

Exercise Sheet 1 : Introduction to telecommunications

Exercise 1

A dipole is traversed by a current $i(t) = I \cos(2\pi ft + \varphi)$. The expression for the voltage across this dipole is given by $v(t) = V \cos(2\pi ft)$.

1. Determine the expression for the instantaneous power.
2. Calculate the average active power absorbed by this dipole.

Exercise 2

A sine wave voltage $v(t) = 120 \cos(100\pi t)$ V is applied across a load with an impedance $Z = 30 + j40 \Omega$.

1. Write the expression for the instantaneous power $p(t)$ delivered to the load.
2. Calculate the average (active) power P_{avg} absorbed by the load.
3. Calculate the reactive power Q absorbed by the load.
4. If the load Z is replaced with a resistor $R = 50 \Omega$, calculate the average power P_{avg} absorbed by the resistor.

Exercise 3

1. A cascade circuit is composed of two amplifiers with voltage gains of 6.8 dB and 14.3 dB, along with two filters with attenuations of 16.4 dB and 2.9 dB. If the output voltage of the circuit is 800 mV, calculate the input voltage.
2. A signal with a power of $P_{\text{in}} = -3$ dBm is applied to an amplifier with a power gain of 20 dB. Calculate the output power P_{out} in both decibels and Watts.
3. If the input power to an amplifier is 15 dBm and the output power gain is 12 dB, calculate the amplifier's power gain in decibels.
4. The noise level at the input of a receiver is -94 dBm. We want the useful signal to be 10 times stronger. Calculate the required signal power.

Exercise 4

1. The signal used to transmit voice ranges from 300 Hz to 3 kHz. Calculate its bandwidth.
2. A television signal occupies a bandwidth of 6 MHz. If the upper frequency is 60 MHz, what is the lower frequency of this band?
3. The bandwidth of a signal is $\Delta f = 6$ MHz, with a center frequency f_0 . Calculate the relative bandwidth, and plot the signal spectrum for the following values of f_0 : 10 MHz, 60 MHz, 300 MHz, and 2.4 GHz.
4. Compare the results.

Exercise 5

Sketch the frequency spectrum of the following signals:

1. $s_1(t) = 2 \cos(10^4 t) + \frac{2}{3} \sin(10^4 t)$
2. $s_2(t) = 2 \cos(10^3 t) + \frac{2}{3} \sin(2 \cdot 10^3 t) + \frac{2}{3} \cos^2(10^3 t)$
3. $s_3(t) = 2(1 + 0.9 \cos(2\pi \cdot 10^3 t)) \cos(2\pi \cdot 10^7 t)$
4. $s_4(t) = 2(1 + 0.9 \cos(2\pi \cdot 10^3 t) + 0.5 \sin(4\pi \cdot 10^3 t)) \sin(2\pi \cdot 10^7 t)$
5. $s_5(t) = 1.8 \cos(2\pi \cdot 10^3 t) \cos(2\pi \cdot 10^7 t)$
6. $s_6(t) = 1.8 \cos(2\pi \cdot 10^3 t) \cos(2\pi \cdot 10^7 t) - 1.8 \sin(2\pi \cdot 10^3 t) \sin(2\pi \cdot 10^7 t)$
7. $s_7(t) = 1.8 \cos(2\pi \cdot 10^3 t) \cos(2\pi \cdot 10^7 t) + 1.8 \sin(2\pi \cdot 10^3 t) \sin(2\pi \cdot 10^7 t)$