Final 1997

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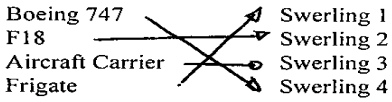
(1/3)

IEEE Carleton

1 nautical mile (NM)= 1852 m
g = 32.2 ft./sec
a = 3443.9 NM = 6378.2 km
$\varepsilon^2 = 6.6957 \times 10^{-3}$
c = 2.9979×10^8 m/sec

1. Radar Fundamentals

a) Match the Targets to their Swerling Classifications



b) Match the probability density functions to the appropriate signal feature

Uniform	Noise in the IF stage of a receiver
Gaussian	Detected envelope of narrow band noise
Rayleigh	Start up phase of a pulsed magnetron
Exponential	Detected envelope of a sinusoid plus narrow band noise
Rice	Swerling 1 cross section
Chi square with m=2	Swerling 3 cross section

c) A 60 cm wavelength radar has a peak transmitter power of 2 MW, a pulse width of 2.5μs and a pulse repetition frequency of 400 Hz. The antenna rotates at 5 rpm, has a gain of 34 dB and a horizontal beam width of 1.2 deg. Assume that the receiver noise figure is 2.5 dB and system losses total 5 dB.

i) For a target of average cross section 1 m^2 and Swerling Case 1 fluctuation characteristics, estimate the maximum range for a detection probability of 0.8 and a false alarm probability of 10^{-6}. 448 km

ii) What signal level expressed in volts at the input terminal of the receiver would be required for the performance specified? Assume that the input impedance of the receiver is 50 ohms. 1.7μV

d) Assuming the following objects have identical projected areas in the direction of the radar, list them in descending order of radar cross section.

- sphere 2
- corner reflector (front coverage) 1
- circular ogive (nose-on aspect angle) 4
- cone sphere (nose-on aspect angle) 3

2. MTI.

a) A 1.3 GHz radar having a pulse width of 1 μsec, a receiver bandwidth of 1 MHz and a prf of 600 Hz experiences an undesired interpulse frequency change of 3 kHz between pulses. What pulse width jitter can be tolerated by the radar such that its contribution to the MTI performance improvement factor is not more than that due to the frequency change? 10^{-8} s

b) An MTI radar employs a 1.3 GHz carrier, a 2 μsec pulse, a prf of 4 kHz and a two pulse canceller

i) What improvement factor can be obtained for a target within a rain cell having an rms clutter velocity spread of 6 m/s and a mean relative velocity of 0 m/s 24 dB

ii) What improvement factor can be obtained for a target within a rain cell having an rms clutter velocity spread of 0 m/s and a mean velocity of 30 m/s 17.86 dB

c). An MTI radar employs a 1.3 GHz, 600W average power transmitter which produces 2 μsec pulses at 800 Hz prf. The radar uses a 1.5 deg. antenna beamwidth with a rotation rate of 12 rpm. MTI operation is achieved with a triple delay canceller.

i) What is the limit imposed on the improvement factor by rain clutter? 53.2 dB

ii) What is the limit imposed on the improvement factor by scanning modulation? 61.3

iii) Is the radar's improvement factor limited by scan modulation or rain clutter?

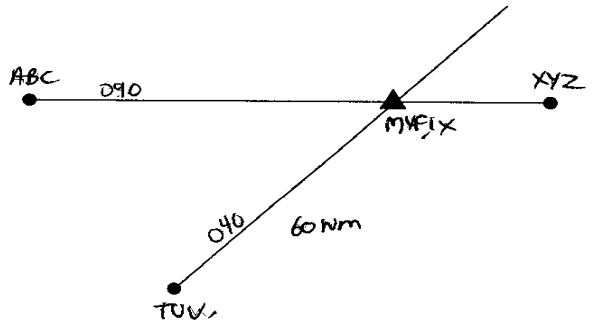
3. Navigation

a) The Russian equivalent of GPS is called GLONASS. The system designs are quite similar except that, instead of using one frequency and multiple codes, GLONASS uses one code and multiple frequencies. The GLONASS code is a simple m-sequence. Why is this feasible for GLONASS and not for GPS which uses the more complex Gold code?

b) In a Local Area Differential GPS system what error component

i) degrades primarily with distance from the reference station?

ii) degrades primarily with a reduction in data rate?



c) VORs ABC and XYZ define a segment of an airway. An aircraft is travelling from ABC to XYZ and air traffic control requires the pilot to report on arriving at MYFIX. Since neither ABC nor XYZ has a DME, the position of MYFIX is defined as the intersection with the 045 radial from VOR TUV. What is

i) the maximum average alignment error for VOR?

ii) the maximum along track error in reporting at MYFIX?

iii) assuming that the aircraft has two VOR receivers, how does the pilot determine that the aircraft is at MYFIX?

d) A DME receiver, in search mode, has an average pulse repetition rate of 135 pulse pairs/sec, and a tracking gate of width 20μsec. It slews the tracking gate at a rate of 120 μsec/sec. Before acquisition what is the average number of pulse pairs detected assuming a transponder efficiency of 80%? What is the average rate of detection (Pulse pairs/sec) when the tracking gate reaches the correct range? What is the average number of pulses detected as the gate passes the correct range?

e) From the attached diagram of the composite signal from a TACAN receiver determine the bearing of the aircraft from the station.