1. $P_0(\frac{R}{4}) = Q(\frac{[M(\frac{R}{4})]_{dB}}{\sigma_{\xi dB}}) = 0.01$.

$[M(R)]_{dB} = P_r(d_0) + 10n\log(\frac{d_0}{R}) - P_{th}$

$[M(R)]_{dB} - [M(\frac{R}{4})]_{dB} = 10n\log(\frac{1}{4}) \approx -6n$

又 $\because M[(\frac{R}{4})]_{dB} = Q^{-1}(0.01)\cdot\sigma_{\xi dB} = 2.32636\sigma_{\xi dB}$

(1) $\therefore P_0(R) = Q(\frac{[M(R)]_{dB}}{\sigma_{\xi dB}}) = Q(\frac{2.32636\sigma_{\xi dB} - 6n}{\sigma_{\xi dB}})$

(2) $\sigma_{\xi dB} = 8dB$, $n=4$, 则 $P_0(R) = 0.745$

2. 10BPSK, $M=2$. $\therefore R_s = R_b = 100kbps$

平坦; $R_s = B_s < (\Delta f)_c = \frac{1}{\overline{T_m}} \Rightarrow \overline{T_m} \leq 10\mu s$

(2) $f_d \approx \frac{v}{c}\cdot f_c = 161$, $B_d = 2f_d = 322$. $(\Delta t)_c \approx \frac{1}{B_d} = 3ms$

(3) $B_s > B_d$. $\therefore$ 是慢衰落

(4) $(\Delta t)_c \cdot R_b = 300\ bit$

3 (1) $f_{X_1(u)X_2(u)}(x_1, x_2) = \begin{cases} 1, & 0<x_1<1 \text{ 且 } 0<x_2<1 \\ 0, & \text{其它} \end{cases}$

$E\{Y_1(u)\} = E\{\sqrt{-2\ln X_1(u)}\}\cdot E\{\cos(2\pi X_2(u))\} = 0$.

同理 $E\{Y_2(u)\} = 0$. $E\{Y_1(u)Y_2(u)\} = E\{-\ln(X_1(u))\}\cdot E\{\sin(4\pi X_2(u))\} = 0$.

(2) $R = \sqrt{-2\ln(X_1)}$ $\frac{\partial R}{\partial X_1} = \frac{-1}{X_1\sqrt{-2\ln X_1}} < 0$.

$\therefore R(X_1)$ 是单调函数. $\Rightarrow f_R(r) = f_{X_1}(X_1(r))\cdot|X_1'(r)|$.

$\because X_1 = e^{-\frac{R^2}{2}}$ $\therefore \frac{\partial X_1}{\partial R} = -re^{-\frac{r^2}{2}}$

$\therefore f_{R(u)}(r) = f_{X_1}(X_1(r))\cdot|\frac{\partial X_1}{\partial R}| = r\cdot e^{-\frac{r^2}{2}}\ (r>0)$

$\therefore R(u)$ 是服从 $\sigma=1$ 的瑞利分布.

(3) $\because$ 令 $Z = R^2\ (R\geq 0, Z>0)$ 单调函数.

$\therefore f_Z(z) = \frac{1}{2}e^{-\frac{z}{2}}, (z>0)$ 又 $Z = Y_1^2 + Y_2^2$

$\Rightarrow f_{(Y_1,Y_2)}(y_1,y_2) = \frac{1}{2}e^{-\frac{(y_1^2+y_2^2)}{2}}$, $(y_1, y_2 \in R)$.

(4) $E(X_1,X_2) = E[X_1]\cdot E[X_2] = \frac{1}{4} \neq 0$.

X_1与X_2不正交且不相关.

$f_{Y_1}(y_1) = \int_{-\infty}^{+\infty} f_{(Y_1,Y_2)}(y_1,y_2)\,dy_2 = \frac{\sqrt{2\pi}}{2} e^{-\frac{y_1^2}{2}}$

同理 $f_{Y_2}(y_2) = \frac{\sqrt{2\pi}}{2} e^{-\frac{y_2^2}{2}}$.

$f_{(Y_1,Y_2)}(y_1,y_2) \neq f_{Y_1(y_1)}(y_1)\cdot f_{Y_2(y_2)}(y_2)$.

$E[Y_1Y_2] = E[Y_1]\cdot E[Y_2] = 0$

$\therefore Y_1, Y_2$ 不独立. 但 相关且正交.

$R = \sqrt{-2\ln(X_1)}$, X_1与X_2独立. $\therefore R$与X_2也独立