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Radiated Electromagnetic Interference (Emi) Mechanism of High Power Inverter

By Lingxiang Deng, Pengfei Li, Wanning Bai, Jian Chen, Juhao Fang & Qiangqiang Liu

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Abstract- In this paper, the generation mechanism of radiated EMI noise in inverter circuit is analyzed. On the basis of analyzing the equivalent model of common mode and differential mode radiated EMI noise, the radiated EMI noise is separated by common mode and differential mode by using the fast Fourier transform principle. The effectiveness of the radiated EMI noise separation method is verified by experiments.

Keywords: *high-power inverter, electromagnetic interference (EMI), radiation emission (RE), common mode radiation, differential mode radiation, radiated EMI noise separation method.*

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Radiated Electromagnetic Interference (EMI) Mechanism of High Power Inverter

Lingxiang Deng ^α, Pengfei Li ^σ, Wanning Bai ^ρ, Jian Chen ^ω, Juhao Fang [¥] & Qiangqiang Liu [§]

Abstract- In this paper, the generation mechanism of radiated EMI noise in inverter circuit is analyzed. On the basis of analyzing the equivalent model of common mode and differential mode radiated EMI noise, the radiated EMI noise is separated by common mode and differential mode by using the fast Fourier transform principle. The effectiveness of the radiated EMI noise separation method is verified by experiments.

Keywords: high-power inverter, electromagnetic interference(EMI), radiation emission (RE), common mode radiation, differential mode radiation, radiated EMI noise separation method.

I. INTRODUCTION

With the rapid development of power electronics, inverter systems with highpower inverter power supply as the core are more and more widely used in large-scale power equipment[1-5]. However, the increase of power density leads to the increasingly complex electromagnetic environment inside the inverter system[6-10]. The resulting radiated electromagnetic interference can cause equipment failure and pose a potential hazard to the safe and reliable operation of itself and other surrounding equipment[11-12]. Therefore, it is necessary to study the mechanism of radiated electromagnetic interference of high-power inverters [13].

The radiated EMI noise is generated by the inverter circuit and the loop equivalent antenna [14-15]. The device under tested (EUT) is placed at the coordinates , the measured point is at x, and the length of the EUT equivalent radiating antenna is l, then the equivalent radiated antenna is measured. The distance between points can be expressed as

$$r=R-n \cdot x' \quad (1)$$

Where R is the distance between the origin and the point to be measured, and n is the unit vector in the R direction. The wavelength corresponding to the radiation noise is

$$\lambda=\frac{c}{f} \quad (2)$$

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In the above formula, c is 3×10^8 m/s, λ is the wavelength corresponding to the radiation noise, and f is the frequency of the radiated EMI noise caused by the EUT.

Because the size of the high-power inverter power cabinet is 800mm \times 500mm \times 1500mm (width \times depth \times height), and according to the simulation calculation f is about 80kHz, λ is 3750m, the transmission control cabinet The size is obviously less than 1/10 of the wavelength of the radiation. It can be considered that the above radiation test condition is a small size characteristic, and the current density in the equivalent antenna is J, which can be derived.

$$A(x)=\frac{\mu_0}{4\pi} \int \frac{J(x')e^{jk(R-n \cdot x')}}{R-n \cdot x'} dV' \quad (3)$$

A is a retarded potential, and k is the wave vector. The $-n \cdot x'$ term in the denominator of (3) can be omitted, and $e^{-jkn \cdot x'}$ will be expanded by $kn \cdot x'$.

$$A(x)=\frac{\mu_0 e^{j k R}}{4\pi} \int J(x')(1-jkn \cdot x'+\dots) dV' \quad (4)$$

The first two parts of equation (4) represent electric dipole common mode radiation and magnetic dipole differential mode radiation, respectively.

II. RADIATED EMI NOISE MODELING

a) Common mode EMI noise model

As shown in Fig. 1, for common mode radiation, it can be equivalent to an electric dipole antenna, and the delay potential is the first part of equation (4).

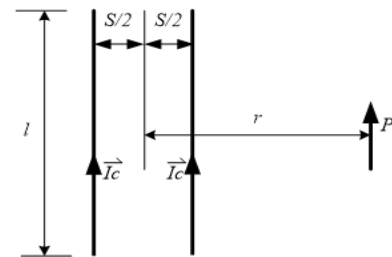


Fig. 1: Common mode noise equivalent model

$$A(x)=\frac{\mu_0 e^{j k e R}}{4\pi R} \int J(x') dV' \quad (5)$$

In the electric dipole antenna, there are ni particles with a velocity of vi and a charge of qi per unit volume. then

$$J = \sum_i n_i q_i v_i \tag{6}$$

$$P = \sum q_i v_i \tag{7}$$

Where \dot{p} is the first derivative of the electric dipole moment versus time.

Therefore, the magnetic field strength, electric field strength, energy flow density and radiation power of the electric dipole can be derived.

$$B_{CM} = \frac{1}{4\pi\epsilon_0 c^3 R} \left| \dot{p} \right| e^{jkR} \sin \theta e_\phi$$

$$E_{CM} = \frac{1}{4\pi\epsilon_0 c^2 R} \left| \dot{p} \right| e^{jkR} \sin \theta e_\phi$$

$$S_{CM} = \frac{1}{32\pi^2 \epsilon_0 c^3 R^2} \left| \dot{p} \right|^2 \sin^2 \theta_n$$

$$P_{CM} = \frac{1}{4\pi\epsilon_0} \frac{\left| \dot{p} \right|^2}{3c^3}$$
(8)

According to equation (8) and Maxwell's equations, the calculated common mode radiated noise generated by the electric dipole at far field r is

$$E_{CM} = 12.6 \times 10^{-7} \frac{f I_{CM}}{r} \tag{9}$$

I_{CM} is the common mode current in the electric dipole, l is the length of the electric dipole antenna, and r is the distance between the measured point and the center of the electric dipole. Therefore, equations (8), (9), and (1) can describe the principle and model of electric dipole common mode radiation noise.

b) Differential mode EMI noise model

As shown in Fig. 2, for differential mode radiation, it can be equivalent to a magnetic dipole antenna, which delays the second part of the potential size formula (4).

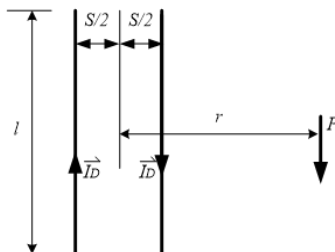


Fig. 2: Differential mode noise model

$$A(x) = \frac{-jk\mu_0 e^{jkR}}{4\pi R} \int J(x')(n \cdot x') dV' \tag{10}$$

The magnetic field strength, electric field strength, energy flow density and radiant power of the magnetic dipole antenna are

$$B_{DM} = \nabla \times A = \frac{\mu_0 e^{jkR}}{4\pi c^2 R} (m \times n) \times n$$

$$E_{DM} = cB \times A = -\frac{\mu_0 e^{jkR}}{4\pi c R} (m \times n)$$

$$S_{DM} = \frac{\mu_0 \omega^4 |m|^2}{32\pi^2 c^3 R^2} \sin^2 \theta_n$$

$$P_{DM} = \frac{\mu_0 \omega^4 |m|^2}{12\pi c^3}$$
(11)

From the equation (11) and the Maxwell equations, considering the grounding total reflection, the differential mode radiated noise of the magnetic dipole antenna at the far field r

$$E_{DM} = 2.632 \times 10^{-14} \frac{f^2 A I_{DM}}{r} \tag{12}$$

I_{DM} is the differential mode current in the magnetic dipole, A is the area of the magnetic dipole antenna, and r is the distance between the measured point and the center of the electric dipole. Therefore, equations (11), (12), and Fig. 2 can describe the principle and model of magnetic dipole differential mode radiated noise.

III. RADIATED EMI NOISE SEPARATION METHOD

The second section of the above section establishes the electric dipole common mode radiation and the magnetic dipole differential mode radiation acoustic model, The nature of the radiated noise is analyzed when the radiated noise is suppressed. Therefore, this section designs a radiated noise separation method based on short-time fast Fourier transform and independent component analysis for common mode noise and differential mode noise electromagnetic characteristics.

Using the field probe to receive the radiated noise $Z_1(t), Z_2(t), \dots, Z_N(t)$ of the N sets of EUTs, perform short-time fast Fourier transform on the acquired time domain signal $Z(t)$.

$$SIFT_z(t, f) = \int_{-\infty}^{\infty} [z(t') \gamma'(t-t')] e^{-2\pi f t'} dt' \tag{13}$$

Where $\gamma(t)$ is the time window and $*$ indicates its conjugate complex number. The time-rate energy distribution (instantaneous power spectral density) of the STFT is the square of the STFT(t, f) modulus.

$$SPEC(t, f) = |STFT(t, f)|^2 \tag{14}$$

The digital representation of the STFT can be derived from the equations (13) and (14).

$$STFT(n, k) = \sum_{i=0}^{N-1} [x_i \gamma^*(i-n)] \exp(-j \frac{2\pi ki}{N}) \tag{15}$$

$$SPEC(n, k) = |STFT(t, f)|^2 \tag{16}$$

Where N represents the amount of FFT data, and n and k represent the discrete time number of the time-frequency and the number of frequency grids, respectively. In the application, the fast algorithm of equation (16) is generally implemented by Fourier transform.

Through independent component analysis, the characteristics of the received noise signal are extracted, and then the short-time fast Fourier transform is used to convert the separated time domain noise signal into the frequency domain, and compared with the circuit under test, the source of the radiated electromagnetic interference noise is located. the specific method implementation steps are as follows:

- a) Using a high-speed oscilloscope to perform near field testing on the EUT, extracting N sets of mixed radiated noise time domain signals $Z(t)$; b) Perform independent component analysis on the noise signal $Z(t)$ and separate the mixed signal into N independent radiated noise signal sources $Z_1(t), Z_2(t), \dots, Z_N(t)$ as alternative sources of radiated noise ;
- b) The independent noise sources $Z_1(t), Z_2(t), \dots, Z_N(t)$ are obtained by short-time fast Fourier time frequency analysis, and the signal characteristics of the noise source are extracted;
- c) Compare the signal characteristics obtained after analysis with the circuit under test to find out the components that cause the radiation to exceed the standard.

IV. RADIATED EMI NOISE SEPARATION EXPERIMENT

This verification experiment uses a multi track high speed oscilloscope to measure the radiated noise time domain signal of the EUT through a mufti channel test port with a near-field magnetic field probe, as shown in Fig. 3.

The near-field magnetic field probe uses Rhode & Schwarz's near-field probe set HZ-11, which has a

frequency detection range of 10 kHz to 2 GHz as shown in Fig. 3. The multi track high-speed oscilloscope uses the Tektronix DPO5204 model with a bandwidth of up to 2 GHz and four test channels with a sampling rate range of 5 GS/s - 10 GS/s. In the experiment, the sampling rate of the oscilloscope DPO5204 is set to 1GS/s, and the EUT radiated noise time domain signal can be acquired.

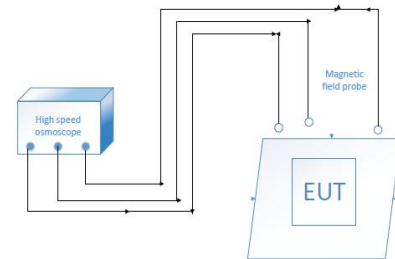


Fig. 3: Experimental arrangement

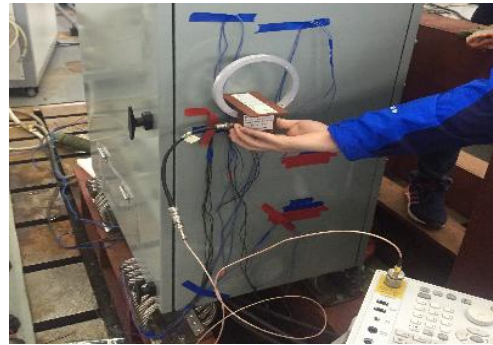


Fig. 4: Experimental measurement

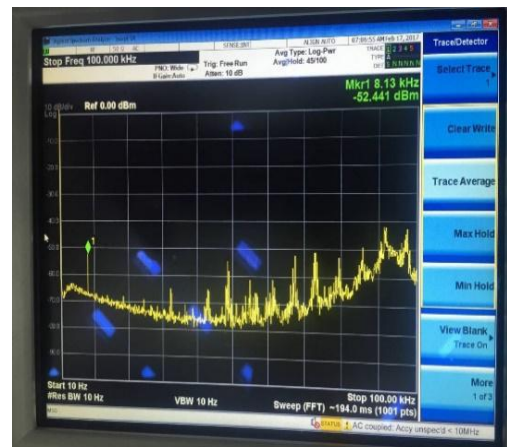
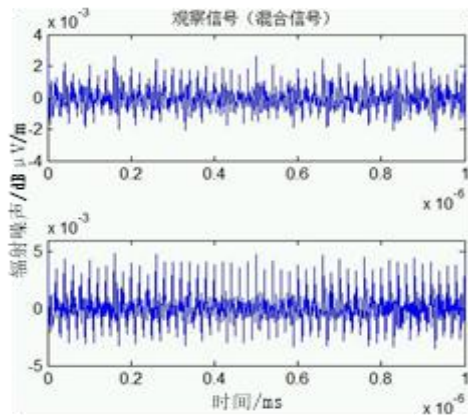


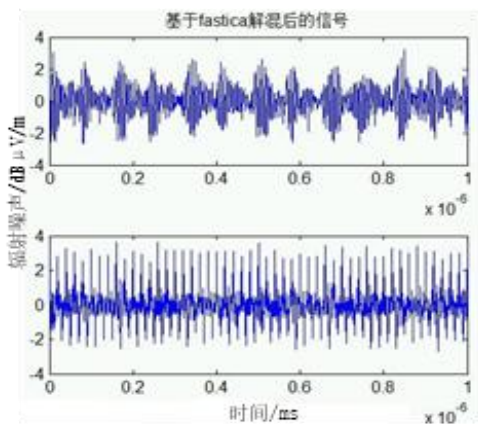
Fig. 5: Inverter power supply radiation noise near field test results

Firstly, the radiated noise mixed time domain signal of the high-power inverter power supply is collected. The measured near-field noise test result is shown in Fig. 6. After the noise signal is introduced into MATLAB, the time domain characteristics of the noise

signal are shown in Fig. 6 (a). Perform independent component analysis, as shown in Fig. 6(b). There are two independent noise signals Z1(t) and Z2(t). The time-frequency analysis is shown in Fig. 7. As can be seen from Fig. 7(a), the data with the strongest energy in the noise is extracted as shown in Table 1. The average value of the data in the table is about 240 MHz. It can be seen that the noise is strongest around 240 MHz, and the internal inverse is observed. The variable circuit found that the crystal frequency of the control board is 30MHz, and 240MHz is its frequency multiplication, so the noise is the radiation noise generated by the 30MHz crystal oscillator. As seen in Fig. 7(b), the noise is the strongest at 300KHz, and the noise signal data at the strongest energy is extracted as shown in Table 2. The average value is 299.85KHz, which is compared with the internal inverter circuit. The power master chip operates at a frequency of 100 kHz and 300 kHz as its frequency multiplier. Therefore, the noise after the separation is the radiation noise of the 100 KHz master chip. It can be seen that the radiation noise of the device is mainly generated by the 30M crystal oscillator and the 100KHz main control chip.



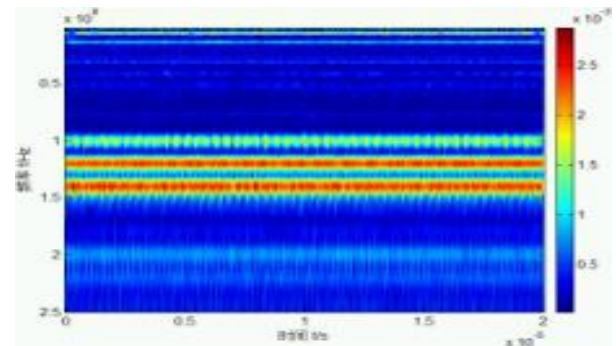
(a) Mixed time domain signals



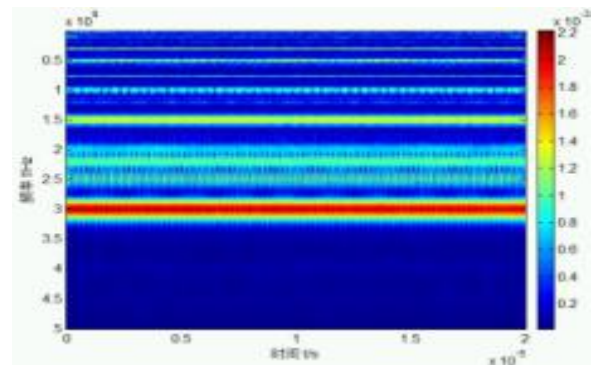
(b) Time domain signal after separation

Fig. 6: Time domain signal before and after the separation of radiated noise of inverter power supply

Comparing the separated noise signals can judge the strength of the two signals. Comparing Tables 1 and 2, the energy intensity of the 30MHz noise signal is stronger in the noise signals after separation between the two groups. Therefore, the 30MHz noise signal is the main cause of the radiation noise exceeding the standard of the device under test. From the above analysis, the 30MHz crystal oscillator is large. The main reason for the excessive radiation noise of the power inverter power supply cabinet provides a theoretical basis for the suppression of subsequent radiation noise.



(a) Time-frequency analysis results of Z1(t)



(b) Time-frequency analysis results of Z2(t)

Fig. 7: Time-frequency analysis results of radiation noise of high-power inverter power supply

Table 1: Time-frequency analysis data of the radiated noise Z1(t) after separation

| time*10 μ s | frequency/MHz | Energy intensity *10 $^{-3}$ |
|-----------------|---------------|------------------------------|
| 2.475 | 239.4 | 2.484 |
| 5.723 | 239.4 | 2.343 |
| 9.446 | 239.7 | 2.513 |
| 13.21 | 240.0 | 2.311 |
| 15.74 | 239.4 | 2.64 |
| 18.59 | 240.1 | 2.46 |

Table 2: Time-frequency analysis data of the radiated noise Z2(t) after separation

| time*10 μ s | frequency/MHz | Energy intensity *10 $^{-3}$ |
|-----------------|---------------|------------------------------|
| 1.525 | 299.5 | 1.147 |
| 2.059 | 299.5 | 1.017 |
| 6.99 | 300.0 | 1.029 |
| 13.64 | 300.3 | 1.032 |
| 15.78 | 299.7 | 1.136 |
| 18.28 | 300.1 | 1.022 |

V. CONCLUSION

In short, the mechanism of radiated EMI noise generation in inverter circuit has been analyzed, and the method of common mode and differential mode separation of radiated EMI noise by using the principle of fast Fourier transform is proposed. The effectiveness of the method of radiating EMI noise separation is verified by experiments. Sex. As a result, a better solution to EMI noise can be proposed.

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Numerical Simulation and Characteriation of Pentacene based Organic Thin Film Transistors with Top and Bottom Gate Configurations

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Abstract- In this paper, we model the characteristics of top and bottom gate configurations of organic thin film transistors (OTFTs) including top gate top contact (TGTC), top gate bottom contact (TGBC), bottom gate top contact (BGTC) , bottom gate bottom contact (BGBC). The path of charge carriers changes in different geometries which possess difference in the electrical behaviour of the devices. The performances of bottom and top gate pentacene based OTFT devices have been analyzed and their performance parameters like mobility, threshold voltage, sub threshold slope, trans conductance, on off ratio have been extracted and compared.

Keywords: *organic thin film transistors (OTFTS), numerical simulation, pentacene, top gate top contact (TGTC), top gate bottom contact (TGBC), bottom gate top contact (BGTC) and bottom gate bottom contact (BGBC).*

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Numerical Simulation and Characteriation of Pentacene based Organic Thin Film Transistors with Top and Bottom Gate Configurations

A. D. D. Dwivedi ^α & Pooja Kumari ^σ

Abstract In this paper, we model the characteristics of top and bottom gate configurations of organic thin film transistors (OTFTs) including top gate top contact (TGTC), top gate bottom contact (TGBC), bottom gate top contact (BGTC), bottom gate bottom contact (BGBC). The path of charge carriers changes in different geometries which possess difference in the electrical behaviour of the devices. The performances of bottom and top gate pentacene based OTFT devices have been analyzed and their performance parameters like mobility, threshold voltage, sub threshold slope, trans conductance, on off ratio have been extracted and compared.

Keywords: organic thin film transistors (OTFTS), numerical simulation, pentacene, top gate top contact (tgtc), top gate bottom contact (TGBC), bottom gate top contact (BGTC) and bottom gate bottom contact (BGBC).

I. INTRODUCTION

Organic electronics is the field which is fast developing in today's scenario. Organic semiconductors (OSC) have made the device low cost and made the field of organic electronics active. Organic transistors can be directly fabricated on flexible cheap substrates and it requires low temperature which makes the device cost efficient. Various researchers used the flexible substrates like glass [1] and plastic [2] which led the fabrication cost very low. Organic thin film transistors have been used in various applications like Organic light emitting diodes (OLEDs) [3], Organic displays [4], Organic radio frequency identification tags [5-23], organic sensors[6-23] and many more high end applications. Several improvements have been made by researchers in geometry, materials, insulators and fabrication to make the device more reliable in performance issues and still it is needed to be improving to implement in basic electronic circuitry.

Numerical simulation is very useful in understanding the sub threshold characteristics and electrical properties of a device which is also helpful in designing of a better model. 2D device simulator like ATLAS from Silvaco international would be suitable for the purpose. In this paper, numerical simulation of the

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device is done with top and bottom gate configurations to understand how the device behaves physically.

A number of devices with different geometry were implemented in the structure of device and their performance was noted down. Pentacene organic semiconductor was used as an active layer of transistor because of its high mobility. In this paper, we model the characteristics of top and bottom gate configurations including top gate top contact (TGTC), top gate bottom contact (TGBC), bottom gate top contact (BGTC), bottom gate bottom contact (BGBC). The path of charge carriers changes in different geometries which possess difference in the electrical behavior of the devices. The performances of bottom and top gate pentacene based devices are compared and their performance parameters like mobility, threshold voltage, sub threshold slope, trans conductance, on off ratio are summarizing in detail.

II. EXPERIMENTAL SETUP

Top and bottom gate configurations of the Pentacene based Organic thin film transistor have been implemented and the schematic of the bottom gate configuration and top gate configuration are shown in Fig.(1) and Fig (2) respectively. For the fabrication of OTFT devices, Layer by Layer (LBL) technique is used in which the materials are evaporated in form of layers one by one.[7] Bottom and top contact structure are differentiated in terms of position of source and drain contacts with respect to active semiconductor layer and keeping gate at constant position. Fig.1. shows the top gate geometry with top contact fig.1 (a) and bottom contact fig.1 (b) used in the simulation.

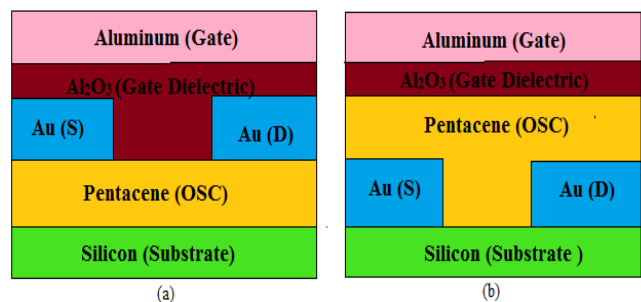


Fig. 1: Schematic of Top gate configuration (a) top gate top contact (TGTC) (b) top gate bottom contact (TGBC)

Numerical simulation and electrical characterization of the bottom gate and top gate configuration is done in tend to compare the performance parameters with a channel length and width of 10 μm and 220 μm respectively. Organic semiconductor is used as pentacene with doping concentration of 3×10^{17} and with a thickness of 0.03 μm . Al_2O_3 which has permittivity of 8.5 is taken as gate dielectric with thickness of 0.0057 μm . Source and drain contacts and gate electrode are of aluminum(Al) and gold (Au) with thickness 0.03 μm and 0.02 μm respectively. Bottom gate configurations with top contact and bottom contact are shown in fig.2(a) and fig.2(b) respectively. The electrical characterization shows a difference in bottom and top gate geometries due to the unlike path travelled by charge carriers between source and drain electrodes.[8] the structural dimension used in the work for top and bottom gate configurations are summarized in Table 1.

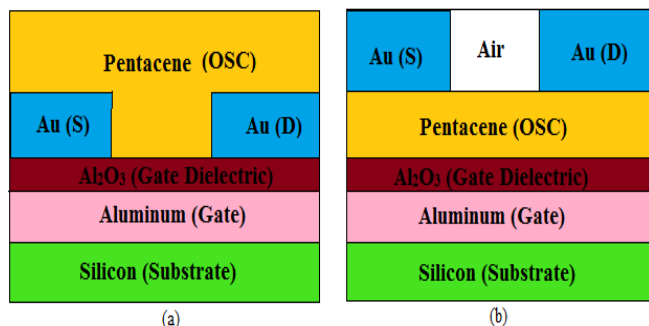


Fig. 2: Schematic of bottom gate configuration (a) Bottom gate bottom contact (BGBC) (b) Bottom gate top contact (BGTC)

Table 1: Structural dimensions used in top and bottom gate configuration

| Device Parameter | Value (μm) |
|--|-------------------------|
| Channel Width (W) | 220 |
| Channel length | 10 |
| Gate thickness, T_G | 0.02 |
| Dielectric thickness, t_{ox} | 5.7×10^{-3} |
| Organic semiconductor thickness, t_{osc} | 0.03 |
| S/D contact thickness, t_c | 0.03 |

III. MODELLING AND NUMERICAL SIMULATION

Numerical simulation of Electrical characteristics of the top and bottom gate configuration is measured using TCAD ATLAS by Silvaco International software. TCAD ATLAS by Silvaco International is physically based, numerical device simulator which predicts the electrical behavior of device and used to design a high performance device. This section describes the simulation procedure followed by ATLAS software. This software follows some fundamental equations that are linked with performance parameters.

The equations used by the ATLAS to simulate the Device are Poisson's equation and Continuity equation which were used to measure the characterization of these two devices.[9-23]

a) Poisson's equation

Poisson's Equation relates variations in the electrostatic potential to local charge densities. It is mathematically described by the following relation [9-23],

$$\nabla \cdot (\epsilon \nabla \psi) = -\rho \quad (1)$$

$$\nabla \cdot (\epsilon \nabla \psi) = -q(p - n + N_d^+ - N_a^-) \quad (2)$$

Where ψ is the electrostatic potential, ρ is the local space charge density, ϵ is the local permittivity of the semiconductor (F/cm), p is the hole density (cm^{-3}), n is the electron density (cm^{-3}), N_d^+ is the ionized donor density (cm^{-3}) and N_a^- is the ionized acceptor density (cm^{-3}). The reference potential is always taken as the intrinsic Fermi potential for simulations in ATLAS. The local space charge density is the sum of all contributions from all mobile and fixed charges, including electrons, holes and ionized impurities.

b) Continuity Equations

For electrons and holes, the continuity equations are defined as follows:

$$\frac{\partial n}{\partial t} = \frac{1}{q} \nabla \cdot J_n + G_n - R_n \quad (3)$$

$$\frac{\partial p}{\partial t} = -\frac{1}{q} \nabla \cdot J_p + G_p - R_p \quad (4)$$

where n and p are the electron and hole concentrations, J_n and J_p are the electron and hole current densities, G_n (R_n) and G_p (R_p) are the generation (recombination) rates for the electrons and holes, respectively and q is the fundamental electronic charge. ATLAS incorporates both eqns. In simulations, but, also gives the user an option to turn off one of the two equations and solve either the electron continuity equation.

c) Transport Equations

These equations are to specify the physical models for electrons and holes current densities and generation (recombination) rates. The Current density equations are obtained by using the "drift-diffusion" charge transport model. The reason for this choice lies in the inherent simplicity and the limitation of the number of independent variables to just three, ψ , n and p . The accuracy of this model is excellent for all technologically feasible feature sizes. The drift-diffusion model is described as follow:

$$J_n = qn\mu_n E_n + qD_n \nabla n \quad (5)$$

$$J_p = qn\mu_p E_p - qD_p \nabla p \quad (6)$$

where μ_n and μ_p are the electron and hole mobilities, D_n and D_p are the electron and hole diffusion constants, E_n and E_p are the local electric fields for electrons and holes, respectively, and Δn and Δp are the three dimensional spatial gradient of n and p . The local electric fields are defined as follows:

$$E_n = -\nabla(\psi + \frac{kT_L}{q} \ln n_{ie}) \quad (7)$$

$$E_p = -\nabla(\psi - \frac{kT_L}{q} \ln n_{ie}) \quad (8)$$

Where n_{ie} is the local effective intrinsic carrier concentration.

For numerical simulation of OTFT device with top and bottom gate configuration, the Poole-Frenkel mobility model has been employed for Pentacene active channel and defines the dependency of mobility capability due to electric field, this model is expressed as [20-23],

$$\mu(F(x), T) = \mu_0(T) \exp[\gamma(T)\sqrt{F(x)}] \quad (9)$$

Here, in equation (9), μ_0 is zero field mobility, F is electric field, and γ is characteristic parameter for the field dependence.

IV. THE DENSITY OF DEFECT STATES

The density of the defect states (DOS) $g(E)$, which dominates the properties of amorphous or polycrystalline TFTs, is modeled as a combination of four components [3] an acceptor-like exponential band tail function $g_{TA}(E)$, a donor-like exponential band tail function $g_{TD}(E)$, an acceptor like Gaussian deep state

function $g_{GA}(E)$ and a donor like Gaussian deep state function $g_{GD}(E)$, where E denotes the state energy. The equations describing these terms are given as follows [8]

$$g_{TA}(E) = N_{TA} \exp\left[\frac{E - E_C}{W_{TA}}\right] \quad (10)$$

$$g_{TD}(E) = N_{TD} \exp\left[\frac{E_V - E}{W_{TD}}\right] \quad (11)$$

$$g_{GA}(E) = N_{GA} \exp\left[-\left[\frac{E_{GA} - E}{W_{GA}}\right]^2\right] \quad (12)$$

$$g_{GD}(E) = N_{GD} \exp\left[-\left[\frac{E - E_{GD}}{W_{GD}}\right]^2\right] \quad (13)$$

where E is the trap energy, E_C is conduction band energy, E_V is valence band energy, and the subscripts T, G, A, D stand for tail, Gaussian (deep level), acceptor and donor states respectively. The exponential distribution of DOS is described by conduction and valence band intercept densities (N_{TA} and N_{TD}), and by its characteristic decay energy (W_{TA} and W_{TD}). For Gaussian distributions, the DOS is described by its total density of states (N_{GA} and N_{GD}), its characteristic decay energy (W_{GA} and W_{GD}), and its peak energy/peak distribution (E_{GA} and E_{GD}).

Input parameters used in the simulation of the OTFT devices with different geometries are summarized in Table II.

Table 2: Parameters used during the simulation of top and bottom gate organic tft Devices

| Parameters | Values |
|---|---|
| Effective density of state in conduction band (N_c) | $1.0 \times 10^{21} \text{ cm}^{-3}$ |
| Effective density of state in valence band | $1.0 \times 10^{21} \text{ cm}^{-3}$ |
| Dielectric constant for Al_2O_3 | 8.5 |
| Electron gap at 300K | 2.8 |
| N_{TD} | $1.0 \times 10^{18} \text{ cm}^3/\text{eV}$ |
| N_{TA} | $2.5 \times 10^{18} \text{ cm}^3/\text{eV}$ |
| W_{TD} | 0.5eV |
| W_{TA} | 0.129eV |
| W_{GA} | 0.15eV |

| | |
|---|---|
| W_{GD} | 0.15eV |
| E_{GD} | 0.78 |
| E_{GA} | 0.62 |
| Doping concentration | $3 \times 10^{17} \text{cm}^{-3}$ |
| Permittivity for Pentacene | 4.0 |
| Activation energy for Zero electric field for holes (deltaep.pfmob) | $1.792 \times 10^{-2} \text{eV}$ |
| Hole poole frenkel Factor (betap.pfmob) | $7.758 \times 10^{-5} \text{eV}(\text{cm/V})^{1/2}$ |
| Workfunction for Au (S/D) | 5.1 |
| Workfunction for Al (gate) | 4.28 |

V. RESULTS AND DISCUSSIONS

All Organic thin film transistor devices were built up with technique of top gate and bottom gate configuration with top and bottom contacts. Electrical characterization and numerical simulation of the devices are measured using TCAD ATLAS by Silvaco International software and with the help of characterization of devices, electrical performance parameters such as Mobility, Trans conductance, threshold voltage, Sub threshold sweep and on/off ratio were calculated.

Mobility is the rate of flow of charge carriers in the electric field. It is the parameter which deals with processing speed of device. This mobility (μ) has been calculated using the following equations,

$$\mu = (L \times g_m) / (W \times C_{ox} \times V_{ds}) \quad (10)$$

$$g_m = dl_{ds} / dV_{gs} \quad (11)$$

$$C_{ox} = \epsilon_{ox} / d_{ox} \quad (12)$$

Here, g_m is the trans conductance which is calculated by transfer characteristics curve (I_{ds} / N_{ds}) and calculation is done by equation (11). L and W are length and width of device respectively. C_{ox} is the capacitance of oxide with is the ratio of permittivity of oxide and thickness of oxide, given by equation (12). V_{ds} is drain voltage which is taken as 1V for all the devices.

Minimum voltage required for the device to be in ON state or the accumulation of charge carriers at gate dielectric-semiconductor interface is said as Threshold Voltage or Cut-in Voltage. Sub threshold sweep is ratio of change in gate biasing to change in logarithm scale of drain current. It can be expressed as,

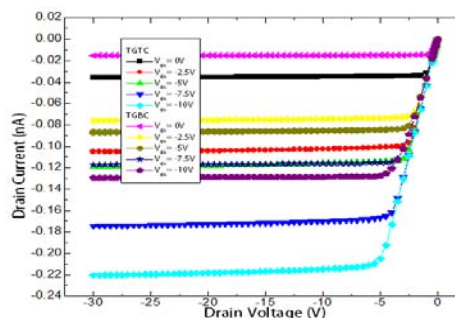
$$SS = \partial V_{gs} / \partial \log_{10} (I_{ds}) \quad (13)$$

a) Top gate configuration

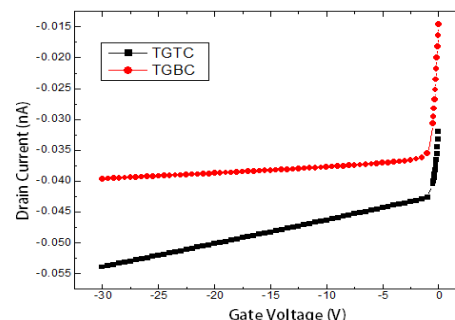
Fig. 2 (a) and (b) shows the output and transfer characteristics of top gate top contact configuration top gate bottom contact configuration. At high operating

gate voltage, linear and saturation region are expect in the thin film transistor and the same is observed in the output graph for Top gate configuration at top contact and bottom contact. Similar characteristics behavior is also observed in am bipolar organic TFT reported in [10]. Figure 2(a) is the comparison of top gate top contact and top gate bottom configuration which tend to gain better characteristics in top gate top contact than top gate bottom contact.

Transfer characteristics shows a good electrical performance with good electrical parameters with higher on-off ratio greater than 10^5 and sub threshold sweep of 0.11 in top gate bottom contact and 0.02 in top gate top contact shown in fig. 2(b).



(a)



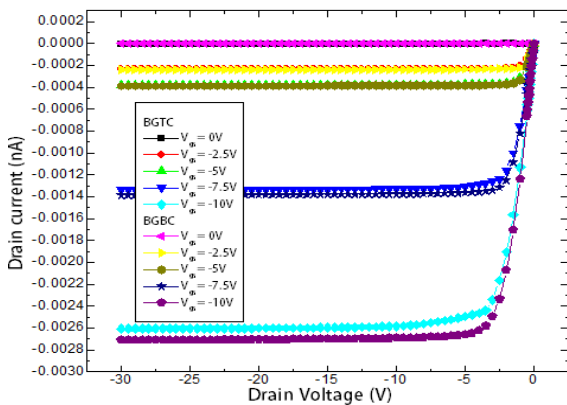
(b)

Fig. 2: (a) Output (b) Transfer characteristic curve ($V_{ds} = -1V$) of OTFT in TGTC and TGBC configurations

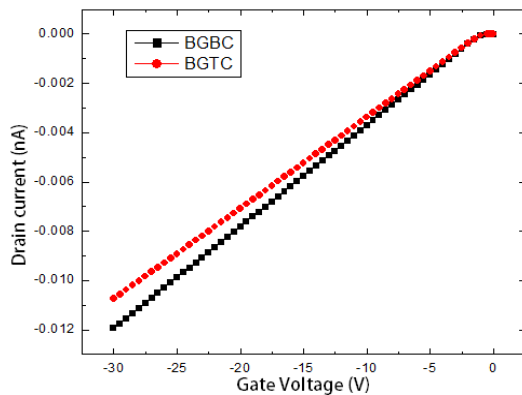
b) Bottom gate configuration

Fig. 3(a) and (b) inset shows the output and transfer characteristics of bottom gate configuration with bottom contact and top contact respectively. It is observed that both the BGBC and BGTC configurations have same output characteristics at low gate voltage ($V_{gs} \leq 5V$) but if the gate voltage is high ($V_{gs} > 5V$) it shows a drastic increment in the output characteristics which is greater in Bottom gate bottom contact than bottom gate top contact configuration.

Transfer characteristics shows good performance characteristic with linear increment at drain voltage of -1V with higher on off ratio greater than 10^3 and sub threshold slope of 0.26 in BGBC and 0.32 in BGTC configurations. All the extracted values of electrical parameters are tabulated in table III.



(a)



(b)

Figure 3(a): Output (b) transfer characteristics curve (at $V_{ds} = -1V$) of OTFT in BGTC and BGBC configuration

Table 3: Extracted Values of parameters of top and Bottom gate configuration in organic thin film transistor

| Parameters | Structures | | | |
|--------------|-------------------|-------------------|-------------------|-------------------|
| | BGBC | BGTC | TGBC | TGTC |
| V_t (V) | 1.1 | 1.2 | 0 | 0 |
| On off ratio | 1.9×10^4 | 9.5×10^3 | 1.9×10^8 | 7.9×10^8 |

| | | | | |
|------------------------------|-----------------------|------------------------|-----------------------|-----------------------|
| Sub threshold slope(V/dec) | 0.26 | 0.32 | 0.11 | 0.02 |
| Transconductance (μS) | 4.13×10^{-6} | 3.759×10^{-6} | 6.62×10^{-7} | 3.73×10^{-6} |
| Mobility(cm^2/vs) | 0.14 | 0.129 | 0.022 | 0.128 |

From above calculation, it was observed that bottom gate configuration perform better than top gate configuration in terms of mobility, sub threshold slope and with good on off ratio but top gate configuration have higher on off ratio as compared to bottom gate configuration which is in magnitude of 10^8 .

VI. CONCLUSION

This paper presented the numerical simulation and characterization of bottom and top gate pentacene based OTFTs. The performances of these devices have been analyzed and their performance parameters like mobility, threshold voltage, sub threshold slope, trans conductance, on off ratio have been extracted and compared. It was observed that bottom gate configuration perform better than top gate configuration in terms of mobility, sub threshold slope and with good on off ratio but top gate configuration have higher on off ratio as compared to bottom gate configuration which is in magnitude of 10^8 .

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Model of Flicker Noise

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Bohdan Stadnyk ^α, Zenoviy Kolodiy ^σ & Svyatoslav Yatsyshyn ^ρ

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I. INTRODUCTION

Most of the signals that we may come across with in the real life are similar to temperature changes of the environment during some period of time, oscillations in potential difference on the resistor, changes of stock exchange rate, deviations in intensity of car traffic, etc. For instance, it is presented below the encephalogram of the cerebral cortex of the patient (fig.1).

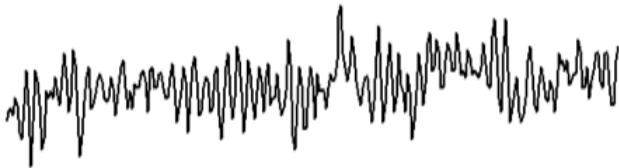


Fig. 1: Example of stochastic signal

Further processing of such signal that includes computing of its power spectral density (PSD) $S(f)$ mainly

leads to frequency dependence such as: $S(f) = \frac{c}{f^\gamma}$,

where $\gamma \approx 0.8 \div 1.2$. Signals the spectrum of which corresponds to high-mentioned PSD are known as FN or $1/f$ -noise.

An obstacle for creating FN model is a few of unsolved yet contradictions between the FN concept and experiment. Among them we highlight the next items: 1) contradiction between model of singular FN source and experimental results of FN studies caused by finite probability of different sources existence in the same objects; 2) contradiction between FN models of $S(f) \sim 1/f^\gamma$, where degree of power γ is clearly defined ($\gamma=1$ or $\gamma=2$), and results that underlines the variance of

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γ values ($\gamma=0.8 \div 1.2$); 3) models, that satisfactory describe experimental results of FN-study in electrical systems, are not able to explain of FN existence for biological, geological and other systems. and vice versa.

Therefore, the creation of an adequate FN model, which would be confirmed by the experimental results and would be able to explain the mechanisms of FN formation, seems to be quite important problem. If it could be solved, we would be able to select the electronics components with guaranteed low level of their own noise in low frequency range, and, as a result, to increase sensitivity of measuring equipment at aforementioned frequencies. That is important in medical, biological, and other branches/

II. STUDY OF EQUILIBRIUM AND NON-EQUILIBRIUM SYSTEMS NOISE

Basing on own FN studies or/and on analysis of known results authors of [1-11] have suggested the mechanisms that explain the $1/f$ type spectrum specific. Nevertheless, this approach his suitable more or less for the particular experimental results in contrast to most other studies unattainable using it. Reasons are rooted in limits of authors' possibilities that are the next. Finite choice of studied objects and complexity of manipulation of their parameters as well as of the measurement process usually restrict the research. This problem could be solved to some extent with simulation modeling.

Particular interest among various hypotheses on FN formation is induced to hypothesis of FN formation in non-equilibrium thermodynamic systems assured by computer simulation. Aforesaid model is developed in this paper. It allows mimicking the fluctuations in equilibrium and non-equilibrium systems by chaotic movement of balls in flat rectangle where nontransparent partitions could be placed. Size and allocation of partitions, number of balls and their speed could be changed. During chaotic movement of balls they elastically bounce from the partitions and walls of the rectangle. During defined temporal range (N sample) the number of balls that touched the right and left sides of the rectangle is calculated; their difference Δn is computed and displayed in fig. 2. PSD of such fluctuations is also computed and presented below as diagram. Such computer model is able to mimic the change of potential difference / noise on the edges of unloaded film resistor.

Imitation of fluctuations in the equilibrium system was performed during chaotic movement of balls in 2-dimension space of rectangle without partitions or with entire partition that divides the rectangle on parts. Probability of location of any ball at any place of considered space is the same. It explains the equilibrium of such system. Some models of equilibrium

systems and corresponding PSDs of chaotic movement of balls are shown in fig.3. As you can see, PSD of simulated system is unchanged in the studied frequency range regardless of the location of the partition.

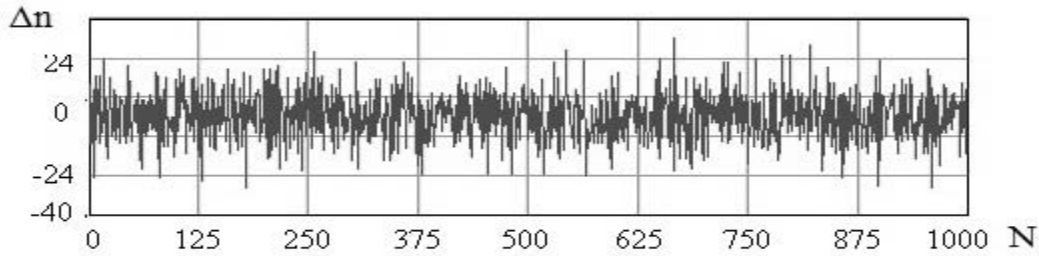


Fig. 2: Computer model of fluctuations

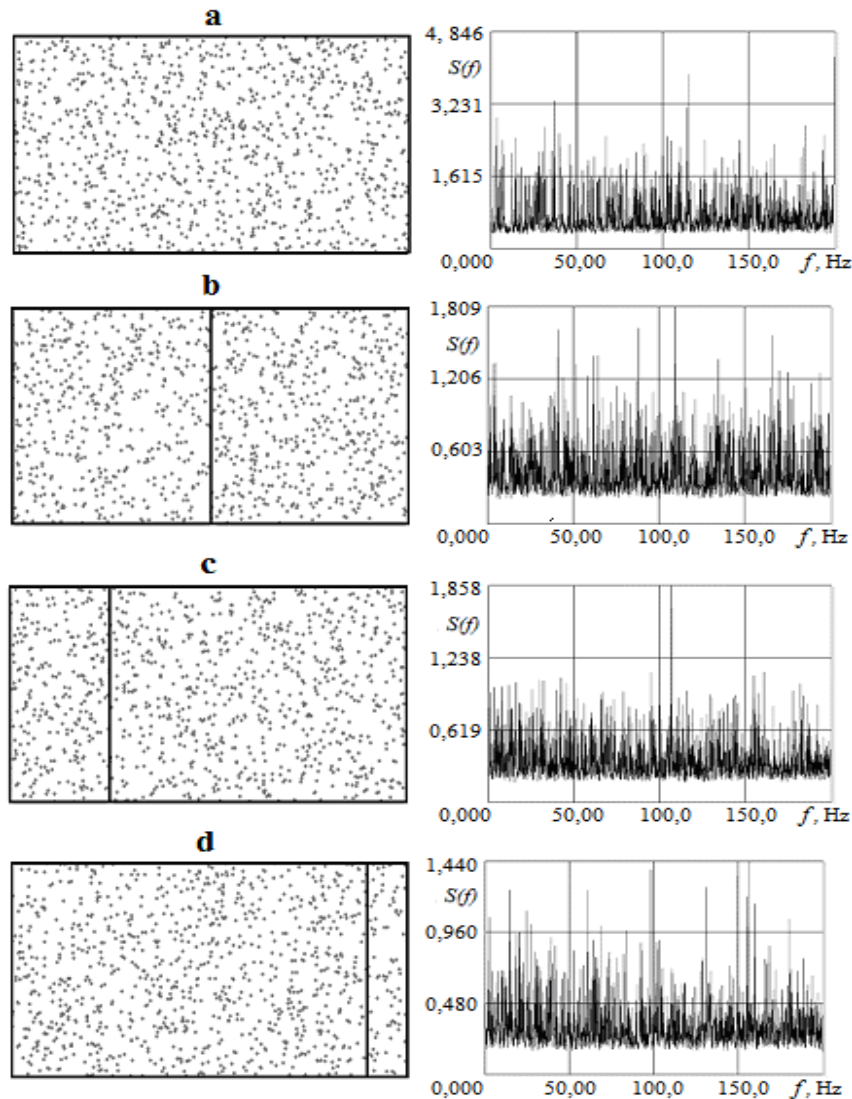


Fig. 3: Models of equilibrium systems and their corresponding PSD at chaotic movement of balls

Non-equilibrium of the system was modeled by the presence of slits in the partition (fig.4.) since the probability of location of any ball at any place of considered space is not the same. The narrower the slit or the more the non-equilibrium system is, the more similar the energy spectrum to the flicker noise. If the slit is expanding or system moves to a state of equilibrium, energy spectra smoothly transform into the spectrum of equilibrium system. Conclusion of results analysis of computer modeling leads to the possibility to state following:

- For equilibrium systems the PSDS (f) of fluctuations in the range from 0 to the frequency that tends to infinity, is the same.
- Raise of PSD $S(f)$ of fluctuations when f moves to zero ($f \rightarrow 0$) is inherent in the systems that are in non-equilibrium state.

Since real systems are in a non-equilibrium state, non-equilibrium state can be considered as a particular case of the equilibrium state; if external influences on the system are absent or the last one is isolated, after a while appears that it is in equilibrium.

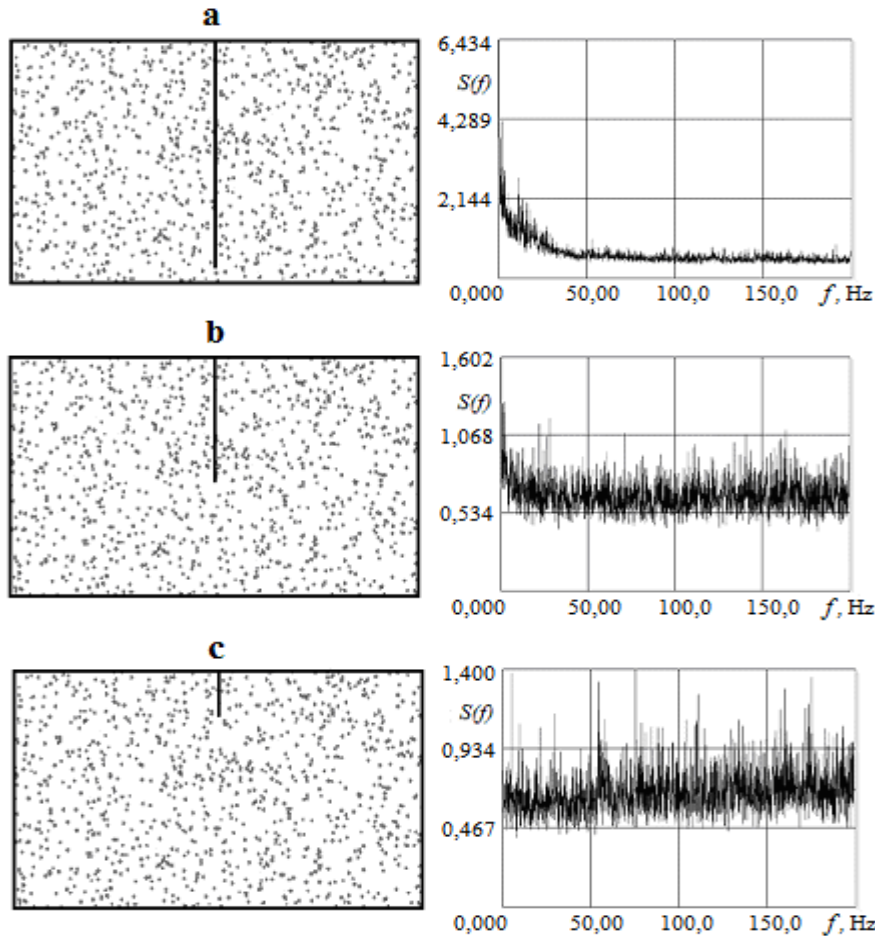


Fig. 4: Model of unbalanced system and its PSD for chaotic movement of balls

Let's designate P_B as fluctuations probability of parameters of system in an equilibrium state, and P_{NB} as similar probability of non-equilibrium system. Accordingly, PSD of fluctuations in equilibrium system is $S_B(f)$, and the same parameter in non-equilibrium system is $S_{NB}(f)$.

The link between $S_B(f)$ and $S_{NB}(f)$ for isolated system, that for a certain time period is smoothly changing from non-equilibrium state to equilibrium, can be expressed as:

$$P_B \cdot S_B(f) = P_{NB} \cdot S_{NB}(f). \quad (1)$$

Value of P_{NB} from [12] representing the fluctuations probability of non-equilibrium system is the next:

$$P_{NB} = 1 - e^{-f \cdot \tau} \quad (2)$$

Here f is fluctuations frequency; τ is system relaxation time. From thermodynamics, probability of fluctuations in isolated system which is in equilibrium state, equals to 1 ($P_B = 1$), and PSD of considered system is unchanged able $S_B(f) = S_0 = const$ with in frequency range from 0 up to ultrahigh frequencies, where quantum effects arise [13]. From (1) and (2) it can

be obtained equation for PSD of fluctuations of non-equilibrium system:

$$S_{NB}(f) = \frac{e^{f \cdot \tau}}{1 - e^{f \cdot \tau}} \cdot S_B(f) \quad (3)$$

From (3) at $\tau \rightarrow \infty$ where system will be in equilibrium, $S_{NB}(f) = S_B(f) = S_0 = const.$ For $\tau < \infty$ and $f \rightarrow 0$ formula (3) takes the form:

$$S_{NB}(f) = \frac{e^{f \cdot \tau}}{1 - e^{f \cdot \tau}} \cdot S_B(f) \approx S_B(f) + \frac{1}{f} \cdot \frac{S_B(f)}{\tau} = S_0 + \frac{1}{f} \cdot \frac{S_0}{\tau} \quad (4)$$

The last contains two components, one of which corresponds to equilibrium fluctuations $S_B(f) = S_0$, and the other one to fluctuations of $1/f$ type (flicker noise). This is consistent with known experimental results.

By experimentally determined fluctuations spectrum, from (3) at $f_0 = \frac{1}{\tau}$ one can define relaxation time of system. So, $S_{NB}(f_0) \approx 1.58 \cdot S_0$, where the value of S_0 corresponds to $S_{NB}(f)$ in range of middle frequencies, and relaxation time is $\tau = \frac{1}{f_0}$. Analysis of the results of computer modeling shows that the relaxation time τ depends on the characteristics of internal structure of system.

Fig.5 is given the computer modeling of the system with different inner structure and energy spectrum approximated by (3). There from, it can be seen that different structures are inherent in the different values τ . Apparently, FN can be considered not only as interference, but as informative signal that holds data about the features of internal structure of system [14].

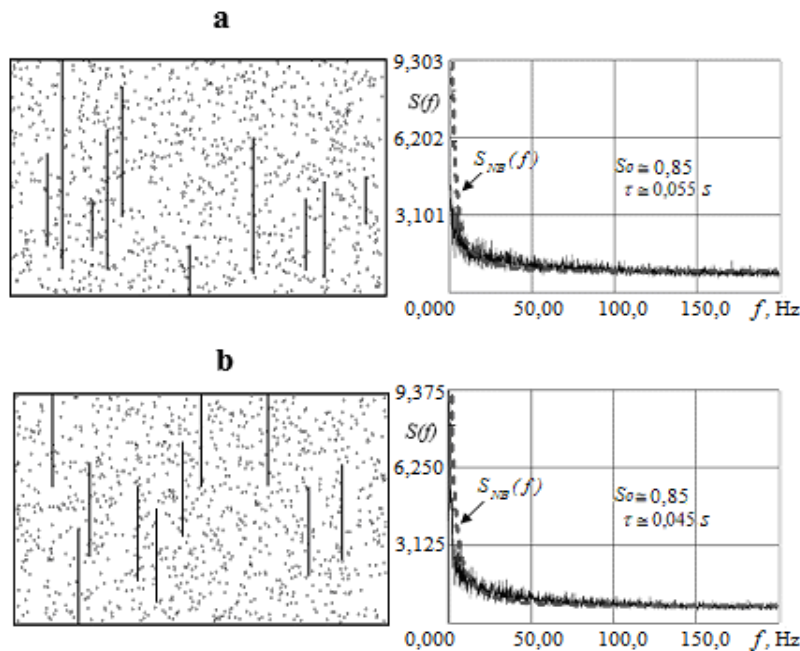


Fig. 5: Dependence of parameter τ on internal structure of system

Equation (3) is applied for approximation experimental energy spectra of: encephalograms of patients P1 and P2 (fig.6.a, [15]), noise of graphene FETs (fig.6.b, [16]), noise of FETs (fig.6. c, [17]). It can be concluded from fig.6 that the quality of approximation is sufficiently high. S_0 and τ are needed while approximation. For the electronic elements the value of S_0 is equal to PSD the latter is computed with help of Nyquist formula designed for the equilibrium thermodynamic system; the value of τ can be found experimentally, as it was mentioned before or perhaps it is possible to calculate τ using diffusion coefficient.

III. CONCLUSIONS

Considered noise model of thermo dynamic systems that can exist in equilibrium and non-equilibrium states enables to avoid the row of contradictions between FN concept and experimental data. System in equilibrium state does not generate flicker noise.

Derived formula describes PSD fluctuations in any real non-equilibrium system, regardless of its nature. It is revealed that dependence of the PSD of FN is exponential and not $\sim 1/f^\gamma$. Nature of $1/f$ noise is the same as of thermal noise. The first one cannot be

considered as a specific noise caused by the particularity of processes in the system (slow relaxation processes, superposition of random processes, abnormal Brownian motion, etc.).

So, it becomes possible to explain the dissimilarity between the noises of low-frequency energy spectra of two similar samples due to difference of their internal structures in τ parameter.

Growth of spectral components at $f \rightarrow 0$ indicates that the system is in a non-equilibrium state; its flicker noise is caused by chaotic motion of the particles (electrons, ions) from which the system consists and their interaction with structural elements (defects) of system.

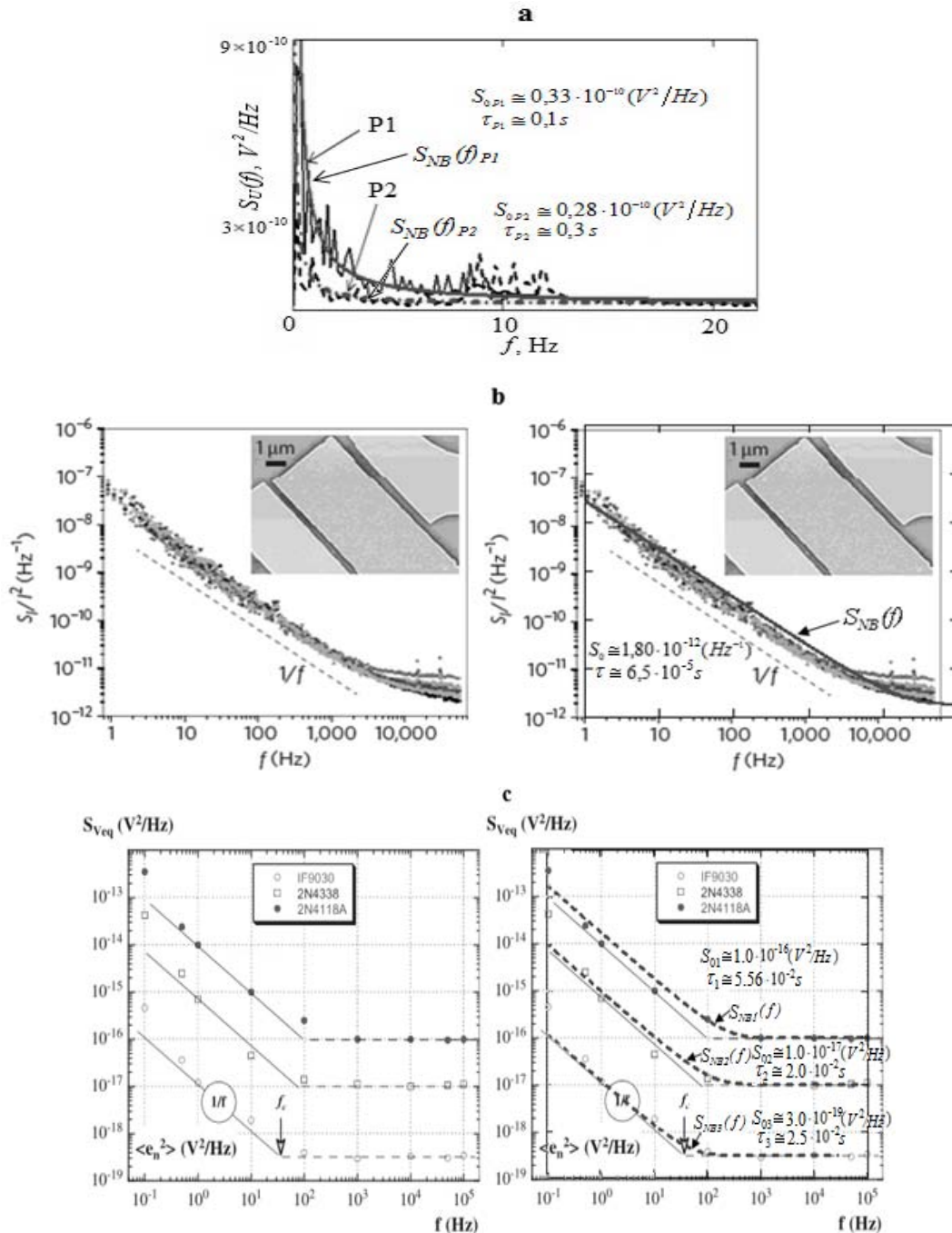


Fig. 6: Experimental PSDs and their approximation for: human encephalograms (a), noise of graphene FET (b), noise of FET (c)

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Design & Simulation of Microstrip Patch Antenna for C-Band Communication Services

By Lavesh Gupta & Dr. Arun Dev Dhar Dwivedi

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Abstract- When a fewer number of microstrip antennas are to be used for the transmission and reception of electromagnetic signals in a system, the size of the antenna array becomes a critical issue to deal with. Instead of using a number of antennas, we can use the desired number of patch antennas over a single substrate only. Main motive is to maintain the coupling suppressing sectional structure in simple manner, whilst providing a higher amount of efficiency in coupling of microstrip patch elements/antennas. At microwave frequency, the microstrip is often used as a transmission line because of its very good efficiency in transferring energy/microwave signals. In this work, an antenna design is simulated at 4.8 GHz for its working in the C-Band communication services. The size of the array structure is kept to the minimum value.

Keywords: *antenna array, mutual coupling, microstrip patch antenna, performance optimization.*

GJRE-F Classification: FOR Code: 090699



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Lavesh Gupta ^α & Dr. Arun Dev Dhar Dwivedi ^σ

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Keywords: antenna array, mutual coupling, microstrip patch antenna, performance optimization.

I. INTRODUCTION

Microstrip Patch antenna is currently, the most famous and hot topic in antenna field technology. It is highly useful in aircrafts with high performances, space-crafts, satellite and other applications as these are the areas where weight, size, cost, performance, ease of installation, and aerodynamic profile are the big constraints & a cheap patch microstrip antenna is needed [1-3].

At the microwave range of frequency value, the microstrip line is used as x-mission line as it has excellent performance in the transfer of energy & microwave signals. The most significant merit of microstrip line is, it does not produce large parasitic capacitances/inductances. While comparing it with other transmission-lines, it is found that the stripline and microstrip are very easy to use, feasible and less expensive to manufacture/fabricate and are feasible to attach to surface-mounted components & structures[4-5].

The operating frequency of microstrip antennas usually ranges from 1 to 50 GHz [6-7]. The following figure shows the block diagram of basic microstrip patch antenna system.

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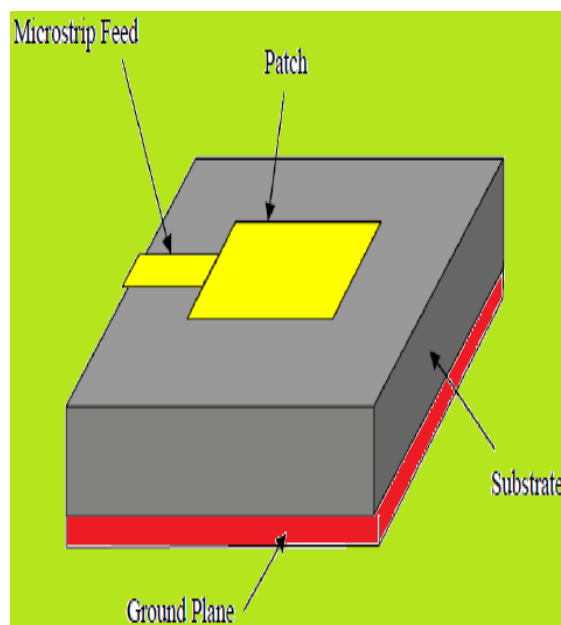


Fig. 1: Microstrip Patch Antenna

II. QUARTER WAVE TRANSFORMER

It is quarter wavelength section of a transmission line. It is used to match the impedance between antenna and main transmission feed-line. It is not hard to construct the quarter wave line sections at low values of impedances [8-10]. It has an impedance of 70 ohms, which provides exact match to the impedances b/w strip line and the patch antenna elements.

III. DESIGN PARAMETERS FOR C-BAND SYSTEMS

We start with the microstrip patch antenna by calculating the length and width of a rectangular microstrip antenna for resonance at 4.8 GHz.

- Frequency (Resonance) of Operation (f_r):

Resonant frequency of the microstrip antenna should be selected wisely. Hence, the antenna design must be able to operate in the specific frequency range. The resonant frequency selected for my design is 4.8 GHz.

- Permittivity of FR-4 (ϵ_r):

The dielectric material selected for the design is FR-4, which has a dielectric constant of 4.4.

- Height of Dielectric Substrate (h):

For the microstrip patch antenna, the height of the dielectric substrate is selected as 1.60 mm. Hence, the essential parameters for the design are:

Resonating frequency, $f_r = 4.8$ GHz..

Permittivity of substrate,

$$\epsilon_r = 4.4.$$

Height h of substrate,

$$h = 1.60 \text{ mm.}$$

Substrate used,

FR-4.

IV. DESIGN EQUATIONS

Due to fringing effects, electrically patch of antenna looks larger than physical specifications. Enlargement on 'L' is given by [11-12]:

$$\Delta L = 0.412(\epsilon_{\text{reff}} + 0.3)(Wh^{-1} + 0.264) / [(\epsilon_{\text{reff}} - 0.258)(Wh^{-1} + 0.8)] \quad - (1)$$

Here, effective relative permittivity is as follows:

$$\epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2\sqrt{1 + 12hW^{-1}}} \quad - (2)$$

This is related to the ratio of h/W . The larger the h/W , the smaller is the effective permittivity. The effective length of the patch is given by:

$$L_{\text{eff}} = L + 2\Delta L \quad - (3)$$

The resonance frequency or the TM₁₀ mode is given by:

$$f_r = \frac{1}{2L_{\text{eff}}\sqrt{\epsilon_{\text{reff}}}\sqrt{\epsilon_o}\mu_o} = \frac{1}{2(L + 2\Delta L)\sqrt{\epsilon_{\text{reff}}}\sqrt{\epsilon_o}\mu_o} \quad - (4)$$

Optimized width for efficient radiator is as follows:

$$W = \frac{1}{2f_r\sqrt{\epsilon_o}}\sqrt{\frac{2}{\epsilon_r + 1}} \quad - (5)$$

The reflection coefficient and VSWR can be related through the following formula as:

$$VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|} \quad - (6)$$

The value of reflection coefficient is given by:

$$\Gamma = (Z_L - Z_0) / (Z_L + Z_0) \quad - (7)$$

The return loss should be a large negative number as possible. It is defined empirically through following:-

$$LRT = -20 \log_{10}(|\Gamma|) = -20 \log_{10} \left| \frac{Z_a - Z_0}{Z_a + Z_0} \right| \quad - (8)$$

The impedance bandwidth is inversely proportional to quality factor of an antenna and is given by:-

$$BW = \frac{VSWR - 1}{Q\sqrt{VSWR}} \quad - (9)$$

The bandwidth of an antenna is given by:-

$$BW = \left\{ \frac{2(f_u - f_l)}{f_u + f_l} \right\} \times 100\%$$

(Bandwidth < 100 %) or,

$$BW = \left\{ \frac{f_u}{f_l} : 1 \right\} \quad - (10)$$

(Bandwidth > 100 %)

Mathematically, directivity (dimensionless) can be written as:

$$D_n = \frac{U(\theta, \phi)}{U(\theta, \phi)} = \frac{4\pi U(\theta, \phi)}{P_t} = \frac{4\pi U(\theta, \phi)}{\iint U d\Omega} \quad - (11)$$

V. DESIGN PROCEDURE

If the substrate parameters (ϵ_r & h) & operational frequency (f_r) are known, then we can easily find out patch array dimensions, using above simplified equations and by following the below design procedure:

Step 1: Width Calculation:

Use the above equation to find the patch width W . by substituting the value of $f = 4.8$ GHz and permittivity as 4.4, the width of the antenna patch comes out to be as 19 mm.

Step 2: Calculation of the effective permittivity:

By using the above mentioned equations & putting the value of permittivity as 4.4, width as 19 and height as 1.6 mm, the effective value of dielectric constant is obtained as 3.8985.

Step 3: Computation of the extension of length:

The value of extended length comes out to be as 0.7277 mm by using the aforesaid equations [13-14].
Step 4: Determine the actual length 'L':

Solving the following equation for 'L' which is given by:

$$L = \frac{1}{2f_r\sqrt{\epsilon_{\text{reff}}}\sqrt{\epsilon_o}\mu_o} - 2\Delta L \quad (12)$$

Here, difference in length comes out to be 0.7277 mm. The actual length of the patch is obtained as 14.37 mm, while its width comes out to be 19 mm ($W/L < 2$). The effective value of permittivity of FR-4 is obtained as 3.8985.

VI. DESIGN OF 50 OHMS FEEDING-LINE

To design a feed line, the ratio of width of feed line to height of substrate must be less than 2. Their ratio is given by the

following relation:

$$W/d = \{8.e^A/(e^{2A}-2)\} < 2 \quad (13)$$

$$\text{So, } A = \{(Z_0)/60\}[(1 + \epsilon_r)/2]^{1/2} + [(-1 + \epsilon_r)(.23 + .11/\epsilon_r)/(1 + \epsilon_r)]$$

Here, the thickness (d) of the substrate is 1.60 mm, ϵ_r is 4.4, length (l) of the feed line is assumed as 07 mm and input impedance of feed line is 50 ohms. The value of constant 'A' is calculated as 1.5297 and that of ϵ_{eff} (effective) is obtained as 3.8985. Also, w/d is less than 2. So, the width of both the feeding lines comes out to be 3.05 mm. Therefore, $W = 3.05$ mm and $L = 7$ mm.

VII. DESIGN OF QUARTER-WAVE TRANSFORMER

The input resistance to patch is denoted by R_{in} & is given by:

$$R_{in} = (120/2 * \text{width of patch}) * (c/f) * (\epsilon_{eff})^{-1/2} \quad (14)$$

From the above equation, the input resistance is obtained as 100 ohms, by putting effective permittivity as 3.8985, frequency as 4.8 GHz and patch width as 19 mm. Therefore, the equivalent resistance is given by [15-16]:

$$Z_q = (50 * R_{in})^{1/2} \quad (15)$$

So, the equivalent resistance comes out to be 70 ohms. The value of 'A' is obtained as 2.07, by putting permittivity as 4.4 and Z_q as 70 ohms. Also, the transformer's width is obtained as 1.656 mm. The length of the transformer is given by the following relation:

$$L = (1/4) * (\epsilon_{eff})^{-1/2} * (\text{wavelength of EM wave}) \quad (16)$$

For a height of 1.6 mm and transformer width of 1.656 mm, the value of effective permittivity comes out to be as 3.18. The parametric values of transformer are obtained as: $L = 8.76$ mm, $W = 1.66$ mm, $R_{in} = 100$ ohms & Z_q (equivalent) = 70 ohms.

VIII. MATHEMATICAL MODEL LING

The expression for the effective permittivity is given by the following relation:

$$\epsilon_{eff} = \frac{1 + \epsilon_r}{2} + \frac{\epsilon_r - 1}{2} \left(1 + \frac{12h}{W}\right)^{-0.5} \quad (17)$$

Where, h = Height of dielectric substrate, &
W = Width of the patch.

The fringing fields along the width are modelled as radiating slots and electrically, patch of the microstrip antenna looks larger as compared to the physical dimensions. The dimensions of patch along with its length are extended on each end by the distance Δl , which is given empirically by the following relation:

$$\Delta l = 0.412h \left(\frac{0.262 + W/h}{0.814 + W/h} \right) \left(\frac{\epsilon_{eff} + 0.3}{\epsilon_{eff} - 0.258} \right) \quad (18)$$

The effective length of the patch L now becomes:

$$L = \frac{c}{2f_r \sqrt{\epsilon_{eff}}} - 2\Delta l \quad (19)$$

For efficient radiation, the width W is given by:

$$W = \frac{c}{2f_r} \left(\frac{\epsilon_r + 1}{2} \right)^{-0.5} \quad (20)$$

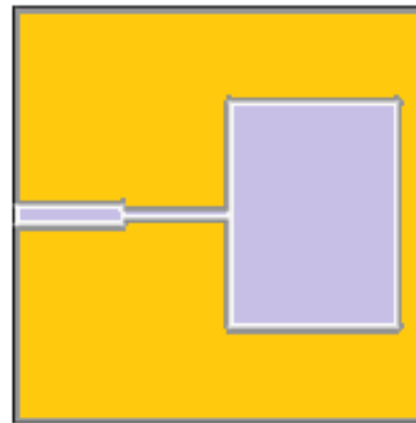


Fig. 2: Microstrip Patch Antenna with Feed, Patch & Impedance-Matching Transformer

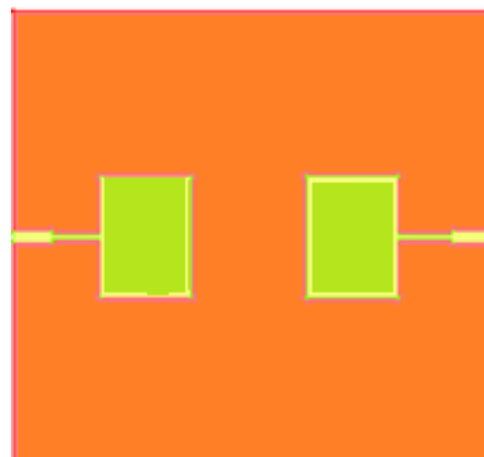


Fig. 3: Microstrip Patch Antenna Array

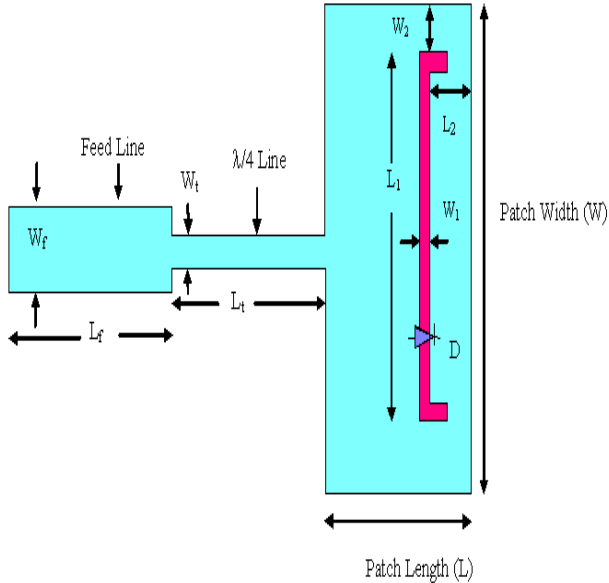


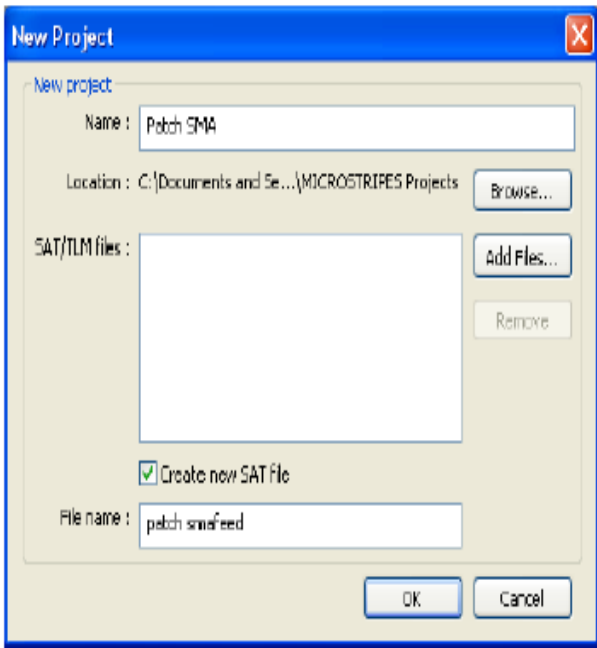
Fig. 4: Antenna Design Specifications

IX. SIMULATION STEPS

Antenna simulation is performed by CST Microstripes Software, which is based on Transmission Line Model.

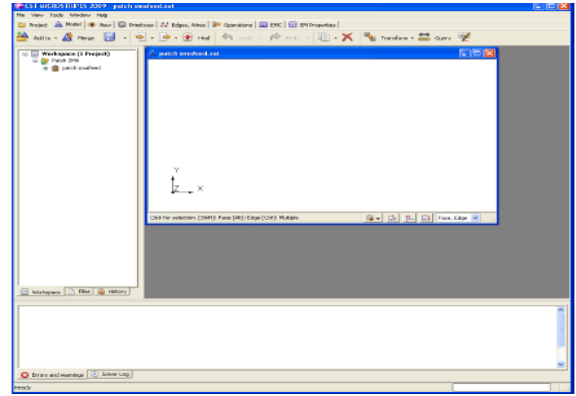
Step 1: To open the window:

Launch CST MICROSTRIPES from the Start menu, and click on the Create a new project button.



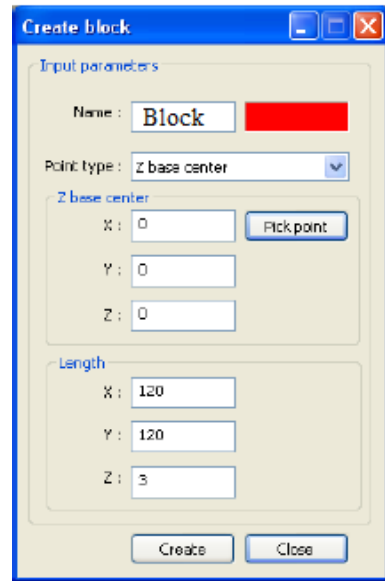
Step 2: To create a new project:

Create a new project with an empty model, a Build window will open within the CST MICROSTRIPES window.



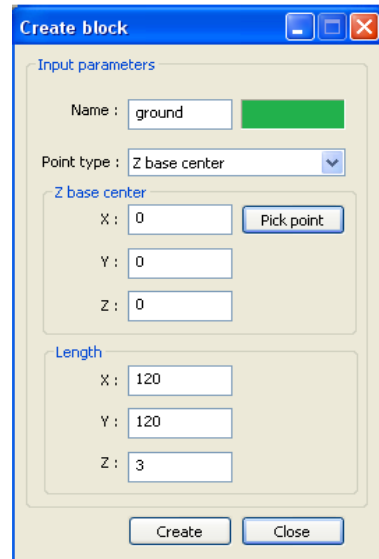
Step 3: To create substrate Block:

Create block of substrate plane using the solid block primitive by clicking its tab.



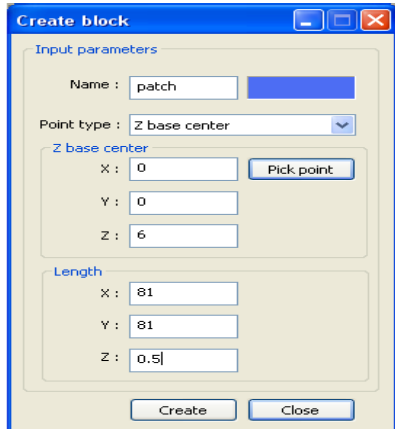
Step 4: To create ground plane

Create the ground on dielectric substrate; the ground will be of the same dimensions as the substrate plane.



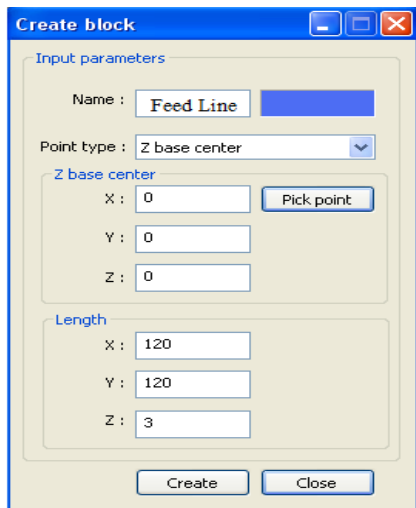
Step 5: To create Patch:

Create a rectangular patch on top of the dielectric substrate.



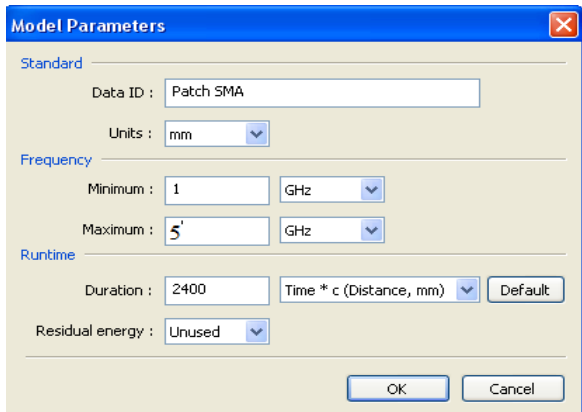
Step 6: To create Feed-Line:

Create a 50 ohms feed-line for the patch antenna.



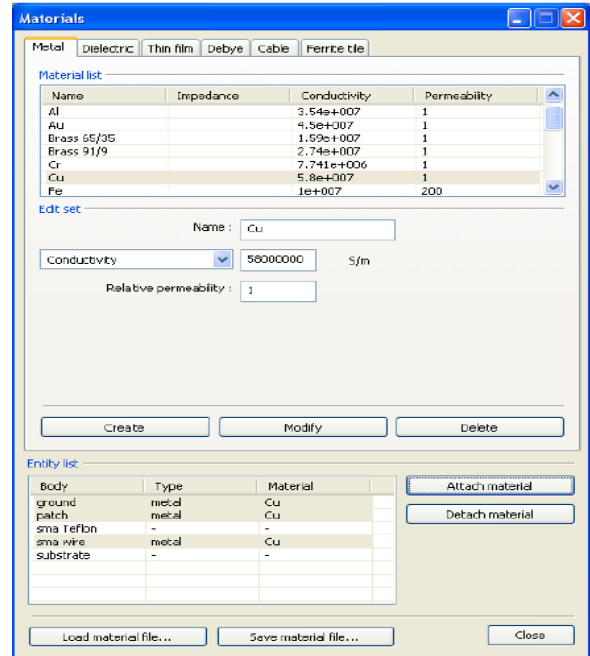
Step 7: To set electromagnetic parameters:

Construct the geometry of the patch antenna. The next step is to describe the electromagnetic parameters of the model.



Step 8: To define material parameters:

Define the materials used in the design and attach them to the geometrical bodies created in the previous section.



Step 9: Result Analysis:

- ◆ Analyze the model and display the results in the CST MICROSTRIPES window.
- ◆ The results for the “return loss v/s frequency” will automatically be displayed.

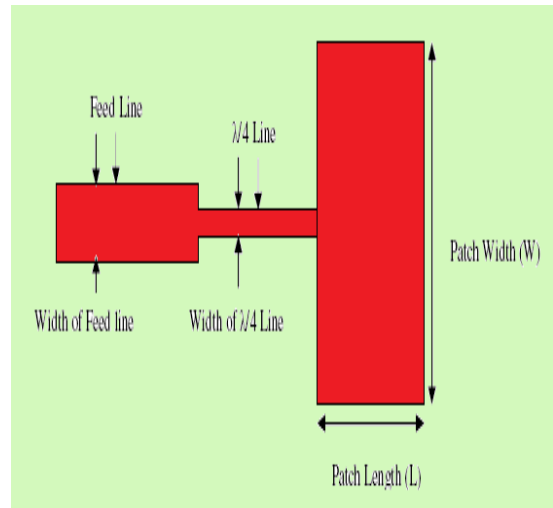


Fig. 5: Antenna Design with Feed-line, Patch & Transformer

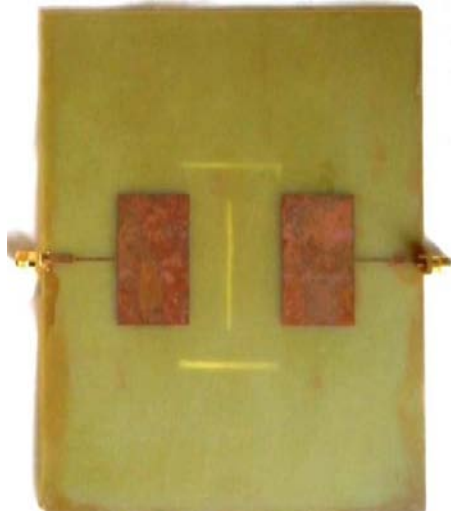


Fig. 6: Designed Antenna Array Structure

X. CONCLUSION

- ◆ The Microstrip Patch Antenna Array has been analyzed at the resonance frequency of 4.8 GHz for C-Band Wireless Communication Application and Services.
- ◆ Compactness, easy fabrication and cost effectiveness of the proposed antenna is useful for commercial wireless communication applications.
- ◆ The antenna array design consists of a feed-line (50 ohms), an impedance matching quarter-wave transformer and patch antenna elements for transmission and reception of the EM signals in the system.
- ◆ The length and width of the patch antenna elements are respectively 14.37 mm and 19 mm.
- ◆ The length and width of the feed-line is respectively 07 mm and 3.05 mm.
- ◆ The length and width of the quarter-wave transformer is respectively 8.76 mm and 1.66 mm.
- ◆ The FR-4 Substrate had the dimensions of 75 mm* 75 mm, with a height of 1.6 mm and a permittivity of 4.4.
- ◆ The antenna array has been designed & simulated over CST-Microstripes electromagnetic Simulator Software.
- ◆ The antenna and radiation efficiencies of over 90% have been obtained in the given wireless communication antenna array system.
- ◆ The antenna array design works successfully at 4.8 GHz for the C-Band Communication Service/System.

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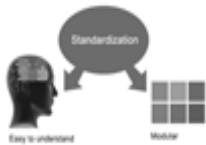
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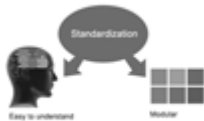


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- k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.



FORMAT STRUCTURE

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.



Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

PREPARATION OF ELETRONIC FIGURES FOR PUBLICATION

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

TIPS FOR WRITING A GOOD QUALITY ENGINEERING RESEARCH PAPER

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow [here](#).



6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.



21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.



Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.



Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.



Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

THE ADMINISTRATION RULES

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

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Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.



CRITERION FOR GRADING A RESEARCH PAPER (COMPILATION)
BY GLOBAL JOURNALS

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

| Topics | Grades | | |
|-------------------------------|--|---|--|
| | A-B | C-D | E-F |
| <i>Abstract</i> | Clear and concise with appropriate content, Correct format. 200 words or below | Unclear summary and no specific data, Incorrect form Above 200 words | No specific data with ambiguous information Above 250 words |
| <i>Introduction</i> | 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 |
| <i>Methods and Procedures</i> | 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 |
| <i>Result</i> | 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 |
| <i>Discussion</i> | 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 |
| <i>References</i> | Complete and correct format, well organized | Beside the point, Incomplete | Wrong format and structuring |



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