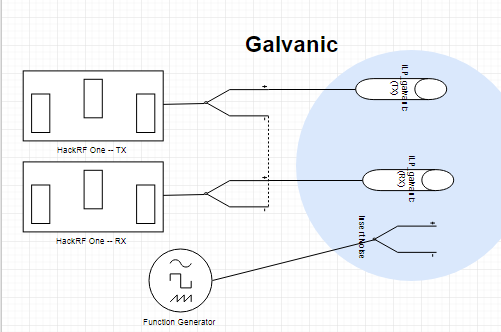
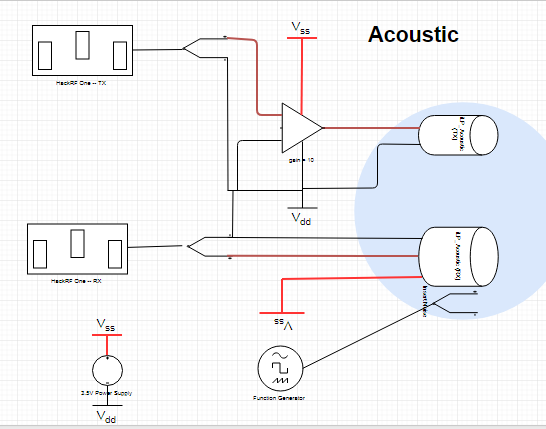
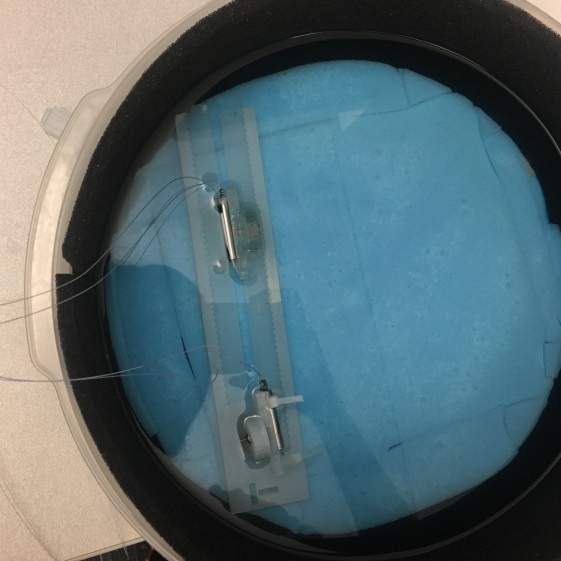
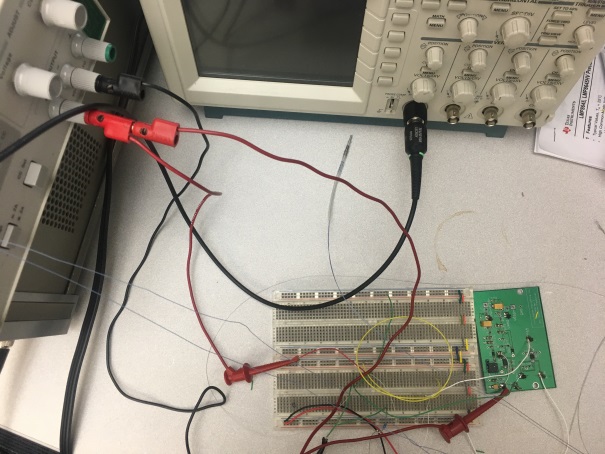
* Instruments and Schematic:





* Setting examples:
  1. 
* Parameter Explanation:
  1. Message Related:
     1. Message Length: 1 byte (1 character) ; 10 byte : 1 byte (1 character)
     2. Message Interval: The interval time between two messages, range from 150 ms to 500 ms. Here I test 500ms
  2. Physical Setting related:
     1. iLP\_device:
        + **Acoustic:** best operation frequency field is 300KHz – 310 KHz.

As shown by the schematic, need additional power and if connect to the Hackrf One, need an external amplifier.

* + - * **Galvanic:** It theoretically can transmit any frequency. But because Hackrf One cannot produce enough amplitude when f < 1M and will include more noise when amplify low frequency, so the minimum frequency for testing galvanic iLP is:
        + 600 KHz without external noise (TX amp ~=92-650mV)
        + 700KHz with external noise (TX amp ~=94-751mV)
    1. Orientation: Each iLP can be freely rotated along y-axis or x-axis

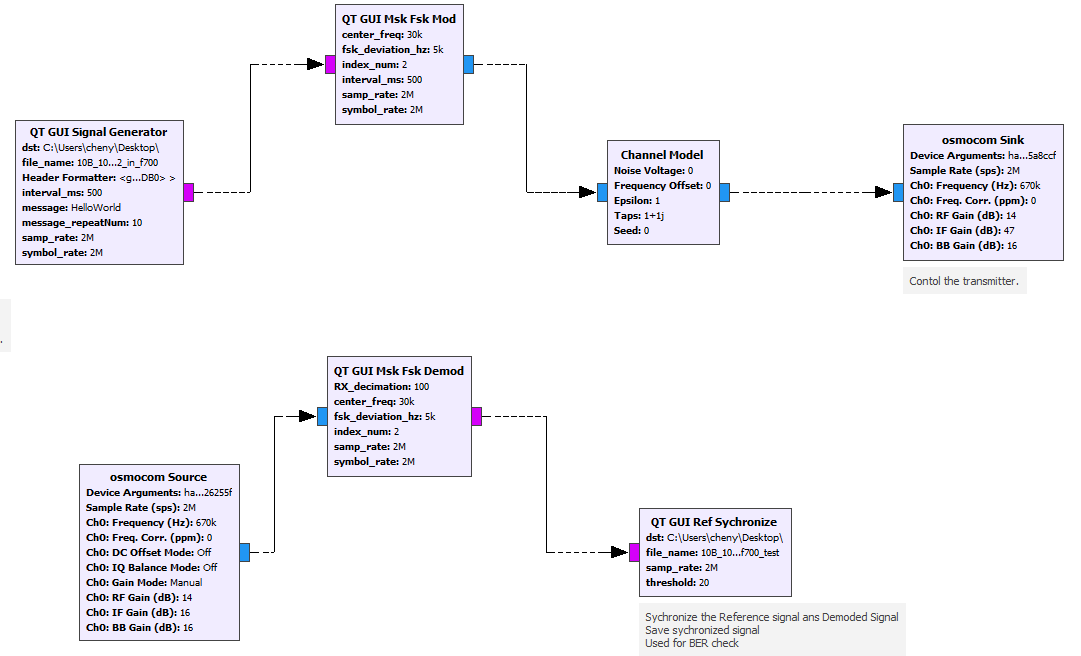
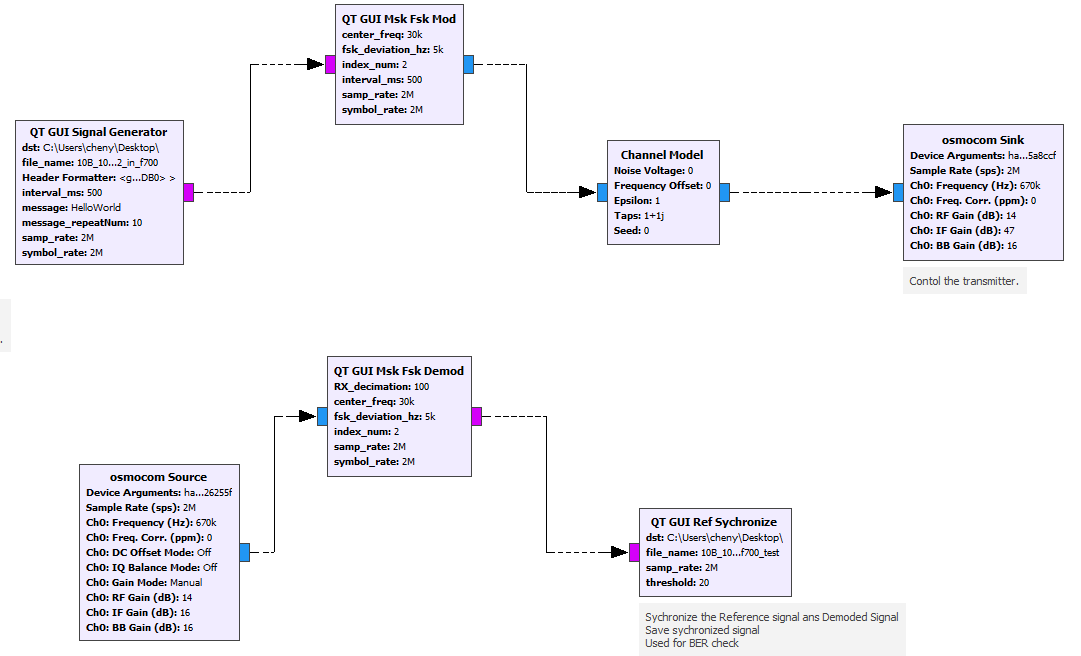
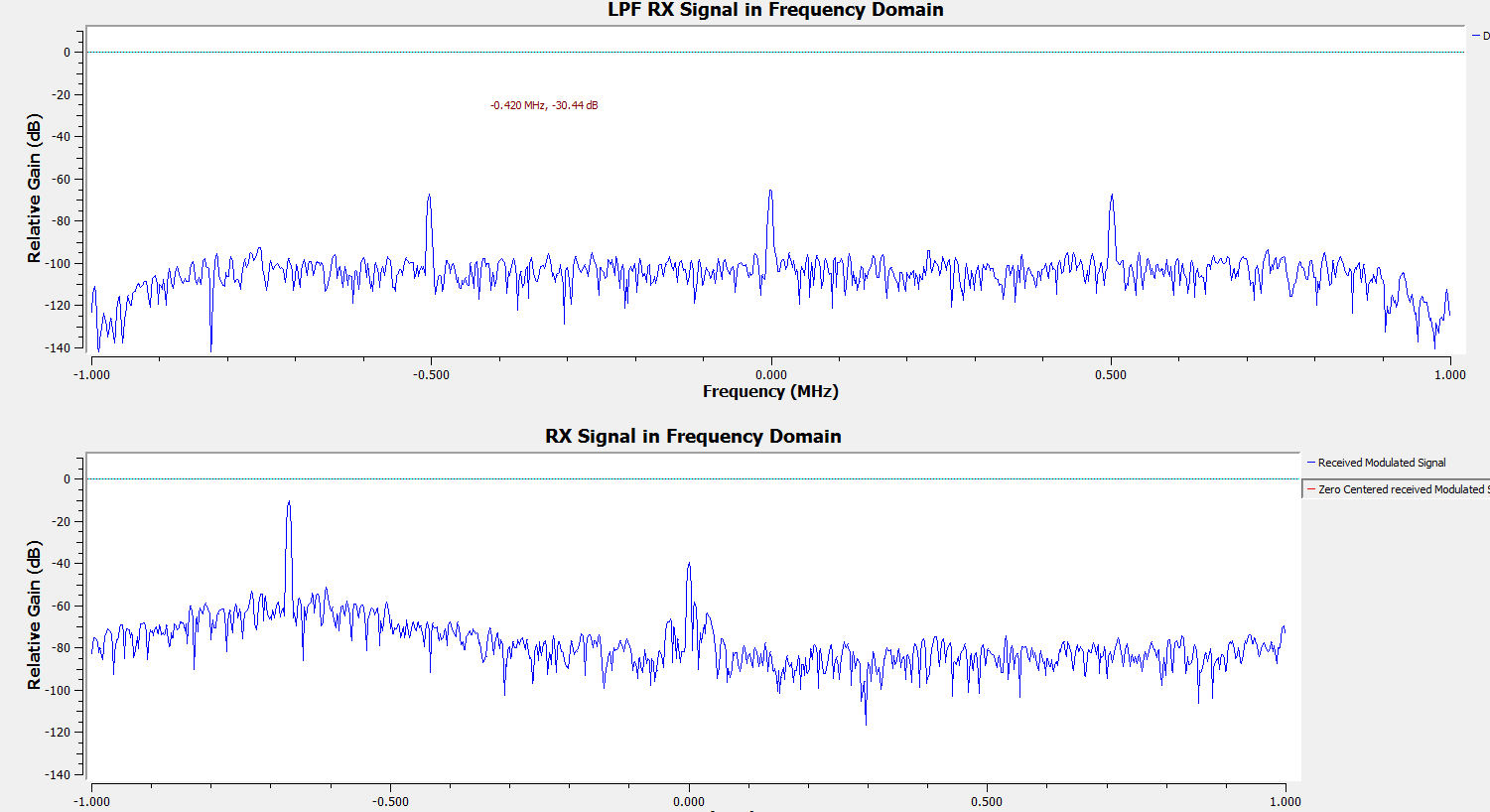
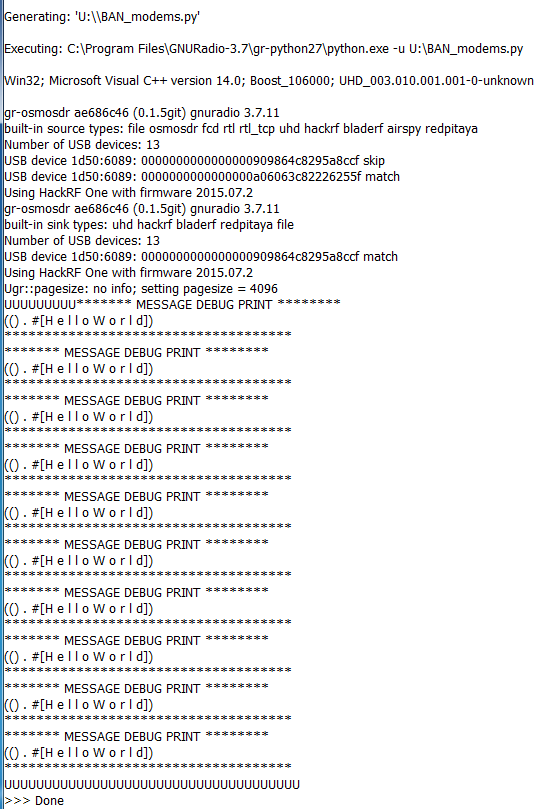
**Z**

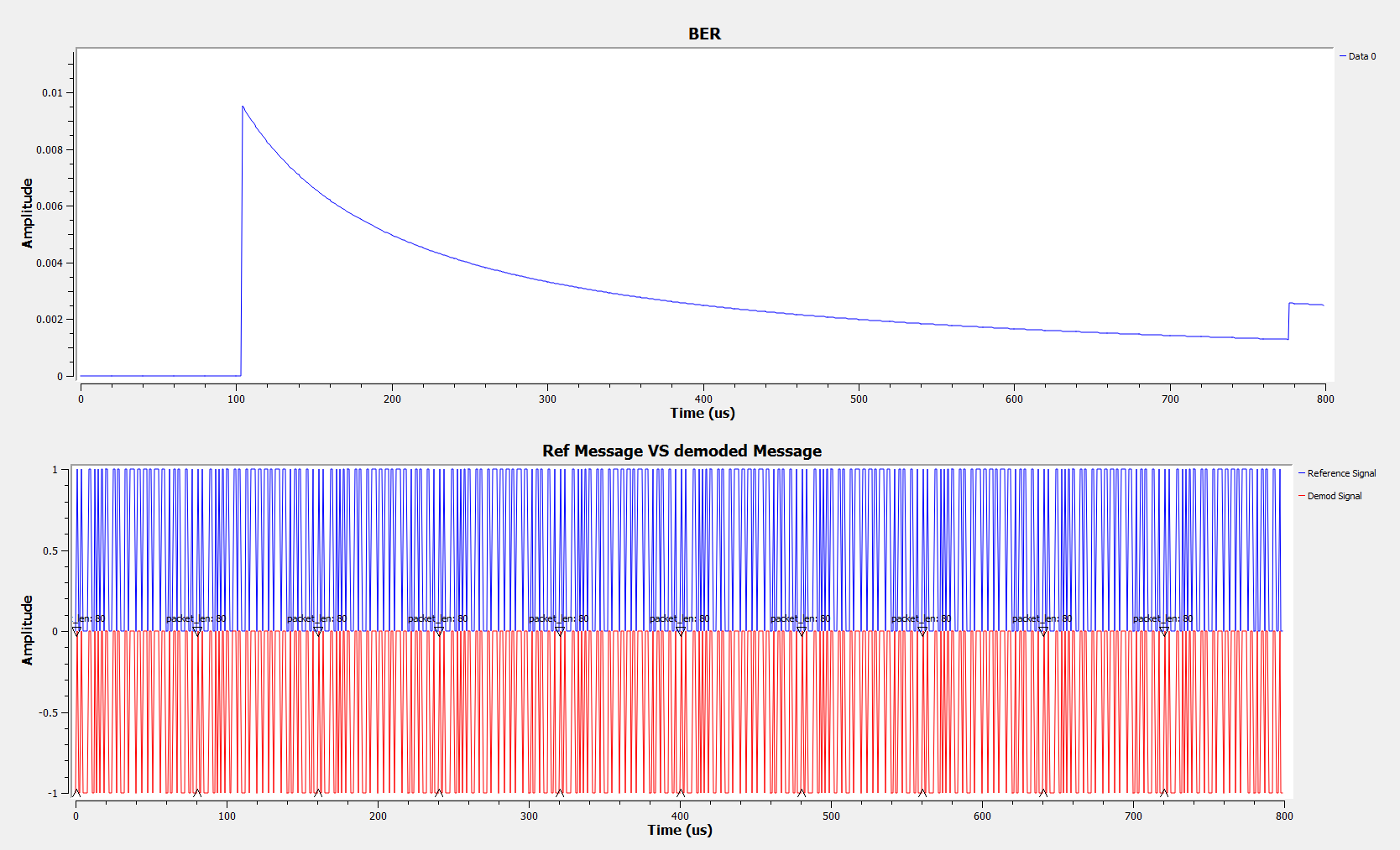
**x**

**y**

Below is the three most typical one I choose in this experiment

|  |  |  |
| --- | --- | --- |
|  | TX’s position | RX’s position |
| parallel | + y-axis | + y-axis |
| cross | + y-axis | - x-axis |
| Face-to-face | + x-axis | - x-axis |

* + 1. Distance: the distance between two middle of iLP, can varies between 40mm – 250mm. In this experiment I choose 100 mm as the most usual distance.
    2. Transmission Media: In this experiment I only use water as media.
       - Water (conductivity = 0.45)
       - Air (in the balloon)
  1. Environment related:
     1. Noise:
        + The algorithm is theoretically designed as a Low pass filter to reject noise with frequency out of range carrier\_wave+- Total\_Bandwidth/2.
          - So test the out-of-range noise first, if BER incease a lot, this might due to build-in amplifier for Hackrf.
          - If the Low pass filter works, then you can test noise at or slightly within the boundary. The closer the noise is to the carrier wave, the harder it can be filtered out.
        + In this experiment I choose noise amplitude with 0V (no noise) and 0.6V
  2. Software algorithm related:
     1. Modulation Algorithm: In this experiment, FSK is the primary choice.
        + FSK: Theoretically this is the most preferable algorithm.
        + PSK: This one take longer time to process and maybe more power consumption. But can still try.
        + OOK: This one is very subjective to noise. So I not recommended trying this on.
     2. Total Bandwidth (= Minimum required sample rate): Suppose we are able to do all frequency down-converting in the analog device, which means after A to D converting, signal in the frequency domain will be zero – centered. This is the total Bandwidth that contains the targeted message information.
        + Total Bandwidth < RX\_sample\_rate <= TX\_sample\_rate
        + Total Bandwidth = BW + EBW
        + This parameter depends on other parameters. Please refer to the comprehensive excel sheet for more reference.
* Targeted Result:
  1. Bit Error Rate (Error Bits/ Total Received Bits)
  2. Relative power-consumption (could be roughly estimated from following parameters):
     1. Amplify gain (the lower the better)
     2. Total Bandwidth (= Minimum required sample rate): (the lower the better)
* Testing examples:
  1. Settings
     1. Message Length: 10 bytes (‘Helloworld’), sent 10 times
     2. Device: galvanic to galvanic
     3. Orientation: face-to-face
     4. Distance: 100mm
     5. Noise Amplitude: 0V (no noise)
     6. Modulation Algorithm: FSK
     7. Total Required bandwidth (=Minimum required sample rate): 20KHz
  2. Software Modem
  3. Top: Received signal; Bottom: signal after eliminating DC offset and Down-sampling (Low Pass Filter)
  4. Received Message printout in the console
  5. Check bit error rate and the result: I assess the BER using moving average, so when pool is small, BER will begin with a larger value but wil finally converge towards 0.2%. (P.S. the end of BER curve always jump to high I think it may due to some Hackrd One problem when turn 0ff the signal. I would recommended ignore that when do assessment)



* Debug Suggestions:
  1. Check if Hackrf One is working: the 3V3,1V8,RF and USB LEDs should all be on. During transmission RX/TX should be on.
  2. Check if all the cable connected works
  3. Check if amplifier works (If you smell something burned or the power supply to amplifier failed to provide 3.5V power, then some components in amplifier may be short)
  4. When using oscilloscope and function generator to debug: If you see the RX signal from oscilloscope but is very weak, that signal may not from the Receiver but from the EM field generated by Function Generator!