DESIGN OF An RF REPEATER FOR WIRELESS COMMUNICATIONS

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Project Objectives

- Understand the basic concept of wireless repeater.
- Be familiar with the components and understand the function of each one.
- Analyze the signal strength in building 59.
- Design and prototype the repeater.
- Experimentally validate the designed repeater and its ability to improve the quality of the coverage.

Design Details

This project mainly focuses on the design of the repeater, studies the essential parameters and factors that affects the design, and finds the best solutions.

- Repeater Components:

1. Antennas: it is a tri-band antenna, which includes three different separated frequency bands (824-960MHz).
2. Band-Pass Filters: The filters are designed to pass the frequency band between 875 and 1010MHz which covers the GSM-900 frequency range.
3. Amplifiers: The main function of a repeater is to amplify incoming signals, it supports wide bandwidth with low noise and reasonable amounts of gain.
4. Coaxial Cable: mainly used to transmit the signal between the receiving and the transmitting antennas since these might be separated by a significant distance

Measurements and calculation

❖For measurements : numerous measurements were taken at different times with several devices and methods each time.

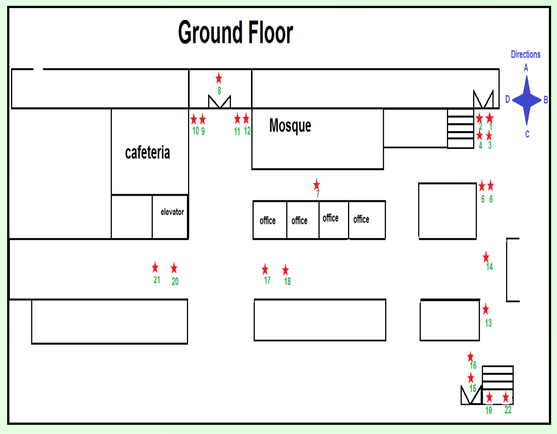

Fig 1: Measurement points location in ground floor

❖The best spot outside and weakest one inside were approximately located and found to correspond to signal power levels of approximately -53dBm and -97dBm, respectively.

❖For calculation

☞The calculations part concerns mostly about the losses of the repeater components, and consequently.

Table 1 summarizes the losses of the components.

	Band-pass Filter	Coaxial Cable	Amplifier
Loss (Gain)	1.1 dB	0.75 dB	19.1 dB (gain)
Number used	1	15	1 or 2
Total Loss (Gain)	1.1 dB	11.25 dB	19.1 dB – 38.2 dB (gain)

Software Implementation

- The main objective of the simulation part is to compare between the performances of various possible architectures in terms of noise figure.
- Advanced Digital System (ADS) from Agilent Technologies is the software which is going to be used to simulate and test the electronic designs circuits of the repeater.
- equation (1) and equation(2) are showing how the noise figure is related to the signal to noise ratio.

$$\mathbf{NoiseFigure[dB] = 10 * LOG\,(NoiseFactor)[linear]} \quad (1)$$

$$\mathbf{NoiseFactor(linear)} = \frac{\mathbf{SNR_{input[linear]}}}{\mathbf{SNR_{output[linear]}}} \quad (2)$$

- the noise figure is affection the minimum detectable signal of the system as show in equation (3).

$$\mathbf{SDM = -174 + NoiseFigure_{[dB]} + SNR_{output[dB]} + 10\log(BW)}$$

- Based on the result from the equations above , the amplifiers will be placed as close as it can be to the receiving antenna,

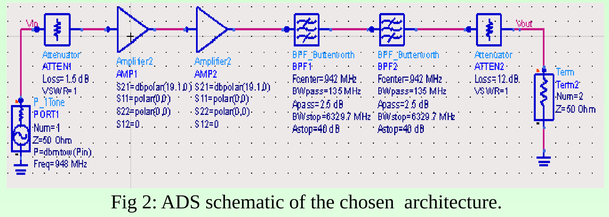

Fig 2: ADS schematic of the chosen architecture.

Table 2: Noise figure of the third architecture.

Cmp_Index	NF_Refln_Noimage_dB
0	1.500
1	2.600
2	2.612
3	2.612
4	2.612

❖ The block diagram of the circuit obtained after placing the amplifier in the first position is shown in Figure 3.

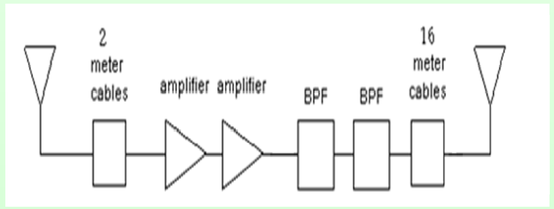

Figure 3: Block diagram of the third architectureHardware implementation

❖S-parameters and harmonic balance simulations were performed, and the noise figure of the architecture calculated. The results of this architecture are summarized in Figures 4 and 5.

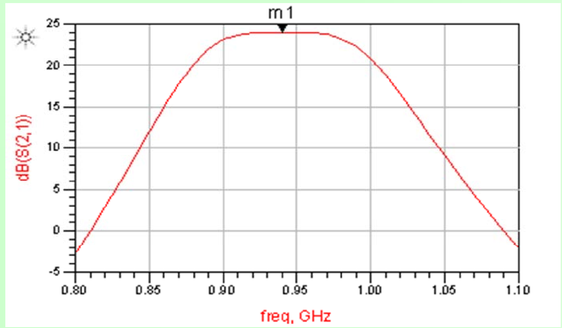

Figure 4: Power increase at output

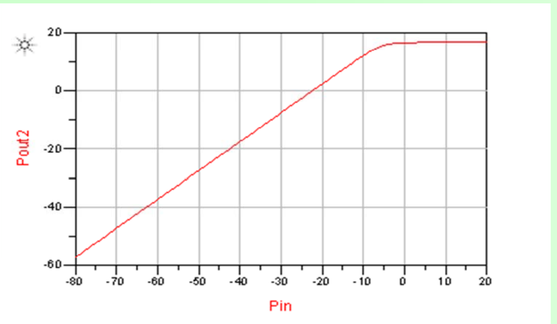

Figure 5: Nonlinearity characteristic of the first architecture

❖As shown in Figure 5, the nonlinearity of the repeater will appear for input power levels exceeding -2dB, which is much higher than the power level that will be handled by the repeater. So, the circuit will behave linearly over the operation power range.

Hardware Implementation

- The repeater circuit was build based on the results that was mentioned about the software implementation results.
- This section is divided into two parts.

1. first part shows the result of field test after completing the circuits.

- The frequency generator was used to send a signal for testing the circuit. The output of the generator was connected to the input of the circuit, and the circuit's output was connected to the spectrum analyzer to check the gain resulting from the amplifiers.

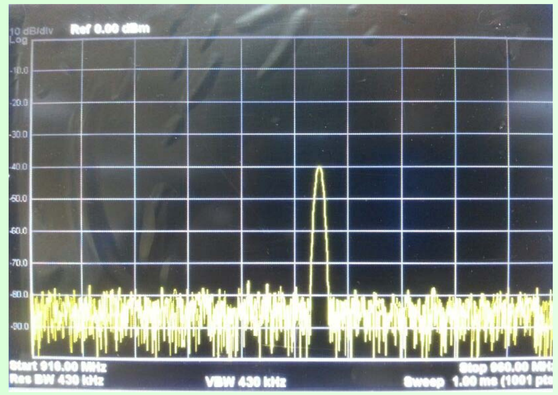

Figure 6: Results of the repeater circuit

2. Second part represents the final results:

- After successful preliminary trials in the lab, some tests were taken in the weakest spots near to Mosque area of building 59 where there was no signal. The power level of the signal before and after turning on the system is shown in the next Table.

Table 3: Measured power levels before and after turning on the designed repeater

	Near to Mosque Door		Reference spot	
	With system OFF	With system ON	With system OFF	With system ON
Power Level	No signal	-89dBm	-91dBm	-73dBm
Able to Call?	NO	YES	YES	YES

Conclusion

❖The goal of the project was to improve the mobile signal in a weak spot that had been specified to be near to the Mosque door inside building 59.

- The project start with the design details , the different components that been used based on the measurements, implementing the circuit by using ADS software and ending by building and test the prototype .

❖The aim of the project was established by making a call using a mobile that receives the signal from the repeater's transmitting antenna .