Assignment-V and Its Solution

1. An earth station receiving at 20 GHz from a satellite at 20° elevation, has link availability of 99.9% and it experiences 11.31 dB attenuation during rain. What will be the diversity gain in dB when a diversity station is added at a distance of 10 Km with baseline orientation angle of 85° to satellite.
   A. 3.69
   B. 5.84
   C. 8.53
   D. 9.63

   **Solution:**
   We know that the diversity gain due separation of distance \( d \) (Km) and rain attenuation \( A \) (dB) can be mathematically represented as \( G(d, A) = a(1 - e^{-bd}) \). Where, \( a = 0.78A - 1.94(1 - e^{-1.14A}) \) and \( b = 0.59(1 - e^{-0.11A}) \). Here, \( A = 11.31 \) and \( d = 10 \).
   Hence, by using these values we get \( a = 0.78 \times 11.31 - 1.94(1 - e^{-1.14 \times 11.31}) = 7.44 \)
   \( b = 0.59(1 - e^{-0.11 \times 11.31}) = 0.4 \). So, the diversity gain due to distance and attenuation can be calculated as \( G(d, A) = 7.44 \times (1 - e^{-0.4 \times 10}) = 7.3 \)
   Now, the diversity gain due to operating frequency can be calculated as \( G_f(f) = e^{-0.025f} \), where \( f \) is operating frequency measured in GHz. So, \( G_f(f) = e^{-0.025 \times 20} = 0.61 \)
   Similarly, we can calculate the diversity gain due to elevation angle \( G_e(\theta) = 1 + 0.006\theta \). Here the quantity \( \theta \) is measured in degrees. So, \( G_e(\theta) = 1 + 0.006 \times 20 = 1.12 \).
   And, the diversity gain due to baseline orientation angle is \( G_\phi(\phi) = 1 + 0.002\phi = 1 + 0.002 \times 85 = 1.17 \)
   Now, the total diversity gain in dB will be the product of all the individual gains.
   Hence, \( G_D = 7.3 \times 0.61 \times 1.12 \times 1.17 = 5.84 \text{ dB} \). So, the appropriate choice is **B**

2. What is meant by F in direct method of \( G/T \) measurement using Y factor, which is expressed as \( G/T = \frac{(Y-1)8\pi k}{F \lambda^2} \)?
   A. noise figure
   B. flux density of radio star
   C. failure rate
   D. none of these

   **Solution:**
   F represents the flux density received from the radio stars with random polarization. Hence, the appropriate option is **B**.

3. For a given earth station \( D = 75 \), as per ITU mask for earth station reference antenna radiation, the gain \( G(\theta) \) in dB at \( \theta \) degree away from peak gain in dB will be.
   A. 29
   B. 30
   C. 31
D. 32

Solution:
Given \( \frac{D}{\lambda} = 75 \), \( \Phi = 75 \frac{\lambda}{D} = \frac{75}{D/\lambda} = 75/75 = 1^0 \). As per ITU recommended mask for reference antenna gain at \( \theta = 1^0 \) will be \( \phi(\theta) = 32 - 25 \log(\theta) \) for \( D/\lambda \geq 50 \) 
So, \( \phi(1^0) = 32 - 25 \log(1) = 32 \text{ dB} \). So, the correct answer is D.

4. A VSAT network is allotted 42 dBw in a linearized transponder. The network will operate with two carriers from Hub to support many VSAT carriers. The two Hub carrier need 36dBw each. And each VSAT carrier need 26dBw. How many VSAT carriers can be accommodated in the transponder?

A. 20  
B. 17  
C. 21  
D. 19

Solution:
The VSAT network has power limited transponder. Each hub carrier takes 36 dBw power and the network has two hub carrier. Hence the power consumed by the two hub carrier is \( 10 \log(2 \times 10^{3.6}) = 36 + 10 \log 2 = 39 \text{ dBw} \).
Let us assume we can accommodate \( N \) number of carriers. Therefore,
\[
N = \frac{10^{4.2} - 10^{3.9}}{10^{3.6}} = 19.85.
\]
As we cannot accommodate any fractional number of carriers thus, the maximum number of carriers can be accommodated is 19. So, the correct choice is D.

5. Why most of the VSAT antennas use offset feed mount?

A. To maintain the balance in the antenna setup  
B. To increase the efficiency of the antenna above 80%  
C. To minimize the signal blockage  
D. none of these

Solution:
The offset feed is used to reduce the blockage of the received signal. Hence, the appropriate option is C.

6. A satellite link in clear sky is using 8–PSK modulation scheme. It is needed to change the modulation scheme to counter the rain fade. Find out the suitable modulation scheme amongst the following

A. BPSK  
B. 16-PSK  
C. 32-PSK  
D. 64-PSK
Solution:
The number of constellation point in a modulation scheme directly affect the average power required by a modulation technique. Higher number of signal points in constellation diagram demand higher power. Reduction in number of signal points in a modulation scheme helps in power reduction. So the rain fade can be countered by reducing the number of signal points in a modulation scheme. So, the appropriate option is A.

7. To improve the single site attenuation of 10.31 dB at annual link availability of 99.9%, a second site is added to get diversity gain of 5.84 dB. What is the joint site rain attenuation for the same link availability?
   A. 3.56 dB
   B. 4.47 dB
   C. 5.78 dB
   D. 9.40 dB

Solution:
The diversity gain $G_D$ can be expressed as $G_D = A(p) - A_j(p)$. Where, $A(p)$ represents the single site attenuation at probability level $p$ and $A_j(p)$ represents the joint site attenuation at probability level $p$. Hence, by using this formula, $A_j(99.99)$ becomes 4.47 dB. hence, the appropriate option is B.

8. Using radio star based G/T measurement, where, F is radio star flux density, $A_e$ is the antenna effective aperture and $f$ is the frequency. The noise power ratio $Y$ is given as
   A. $Y = \frac{F A_e}{2kT}$
   B. $Y = 1 + \frac{F A_e}{2kT}$
   C. $Y = 1 - \frac{F A_e}{2kT}$
   D. $Y = 1 + \frac{2FA_e}{3kT}$

Solution:
In $Y$–factor based noise power measurement, $Y = \frac{P}{P_1} = \frac{0.5FA_eB + kT_k B}{kT_k B} = 1 + \frac{FA_e}{2kT_k}$. So, the appropriate one is B.

9. Earth station transmit power amplifier output is monitored through a 20 dB coupler. When a power meter shows 1 watt power at the coupler output, what was the power amplifier output in dBw?
   A. 19
   B. 20
   C. 21
   D. 22

Solution:
Assume power output of power amplifier is $P$ Watts. Hence, the output power from a 20 dB coupler will be $10 \log(P) 20$ dB.
In watts, it will be $P/100$ watts. Now it is mentioned that the measured output power from the coupler is 1 watt. So, $\frac{P}{100} = 1$, then $P = 100$ watts or $P = 20$ dBw. Hence the correct answer is B.

10. ITU recommends that ground station antenna Side lobes (for $\theta = 1^0$ to $20^0$ and for $\frac{D}{\lambda} \geq 50$) should be restricted such that 90% of Side lobe peak should not exceed this relation

A. $G(\theta) = 32 - 25 \log \theta$
B. $G(\theta) = 31 - 25 \log \theta$
C. $G(\theta) = 30 - 25 \log \theta$
D. $G(\theta) = 29 - 25 \log \theta$

**Solution:**

D