P20

A fixed radio link has the following parameter values:

| | |
|---|---|
| ▪ $d$ = 49 km<br>▪ $f_c$ = 6.2 GHz<br>▪ $h_{rx}$ = 118 m<br>▪ $h_{tx}$ = 215 m<br>▪ $FFM$ = 35 dB<br>▪ $dN_1$ = –400 NU/km<br>▪ $B_{MP} = B_{NMP}$ =22 dB<br>▪ $W_{MP} = W_{NMP}$ = 20 MHz<br>Signature parameters are determined with $\tau$ = 6.3 ns | $P_{SF}$ = 0.015<br>$P_{FF,o}$ = 0.12,<br>$P_{o,FF} = P_{FF,o} \cdot 10^{-0.1FFM}$<br>$P_{FF,div}$ = 12.0,<br>$P_{o,FF} = P_{FF,div} \cdot 10^{-0.2FFM}$<br>$B_{m,o}$ = 4.5 dB<br>$B_{m,div}$ = 2.5 dB<br>$S$ = 10 m |

Calculate the total outage probability with the measured channel model in the above table as a function of FFM and compare to the total outage probability obtained with the method in ITU-R Recommendation P 530-11. Perform the calculations both for a link without diversity and a link with space diversity.

P21

Channel measurements show that during the worst month the flat fade and selective fade probabilities can be calculated from the following expressions:

❒ without diversity: $P_{o,FF} = 0.12 \cdot 10^{-0.1FFM}$ $P_{o,SF} = 0.01W\tau e^{-B/3.8}$

❒ with diversity: $P_{o,FF} = 12 \cdot 10^{-0.2FFM}$ $P_{o,SF} = 0.01W\tau e^{-B/2.2}$

The outage domain parameters measured with the delay difference $\tau$ = 6.3 ns without and with an equaliser are:

| basic receiver | equaliser receiver |
|---|---|
| $B$ = 6 dB | $B$ = 20 dB |
| $W$ = 30 MHz | $W$ = 15 MHz |
| $FFM$ = 38 dB | $FFM$ = 38 dB |

The total outage probability can be predicted with the expression $P_o = \left( P_{o,FF}^{0.75} + P_{o,SF}^{0.75} \right)^{1.33}$.

a. Calculate $P_o$ without equaliser and diversity.

b. Calculate $P_o$ and the improvement compared to the result in a. with equaliser but without diversity.

c. Calculate $P_o$ and the improvement compared to the result in a. without equaliser but with diversity.

d. Calculate $P_o$ and the improvement compared to the result in a. with equaliser and diversity.

e. Is the improvement in d. larget than the product of the improvements in b. and c., or will the simultaneous use of both equaliser and diversity bring some synergy?

P22

In this problem the accuracy of the two-path radio channel model with fixed delay difference is investigated. The impulse responses of quasi-static channels with two and three physical propagation paths are

$h(t) = h_0\delta(t) + h_1\delta(t-\tau_1)$ and $h(t) = h_0\delta(t) + h_1\delta(t-\tau_1) + h_2\delta(t-\tau_2)$

respectively. The complex path amplitudes are $h_i = a_i\, \mathrm{e}^{j\phi_i}$. The impulse response of the channel model is $h_m(t) = g_0\delta(t) + g_1\delta(t-\tau)$. The pulse shape at the decision sampling is $\boldsymbol{x(t)}$ in a single path channel.

a) Derive expressions for the complex channel model taps under the assumption that the two strongest pulse samples spaced by an symbol interval and obtained with the channel model should equal the samples produced with the real channel.

b) Assuming rectangular transmitted pulses the input pulse to the decision sampler with a single path channel would be triangular. Assuming sampling synchronisation to the pulse peak value derive the channel model tap expressions with a physical 2-path channel.

c) Draw the amplitude function of the real two path channel and of the channel model for some $\tau$-values (t < T) when $|h_1/h_0| = 0.9$ and $\phi_1 - \phi_0 = \pi/6$.

Homework 4

During the worst month the measured channel model of a terrestrial radio relay hop gives the following prediction formulas for the outage probability caused by frequency selective fading and flat fading respectively: $P_{o,sf} = P_{sf} W \tau \, \mathrm{e}^{-B/4.0}, P_{o,ff} = r \cdot 10^{-FFM/10}$.

| | |
|---|---|
| the parameter values of the channel models are:<br>• $P_{sf} = 0.01$<br>• $r = 0.1$<br>• $q = 5$<br>• $\tau = 6.3$ ns | the fade tolerance parameters of the receiver are:<br>• $FFM = 45$ dB<br>• $B$ is the M-signature height (dB)<br>• $W$ is the signature width (GHz)<br>The signature is the same in both minimum phase and non-minimum phase channel |

The total outage target due to flat and selective fading is 0.001%. Calculate the necessary signature height when the signature width is a) 10 MHz, b) 20 MHz, c) 30 MHz. outage improvement.