**Test Plan to Evaluate Custom Built Antenna**

**1. Objectives.** To conduct laboratory experiment to evaluate the backscatter RF signal strength of custom-built flexible antennas by comparing their effectiveness with COTS antennas. The goal of this experiment is to shortlist the type of custom build flexible antenna to be used in the project based on the effective of these antennas, made from various conductive materials and substrates, the ability to transmit backscatter RF signal.

**2. The details of the experiment are as follow:**

a. Testing Environment. Laboratory space with no metallic elements and electronic devices within the vicinity to prevent RF interference by EM waves or RF reflection.

b. Equipment:

* RF generator (RFG) to connect antenna generating raw RF signal and reflecting backscatter signal at 1Mhz (Diligent Analogue Discovery 2)
* 01 x RF Transmitter (RFT) to transmit carrier signal from the RFG
* 01 x Spectrum Analyser (SA) to receive RF signal

c. Antenna to test:

* 01 x Custom built copper plate on corrugated board 868 MHz flexible antenna.
* 01 x Custom built copper conductive ink on corrugated board 868 MHz flexible antenna.
* 01 x COTS flexible antenna
* 01 x COTS monopole antenna

d. Testing Process:

* Ensure the fabrication process is standardized, such as:
  + - Usage of the same type/batch of transistor
    - Usage of the same type/size/thickness of substrate
    - Usage of the same type/batch of conductive material
    - Usage of the same type/batch of cable/wire
* Ensure there is continuity for each antenna with a multi-meter
* Ensure other components (eg wires, metal cable) soldered to the antenna are not transmitting the signal by testing the antenna with direct connection without transistor
* Ensure the placement of the testing equipment is consistent throughout the test based on the layout shown in figure 14.
* Determine polarity of each antenna interfacing with the transmitter to obtain optimal backscatter signal strength before collecting data.

**ANNEX C2**

* Usage of SA to measure backscatter signal strength between RFG and RFT that will start from 10cm to 200cm. There will be 5cm incremental interval until 50cm, 10 cm incremental interval until 100cm and 50cm incremental interval until 200cm. The SA will be a constant between the RFG and RFT located at 100cm away from them throughout the experiment (show in Figure 16Figure 16 - Placement of Backscatter Testing Equipment). The reading to be taken are:
  + x reading of carrier signal strength of each location.
  + x reading of backscatter signal strength of each location.
  + Mean of carrier and backscatter signal strength will be tabulated for each location.
* Plot line chart of the signal strength of each location for all the 4 antennas and analyse the test results.

A diagram of a diagram

Description automatically generated

Figure 21 - Placement of Backscatter Testing Equipment

**ANNEX C3**

Figure 1 shown the overview of the actual experiment setup which includes a spectrum analyser (SA) to measure backscatter signal strength between an RF transmitter (RFT) and RF Generator (RFG) which be reflecting backscatter signal with the custom-made antenna connected.

A room with a computer and computers

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Figure 22 - Actual Experiment Placement of Equipment

Observations of experiments of carrier signal strength. The carrier signal strength from all the 4 antennas (shown in figure T2) are consistent and have a range of -35.75 dBm to -49.21dBm with a mean of -40.84dBm. It is observed that the copperplate antenna fluctuates in a non-increasing pattern when the distance is 100cm and above. The COTs flexible antenna signal strength fluctuated in the beginning of the tests between 10cm to 35cm but regained its consistency thereafter. In general, there is not much changes in the carrier signal strength observed across the 4 antenna as they are quite stable, most likely due to the short distance involved in the test which is within 200cm.

Table 15 - Carrier Signal Strength of Flexible Antennas