elevation Vs azimuth angle. The collapsing of the 3D radar information (range, azimuth and elevation) onto a 2D (range, azimuth) display results in a loss. The collapsing loss is also occurs in the following two cases,

1. If the outputs of two radar receivers are combined and one contains signal while other contains noise.
2. When the output of high resolution radar is displayed on a device whose resolution is coarser than that inherent in the radar.

Mathematically, the collapsing loss is defined as,

$$L_i(m, n) = \frac{L_i(m+n)}{L_i(n)}$$

Where,

$L_i(m, n)$ – Integration loss for $m + n$ pulses

$L_i(n)$ – Integration loss for n pulses

m – Noise pulses

n – Signal plus noise pulses.

Limiting Loss

The probability of detection can be lowered by limiting in the radar receiver, some receivers might employ limiting for some special purpose i.e., for pulse compression processing. For a limiting ratio of 2 or 3, the limiting loss is only a fraction of a decibel for the integration of a large number of pulses. In the analysis of band pass limiters, the reduction in the signal-to-noise ratio of a sine-wave embedded in narrowband Gaussian noise is "$\pi/4$", for small signal-to-noise ratio.

However, the degradation can be made negligibly small by appropriately shaping the spectrum of the input noise.

Operator Loss

Most modern high-performance radars provide the detection decision automatically without intervention of a human operator. Processed information is presented directly to an operator or to a computer for some other action. Then the operator efficiency factor is given by,

$$\boxed{\rho_0 = 0.7(P_d)^2}$$

Where,

P_d – Single-scan probability of detection.

In radar equation, it is usual to find that no account of the operator loss has been taken. It is also justified when automatic detections are made without the aid of an operator. When the operator does introduce loss into the system, it is not easy to select a proper value to account for it. Finally, the better action is to take steps to correct loss in operator performance rather than to tolerate it by including it as a loss factor in the radar equation.

Straddling Loss

The loss which occurs in signal-to-noise ratio for targets not at the center of the range gate or at the center of the filter in a multiple-filter-bank processor is known as straddling loss. These losses occur in both analog and digital processing.

Field Degradation

When a radar is operated under field condition, performance usually deteriorates due to the following factors,

1. Water in transmission lines
2. Loose cable connections
3. Poor tuning
4. Incorrect mixer-crystal current
5. Weak tubes
6. Deterioration of receiver noise figure etc.

By designing the radars with built-in automatic performance-monitoring equipment, the field degradation can be minimized. The performance of the radar system can be increased by the careful observation of performance-monitoring instruments and timely preventative maintenance.

Field degradation cannot be predicted and is dependent upon the particular radar design and the conditions under which it is operating. So, a good estimate of it is very difficult to obtain.