Wireless Networking

Course code: CS4222/5422, Tutorial session: #4

Brief Instructions regarding the tutorial session

1. The attendance to tutorial sessions would contribute towards the determination of final grade
2. Please review the questions before coming to the tutorial session
3. Make an effort to solve the questions before attending tutorial. The teaching assistants will help in case of issues
4. The designated time for the tutorial session is one hour. Please contact the teaching assistants or the instructor if you need any further clarification regarding the tutorials outside the allocated period. Please send them an email.

Question 1: An embedded device utilizes its radio transceiver to emit radio waves with a transmission power of 15 dBm. During its journey from the transceiver to the board's antenna, the signal undergoes a 2 dB attenuation owing to mismatch. The antenna itself has a gain of 8 dBi. Please calculate the strength (power) of the radio signal radiated out from antenna? This is also referred to as effective radiated power (EIRP). Additionally, please provide the strength of the radiated signal expressed in the unit of watts and dBm.

Answer 1: Pt (Transmit power of transceiver) = 15 dBm
Gt (Antenna gain) = 8 dBi
Losses (mismatch) = 2 dB

EIRP = 15 + 8 - 2 = 21 dBm

$$P_{(\mathrm{mW})} = 1\mathrm{mW} \cdot 10^{(P_{(\mathrm{dBm})}/\,10)}$$

The radiated signal in the unit of watts is: 125.6 mW, 0.126 Watts

Question 2: An antenna is engineered to emit a wireless signal that is 1000 times stronger than an isotropic antenna. Could you calculate the antenna's gain expressed in dBi and dBd units? Furthermore, if the Effective Isotropic Radiated Power (EIRP) is 18 dBm, and there is a loss of 4 dB between transceiver and antenna, what would be the transmitter power (i.e., the strength of the signal generated by the transceiver)?

Answer 2:

The antenna gain is described as being 1000 times greater than that of an isotropic antenna. The unit dBi is typically employed to quantify an antenna's gain, representing it in a logarithmic scale relative to an isotropic antenna. Therefore, to express the specified gain ratio of 1000 in dbI, we must convert this ratio into the decibels.

Antenna gain (dBi) = 10 $\log_{10}(1000)$ = 30 dBi

dBd is another unit of antenna gain where the antenna gain is is related to a reference dipole antenna. The relationship between the antenna gain in dBi and dBd is as follows.

Gain in dBi = Gain in dBd + 2.15 dB

Through the above formula you can estimate the gain to be 30 - 2.15 or 27.85 dBd.
EIRP = Transmit Power + Antenna Gain - Losses

In this case:

18 = Transmit Power + 30 - 4, Transmit Power = -8 dBm

Question 3: Please identify the type of the following antenna. All these are commercial antennas are designed to radiate or receive energy at very similar frequency. Furthermore, please align the antenna and type with their corresponding gain.




Gain of antenna (random ordering): 8.8 dBi, -1 dBi, 23 dBi, and 3.8 dBi

Answer 3:

Yagi antenna with multiple elements. Due to larger number of antenna elements the gain is high. It is highly directional with gain of 23 dBi.

This is also a yogi directional antenna, but with lesser number of elements. Hence, the gain of the antenna is much smaller and it is 8.8 dBi. However, it is still highly directional.

This is a chip antenna or SMD antenna. It has a small form factor, but it leads to a much smaller gain which is -1 dBi in this case.

This is a whip antenna. Its gain is 3.8 dBi. It is a form of monopole antenna.

Question 4: Please identify the category and specific kind of sensors that you would employ for support of the following application scenarios.

- To estimate the number of steps traversed by the user of a wearable device
- To measure the blood pressure of the end-user using sensors on a smart watch
- To estimate the distance of a vehicle from a wall to prevent collisions while parking
- Detect breathing rate using sensors on a wearable device worn on the chest

Answer 4:

- To estimate the number of steps traversed by the user of a wearable device

We can use motion sensor together with GPS. The motion sensor can be an accelerometer. Typically, these are examples of passive sensors.

- To measure the blood pressure of the end-user using sensors on a smart watch

We can use PPG sensor. It helps to measure the blood flow which can then be used to measure the blood pressure.

- To estimate the distance of a vehicle from a wall to prevent collisions while parking

We can use a distance sensor such as ultrasonic sensor to detect distance from wall. It is an example of an active sensor.

- Detect breathing rate using sensors on a wearable device worn on the chest

They can use some form of motion sensor like accelerometer to track the breathing of the user. This would be an example of passive sensor.

Question 5: You are in the process of designing a wireless embedded device with the dimensions of a cube, each side measuring approximately one centimeter. The device utilizes compact batteries that are surface-mounted. An example of such a battery is the CeraCharge from TDK. Specifically, the battery in question has a capacity of 100 μAh and operates at a rated voltage of 1.5 Volts. The microcontroller integrated into the device, an MSP430, exhibits a peak current consumption of 200 μA. Your task is to determine the operational lifespan of the device under the conditions. It is assumed for the purpose of this calculation that no other components are consuming power. Also assume that the sensors are continuously active. They are always ACTIVE. Please provide the lifespan estimation for the device utilizing only one sensor at a time from the list provided.

Sensor	Current Consumption
Accelerometer	30 microamperes
Temperature and Humidity sensor	50 microampere
Camera	1500 microampere
Light sensor	100 microampere

Answer 5: Battery capacity = 100 µAh

Current consumption and lifespan for various scenarios

Scenario	Total current consumption	Lifespan
Microcontroller with Accelerometer	230 microampere	100/230 (hours)
Microcontroller with temperature/ humidity sensor	250 microampere	100/250 (hours)
Microcontroller with camera	1700 microampere	100/1700 (hours)
Microcontroller with light sensor	300 microampere	100/300 (hours)