**Problem Statement**

A wireless sensor network is a network of wirelessly connected devices designed to collect data through sensors and send these data over a wireless link. Depending on the application type, different radio frequency configurations are necessary to meet the connectivity requirements. In this project, the objective is to evaluate several configurations of the CC1310 wireless MCU, related to its ability to cover short, medium and long range connectivity by modifying its radio and medium access control parameters such as transmission power, number of frame retransmissions, modulation scheme, and data rate.

The team will use two CC1310 LaunchPad development kits to measure the packet error rate (PER) of the wireless channel under varying conditions. Input parameters for the experiment include the line-of-sight distance between the two LaunchPads, the transmitted power level and the selected bit rate (three rates will be tested).

**Components**

1. Two (2) CC1310 LaunchPads (Radio boards).
2. Code Composer Studio 7.0 or later (Software to program, compile, load and debug your code in the device).
3. One (1) PC to connect one CC1310 LaunchPad acting as the receiver.
4. One (1) PC to connect one CC1310 LaunchPad acting as the transmitter.

**Procedure**

The transmission range of the two LaunchPads can be obtained by measuring the TX-RX distance that allows a specified PER value. Therefore, your task is to find the transmission range that allows a PER of 1%, 2%, 5% and 10%, operating the radios at data rates of 625bps, 50kbps and 4Mbps, with transmission power levels of 0dBm and 14dBm. The experiment is graphically illustrated below.
You will be provided with the code that performs a packet error rate test, but you need to adjust the code in order to set the number of retransmissions to zero, that is, every packet will only have one transmission attempt regardless of the result (by default, this value is set to 2). While finding the transmission range you must record all of your trials using the table in step 9 reported below. Complete the following steps to setup and run your experiment.

1. Open CCS, select Resource Explorer and install the **TI-RTOS for CC13xx and CC26XX**. Then, import the project example Packet Error Rate to CCS.

![TI-RTOS for CC13xx and CC26XX](image1)

2. To adjust the bit rate at TX and RX, open the file smartrf_setting.c in folder smartrf_settings of the project PacketErrorRate. Look for the data structure **CMD_PROP_RADIO_DIV_SETUP** that contains all the RF parameters the radio will use. The symbol rate is programmed using **symbolRate**, by applying the following expression:

   \[ f_{\text{baud}} = \frac{(R \times f_{\text{sck}})}{(p \times 2^n)} \]

   where
   
   - \( f_{\text{baud}} \) is the obtained baud rate
   - \( f_{\text{sck}} \) is the system clock frequency of 24 MHz
   - \( R \) is the rate word given by symbolRate.rateWord
   - \( p \) is the prescaler value, given by symbolRate.preScale, which can be from 4 to 15

   The equation above uses integer values, so you need to put the corresponding hexadecimal values in the data structure **CMD_PROP_RADIO_DIV_SETUP**. As an example, using the predefined values, the resulting data rate \( f_{\text{baud}} = 50 \text{Kbps} \).

   Similarly, to adjust the transmitted power, change the default value given by txPower (0xA73F) in data structure **CMD_PROP_RADIO_DIV_SETUP**. The allowed transmitted power values by the CC1310 can be found in file smartrf_setting_predefined.c by looking into the data structure **rfPowerTable[]**.

3. Once you have adjusted the RF parameters for the test, connect one CC1310 to the PC USB port and then compile, load and run the project PacketErrorRate on it. Repeat this step for the second LaunchPad.

4. Open a serial port terminal (like Hyperterminal, putty, etc) to setup your test and display the PER collected at every step of the experiment (the number of transmitted packets is fixed to be 100 for...
each round of testing). The parameters for this serial connection are: baud rate 115200, no parity bit, one stop bit.

5. Load and run the project on the second CC1310 LaunchPad.
6. Make sure that one LaunchPad is set to act as TX and the other as RX. Both LaunchPads must have the same RF parameters in order to communicate each other.
7. Using a GPS built-in smartphone record the coordinates of TX and RX to calculate the distance between them. During each experiment round the location of TX and RX must be fixed.
8. Start collecting data by facing the two LaunchPads at the same height relative to ground and press the start button at the transmitter. You may want to run multiple rounds of experiment at any given distance, to ensure consistency of collected data.
9. Record all the measurements in the table below, and plot the PER vs. distance with the data collected. Please note that for each possible pair (bit rate, TX power), you need to report the PER and RSSI for multiple distances, ensuring that the reported experiments can cover 1%, 2%, 5% and 10% PER.

<table>
<thead>
<tr>
<th>TX-RX Distance</th>
<th>Packets Transmitted</th>
<th>TX Power (dBm)</th>
<th>Data Rate (bps)</th>
<th>RSSI at RX (Average)</th>
<th>PER (%)</th>
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**Analysis**

1. Using the collected data, find a polynomial approximation or mathematical expression reporting PER versus distance?
2. Compare the RSSI obtained for a PER ~ 1% with the receiver sensitivity reported by the manufacturer (look for this value in the datasheet of the CC1310)?