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DEVELOPMENT OF A LOW-COST MICROWAVE FILTER ANTENNA FOR 4G AND 5G WIRELESS NETWORK

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ABSTRACT

This paper is aimed at designing an antenna with filtering features and properties also called resonator filter antenna covering 850MHz to 3.1GHz and is suitable for WIFI applications. The problem of unwanted noise signals affects effective communication. Signal interferences affect signal quality and thus hinder effective voice communication. This paper collates signal-to- noise ratio, signal quality, return loss and signal strength among other signals of the Base transceiver station. It was observed that signal-to-noise ratio was relatively poor. Various factors could be attributed like poor filtering feature at the frontend of the Base transceiver station and lack of integration of the filter and antenna as in conventional communication systems where its front end contains an antenna and a separate tuning circuit (filtering or filter circuit). The integration of the antenna and filter increases its efficiency. In this paper, an antenna is integrated with a filter at the front end to improve signal quality and reduce noise interferences. A three-pole filter antenna is developed at 2.4GHZ and a two-pole filter antenna is also designed to cover frequencies ranging from 850MHz to 3.1GHz. They are both simulated using High-frequency structure simulator software. The dual filter antennas are measured and results show that the antenna filter performances are excellent.

Keywords: *Filter antenna, signal-to-noise ratio, signal quality, noise interferences, mobile communication system.*

INTRODUCTION

Antennas have played a major role in telecommunication systems as they are designed to receive weak signals (Youngtaek et al,2014). As communication technology complexity increases, more efficient antenna systems are needed. Moreover, as mobile communication becomes robust and sophisticated, enhanced antenna that can be able to remove unwanted noise at the front end becomes a necessity which led to the development of a joint antenna and a filter circuitry. In addition, the development of an antenna and filter as a single circuitry boost mobile communication efficiency (Yasir et al, 2020). A filter antenna comprises of antenna and a filter.

A patch antenna consists of thin metallic strip usually equivalent to fractions of free space wavelength and is mounted approximately at 0.05 free space wavelength above ground. Its length ranges from 0.333 to 0.5 free space wavelength with a dielectric constant of amaximum of 12. A thick substrate is preferred for its higher efficiency (Youngtaek et al,2014). The patch and the feedline are usually etched out. Similarly, in antenna filters, the patch, the feedline and the filters are also etched(Al-Yasir,2020). The researcher Yasir et al (2020) designed a four-pole bandpass filter cascaded with a microstrip antenna of monopole form and determined the effect of dielectric chosen on its performances. The higher the dielectric constant, the better the performance of the antenna. A fourth order planar filter is integrated with a microstrip antenna using different substrates of Rogers RT5880, FR-4 and RT/Duroid5880 and a dielectric height of 0.8 mm. Centre frequency and return loss differs among the different substrate. RT/5880 substrate has the highest centre frequency and return loss, followed by RT/Duroid and FR-4 substrate respectively. The filter antenna operates on a single range of frequencies.

The relationship between dielectric constant and filter performance have also been proposed by several researchers. It is equally worthy of note that a higher number of poles of a filter increases its size. Moreover, increasing the bandwidth of the antenna can also be achieved on microstrip technology using specialized polygon shape patch that ranges from quadrilateral to octagon with the polygon shapes also able to cover several bands of the electromagnetic spectrum (Youngtaek et al, 2014).The multiband antenna system covers 3G and 4G with a 6dB return loss of operating frequencies.Masataka and Zhewang (2015) investigated an efficient design method of microstrip filtering antenna suitable for circuit synthesis of microwave bandpass filters. The filter antenna is designed by integrating two adjacent half wavelength microstrip resonators to a patch antenna. Part of the ground plane is etched to control the radiation quality factor of the filter antenna. The return loss is 15 dB and the filter antenna has a single range of frequency with centre frequency at 2.5 GHz.

Moreover, Fatimah et al (2022) examined the design and implementation of a miniaturized filtering antenna for 5G midband applications. The entire structure consists of a sickle-shaped antenna integrated with a microwave bandpass filter. It operates in the 5G frequency range of 3.6 GHz to 3.8GHz with a return loss that varies as the length of the capacitive loaded loop. The return loss increases as the length of the capacitive loop increases. This filter antenna covers a single range of frequency.

Furthermore, Ramesh, Arindam, and Jibendu (2023) investigated the design of a microstrip filtering antenna for 4G and 5G wireless networks. The filter antenna structure is composed of a three-pole hairpin bandpass filter integrated with an elliptical shaped antenna which is designed to operate at 2.6GHz. The filter antenna is fabricated on FR-4 dielectric with a relative permittivity of 4.4, loss tangent of 0.0025 and a dielectric height of 0.8mm. It has a good return loss of 28 dB and covers a single range of frequency.

Again, Jianfeng et al (2023) examined compact dual-polarized duplex filtering antenna with high isolation. The antenna filter structure is made up of antenna integrated with cascaded resonators. It utilizes the even and odd mode of a resonator to create two channels and operates between 2.3GHz to 2.6GHz. The design is complex and operates on a single range of frequency.

In addition, Chun et al (2021) reviewed filtering antennas: design methods and recent developments. The researcher elaborately presented filtering antenna using variety of configuration and structures.

This research article utilizes a two-pole and a three-pole patch filter antenna. A two-pole and three-pole patch filter antenna can be easily be designed using microstrip technology. The filter is first designed at a given frequency using methods of filter design. For the filter design, a two and 3-poles resonators are being designed using coupling matrix from where the transversal and folded matrix are obtained followed by the physical realization of the filter. The antenna is also designed to operate at the same frequency as

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the filter and they are integrated together by transmission lines. This is unlike the conventional antenna at the front end of a communication network where the antenna and tuning circuit (or filtering) network are separate. The integration of antenna and filter increases the efficiciency of mobile communication networks (Yasir et al, 2020).

This research unlike many research works on filter antenna, took measurements of signal-to-noise ratio as well as signal quality to determine the amount of filtering required for areas with good signal to noise ratio and areas with poor signal to noise ratio. A poor signal-to- noise ratio requires higher filtering and hence a higher pole filter that is very selective whereas a good signal to noise ratio requires less filtering and hence lesser number of poles filters. The designed filter antenna, part from being cost effective simple design, covers multi-band frequencies and therefore provides more channels of communication.

Futhermore, a two pole filterantenna was also designed and fabricated which can easily be deployed in GSM mobile across Africa.

MATERIALS AND METHOD

Experimental Setup

(i) Measurement of Signal

Measurement of signal-to-noise ratio, return loss and signal quality of a Base transceiver station was carried out at Sango and the signal to noise ratio fell below the acceptable 25dB or more for voice communication (Cisco meraki, 2023). These measurement demonstrates that filtering antenna is needed to remove or eliminate noise interference at the front end of a mobile communication system. The measurement was done using Site master Antenna Analyzer/ network vector analyser.

(ii) Design of three-pole filterAntenna.

Filter antenna is used to characterized an antenna that has filtering properties. To reduce the effect of noise on signal, antenna should be integrated with a filter and integration of the mobile communication system results in a higher efficiency.

Design Dimensions:

Patch Antenna

Width of patch $W_p = \frac{C}{2f_r\sqrt{\frac{\epsilon_r+1}{2}}}$

$\epsilon_{eff}=\frac{\epsilon_r+1}{2}+\frac{\epsilon_r-1}{2}[\sqrt{1+\frac{12h}{w}}$

$$L_{eff} = \frac{C}{2f_r\sqrt{\epsilon_{eff}}} \approx W_p$$

$$\Delta L = 0.412h\frac{(\epsilon_{eff}+0.3)(0.264+\frac{w}{h})}{(\epsilon_{eff}-0.3)(0.8+\frac{w}{h})}$$

Length of patch (L) = $L_{eff} - 2\Delta L$
Length of substrate $L_g = 6h + L$
Width of substrate $w_g = 6h + W_p$ (Singh et al., 2016)
f_r refers to resonant frequency or centre frequency
ϵ_{eff} refers to effective permittivity
ϵ_r refers to relative permittivity or dielectric constant
w refers to width
h refers to height

Design Specification of Patch Antenna

Frequency: 0.9GHz to 3.55GHz

Return loss: varies from 4dB to 16dB

Material: Fr-4 epoxy substrate with a dielectric constant of 4.4, metallization of 0.035mm and loss tangent of 0.0002

Table 1. Physical dimensions of the patch antenna

S/N	Parameter	Value(mm)
1	Width of patch	82.00
2	Length of patch	82.00
3	Length of substrate	91.60
4	Width of substrate	91.60

Hairpin Resonator Filter

The guided wavelength of the micro strip is given by

$$\lambda_g = \frac{300}{f(GHZ)\sqrt{\varepsilon_{re}}}\ \text{mm}$$

Where λ_g is the guided wavelength operation frequency f(GHz).

The propagation constant β and phase velocity V_P can be determined by

$$\beta = \frac{2\pi f}{V_p} = \frac{2\pi}{\lambda g} = \frac{2\pi f\sqrt{\varepsilon_{re}}}{C}$$

Where C is the velocity of light ($C = 3\times10^8$m/s)

The relationship between electrical length θ and physical length l of the micro strip line is given by

$$\theta = \beta l$$

When $\theta = \pi$ and $l = \frac{\lambda g}{2}$)

This is called the half-wavelength micro strip line (Kopang,2018).

Table 2. Physical dimensions of the hair pin resonator

S/N	**Parameter**	**Value(mm)**
1	Length of Hairpin resonator	38.32
2	Width of Hairpin resonator	7.63
3	Gap between Hairpin	0.363

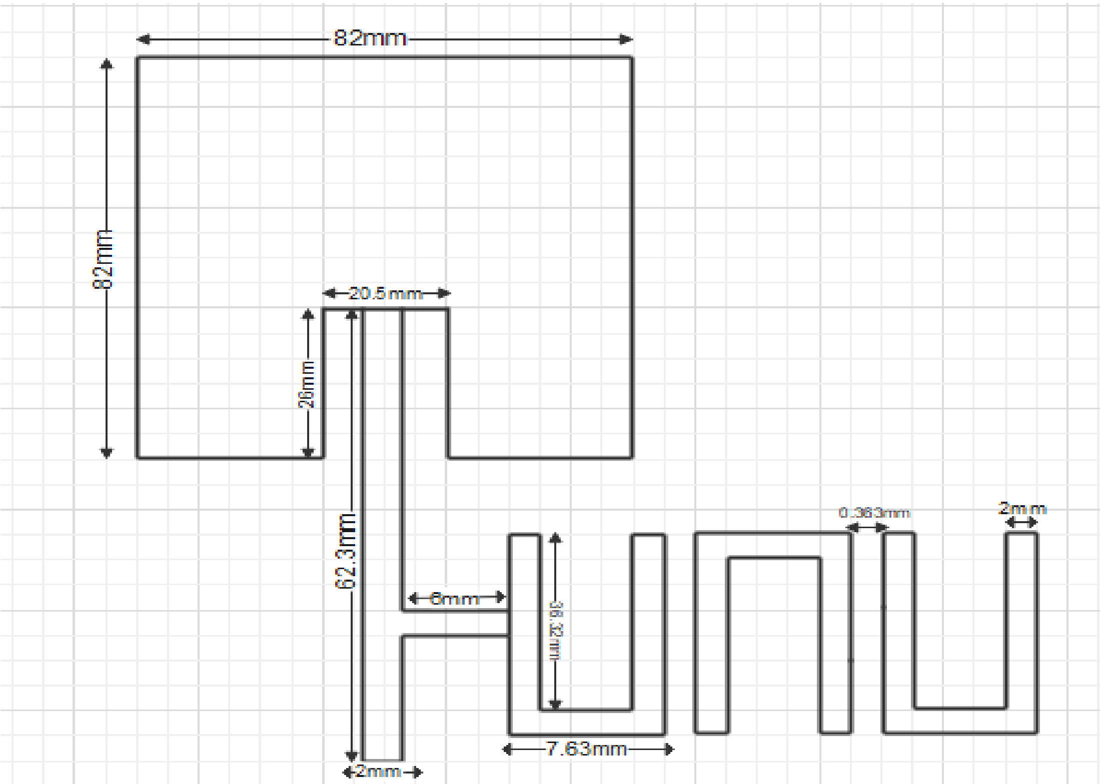

Figure 1: Patch antenna filter structure

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This antenna filter covers a wide range of frequency that covers both 2G ,3G and 4G and 5G.. It can be made smaller and incorporated to mobile devices. The return loss ranges is excellent and it shows it can transmit more compare to what it is reflected.

The range of frequencies from1.7GHz to 2.6 GHz is 4GLTE while Mid-band 5G covers (600MHz to 6 GHz).International Telecommunications Union recommended2.5GHz to 2.69 GHz for4G and5G (Ramesh, Arindam and Jibendu,2023); (CableFree, 2024).

Design Specification of Two pole filter Antenna

Frequency: 850MHz to 3.1GHz

Return loss; varies from 2.5dB to 6dB

Material: Rogers substrate Duroid having a dielectric constant of 6.15, metallization of 0.0745mm and loss tangent of 0.0002.

Table 3: Physical dimension of Antenna Filter

S/N	Parameter	Value(mm)
1	Length of antenna(first arm)	48.50
2	Length of hair pin resonator	42.50
3	Width of Hairpin resonator	5.00

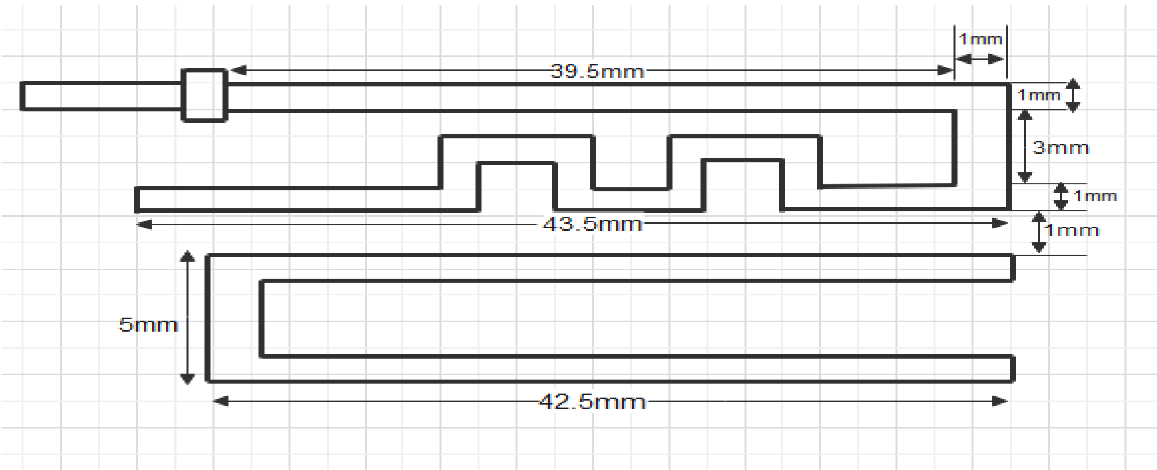

Figure 2 : Layout of folded monopole Antenna Filter structure

The above antenna structure layout is made up of hair pin resonator and first outer arm as the antenna. Its frequencies ranges from 850MHz to above 3GHz. Its small size ensures that it can easily fit into a mobile phone.

The range of frequencies from 1.7GHz to 2.6 GHz is 4G LTE while Mid-band 5G covers (600MHz to 6 GHz). International Telecommunications Union recommended 2.5GHz to 2.69 GHz for 4G and5G. (Ramesh, Arindam and Jibendu, 2023); (CableFree, 2024).

RESULTS AND DISCUSSIONS

According to cisco Meraki (2023), Received Signal, Signal to noise ratio (RSSNR) of 25dB or more, is required for voice communication signals and RSSNR of 20dB or more, is required for data network.

Table 4: December 2020 Readings of Base Transceiver Station (Sango- Ota, Ogun State).

DAY	KPI	MORN	AFT	EVEN	DAY	KPI	MORN	AFT	EVEN
	RETURN LOSS	-25.01	-25.01	-25.01		RETURN LOSS	22.65	22.65	22.65
12/01/2020	RSRP	-62	-66	-104	19/12/2020	RSRP	-61	-60	-107
	SIGNAL STRENGHT	-110	-108	-116		SIGNAL STRENGHT	-100	-101	-116
	RSSNR	0.2	1.2	0.7		RSSNR	0.2	1.2	0.7
	RSRQ	-12	-15	-10		RSRQ	-12	-11	-11
	RETURN LOSS	-24.21	-24.21	-24.21		RETURN LOSS	-25.07	-25.07	-25.07
12/02/2020	RSRP	-61	-65	-102	20/12/2020	RSRP	-63	-64	-107
	SIGNAL STRENGHT	-100	-101	-116		SIGNAL STRENGHT	-100	-101	-116
	RSSNR	2	9.5	0.7		RSSNR	2	9.5	0.7
	RSRQ	-11	-9	-9		RSRQ	-12	-10	-12
	RETURN LOSS	-22.05	-22.05	-22.05		RETURN LOSS	-22.55	-22.55	-22.55
12/03/2020	RSRP	-103	-102	-104	21/12/2020	RSRP	-102	-111	-105
	SIGNAL STRENGHT	-100	-101	-116		SIGNAL STRENGHT	-100	-101	-116
	RSSNR	0.2	1.3	0.7		RSSNR	2.5	6.5	2.7
	RSRQ	-12	-10	-10		RSRQ	-13	-10	-12
	RETURN LOSS	22.44	22.44	22.44		RETURN LOSS	-24.01	-24.01	-24.01
12/04/2020	RSRP	-100	-103	-106	22/12/2020	RSRP	-61	-64	-106
	SIGNAL STRENGHT	-99	-98	-100		SIGNAL STRENGHT	-100	-101	-116
	RSSNR	10.2	4.7	2.5		RSSNR	0.2	1.2	0.7
	RSRQ	-10	-14	-11		RSRQ	-14	-11	-14
	RETURN LOSS	24.24	24.34	24.34		RETURN LOSS	22.65	22.65	22.65
12/05/2020	RSRP	-104	-104	-104	23/12/2020	RSRP	-98	-95	-100
	SIGNAL STRENGHT	-103	-104	-116		SIGNAL STRENGHT	-100	-101	-116
	RSSNR	1.5	2.7	0.7		RSSNR	1.8	8.5	1.7
	RSRQ	-12	-11	-10		RSRQ	-10	-12	-10
	RETURN LOSS	20.88	20.88	20.88		RETURN LOSS	21.58	21.58	21.58
12/06/2020	RSRP	-82	-86	-97	24/12/2020	RSRP	-61	-65	-102
	SIGNAL STRENGHT	-99	-104	-102		SIGNAL STRENGHT	-108	-112	-113
	RSSNR	2.5	6.5	1.7		RSSNR	1.8	2.5	1.7
	RSRQ	-13	-11	-10		RSRQ	-12	-12	-15
	RETURN LOSS	24.24	24.34	24.34		RETURN LOSS	20.85	20.85	20.85
12/07/2020	RSRP	-75	-86	-96	25/12/2020	RSRP	-101	-111	-114
	SIGNAL STRENGHT	-102	-103	-106		SIGNAL STRENGHT	-105	-101	-119
	RSSNR	2.7	5.5	1.9		RSSNR	2.9	4.5	2.9
	RSRQ	-13	-13	-11		RSRQ	-10	-10	-13
	RETURN LOSS	21.54	21.54	21.54		RETURN LOSS	24.24	24.34	24.34
12/08/2020	RSRP	-105	-103	-103	26/12/2020	RSRP	-99	-100	-102
	SIGNAL STRENGHT	-103	-110	-116		SIGNAL STRENGHT	-110	-111	-111
	RSSNR	4.2	3	4.5		RSSNR	2.5	6.5	1.7
	RSRQ	-13	-12	-12		RSRQ	-12	-12	-11
	RETURN LOSS	-24.55	-24.55	-24.55		RETURN LOSS	21.54	21.54	21.54
12/09/2020	RSRP	-65	-61	-76	27/12/2020	RSRP	-82	-86	-100
	SIGNAL STRENGHT	-100	-102	-115		SIGNAL STRENGHT	-111	-113	-112
	RSSNR	2.7	5.7	2.9		RSSNR	2.3	5.8	1.5
	RSRQ	-10	-15	-12		RSRQ	-11	-14	-15
	RETURN LOSS	24.75	24.75	24.75		RETURN LOSS	-25.55	-25.55	-25.55
12/10/2020	RSRP	-113	-111	-100	28/12/2020	RSRP	-110	-111	-114
	SIGNAL STRENGHT	-102	-105	-106		SIGNAL STRENGHT	-115	-105	-112
	RSSNR	2.2	3.2	4.1		RSSNR	3.5	3.3	2.5
	RSRQ	-12	-11	-11		RSRQ	-15	-14	-13

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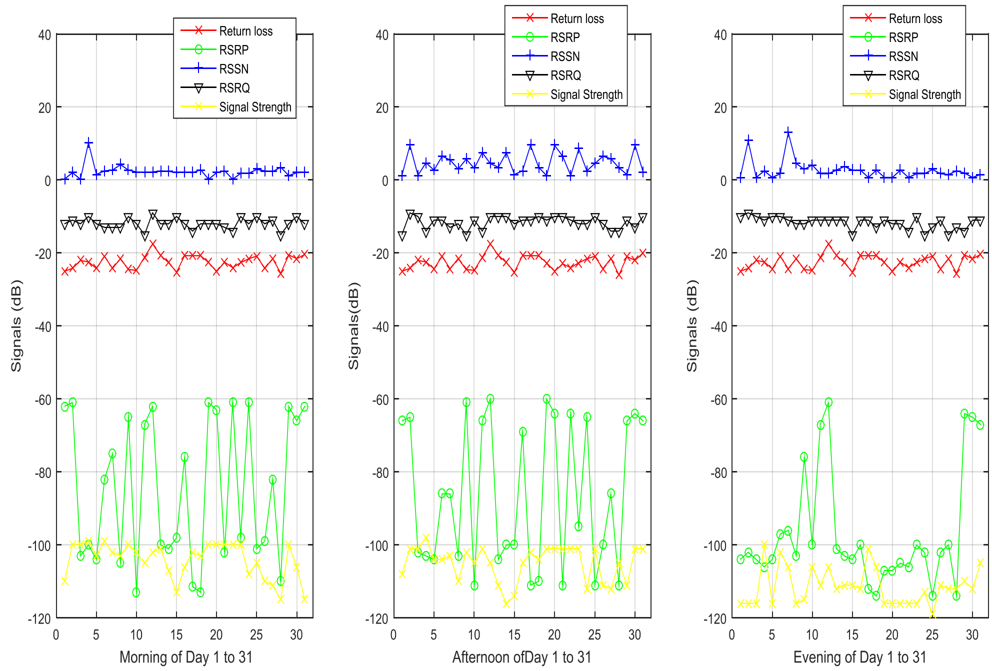
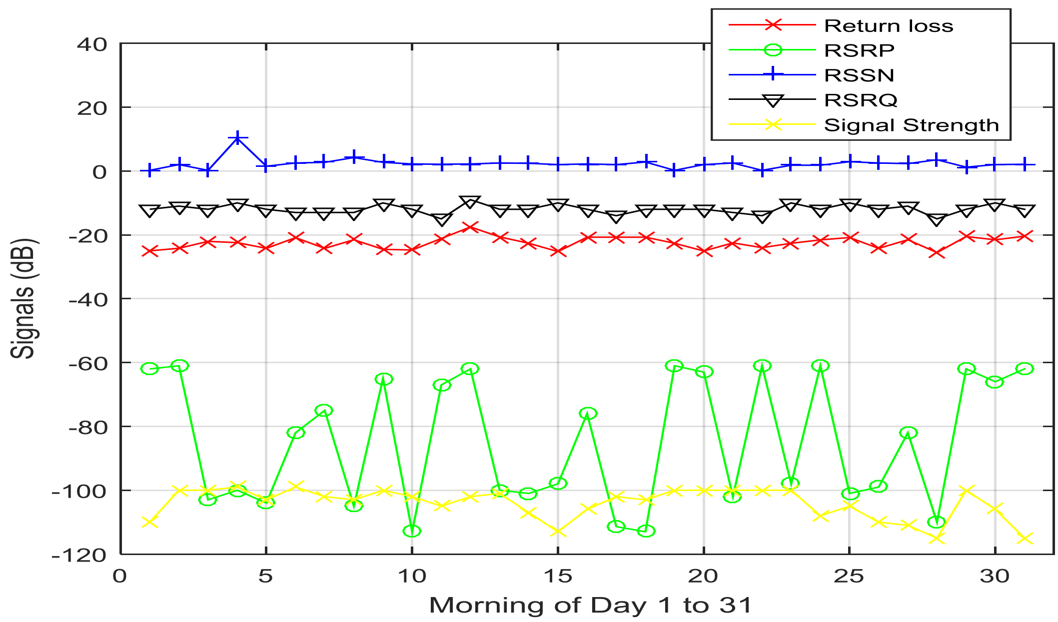
	RETURN LOSS	-21.15	-21.15	-21.15		RETURN LOSS	-20.54	-20.54	-20.54
12/11/2020	RSRP	-67	-66	-67	29/12/2020	RSRP	-62	-66	-64
	SIGNAL STRENGHT	-105	-101	-111		SIGNAL STRENGHT	-100	-111	-110
	RSSNR	2.1	7.5	1.7		RSSNR	1.2	1.5	1.9
	RSRQ	-15	-14	-11		RSRQ	-12	-11	-14
	RETURN LOSS	-17.54	-17.54	-17.54		RETURN LOSS	-21.55	-21.55	-21.55
12/12/2020	RSRP	-62	-60	-61	30/12/2020	RSRP	-66	-64	-65
	SIGNAL STRENGHT	-102	-105	-106		SIGNAL STRENGHT	-106	-101	-112
	RSSNR	2.2	4.5	1.7		RSSNR	2	9.5	0.7
	RSRQ	-9	-10	-11		RSRQ	-10	-13	-11
	RETURN LOSS	-20.65	-20.65	-20.65		RETURN LOSS	-20.43	-20.43	-20.43
13/12/2020	RSRP	-100	-104	-101	31/12/2020	RSRP	-62	-66	-67
	SIGNAL STRENGHT	-101	-111	-112		SIGNAL STRENGHT	-115	-101	-105
	RSSNR	2.5	3.5	2.7		RSSNR	2.1	2.2	1.5
	RSRQ	-12	-10	-11		RSRQ	-12	-10	-11
	RETURN LOSS	-22.65	-22.65	-22.65					
14/12/2020	RSRP	-101	-100	-103					
	SIGNAL STRENGHT	-107	-116	-111					
	RSSNR	2.4	7.5	3.7					
	RSRQ	-12	-10	-11					
	RETURN LOSS	-25.25	-25.25	-25.25					
15/12/2020	RSRP	-98	-100	-104					
	SIGNAL STRENGHT	-113	-114	-111					
	RSSNR	2	1.5	2.7					
	RSRQ	-10	-12	-15					
	RETURN LOSS	20.74	20.74	20.74					
16/12/2020	RSRP	-76	-69	-100					
	SIGNAL STRENGHT	-106	-105	-112					
	RSSNR	2.2	2.5	2.7					
	RSRQ	-12	-11	-11					
	RETURN LOSS	20.74	20.74	20.74					
17/12/2020	RSRP	-1.4	-111	-112					
	SIGNAL STRENGHT	-102	-102	-101					
	RSSNR	2	9.5	0.7					
	RSRQ	-14	-11	-11					
	RETURN LOSS	20.74	20.74	20.74					
18/12/2020	RSRP	-113	-110	-114					
	SIGNAL STRENGHT	-103	-104	-106					
	RSSNR	2.8	3.5	2.7					
	RSRQ	-12	-10	-13					


Return loss
RSRP
RSSN
RSRQ
Signal Strength
Signals (dB)
Signals(dB)
Signals (dB)
Morning of Day 1 to 31
Afternoon ofDay 1 to 31
Evening of Day 1 to 31

(a)


Return loss
RSRP
RSSN
RSRQ
Signal Strength
Signals (dB)
Morning of Day 1 to 31

(b)

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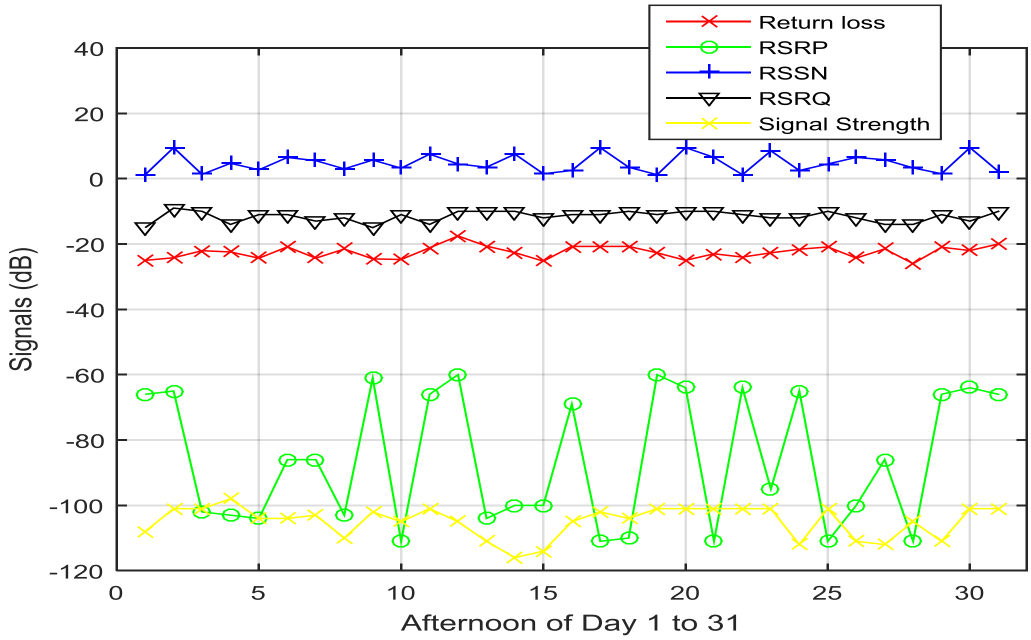
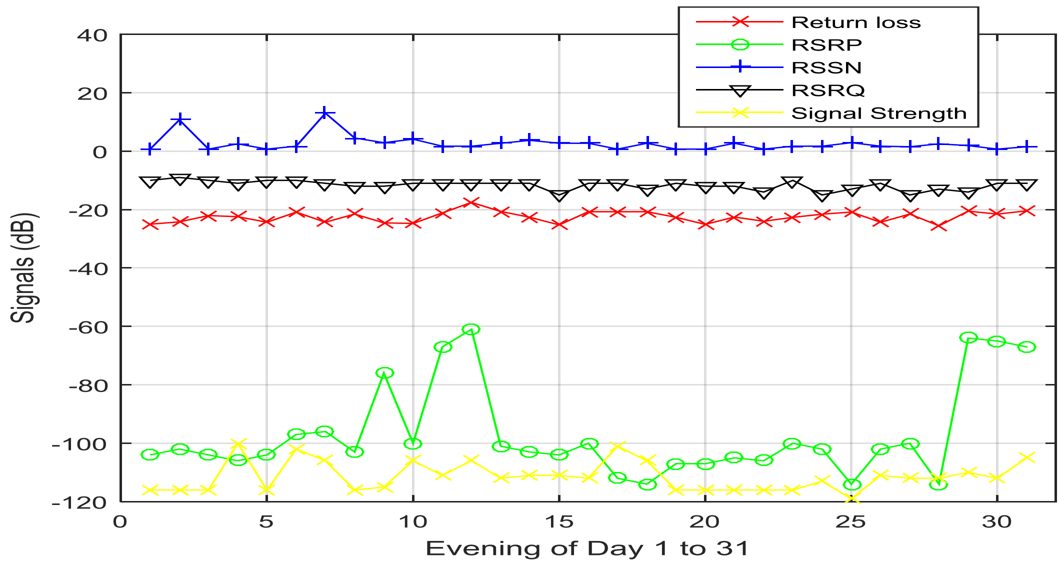


(c)



(d)

Figure 3: Readings of Return loss, Reference Signal to Noise Ratio(RSSNR), Reference Signal Received Quality(RSRQ), Reference Signal Received Power(RSRP) and Signal Strength of a mobile communication signal of a Base Transceiver Station.

Observation:

Figure 3a shows all the readings of the month of December highlighting morning, afternoon and evening readings. Figure 3b shows only the morning readings of the month of December. Figure 3c shows the afternoon readings of the month of December. Figure 3d shows the evening readings of the month of December. The figures show return loss, signal to noise ratio, reference signal received quality, reference signal received power and signal strength. In this paper, the reference signal to noise ratio or signal to noise ratio is used only.

The signal to noise ratio was relatively poor through the month except on the 4th and 8th day of December. The value was fair in the afternoon and evening of most days in the month.

DISCUSSIONS

According to Cisco Meraki (2023) Signal to noise ratio of 25dB or more is required for voice communication. The signal to noise ratio obtained was lesser and as such filtering is require to reduce the ratio of noise present in the transmitted signal. The higher the ratio, the better the signal which means that the signal has less interferences. The lower the ratio, the more interferences present with the signal.

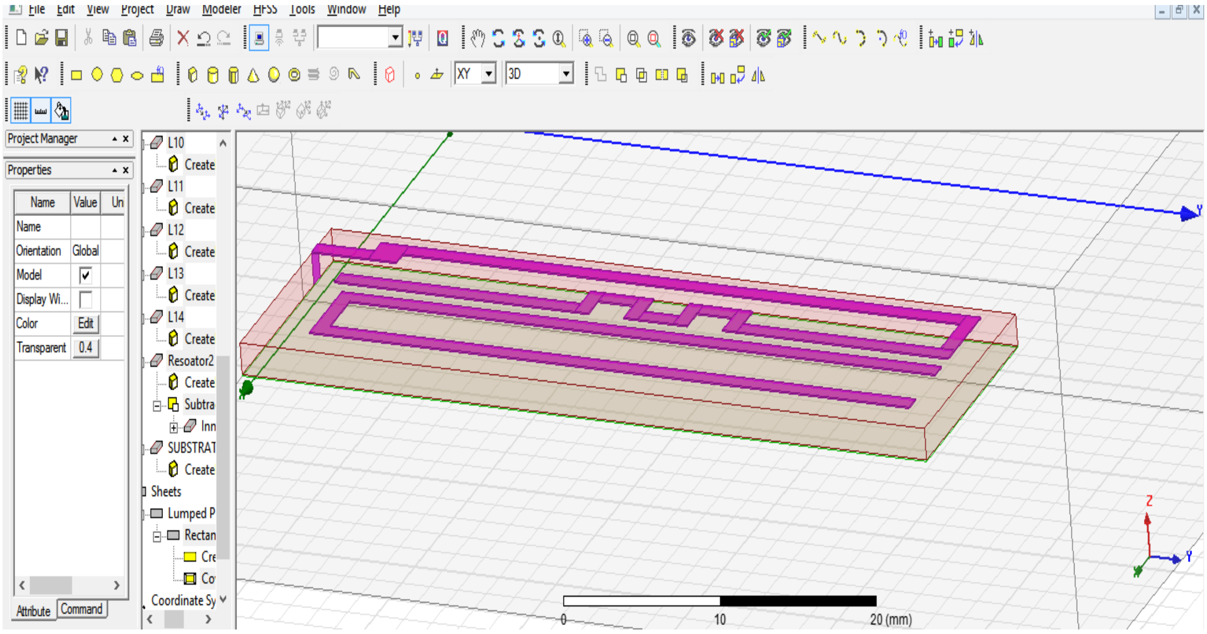


Figure 4: Structure of the simulated folded two pole Filter Antenna.

Similarly, figure 4 shows the simulated two pole antenna using High frequency structure simulation software and the simulation result shows the reflection coefficient S_{11} shown in figure 5.

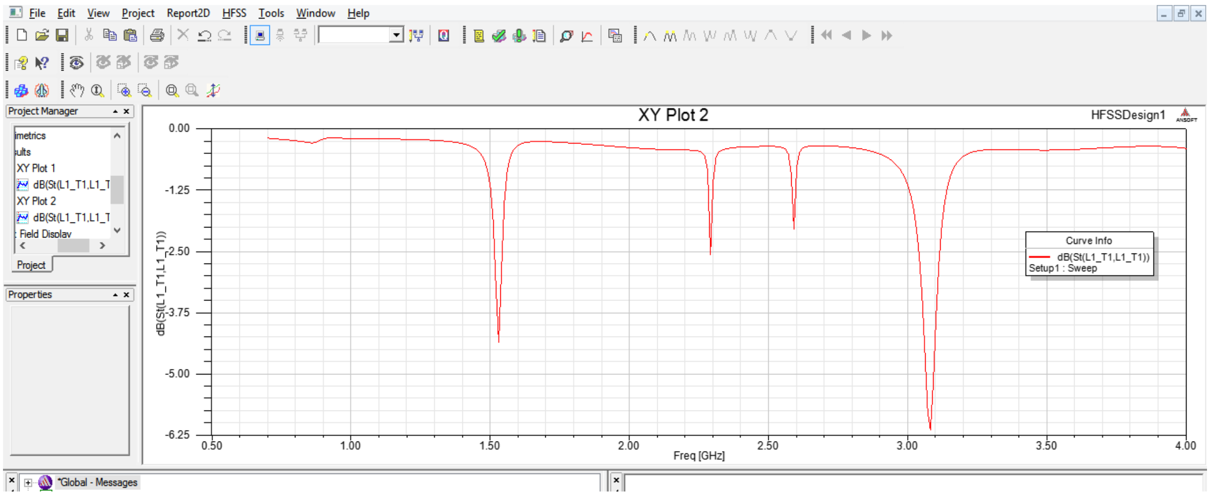


Figure 5: reflection coefficient S_{11} of the folded monopole antenna filter.

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Figure 5 shows the reflection responses S_{11} with the received signal at centre frequencies 1.51GHz, 2.3GHz, 2.6GHz and 3.1GHz with return loss of 3.85dB, 2.50dB, 1.35dB and 6dB.It covers a multi-band frequencies ranging from 1.4 GHz to 1.6 GHz with centre frequency at 1.51 GHz, 2.25 GHz to 2.35 GHz with centre frequency at 2.3 GHz, 2.55 GHz to 2.65GHz with centre frequency at 2.6 GHz and 2.90 GHz to 3.3 GHz with centre frequency at 3.1 GHz. All other frequencies are out of band or rejected (ones with almost zero reflection loss).

It shown be noted that the higher the reflection coefficient, the more signal it received and less is reflected. The size of the antenna filter can fit into the back of a smart mobile phone and also perform relatively well but lesser than the performance of the patch antenna which is relatively larger in size.

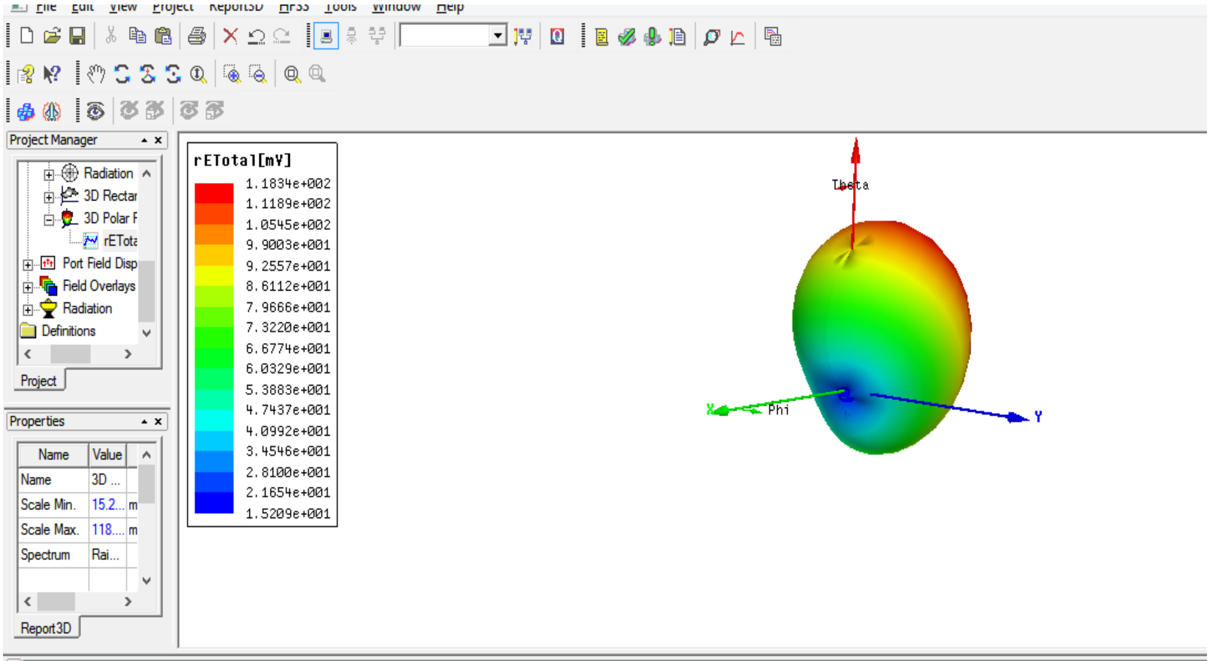

Figure 6: 3-D polar far field radiation at 850MHz of the folded 2 pole FilterAntenna

Correspondingly, the 3-dimensional radiation pattern is shown in figure 6. Figure 6 also shows that the antenna is omnidirectional or isotropic i.e it can receive signals in all directions. This is similar to half wave dipole antenna that is vertically polarized.

Figure 7: Fabricated PCB physical structure of the antenna filter (filter antenna).

Figure 8: SIM800 GSM MODEM Antenna (Existing antenna).

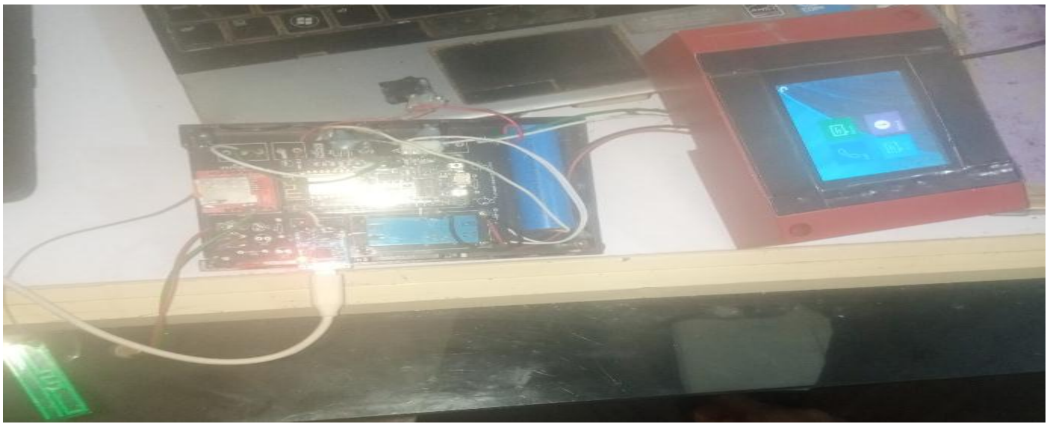

Figure 9: 2 pole filterantenna connection with a locally designed mobile phone

Table 5: Comparison between SIM 800 module antenna (existing) and two-pole Filter Antenna

SIM 800 GSM MODEM Antenna(Existing)	2 Pole Filterantenna (designed)
1. SIM 800 GSM MODEM antenna has a noisy signal reception.	1. Filterantenna has a clear signal reception.
2. Background noise from noise interference is high	2. No noise interference present.
3. The network is unstable and sometimes not reacheeable as the antenna is unable to pick signaleasily.	3. The network is always reachable as the antenna filter picks the network easily.

Table 6:Return Loss Measurement of Fabricated filter antenna compared with the readings of SIM 800 module antenna (existing).

S/N	**Frequency(MHz)**	**Return Loss(GSM Module Antenna)(dB)**	**Return Loss (Designed Filter AntennA)(dB)**
1	820	-1.2	-2.53
2	822.4	-1.21	-2.51
3	824.4	-1.22	-2.47
4	826.6	-1.23	-2.47
5	828.4	-1.24	-2.45
6	830.2	-1.26	-2.44
7	832.8	-1.28	-2.45
8	834.4	-1.31	-2.44
9	836.2	-1.32	-2.42
10	838.6	-1.35	-2.43
11	840.4	-1.38	-2.43
12	842.2	-1.41	-2.42
13	844.6	-1.43	-2.42
14	846.4	-1.48	-2.42
15	848.2	-1.5	-2.41
16	850	-1.55	-2.41

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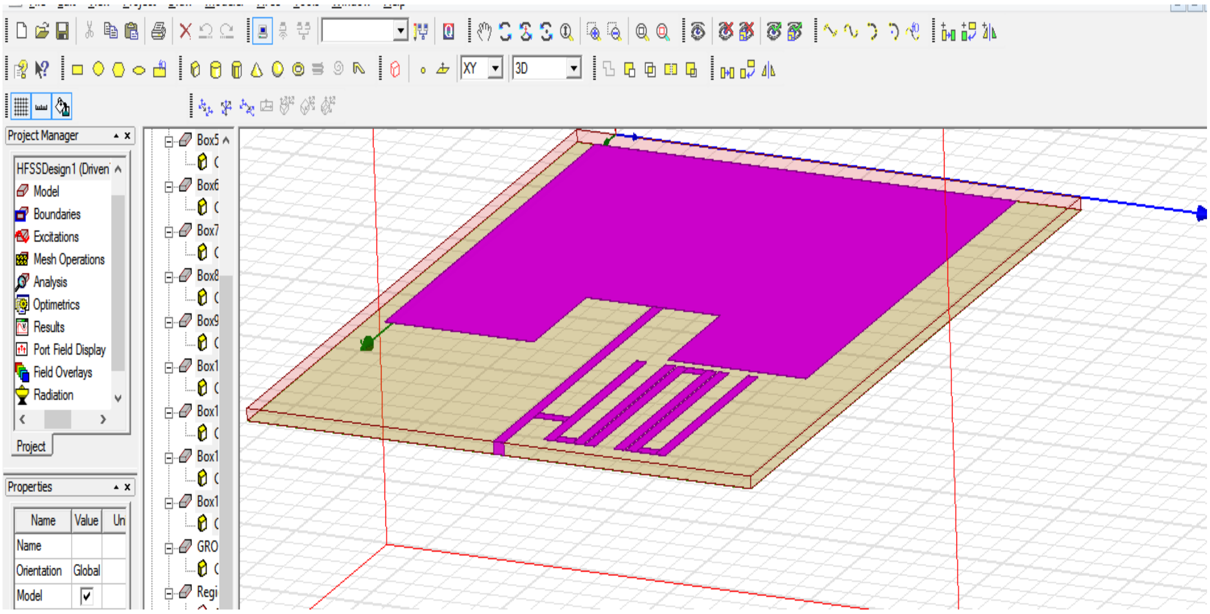

Figure 10 : Physical structure of the simulated three-pole Filter Antenna

The above figure 10 shows the patch antenna incorporated with a 3 pole hair pin resonator filter. The filter antenna was designed using high-frequency structure simulator software. The designwas tested to verify its performances

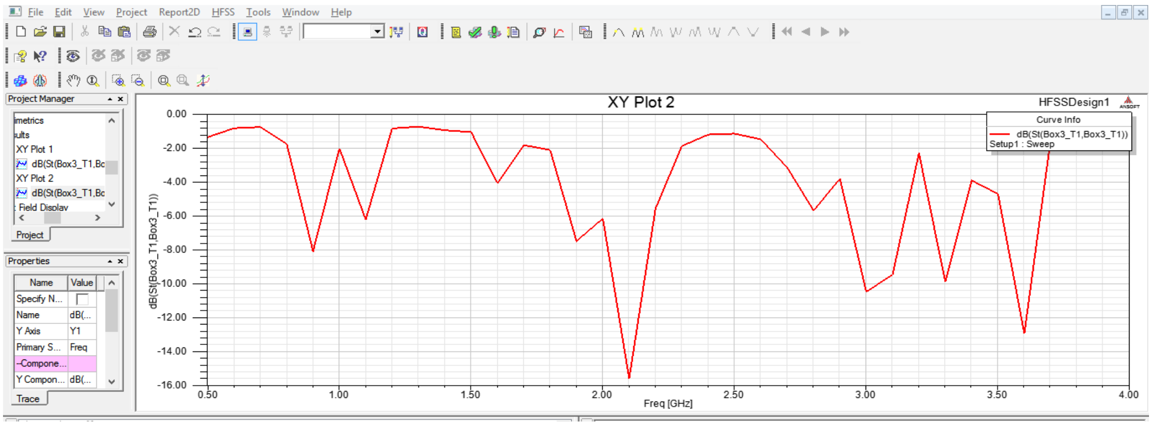

Figure 11: Reflection coefficient $S_{11}$of 3pole FilterAntenna.

Its performance is shown in figure 11 as reflection coefficient S_{11}. Antenna performance is determined from its S_{11} parameters. It is seen from figure 11 that this filter antenna covers multiband frequencies with their centre frequencies at 0.9 GHz, 1.1GHz, 1.5 GHz, 2.1 GHz, 2.85 GHz, 3.0 GHz, 3.3 GHz and 3.6 GHz. These frequencies covers 2G, 3G, 4G and 5G.The least reflected signal was obtained at the highest return loss of 15.6dB at 2.1GHz.

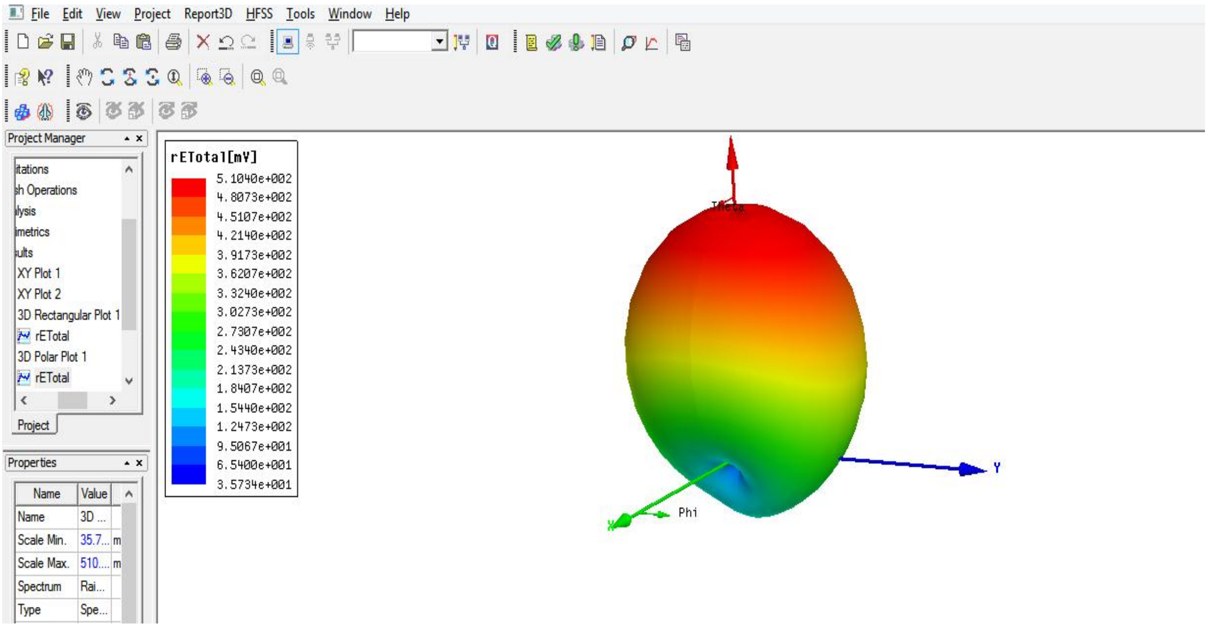

Figure 12: 3-D far field polar radiation at 850MHz of the 3polefilteAntenna.

The 3 dimensional polar plot at 850MHz is shown in figure 12 above. It shows that it performs as an excellent antenna at 850MHz with the radiation pattern in three dimensional form and as such can as well be deployed at such frequency up to 4 GHz as shown in the reflection coefficient of figure 11. The radiation pattern which is the shape of electromagnetic spectrum indicates it is omnidirectional or isotropic i.eit can receive signal from all direction.

CONCLUSIONS

Signal-to-noise ratio indicates the ratio of signal with noise. The higher the ratio, the better the signal which means that the signal has less interferences. The lower the ratio, the more interferences present with the signal.

The experimental values of signal to noise ratio collated gives an idea of the amount of filtering that will be needed in such locality where the readings are taken. The higher the signal to noise ratio, the less filtering required and as such less number of poles of resonator filter is required. Similarly, the lesser the signal to noise ratio, the more filtering that will be required and also as such, more number of poles of resonator filter are required to make it more selective.

Based on the signal to noise ratio readings that is relatively poor, two filterantennas having two and three resonators are designed. The two pole filter antenna is fabricated and connected to a local assembled mobile phone. It was observed that the fabricated antenna performs better than the existing one.

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