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Optimal Sequence Design

Highlights

Developing Frequency Falling

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Discovering Thoughts, Inventing Future

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Improving Profile Parameters of the Power System Network Using Krill Herd Algorithm with Facts Device: UPFC

Sunil Kumar Jilledi
OPJS University

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Keywords: krill herd algorithm (kha),UPFC facts-optimal Power Flow.

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IMPROVINGPROFILEPARAMETERSOFTHEPOWERSYSTEMNETWORKUSINGKRILLHERDALGORITHMWITHFACTSDEVICEUPFC

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Keywords: krill herd algorithm (kha), UPFC, facts - optimal power flow.

Nomenclature

B_{ij} = Suspectance between i^{th} bus and j^{th} bus
C_f = Empirical constant [0, 2]
C^{food} = Coefficient of Effective food
D^{max} =Maximum diffusion speed
D_i = Random Diffusion
F_i^{old} = Last foraging motion
F_i =Foraging motion
G_{ij} = Conductance between i^{th} bus and j^{th} bus
I_i = current at the i^{th} bus *forward*
I_{max} = Total number of Iterations
K^{best} and K^{wrost} = Best and worst fitness of each individual
K_i and K_j = Fitness value of the i^{th} and j^{th} krill individual
NN = Total number of Neighbours
NV = Number of Variables
N_{PV} = Number of generator buses
N_{PQ} = Number of Load buses
N_L = Number of Transmission lines
N_T = Number of Tap setting Transformers
n = exponent taken as"1"
N = Number of buses
N_{UPFC} = bus where UPFC is connected
N_i^{old} = Motion induced by the previous Krill
N_i =Motion induced on the i^{th} krill individual depending on the other krill individual
N^{max} =Maximum induced speed
P_{Gi} = Total power generated at i^{th} bus
P_d = Total power demand
P_L = Total power Losses
P_{Gi}^{min} and P_{Gi}^{max} = Minimum and maximum real power generated at the i^{th} $generator$
P_{GP} and Q_{GP} = real and reactive powers at P^{th} bus
P_{PK} and Q_{PK} = real and reactive powers injected by the UPFC at P^{th} bus
S_{P-Q} = Apparent power in the line connected between buses P and Q bus
UB_j and LB_j = Upper and Lower boundaries of the variables
V_i = i^{th} bus voltage
V_{sh} = Controllable voltage at the shunt converter
V_{se} = Controllable voltage at the series converter
Y_{se} and Y_{sh} = Admittance at the series and shunt converter
Z_{se} and Z_{sh} = Impedance at the series and shunt converter
X= Relative position of each Krill
δ_{sh} = Phase angle of voltage source at the shunt converter
δ_{se} = Phase angle of the voltage source at the series converter
ω_n =Weight of Inertia
β_i^{local} = Local effect provided by neighbouring krill
β_i^{target} = Target effect provided by individual the best krill individual
$\in$ = Small positive number
V_f = Foraging speed
ω_f = Inertia motion of foraging speed
γ_i^{food} and γ_i^{best} = Effect due to presence of food and Effect due to current Krill's best fitness value recorded
ζ = Random directional vector
θ_{PQ} = Admittance angle of the transmission line connected between p- bus and Q – bus
ω_f = real non negative weighing coefficient

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I. Introduction

The optimal power flow problem is becoming a peculiar topic in the power systems. Due to increasing of load demand the power systems are becoming large by interconnecting with different regional systems. Interconnected systems are facing more failures [1]. It is becoming a tedious task for the power system engineers to utilize the existing transmission lines efficiently. Optimal power solution is the best process to get better output with the existing systems, by generation relocation. For efficient utilization of the existing system the shunt capacitors and shunt reactors are incorporating to improve the voltage profile and transmission line reactance as well as power transfer capability. To improve the phase shift between receiving and sending voltages phase shifting transformers are using. Moreover the faster expansion and interconnection of the regional systems voltage stability, power system securities are facing in the deregulated market. In the literature different authors described about the voltage collapse [2, 3]. The power electronic devices are playing a key role in the recent era. The advanced development in the power electronics controllers leads to develop the Flexible AC Transmission System (FACTS) to supply flexible power in the system. Optimize the utilization of the existing system by incorporating the FACTS devices. The FACTS devices technology was presented by Electric Power Research Institute (EPRI) in the year 1980s. These devices has the capability to control the different parameters of the transmission line such as shunt/ series impedance, phase angle, real and reactive power compensation, etc The FACTS family include number of devices such as Stastic VAR Compensator(SVC), thyristor controlled reactor (TCRs), are Shunt FACTS devices, later the series FACTS devices[4].UPFC powerful FACTS device, combination of Static Synchronous Compensator(STATCOM) and Static Synchronous Series Compensator(SSSC) coupled by DC link [5]. Optimal power flow problem is solved by adjusting several variables in the objective function considering generations cost, loss function.etc. Over the decades many researchers presented different solutions to optimal power flow by using different methods Newton Method, Genetic algorithm [6], Differential Evolution and Evolutionary programming, BAT Algorithm[7,8]. Researchers are showing interest on meta-heuristic techniques which includes Genetic Algorithm (GA), Practical Swarm optimization(PSO),Ant colony Algorithm. In the literature authors [9] proposed optimal power flow using GA other [10], gravitational search algorithm (GSA) [11], artificial bee colony (ABC) optimization [12] using swarm intelligence for the optimal power flow. Researchers proposed these algorithms to overcome the failures of the conventional methods. Some of the Bio-inspired Algorithms are implemented to solve the optimal power flow problem. In this paper the Krill Herd (KH) a Meta heuristic algorithm is proposed it is one of the bio-based swarm intelligence algorithms. The Krill Herd is developed based on the behaviour of Krill Swarms [13] i.e., distance between food and highest density of swarms simulates the objective function of individual krill. Comparing with other optimization techniques in the KH the controlling variables are very few. The Krill Herd already using in some research areas like optimization problems [14]. This paper solves the optimal power flow without and with UPFC using the Krill Herd algorithm for different IEEE standard bus systems. The main objective function considered is minimization of the real power losses, voltage deviation, incorporation of UPFC is considered based on the real power losses. The results obtained are presented clearly. KH algorithm optimal power flow results with UPFC is compared with GA and BAT algorithm. The paper organization is follows in the coming section about the KHA, Formulation of UPFC model, optimal power flow using conventional method and proposed method using KHA. Problem solving using the Matlab simulation results and discussion finally the conclusion of the paper and the future work

II. Power Flow Model of UPFC

Gyugyi proposed the Unified Power Flow Controller (UPFC), for real time control and dynamic compensation of AC transmission systems. UPFC consists of Static Synchronous series Compensator (SSSC) and STATCOM connected by a DC link capacitor. UPFC is capable to control the active and reactive power and voltage magnitudes simultaneously at the terminals of UPFC [15]. UPFC consists of two converters, Converter 2 controls the power flow of the device by infuse of an AC voltage V_pq in controllable magnitude and phase angle in series to the transmission line. Similarly the converter 1 can absorb or supply the real power demand by the converter 2 at the DC link. Each converter can supply or absorb the real and reactive power demanded by the system independently [16]. Finding the load flows of any power system is the initial stage to evaluate the power system. Many iterative solutions are there for finding the load flow like Gauss, Newton Raphson method, decouple, fast decouple, Ranga-Kutta methods are available. In this paper the load flows are performed by Newton Rahson Method by using the polar coordinates.Fig.01 shows the clear model of UPFC connected between the bus i and j. and power flow directions of real and reactive power at the shunt and series elements where UPFC is connected.

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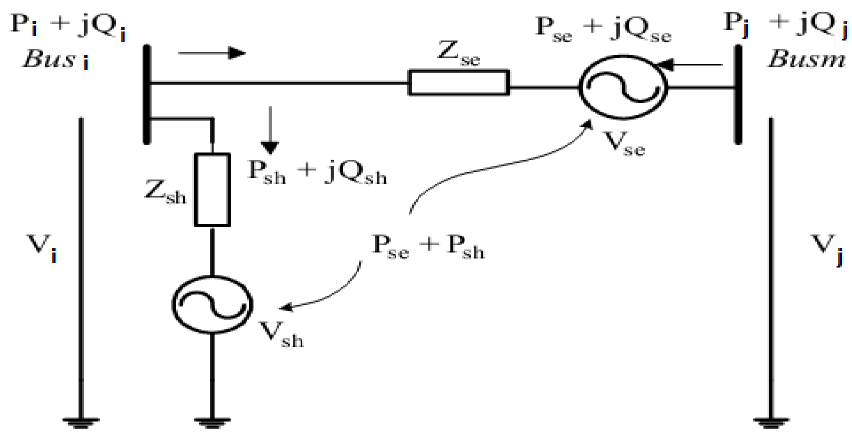

Fig. 01: UPFC voltage source model connected between i ^ (th) and j ^ (th) bus

For each bus the real and reactive powers are computed by Eqs (1) and (2)

$$P_i = \sum_{j=1}^{N} V_i V_j (G_{ij}\, cos\,\theta_{ij} + B_{ij}\, sin\,\theta_{ij}) \tag{1}$$

$$Q_i = \sum_{j=1}^{N} V_i V_j (G_{ij} \sin\theta_{ij} - B_{ij} \cos\theta_{ij}) \tag{2}$$

After finding the load flows by the conventional method, the UPFC is incorporated in the system, compute the power flows with UPFC. The UPFC voltage sources are given in Eqs. (3) and (4)

$$E_{sh} = V_{sh}(cos\,\delta_{sh} + sin\,\delta_{sh} \tag{3}$$

$$E_{sr} = V_{sr}(\cos\delta_{sr} + \sin\delta_{sr}) \tag{4}$$

The active and reactive power equations are given in Eqs. (5) – (8)

At bus-i

$$P_i = [V_i V_j B_{ij} \sin(\theta_i - \theta_j) + V_i V_{sr} B_{ij} \sin(\theta_i - \delta_{sr})] + V_i V_{sh} B_{sh} \sin(\theta_i - \delta_{sh})] \tag{5}$$

$$Q_i = [V_i^2 B_{ii} \quad - [V_i V_j B_{ij} \cos(\theta_i - \theta_j)] - [V_i V_{sr} B_{ij} \cos(\theta_i - \delta_{sr})] - V_i V_{sh} B_{sh} \cos(\theta_i - \delta_{sh})] \tag{6}$$

At bus –j

$$P_j = [V_j V_i B_{ji} \sin(\theta_j - \theta_i) + V_j V_{sr} B_{jj} \sin(\theta_j - \delta_{sr})] \tag{7}$$

$$Q_j = -V_j^2 B_{jj} \quad - [V_j V_i B_{ij} \cos(\theta_j - \theta_i)] - [V_j V_{sr} B_{jj} \cos(\theta_j - \delta_{sr})] \tag{8}$$

Power flow equations at the converter terminals of UPFC Eqs. (9)- (12)

At the series converter

$$P_{sr} = [V_{sr} V_i B_{im} \sin(\delta_{sr} - \theta_i)] + [V_j V_{sh} B_{jj} \sin(\delta_{sr} - \theta_j)] \tag{9}$$

$$Q_{sr} = -V_{sr}^2 B_{jj} \quad - [V_i V_{sr} B_{ij} \cos(\theta_j - \theta_i)] - [V_j V_{sr} B_{jj} \cos(\theta_j - \delta_{sr})] \tag{10}$$

At the shunt converter

$$P_{sh} = V_{sh} V_i B_{sh} \sin(\delta_{sr} - \theta_i) \tag{11}$$

$$Q_{sh} = V_{sh}^2 B_{sh} \quad - [V_i V_{sh} B_{sh} \cos(\delta_{sr} - \theta_i)] \tag{12}$$

For the analysis in this paper the source reactance are considered as X_sr=X_sh=0.1 p.u. The UPFC Source voltage and phase angles are considered as V_sr=0.02 p.u,V_sh=1 p.u,δ_sr=85 δ_sh=0.

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When UPFC is connected between bus-i and j in the power system

$$\begin{bmatrix} I_i \\ I_j \end{bmatrix} = \begin{bmatrix} y_{se} + y_{sh} & -y_{se} & -y_{se} & -y_{sh} \\ -y_{se} & y_{se} & y_{se} & 0 \end{bmatrix} \begin{bmatrix} V_i \\ V_j \\ V_{se} \\ V_{sh} \end{bmatrix} \quad (13)$$

Where $y_{se} = \frac{1}{Z_{se}}$ and $y_{sh} = \frac{1}{Z_{sh}}$

III. Krill Herd Algorithm

Krill Herd Algorithm (KHA) proposed by the researchers Gandomi and Alavi in 2012. KHA is a meta-heuristic algorithm enthused by bio-based swarm intelligence algorithm. KHA is simulated based on the behaviour of the Krill Swarms. Mostly based on the food of the highest density of the Swarms forming the objective function of each Krill folk. The position of each Krill folk is dependent on following factors [17]:

a) Movement induced by other Krill folk
b) Foraging Activity
c) Random Diffusion

The imaginary distances between the krill herd and food give the best fitness value .The main two characteristics considered in the engineering optimization problems are exploration and random search are needed for better performance. The main objective function of the KHA is from the Lagrangian model [17-19]. In the two dimensional problems the above mentioned factors are sufficient, for the n-dimensional problem analysis for the i^th krill individual is given by

$$\frac{dX_i}{dt} = N_i + F_i + D_i \quad (14)$$

Motion Induced by other Krill Individuals:

The fitness function mainly depends on the concreteness of the krill's in the searching space. The main significant and essential thing to obtain the optimum solution is to maintain the krill density. The motion of the individual krill is promptly dependent on the adjacent individual krill and the effects between them. The direction of individual krill movement is designed on different swarm densities [19].

a) Local effect provided by local krill density
b) Target effect provided by target krill density
c) Repulsive effect provided by repulsive swarm density

$$N_i^{new} = N^{max}\, \beta_i + \omega_n N_i^{old} \quad (15)$$

Where $\beta_i = \beta_i^{local} + \beta_i^{target}$

The effect of krill individual on the nearest krill is calculated by

$$\beta_i^{local} = \sum_{j=1}^{NN} \overline{K}_{ij}\, \overline{X}_{ij} \quad (16)$$

Where $\overline{X}_{ij} = \frac{X_j - X_i}{\|X_j - X_i\| + \varepsilon}$; $K_{ij} = \frac{K_j - K_i}{K^{worst} - K^{best}}$;

To know the distance between each individual is given by

$$d_{si} = \sum_{j=1}^{NN} \|X_i - X_j\| \quad (17)$$

Foraging activity:

Foraging activity is computed based on two main factors, First factor is current food location, second is prior food location information. The foraging velocity of the ith krill individual is given by the formula (18) [13]

$$F_i = V_f\, \gamma_i + \omega_f\, F_i^{old} \quad (18)$$

Where $\gamma_i = \gamma_i^{food} + \gamma_i^{best}$

Food attraction is calculated by Eqs. (19)

$$\gamma_i^{food} = C^{food}\, \overline{K}_{i,food}\, \overline{X}_{i,food} \quad (19)$$

Where $C^{food} = 2(1 - \frac{I}{I_{max}})$

Physical Diffusion:

In the diffusion process mainly considered to increase density of population. This motion is a based on maximum diffusion speed and random directional vector, It is given by Eqs.(20) [13]

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$$D_i = D^{max}\ \xi \qquad (20)$$

Motion process in KHA

Depending up on the local effect, global effect, presence of food, best fitness position, the presence of the i^th krill stays in the time interval [t,t+Δt] given by Eqs.(21 and 22)

$$X_i\,(t + \Delta t) = X_i(t) + \Delta t \frac{dX_i}{dt} \qquad (21)$$

$$dX_i = N(i) + F(i) + D(i) \qquad (22)$$

The scaling factor Δt is formulated in Eqs.(23)

$$\Delta t = C_t \sum_{j=1}^{NV} (UB_j - LB_j) \qquad (23)$$

Step by Step procedure of KHA

The step by step analysis in the flow chart is represented in fig.02. The sequence process of KHA algorithm is presented below.

Algorithm for KHA:

Step 1 Initialization of the parameters

Population size (N_P)

Fitness function evaluation ($NFFE_{max}$)

Maximum induced speed (V_i^{max})

Foraging speed (V_f)

Maximum diffusion speed (V_{Di}^{new})

Step 2 Identify the population and iteration

Step 3 Evaluation of the Fitness. Each individual krill position is generated randomly and each individual krill fitness function is evaluated

Step 4 List the fitness function of individual krill based on the current position.

Step 5 while criteria is not satisfied

t<NFFE max do

pick out the best individual and store.

for i=1:N_P Calculate the following motions

a. Induced Motion

b. Foraging Motion

c. Physical diffusion

Update the new krill position based on the new values and again evaluate the new position

end (for)

current best t= t+1;

end (while)

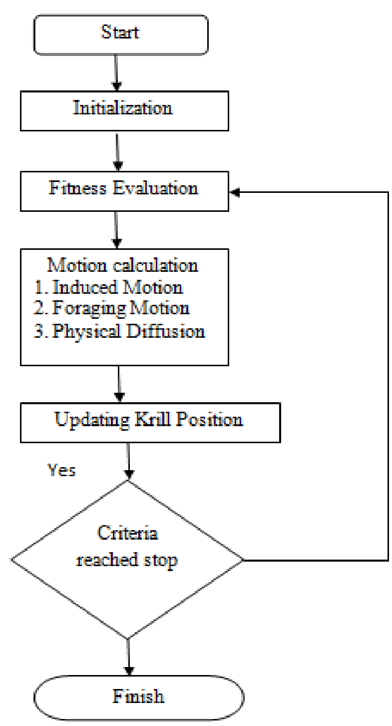

Fig. 02: Flow chart of KHA

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IV. Mathematical Modelling with UPFC and KHA

By satisfying the equality and inequality constants minimize the objective function is the main objective of optimal power flow (OPF). OPF is used for the incorporation of UPFC in the system, considering four different objective functions by fulfilling equality and inequality constraints.

The general optimization problem constraints are as follows

Objective function to be minimised is Min(u, v), and subjected to g(u, v)=0; h(u, v)≤0, the g(u, v) is equality constraints, h(u, v) is inequality constraints, u is dependent variable , v is independent variable. The dependent variables considered in the problem formulation are generator active power (slack bus) P_G1, load voltages (V_(L1,) V_L2, …….V_(〖LN_PQ)), reactive power at the generators (Q_(G1,) Q_G2,…… Q_(GN〗 _PV)), Line loading of the transmission system (S_L1,S_L2,…….S_(LN〗 _L)). The independent variables are active power of the generators apart from slack bus (P_G1,P_G2…….P_(〖GN〗 _PV)), generator voltages (V_(G1,) V_G2, …….V_(〖GN〗 _PV)), Transformer tap settings (T_(1,) T_2,…….. T_(N_T)), active power injections (P_c1,P_c2,…….P_(CN_U)), reactive power injection (Q_c1,Q_c2,…….Q_(CN_U)) [20-25].

Equality and Inequality constraints:

Mentioned above g is the set of equality constraint and h is inequality constraint. With the help of load flow equations the equality constraints are represented by Eqs.(24-25). The inequality constraint h is the operating limits represented by Eqs.(26-30)

$$\sum_{p=1}^{N_B} P_{Gp} - P_{Lp} + \sum_{p=1}^{N_{UPFC}} P_{Pk} = \sum_{p=1}^{N_B}\sum_{q=1}^{N_B} |V_P|\,|V_Q|\,|Y_{PQ}|\cos(\theta_{PQ} + \delta_P - \delta_Q) \tag{24}$$

$$\sum_{p=1}^{N_B} Q_{Gp} - Q_{Lp} + \sum_{p=1}^{N_{UPFC}} Q_{Pk} = -\sum_{p=1}^{N_B}\sum_{q=1}^{N_B} |V_P|\,|V_Q|\,|Y_{PQ}|\sin(\theta_{PQ} + \delta_P - \delta_Q) \tag{25}$$

In equality constrains are Generator active and reactive powers, voltage magnitudes, Transformer tap settings, UPFC settings. The limits of the generator real and reactive powers limits at P^th bus should lie between maximum and minimum limits Eqs.(26-27). The voltage magnitude at the each load bus is given in Eqs.(28). Transformer tap setting minimum and maximum conditions is given in Eqs.(29). Transmission line loading should not violate the loading limits is Eqs (30) [20-25]

$$P_{GP}^{min} \le P_{GP} \le P_{GP}^{max} \text{ where } P = 1,2,3,\dots\dots N_{PV} \tag{26}$$

$$Q_{GP}^{min} \le Q_{GP} \le Q_{GP}^{max} \text{ where } P = 1,2,3,\dots\dots N_{PV} \tag{27}$$

where P_{GP}^{min}, P_{GP}^{max}, Q_{GP}^{min}, Q_{GP}^{max} are minimum and maximum limits of real and reactive powers at P^{th} bus.

$$V_{LP}^{min} \le V_{LP} \le V_{LP}^{max} \text{ where } P = 1,2,3,\dots\dots N_{PQ} \tag{28}$$

where V_{LP}^{min}, V_{LP}^{max} are minimum and maximum limits of voltage at P^{th} bus .

$$T_P^{min} \le T_P \le T_P^{max} \text{ where } P = 1,2,3,\dots\dots N_T \tag{29}$$

where T_P^{min}, T_P^{max} are minimum and maximum tap setting limits of transformer .

$$S_{LP} \le S_{LP}^{max} \text{ where } P = 1,2,3,\dots\dots N_L \tag{30}$$

Where S_{LP}, S_{LP}^{max} are the total power flow in the P^{th} ***branch.***

Objective function

The objective functions considered in this article are based on the fuel cost [25]

$$Fuel\ cost\ (F_C) = \sum_{P=1}^{N_{PV}} (a_P + b_P P_{GP} + C_P P_{GP}^2) \tag{31}$$

For minimization of transmission losses, the mathematical formula is given as

$$\text{Min } P_{Loss} = \sum_{k=1}^{N_L} G_k\,[V_p^2 + V_q^2 - 2|V_p||V_q|\cos(\delta_p - \delta_q)] \tag{32}$$

Line identification is very essential to locate the UPFC in the proposed system. Optimal location of UPFC is calculated by using the Performance Index (PI) given Eqs.(33)

$$\text{PI} = \frac{W_m}{2n}\left(\frac{S_{p-q}}{S_{p-q\ max}}\right)^{2n} \tag{33}$$

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Voltage Deviation should be very minimum at all the bus formulated as Eqs.(34)

$$F_{TVD} = \min(TVD) = \min \sum_{l=1}^{N} |V_l - V_l^{ref}| \quad (34)$$

V. Simulation Results and Discussion

For better understanding analysis of the proposed KHA is simulated by using IEEE 14 and 30 bus standard systems. At the initial state IEEE 14 and 30 bus system load flows are run by Newton Raphson Method using the polar coordinates in the MATLAB environment. IEEE 14 bus system is included by 5 generation units which are located at the Bus No. 1, 2, 3, 6, 8 and 20 transmission lines are used to interconnect the system and tap changing transformers are connected between the buses(4-7,4-9 and 5-6) and for the Bus-9 and 14 shunt VAR compensators are connected . The total demand by the system is 2.98p.u. at 100MVA base. Control variables and line data is considered [26]

The data of the Modified IEEE 30 bus system is having six generators located at the buses -1, 2, 5, 8, 11, 13 and remaining 24 are the load buses, 41 transmission lines are used to interconnect the system. The slack bus is considered as bus -1. Total demand by IEEE 30 bus system is 2.83 p.u at 100 MVA base. In the system load bus, voltages are considered in the range of 0.95 to 1.1p.u. IEEE-14 bus system minimum and maximum constraints is shown in Table.01 [26]

Table- 01: IEEE -14 bus data with minimum and maximum constraints

Generating Unit	Q_{Gmin}(p.u)	Q_{Gmax} (p.u)
Pg1	0.00	0.1
Pg2	-0.4	0.5
Pg3	0.00	0.4
Pg6	-0.06	0.24
Pg8	-0.06	0.24
Voltage Limits	$V_G^{min} = 0.95$	$V_G^{max} = 1.05$
Transformer tap changer	$T^{min} = 0.9$	$T^{max} = 1.1$
Line voltage	$V_G^{min} = 0.95$	$V_G^{max} = 1.05$

The IEEE 30 bus system active power generating limits and unit cost of generators are presented in table-2.

Table- 02: Cost constraints and maximum and minimum power limits of the generator units [27]

Generating unit	P(min)	P (Max)	A_i	$B_i * 10^{-2}$	$C_i * 10^{-4}$
	MW	MW	$\$/h$	$\$/MWh$	$\$/MW^2h$
Pg1	50	200	0.00	200	37.5
Pg2	20	80	0.00	175	175.0
Pg5	15	50	0.00	100	625.0
Pg8	10	35	0.00	325	83.0
Pg11	10	30	0.00	300	250.0
Pg13	12	40	0.00	300	250.0

Case study-i:

Optimal power flow results of IEEE-14 bus system are presented. Voltage profiles, real power flows. Active power transmission losses (APTL) presented clearly. Results obtained with and without UPFC has presented Table.03. UPFC is incorporated between the buses 5 and 6. The results obtained using the Krill Herd is compared with GA and PSO.

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Table- 03: Voltage profile of IEEE-14 bus system

Bus Number	NR method	Genetic Algorithm	PSO	Krill Herd Algorithm
1	1.047	1.047	1.05	1.05
2	1.048	1.049	1.0791	1.0048
3	1.029	1.031	1.0485	1.0161
4	1.003	1.004	1.0211	1.0138
5	1.024	1.038	1.0465	1.0145
6	1.017	1.037	1.0452	1.0121
7	0.998	0.997	1.0314	1.0053
8	0.996	0.997	1.0326	1.0042
9	1.028	1.028	1.0356	1.0282
10	1.017	1.017	1.0298	1.0126
11	1.014	1.013	1.0245	1.0006
12	1.001	1.001	1.0787	1.0079
13	1.013	1.015	1.0014	1.0098
14	0.999	1.001	1.0345	1.0091

The results presented in Table-03 are the voltage profile at different buses. Power flow studies of IEEE 14 bus system is simulated by NR method without incorporating the UPFC. By incorporating UPFC between bus 5 and6 the test system results presented in Table.03. These results are compared with GA, PSO. Compared with the other algorithms the voltage profile is improved more in KHA at bus 5 and 6.APTLof the Test system IEEE-14 bus system is presented Table.04. Based on maximum power loss in lines the UPFC can be shifted to another line, comparing with other results with different algorithms KHA is giving better optimality. Active power transmission loss obtained from the KHA is 12.352 as compared with the other OPF it is reduced by 0.08%. The APTL are clearly yield in the table.04.

Table. 04: APTL of the IEEE-14 bus system

Implemented Algorithm	NR Method	GA	PSO	Krill Herd Algorithm
Loss in p.u	13.50	13.346	13.152	12.352

Total APTL are presented clearly in the Fig.03, from which it is clearly observed that the APTL are smoothly reduced as compared with the GA and PSO. From the convergence results, it is clearly observed that APTL are reduced by 0.8p.u in contrast with GA and PSO. By implementing the KHA almost APTL are reduced by 80% with respective to other algorithms.

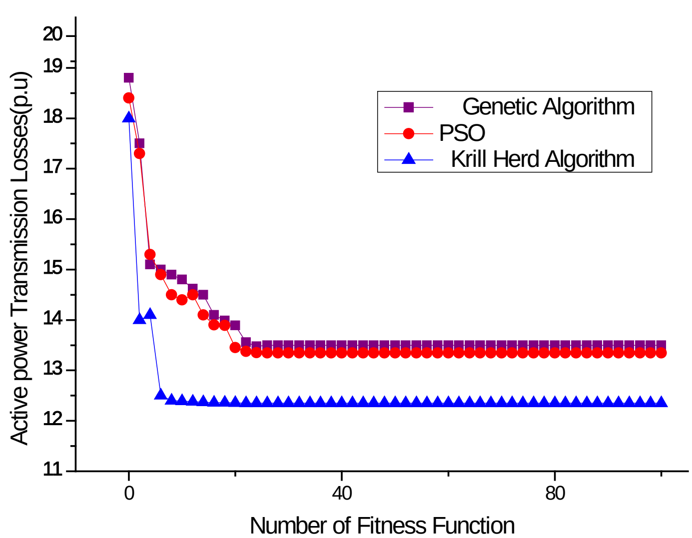

Fig. 03: Comparative Active power transmission losses (APTL) of GA,PSO and Krill Herd for IEEE 14 bus sytem.

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Case study-ii

IEEE 30 bus system is considered for the enhanced analysis. Voltage profiles, real power at generating units, APTL, Cost analysis is evaluated in the MATLAB environment. The bus system is simulated with and without incorporation of UPFC. Based on TVD the UPFC is incorporated. The UPFC is installed between bus 24 and 25. The bus data, line data, generation data are considered from [28].

The voltage profiles of the IEEE 30 bus system is obtained by simulating in MATLAB,and the results are presented in Table.05 is incorporating the UPFC in line 33 between 24 and 25 buses. As compared with NR, GA, FF, ABC [28-32] with KHA the voltage profiles are smoothly and drastically increased in the system. Voltage profile is improved almost 0.06% compared with the conventional and remaining algorithms.

Table. 05: Voltage profile of IEEE 30 bus system compared with different algorithms

Bus number	NR Method voltage [32]	ABC [31]	GA Method [30]	PSO[33]	free fly [28]	KHA
1	1.06	1.06	1.06		1.06	1.06
2	1.043	1.043	1.043		1.043	1.031
3	1.0253	1.0253	1.0254		1.029	1.03
4	1.017	1.017	1.017		1.019	1.001
5	1.01	1.01	1.01		1.018	1.012
6	1.0144	1.0145	1.0147		1.0149	1.0139
7	1.004	1.0039	1.0049		1.005	1.01
8	1.01	1.01	1.01		1.019	1.001
9	1.0526	1.0529	1.053		1.053	1.043
10	1.0461	1.0465	1.0468	0.99402	1.047	1.029
11	1.082	1.082	1.082		1.081	1.048
12	1.0598	1.0599	1.0598		1.0598	1.039
13	1.071	1.069	1.071		1.071	1.027
14	1.0448	1.049	1.0449	0.98576	1.05	1.04
15	1.04	1.04	1.0402	0.99541	1.05	1.04
16	1.0468	1.0469	1.0471	0.98307	1.05	1.04
17	1.041	1.042	1.0415	0.98056	1.048	1.0019
18	1.043	1.042	1.0304	1.05500	1.0412	1.029
19	1.0272	1.0273	1.0277	1.01710	1.02	1.028
20	1.0312	1.0315	1.0317	1.00930	1.032	1.029
21	1.0339	1.034	1.0345	0.96099	1.044	1.009
22	1.0344	1.0342	1.035	0.96705	1.04	1.009
23	1.0293	1.0292	1.0295	0.98157	1.03	1.0019
24	1.0234	1.0239	1.0237	0.98194	1.028	1.0021
25	1.0204	1.0214	1.0205	1.01800	1.027	1.0018
26	1.0027	1.0028	1.0029	0.98311	1.009	1.01
27	1.0269	1.027	1.0273	1.05700	1.029	1.021
28	1.0125	1.0128	1.0125		1.02	1.0018
29	1.0071	1.007	1.0075	1.00760	1.01	1.0019
30	0.9957	0.9994	0.9961	0.97714	0.998	0.9999

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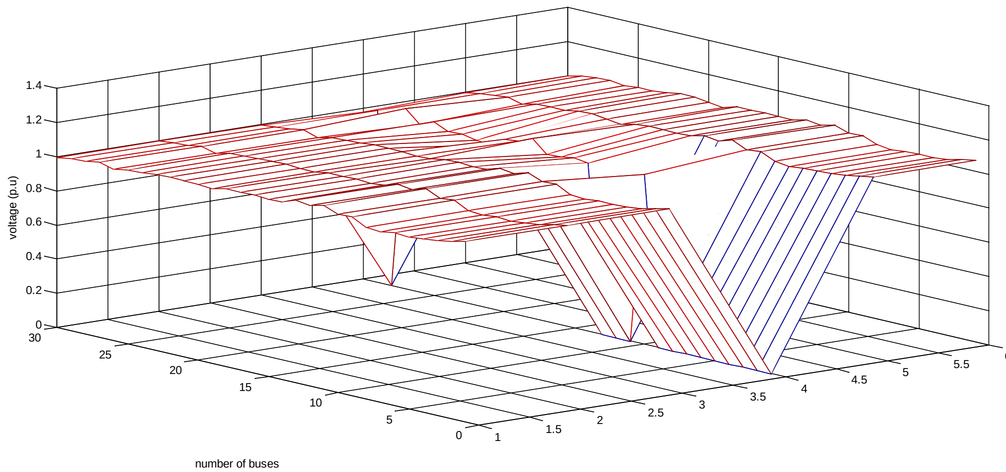

Fig. 04: Comparative voltage profile of IEEE 30 bus system for different algorithms

Considering the fuel cost minimization as objective function the best control variables for the optimal power flow is presented in Table.06. Results of KHA are compared with the other optimization techniques like FF [28], GA[30], ABC [31], PSO [33]. The total power generated by using KHA is decreased by 1.4% as compared with ABC with the incorporation of UPFC between bus 24 and 25. The results of ABC are mentioned in [31]. Similarly there is a decrease of 1.06% for GA is reported in [30], and 1.248% decrease for FF reported in [28]. By using the fuel cost optimization for the KHA method, the power losses have reduced to 4.6986% as compared with the other optimization techniques.

Table. 06: Best optimal control settings for the fuel cost minimization objective of the IEEE 30 bus system for different algorithms

Generator	ABC	GA	FF OPF	PSO	KHA OPF
PG1	180.5218	176.7307	176.7311	174.26	174.16
PG2	48.7845	48.8488	48.8454	49.77	48.754
PG5	21.2598	21.4941	21.4931	21.05	21.82
PG8	18.6469	21.6881	21.6923	21.4	20.61
PG11	11.8145	12.1530	12.1535	11.93	11.95
PG13	12.1011	12.0009	12.000	12.00	12.01
TOTAL	293.3805	292.3805	292.9154	290.41	289.304
COST	802.1649	802.717	802.3646	802.36	795.41
P_{Loss}	9.7286	9.5156	9.5155	9.3064	9.292

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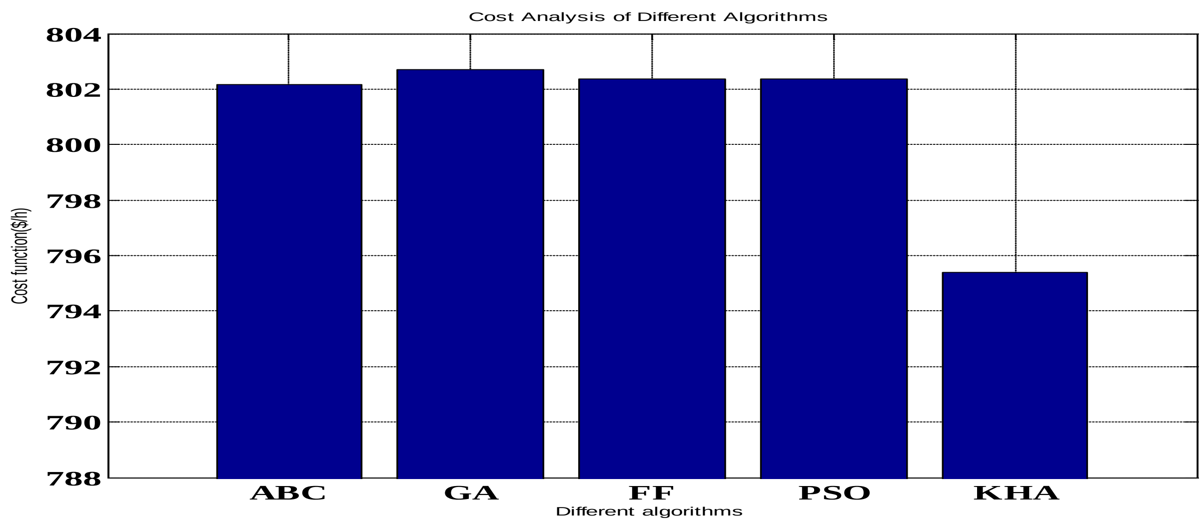

Fig. 04: Cost Analysis of different algorithms for the IEEE 30 test bus system

Considering the minimization of transmission loss as objective function the best control variables for the optimal power flow is presented in Table.07. With Results of KHA presented clearly. The total power generated using the APTL objective function is 284.316MW comparing with the cost objective function the total power generated is reduced by 4.88MW which is1.75%.The results has tabulated in the Table.07. In Fig.05 APTL has compared with different optimization algorithms. From the graph it is clear that the KHA is provides the better performance.

Table. 07: Best optimal control settings for the APTL objective of the IEEE 30 bus system for different algorithms

Generator	PG1	PG2	PG5	PG8	PG11	PG13	TOTAL	COST	P_{Loss}
KHA OPF	74.356	63.509	49.999	33.431	28.77	34.251	284.316	952.56	2.753

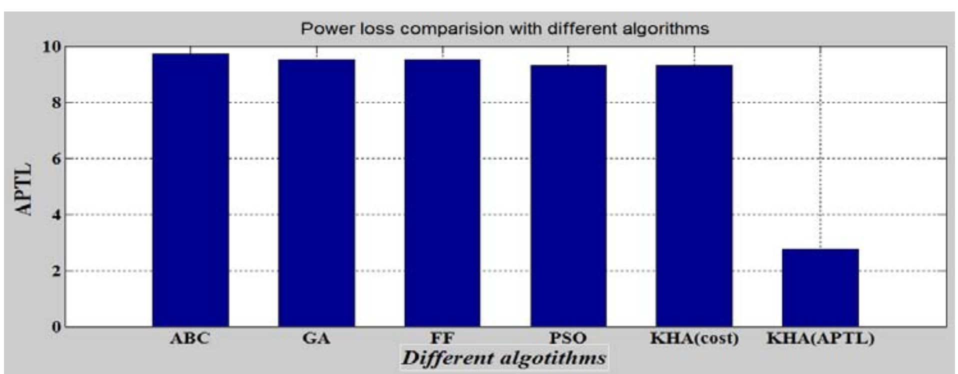

Fig.05: Power losses comparison with different algorithms for IEEE -30 test bus system

VI. Conclusion and Future Scope

A novel Meta heuristic algorithm KHA is used to solve the Optimal power flow problem of the proposed power system networks IEEE-14 and 30 bus systems. Two main objective functions has considered (i) cost function (ii) Active power transmission losses due to high impact of equality and inequality constraint each objective function is studied individually. For the analysis of the KHA, FACTS device UPFC is incorporated in the system. Results obtained using KHA is compared with Genetic Algorithm, Practical Swarm Algorithm, Fire Fly and ABC algorithms and compared with the other popular optimization techniques for the optimal power problem, The results obtained from the KHA are better and robustness, stability and the convergence rate is faster than the other methods. By this article the new algorithm KHA may be extended for other optimization methods for the further research. In future the KHA can be extended to OKHA, and can be implemented for the other FACTS devices like IPFC, UPQC etc,. for the better analysis.

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A Circularly Polarized Planar Monopole Antenna with Wide AR Bandwidth Using a Novel Radiator/Ground Structure

By Mubarak Sani Ellis, Abdul-Rahman Ahmed & Jerry John Kponyo
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Abstract- A wideband circularly polarized (CP) printed monopole antenna is proposed. The 3-dB axial ratio (AR) is realized by protruding a horizontal stub from a vertical monopole and creating a slot on the ground plane beneath the protruded stub. The monopole and slot resemble rotated T-shape structures when viewed from the top. The proposed antenna has a size of 25 × 25 mm2. Numerical results show that the antenna can realize an S11≤ -10 dB impedance bandwidth of 85.6 % from 4 -10 GHz, and a broadband 3-dB AR bandwidth of 73.9 %, from 4.54 – 9.8 GHz. The proposed antenna is simple to design, compact and suitable for circular polarization applications in C band.

Keywords: monopole, circularly polarized (cp), axial ratio.

GJRE-F Classification: FOR Code: 090609

ACIRCULARLYPOLARIZEDPLANARMONOPOLEANTENNAWITHWIDEARBANDWIDTHUSINGANOVELRADIATORGROUNDSTRUCTURE

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I. Introduction

With the rapid development of wireless communications systems, antennas with different polarizations have become very important. Circular polarization (CP) has become very useful in many communication systems due to its resilience to polarization mismatch which is otherwise a problem in linearly polarized (LP) antennas. A lot of research has focused on implementing CP in slot antennas due to their relatively wide impedance bandwidths [1] – [7]. In [1] – [3], L shaped ground strips were embedded inside a square slot to achieve and improve the AR bandwidth. In [4] – [6], perturbations in the form of feed lines were introduced in the slot antenna to realize CP characteristics.

Another uncommon technique is introducing sequential array configuration [7], [8] aside using slot antennas. This method can realize wideband AR but the design is complicated due to the array design and the use of a power divider and a large circuit board. Recently, research has gone into using planar monopole antennas to realize broadband CP [9] – [12] but some of these designs have wide AR bandwidths and/or suffer from design and fabrication complexities. There is a scarcity of techniques to achieve CP with planar monopole antennas compared to slot antennas.

In this work, a new and structurally simple planar monopole broadband CP antenna is proposed. The presented antenna consists of a microstrip-fed vertical radiator and a rectangular ground plane structure. To realize broadband CP, a horizontal stub is protruded from the vertical radiator above the ground plane, and an identical slot structure is created on the ground plane just beneath the radiator. In this design, the 3-dB AR bandwidth reaches as large as 5.26 GHz which is about 73.9 % which covers the WLAN (5.2 GHz, 5.8 GHz), WiMAX (5.5 GHz) and other wireless systems in C band.

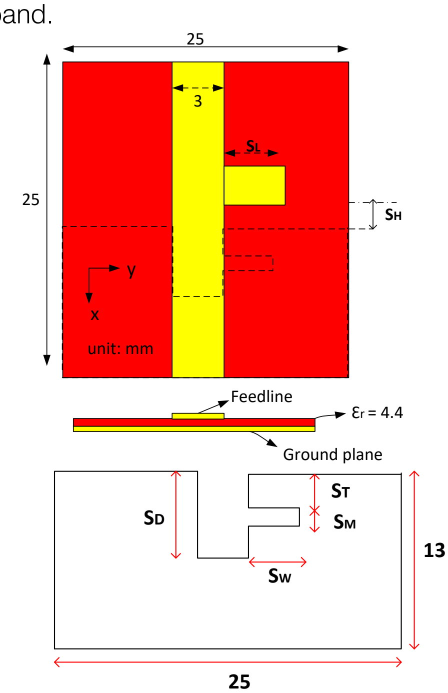

Fig. 1: Geometry of the proposed antenna (S_D = 4, S_L = 4, S_W = 4, S_M = 0.5, S_T = 2, S_H = 1.5)

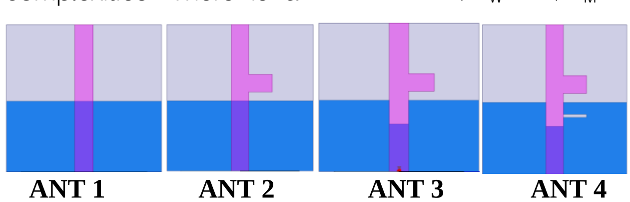

Fig. 2: Evolution of the proposed antenna

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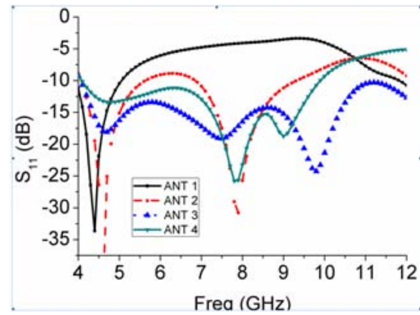
II. Antenna Design

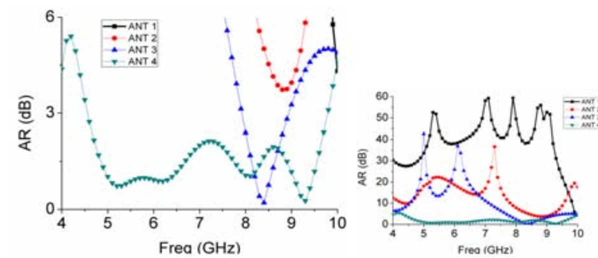
1. The geometry of proposed antennas is shown in Fig. 1. The proposed antenna is fed by a 50-Ω microstrip feedline printed on the top of an FR4 substrate of thickness 1.6 mm and dielectric constant of 4.4. The ground plane is printed on the bottom of the substrate. A horizontal stub is protruded from the monopole towards the +y axis, just above the ground plane. A gap is created in the middle-top of the ground plane towards the +x axis. Another slot is created from the first slot and moved towards the +y axis. The overall area of the proposed antenna is 25 × 25 mm^2. The antenna is printed on the *xoy* axis as shown in Fig.1.
2. The evolution of the proposed antenna is shown in Fig. 2. in order to explain how the CP performance is introduced into the antenna. Four separate antennas will be discussed. These are: antenna 1 (Ant 1), antenna 2 (Ant 2), antenna 3 (Ant 3), and antenna 4 (Ant 4). Ant 1 is a fundamental monopole antenna which has been widely used [13] while Ant 4 is the proposed antenna. At the first stage, Ant 1, which is simply a micro strip antenna which consists of a vertical monopole and a ground plane, is designed. In Ant 2, a horizontal stub is protruded from the radiating monopole (towards the +y axis) at a short distance above the ground plane. The radiator, here, resembles a rotated uneven T-shaped monopole. In Ant 3, a slot is created on the ground plane just beneath the radiating monopole, along the +x axis. Lastly, in Ant 4, a horizontal slot is created on the ground plane along the initial slot and towards the +y axis to resemble a rotated T-shaped slot. The effect of each antenna will be discussed in Section III.

III. Results and Discussion

The antennas were simulated with Ansoft commercial high frequency structure simulator (HFSS) software. To demonstrate the performance of the proposed antenna from stages 1 to 4, the S_{11} bandwidth and AR performances have been compared in Fig. 3. It can be noticed in Fig. 3(a) that Ant 1 resonates around 4.5 GHz which corresponds to a quarter of the guided wavelength for the monopole's length above the ground plane. The bandwidth is however very small and the impedance matching becomes poor after 5 GHz. It is also linearly polarized with an AR value around 50 dB as seen in Fig. 3(b). To enhance the S_{11} bandwidth significantly, a horizontal stub is protruded from the monopole, like in Ant 2. From Fig. 3, the S_{11} bandwidth is greatly enhanced due to another resonance at 8 GHz. The AR is also improved from 50 dB to about an average of 20 dB average across band, except at 9 GHz.



(a)



(b)

Fig. 3: Simulated (a) S_{11} and (b) AR results for antennas 1 – 4

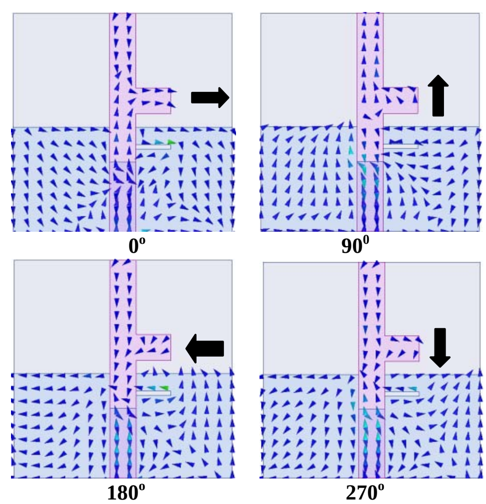


Fig.4: Distribution of surface current at 7 GHz at 0°, 90°, 180°, and 270°

where the AR improves to 4 dB. Overall, Ant 2 is still linearly polarized with enhanced S_{11}.

CP is generated by two orthogonal electric vectors with equal amplitude and 90 degrees phase difference, where the complex E-vectors are the vertical E-field, E_{VER}, and the horizontal E-field, E_{HOR}. When the slot is created on the ground plane in Ant 3, the S_{11} plot shows an improved overall S_{11} performance thereby increasing the bandwidth. This is because the slot reduces the coupling between the ground plane and feed line, which in return reduces the reflection coefficient at those frequencies. Fig. 3(b) shows that Ant 3 realizes CP performance between 8 and 9 GHz which is an improvement of Ant 2. To significantly enhance the

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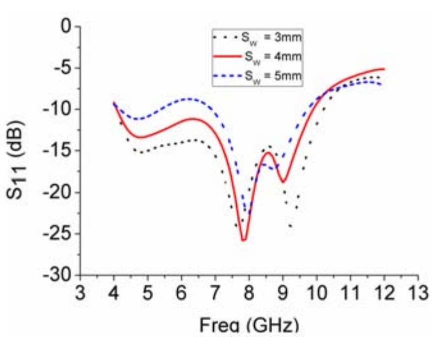
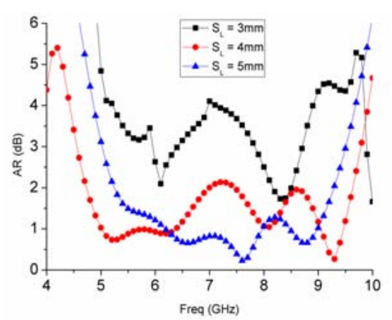
bandwidth of Ant 3, a slot is created from the initial slot in Ant 3 and extended towards the +y axis to complete the slot structure on the ground plane. Here, the overall slot resembles an uneven rotated T-shape, like the monopole structure. This is illustrated in the proposed design (Ant 4). Fig. 3(a) shows that Ant 4 has better S_{11} performance than Ant 1 and Ant 2, but not Ant 3. Ant 3 has an S_{11} bandwidth from 4 GHz - over 12 GHz, while Ant 4 has an S11 bandwidth from 4 GHz - 10 GHz.

However, the AR performance shows a significantly improved performance in Ant 4: from 4.6 GHz to 9.8 GHz. Here, a phase difference of 90^0 is achieved over a wide bandwidth between E_{VER} and E_{HOR}.

The time-varying surface current distribution of the proposed antenna (Ant 4) is shown in Fig. 4. It can be seen that the surface current distribution at 0^0 and 90^0 are equal in magnitude and opposite in phase to 180^0 and 270^0. This shows right-hand circular polarization (RHCP) in the +z direction, but left-hand circular polarization (LHCP) in the -z direction.

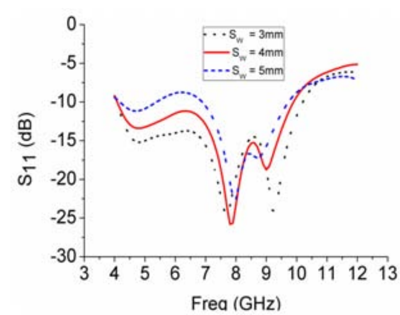


(a)



(b)

Fig. 5: Effect of stub length S_L on S_{11} and AR



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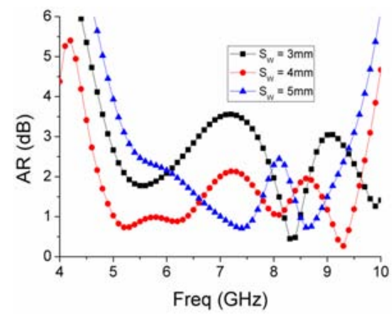
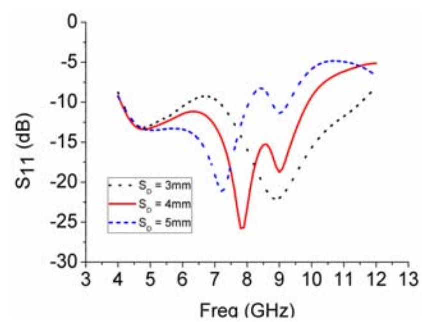


(b)

Fig. 6: Effect of stub length S_w on S_{11} and AR



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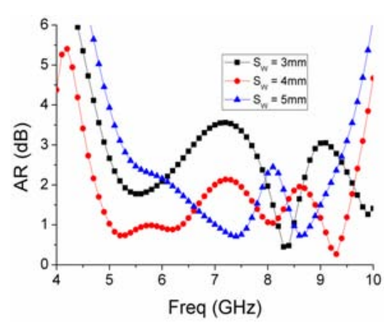

(b)

Fig. 7: Effect of slot length S_D on S_{11} and AR

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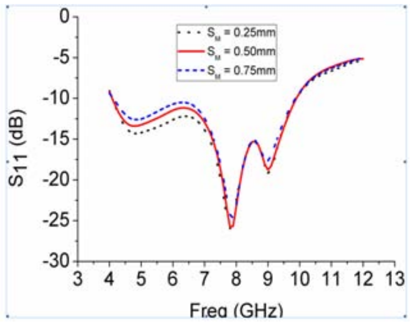

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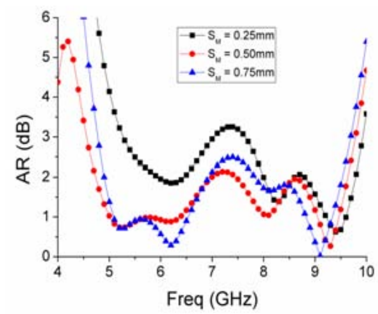
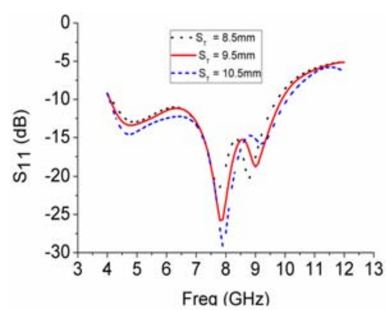


(b)

Fig. 8: Effect of slot length S_M on S_{11} and AR



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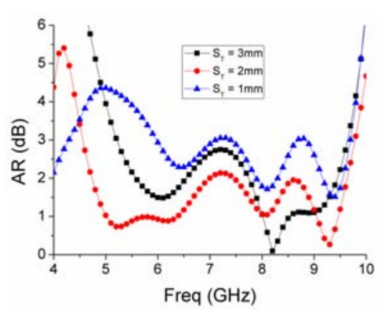
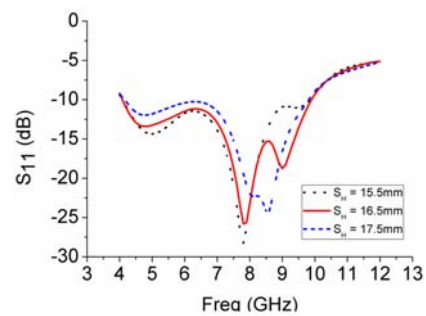


(b)

Fig. 9: Effect of slot length S_T on S_{11} and AR



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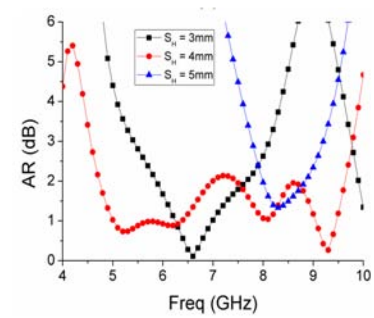

(b)

Fig. 10: Effect of slot length S_H on S_{11} and AR

IV. Parametric Analysis

The results of parametric studies on the proposed antenna are presented in this section. The parameters discussed here are the stub length (S_L), slot length (S_D), slot length (S_W), slot width (S_M), slot position (S_T), and stub position (S_H). For each varying parameter, the other dimensions remain fixed as the values indicated in the caption of Fig. 1. The results will be discussed to provide knowledge on how the antenna's S_{11} and AR performances are affected by each parameter.

A. Effect of S_L

The results of different S_L values on AR and S_{11} are shown in Figs. 5(a) and (b). It can be realized that the S_{11} does not significantly change when S_L is varied except at low frequency, between 4 GHz – 7 GHz, where the S_{11} worsens as S_L increases. In the AR plot in Fig. 5(b), the AR value decreases (improved CP) as S_L increases from 3mm to 5mm, especially between 6 – 8 GHz. For an AR $\leq$ 3 dB threshold, the bandwidth however is largest when S_L = 3mm.

B. Effect of S_W

The effect of S_W values on AR and S_{11} bandwidths is demonstrated in Fig. 6(a) and (b). The S_{11} is affected at the low frequency points when S_W increases. The AR value decreases as S_W increases, especially around 7 GHz. The largest bandwidth is however achieved when S_W = 4.

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C. Effect of S_D

Figures 7(a) and (b) show the effect of L_W on AR and S_{11}. Above 5 GHz, the S_{11} is greatly affected by S_D. When S_D is small, there is considerable coupling between the ground and monopole which is reduced when a gap of adequate length is created. When the gap is relatively big however, (e.g. S_D = 5mm), the worst S_{11} is achieved since the ground plane's effective area is reduced. In the AR plot, a small gap produced a poor AR at lower frequencies below 6.5 GHz, which improved when the S_D increased. After 6.5 GHz, an insignificant change is noticed with changes in S_D.

D. Effect of S_M

The effect of S_W on AR and S_{11} bandwidths is demonstrated in Figs. 8(a) and (b). S_M does not affect the S_{11} and AR significantly. The S_{11} plot remains unchanged except at low frequency where an increase in S_M worsens the S_{11} slightly. The AR plot is also significantly affected only at lower frequency when S_M = 0.25mm. At S_M = 0.5mm and 0.75mm, the AR remains unchanged except with S_M = 0.5mm realizing a slightly larger bandwidth than S_M = 0.75mm.

E. Effect of S_T

The effect of S_W on AR and S_{11} bandwidths is shown in Figs. 9(a) and (b). The S_{11} plot shows no significant change except very slightly at lower frequency. In the AR plot however, significant changes are noticed, i.e., when the gap between the horizontal slot and top edge of the ground is close, the AR is worsened but improves when the gap is increased. The largest bandwidth for AR≤ 3 dB is achieved when the gap, S_T, is 2mm.

F. Effect of S_H

The effect of S_H on AR and S_{11} bandwidths is shown in Figs. 10(a) and (b). A significant change is noticed in the AR plot while a slight change is noticed in the S_{11} plot when S_H changes. From Fig. 10 (b), it shows that the AR bandwidth is dependent on S_H. When S_H is 3mm, a wideband AR is achieved from 5.5 – 8 GHz. When S_H increases to 5mm, the AR shifts to about 7.8 – 9.2 GHz. The largest bandwidth is realized when S_H = 4mm.

V. Conclusions

A novel, low profile, broadband CP monopole antenna is introduced in this work. The results show that the antenna can achieve a broadband AR bandwidth from 4.54 – 9.8 GHz (73.9 % fractional bandwidth) and an impedance bandwidth from 4 – 10 GHz (85.7 % fractional bandwidth). To achieve CP performance, a rotated T-shaped monopole and a rotated T-shaped slot are employed. In addition to the simple structure, the proposed antenna provides a novel design in enhancing AR bandwidth and CP operation. The proposed antenna is useful for wireless communications in C-band, including WLAN (5.2, 5.8 GHz) and WiMAX (5.5 GHz).

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Protection of Diesel Generators from an Electromagnetic Pulse (EMP)

Vladimir Gurevich

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Keywords: HEMP, emergency diesel generator, protection, microprocessor, controller.

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PROTECTIONOFDIESELGENERATORSFROMANELECTROMAGNETICPULSEEMP

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Keywords: HEMP, emergency diesel generator, protection, microprocessor, controller.

I. Introduction

The electromagnetic pulse that emerges during the high altitude (40-400 km) nuclear explosion (HEMP) generates the electric field density of up to 50 kV/m at the earth surface. This creates extreme danger for all types of electric and electronic equipment [1]. Thus, the problem of diesel generator (DG) protection from HEMP becomes particularly relevant. First of all, DGs act as backup power sources and are designed to power up critical loads in emergency situations. Consequently, they need to be 100 percent ready for use even after the HEMP. Secondly, DGs are often stored outdoors (outside of the buildings that can partially mitigate the HEMP impact).DGs stored outdoors may also become a target for Intentional Destructive Electromagnetic Interferences (IDEI), which can be produced by portable devices that generate pulse emissions of several Gigawatts in the directional antenna [1].

Nowadays there are thousands of kinds of DGs with the power rating from several kilowatts to dozens of megawatts. Some of them are small open-design portable devices that can be stored in a metal container protected from electromagnetic emissions. These can be used when necessary after removal from the container. Generally speaking, these low capacity DGs have a simple design without sensitive electronics and are relatively inexpensive. Thus, it makes no sense to use any special measures to protect these DGs (except for metal enclosure).

II. Increased Susceptibility of Medium- and High-Capacity DGs

Medium-capacity industrial DGs (from dozens to hundreds of kilowatts) are large and heavy devices that are intended for transportation. As a rule, they are confined in a casing with many sensors and microprocessor-based controllers that control the DG's operation, measure and display various parameters, as well as protect them from overload and emergency modes. Protection from emergency modes in high capacity (1-50 MW) DGs is performed by digital protective relays (DPR) of the same type as those used in the electric industry in conventional power plants and substations. They are usually confined in standard relay protection cabinets that are installed inside the DG's casing. These cabinets are usually of the same type as those used in the electric energy industry in power plants and substations.

Use of microprocessor-based controllers and DPR that are especially susceptible to HEMP and IDEI [2] in medium- and high-capacity DGs, results in a dramatic drop in the DG's efficiency as a backup power source for critical loads. Consequently, they need to be urgently addressed. It should be noted that there are two absolutely different modes of DG use (from the HEMP protective measures standpoint). One mode presupposes storage of de-energized DGs at warehouses, whereas in the other mode they are constantly connected to local the consumers' electric network and can automatically start at any time should it become necessary to re-energize the power supply, or to flatten the load peaks. Let us look at the possible protection measures for medium- and high capacity DGs in these two situations.

III. Protection Of DGs Stored De-Energized Outdoors

It should be immediately stressed that it is inappropriate to store DGs at centralized warehouses (as it usually happens). DGs are backup power sources that should be ready for use within the shortest possible time after emergency occurrence (after HEMP in this situation). As HEMP impact is all encompassing and creates problems for transport, communication systems and computerized warehouse equipment, it becomes obvious that we need to aim at decentralization of backup DGs storage places, moving them closer to potential consumers.

The easiest solution to protect internal equipment of de-energized DGs from HEMP is to put metal casing on top of the DGs. However, this approach has some serious drawbacks. First, the casing for

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medium capacity DGs (5-8 meters long; 1.5-2 meters wide; 3 meters high) should be equipped with special stiffeners. The metal casing should be made of sufficiently thick metal welded together to provide for the necessary rigidity of the structure. Such casing will be so heavy that a user will need a crane to remove it from the DGs and prepare the DGs for a start up. However, this can hardly be a reasonable approach in a critical situation. Moreover, this casing will protect the DGs from 5 sides. And what about protection from the bottom ? What about inevitable multiple and large gaps between the casing walls and the foundation of the DGs? On the other hand, medium- and high capacity DGs are usually equipped with their own metal casing. Nevertheless, it should be noted that such casing has many cutouts, holes and blinds that drastically reduce its screening properties.

Taking the above mentioned into account, I suggest the following concept for medium capacity DG protection:

1. Improvement of screening capacity of the DG's own casing by closing all the cutouts, holes and blinds with removable metal patches that can easily be removed when preparing the DGs to startup.
2. Disconnection of connectors of all the electronic appliances and sensors from internal wiring and cable harness.
3. Installation of the same type of connectors' counterparts with short-circuited pins into connectors both on the side of electronic appliances and sensors and on the side of cable harness. Points of common coupling of all the cable harness wires should be connected to the DG's chassis.
4. Short-circuiting of all the power leads of the generator's rotor and stator into a point of common coupling and connection of this point with the DG's chassis.
5. Removal of the electronic unit from the automatic power circuit breaker at the generator's output and placing it into the screened casing.

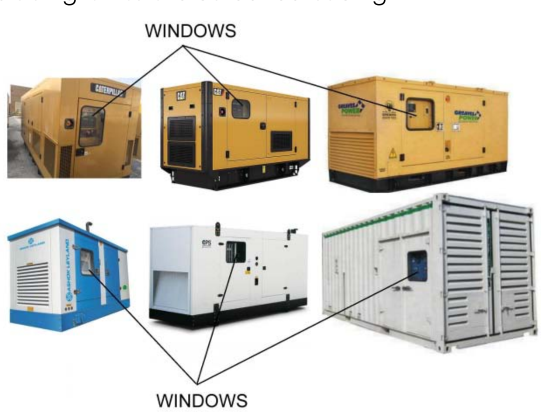

Fig. 1: Windows in front of controllers' screens cutout in casings of most DG types

When deploying clause 1 of the suggested concept, a special emphasis should be put on the window, which is cut out in the DG's casing in front of the microprocessor-based controller's screen. Such windows are present in most DG types, see Fig. 1. They are intended for visual monitoring of the controller's readings. However, they pose the biggest danger from the point of view of the DG's susceptibility to HEMP.

These windows should be tightly closed with a welded-on or bolted steel plate contoured with conductive rubber gaskets. The controller's readings are not taken continuously. When the DG is started, it is enough to read its parameters by opening the door in the DG's casing, which is located near the controller. Should it be absolutely necessary, it is possible to weld a small door opposite the controller's screen (instead of the steel plate) or use conductive glass to cover the windows, or glue a transparent conductive film [3] to the ordinary glass. However, one needs to understand that all of these alternative options will be less efficient than the first option.

The second approach to improve the screening ability of the DG's casing is to close the air intake and exhaust apertures and blinds, see Fig. 1, with a solid steel plate fixed with welded bolts and contoured with conductive rubber gaskets. These screening plates should be removed before the DG start-up. Another large opening in the DG's casing is the cutout designed to connect external power cables to the DGs. This opening should also be closed by a removable bolted steel plate.

Fig. 2: Standard connectors of various types used to connect sensors to the DGs

When deploying other methods of the offered concept (related to disconnection of highly sensitive electronic equipment from internal electric circuit), it should be kept in mind that each point of intrusion into the internal arrangement of the DGs should be registered in the check list and each procedure of

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disconnection and restoration of circuits should be marked in this check list.

Fig. 3: Widely used DG controller, type EMCP 4

In order to connect multiple DG sensors to the cable harness, standard connectors (Fig. 2) are used. Subsequently, it is easy to buy mating parts to these standard connectors and use them as caps to short circuit the terminals of sensors and wires in harnesses.

Different types of DGs use different types of controllers. Producers of these controllers often use their own, non-standard connectors to connect external circuits. For example, one of these connectors, marked as 160-7689 in the documentation, is used in a well known EMCP 4 controller, which is widely used in various types of DGs, see Fig. 3. Some diesel units have another non-standard connector marked as 9X-4391. However, non-standard connectors are not really a problem as they (and many other types of connectors used in DGs) are readily available as spare parts and can be purchased both from a controllers' manufacturer and on the web, say eBay (see Fig. 4) at a relatively low price (50-60 USD).

Fig. 4: Non-standard 160-7689 and 9X-4391 connectors of DG controllers, which are readily available in the market

IV. Protection of DGs Connected to Consumer's Network

There are two options here:

– Immovable DGs located in a permanent place. These start-ups automatically whenever necessary;
– Transport table DGs that are arranged temporarily to power up a consumer. These are intended for frequent start-ups and for continuous operation during specific limited periods. In some circumstances, these DGs can be started in advance as a response to intelligence data about a danger of pending electromagnetic impact. Thus, they can be working during the HEMP impact.

In the first case, the most efficient protection is achieved when locating the DGs in a closed container made of reinforced concrete with a fine mesh reinforcement or a metal-sheet fabricated container. These containers should have no windows and their vents should be intended for cooling air intake and release, the exhaust gas holes also need to be closed with special honeycomb structure blocks. These blocks that close the vents are clearly seen in Fig. 5.

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Fig. 5: Protective containers for immovable DGs. The vents are closed with special honeycomb structure blocks

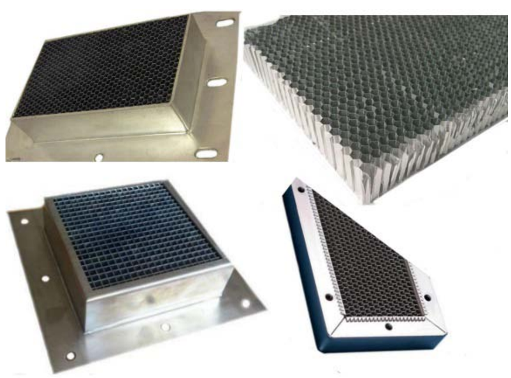

Fig. 6: Honeycomb structure blocks designed to close the vents

The honeycomb structure blocks (Fig. 6) are made of round or rectangular (sometimes hex-shaped) section pipes welded alongside. The purpose of these blocks is to ensure cooling air (or exhaust gases) circulation and prevent electromagnetic emissions from penetration into the protected area.

It is commonly known that the hollow metal pipe acts as a waveguide that conducts the high-frequency electromagnetic wave. Nevertheless, in order to have this pipe act as a waveguide, it should have specific geometric dimensions that are related to the wave length. If the dimensions of the pipe (waveguide) are different, it can cause significant wave decay (up to 80-100 dB). In other words, it does not conduct the electromagnetic wave. The waveguides that do not conduct electromagnetic waves at a frequency rate lower than the defined value (also known as the cutoff frequency) are called waveguides-below-cutoff. The size of waveguides-below-cutoff (i.e. the size of pipes used to produce the honeycomb structure blocks in our case) is determined by known formulas, see Fig. 7.

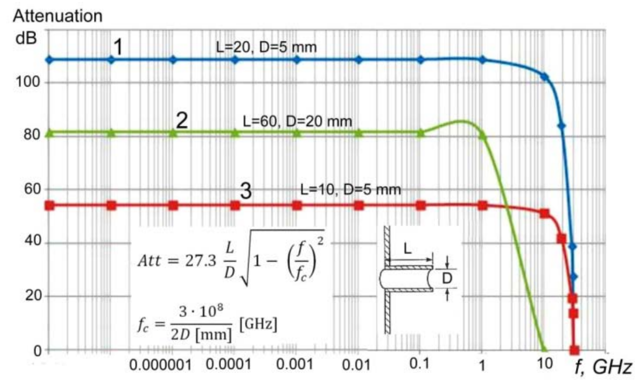

Fig. 7: Correlation between the index of electromagnetic emission attenuation by waveguides-below-cutoff and their geometrical dimensions and frequency. L– length of round section waveguide; D– diameter of the waveguide; f– frequency of emission; fc– cutoff frequency.

The curves in Fig. 7 (determined by [4] using these formulas) show that the ability of waveguides-below-cutoff to weaken the electromagnetic emissions is maintained in a wide range of frequencies up to the cutoff frequency.

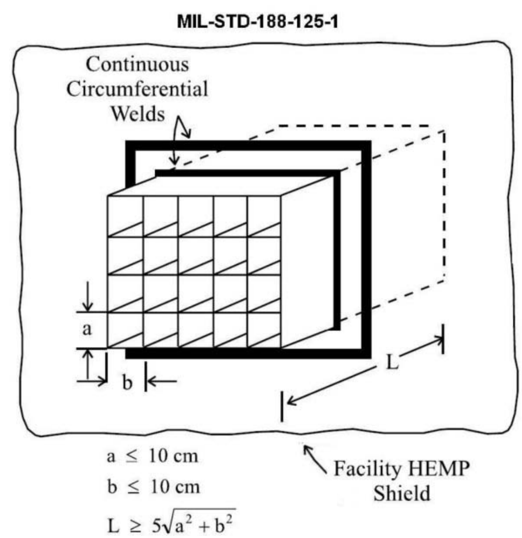

Fig. 8: The ratios to select the size of simple rectangular section pipes for the honeycomb structure [5].

In order to ensure the reliable operation of the waveguide-below-cutoff, it is necessary to select its cutoff frequency with a one and a half period margin in relation to the maximum working frequency. The military standard [5] suggests the ratios for selection of the size

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of simple rectangular section pipes for the honeycomb structure, see Fig. 8. In addition to the above mentioned honeycomb blocks, the DGs located in a protective container should be equipped with special HEMP filters installed between the power leads of the DGs and the load located outside the protected area. These filters which are designed for full load current (Fig. 9) are rather large and heavy. They need to be attached to the protective container in such a way that only the filters' exit cables are free from pulse overloads and powerful high-frequency signals can enter the protected area.

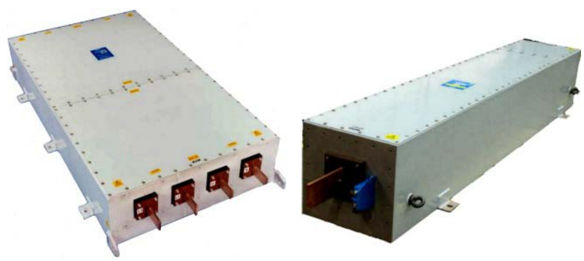

Fig. 9: Powerful HEMP filters for power circuits rated 800 and 1,200 A

The same is applicable to all control cables that also need to be run through corresponding filters before entering the protected area. All such filters need to be located in a separate container, see Fig. 10.

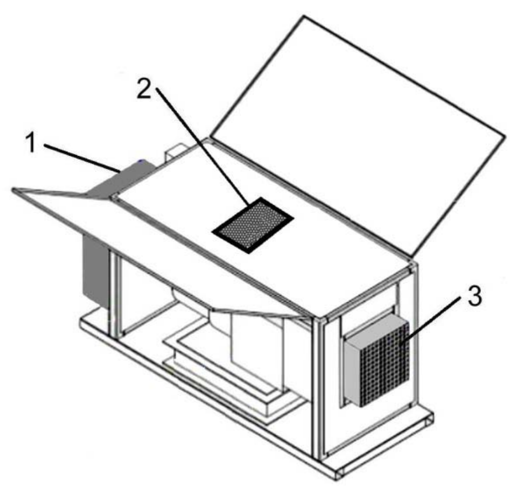

Fig. 10: Protective container for immovable DGs. 1 – filter block; 2 – honeycomb structure block closing the opening for air bleeding and the exhaust aperture; 3 – honeycomb structure block closing the cooling air intake opening.

Actually, such protective containers will fit for not only immovable, but also movable DGs, but relatively low capacity (up to 100-200 kW). This type of protected DG is produced by some companies, e.g. EMP Engineering. The price of a 60 kW DG in a protected container is $85,000 US. Both such DGs and those located in immovable protective containers can work properly during the HEMP impact.

Since HEMP impact is global and affects large regions and sometimes even entire countries, the approach to backup DGs use should be different from that employed for man-induced (technological) or natural disasters, as the latter are: 1) limited in space; and 2) this space is not known in advance. Unlike local technological or natural disasters, locations for DGs installation in case of global HEMP impact can be determined in advance. Consequently, one of the approaches to protect heavy and large movable, large capacity DGs (more than 0.5 - 1 MW) without protective containers intended for operation at different consumers' during HEMP impact, is early location of fully equipped empty protective containers at critical loads, which will be powered from backup DGs during HEMP impact. Moreover, the DGs need to be delivered to the site and installed in the previously prepared protective containers.

Early transfer of critical loads to DG power and their disconnection from a centralized power supply in case of HEMP danger gives an additional positive effect. This is due to significant risk reduction of power system damage, when it is off (disconnected). Thus, this approach may be demanded in practice.

A more complicated and less reliable solution to ensure efficiency of large DGs that have no special protective casing under the possible HEMP impact is to use well-known standard approaches to protection of electric and electronic equipment of power plants and substations [1], in addition to installation of honeycomb structure blocks on vents, power filters and weld sealing of a window in front of controller. The above mentioned known protection measures include:

- use of shielded control cables inside the DG's casing;
- use of metal (instead of plastic) cable trays;
- use of filters embedded into control cables or ferrite filters put onto the control cable harness;
- installation of excess voltage suppressors that employ zinc-oxide varistors or powerful avalanche diodes in all the power and control circuits;
- introduction of a high-frequency choke into the grounding circuit.

Obviously, such a solution [1] is the most difficult to employ for a consumer having an unprotected DG. However, in some cases it can be the preferred approach, e.g. if the manufacturer of the DGs will initially adopt the above-mentioned protective measuresat the order processing stage.

V. Conclusion

Technical measures of DG protection from HEMP discussed in the article touch upon DGs of various typical sizes and purpose. Adoption of such measures is fairly easy for semiskilled technical staff and does not require high investments. In addition, it should

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be considered that DGs would not perform properly upon HEMP impact without such investments.

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A Study of Open Source Toolkits of Image Processing for Healthcare Industry

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Abstract- Image processing is used in every sector of life. The development of medical field is entirely contingent on image processing algorithms. Radiologists utilize these algorithms for detection of diseases such as tumors. These algorithms are designed using proprietary tools which enhance the cost of disease detection. In this paper, various open source toolkits for medical image processing such as ITK, VTK, VV, 3D Slicer, Bioi mage XD are explored. We have also performed various image processing operations such as inversion, enhancement and segmentation using these toolkits. These toolkits provide a cost effective solution to healthcare industry.

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GJRE-F Classification: FOR Code: 080106

ASTUDYOFOPENSOURCETOOLKITSOFIMAGEPROCESSINGFORHEALTHCAREINDUSTRY

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A Study of Open Source Toolkits of Image Processing for Healthcare Industry

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I. Introduction

Medical imaging plays a pivotal role in detecting disease. Proprietary tools are utilized in order to design image processing algorithms [35]. But these tools are very expensive. Hence open sources are a good option for detecting disease as it provides cost effective solution. Open source softwares are those whose source code can be modified or enhanced by anyone. These are free of cost while proprietary software's are very costly and also it consist some restrictions regarding license availability. Open source softwares provide accurate and cost effective access to the scientist in order to provide the wealth of information. Open source toolkits are used to meet following constraints such as faster feature implementation, free of cost, fast fixes for security and multiple options for a given task and fast upgrades to new releases. Open source tools for image processing can be divided into two categories –general purpose [23] and application specific open source tools. General purpose open sources are Scilab [10] and Open CV (Open computer vision) [2]. Application specific tools are designed for some specific applications. For example the special designed toolkit for medical is not applicable in the field of agriculture and remote sensing etc. For medical image processing, there are some specially designed toolkits which performed operations on medical images. Although general purpose tools are very efficient but still they fails to perform operations such as image labeling and 4d visualization etc. These are some specially designed toolkits for radiologist which can perform all the operations required for medical field.

II. Types of Open Source Toolkits for Medical Image Processing

Application specific open source tools for medical image processing are of three types-programming based, Simulation-based and GUI based. Some open sources are in the form of toolkits and these toolkits can be interfaced with MATLAB/Simulink [29]. There are various types of open source toolkits for medical image processing as depicted in figure 1.

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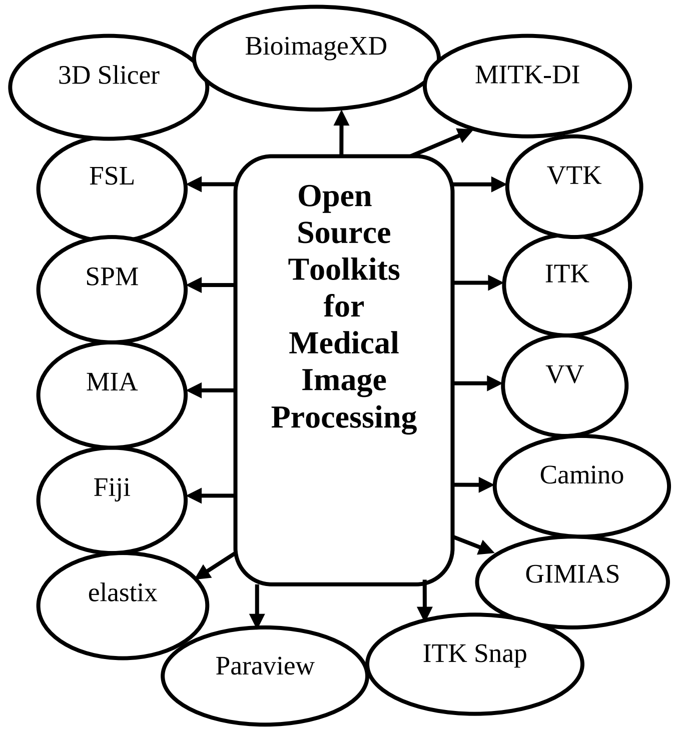

Figure 1: Classification of Open Source Toolkits

a) VTK

Visualization toolkit is free and open source software used for scientific visualization of medical images. It is cross platform software and runs on Windows, Linux, Mac and UNIX platforms and is written in C, C++ and python languages. It is licensed under BSD. It consist a wide variety of visualization algorithms and advanced modeling techniques. It is used in many commercial applications of medical and research and development.

b) ITK

Insight segmentation and registration (ITK) toolkit is open source software which is written in C, C++, FORTRAN and python languages. It is also cross-platform software. It requires CMAKE for its installation which is an open source software used for managing the build process of a software. It is used for segmentation and registration of medical images. In the medical environment, segmentation is used for extraction of data or some kind of disease while registration is used for combining information contained in CT scans and MRI. ITK is also used for visualization, analysis, image-guided surgery applications.

c) FSL

FSL stands for FMRIB Software Library is also open source software which consist a library for analysis of MRI, FMRI (functional MRI). Its size is 1.7 GB and is written in Python language and runs on PCs and apple. It can be run either from command line or from GUI (Graphic User Interface). It has application in analysis of brain imaging data.

d) SPM

SPM (statistical parametric mapping) is an open source for medical image processing which is written by using MATLAB. Also, it contains Matlab scripts, functions, data file. It can run on UNIX, Linux or windows. Its installation requires an operating system, Matlab 5.2.1 or later, ANSII C compiler, internet and a program to convert images into ANALYZE format. It is used for analyzing different medical image modalities such as PET, FMRI, ECG, SPECT, MEG. It is used for data analyses of brain imaging. It supports data sequence of different time interval of same images. It provides statistical parameters for functional imaging in order to test the hypothesis.

e) GIMIAS

GIMIAS stands for the Graphical interface for medical image analysis and simulation. It is written in C++ language and runs on windows and Linux platforms. It performs various image processing operations such as segmentation, Extraction of ROI, filtering etc. It supports DICOM format. It supports a variety of image modalities. It also has a movie control option. It provides multi slice view of medical images. It has applications in neurology, cardiac imaging and angiography imaging.

f) MIA

It is free and open source software which is an image processing toolkit. It is written in C++and distributed under GPLv3+ license. It is compatible with Linux and POSIX (portable operating system interface) which is based on UNIX operating system .MIA is

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basically used for grayscale image processing. It has applications in many research scenarios and performs various tasks on 2D and 3D images such as PNG (portable network graphics), TIFF (tagged image file format) etc. It supports various external packages such as VTK (visualization toolkit data), IT++ which is a signal processing library etc. It is licensed under GNU GPL version 3.It requires a huge knowledge for software development [26].

g) 3D Slicer

Slicer is free and open source software written in C++, Python and QT languages. Its size is 200 MB and is compatible with Linux, Mac OS X and windows. It is distributed under BSD license and supports DICOM images. It is built on VTK. It also provides image registration and builds surface models from image labels, automatic segmentation and 3D visualization. It visualizes MRI data collection. It also supports different image modalities like FMRI and DTI.

h) Camino

Camino is a free and open source toolkit which is written in JAVA which makes it simple. It is designed for a UNIX style interface and compatible with Linux, windows, Mac operating system. It is distributed under Artistic license 2.0. For diffusion, it uses UCL Camino diffusion MRI toolkit. It contains very special cutting edge technique. Camino use data acquired either by using scanners or Camino's data synthesizers. Data obtained from scanners is not correct format hence, Camino rearranges that data. It uses a data pipeline model. Camino's output is in binary format. This software is generally used for detecting brain disorders.

i) ITK- Snap

ITK-snap is open source software leverages from ITK which supports medical image formats like DICOM etc. DICOM (digital imaging and communication in medicine) is a standard for handling and transmitting medical imaging information. It is distributed under GNU General Public License. It is cross platform and written in C++ language. It supports automatic segmentation in order to extract tumors in CT and MRI.

j) Paraview

Paraview is free and open source software. It is written in C, C++, FORTRAN, Python and compatible with Unix/Linux, Mac OS, Microsoft windows. It is distributed under BSD license. It is a multi-platform visualization application consist client-server architecture. It supports a variety of file formats including VTK.VTK is a set of libraries which provides data visualization and pipeline architecture. It was developed to analyze large data sets by using distributed memory resources.

k) VV

VV is free open source software which is implemented in C++ along with QT, ITK and VTK. It is distributed under BSD and Ce CILL-B license. It runs on Linux, windows, Mac OS (32 and 64 bits). For researchers, it is compatible with Linux while for clinicians used it on windows. It visualizes 2D, 3D, 4D images and is very fast and simple to use. It has application in visualization, fusion and placement of landmark. It also performs operations on images like cropping an image, pixel manipulation, image arithmetic and re sampling [33].

l) Fiji

Fiji is an open source whose main purpose is to distribute image processing packages based on ImageJ. ImageJ is an image processing program invented by National institute of health. It is written in java and performs operations like image reading, the creation of histogram and line profile, smoothing, geometric transformation etc. Fiji is compatible with Linux, Intel (32 and 64 bit) and windows but it has the least support for MacOSX/PPC. Fiji has applications in life science as it performs operations like segmentation, registration, visualization and other advanced level operations.

m) Bioimage XD

Bioimage XD is free and open source software which is written in C++ and python and distributed under General Public License. It is compatible with Mac operating system, Windows and Linux. It supports 2D, 3D, 4D and XD data. It performs operations like segmentation, filtering, visualization and qualitative analysis. It also supports on ITK and VTK for image processing and segmentation. It has various advantages like easy access, increasing scientific output.

n) Elastix

Elastix is open source software which is compatible with Linux and windows and Mac Operating system. It is highly configurable, easy to extend, reliable and suitable for a large amount of data. In this scripts are written. It is totally based on ITK and is multi-compiler. It supports various image formats such as hdr (Analyze), mhd (MetaIO), nii (NIFTI), gipl, dcm (DICOM). But elastix not support DICOM directories directly. It is highly applicable for registration of medical images.

o) MITK-DI

Medical Imaging Interaction Toolkit -Diffusion Imaging is open source software is a part of MITK which is written in C++ and runs on windows, Linux and Mac operating system. It is an object-oriented toolkit and in the form of GUI. It is basically used for brain imaging. It also performs operations like pre-processing of diffused image, visualization and reconstruction. It is used for implementation of DTI [31].

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III. Analysis of Image Processing Algorithms Using open Source Medical Toolkits

There are some open sorce toolkits specially designed for medical image processing [34] such as VV, 3D Slicer, Bioimage XD etc in which various image processing operations can be performed in addition to some additional operations which are required for analyzing medical images.

a) Image analysis using VV

There are various image processing operations can be performed in VV which is a 4D slicer. Image inversion is used to obtain information hidden behind white pixels. Image inversion using VV is depicted in figure 2.

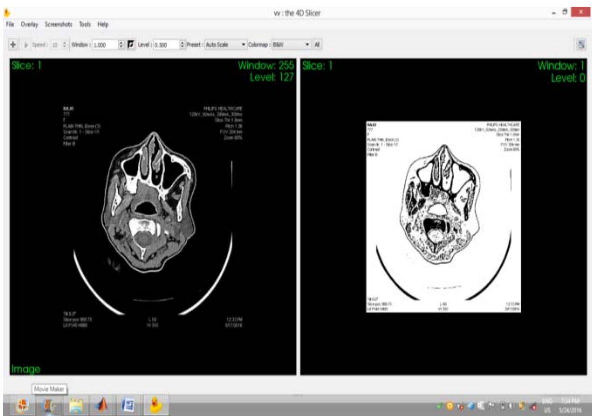

Figure 2: Image inversion using VV with input and output image

Image enhancement operation is performed in order to improve contrast of images. Image enhancement is very important for medical sector as it improve the visualization of images. Hence radiologists can easily detect abnormalities. There are various types of enhancement operations [27] such as mask processing, point processing, histogram based and frequency based operations etc. Image enhancement using VV is depicted in figure 3.

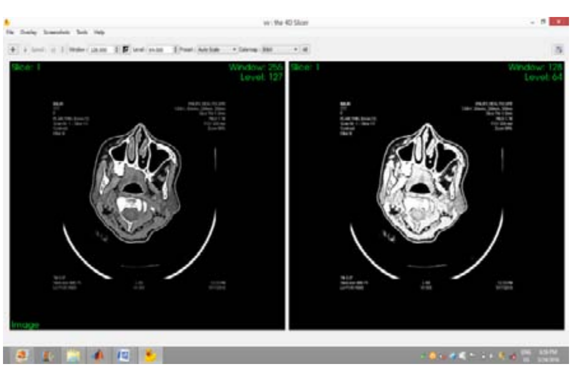

Figure 3: Image enhancement using VV with input and output image

VV performs various image processing operations. VV can perform operations on 2D, 3D and 4D images. Image segmentation plays very pivotal role in detecting location of tumors and artifacts [30]. Edge detection operation is a type of image segmentation operation can be performed using VV is depicted in figure 4.

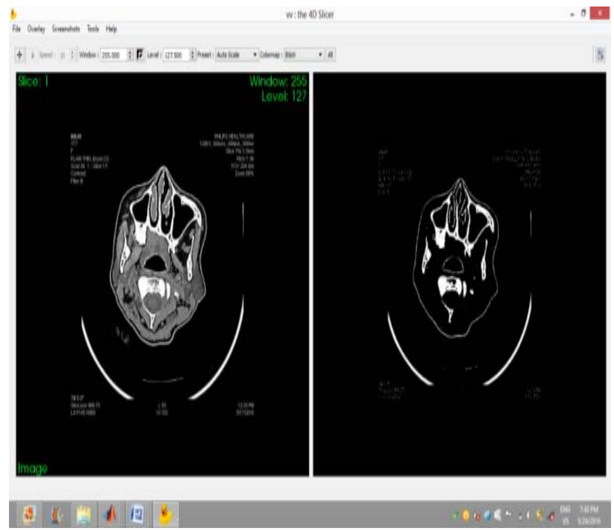

Figure 4: Image edge detection using VV with input and output image

b) Analysis of images using 3D Slicer

3D Slicer performs operations on 2D and 3D images. It support various image formats such as DICOM, PNG and JPEG etc. Image enhancement [25] using 3D slicer is depicted in figure 5.

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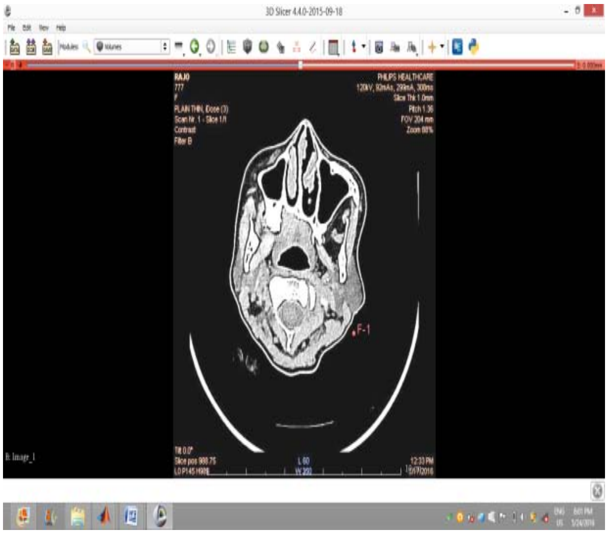

Figure 5: Image enhancement using 3D Slicer

Image thresholding operation which is a method of image segmentation can also be performed using 3D slicer as depicted in the figure 6.

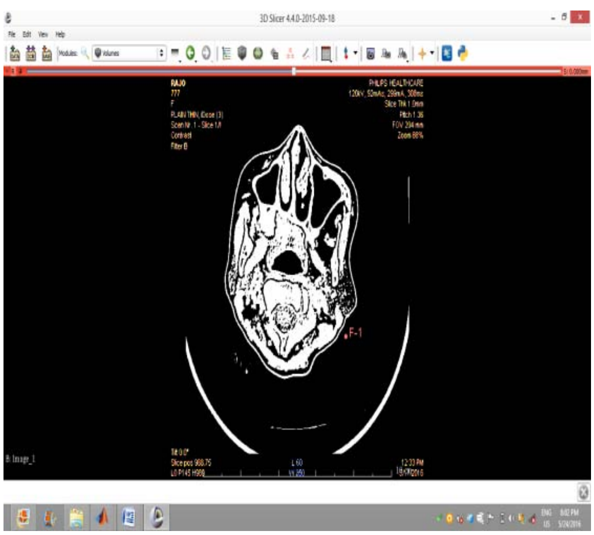

Figure 6: Image thresholding using 3D Slicer

Image segmentation is done in order to segment the tumors and other parts affected due to diseases [29]. Edge detection is a part of image segmentation. Edge detection using 3D Slicer is depicted in figure 7.

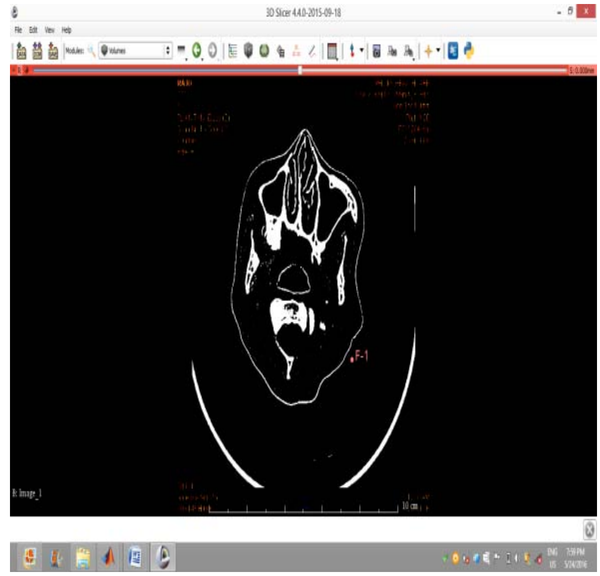

Figure 7: Image segmentation using 3D Slicer

3D Slicer can perform various image processing operations by using 2D as well as 3D images. There are varieties of operations which can be performed using 3D Slicer for detecting diseases.

c) *Analysis of images using Bioimage XD*

Bioimage XD performs operation on signal image and as well as on multiple images. Thresholding is also used in order to segment images. Image thres holding using Bioimage XD is shown in figure 8.

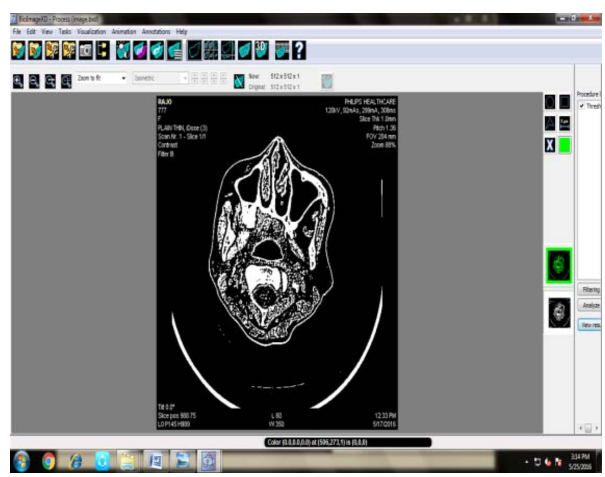

Figure 8: Image thresholding using Bioimage XD

The open source soft wares can also perform the same operations which can be performed using proprietary tools. Biologists directly utilize open sources toolkits for medical applications in order to detect abnormalities and disease. In this thesis, we have designed algorithms for image inversion, enhancement and segmentation using proprietary as well as open source soft wares.

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IV. Conclusion

In summary, we have concluded that there are some specially designed open source toolkits for medical image processing such as ITK, VTK, GIMIAS, VV, 3D Slicer, Bioimage XD and elastix etc. We have performed image inversion, segmentation and enhancement operations using these toolkits and concluded that these toolkits can perform these operations with high speed and accuracy. These toolkits not only perform basic image processing operations such as 3D and 4D visualization. These toolkits are very beneficial for radiologist as they can detect tumors and artifacts easily. Hence we have designed a cost effective framework for health monitoring.

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Developing Frequency Falling EDF with Relatively Greater Power Efficiency and Low Deadline Miss Ratio

Mohammad Nowsin Amin Sheikh, Nazmul Hossain, Ripon Kumar Saha & Atikul Islam Atik

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Abstract- Many scheduling algorithms are available for the real-time system, which maintains hard deadline to solve the issues related to the time that is critical for scheduling in real time system and to provide a better system design in real-time system avoiding poor and erroneous choices for scheduling algorithms. The system is based on a real-time deals with the resource to ensure maximum performance and utilization in real-time. Processor availability plays the main role in choosing the best scheduling algorithm for a real-time system. DVFS is being used extensively for the technique of energy management. The aim of DVFS platform is to minimize energy consumption. In this paper, we will give a new algorithm for DVFS and compare the power consumption and deadline miss ratio of other RT-DVFS algorithm with our algorithm. There are many real time dynamic voltage frequency scheduling (DVFS) algorithms.

Keywords: *RT; DVFS; RT-DVFS; EDF; static EDF; WECT; FF-EDF.*

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Developing Frequency Falling EDF with Relatively Greater Power Efficiency and Low Deadline Miss Ratio

Mohammad Nowsin Amin Sheikh [α], Nazmul Hossain [σ], Ripon Kumar Saha [ρ] & Atikul Islam Atik [Ѡ]

Abstract- Many scheduling algorithms are available for the real-time system, which maintains hard deadline to solve the issues related to the time that is critical for scheduling in real time system and to provide a better system design in real-time system avoiding poor and erroneous choices for scheduling algorithms. The system is based on a real-time deals with the resource to ensure maximum performance and utilization in real-time. Processor availability plays the main role in choosing the best scheduling algorithm for a real-time system. DVFS is being used extensively for the technique of energy management. The aim of DVFS platform is to minimize energy consumption. In this paper, we will give a new algorithm for DVFS and compare the power consumption and deadline miss ratio of other RT-DVFS algorithm with our algorithm. There are many real time dynamic voltage frequency scheduling (DVFS) algorithms. We have analyzed two independent under loaded task-sets for RT-DVFS scheduler algorithm that is Base-EDF and Static-EDF and devise a new DVFS scheduler algorithm named Frequency Falling EDF. Our devised FF-EDF algorithm is more efficient than Base-EDF algorithm in terms of power consumption. It also gives better performance than static-EDF in terms of future deadline handling. FF-EDF algorithm focuses on dynamic voltage frequency scheduling.

Keywords: RT; DVFS; RT-DVFS; EDF; static EDF; WECT; FF-EDF.

I. Introduction

The usages of energy are growing rapidly with the increase of portable devices, embedded system, automation and much real time devices with its energy consuming application. Research is going on to provide better power efficiency both in hardware and software level [1]. In dynamic voltage frequency scheduling(DVFS) many scheduling algorithms are available which can provide a great power efficient task schedule system, but almost not usable in real time system as they have performed very low in case of deadline miss ratio. We have analyzed those algorithms and unlike other DVFS algorithms, we have developed an algorithm named Frequency Falling EDF (FF-EDF) which can provide a greater power efficiency with it's dynamic frequency and also can perform very well in case of future task execution without a great dealing of deadline miss ratio. Here we have presented FF-EDF with it's pseudo code, mathematical model and working principle with it's comparison to Base EDF and Static EDF in case of power consumption and deadline miss ratio. It has been shown here that Frequency Falling EDF can deliver on average 2X power consumption in case of Base EDF without missing relatively as much deadline as other DVFS algorithm miss.

DVFS is a technique that is used in operating system level for optimizing power consumption. When CPU is active its power consumption is calculated by Pactive = C * F3 [2], where C is a constant, F is the speed or frequency of the processor and Pactive is processor active power consumption. Therefore, energy saving highly depends on the number of frequency of the processor while running a task. RT-DVFS scheduling algorithm takes two important decisions. Firstly, which task we should run and secondly which frequency it should run. Static slack and dynamic slack is available for this algorithm. Static slack depends on the characters of task set and dynamic slack is available for variation of execution time. Based on the amount of tasks and their execution time with the actual period Frequency Falling EDF start from a higher frequency and start to lower down the frequency over time to the end of the period. In case of future tasks, it again increases it is frequency to execute the new task within the period. In this paper we have shown up the mathematical model of FF-EDF, how it works and from which frequency it will start and to which frequency it will go. Simulation is also done by a C++ program to compare this developed algorithm with Base EDF and static EDF.

A Significant amount of research has been done in the field of RT-DVFS. Pillni and Shin devised five RT-DVFS algorithms and found that EDF based schedulers outperform the RMA based one [8]. RT-DVFS algorithms are designed for real-time systems and aim at saving energy while maintaining hard real-time constraints.

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They scale the CPU frequency based on the worst-case execution times of the real-time application. Most of the RT-DVFS algorithms differ in their techniques to utilize the static slack available due to the low CPU utilization of the application or dynamic slack available due to the actual execution time being much lesser than the worst case execution time of the real-time application. We have observed that the performance of a RT-DVFS algorithm is highly dependent on the energy efficiency of the idle states of the processor [2]. Energy constraints real time scheduling is discussed and developed by T. A. AlEnawy and H. Aydin [3]. Energy minimization is found by E. Bini, G. Buttazzo, and G. Lipari [4].

Performance comparison of dynamic voltage scaling algorithms for hard real-time systems [7]. Whole system power measured by P. Pillai and K. G. Shin [8].Energy efficient real time task scheduling by C.-M. Hung, J.-J. Chen, and T.-W. Kuo [6]. Voltage scaling for mobile multimedia by W. Yuan and K. Nahrstedt [13]. Optimal procrastinating voltage scheduling for hard real-time systems by Y. Zhang, Z. Lu, J. Lach, K. Skadron, and M. R. Stan [14].Energy efficient real time operating system by Gordon Parke [17]. Dynamic voltage scaling in embedded real time system by Rubathas Thirumathyam [19].

II. Algorithms

There are two types of slacks e.g. static slack and dynamic slack and RT-DVFS Algorithms use these two types of slacks. Three RT-DVFS schedulers are evaluated based on their performance in this section we will discuss about these three algorithms. Two important decisions have to make by RT-DVFS schedulers (i) which task to run and (ii) which frequency to run it at. Each other differ in a way, when they estimate slack to scale the frequency [7]. static slack, which is available due to the characteristic of the task-set itself, such as less than 100% CPU utilization, and dynamic slack, which is available due to variations in the execution time [7].

We will describe the algorithms with the help of an example task-set. Let us consider a three task periodic task-set with tasks T1, T2 and T3 whose characteristics are described by the Table 1.

Table 2.1: Sample Task set with their properties

Task	WCET	Actual Time	Period
T_1	2	1.6	5
T_2	1	0.8	5
T_2	3	2.4	15

The Base EDF scheduler does not involve any type of frequency scaling and run at maximum frequency [8]. The task scheduling is based on the earliest deadline and every task is run at maximum frequency. We have included this experiment for comparison.

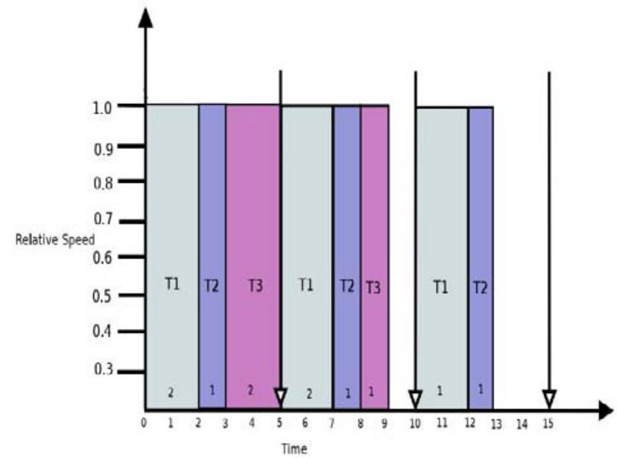

Fig.1: Base-EDF

Static-EDF scheduler uses static slack estimation technique for the CPU frequency to scale up [8]. Based on the utilization value that is static, the task set is used to scale the frequency. From the pseudo code of Base-EDF, we can see that, all the task is running at same frequency so that the utilization of processor is scaled frequency that is 1. This algorithm makes sure that no deadline will miss, although the utilization is equal to or less than 1. The main purpose of this algorithm is to minimize the idle time. Discrete frequency behavior is found in non-ideal processor. A frequency is equal to or less than k is selected for the selected task to run.

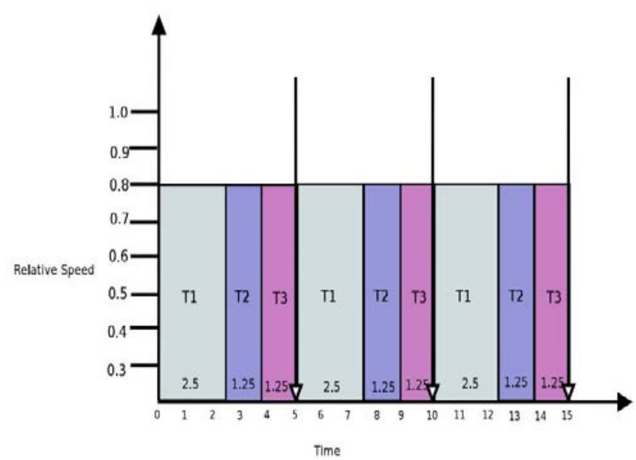

Fig.2: Static EDF

III. Roposed Frequency Falling Edf

In our optimized EDF, from the task set of table 1 if we run Static - EDF algorithm Utilization of task set will,

$$U = \frac{2}{5} + \frac{1}{5} + \frac{3}{15} = 0.8$$

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So U=0.8 as we know that our maximum frequency fm=1 all the task will run at (U*fm) = (1*0.8) =0.8 frequency. As we can see that, STATIC EDF did not consider actual time. In Frequency Falling EDF, initial frequency and ending frequency will follow this rule. Let the frequency we get form STATIC EDF is Fs, FF-EDF initial frequency is Fi and ending frequency is Fe.

Then if $F_s > 0.5 * f_m$

$F_i = f_m$, and $F_e = 2 * F_s - f_m$

In Static-EDF $F_s < 0.5\ f_m$

$F_i = 2 * F_s$ and $F_e = 0$.

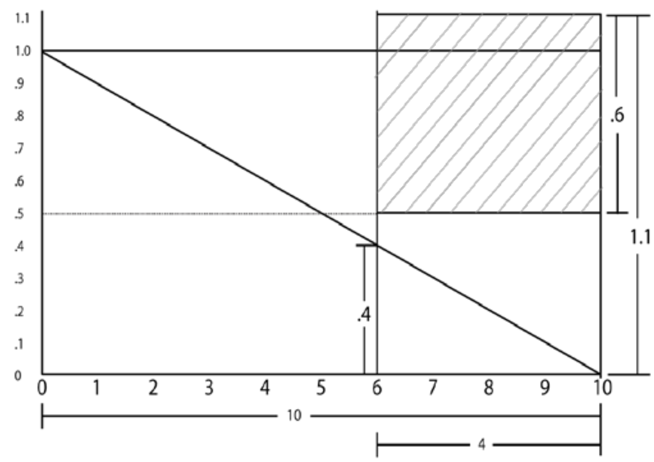

Fig.3: Proposed Frequency Falling EDF

So in that case our frequency will be: - Fi = 1 and Fe = 2 * 0.8 – 1 = 0.6 When a task start for any time frame the amount of portion of task set completed by Frequency Falling EDF is larger than Static-EDF, because FF-EDF try to finish task sooner as the frequency is higher in the first half of the total time frame of combined task set to complete. And in case of task set that occur in last half section of time frame will also execute sooner as the task before that section had executed before the time frame. Moreover, theoretically the last task will finish it execution at the same time as the Static- EDF but with a lower frequency.

From the Figure 3, new task come at 6s whose period is 4s and worst case execution time is 2.4s. In case of Static-EDF time remaining is = 10 – 6 =4s, task remaining for previous task set in Static-EDF is = 4*0.5 = 2.0s, as new task come total task remaining for Static-EDF is = 2.0s +2.4s =4.8s Now our Static –EDF should run at (4.4/4) = 1.1 frequency which is beyond the limit of our maximum frequency. So task set will fail to run in terms of Static –EDF in future task handling. For FF-EDF, Time remaining is =10-6=4s, task remaining for FF-EDF is = 0.5 * 4 * 0.4 = 0.8, as new task come total task remaining for FF-EDF is =0.8 + 2.4 = 3.2s.

As Fs> 0.5
Staring Fi = fm = 1
Ending Fe = (2 * 0.8) – 1 =0.6

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Table 2.2: Sample Task set with their properties

<table>
<tr><th colspan="3">Task set</th><th>Starting frequency of FF-EDF</th><th>Ending frequency of FF-EDF</th></tr>
<tr><td rowspan="7">Task set 1</td><td colspan="2">Number of task</td><td rowspan="7">1</td><td rowspan="7">0.6</td></tr>
<tr><td colspan="2">3</td></tr>
<tr><td>Period</td><td>Execution time</td></tr>
<tr><td>5</td><td>2</td></tr>
<tr><td>5</td><td>1</td></tr>
<tr><td>15</td><td>3</td></tr>
<tr><td></td><td></td></tr>
<tr><td rowspan="7">Task set 2</td><td colspan="2">Number of task</td><td rowspan="7">1</td><td rowspan="7">0.54</td></tr>
<tr><td colspan="2">3</td></tr>
<tr><td>Period</td><td>Execution time</td></tr>
<tr><td>7</td><td>3</td></tr>
<tr><td>5</td><td>1</td></tr>
<tr><td>14</td><td>2</td></tr>
<tr><td></td><td></td></tr>
<tr><td rowspan="7">Task set 3</td><td colspan="2">Number of task</td><td rowspan="7">1</td><td rowspan="7">0.82</td></tr>
<tr><td colspan="2">3</td></tr>
<tr><td>Period</td><td>Execution time</td></tr>
<tr><td>8</td><td>3</td></tr>
<tr><td>5</td><td>2</td></tr>
<tr><td>15</td><td>2</td></tr>
<tr><td></td><td></td></tr>
<tr><td rowspan="7">Task set 4</td><td colspan="2">Number of task</td><td rowspan="7">1</td><td rowspan="7">0.8</td></tr>
<tr><td colspan="2">3</td></tr>
<tr><td>Period</td><td>Execution time</td></tr>
<tr><td>10</td><td>3</td></tr>
<tr><td>5</td><td>2</td></tr>
<tr><td>15</td><td>3</td></tr>
<tr><td></td><td></td></tr>
</table>

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From the Figure 3, new task come at 6s whose period is 4s and worst case execution time is 2.4s. Now in case of Static-EDF time remaining is = 10 – 6 =4s, task remaining for previous task set in Static-EDF is = 4*0.5 = 2.0s, as new task come total task remaining for Static-EDF is =2.0s +2.4s =4.8s Now our Static –EDF should run at (4.4/4) = 1.1 frequency which is beyond the limit of our maximum frequency. So task set will fail to run in terms of Static –EDF in future task handling. For our algorithm, Time remaining is =10-6=4s, task remaining for our algorithm is = 0.5 * 4 * 0.4 = 0.8, as new task come total task remaining for our algorithm is =0.8 + 2.4 = 3.2s.
As Fs> 0.5
Staring Fi = fm = 1
Ending Fe = (2 * 0.8) – 1 =0.6.

IV. Energy Consumption In Two Approaches

Base-EDF always runs the task set with maximum frequency f = fm = 1 and considering texecution = execution time, we can calculate the power consumption of Base-EDF,

$$p = f^3 \times t_{execution}$$

$$p = 1^3 \times 5 = 5$$

Static-EDF run the task with utilization U = 5/10 = 0.5 So U=0.5 as we know that our maximum frequency Fm=1 all the task will run at (U *Fm) = (1*0.5) = 0.5 frequency. Now for Static-EDF power consumption

$$p = f_{static}^3 \times period$$

$$p = 0.5^3 \times 10$$

$$p = 1.25$$

In case of our developed FF-EDF, we can assume the initial frequency = fi, Ending frequency = fe, the total time to run the task = t.

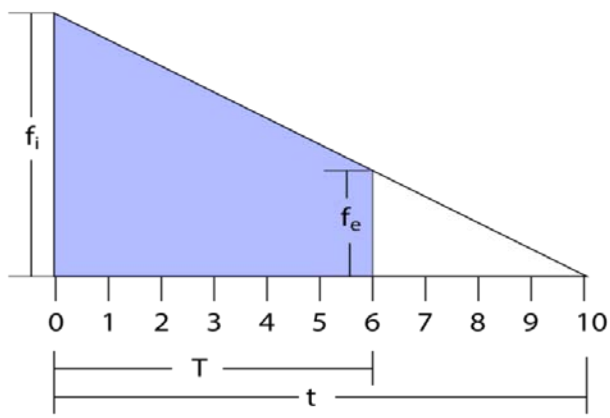

Fig. 4: Energy Consumption of Frequency Falling EDF.

As the frequency start from the initial frequency fi and end to the frequency fe, So, We can calculate the power consumption P as:-

$$p = \int_{f_i}^{f_e} t \times f^3$$

$$p = t \times \left[\frac{f^4}{4}\right]_{f_i}^{f_e}$$

$$P = \frac{t \times (f_i^4 - f_e^4)}{4}$$

Here t = total time. The time by which the frequency will fall from the maximum frequency to the minimum frequency.

If we consider the any interval of time T then T can be calculated by-

$$T = t \times (f_i - f_e)$$

$$or, t = \frac{T}{f_i - f_e}$$

So, Our final equation become:-

$$P = \frac{t \times (f_i^4 - f_e^4)}{4 \times (f_i - f_e)}$$

$$P = \frac{10 \times (1^4 - 0^4)}{4(1 - 0)}$$

$$P = 2.5$$

So, we see that at 10s period and with 5s execution time considering maximum frequency 1 unit the power usage of Base EDF, Static EDF and FF-EDF are consecutively 5, 1.25 and 2.5 unit. Therefore, FF-EDF consumes half power with compare to Base EDF and double power with compare to Static EDF. However, this will be not the case in most of the time. It actually depends on the density of task, which is the ration of execution time and period. Here is the data simulated from Static EDF, Base EDF and FF-EDF:-

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Table 2.3: Power usage calculation of proposed Frequency Falling EDF

Task Density	Base EDF	Static EDF	FF-EDF
0	0	0	0
1	1	0.01	0.02
2	2	0.08	0.16
3	3	0.27	0.54
4	4	0.64	1.28
5	5	1.25	2.5
6	6	2.16	3.12
7	7	3.43	4.06
8	8	5.12	5.44
9	9	7.29	7.38
10	10	10	10

So, we have presented this graph with different task density. Here in X-axis task density is presented that defer from 0 to 10 and in Y-axis the power consumption is presented.

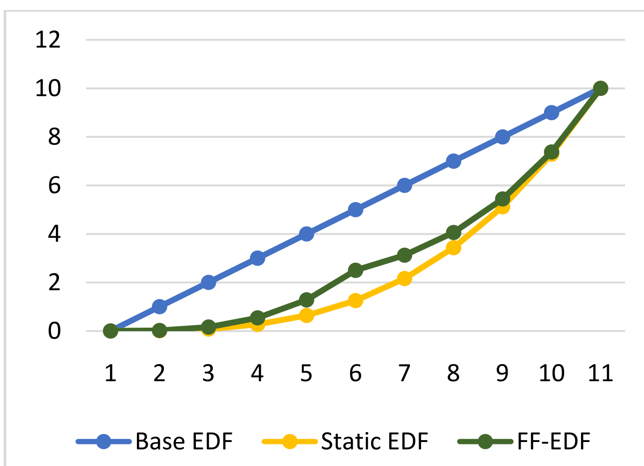

Fig. 5: Comparison of Power Usage of Base EDF, Static EDF and FF-EDF

As we can see that from the above chart that for very low value of time FF-EDF algorithm give less power than Base EDF and Static EDF. If time increases FF-EDF power consumption is better than Base EDF but not better than Static-EDF.

In case of deadline miss ratio, we have tested this entire algorithm by 1 million of task trial at 10 different task densities. Here task density can be defined as the static frequency that it may need to run to execute its entire task within the period.

Base EDF is best algorithm in case of executing the largest number of task without meeting deadline, because it executes its entire task at maximum frequency. It only falls its frequency when there is no task remaining at CPU.

Static algorithm is the best algorithm in case of power saving. However, in case of deadline miss ratio it has the worst performance. Because it runs the entire task at the same frequency. Therefore, when a new task

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comes may not be the time to run the new task at its worst-case execution time.

FF-EDF works as a great tradeoff between these two algorithms. Because this developed algorithm starts the task at a higher frequency and start to fall down by a slope to a lower frequency. By this, it adjusts the power and deadline miss. Here we can see that at the start of the time it has higher execution rate (very similar to Base EDF) with a very low deadline miss ratio and over time, it starts to decrease the execution rate.

Table 2.4: Execution rate of Base EDF, Static EDF & FF-EDF

Task Density	Base EDF	Static EDF	FF-EDF
0	1000000	853253	853253
0.1	995627	747090	985787
0.2	986541	678417	945665
0.3	952076	596407	906522
0.4	926187	497096	852308
0.5	853253	497090	795678
0.6	804899	375987	681505
0.7	678417	221407	564977
0.8	596407	221408	404927
0.9	375988	8	279589

We have compared the Base EDF, Static EDF and FF-EDF by simulation by a C++ program. This program is run at a different frequency. We have assumed that the max frequency is 1 GHz for simplicity. In addition, the simulation is done by taking 10different frequency distributions from 0.0 to 0.9 by a difference of 0.1. The test is done to check how many deadlines usually missed by Base EDF, Static EDF and FF-EDF when new tasks come. The new task can come at any time, at any period and worst-case execution time. For this reason, we have selected starting time, Period and Worst-case execution time randomly. By the simulation, we have taken 1000 trials in each frequency distribution and checked if those algorithms miss the deadline or not.

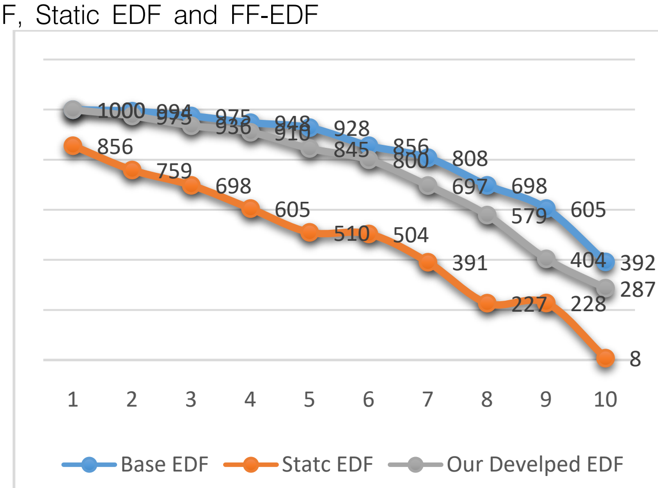

Fig.6: Successful Execution count of Base, Static and Frequency Falling EDF.

We can see that FF-EDF works as a tradeoff between the base EDF and the static EDF in a efficient way. This algorithm is modeled with its pseudo code, and mathematically described how it works with its task set. Also, it has been shown how future task can be handled via changing the instant frequency and the slope of the frequency. The result we got from the simulation and the algorithm process we can decide that in case of RT it will be far useful.

FF-EDF has better power optimization (on average 2X) with compare to base EDF without compromising the deadline miss ratio as much as Static EDF. The Power optimization we got by developed EDF for this deadline miss ration with compared to the Base EDF and Static EDF is relatively high. In the graph, it has been shown that the deadline miss ratio is closer to Base EDF at the start of time. Frequency Falling EDF has designed in such a way that, it can take much load when a future task comes because it has much less task

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than the previous. Therefore, if a large amount of task come after just a small amount of time, it almost works as same as Base EDF.

When a process arrives, it is better to run a task as soon as it arrives as higher frequency as possible because in that case, it is possible to run the entire remaining task at a higher frequency if needed to do that without missing any deadline. In addition, Frequency Falling EDF works as a trade-off between power optimization and deadline miss ratio of EDF. The Base EDF is very power consuming algorithm but has the lowest deadline miss ratio. And The Static EDF has the most efficient in case of power consumption but it almost not efficient because of its deadline miss ratio. For this reason, Static EDF is almost not usable in real time scheduling. So, considering this FF-EDF can be used effectively in any real time system scheduler.

There is a limitation of FF-EDF that in this paper we have modeled and simulated the algorithm via worst case execution time. But it can be better performed via actual time. This developed EDF will automatically adjust the frequency for its actual execution time. So, the actual execution time is avoided for simplicity and to keep the simulation accurate.

V. Conclusion

FF-EDF is working with worst-case execution time. FF-EDF frequency grows in a linear way for the worst-case execution time. If FF-EDF can work with actual time CPU frequency will drop.

We have simulated FF-EDF, but in case of real system, our result may vary for both power consumption and deadline miss ratio. FF-EDF work based on worst-case execution time of a task and did not consider actual time. If we consider actual time, FF-EDF will give a better result for both power consumption and deadline miss ratio. Base-EDF and Static-EDF keep the linear frequency, but in case of FF-EDF, the frequency will fall within a range.

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A Planar Microstrip Antenna with Enhanced Triple-Bands Notched Characteristics for UWB Applications

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Abstract- A compact printed ultra-wideband (UWB) monopole antenna with triple band-notched characteristics is presented. The antenna consists of a square patch and a modified grounded plane. In order to realize Triple band notched bands characteristics, a T-shaped Stripinsert in the square slot of the radiation patch and a pairs of U-shaped parasitic strips beside the feed line is used. To remit the potential interference with coexisting wireless systems operating over 3.3–3.6 GHz, 5.15– 5.35 GHz, or 10.12-10.3 GHz bands, the overall dimensions of the proposed antenna are 31mm×26 mm ×1.6mm.The measured and simulated results are introduced and show that the proposed compact antenna has a stable and omni directional radiation patterns across all the relevant bands.

Keywords: microstrip antenna, band notched uwbantenna, monopole antenna.

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A Planar Microstrip Antenna with Enhanced Triple-Bands Notched Characteristics for UWB Applications

Swapnali G. Pathak [α] & Veeresh G. Kasabegoudar [σ]

Abstract- A compact printed ultra-wideband (UWB) monopole antenna with triple band-notched characteristics is presented. The antenna consists of a square patch and a modified grounded plane. In order to realize Triple band notched bands characteristics, a T-shaped Stripinsert in the square slot of the radiation patch and a pairs of U-shaped parasitic strips beside the feed line is used. To remit the potential interference with coexisting wireless systems operating over 3.3–3.6 GHz, 5.15–5.35 GHz, or 10.12-10.3 GHz bands, the overall dimensions of the proposed antenna are 31mm×26 mm ×1.6mm.The measured and simulated results are introduced and show that the proposed compact antenna has a stable and omni directional radiation patterns across all the relevant bands.

Keywords: microstrip antenna, band notched uwbantenna, monopole antenna.

I. Inroduction

With the definition and acceptance of the ultra-wide-band (UWB) impulse radio technology in the USA [1], there has been considerable research effort put into UWB radio technology worldwide. However, the non-digital part of a UWB system, i.e., transmitting/receiving antennas, remains a particularly challenging topic. In 2002 [1]UWB communication systems have attracted considerable attention due to the advantages of high-speed data rate and extremely low spectral power density, since the Federal Communications Commission (FCC) first approved the frequency band from 3.1 to 10.6 GHz for commercial UWB applications. Since then, the Probable design and implementation of UWB system has become a highly competitive topic in both industry and academy communities of telecommunications. In particular, the antenna ofultra-wide bandwidth is the key component of the UWB system and has attracted significant research power in the past few years [2]. In [3], The FCC approved the frequency range for causing the interference to the existing wireless communication systems ,such as the IEEE 802.16 Wi MAX system at 3.5 GHz (3.3-3.7 GHz) and the IEEE 802.11a wireless local area network (WLAN) system at 5.2/5.8 GHz (5.15-5.825 GHz) and dedicated short-range communication (DSRC) for IEEE 802.11p.

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In the literature, various techniques have been applied in the UWB antenna to achieve the single band-notched function. The widely used methods are etching slots on the patch or on the ground plane, i.e., such as Challenges of the feasible UWB antenna design include the wide impedance matching, radiation stability, low profile, compact size, and low cost for consumer electronics applications. For some UWB applications which does not require overall compact size of the transmitter or receiver, appropriately designed band pass filters or spatial filter such as a frequency selective surface (FSS) above the antenna can be used to suppress the dispensable bands [4].However for the UWB systems which demand a compact, less complex and low cost design, frequency band rejection function may be employed in the antenna itself, which includes embedding optimal shaped slot in the radiating patch or in the ground plane. The main problem of the frequency rejected function design is the difficulty of controlling width of the band-notch in a limited space. Furthermore, strong couplings between two band-notched characteristic designs for adjacent frequencies are obstacles to achieving efficient dual band-notched UWB antenna. [5] Many techniques have already been proposed to design band-notched antennas, for example, `L' shaped slot and a twisted `J' shaped slot , Square Aperture Strip , by etching two round shape slots, U-shaped slot, and by adding Strip like parasitic strip, U shaped antenna,[5-12]And most of the techniques is like the adding Strip and elements and integrate with the feed line of the antenna like Capacitive Loaded Line Resonators (CLLRs), SCRLH resonator structure, band rejected elements, self-complementary structure.[13-21]. And Most of the MIMO antenna technique also evolved for this Notch performance [22] adding two capaciti veloaded loops (CLLs) close to the micro-strip feed line, [23] T-shaped Strip-loaded ring-resonator (SLRR) [24] embedding a Strip that is located to the hollow center of feed [25] ground plane and a T-shaped exciting Strip [26, 27] monopole antenna with notches at four frequencies is presented. Notch characteristic satdesired frequencie sare obtaine dusing smaller ctangular metallic strips. [28]A T-shaped Strip embedded in the square slot of the radiation patch and a pair of U-shaped parasitic strips beside the feed line is used [29].

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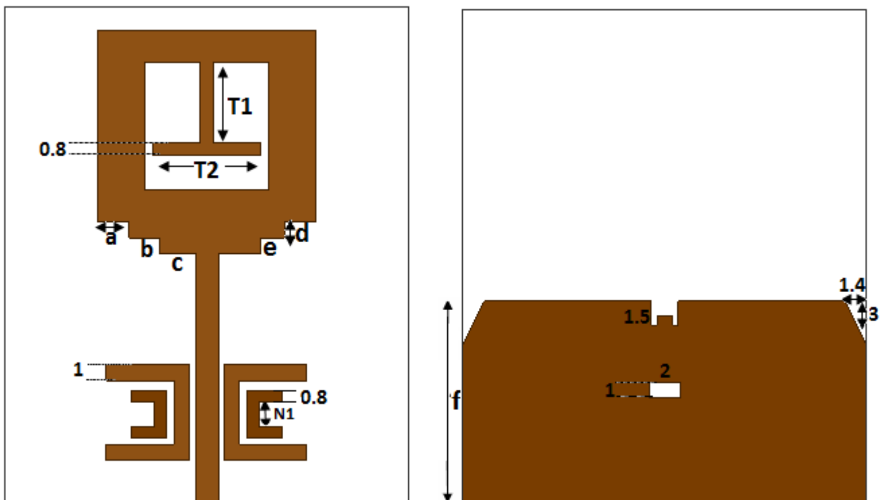
In this paper, a compact, micro strip fed, monopole UWB antenna with triple band notched characteristics is presented. This work adds perturbation in the surface current density of the radiating element and the feed element. Initially a reference antenna is designed, which exhibits radiating characteristics in the frequency band 3-11 GHz. The proposed antenna structure is simulated using the An soft High Frequency Structure Simulator (HFSS), A T-shaped Strip in the radiation patch and four U-shaped Strips beside the feeding line are used to realize triple-band-notch characteristic. The parametrical analyses of these filtering structures are carried out The simulation and measurement both indicate triple bands rejection with central frequencies of 3.6 and 5.5 GHz,10.2GHz respectively, and excellent notched band characteristics.

II. Configuration of Proposed Tipple Band Nothced Antenna



(a) Top view (b) Ground

Fig. 1: Geometry of proposed triple band notched UWB antenna.

In this design, the micro strip line fed triple band notch planar antenna consists of rectangular radiating patch and a partial rectangular ground plane is proposed shown in Figure 1. The patch with a dimension of m x n *is* printed on the top side PCB substrate while the partial ground plane having a side length fis printed on the bottom side. The proposed antenna has a compact size of *31x26*and is printed on 1.6mm thick Fr4 dielectric substrate with dielectric constant 4.4 and loss tangent 0.02. It is composed of a 50Ω micro strip feed line, a planar radiating patch with two round shape Strip and rectangular ground plane with a pair of C-shaped Strip to band stop function.

A. Uwb Monopole Antenna

The evolution process for the compact UWB antenna.UWB monopole antenna the designed antenna of optimized dimensions is implemented with a low-cost on Fr4substrate shown in fig 2. To improve the bandwidth of the antenna, the partial ground plane is modified by cutting triangular shape slots at its top edge. The width of the micro strip feed line is chosen as 1.4 mm to achieve the characteristic cimpe dance of 50. The dimensions of the designed antenna after optimization are as follows: a= 2mm, b=2mm, s=15.5, f=11.5mm, m=12mm, n=14mm, g=1mm, K1=8mm, K2=3mm.

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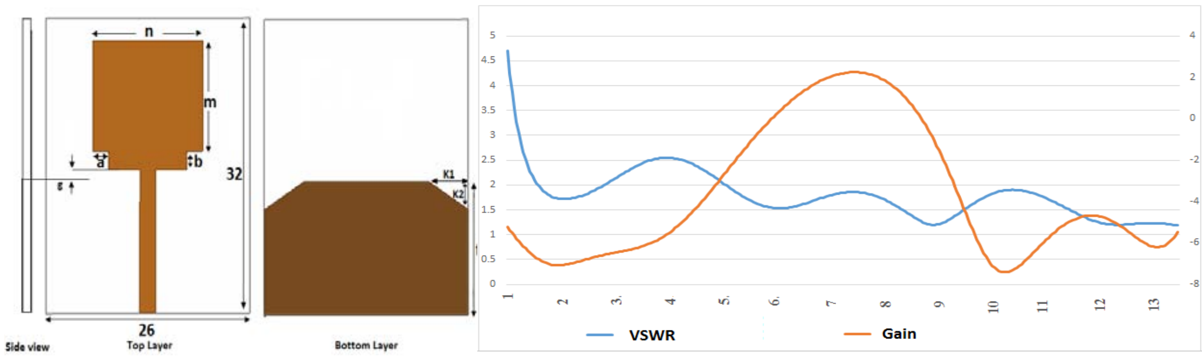
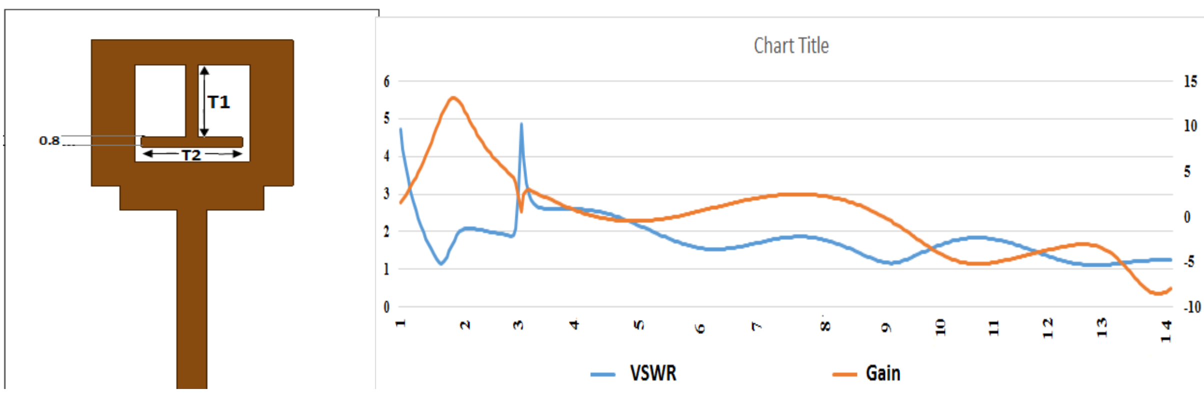


(a) (b)

Fig. 2: Configuration Parameters of The UWB antenna (a) Monopole Antenna (b)Comparison of VSWR and Gain of the Monopole Antenna.

B. Single Band Notched Uwb Antenna



(a) (b)

Fig. 3: (a) Geometry of the Single Band Notched UWB Antenna (b) Simulated VSWR of Single Band Notch UWB Antenna and Gain vs frequency

To reduce the interferences from the Wi MAX systems, the band-notched function is desirable in the UWB system. By inserting a T-shaped $\lambda/4$ open Strip in the micro strip feed line. The notch frequency given the dimensions of the Wi MAX band-notched feature can be postulated as formula [22]

The length of the U-shaped slot can be calculated by,

$$li = \frac{c}{4f_i\sqrt{\frac{\varepsilon_r+1}{2}}}$$

Where c and ε_{eff} are the speed of light in free space and the approximated effective dielectric constant, respectively.

C. Dual Band Notched Uwb Antenna

Then for wideband isolation there is a fork shaped a Strip introduced into the ground plane of the antenna, due to that mutual coupling get reduced.Fig.1. shows the proposed triple band notched UWB antenna. For more specifications of antenna dimensions of a Strip and the more branches get added and enhance the isolation but there is effect on impedance bandwidth. Fig. 4 shows the decreasing in mutual coupling of the antenna due to Strip structure. So the fork Strip here not only performs the role of an isolator, but also acts as a compensating radiator for the UWB antenna [6]. In wireless communication application occurs in UWB such as WLAN IEEE802.11a and HIPERLAN/2 WLAN operate at 5.15-5.35 GHz and 5.725-5.825GHz respectively. In order to reduce the electromagnetic interference, the stop band filter 5-6 GHz is often required for UWB system. However, the UWB systems with extra filter circuits are more complex and expensive.

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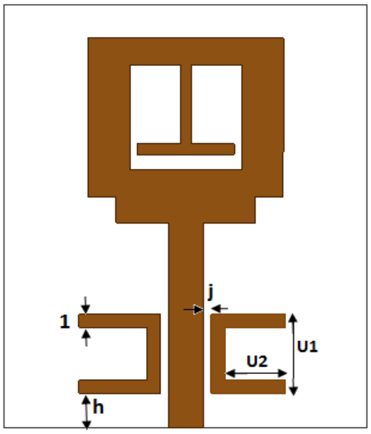
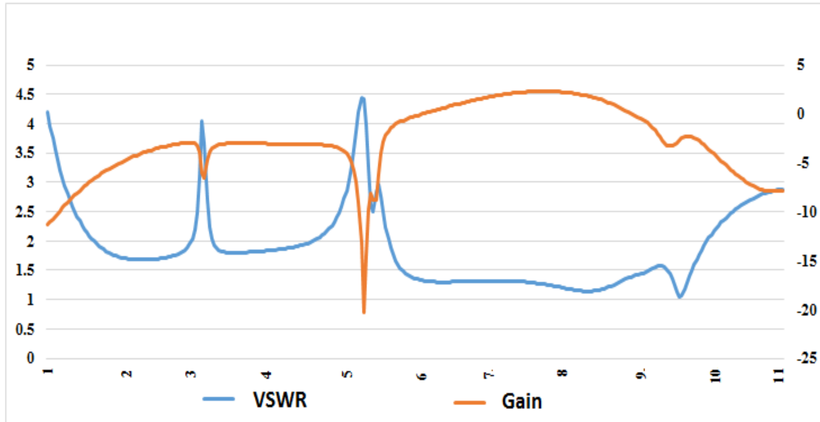


(a)



(b)

Fig 4: (a) Geometry of the Dual Band Notched UWB Antenna (b) Simulated VSWR of Single Band Notch UWB Antenna and Gain Vs frequency

D. Triple Band Notched Band Antenna

For the triple band notch, the insertion of C-shaped resonating element along the symmetrically to feed line of the antenna with respect to the Dual band notch Element. The triple notch create at the 10.12-10.3GHz among the VSWR of the antenna. To minimize the potential interferences between UWB system and WiMAX system, the antenna with dual notched bands becomes necessary. Here a λ/4 C-shaped slits is integrate on antenna to achieve a triple band-notch antenna which is shown in fig 5. By adjusting the ground plane and the c-shaped Strip in the UWB antenna the triple band notched is investigated. These results can readily account for the triple band- notched characteristics.

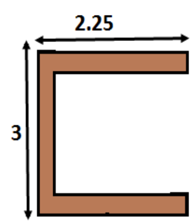


Fig. 5: C-Shaped Strip

To achieve triple band notch characteristics, three resonant elements are placed above the ground plane to generate three notches separately in the Wi MAX, the lower WLAN and the (ITU) 10.2GHzbands shown in fig 6.To create a band notch among the antenna for WLAN and WIMAX the T-shaped for WLAN and two C-shaped Resonating element add in the UWB antenna for the WLAN (3.5GHz) Wi MAX (5.5GHz) and ITU (10.2 GHZ) respectively. The band notch characteristics of the proposed antenna can be controlled by properly adjusting the parameters of these resonant elements placed at the Side of the feed as shown in Fig. 1.

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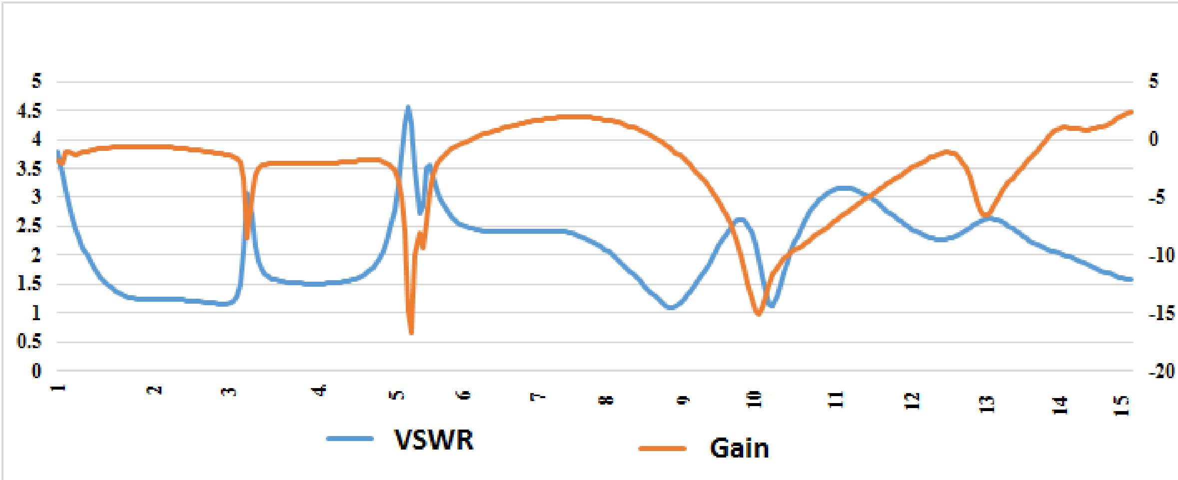
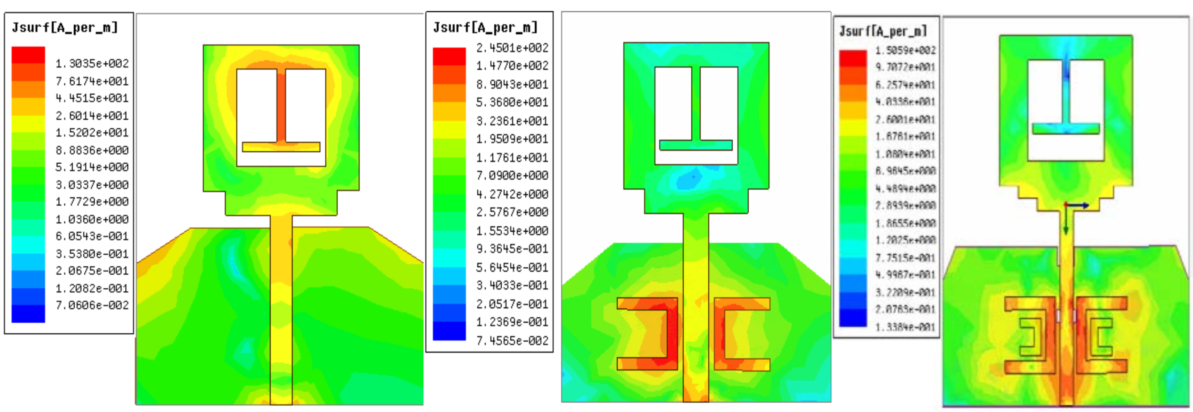


Fig. 6: Simulated VSWR of Single Band Notch UWB Antenna and Gain Vs frequency

As can be seen, the current distributions are mainly concentrated in the signal line and near the gap between the radiator and the ground plane. These sensitive locations therefore have been selected for the band-notched elements in this presented work.The mechanism of frequency rejection could be illustrated and discussed using current distributions along the radiating element. Fig.7 is the cases of wave radiation at frequencies of 3.2 GHz and 5.25 GHz and 10.2 GHz, respectively. It is seen that the current concentrates along curved edges and two sides of patch.



(a) (b) (c)

Fig. 7: Simulated Current Distribution at (a) At 3.2GHz (b) At 5.25GHz(c) At10.2GHz

As a result, the antenna can achieve radiate wave at those frequencies. Fig. 7(b) is the case of rejected frequency at 5.25 GHz. It can be observed that the current only concentrates around c-shaped slit and strongly concentrates at the small gap on the top c-shaped slit. There is no current distribution at the other parts of patch. This operational antenna can be considered as transmission line as the mode published and postulated in [7, 9].

III. Parametric Analysis

a) The Effect of T1 and T2.

A parametric study of the triple band-notched UWB antenna has been conducted by computer simulation to explore how the dimensions of the different resonant elements affect the performances of band notches. Therefore, we need to investigate the individual resonant effects based on length, width, and position. Basically, the length and width of the each resonator acts as the inductance, and the distance between the adjacent arms acts as the capacitance. The couplings between the resonators and the main radiator act as the filter to create a notch band at certain frequency as explained in detail in [18, 19]. Several aspects were considered to optimize the final design like the overall impedance bandwidth of the antenna, the bandwidth of the notched bands, and the level of band rejection at notched frequency. The Impedance bandwidth of the antenna shown in fig 8.

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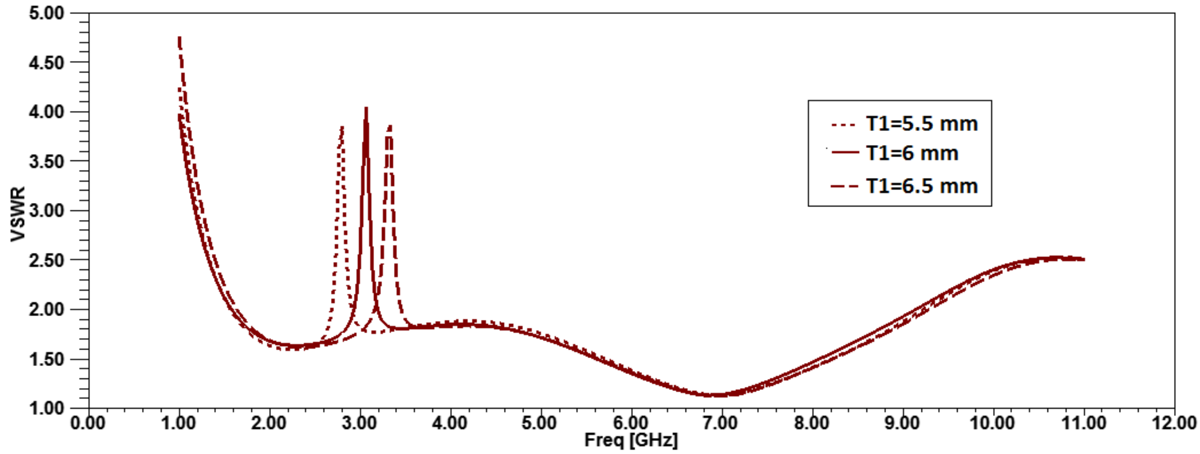
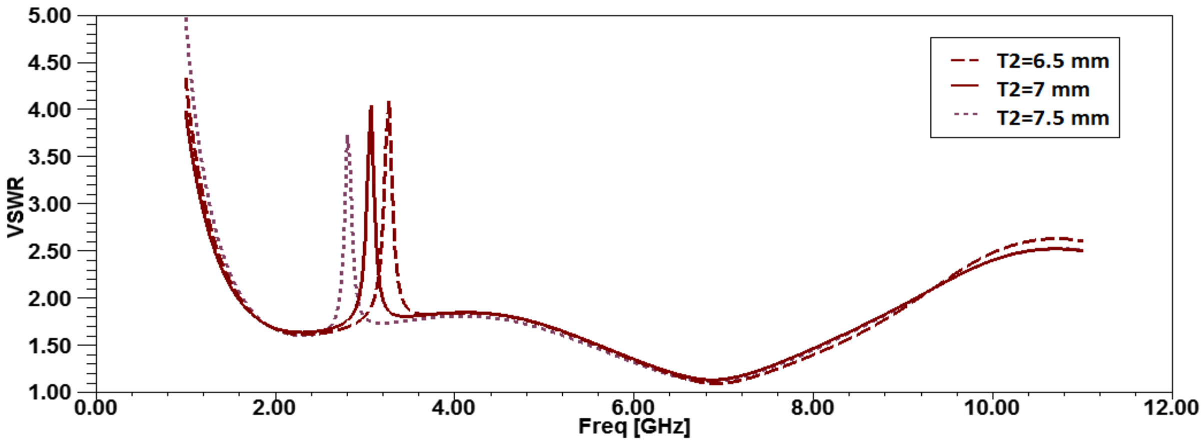


(a)



(b)

Fig. 8: Simulated band-rejection characteristics of the proposed antenna with dual notched bands in case of different (a) T1 and (b) T2

The impedance bandwidth of the antenna shown in above fig.8, which is varies with the dimension of T-shaped strip as the length increases the notch band is increases.

b) The Effect of U1 and U2

A Parametric study is accomplished based on realizing UWB characteristics. To enhance impedance bandwidth and create a band stop function, a Strip is connected to the U-shaped feed line that is located between inserted UWB Antenna. While by adjusting he dimension of U1 and U2 result in the Variation of VSWR of the UWB antenna which shown in fig 8. As we increase the U1 and U2 change in VSWR occurs as in higher frequency. The VSWR shift towards the higher frequency which shown in fig 9 (a) and (b).Obviously, the undesired frequency rejection band of 5.1 to 5.9 GHz is achieved by embedding C-shaped slit into the patch while the other frequencies in UWB are little affected. As this work provides a new design of UWB with triple band rejections.

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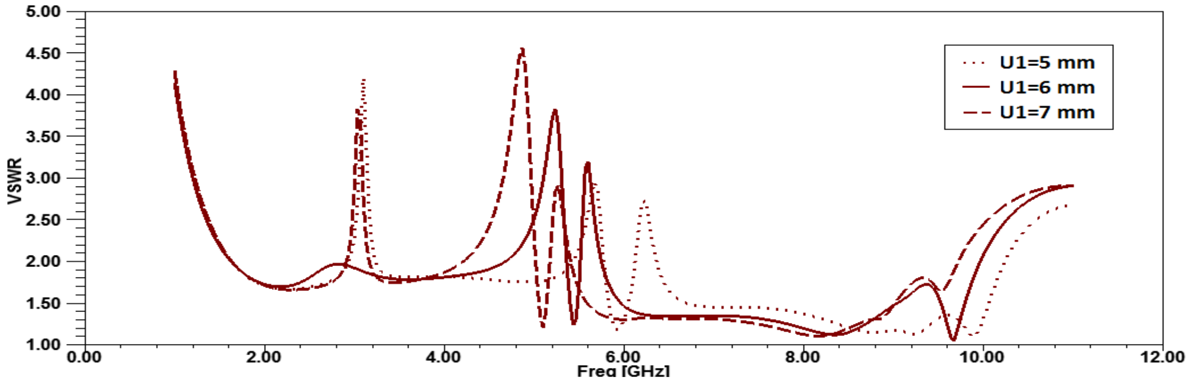
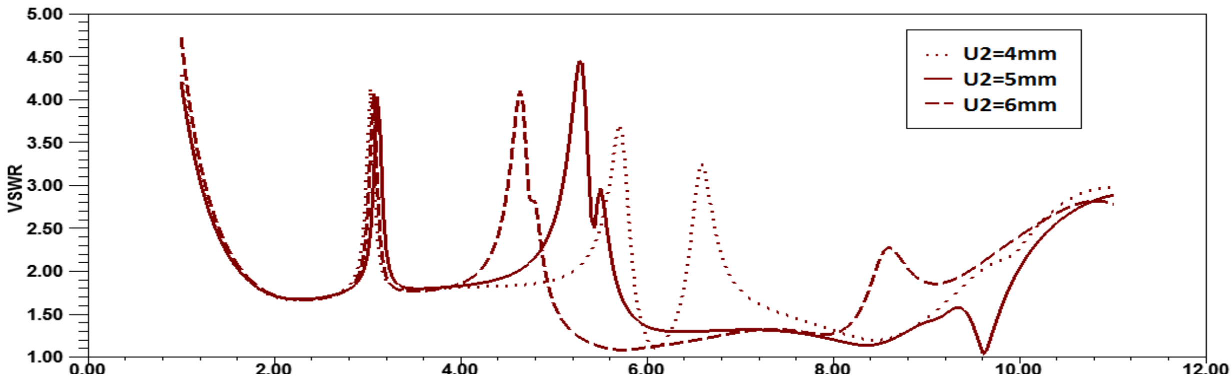


(a)



(b)

Fig. 9: Simulated band-rejection characteristics of the proposed antenna with dual notched bands in case of different (a) U1 and (b) U2

c) The Effect Of N1

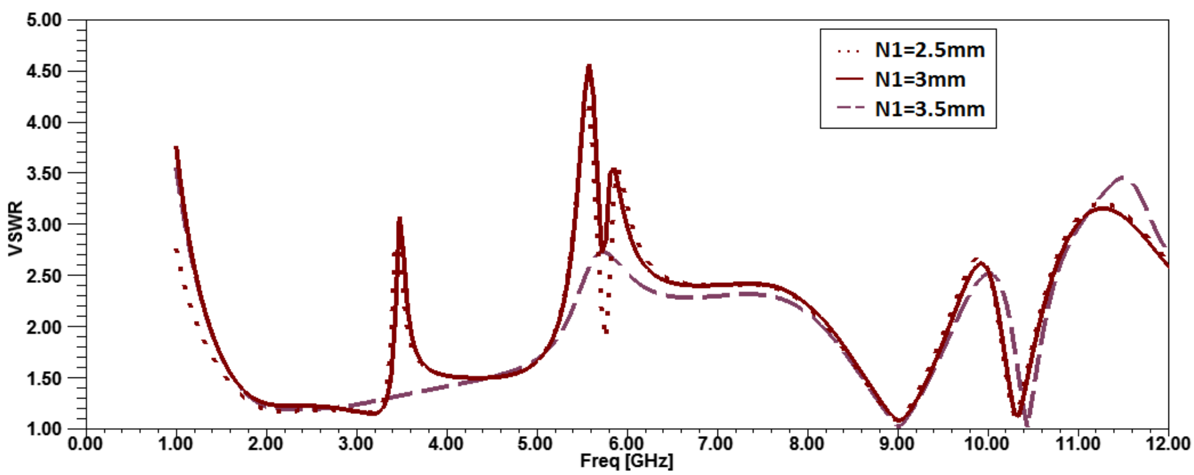


Fig. 10: Simulated band-rejection characteristics of the proposed antenna with dual notched bands in case of different N1

Finally by inserting slot in the ground plane of the UWB antenna and the by adding the C-shaped Strip add in the UWB antenna results in the notch at the higher Band at 10.1-10.3GHz.While we increase the dimensions of N1 the change in impedance bandwidth of the antenna which shown in fig 10. Sizes of these parameters have a serious impact on the position and bandwidth of this notch band. The optimize value of the N1 is taken as 3mm for the better notch at 10.2 GHz which having the third band notch in this design.

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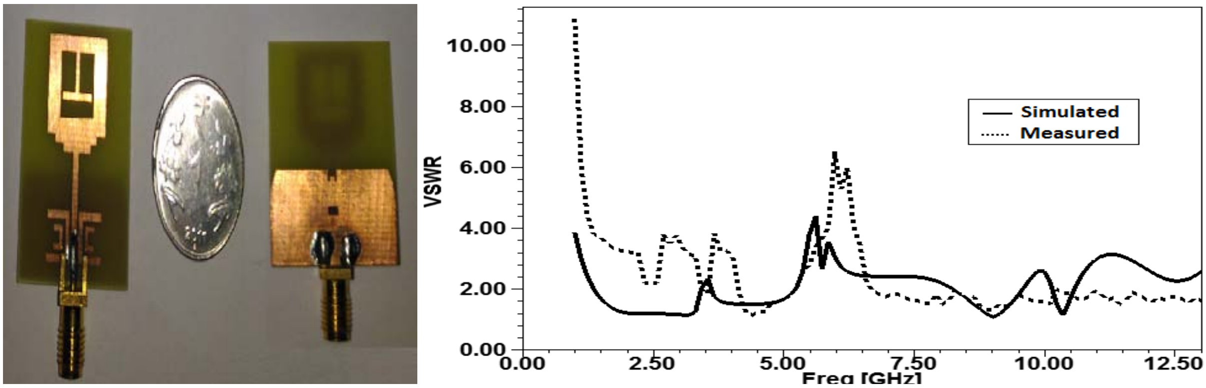
IV. Results and Discussions

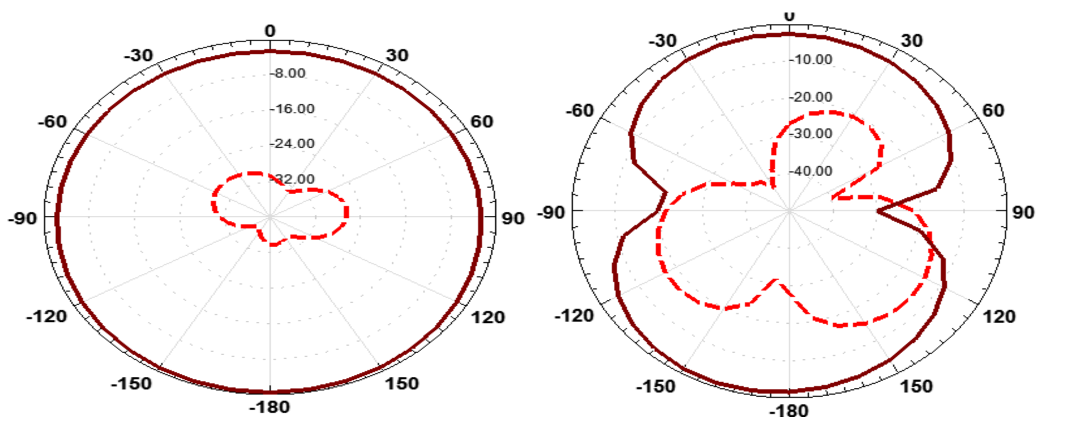


(a) (b)

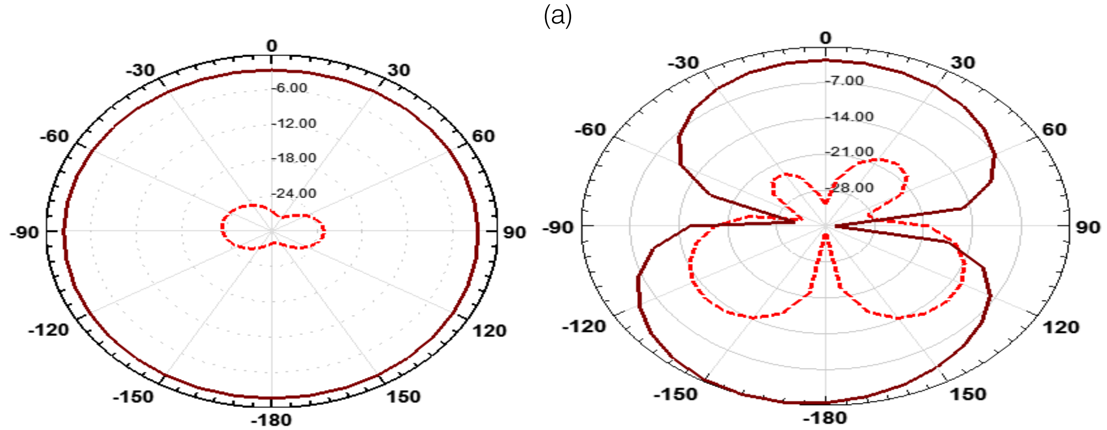
Fig.11: (a) Prototype of Antenna (b) Simulated and Measured Results

The designed antenna has an impedance bandwidth of 3-13 GHz covering commercial UWB band (3.1–12.6 GHz) and rejects the frequency band of 3.3-3.6 GHz, 5.15-5.35 GHz, and 10.1-10.25GHz to eliminate electromagnetic interference (EMI) problems in the UWB communication.The measured and simulated VSWR of the proposed triple band notch antenna is shown in Fig. 11.The comparison between the simulated results using commercial high frequency structure simulator (HFSS) and the results from the measurement of the fabricated antenna using a ROHDE N SCHWARZ ZVL Vector Network Analysers.Fig.11 shows the simulated and measured VSWR for the proposed antenna as well as the baseline antenna. By introducing T-shaped and C-shaped elements, tri-band-notched properties are obtained.

V. Radiation Mechanism



(a)



(b)

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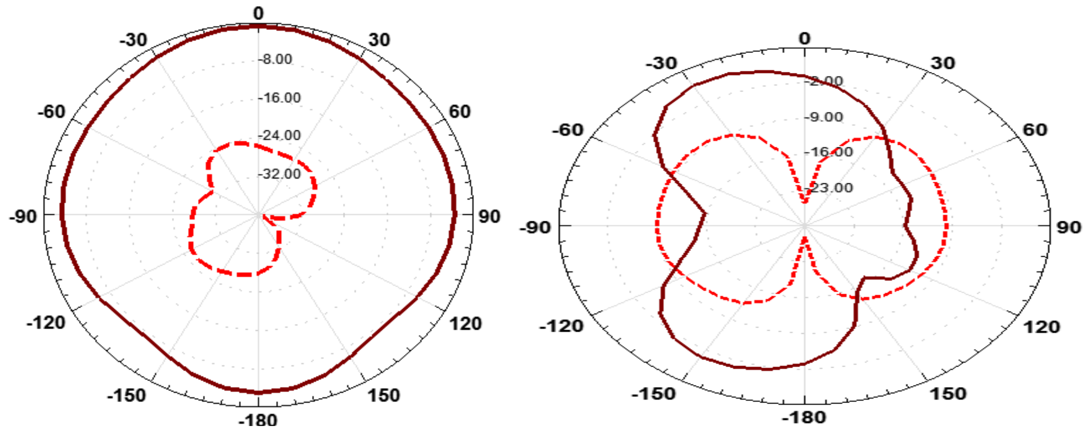

(c)

--------- Cross Polarization Co Polarization

Fig. 12: Simulated far-field radiation patterns; *(left)* H (x-z)-plane and *(right)* E (y-z)-plane at (a) 3.24 (b) 4.22, and (c) 9.12 GHz

The Simulated radiation patterns of antenna 3 at frequencies 3.24 GHz, 4.22 GHz and 9.12 GHz are illustrated in Figure 12. The radiation pattern is bidirectional in *E*-plane (*yoz* -plane) and omni directional in *H*-plane (*xoz* -plane) at 3.24 GHz and 4.12 GHz. It can be regarded as a monopole which features a doughnut-shaped pattern at the fundamental mode. As the frequency increases, the radiation pattern in *H*-plane (*xoz* -plane) is quasi-omni directional, and the cross-polarization component becomes larger at 4.22 GHz. At 9.12 GHz, as the higher-order modes exist, the pattern in the *H*-plane (*xoz* -plane) is similar to the shape of a four-leaved clover, and the cross-polarization component is large. Figure 8 gives the measured peak gains and the radiation efficiency of the antenna from 3.24 GHz-13 GHz. It can be seen that sharp gain drops of the antenna with notch bands occur both in 3.4-3.7 GHz and 5.15-5.825 GHz and 10.1-10.3GHz bands. As discussed in the last section, with the increase of frequency, the efficiency of the antenna is deceased for the dielectric loss and conductor loss. In addition, it can be observed that the measurement decreases sharply in the notched band.

VI. Conclusion

In this Paper the triple band notched at Wi MAX (3.23-3.85GHz), WLAN (5.15-5.85GHz) and ITU at (10.1-10.3GHz) UWB antenna has been successfully implemented and discussed. A VSWR <2 impedance band of 2.8–13 GHz has been obtained.The triple band notched characteristics are obtained by inserting T-shaped Strip and Two C-shaped Strip adding symmetrically along the Feed line of the UWB antenna.The length of each slot has been taken about Quarter of guided wavelength. The antenna is fabricated, and the measured results show good agreement with the simulated ones. The simulated results State that the antenna has a stable far field radiation pattern in *H*- and *E*-planes all over the UWB. Steady gain has been detected, apart from the notched frequency. The proposed antenna is appropriate for practical UWB applications.

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Six Phase Optimal Sequence Design for MIMO Radar

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Abstract- Radar applications desire a set of sequences with discretely peaky autocorrelation and pair_wise cross correlation. Invade such sequences is a combinal problem. If the autocorrelation and cross correlation are convenient in the a periodic sense then there are hardly any theoretical aids available thus the problem of signal design referred to above is a defying problem for which many global optimization algorithms like ant colony optimization ,artificial bee colony (ABC) algorithm and particle swarm optimization algorithm were reported in the literature. The paper intent at gadget of an efficient optimization algorithm is design to find an optimal pulse compression code useful for radar applications. The proposed optimization algorithm particle swarm optimization algorithm for identifying the optimal pulse compression codes and it is a real-time signal processing solution which identifies optimal sequences.

Keywords: ant colony optimization, artificial bee colony algorithm (ABC), mimo, decentralized radar networks (DRNs, particle swarm optimization (PSO).

GJRE-F Classification: *FOR Code: 090609*

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Six Phase Optimal Sequence Design for MIMO Radar

Pandu. J[α], Dr. C.D.Naidu[σ] & Dr. N.Balaji[ρ]

Abstract- Radar applications desire a set of sequences with discretely peaky autocorrelation and pair_wise cross correlation. Invade such sequences is a combinal problem. If the autocorrelation and cross correlation are convenient in the a periodic sense then there are hardly any theoretical aids available thus the problem of signal design referred to above is a defying problem for which many global optimization algorithms like ant colony optimization ,artificial bee colony (ABC) algorithm and particle swarm optimization algorithm were reported in the literature. The paper intent at gadget of an efficient optimization algorithm is design to find an optimal pulse compression code useful for radar applications .The proposed optimization algorithm particle swarm optimization algorithm for identifying the optimal pulse compression codes and it is a real-time signal processing solution which identifies optimal sequences.

Keywords: ant colony optimization, artificial bee colony algorithm (ABC), mimo, decentralized radar networks (DRNs, particle swarm optimization (PSO) .

I. Introduction

Number of waveforms are used for radars signal. Several properties of radar waveforms are discussed in [10], [9], [7]. An un-modulated or modulated continuous signal is used in continuous wave radar. Such a system can detect targets using Doppler offset, but range measurements become difficult. Since the radar transmits continuous waves, the requirement for secondary antenna for reception arises which is considered as another short coming of such a system. Pulsed radar transmits signals at regular time intervals of time unlike the CW radar. pulsed radars could give range measurements. But the selection of pulse width is a co-operation among the required resolution of the system and the detectable maximum Range. Number of characteristics of the radar system such as the Range resolution, range accuracy, target detection, radar range and Doppler shift. are decided by the radar waveforms. For example, the shorter the pulse width, the more accurate rang resolution the system has. But at the similar instance of time, short pulse will not support a good detection range.

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The above problem solved by the Pulse Compression. Pulse compression shares the inkling of transmitting a long-range pulse with some modulation embedded which spreads the energy over the bandwidth necessary for the required resolution. Pulse compressed Wave forms have larger time bandwidth (BT) product compared to uncompressed pulses whose BT=1.The pulse compression technique in the waveforms is employed either in the Frequency coding or Phase coding. An LFM signal is a waveform of frequency modulated whose carrier frequency varies linearly with time, over a specific period. This is one of the oldest and frequently used waveforms. It finds application in CW and pulsed radars. Since an LFM waveform serves as a constant amplitude waveform, it makes sure that the amplifier works efficiently. Also, this waveform spreads the energy widely in frequency domain.

A long pulse is divide in to a number of sub pulses of equal duration and the phase of each sub pulse is modulated with the different phases. This can be merely divided into binary and poly-phaser phase coding. In binary technique, the phase of any sub pulse takes any of the two values, either 1 or -1, in harmony with the sequence. In poly phase coding or Non-Binary coding , the phase of the sub pulse takes any of the M arbitrary values. The poly phase codes are Frank codes,p1 codes,p2 codes , P3 codes and p4 coded waveform are some of the commonly used sequences in Polyphase coding. The range side lobes for polyphase coded waveforms are lower than that of binary-coded waveform of same length, but the Doppler performance gets debilitated.

II. Orthogonal Wave forms

Orthogonal poly phase code consists of Length of the sequence (N_c),set size of the (L) and Phase of the sequence (M). Signals which probably containing N sub pulses represented by a complex number sequence, the set of the sequence is given by

$$s_l(n) = e^{j\,\emptyset_l(n)} \tag{1}$$

Where n=1,2, …., N_c and l=1, 2, …., L Where Øl (n), ($0 \leq \emptyset_l(n) < 2\pi$) is the phase of sub pulse n of signal.

$$\emptyset_l(n)\epsilon\left\{0, \frac{2\pi}{M_c}, 2.\frac{2\pi}{M_c}, \dots, (M_c-1).\frac{2\pi}{M_c}\right\} \tag{2}$$

$$\phi_l(n) = \{\psi_1, \psi_2, \dots, \psi_{M_c}\} \tag{3}$$

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Assume a set a poly phase codes with contains the set as Nc whose set size is L, one can briefly signify the phase values of S with following L× N_c phase matrix.

$$(L, N_c, M_c) = \begin{bmatrix} \phi_1(1) & \phi_2(2) & \cdots & \phi_1(N_c) \\ \phi_2(1) & \phi_2(2) & \cdots & \phi_2(N_c) \\ \vdots & \vdots & & \vdots \\ \phi_L(1) & \phi_L(2) & \cdots & \phi_L(N_c) \end{bmatrix} \quad (4)$$

Here the phase sequence in row (1≤ l ≤ L) is the sequence of polyphase signal, and complete elements in the matrix can be elected from the set of phases. From the cross correlation and autocorrelation distinguishing of orthogonal polyphase codes, we get.

$$A(\phi_l, k) = \begin{cases} \dfrac{1}{N_c}\displaystyle\sum_{n=1}^{N_c-1} \exp j[\phi_l(n) - \phi_l(n+k)] = 0 & 0 < k < N_c \\ \dfrac{1}{N_c}\displaystyle\sum_{n=-k+1}^{N_c} \exp j[\phi_l(n) - \phi_l(n+k)] = 0 & -N_c < k < 0 \end{cases}$$

For l=1, 2, …. L (5)

$$C(\phi_l, k) \approx \begin{cases} \dfrac{1}{N_c}\displaystyle\sum_{n=1}^{N_c-k} \exp j[\phi_q(n) - \phi_p(n+k)] = 0 & 0 < k < N_c \\ \dfrac{1}{N_c}\displaystyle\sum_{n=-k+1}^{N_c} \exp j[\phi_q(n) - \phi_p(n+k)] = 0 & -N_c < k < 0 \end{cases}$$

or p≠q and p, q=1, 2, … L (6)

where $A(\varphi_l.k)$ and $C(\varphi_p.\varphi_q.k)$ are the aperiodic function of autocorrelation polyphase sequence S_l and the function of cross correlation sequences S_p and S_q .Where k defined as the discrete time index. Therefore, crafting of an orthogonal polyphase code made corresponding to the building of a polyphase matrix in equation 6 with $A(\varphi_l.k)$ and $C(\varphi_p.\varphi_q.k)$ constraints in equation 5 and equation 6.For the scheme of code sets of orthogonal polyphase used in MIMO radar systems, an the process of optimization is used not only to suppress the auto correlation side lobe peaks and the cross correlation peak but also to suppress the the total autocorrelation sidelobe energy and cross correlation energy in equation 7. Here λ is the weight factor if it is less than one means more weightage is given to auto-correlation and less weightage is given to cross-correlation.

$$E = \sum_{l=1}^{L}\sum_{k=1}^{N_c}|A(\phi_l,k)|^2 + \lambda\sum_{p=1}^{L-1}\sum_{q=p+1}^{L}\sum_{k=-(N_c-1)}^{N_c-1}\left|C(\phi_p,\phi_q,k)\right|^2 \quad (7)$$

III. MIMO Radar Signal Model

A pure MIMO system is one that operates incoherently where as netted radar (NR) Systems operate Coherently and decentralized radar networks (DRNs) operate incoherently with a two stage processing [12].The basic form of the received signal in a MIMO network is the signal arriving at the k^{th} receiver can be modeled as

$$r_k(t) = \sum_{m=1}^{M}[(H_{\frac{0}{1}} \propto_{m,k}(\sigma)s_m(t-\tau_{m.k}) + c_{m,k}(t-T_{m.k})] + J_k(t) + z_k(t) \quad (8)$$

Where $H_{o/1}$ is 0 or 1 depending the absence or presence of target respectively; s_m is the m^{th} transmitted signal, $c_{m,k}$ is the clutter, z_k is the thermal noise, J_k is an external disturbance (such as jamming), $\tau_{m,k}$ and $T_{m,k}$ are the delays occurring during the path between the m^{th} transmitter and the target/clutter respectively and the k_{th} receiver and $\alpha_{k,m}(\sigma)$ is a coefficient that accounts for the parameters of the mono/bisatic radar equations, the phase shift ,and the RCS-distribution, specifically .

$$\alpha_{k,m}(\sigma) = \sqrt{\frac{P_t}{M}}\sqrt{\frac{G_{tx}G_{rx}\lambda^2\sigma}{(4\pi)^3 {R_m}^2 {R_k}^2} exp\left\{-j\frac{2\pi R_{m.k}}{\lambda}\right\}} \quad (9)$$

Where G_{tx} and G_{rx} are respectively the gains of the transmitting and receiving antennas, σ is the RCS of the target, P_t is the transmitting power, R_m and R_k are the transmitter-target and target-transmitter distances respectively and $R_{m.k}$ is the distance covered by the signal.

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$$r_k(t) = H_{\substack{0\\1}} \sum_{m=1}^{M} (\propto_{m,k} (\sigma) s_m (t - \tau_{m.k}) + J_k(t) + z_k(t) \quad (10)$$

The effects of the clutter are not considered, and hence this leads to the following expression for the received signal.

The received output may be expressed as the result of the cross correlation of the received signal with the transmitted waveforms as follows.

$$x_{h,k} = (r_k)\, t \ \otimes s_h(t)$$

$$= H_{\substack{0\\1}} \sum_{m=1}^{M} (\propto_{m,k} (\sigma) s_m (t - \tau_{m.k}) \otimes s_h(t) + [J_k(t) + z_k(t)] \otimes s_h(t)$$

$$= H_{\substack{0\\1}} \propto_{h,k} (\sigma) R_h (t - \tau_{h.k}) + H_{\substack{0\\1}} \sum_{\substack{m=1\\m \neq h}}^{M} (\propto_{m,k} (\sigma) R_{m.k} (t - \tau_{m.k}) + [J_k(t) + z_k(t)] \otimes s_h(t)$$

$$= H_{\substack{0\\1}} \propto_{h,k} (\sigma) R_h (t - \tau_{h.k}) + H_{\substack{0\\1}} \sum_{\substack{m=1\\m \neq h}}^{M} (\propto_{m,k} (\sigma) R_{m.h} (t - \tau_{h.k}) + n_{h.k}(t) \quad (11)$$

Where $R_h(t)$ is the autocorrelation function of sm and $R_{m,h}$ is the cross-correlation function between s_m and s_h and $n_{h,k}$ is the component of the overall disturbance incoming in the k^{th} receiver after the h^{th} matched filter. Consequently a matrix M_x signals from the same area may be written as follows.

$$M_X = \begin{bmatrix} x_{11} & x_{12} \cdots & x_{1N} \\ x_{21} & x_{22} \cdots & x_{2N} \\ \vdots & \ddots & \vdots \\ x_{M1} & x_{M2} & x_{MN} \end{bmatrix} \quad (12)$$

Alternatively, this equation may be rearranged into vector X as follows

$$X = [x_{11}, \ldots x_{1M}, x_{21}, \ldots \ldots x_{2M}, x_{N1}, \ldots . x_{1N}]^T \quad (13)$$

Where T is the transpose operator.

IV. Optimization Algorithms for MIMO Radar

Many optimization methods have been developed for solving various types of engineering problems. Popular optimization algorithms include particle swarm optimization, neural networks, genetic algorithms, artificial immune systems, and fuzzy optimization. The particle Swarm concept originated as a simulation of simplified social systems. The Particle Swarm Optimization algorithm is basically a population-based stochastic search algorithm and provides solutions to the complex non-linear optimization problems. PSO has the benefits of being more efficient when compared to most other optimization algorithms.

V. Simulation Results

In this paper Optimization of Orthogonal Polyphase Coded Waveform for MIMO Radar using Particle Swarm Optimization Algorithm is carried out. In the present work, Particle Swarm Optimization Algorithm is to optimize the six phase polyphase coded sequence to achieve good auto correlation properties and cross-correlation properties. On the basis of projected algorithm the polyphase six phase coded sequences are set with lengths varying from 7 to 128 and number of transmitting ,receiving antennas L=3 and L=4. The Maximum autocorrelation side lobe peak (ASP) and Maximum cross correlation peak (CP) values obtained using proposed algorithm is compared with literature values. The results shows an advance in Autocorrelation Side lobe Peak (ASP)s and Cross Correlation Peak (CP)s. It infers that sequences generated by Particle Swarm Optimization Algorithm have good correlation properties.

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Table 1: Auto Correlation side lobe peaks of Six phase synthesized sequence sets with L=3, and Sequence length N= 40 to 128.

S.No	Length of Sequence	Max(ASP) Reported	Max(ASP) Literature
1	40	0.0044	0.079
2	48	0.0035	0.0751
3	51	0.0031	0.0808
4	60	0.0032	0.0745
5	65	0.003	0.0769
6	70	0.0019	0.0769
7	75	0.0021	0.0777
8	80	0.002	0.076
9	85	0.0022	0.0704
10	100	0.0019	0.067
11	110	0.0016	0.0692
12	120	0.001	0.0671
13	128	0.0015	0.0662

The auto correlation side lobe peak values obtained for different length of the sequences. the average value of ASPs is 0.0023 it is better than the literature values.

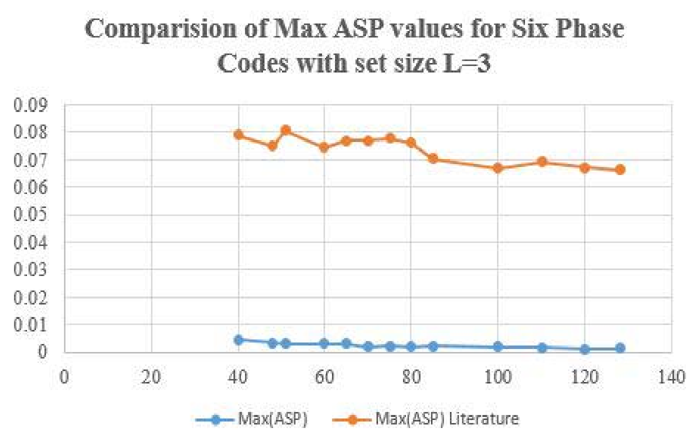

Fig. 1: Max (ASP) values of six phase sequence set L=3 designed using PSO compared with literature values

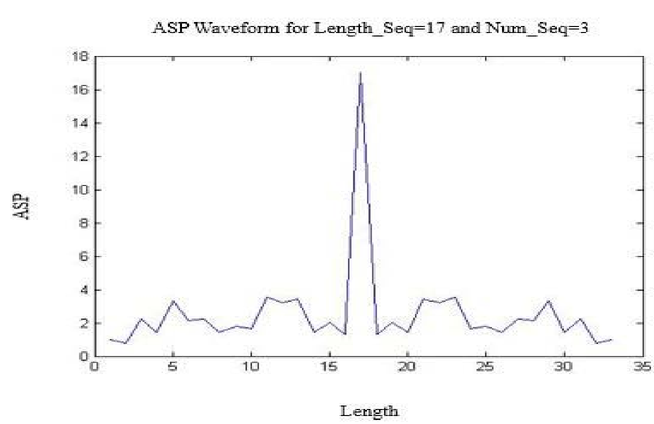

Fig. 2: Minimum Auto correlation Side lobe Peak values of six phase sequence set L=3

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Table 2: Auto Correlation side lobe peaks of Six phase synthesized sequence sets with L=4, and Sequence length N= 7 to 117

S.No	Length of Sequence	Max(ASP) Reported	Max(ASP) Literature
1	7	0.0327	0.079
2	13	0.0179	0.0751
3	17	0.0169	0.0720
4	21	0.0126	0.0731
5	29	0.0061	0.0721
6	31	0.0062	0.0769
7	37	0.0041	0.0777
8	45	0.0036	0.0762
9	49	0.0033	0.0744
10	53	0.0026	0.0731
11	61	0.0017	0.0792
12	87	0.0015	0.0771
13	95	0.0017	0.0762
14	103	0.0011	0.0741
15	113	0.0012	0.0734
16	117	0.0011	0.0733

The auto correlation side lobe peak values obtained for different length of the sequences the average value of ASPs is 0.0069 it is better than the literature values.

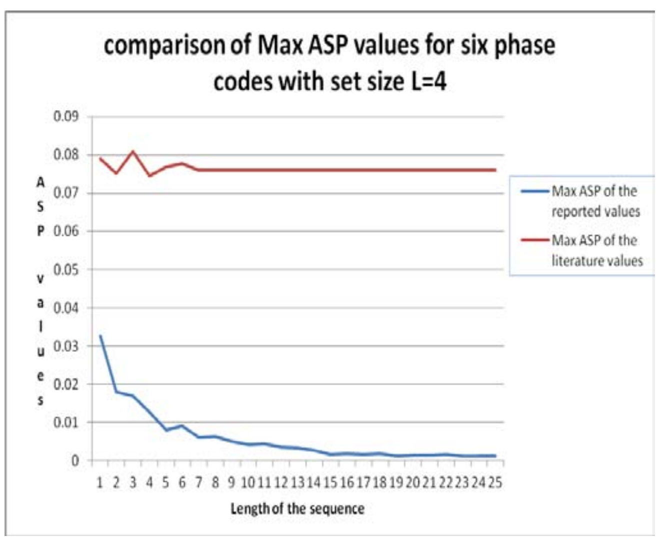

Fig. 3: Max (ASP) values of six phase sequence set L=4 designed using PSO compared with literature values.

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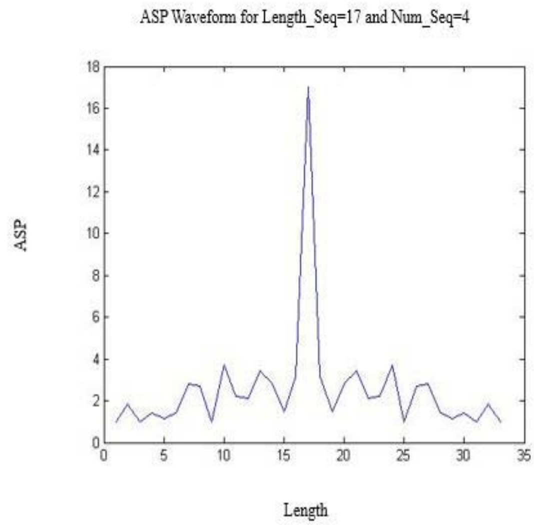

Fig. 4: Minimum Auto correlation Side lobe Peak values of six phase sequence set L=4

Table 1 compares the obtained values of ASPs with literature values. ASPs of Six phase synthesized sequence sets with three transmitting antennas (L=3), and Sequence length varying from N= 40 to 128 are tabularized and Table 2 compares the obtained values of ASPs with literature values. Auto correlation side lobe peaks of four transmitting antennas (L=4) synthesized sequence sets, and Sequence length various from N= 7 to 117. Fig. 1 and Fig.3 illustrates the Max (ASP) values of L=3 and L=4 designed using Particle swarm optimization algorithm compared with literature values.

VI. Conclusion

Properties of Auto correlation side lobe peaks of Six phase produced order sets with three and four transmitting antennas for Sequence length N= 40 to 128 is obtained and compared with the literature values. From the design result, it conclude that the results obtained have great improvement in ASPs things of all the sequence lengths. In order to carry out the implementation of particle swarm optimization algorithm for the optimization of orthogonal poly phase sequences is developed for MIMO radar.

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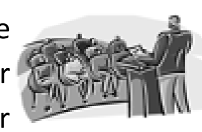

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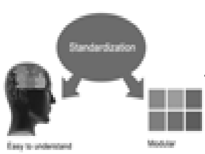

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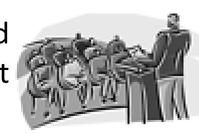

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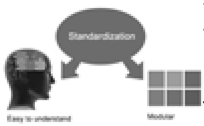

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	A-B	**C-D**	**E-F**
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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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