The LNM Institute of Information Technology

Dept. of ECE, Subject: Cognitive Radio

Mid-semester Examination, Date: 27-02-2020, Full Marks: 30 (5x6)

Q1. A) Mention the various interferences encountered in a radio wireless systems.

B) Consider Fig. 1, depicting the primary receiver (Δ) being affected by N secondary interferences from a disk of radius I. The total interference power at the primary receiver is:

$$\gamma_I = \sum_{j=1}^{N} g(r_j) P_j h_j$$

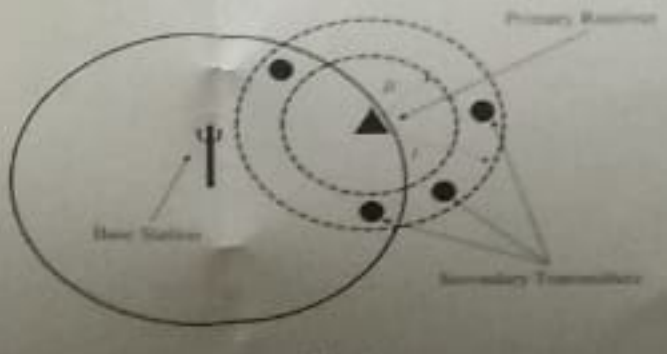

Fig. 1

Identify the parameters: r_j, $g(r_j)$, P_j and h_j

C) What is the expression for the interference temperature at the primary receiver i) for the above case; and ii) when the primary receiver has AWGN power N_0 along with the interference γ_I.

Q2.A) A relayed communication system is shown in Fig. 2

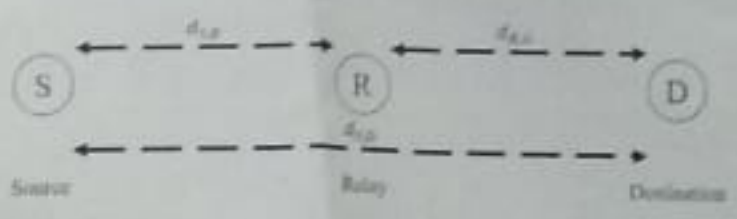

Fig. 2

Show that the power in a relayed system $P_{S,R}$ is less than the power in the S→D direct path, i.e. $P_{S,Direct}$. Assume the needed parameters.

B) Consider a 3-node relayed system as shown in Fig. 3

Fig. 3

Assume both source and relay transmit at the same power P. Write the expression of the output signal at destination (D) in the following 2 phases :

Phase 1 (source sends signal to destination and the relay), $y_{S,D} = ?$ [for S→D communication]

Phase 2 (relay sends signal to destination), $y_{R,D} = ?$ [R→D communication using AF protocol]

C) Find the capacity of the above system, given destination $SNR|_{phase\ 1} = SNR|_{phase\ 2} = 10\ dB$

Q3. A) The complex envelop of a Rician fading channel is given by

$$E = E_0 + \sum_{n=1}^{N} E_n e^{j\theta_n}$$

Define Rician factor K in terms of the above parameters E_0 and E_n.

B) Draw the low-pass (baseband) equivalent model of a Rician channel with Doppler.

C) Write the complex envelope of the following radio frequency signal

$$x(t) = A_{cm}\cos(\omega_c t + \theta) - A_{sm}\sin(\omega_c t + \theta)$$

Q4. A) A power delay profile is given by

$$p(\tau) = \frac{1}{\sqrt{2\pi a^2}} e^{\left(-\frac{1}{2}(\tau/a)^2\right)}$$

What is the value of τ_{rms} in this case?

B) Let $r(t) = \check{x}(t) + j\check{y}(t)$ and $|r(t)|$ is Rayleigh distributed, $\check{x}(t)$ and $\check{y}(t)$ are zero-mean Gaussian and each has a variance of 2. Find the variance of $|r(t)|$.

C) Write down the conditions for a wireless channel to be both frequency flat and time flat.

Q5. A) Define P_{FA}, P_{MD} and P_D considering spectrum sensing as a binary hypothesis problem. Indicate these parameters on the Receiver Operating Characteristic (ROC) curve.

B) i) Enumerate the steps used in cooperative spectrum sensing

ii) Using generalized fusion rule, write the expressions for P_D and P_F in a cooperative spectrum sensing in terms of p_d and p_f, where p_d and p_f refer to prob. of detection and prob. of false alarm in local CR sensing.

C) For an energy detection based spectrum sensing, the test statistic is given by $T(y) = \sum_{n=1}^{N} |y(n)|^2$, where $y(n) = s(n) + w(n)$ and $E(s^2) = P$ and $E(w^2(n)) = \sigma^2$. Find the mean value of $T\left(y/H_1\right)$. H_1 is the hypothesis when signal s is present.