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Energy Audit, Management in Distribution System with and without Renewable Energy

By Megha Trivedi, Prof. Nilay Shah, Mr. Jay Dilipbhai Mathukiya
& Mr. Madhvesh Ramchandrabhai Panchal

Abstract- In this paper we have audited our collage Sardar Vallabhbhai Patel Institute of Technology (SVIT), Vasad. The total connected load of the institute is about 650KW which itself considered as a one of the major consumers of power. In order to reduce power consumption and conserve, energy audit has been taken place. A detail calculation is carried out with and without renewable energy source in the way that energy savings and financial benefit is achieved.

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Energy Audit, Management in Distribution System with and without Renewable Energy

Prof. Megha Trivedi ^α, Prof. Nilay Shah ^σ, Mr. Jay Dilipbhai Mathukiya ^ρ
& Mr. Madhvesh Ramchandrabhai Panchal ^ω

Abstract- In this paper we have audited our collage Sardar Vallabhbhai Patel Institute of Technology (SVIT), Vasad. The total connected load of the institute is about 650KW which itself considered as a one of the major consumers of power. In order to reduce power consumption and conserve, energy audit has been taken place. A detail calculation is carried out with and without renewable energy source in the way that energy savings and financial benefit is achieved.

I. INTRODUCTION

In 21st century energy saving is one of most important things because in human life after food, shelter & clothing another most important thing is energy. Industries, college, school, malls, restaurants etc. are major load consuming components in electrical system. The demand of electricity is increases day by day but we have limited source for power generation. So, it becomes necessary to save energy and use it where is required.

Audit help us to find energy losses and proper solution for energy conservation of any energy related system. Hence, we have taken initiative to study the same for our institute named as Sardar Vallabhbhai Patel Institute of Technology-Vasad (SVIT-Vasad).

The SVIT is organized by The New English School trust (NEST), and it was established in 1997 on the banks of the river Mahi at Vasad-Gujarat. As on date, SVIT Vasad has technical courses i.e. engineering, Computer applications and architecture. It is observed that, this campus was facing over loading condition during peak hours, due to that the main switch at distribution panel was tripping frequently since from june-2017. Hence this energy audit was aimed at obtaining a detailed idea about the various end use energy consumption activities and detecting, computing and evaluating the possible energy saving opportunities.

II. SYSTEM DISCRPTION

The SVIT purchase power supply from GEB situated at Jarod Substation (11kV). This power is utilizing at a supply voltage of 440V, which is step down with a distribution transformer. The contract demand of

collage is 350KVA and average power consumption of 28,000KW per month. This institute implemented a tariff plan name as HTP-I. SVIT has also its own DG set, which is rated as 125 KVA, 415 V. During normal use, the power is consumed from GEB supply however during meetings, seminars and events DG set is switched on to avoid any kind of disturbance due to power cut-off. Hence, the distribution system of college run on GEB supply and DG set.

III. PROCEDURE

a) Initiative

The initiative of audit starts with an idea and the aim for energy saving. With proper guidance of faculties, the audit starts. Permission should be taken of either head of department or principal for further procedure of audit.

b) Preparation Data sheet

Audit starts with collecting data. The data should be collected is like

- Name of department
- Floor
- Name of class or laboratory
- Name of equipment
- Total numbers of equipment in every class or lab
- Load of that equipment
- Power consumption of every equipment every day every month and a year

This all data will be prepared on excel sheet. After preparing data sheet analysis of that data starts.

c) Analysis of data

The data sheet that we have prepared will give the total load and power consumption of every department, every equipment, every floor, every class and laboratory independently. So, we can find load or power consumption of any class or floor or department easily.

So, in the analysis we find total connected load of every department and every equipment. We make different bar chart and pie chart for the better interpretation of load distribution.

All charts will help us to understand where the more energy is going and which equipment is using more energy. So that we can find better replacement of it.

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d) Calculation for equipment replacement

When the more energy used equipment is found. The calculation for more energy efficient equipment is done for same. The energy saving, pay-back period and financial benefit is found for every equipment.

e) Calculation for Renewable energy source replacement

Which renewable sources are efficient, easily available and cost effective is to be found out? The energy saving, pay- back period and financial benefit is estimated to fulfil the energy demand of college by renewable energy sources.

f) Recommendations

The proper recommendations will be given to authorities or trustees about replacement, maintenance and green energy advantages with energy saving and financial benefit data.

IV. ANALYSIS OF DATA

Once audit is completed, analysis of data sheet starts. Using data, we create pie chart and bar chart for proper understanding of load distribution, energy flow and power consumption.

Here we have made different pie chart and bar char for understanding our audited data.

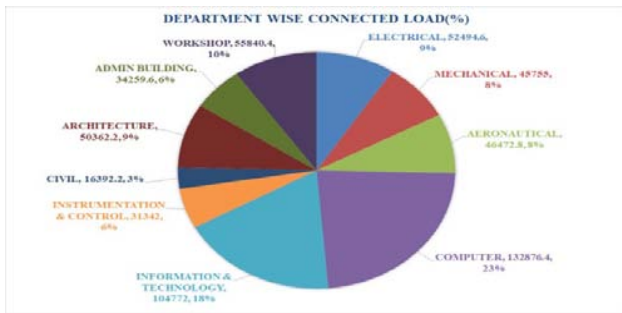


Fig. 1: Pie chart of Department wise connected load

In Fig.1 we have shown the load connected in every department. It is percentage for apprehend of which department has more connected load. The real calculated data is shown aside of percentage.

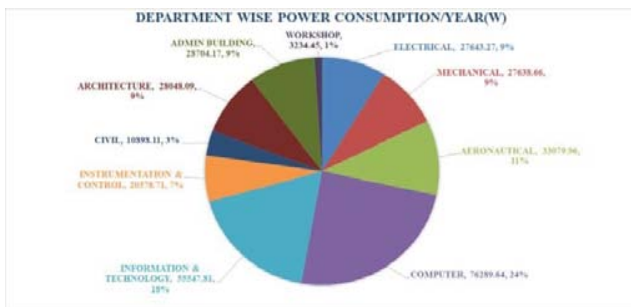


Fig. 2: Pie chart of Department wise power consumption per year

In Fig.2 we have shown actual power consumption of every department. The purpose of this pie chart is to interpret how much power is consumed by every department throughout a year and how much it is in percentage from total power consumption of college. The aside calculated data will help to determine which department is consuming more power and how we can reduce them.

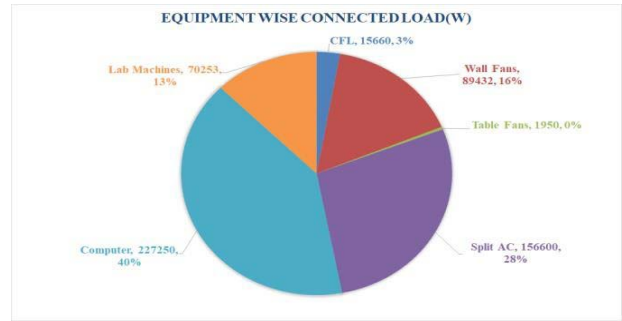


Fig. 3: Pie chart of Equipment wise connected load

From Fig.3 we can know that how much load is connected in college of every equipment. It shows that which equipment has more load.

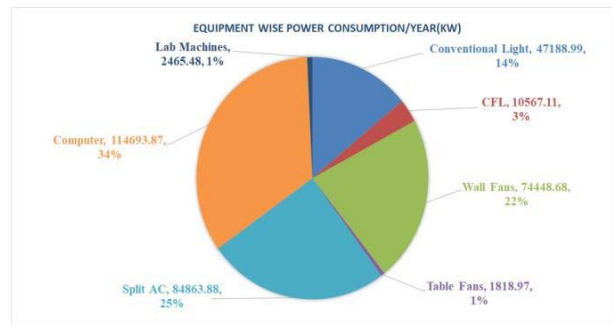


Fig. 4: chart of Equipment wise power consumption per year (in KW)

This pie chart Fig. will inform us about actual power consumed by every equipment. The comparison of Fig.3 and Fig.4 will show us how much difference is in between the connected load of an equipment and actual power consumption of it and we can see that there is a quite difference between them.

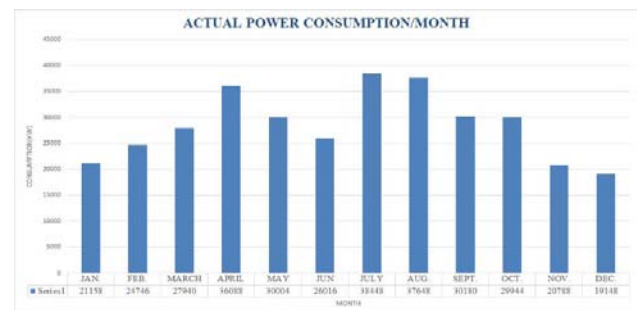


Fig. 5: Actual power consumption of college per month

Also Fig.4 will helps to determine which equipment is using more power and how can we reduce them.

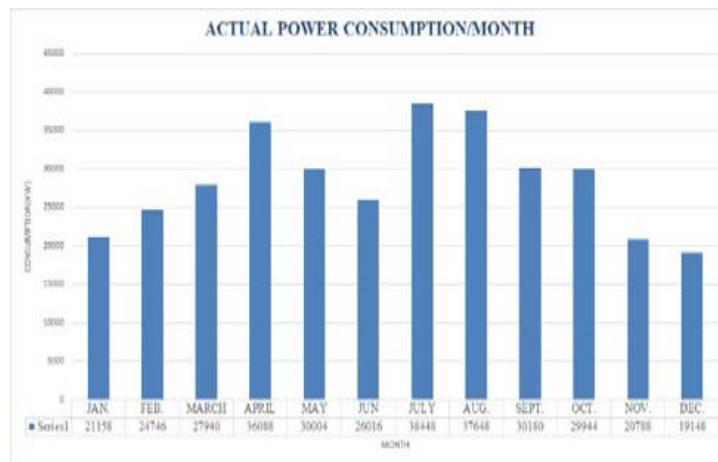


Fig. 5: A ctual power consumption of college per month

The Fig.5 shows the actual power consumption of college which is obtained by the light bill of year 2078-18.

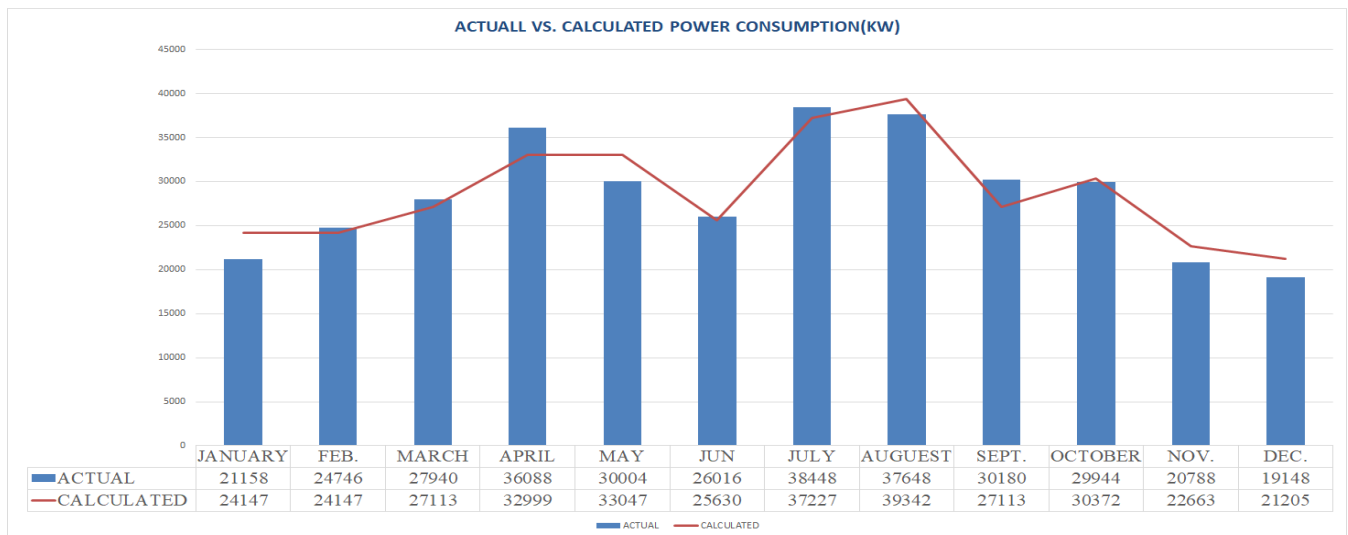


Fig. 6: Actual Vculated power consumption of college every month

The fig.6 is indicating the difference between actual power consumption data obtain by light bill and calculated by us. With line and bars, the difference observed clearly and this will help us to find error in our calculation and make it more efficient.

After analysing all the data and graphs we can know how we will reduce power consumption with minimum capital cost, more energy saving and for longer period.

Now the calculation is made for power savings by replacing aged equipment with new and energy efficient equipment for example replacing old Tube light

and CFL with LED tube light effectively reduces power consumption and saves light bill cost. The same calculation is made for all the equipment who has higher power consumption.

As an example, the calculation for replacing Tube light with LED is shown further down

V. CALCULATION FOR EQUIPMENT REPLACEMENT

In this portion we calculate exactly how much energy we can save and how much financial profit will

made with the help of capital cost and pay back period. Here we took tube light replacement example for understanding.

- Comparison Between Conventional light and LED light

Total No. of Lights = 1120

	Tube light	LED light
Power Consumption/hour	55 W	25 W
Power Consumption/year	50000 KW	22000 KW
Life Span	1.5 Years	5 Years
Cost	20 Rs/pc	400 Rs/pc

$$\begin{aligned} \text{Savings per Year} &= 50,000 - 22,000 \\ &= 28,000 \text{ KW/year} \end{aligned}$$

$$\begin{aligned} \text{Savings per Year in Rupee} &= \text{cost per unit} \times \text{no. of units} \\ &= 7 \times 28000 \\ &= ₹ 2,00,000 \end{aligned}$$

For 5-year span

$$\text{Capital Cost of tube light} = \frac{\text{Span} \times \text{Capital cost} \times \text{Total no of lights}}{\text{Life span of light}}$$

$$\begin{aligned} &= \frac{5 \times 20 \times 1120}{1.5} \\ &= ₹ 75,000 \end{aligned}$$

$$\begin{aligned} \text{Capital Cost of LED light} &= \frac{5 \times 400 \times 1120}{5} \\ &= ₹ 4,48,000 \end{aligned}$$

$$\begin{aligned} \text{Total Savings in 5 year} &= 200000 \times 5 \\ &= ₹ 10,00,000 \end{aligned}$$

$$\begin{aligned} \text{Pay-back Period} &= \frac{\text{Net investment of capital cost}}{\text{Net annual Savings}} \\ &= \frac{448000}{200000} \\ &= 2.25 \text{ Years} \end{aligned}$$

$$\begin{aligned} \text{Return on Investment} &= \frac{\text{Net annual return}}{\text{Capital Investment}} \times 100\% \\ &= \frac{200000}{448000} \times 100\% \\ &= 40\% \end{aligned}$$

$$\begin{aligned} \text{Total Savings in 5 years} &= 1000000 - 448000 \\ &= ₹ 5,52,0 \end{aligned}$$

The above calculation shows us how much energy we can save by just replacing Tube lights with LED. It also shows us the amount we can save in the period of five years.

The same calculation is done for all other equipment replacement like 3-star air conditioner to 5-star air conditioner, large power using computers to less energy using and compact computers or laptops etc.

VI. CALCULATION FOR RENEWABLE ENERGY SOURCE REPLACEMENT

There are many renewable energies sources are available in present but for college solar source is most efficient way for energy generation Then any other renewable energy source.

In order to generate renewable energy for college some parameters should be known like,

- Area available for solar panel implementation
- Maximum power demand of college per day and per month
- Minimum power demand of college per day and per month.
- Average Solar power generation in that area in every season

The below shown table is a calculation of 1 KW solar panel

Area required	1 m ²
Minimum generation	3.5 KW
Maximum generation/day	7 KW
Average generation/day	4.5 KW

The next table is the energy requirement of college.

Minimum demand/day	1000KW
Maximum demand/day	1900KW
Maximum demand/month	20,000 KW
Maximum demand/month	38,500 KW

So, the capacity of solar panels that should be installed to generate power enough to satisfy maximum demand of college is 320KW.

With time load will increase, so does demand and power consumption. So, with the consideration of future demand the solar panels that should be install have capacity of at list 350KW.

The 1KW solar panel cost around ₹ 40,000. So,
 Cost of 350KW solar panel = 350×4000
 = ₹ 1,40,00,000

The annual cost of power consumption = ₹ 40,00,000
 Above cost of power consumption of college if referred using college light bills.

$$\text{Pay back period} = \frac{14000000}{4000000} = 3.5 \text{ years}$$

Return on investment = 28.5 %

The above calculation is made base upon to fulfil maximum demand of college.

College don't get use the generated power. the generated power directly goes to GEB. The Gujarat Electric Board gives reduction in tariff of light bill.

The GEB gives reduction of ₹3 per unit generated. The power generation capacity of whole campus is 600KW.

Here the solar panel is mounted on the roof top of all department and admin building.

Tariff of GEB	₹ 3/unit
Generation capacity	600KW
Generation of 1KW panel	1,600KW/year
Cost of 1KW panel	₹ 40,000

$$\begin{aligned} \text{Total generation capacity} &= 600 \times 1600 \\ &= 96,000 \text{ KW/year} \\ \text{Tariff reduction in a year} &= 96000 \times 3 \\ &= 28,80,000 \text{ ₹/year} \end{aligned}$$

So, every year there will be savings of 96,000KW power and ₹28,80,000 in tariff.

$$\begin{aligned} \text{Capital cost of 600KW panels} &= 600 \times 40000 \\ &= ₹ 2,40,00,000 \end{aligned}$$

$$\begin{aligned} \text{Pay-back period} &= \frac{24000000}{2880000} \\ &= 8 \text{ years and 2 months} \end{aligned}$$

$$\text{Return on investment} = 12 \%$$

- Another energy saving, we found while referring light bill of college

The contract demand of college is 350KVA and college have to pay fix charge to GEB of 85% of contract demand every month.

The actual consumption is very less.

Contract demand	350KVA
85% of demand	300KVA
Fixed charge/KVA	150 ₹
Actual consumption	180KVA

From the table just by reducing the contract demand we can save 18,000 ₹/month.

In summary of this calculation

	Savings	Pay- back period	Return on investment
Tube light replacement	1,10,000 ₹/year	2.25 years	40%
Renewable energy replacement (satisfying maximum demand)	40,00,000 ₹/year	3.5 years	28.5%
Renewable energy replacement (reduction in tariff)	28,80,000 ₹/year	8.1 years	12%
Contract KVA reduction	2,16,000 ₹/year	-	-

VII. CONCLUSION

From our comparative study, it can be proven that with the use of LED in place of tube light, the energy is saved up to 28,000KW which in turn a saving of 1.1 lakh per year is achieved. Another study shown that, with the penetration of renewable energy can also save energy up to 96,000KW per year which plays the major

role in energy conservation. Hence, by reducing contract demand a saving of 2.16 lakh per year is gained. Installing an automatic power factor control panel will also reduce tariff.

The analysis brings an entry point of new energy planner. It is also significant to reduce energy consumption and power losses.

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Double Swept Band Selective Excitation

By Navin Khaneja

Abstract- The paper describes the design of band selective excitation and rotation pulses in high-resolution NMR by the method of double sweep. We first show the design of a pulse sequence that produces band selective excitation to the equator of the Bloch sphere with phase linearly dispersed as frequency. We show how this linear dispersion can then be refocused by nesting free evolution between two adiabatic inversions (sweeps). We then show how this construction can be generalized to give a band selective x rotation over a desired frequency band. Experimental excitation profiles for the residual HDO signal in a sample of 99.5% D_2O are obtained as a function of resonance offset.

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Double Swept Band Selective Excitation

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Abstract- The paper describes the design of band selective excitation and rotation pulses in high-resolution NMR by the method of double sweep. We first show the design of a pulse sequence that produces band selective excitation to the equator of the Bloch sphere with phase linearly dispersed as frequency. We show how this linear dispersion can then be refocused by nesting free evolution between two adiabatic inversions (sweeps). We then show how this construction can be generalized to give a band selective x -rotation over a desired frequency band. Experimental excitation profiles for the residual HDO signal in a sample of 99.5% D₂O are obtained as a function of resonance offset.

I. INTRODUCTION

Frequency-selective pulses have widespread use in magnetic resonance and significant effort has been devoted to their design [1]-[46]. Several experiments in high-resolution NMR and magnetic resonance imaging require radiofrequency pulses which excite NMR response over a prescribed frequency range with negligible effects elsewhere. Such band-selective pulses are particularly valuable when the excitation is uniform over desired bandwidth and of constant phase.

In this paper, we propose a new approach for the design of a uniform phase, band selective excitation and rotation pulses. In this approach, using Fourier series, a pulse sequence that produces band selective excitation to the equator of the Bloch sphere with phase linearly dispersed as the frequency is designed. This linear dispersion is then refocused by nesting free evolution between two adiabatic inversions (sweeps). This construction is generalized to give a band selective x -rotation over desired bandwidth. We assume uncoupled spin $\frac{1}{2}$ and neglect relaxation.

Since we use adiabatic sweeps, it should be mentioned that adiabatic sweeps have been previously employed in NMR for producing band selective excitation as in AB-STRUSE pulse sequence [47] and for broadband excitation as in CHORUS [50] and chirp spectroscopy [48, 49].

The paper is organized as follows. In section 2, we present the theory behind double swept **bandselective** **excitation**, we call **BASE**. In section 3, we present simulation results and experimental data for band selective excitation and rotation pulses designed using double sweep technique. Finally, we conclude in section 4, with discussion and outlook.

II. THEORY

We consider the problem of band selective excitation. Consider the evolution of the Bloch vector X (We use Ω_α to denote the rotation matrix, such that $\alpha \in \{x, y, z\}$) of a spin $\frac{1}{2}$, in a rotating frame, rotating around z -axis at Larmor frequency.

$$\frac{dX}{dt} = (\omega\Omega_z + A(t) \cos \theta(t)\Omega_x + A(t) \sin \theta(t)\Omega_y)X, \quad (1)$$

where $A(t)$ and $\theta(t)$ are amplitude and phase of rf-pulse, and we normalize the chemical shift, $\omega \in [-1, 1]$. In what follows, we choose phase $\sin \theta(t) = 0$ and let

$$\frac{dX}{dt} = (\omega\Omega_z + u(t)\Omega_x)X, \quad (2)$$

where $u(t)$ is the amplitude modulated pulse for $t \in [0, T]$.

Going into the interaction frame of chemical shift, using

$$Y(t) = \exp(-\omega(t - \frac{T}{2})\Omega_z)X(t),$$

we obtain,

$$\frac{dY}{dt} = u(t)(\cos \omega(t - \frac{T}{2}) \Omega_x - \sin \omega(t - \frac{T}{2}) \Omega_y)Y; \quad Y(0) = \exp(\omega\Omega_z \frac{T}{2})X(0). \quad (3)$$

We design $u(t)$, such that for all $\omega \in [-B, B]$, we have

$$\int_0^T u(t) \cos \omega(t - \frac{T}{2}) dt \sim \theta, \quad \int_0^T u(t) \sin \omega(t - \frac{T}{2}) dt = 0. \quad (4)$$

Divide $[0, T]$ in intervals of step Δt , over which $u(t)$ is constant. Call these amplitudes, $\{u_{-M}, \dots, u_{-k}, \dots, u_0\}$ over $[0, \frac{T}{2}]$ and $\{u_0, \dots, u_k, \dots, u_M\}$ over $[\frac{T}{2}, T]$.

$$\int_0^T u(t) \cos \omega(t - \frac{T}{2})dt \sim (u_0 + \sum_{k=-M}^M u_k \cos(\omega k \Delta t))\Delta t, \quad (5)$$

where write $\Delta t = \frac{\pi}{N}$ and choose $u_k = u_{-k}$. This insures that sine equation in Eq. (4) above is automatically satisfied. Then we get,

$$\int_0^T u(t) \cos \omega(t - \frac{T}{2})dt \sim 2 \sum_{k=0}^M u_k \cos(\omega k \Delta t)\Delta t = 2 \sum_{k=0}^M u_k \cos(kx)\Delta t, \quad (6)$$



where for $x \in [-\frac{B\pi}{N}, \frac{B\pi}{N}]$, we have $2 \sum_{k=0}^M u_k \cos(kx) \Delta t \sim \theta$ and 0 for x outside this range. This is a Fourier series, and we get the Fourier coefficients as,

$$u_0 = \frac{B\theta}{2\pi} ; \quad u_k = \frac{2\theta \sin(\frac{k\pi B}{N})}{\pi \frac{2k\pi}{N}}. \tag{7}$$

For $\theta = \frac{\pi}{2}$, we get,

$$u_0 = \frac{B}{4} ; \quad u_k = \frac{\sin(\frac{Bk\pi}{N})}{\frac{2k\pi}{N}}. \tag{8}$$

In Eq. (3), using small flip angle θ , we approximate,

$$Y(T) \sim \exp\left(\int_0^T u(t) \cos \omega(t - \frac{T}{2}) dt \Omega_x\right) Y(0). \tag{9}$$

Starting from the initial state $X(0) = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$, we have from Eq. 3,

$$X(T) \sim \exp\left(\frac{\omega T}{2} \Omega_z\right) \exp\left(\int_0^T u(t) \cos \omega(t - \frac{T}{2}) dt \Omega_x\right) \exp\left(\frac{\omega T}{2} \Omega_z\right) X(0) \sim \exp\left(\frac{\omega T}{2} \Omega_z\right) \exp\left(\frac{\pi}{2} \Omega_x\right) X(0), \tag{10}$$

for $\omega \in [-B, B]$. There is no excitation outside the desired band.

This state is dephased on the Bloch sphere equator. We show, how using a double adiabatic sweep, we can refocus this phase. Let $\Theta(\omega)$ be the rotation for a adiabatic inversion of a spin. We can use Euler angle decomposition to write,

$$\Theta(\omega) = \exp(\alpha(\omega) \Omega_z) \exp(\pi \Omega_x) \exp(\beta(\omega) \Omega_z). \tag{11}$$

The center rotation should be π , for $\Theta(\omega)$ to do inversion of $\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \rightarrow \begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix}$.

We can use this to refocus the forward free evolution. Observe

$$\Delta(\omega, \frac{T}{2}) = \exp\left(-\frac{\omega T}{2} \Omega_z\right) = \Theta(\omega) \exp\left(\frac{\omega T}{2} \Omega_z\right) \Theta(\omega). \tag{12}$$

Then

$$\Theta(\omega) \exp\left(\frac{\omega T}{2}\Omega_z\right) \Theta(\omega)X(T) \sim \exp\left(\frac{\pi}{2}\Omega_x\right)X(0), \tag{13}$$

which is a bandselective excitation.

In summary, the pulse sequence consists of a sequence of x-phase pulses, which produce for $\omega \in [-B, B]$, the evolution

$$U(\omega, \theta) = \exp\left(\frac{\omega T}{2}\Omega_z\right) \exp(\theta\Omega_x) \exp\left(\frac{\omega T}{2}\Omega_z\right), \tag{14}$$

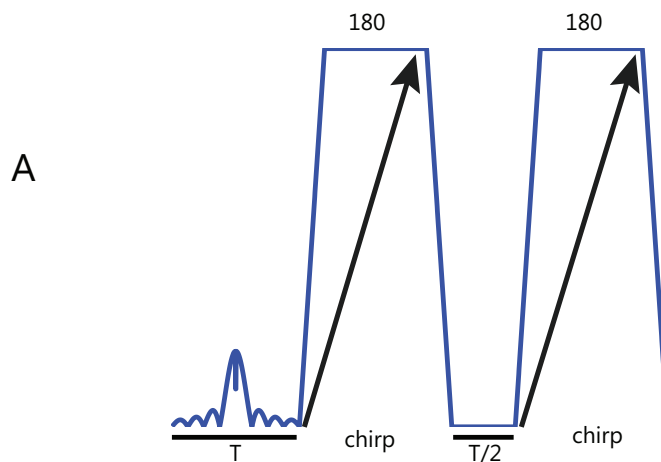
where $\theta = \frac{\pi}{2}$, as described above, followed by a double sweep rotation $\Delta(\omega, \frac{T}{2})$. This required a peak amplitude of $u(t) \sim \frac{B}{2}$. Fig. 1A shows the pulse sequence for $B = \frac{1}{5}$. The sweep(chirp) is done with a peak amplitude of $\frac{1}{2}$, $T = 40\pi$.

We talked about band selective excitations. Now we discuss band selective $\frac{\pi}{2}$ rotations. This is simply obtained from above by an initial double sweep. Thus

$$U_1 = \Delta\left(\omega, \frac{T}{2}\right) U\left(\omega, \frac{\pi}{2}\right) \Delta\left(\omega, \frac{T}{2}\right), \tag{15}$$

is a $\frac{\pi}{2}$ rotation around the x -axis. Fig. 1B shows the band selective rotation pulse sequence for $B = .2$. The chirp is done with a peak amplitude of $\frac{1}{2}$, $T = 40\pi$.

If there is rf-inhomogeneity, then Eq. (2) takes the form $\frac{dX}{dt} = (\omega\Omega_z + \epsilon u(t)\Omega_x)X$, where ϵ is inhomogeneity parameter which takes value 1 in the ideal case. The evolution in Eq. (10) then takes the form $X(T) \sim \exp\left(\frac{\omega T}{2}\Omega_z\right) \exp\left(\epsilon\frac{\pi}{2}\Omega_x\right)X(0)$. The excitation angle is therefore linearly effected by rf-inhomogeneity.



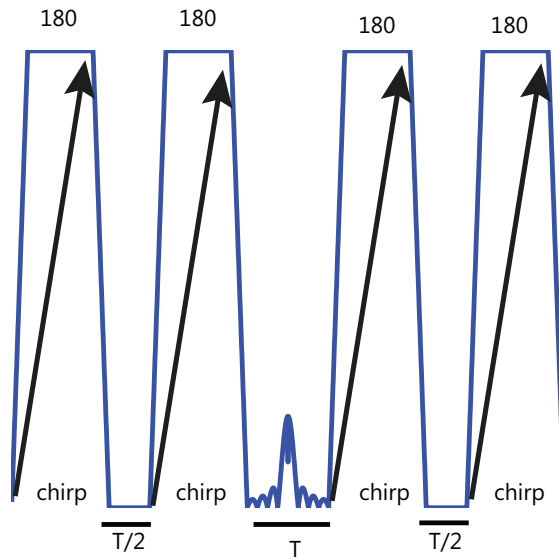


Figure 1: Fig. A, shows the **BASE** pulse sequence (amplitude) with a double sweep that performs band selective excitation as in Eq. (13) for $B = \frac{1}{5}$. Fig. B, shows the **BASE** pulse sequence with two double sweeps that performs band selective rotation as in Eq. (15) for $B = \frac{1}{5}$.

III. SIMULATIONS

We normalize ω in Eq. (1), to take values in the range $[-1, 1]$. We choose time $\frac{T}{2} = M\pi$, where we choose $M = 20$ and $N = 10$ in $\Delta t = \frac{\pi}{N}$ in Eq. (5). Choosing $\theta = \frac{\pi}{2}$ and coefficients u_k as in Eq. (8), we get the value of the Eq. (6) as a function of bandwidth as shown in left panel of Fig. 2 for $B = .2$. This is a decent approximation to $\frac{\pi}{2}$ over the desired bandwidth. The right panel of Fig. 2, shows

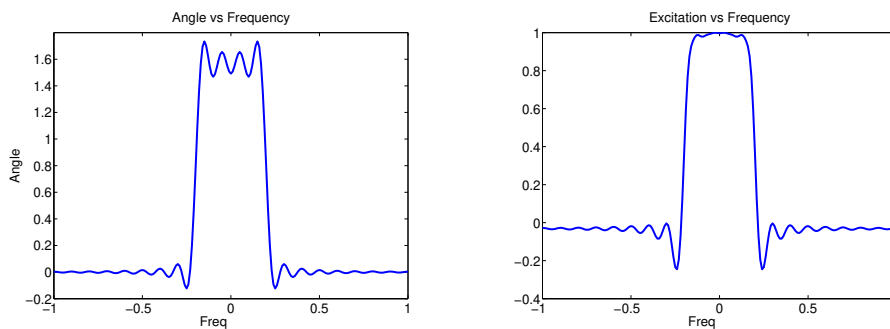


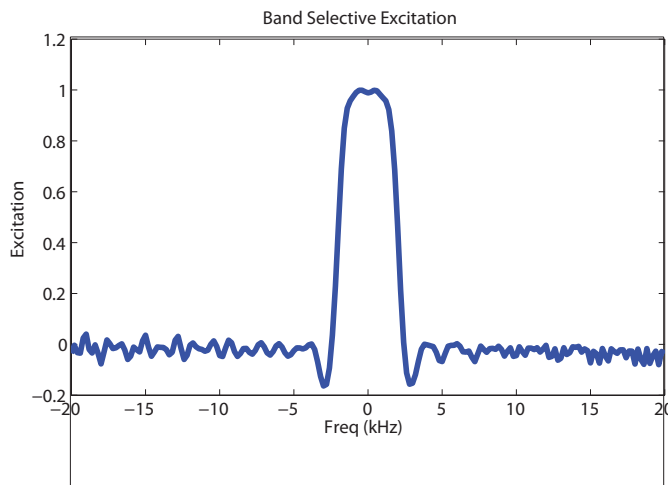
Figure 2: Left panel shows the value of the Eq. (6) as a function of bandwidth when we choose $T = 40\pi$ and $\Delta t = \frac{\pi}{10}$, $B = \frac{1}{5}$. The right panel shows the excitation profile i.e., the $-y$ coordinate of the Bloch vector, after application of the pulse in Eq. (13), with u_k

the excitation profile i.e., the $-y$ coordinate of the Bloch vector after application of the pulse in Eq. (13), where we assume that adiabatic inversion is ideal. The peak rf-amplitude $A \sim \frac{B}{2}$ for $B = .2$.

Next, we implement the nonideal adiabatic sweep with a chirp pulse, by sweeping from $[-1.5, 1.5]$ in 300 units of time. This gives a sweep rate $\frac{1}{100} \ll A^2$, where $A = \frac{1}{2}$. The chirp pulse is depicted in Fig. 1. The chirp operates at its peak amplitude over sweep from $[-1, 1]$. The resulting excitation profile of Eq. (13) is shown in Fig. 3 A, where we show the $-y$ coordinate of the Bloch vector. After scaling, $\omega \in [-20, 20]$ kHz, $B = 2$ kHz and $A = 10$ kHz, this pulse takes 6.27 ms. In Fig. 3 B, and 3 C, we have $B = 4$ kHz and $B = 8$ kHz respectively. The pulse time is same 6.27 ms. $T = 1$ ms in Fig. 1A.

Next, we simulate the band selective x rotation as in Eq. (15). This requires to perform double sweep twice as in Eq. (15). Adiabatic sweep is performed as before. The resulting excitation profile of Eq. (15) is shown in Fig. 4 A,B and C, where we show the z coordinate of the Bloch vector starting from initial $y = 1$ for $B = [-2, 2]$ kHz, $B = [-4, 4]$ kHz and $B = [-8, 8]$ kHz respectively. This pulse takes 11.54 ms in each case.

A



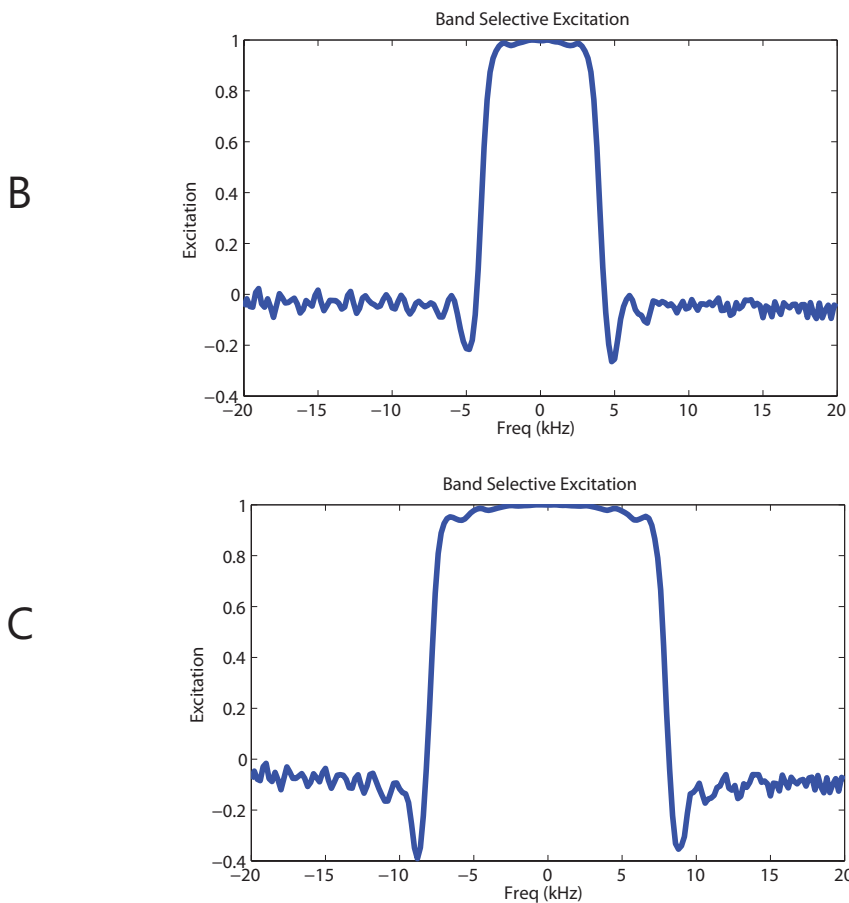
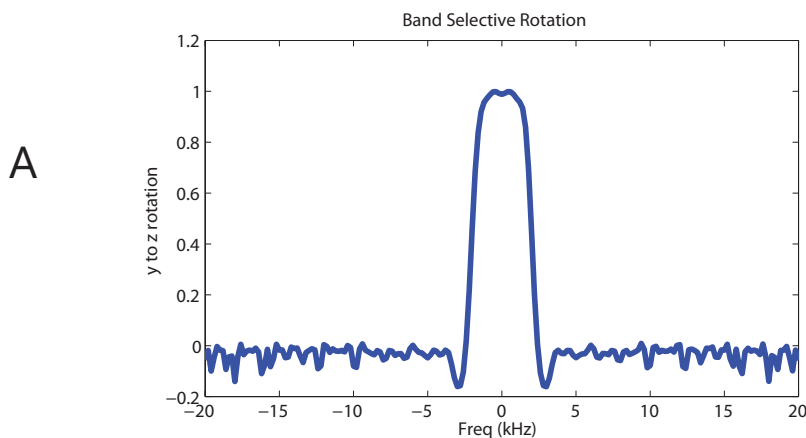
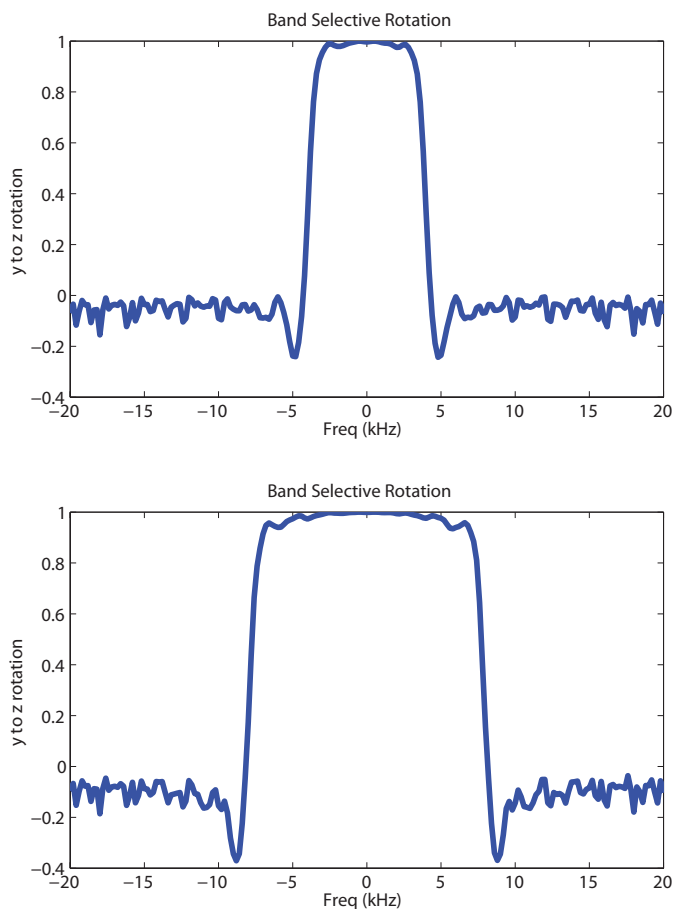


Figure 3: Fig. A, B, C shows the excitation profile (the $-y$ coordinate of Bloch vector) for the **BASE** pulse in Eq. (13) with $B = [-2, 2]$ kHz, $B = [-4, 4]$ kHz and $B = [-8, 8]$ kHz, respectively. The peak amplitude is $A = 10$ kHz. Time of the pulse is 6.27 ms. $T = 1$ ms in Fig. 1A.

a) Experimental

All experiments were performed on a 750 MHz (proton frequency) NMR spectrometer at 298 K. Fig. 5 shows the experimental excitation profiles for the residual HDO signal





C

Figure 4: Fig. A, B, C shows the y to z rotation profile (the z coordinate of Bloch vector) for the band selective x rotation pulse in Eq. (15) with $B = [-2, 2]$ kHz, $B = [-4, 4]$ kHz and $B = [-8, 8]$ kHz, respectively. The peak amplitude is $A = 10$ kHz. Time of the pulse is 11.54 ms. $T = 1$ ms in Fig. 1B.

in a sample of 99.5% D_2O displayed as a function of resonance offset. Fig. 5A, B, C shows the excitation profile of **BASE** sequence in Fig. 3 A, B, C respectively. The frequency band of interest is $[-2, 2]$ kHz, $[-4, 4]$ kHz and $[-8, 8]$ kHz respectively. In each case, the peak amplitude of the rf-field is 10 kHz and duration of the pulse is 6.27 ms. The pulse sequence uses one double sweep. $T = 1$ ms in Fig. 1A. To show the performance of the **BASE** sequence as a function of frequency, the offset is varied over a range of $[-20, 20]$ kHz with on-resonance at 3.53 kHz (4.71 ppm).

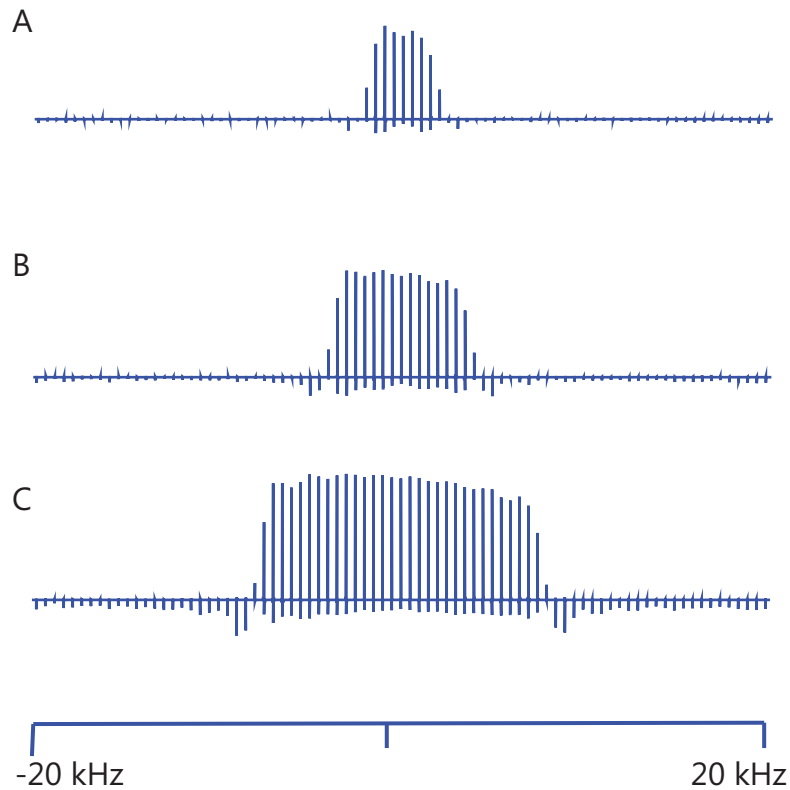
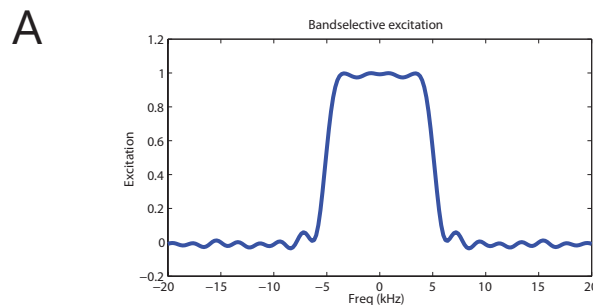


Figure 5: Fig. A, B, C show the experimental excitation profile of **BASE** sequences in Fig. 3A,B and C, respectively, with $B = [-2, 2]$ kHz, $B = [-4, 4]$ kHz and $B = [-8, 8]$ kHz, respectively, in a sample of 99.5% D₂O. The offset is varied over the range as shown and the peak rf power of all pulses is 10 kHz. The duration of the pulses is 6.27 ms.

IV. CONCLUSION

In this paper we showed design of band selective excitation and rotation pulses (**BASE**). We first showed how by use of Fourier series, we can design a pulse that



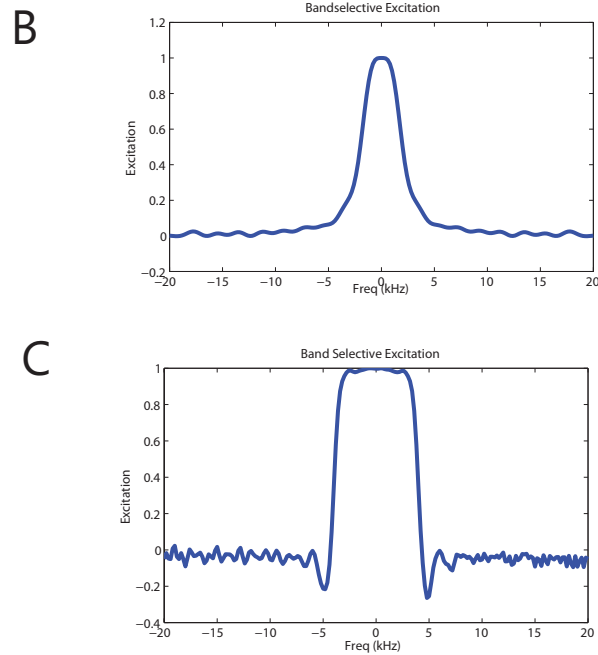


Figure 6: Fig. A, B, C show the simulations of excitation profile of **BURP**, **SNOB** and **BASE** sequences respectively. The excitation bandwidth of **BURP** sequence is $[-4, 4]$ kHz and is .5 ms sequence. The excitation bandwidth of **SNOB** sequence is $[-2.8, 2.8]$ kHz and is .5 ms sequence. The excitation bandwidth of **BASE** sequence is $[-4, 4]$ kHz and is 6.27 ms sequence.

does band selective excitation to the equator of Bloch sphere. The phase of excitation is linearly dispersed as function of offset, which is refocused by nesting free evolution between adiabatic inversion pulses. We then extended the method to produce band selective rotations. The pulse duration of the pulse sequences is largely limited by time of adiabatic sweeps. This increases, if we have larger working bandwidth. However, for very large bandwidths, we may invert only the band of interest. Thereby, we may be able to reduce the time of the proposed pulse sequences.

It is worthwhile, to compare the **BASE** sequence, with state of the art pulse sequences like **BURP** [22] and **SNOB** [32]. In **BURP** and **SNOB**, the pulse sequence is amplitude modulated, with amplitude $u(t)$, parameterized through a Fourier series as,

$$u(t) = \frac{2\pi}{T} \left(a_0 + \sum_{k=1}^n a_k \cos \frac{2\pi kt}{T} + b_k \sin \frac{2\pi kt}{T} \right),$$

where T is pulse duration and the Fourier coefficients a_k, b_k are determined by a simulated annealing optimization procedure [22]. Fig. 6 shows the simulations of excitation profile of **BURP**, **SNOB** and **BASE** sequences. The transition from passband to stopband is much sharper for the **BASE** sequence. Although Fourier series appears in all these sequences, its manifestation in **BASE** is very different from **BURP** and **SNOB**, making it possible to analytically design rather than numerically optimize.

The principle merit of the proposed **BASE** pulse sequence is the analytical tractability and conceptual simplicity of the design.

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Transformer Protection using PLC and GSM Technology

By Megha A Trivedi, Mr. Shivang Dalvi, Mr. Ravi Devaiya,
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Abstract- Distribution transformers of substation are one of the most important equipment in power system network. Because of, the large number of transformers and various components over a wide area in power systems, the data acquisition, condition monitoring, automatic controlling are the important issues. This paper presents design and implementation of automatic control circuits which is used in PLC automation to monitor as well as diagnose condition of transformers, like load currents, temperature and voltages. The proposed on-line monitoring system integrates a solid state device named PLC (programmable logic controllers) and sensor packages. The suggested plc monitoring system will help to detect the internal fault as well as external fault of transformer and also diagnose these faults with the help of desired range of parameters which is setting by programme.

Keywords: *PLC, transformer, monitoring, protection, fault detection, relays, sensors, converter, GSM.*

GJRE-F Classification: *FOR Code: 290903*



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Transformer Protection using PLC and GSM Technology

Prof. Megha A Trivedi ^α, Mr. Shivang Dalvi ^σ, Mr. Ravi Devaiya ^ρ
Mr. Ridhin Raju ^ω & Mr. Yash Modi [¥]

Abstract- Distribution transformers of substation are one of the most important equipment in power system network. Because of, the large number of transformers and various components over a wide area in power systems, the data acquisition, condition monitoring, automatic controlling are the important issues. This paper presents design and implementation of automatic control circuits which is used in PLC automation to monitor as well as diagnose condition of transformers, like load currents, temperature and voltages. The proposed on-line monitoring system integrates a solid state device named PLC (programmable logic controllers) and sensor packages. The suggested plc monitoring system will help to detect the internal fault as well as external fault of transformer and also diagnose these faults with the help of desired range of parameters which is setting by programme.

Keywords: PLC, transformer, monitoring, protection, fault detection, relays, sensors, converter, GSM.

I. INTRODUCTION

Now day's protection of equipments in power system is a very important aspect. The power system equipments are valuable and important for well operation of power system network. A Transformer is such equipment which is one of the most important machines in the power system network. High reliability is must for a transformer even in adverse condition. For this condition PLC automation is used; various types of faults in a transformer can be detected and rectified. The Power system without a transformer is like a human without heart. So the protection of a transformer is of utmost importance. The Relays here are provided for sensing the fault current and provide the protection to the transformer. The user gets a message in the form of a SMS (short service message) with the help of a GSM module interfaced with a PLC.

II. FAULT DETECTION IN TRANSFORMER

a) Under Voltage

The under voltage fault is when the voltage value gets below some percentage of the rated value according to the countries electrical standards. Here in India according to IES the rated permissible voltage is as below

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- Above 33kV (-) 12.5% to (+) 10%.
- Up to 33kV (-) 9.0% to (+) 6.0%.
- Low voltage (-) 6.0% to (+) 6.0%

The faults can be detected using a voltage sensor or a Potential Transformer. So there is a PT connected to a transformer which steps down the voltage. The voltage is then converted to current through V to I converter and then that current is fed to the PLC. The fed current from the V to I converter will be in the range of 4 to 20 MA.

b) Over Voltage

The over voltage fault occurs when the value of voltage exceeds some percentage of the rated value as per the countries electrical standards. In India the electrical standards are as shown above.

Due to sudden disconnection of a large load there is possibility of an increase in voltage. Over voltage in the power system generally causes an increase in stress on the insulation of transformer. Here also PT is used which steps down the voltage. Then the voltage is converted to current using V to I converter. This output current from the V to I converter will be in the range of 4 to 20 MA.

c) Over Load/ Over Current

Over loading is when over current stats flowing on the secondary side of a transformer. The over load or the over current fault occurs when the current in a transformer exceeds its rated current value. Sometimes due to sudden increase in the load more amount of current gets drawn which is higher than the rated current of our transformer. This condition occurs for a very short time as it is a harmful condition for our transformer and is tripped rapidly. So a CT is used which steps down the current and gives input to our PLC in the range of 4 to 20 MA.

d) Temperature

When the temperature inside transformer goes above a rated value it is harmful for the windings. The transformer rated on a 24-hour average ambient temperature of 30°C (86°F). Increase in over current and over voltage leads to increase in the temperature of transformer oil which might weaken the breakdown strength of the winding insulation. This temperature increase can be a result of high current, seasonal change, region of operation. Due to high temperature

the insulation can break down and following which a short circuit may occur. This fault can be detected using a temperature transducer.

e) *Phase to Phase Fault*

This type of fault occurs when one phase gets shorted to the other. This gives rise to high current to flow compared to the earth fault current.

II. PLC (PROGRAMMABLE LOGIC CONTROLLERS)

1. Components of the PLC system

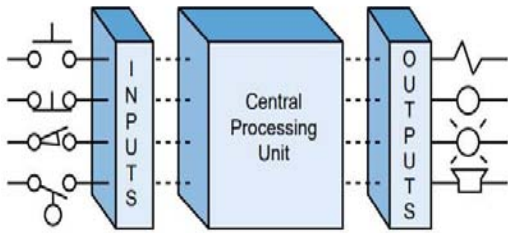


Figure 1: Programmable Controller Block diagram

a) *CPU or processor*

The main processor i.e. Central Processing Unit or CPU) is a microprocessor-based system that executes the control program after reading the status of inputs and then sends commands to outputs.

b) *I/O section*

The I/O modules or Input/output modules act as “Real Data Interface” between field and CPU. The PLC determines the real status of devices, and controls the devices by the means of the I/O cards.

c) *Programming device*

A CPU card can be connected with a programming device through a communication link via a programming port on the CPU.

d) *Operating station*

An operating station provides an “Operating Window” to the process. It is usually a separate device (generally a PC), That is loaded with HMI (Human Machine Interface) software.

III. PLC HARDWARE

The hardware of PLC is made of CPU, Memory, Input/output, Power supply unit, and programming device. Below is a diagram showing the components of PLC and its functioning.

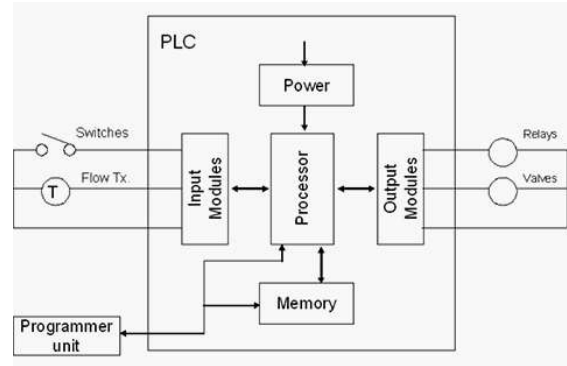


Figure 2: Hardware components of PLC

The heart of the “PLC” is in the centre, i.e. the Processor or CPU (Central Processing Unit)

- a) *The CPU* executes the PLC program, data storage, and data exchange with I/O modules. It processes the input data and according to program produces output data.
- b) *Input and output modules* are the medium for data exchange between devices and CPU. It tells CPU the exact status of devices and also acts as a medium to control them.
- c) *A programming device* is a PC loaded with programming software, which allows a user to create, transfer and make changes in the PLC software.
- d) *Memory* provides the storage media for the PLC program as well as for different data. The processed data is also stored in the memory only.
- e) *Power supply* is generally isolated. Most of the PLCs work at 220VAC or 24VDC.

IV. GSW



Figure 3: Sim 900A module

GSM: - Global System for Mobile communication (GSM) has been the best trustable and access wireless communication systems and is used widely. We can communicate with the user by using a mobile phone over GSM network. The GSM is interfaced

with a Programmable Logic Controller (PLC) and the GSM is connected to mobile phone.

The GSM sends data in the form of SMS (short message service) message to indicate if any fault occurs or if there is any abnormal condition. The GSM module can also send the user the status and alarms. This GSM Modem can accept any GSM network operator SIM card. Advantage of using this modem will be that you can use its RS232 port to communicate and develop embedded applications.

Applications like SMS Control, data transfer, remote control and logging can be developed easily. The modem can either be connected to PC serial port directly or to any microcontroller or PLC. It can be used to send and receive SMS. Components that are needed to interface the GSM with PLC are RS485 to RS232 converter, RS232 cable, SMPS for PLC power supply, GSM module and PLC.

V. DESIGN OF PLC BASED TRANSFORMER PROTECTION

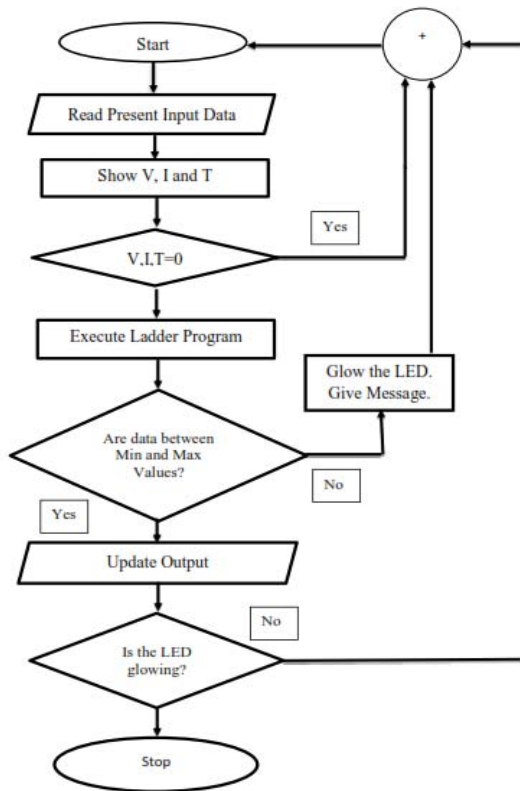


Figure 4: Block diagram of Transformer protection using PLC

The Transformer protection using PLC consists of different blocks of function as shown above.

a) CT

The current through the transformer is passed through CT and following which the CT steps down the current to the range of 4 to 20 MA.

b) Rectifier

The output of CT is connected to a rectifier and so the current is fed to the PLC after rectifying through a rectifier. Here Schottky diode is used for rectifying for low voltage drop by the rectifier. The normal diode has high voltage which decreases the accuracy.

c) PT

The voltage through the transformer steps down using a potential transformer. This voltage is then fed to the VI converter for PLC input

d) V to I converter

The VI converter converts the change in voltage to subsequent change in current.

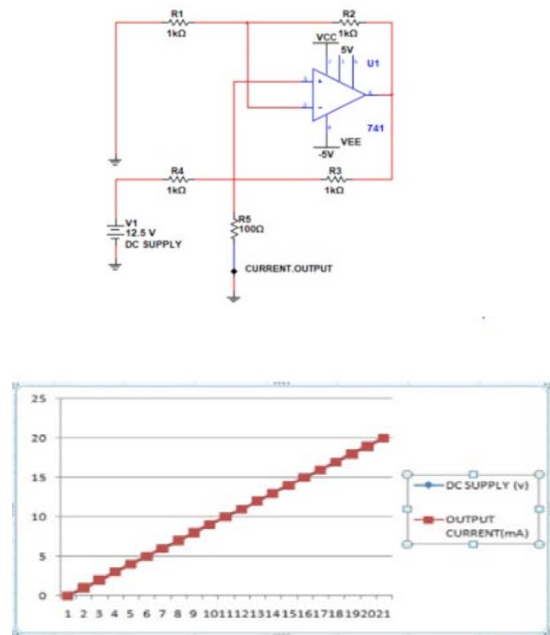


Figure 5: V to I converter circuit diagram and graph

The main need of the V to I converter is because the PLC we used only accepts current input in the analog channel with range of 4 to 20mA. The 1k ohm resistors across the op-amp converts the voltage to current by the means of ohms law and further the 1k ohm makes the rated current value up to 12mA.

e) Temperature transducer

The temperature transducer is used for sensing the temperature the sending the temperature data to the PLC to compare it with the reference set by the user in downloaded program.

f) PLC

The PLC is fed with the current and voltage through CT and VI converter in form of 4 to 20 MA. The program is downloaded to the PLC with the calculated reference of fault and to trigger the tripping command when the value exceeds the reference limit set by the user.

When the parameters being tested are in rated condition the the PLC will trigger the healthy output signal to the healthy system indicated LED. During fault the parameters V and I will exceed its lower or upper limit with respect to the PLC's fed reference input. During this condition the PLC will immediately trigger the respective trigger pulse.

g) *PLC Output*

During the time of fault the PLC triggers signal pulse to the trip circuit and alarm circuit. Here there is a LED as an indication for the faulty condition. Each colour LED states different type of fault. Further the PLC sends the command to the GSM module fed with a program to send the fault message.

h) *GSM*

The GSM when gets a command from the PLC about the occurred fault and the nature of fault. Further according to the programmed GSM and fed message about the respective fault the message of the fault is send to the user. Thus the fault message is displayed on the users mobile phone.

VI. CHARACTERISTIC DATA

Transformer rating:-230/12 V, 60VA

CT turns ratio:-1/450

Voltage (V)	Current (I)	V to I (DC) (mA)	I to I (DC) (mA)
160	2.4	9.56	4.23
180	2.7	10.70	4.82
200	3	11.77	5.45
220	3.3	11.89	5.96
230	3.5	11.93	6.37
240	3.6	11.95	6.63
250	3.8	11.98	6.94



Figure 6: Proposed Model

VII. CONCLUSION

In this proposed system we have designed a protection system of transformer based on PLC that is used to observe and control the current, voltage and temperature of a power and distribution transformer on both the primary and secondary sides. The proposed PLC system which has been designed to monitor the transformer's required parameter. It continuously monitors these parameters throughout its operation. When the PLC identify any change in the level of voltage, current or temperature values exceeding the upper or lower limit of rating respectively, the transformer has been made shut-down in order to protect from damages with the help of relays in the system. The system not only controls the transformer in the substation by shutting it down, but also displays the values throughout the process for users on HMI screen of PLC. This demand that the proposed design of the PLC system makes the transformer more robust against the adverse issues which makes the voltage, current or temperature to peak. Hence the distribution is made more secure, reliable and highly efficient by means of the proposed system. From this model we protect the distribution or power transformer from the adverse condition hence total life span of the transformer increase up to some extent.

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Research on Emi Noise Suppression Method Based on Electromagnetic Shielding of Cabinet

By Baoting Li, Wanning Bai, Wei Yan & Wei Qiu

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Abstract- This paper mainly analyzes the influence of cabinet characteristics on the shielding effectiveness of the transmission control cabinet. Through the CST electro-magnetic simulation software, the simplified model of the actual transmission control cabinet is established, and the excitation source is set. The influence of the opening position of the cabinet, the shape of the opening and the design of the shielding layer of the cabinet on the shielding effectiveness of the transmission control cabinet are studied, thereby improving the electromagnetic characteristics of the cabinet.

Keywords: *shielding effectiveness, CST, opening position, opening shape, shielding layer.*

GJRE-F Classification: *FOR Code: 090699*



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Baoting Li ^α, Wanning Bai ^σ, Wei Yan ^ρ & Wei Qiu ^ω

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I. INTRODUCTION

Metal-shielded cavities have long been used to protect components and circuits inside electronic devices from electromagnetic interference and their shielding performance is measured by shielding effectiveness (SE). At present, domestic and foreign scholars have also done a series of research on the shielding effectiveness of the cavity. The EMC scanner directly obtains the electric field interference distribution on the surface of the transmission control cabinet, avoiding long-distance electromagnetic fields during wiring and reducing interference. Based on the interference situation and the coupling coefficient, [1] developed some auxiliary design software to solve some design problems of the electromagnetic compatibility of the transmission control cabinet. [2-6] used the time domain finite integration method to establish a coupled model of a cavity with plane wave radiation, and specifically studied the effect of the length, width and depth of the rectangular hole on the shielding effectiveness of the cabinet. [7-9] analyzed the scattering matrix equation and the transfer matrix equation of complex multi-cavity, and proposed a fast algorithm for multi-cavity shielding effectiveness based on electromagnetic topology theory, which improved the simulation efficiency and simulation precision. [10-12] used the pattern matching method and the matrix method to predict the shielding effectiveness of the

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metal-shielded cavity with perforated seams. Through cavity modeling, the shielding effectiveness of the metal-shielded cavity with perforated seams. Through cavity modeling, the shielding effectiveness of a square hole seam is better than that of the rectangular hole when the hole area is the same. Therefore, to obtain the best shielding efficiency under the working condition of the inverter circuit, it is necessary to optimize the design of the high-power inverter power supply cabinet to achieve the optimal electromagnetic shielding effect.

II. BASED ON CST CABINET MODELING

According to the actual inverter power cabinet, the cabinet model shown in Fig. One is established. The cabinet dimensions are 800mm × 500mm × 1500mm (width × depth × height), and the weight is 780Kg. The internal drive control circuit.

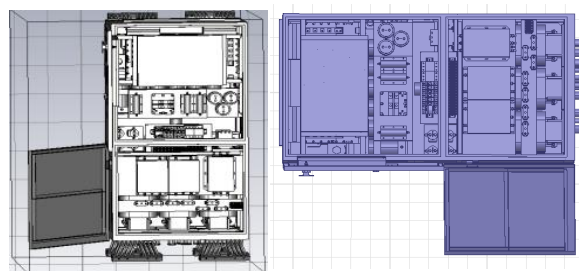


Fig. 1: Transmission control cabinet CST modeling

Because the simulation operation time is long and the efficiency is very low under this model, and the influence of the shock absorbers on the upper and lower sides of the cabinet on the shielding effectiveness of the transmission control cabinet is negligible, we have simplified the original model. The equivalent model is shown in Fig. 2.

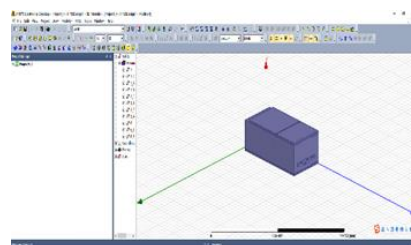


Fig. 2: A simplified model of the transmission control cabinet

The actual cabinet features such as cable bundle holes and gaps of the cabinet are reserved, and the material parameters of the simulation model are modified according to the actual cabinet material: The density at room temperature is 7850kg/m³; the resistivity is 1.3e-8 Ω·m, the relative magnetic permeability is set to 0.98, and the electrical conductivity is set to 0 (both inside and outside the cabinet are coated with insulating varnish). The thickness is 8mm. Based on the model construction, CST simulation is used to analyze the electromagnetic characteristics and shielding effectiveness of the inverter power cabinet.

III. RESEARCH ON THE INFLUENCE OF CABINET SHIELDING EFFECTIVENESS

a) Influence of opening position on shielding effectiveness of cabinet

CASE 1. According to the model, there are six circular holes on the top surface of the cabinet, each radius R=30mm, as shown in Fig. 3, the coordinates of the bottom corner of the cabinet is the coordinate origin (0,0,0), and the left side of the diagonal is (800,500,1500). The sweep range is set to 25Hz-1GHz and the sweep step is 10KHz.

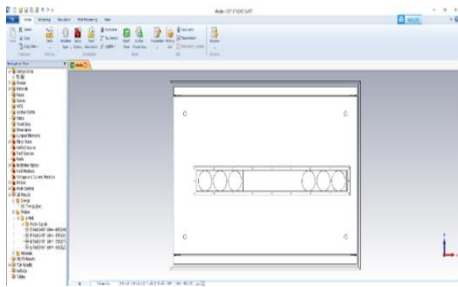


Fig. 3: Drive control cabinet model bottom opening view

CASE 2. Under the premise of not changing the number of openings and the area of the opening, modify the simulation model of the cabinet, and modify the opening position from the bottom side of the cabinet to the lower side of the back. The center of the opening is 50 mm away from the bottom edge to facilitate the cable bundle passed. The model is modified as shown in Fig. 4.

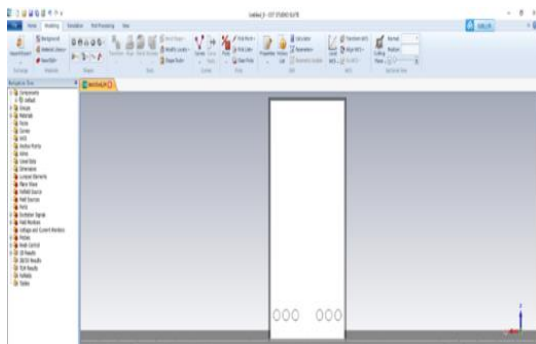
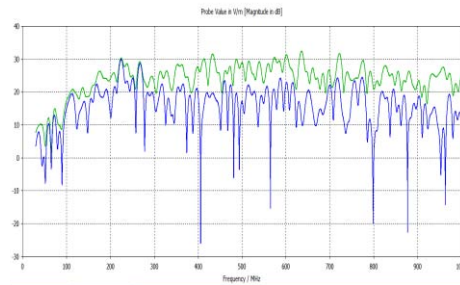


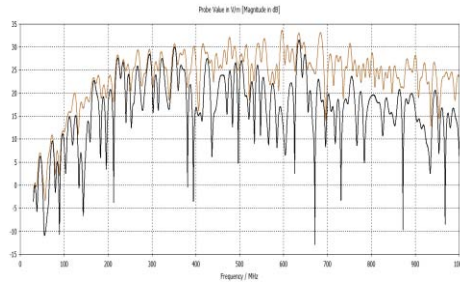
Fig. 4: Drive control cabinet model back opening view

Set the excitation source to a plane wave, the excitation source radiation size is 1V/m, and the radiation source location is set to the center of the model cabinet, that is, The plane wave center coordinate is (400, 250, 750). The plane wave incident direction is perpendicular to the plane of the hole slot (Z-axis positive direction), Three field probes are set. The probe one is placed 100mm away from the cabinet, the field probe coordinates (400, 250, -100), and the probe 2 and probe three are set to coordinates (400, -100, 750) and (400, 600, 750) respectively. Through simulation, the shielding effectiveness of the transmission control cabinet under plane wave excitation is analyzed.

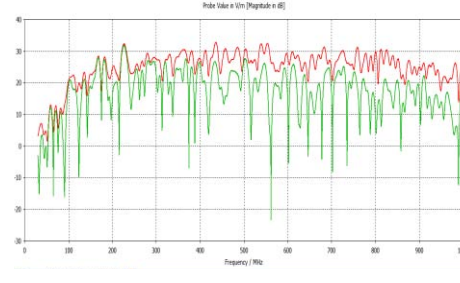
The data of the simulated electric field curves in the two aperture modes are fitted, and the results are shown in Fig. 5.



a. Comparison of electric field shielding effectiveness of probe 1



b. Comparison of electric field shielding effectiveness of probe 2



c. Comparison of electric field shielding effectiveness of probe 3

Fig. 5: Comparison of electric field shielding effectiveness

By observing the comparison of the shielding effectiveness, it is found that the shielding effectiveness

of the back-opening model is better than the bottom opening model by 5.63dB and 4.15dB, respectively, at the position of the field probe 1 and the field probe 2. The shielding effect of the bottom-opening model of the field probe three position is better than the back-opening model of 1.98dB. Also, since the back of the transmission control cabinet is generally placed on the side of the ship, the back side is the ship's silo shell, and the sensitive receiving equipment is not facing. In summary, we have found that under the premise of the same number, shape and area of the same opening, the shielding effect of the back opening is better than that of the bottom opening.

b) Effect of opening shape on shielding effectiveness of cabinet

To better study the influence of the transmission control cabinet structure on the shielding effectiveness of the cabinet, the shielding effectiveness was analyzed by changing the shape of the opening from a circle to a square and a regular hexagon. Due to the strict requirements on heat dissipation and cable bundle width, it is necessary to ensure the same opening area. The radius of the circular opening is 30mm. According to the principle of equal area, when the shape of the opening is changed to square, the length of the opening should be set to 53.17mm. When the shape of the opening is a regular hexagon, the side length of the opening is set to 32.99 mm.

Plane incident waves with a radiation size of 1 V/m are placed in the center of the cabinet. Since the opening position is set on the back, the shape of the opening has little effect on the shielding performance at the positions of the probes 1 and 2. Therefore, only the shielding effectiveness of the position of probe three at the back of the opening is discussed, and the shielding effectiveness simulation is shown in Fig. 6 and Fig. 7. Among them, green, blue and red are regular hexagonal, circular and square opening shielding effectiveness.

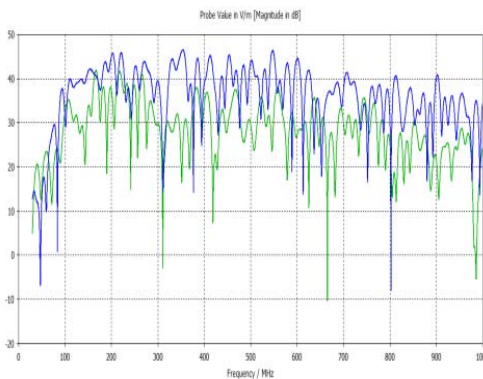


Fig. 6: Comparison of shielding effectiveness between regular hexagon and circular

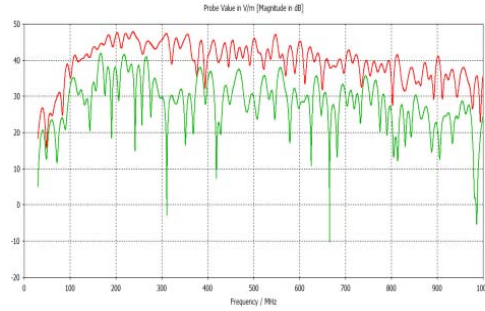


Fig. 7: Comparison of shielding effectiveness between regular hexagon and square

The shielding performance of the regular hexagon is almost better than the square in each frequency band. It can be seen from the calculation that the shielding performance of the entire frequency band is better than the circular 3.32dB. Therefore, it is determined that the opening is a regular hexagonal opening with a side length of 32.99 mm and a position of 50 mm from the bottom side of the back side.

c) Impact of shielding layer on cabinet shielding effectiveness

When there is alternating current or alternating the electromagnetic field in the cabinet, the induced the electromagnetic field inside the cabinet is unevenly distributed, and the current is concentrated in the "skin" part of the cabinet. That is to say, the current is concentrated on the thin layer on the surface of the cabinet, and the closer to the surface of the cabinet, the greater the density of the current, so that the power loss of the cabinet is also increased. This phenomenon is called skin effect. Skin depth expression is

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}} \tag{1}$$

In the actual engineering rectification, the magnetic permeability, $\mu=4\pi \times 10^{-7} H/m$ conductivity, $\sigma=5.82 \times 10^7 / \Omega \cdot m$ The formula (1) can be simplified to

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}} = \frac{1}{15.185 \sqrt{f}} (m) \tag{2}$$

According to the establishment of the previous theoretical shielding model, the absorption loss of the shield can be expressed as .After the electromagnetic wave passes through the metal shield, the power loss is caused by the presence of the induced current. In addition, the heat of the material absorbs a certain amount of electromagnetic wave energy, and the magnitude of the field strength decreases exponentially. We can simplify the expression of absorption loss to

$$20 \lg e^{-rt} = 8.686 \cdot rt = 8.686 \frac{t}{\delta} \tag{3}$$

It can be seen from the expression of absorption loss:

1. When the shielding cabinet material is the same, the absorption loss is related to the thickness of the shielding cabinet. The thicker the shielding cabinet, the greater the absorption loss;
2. When the shielding cabinet material and thickness are the same, the absorption loss is related to the electromagnetic wave frequency that the shielding cabinet is traversed. The higher the frequency, the larger the absorption loss;
3. The absorption loss of the shielding body is also related to the skin depth, that is, the electrical conductivity and magnetic permeability of the shielding cabinet material. At the same frequency, the greater the conductivity and magnetic permeability of the shielding material, the greater the absorption loss.

According to the skin effect, using the previously optimized transmission control cabinet, under the model of the regular hexagonal hole on the back side, optimize the setting again, and set a layer of copper foil on the inside of the cabinet, the thickness is set to 0.065mm, and the copper foil is laid. After that, the field probe is set and simulated in the same position. The comparison between the shielding performance and the unshielded layer is shown in Fig. 8. Blue and brown are the shielding effectiveness before and after the shielding layer is laid.

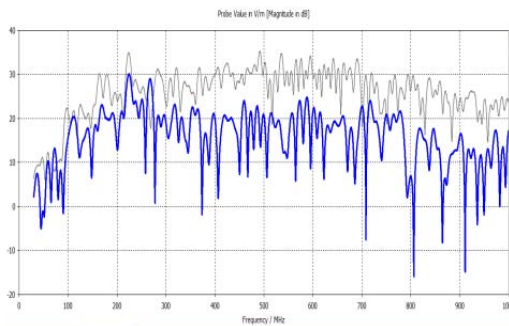


Fig. 8: Comparison of shielding effectiveness of cabinets before and after shielding

From the shielding effectiveness diagram, we can find that the shielding layer can greatly improve the shielding effectiveness of the cabinet. The shielding effectiveness is optimized to an average of 7.63dB compared to when not laid. Therefore, the shielding layer has the greatest influence on the shielding effectiveness of the transmission control cabinet, and the adoption of this measure is also indispensable in suppressing radiated EMI noise.

IV. CONCLUSION

This paper mainly uses CST electromagnetic simulation software to model and analyze the

electromagnetic shielding effect of the cabinet under different models. The simulation results show that the shielding effectiveness of the back opening is better than that of the bottom opening under the premise that the number, shape and area of the same opening are the same; the shielding effect of the regular hexagonal opening is better than that of the circular opening and the square opening; The laying of the shield copper foil can improve the shielding effectiveness of the cabinet by about 7.63dB. It provides a theoretical reference for optimizing the characteristics of the actual transmission control cabinet.

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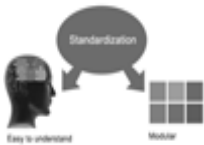
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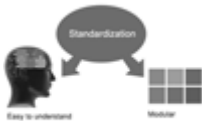


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9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams 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.

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BY GLOBAL JOURNALS

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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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