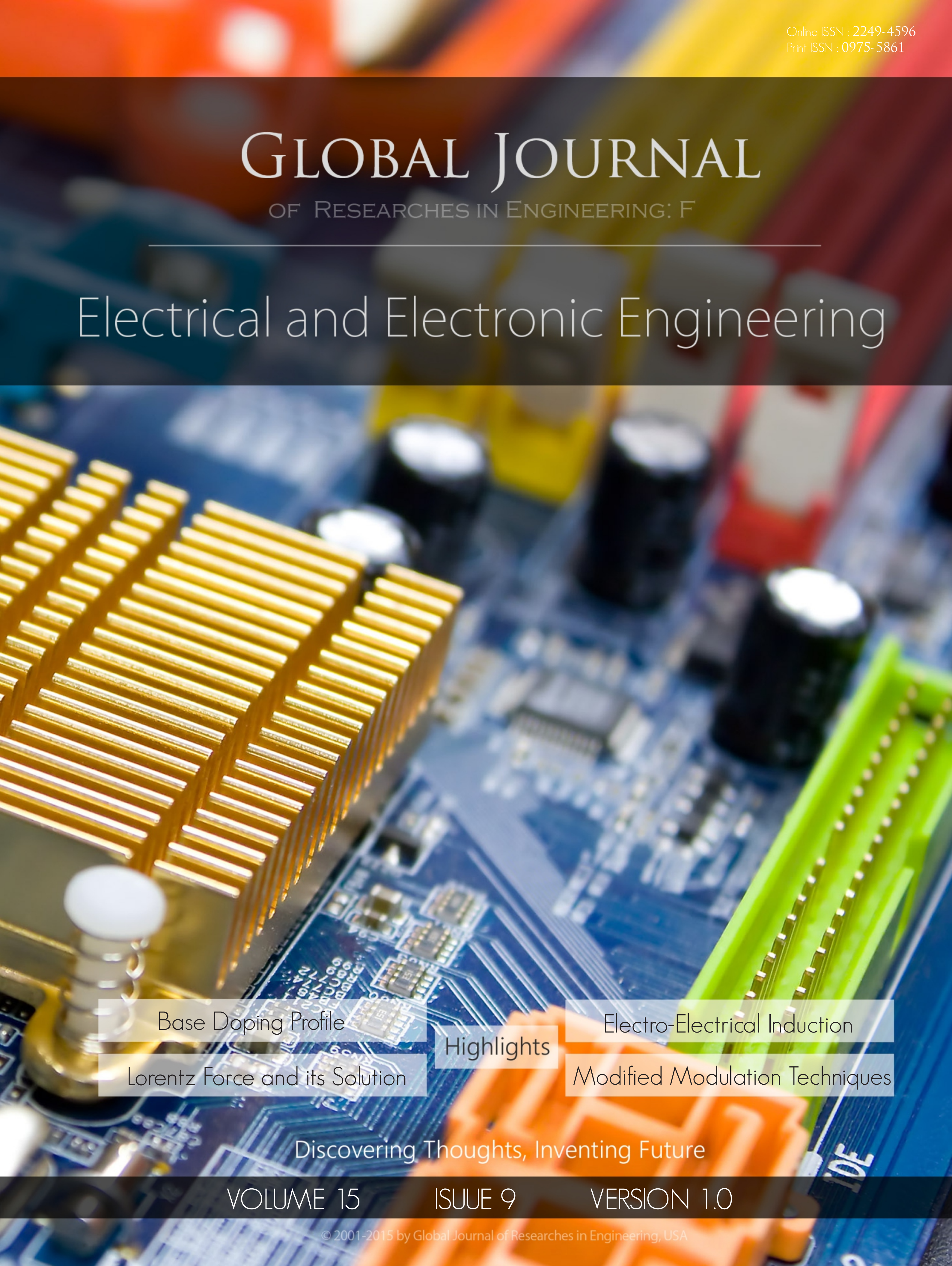

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Electrical and Electronic Engineering

Base Doping Profile

Lorentz Force and its Solution

Highlights

Electro-Electrical Induction

Modified Modulation Techniques

Discovering Thoughts, Inventing Future

VOLUME 15 ISUE 9 VERSION 1.0

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Base Doping Profile Investigation in to Transient base Charge Modeling of IGBT

By Avijit Das, Md. Nazmul Islam & Md. Ziaur Rahman Khan
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Abstract- The study of doping concentration in the carrier storage region of IGBT is considered desirable in many power converter applications. This Letter presents base doping profile estimation through investigation into transient base charge modeling of Non-punch through (NPT) Insulated Gate Bipolar Transistor (IGBT). Parabolic profile has been used for base carrier concentration which consequently leads to an analytical model for transient base charge decay of IGBT. The proposed model shows better consistency compared to the previously used linear model in all doping profiles. Finally, the implications of doping dependence on the base charge decay are explained, including implementation of doping profile estimation technique.

Keywords: *base doping profile, transient base charge, parabolic approximation, effective base width, ambipolar diffusion length.*

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BASEDOPINGPROFILEINVESTIGATIONINTOTRANSIENTBASECHARGEMODELINGOFIGBT

Base Doping Profile Investigation in to Transient base Charge Modeling of IGBT

Avijit Das [α], Md. Nazmul Islam [σ] & Md. Ziaur Rahman Khan [ρ]

Abstract- The study of doping concentration in the carrier storage region of IGBT is considered desirable in many power converter applications. This Letter presents base doping profile estimation through investigation into transient base charge modeling of Non-punch through (NPT) Insulated Gate Bipolar Transistor (IGBT). Parabolic profile has been used for base carrier concentration which consequently leads to an analytical model for transient base charge decay of IGBT. The proposed model shows better consistency compared to the previously used linear model in all doping profiles. Finally, the implications of doping dependence on the base charge decay are explained, including implementation of doping profile estimation technique.

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I. Introduction

Since its invention in 1979 [1], IGBT has been considered a preferred switching device in power electronic systems and significantly improved the quality of life of people. Specially 90% of low voltage products (600V to 1700V) are being occupied by IGBTs. Compared to the first and second generation of NPT IGBTs, the device performance using latest thin film technology has been improved by introducing various doping concentrations in the Carrier Storage Region (CSR), specially known as SPT technology [2] or field stop concept [3]. The advantages of the first two generations have been combined by this technology, resulting in evolution of further generations [4-6]. Different doping profiles have significant effects on the base charge distribution of NPT IGBTs, which can be thoroughly studied by proper estimation of doping concentration in the effective base region (CSR) of IGBT. In recent times, high doping profile has been considered as a matter of concern in the steady-state and transient operation of IGBT. However, with the modern IGBT structure having highly doped CSR, a MOSFET-like behaviour has been seen at low collector-emitter voltage when the gate is fully turned on [7]. Actually increasing the base doping concentration can reduce the on-state loss while maintaining the desirable blocking voltage. But too high doping may affect the injection efficiency of p-emitter and result in some undesirable effects [8], which need to be avoided. This has caused considerable interest in modeling of base doping profile in DC linked type circuits [9] as well as motor drive applications [10]. However, the accurate and effective study of IGBT requires proper modeling of doping profiles in the CSR with systematic estimation technique. This paper introduces the idea of doping profile modeling in the base through investigation into the transient characteristics of IGBTs. The steady state minority carrier concentration is proposed through a parabolic profile [11]. Using this profile, an analytical model is derived for explaining transient base charge decay during turn-off. Fourth order Runge-Kutta (RK4) method is used to validate the model over a wide range of doping concentration. Finally being consistent with the practical results, base doping profile is investigated through turn-off base charge distribution on different time instances.

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II. Turning of Operation of Igbt

During the turn-off operation of IGBT the gate voltage is kept less than the threshold voltage. It is assumed that the anode voltage is kept constant during the current decay, but it may be different from the anode voltage of the steady state. Fig. 1 shows the cross section schematic of IGBT half cell and Fig. 2 shows the schematic diagram of excess minority carrier distribution for two doping profiles, Low-doped Base (LDB) and High-doped Base (HDB). The figure shows charge distribution for immediately before (steady state) and after the channel current has been removed. It can be seen that the minority carrier holes decreases quickly to zero after switching in case of LDB, resulting in a large depletion region. This causes the effective base width (W) smaller than the ambipolar diffusion length (L). On the other hand, the HDB causes the carrier reduction much slower after turn-off, causing a smaller depletion region. In this case the effective base width is not very small compared to the total base width (WB), resulting in W being comparable or even larger than L. So the transient operation is very much dependent on the base doping profile.

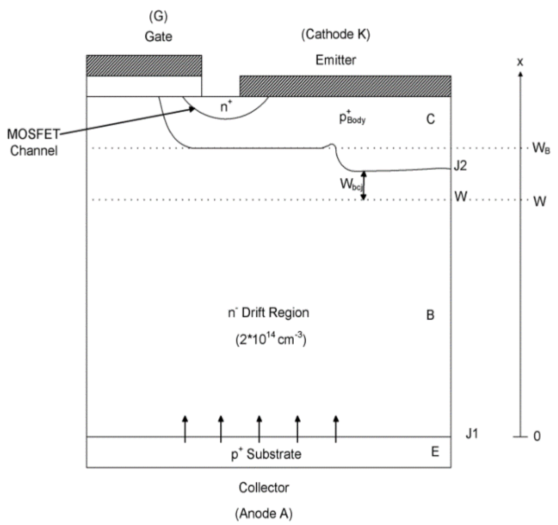

Fig.1: A cross section schematic of IGBT half cell

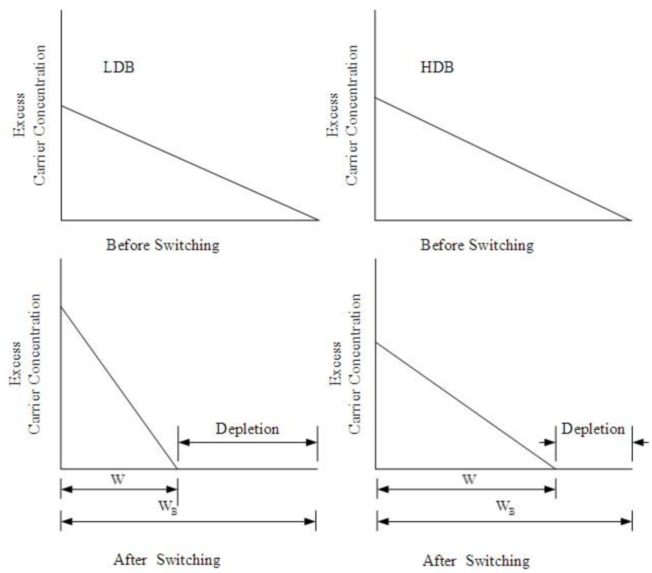

Fig. 2 : Schematic of excess charge distribution in LDB and HDB immediately before and after switching.

III. Expression for Transient base Charge

The main foundation of the previously established models was based on the assumption that W must be much smaller than L, which corresponds to LDB. But these models are inefficient in case of other doping profiles and thus fail to optimize power in NPT and PT IGBTs. The proposed model takes this into account and provides consistent results in all base doping concentrations.

The initial expression for time independent minority carrier concentration is assumed by taking parabolic approximation in the hyperbolic function

$$p(x) = P_0 \frac{1+\frac{1}{6}\left(\frac{W-x}{L}\right)^2}{1+\frac{1}{6}\left(\frac{W}{L}\right)^2} \qquad ....(1)$$

where P_0 is minority carrier concentration at the collector-base junction, W is effective base width, L is ambipolar diffusion length and x is the distance from emitter to collector region.

Using this assumption in the ambipolar diffusion equation and integrating the equation with boundary conditions x=0;p= P_0 and x=W;p=0, a time dependent expression for minority carrier concentration is found in the previous work [11].

$$\begin{aligned}
P(x,t) = {} & \frac{P_0}{4L^2W(6L^2+W^2)}\left[4L^2(W-x)^3+\frac{(W-x)^5}{5}\right] \\
& -\frac{1}{D}\frac{P_0}{W}\frac{\partial W}{\partial t}\frac{1}{4W(6L^2+W^2)}\frac{12L^2-3W^2}{12L^2-W^2} \\
& \left[4L^2(W-x)^3+\frac{(W-x)^5}{5}\right] \\
& +\frac{1}{D}\frac{P_0}{W^2(6L^2+W^2)}\frac{\partial W}{\partial t}\left[(6L^2+W^2)\frac{x^3}{6}-W\frac{x^4}{6}+\frac{x^5}{20}\right] \\
& +\frac{1}{D}\frac{2P_0}{W(6L^2+W^2)^2}\frac{\partial W}{\partial t} \\
& \left[W(W^2-6L^2)\frac{x^3}{6}-(2W^2-6L^2)\frac{x^4}{12}+W\frac{x^5}{20}\right] \\
& -\frac{1}{D}\frac{P_0 x}{5}\frac{\partial W}{\partial t}\frac{20L^2+W^2}{6L^2+W^2}\frac{6L^2-W^2}{12L^2-W^2} \\
& -\frac{1}{D}\frac{P_0 x W^2}{(6L^2+W^2)^2}\frac{\partial W}{\partial t}\frac{W^2-10L^2}{10} \\
& -\frac{P_0 x}{W}+\frac{P_0 x}{20}\left(\frac{20L^2+W^2}{6L^2+W^2}\right)\frac{W}{L^2}+P_0 \\
& -\frac{P_0}{20}\left(\frac{20L^2+W^2}{6L^2+W^2}\right)\left[\frac{W^2}{L^2}-\frac{1}{D}W\frac{\partial W}{\partial t}\frac{12L^2-3W^2}{12L^2-W^2}\right] \qquad .....(2)
\end{aligned}$$

where D is ambipolar diffusivity.

Integrating the excess carrier concentration with respect to x having limit of zero to W and then multiplying by charge (q) and area (A), an expression for stored base charge is found

$$Q(t) = qAP_0\left[\frac{W(t)}{2}-\frac{W(t)^3}{24L^2}\right] \qquad ....(3)$$

The charge decay rate relates to the electron current at emitter-base junction through the following expression

$$\frac{dQ(t)}{dt} = -\frac{Q(t)}{\tau_{HL}} - I_n(0) \quad \text{.......................(4)}$$

Using the quasi-equilibrium simplification and assuming high-level injection of the holes into the base, an expression for transient base charge decay is found

$$\frac{dQ(t)}{dt} = -\frac{Q(t)}{\tau_{HL}} - \frac{Q(t)^2}{q^2A^2\left(\frac{W(t)}{2} - \frac{W(t)^3}{24L^2}\right)^2}\frac{I_{sne}}{n_i^2} \quad \text{....(5)}$$

where I_{sne} is the emitter electron saturation current and τ_{HL} is high level excess carrier lifetime.

For W<<L, the equation is reduced to the exact form reported in [12]. Fourth order Runge-Kutta (RK4) method is later used to plot Q vs t graph to validate the expression numerically with the practical data. Eventually the expression instigates the idea of Base Doping Profile estimation at several time instances.

IV. Result and Discussion for Transient Modeling

Fig. 3, Fig. 4 and Fig. 5 show the simulation results of the parabolic approximation taken in this proposal. Here effective base width (W) is considered to be $4.2 * 10^{-3}$ cm. The results are compared to those of experimental data and linear forms used in [12]. Simulations are shown for three cases:

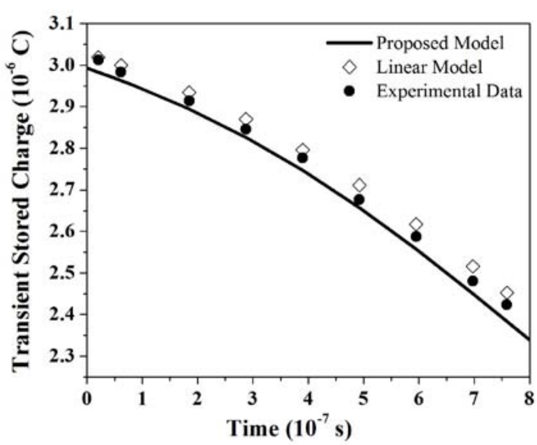

Fig 3 : Transient base charge decay with time for Low doping concentration (N_B=0.7x10^{14} cm^{-3})

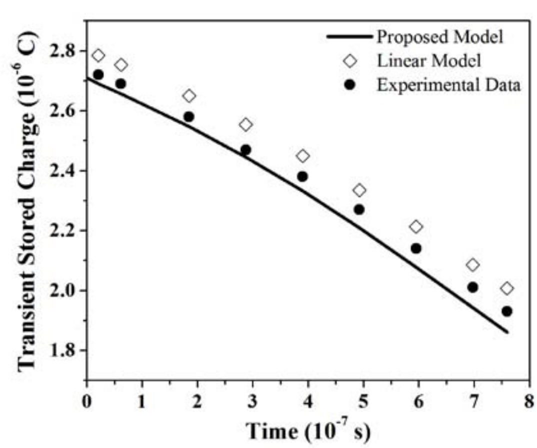

Fig. 4 : Transient base charge decay with time for Moderate doping concentration (N_B=2x10^{14} cm^{-3})

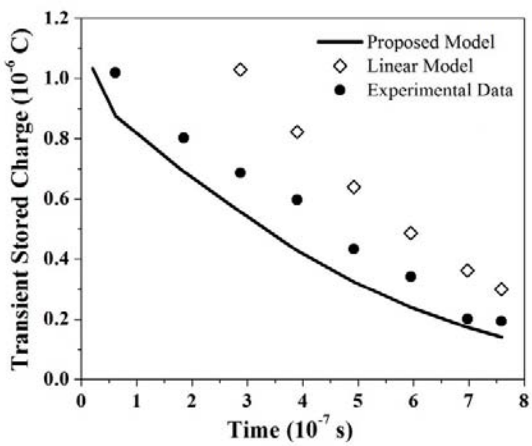

Fig. 5 : Transient base charge decay with time for High doping concentration (N_B=3.5x10^{14} cm^{-3})

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a) Case: Low Doping Profile

The case of $N_B = 0.7x10^{14} cm^{-3}$ is shown in Fig. 3, which explains the case of high carrier lifetime as well as low doping profile. Both the proposed model and linear model are in good agreement with the experimental data. This follows from the fact that during turn-off operation, a large number of charges fail to recombine resulting lower rate of charge decay in the base. Both the parabolic and linear expression depict this buildup correctly.

b) Case: Moderate Doping Profile

In case of $N_B = 2x10^{14} cm^{-3}$, the doping concentration is neither high nor low. From Fig. 4, it is seen that the traditional model shows some deviation with the experimental data, while the proposed model shows better consistency. This is due to the fact that when doping in base is neither high nor low, only some of the charge carriers are able to reach the collector base junction due to significant recombination during turn-off. This results in comparatively higher rate of decay in the transient base charge. The proposed model is able to account for this effect correctly but the linear model fails to do so.

c) Case: High Doping Profile

Fig. 5 shows the case of high doping profile, where $\mathbf{N_B}$ is considered to be $\mathbf{3.5x10^{14} cm^{-3}}$. The parabolic model maintains good consistency with the practical data, while the linear model continues to show deviation as the assumption it is based upon, no longer holds true in case of high doping profile. Base doping being high causes higher rate of charge recombination during turn-off, resulting in conduction of charge approximately to zero. Once again, the proposed model is able to predict this phenomenon, while the linear model falls short.

Different doping profiles considered in Fig. 3, Fig. 4 and Fig. 5 have been shown in tabular form in Table I in terms of Transient base charge values extracted from the graphs on different time instances, which clearly shows the consistency of the proposed model with practical data. The traditional model provides good results in case of low doping profile only, where proposed model validates the experimental observation in all doping concentrations.

V. Investigation in to base Doping Profile

From the following discussion, it is evident that the proposed model shows better consistency with the experimental observations than the traditional linear model. Through this, an opportunity has been created for investigating doping profiles in the Carrier Storage Region (CSR) using dQ/dt dependence of IGBT. Base doping concentrations can be thoroughly estimated through investigation into transient base charge profile on specific time instance. Here the model is analyzed for two time instances; 0.1 μs and 0.8 μs.

Fig. 6 and Fig. 7 show the modeled dependence of base charge decay on base doping profiles at time instance of 0.1 μs and 0.8 μs accordingly. It can be clearly seen that the proposed model predicts nearly same as the linear one in case of low transient charge, but deviates significantly when charge decays from a higher value. In case of LDB, emitter-base junction current (In) depends on the variation of W compared to L. But when doping is considerably high, W becomes insignificant respective to L which causes the prediction of the two models nearly same, which has been shown in Table II.

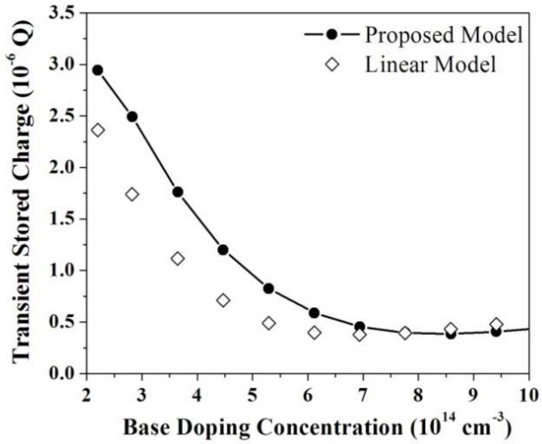

Fig 6 : Modeled dependence of transient base charge on doping concentration at time instance of 0.1 μs

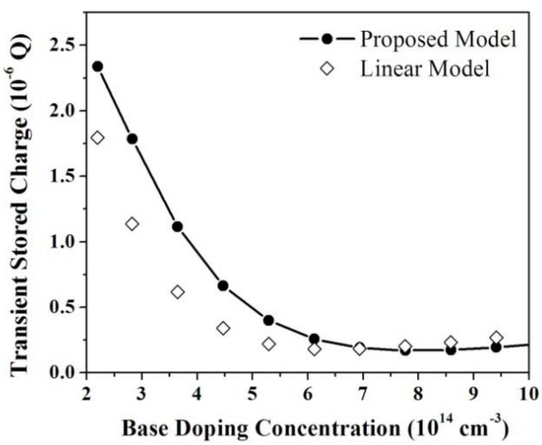

Fig. 7 : Modeled dependence of transient base charge on doping concentration at time instance of 0.8 μs

VI. Conclusion

After review and comparison with the experimental data and linear profiles, a parabolic model is introduced in this Letter to derive the transient base charge decay of NPT IGBT. Better consistency has been shown through this modeling with practical observations in all base doping profiles. The consequence of this doping dependency is then incorporated in the transient stored charge vs doping profile which is used as a means of base doping concentration estimation.

Table I : Data Analysis of Transient base Decay In Different Doping Concentrations

Base Doping Concentration (10^{14}cm^{-3})	Time (10^{-7} s)	Transient Base Charge (10^{-6} C)		
		Experimental	*Proposed*	*Linear*
Low (0.7)	0.2	3.01	2.99	3.02
	2.0	2.91	2.89	2.93
	4.0	2.78	2.75	2.80
	6.0	2.59	2.56	2.62
	7.5	2.42	2.34	2.45
Moderate (2)	0.2	2.72	2.69	2.79
	2.0	2.58	2.55	2.65
	4.0	2.38	2.33	2.45
	6.0	2.14	2.08	2.21
	7.5	1.93	1.86	2.01
High (3.5)	0.2	1.24	1.20	1.66
	2.0	0.81	0.69	1.25
	4.0	0.59	0.42	0.82
	6.0	0.34	0.24	0.48
	7.5	0.19	0.14	0.30

Table II : Estimation of base Doping Concentration

Time Instance (µs)	Transient Charge (10^{-6}C)	Base Doping Concentration ($10^{14}cm^{-3}$)	
		Proposed	*Linear*
0.1	2.5	2.8099	2.0853
	2	3.3783	2.4973
	1.5	4.0035	3.1936
	1	4.8845	3.9609
	0.5	6.6892	6.3108
0.8	2	2.5950	2.0113
	1.5	3.1901	2.3644
	1	3.8562	2.9737
	0.75	4.3103	3.4420
	0.5	4.9495	4.4095

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Unipolar Induction in the Concept of the Scalar-Vector Potential

By F. F. Mende & A. S. Dubrovin

Abstract- The unipolar induction was discovered still Faraday almost 200 years ago, but in the classical electrodynamics of final answer to that as and why work some constructions of unipolar generators, there is no up to now. Let us show that the concrete answers to all these questions can be obtained within the framework the concept of scalar-vector potential. This concept, obtained from the symmetrical laws of induction, assumes the dependence of the scalar potential of charge and pour on it from the charge rate. The symmetrization of the equations of induction is achieved by the way of their record with the use by substantial derivative. Different the schematics of unipolar generators are given and is examined their operating principle within the framework of the concept of scalar- vector potential.

Keywords: *laws of induction, scalar-vector potential, unipolar induction, unipolar generators, substantial derivative.*

GJRE-F Classification: *FOR Code: 240504p*

UNIPOLARINDUCTIONINTHECONCEPTOFTHESCALARVECTORPOTENTIAL

Strictly as per the compliance and regulations of:

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F. F. Mende [α] & A. S. Dubrovin [σ]

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I. Introduction

The unipolar induction was discovered still By faradeem almost 200 years ago [1], but in the classical electrodynamics of final answer to that as and why work some constructions of unipolar generators, there is no up to now. Is separately incomprehensible the case, when there is a revolving magnetized conducting cylinder, during motion of which between the fixed contacts, connected to its axis and generatrix, appears emf. Is still more incomprehensible the case, when together with the cylindrical magnet revolves the conducting disk, which does not have galvanic contact with the magnet, but fixed contacts are connected to the axis of disk and its generatrix. In some sources it is indicated that the answer can be obtained within the framework special relativity (SR), but there are no concrete references, as precisely SR explain the cases indicated. Let us show that the concrete answers to all these questions can be obtained within the framework the concept of scalar- vector potential. This concept, obtained from the symmetrical laws of induction, assumes the dependence of the scalar potential of charge and pour on it from the charge rate.

II. Concept of Scalar-Vector Potential

The Maxwell equations do not give the possibility to write down fields in the moving coordinate systems, if fields in the fixed system are known [2]. This problem is solved with the aid of the Lorenz conversions, however, these conversions from the classical electrodynamics they do not follow. Question does arise, is it possible with the aid of the classical electrodynamics to obtain conversions fields on upon transfer of one inertial system to another, and if yes, then, as must appear the equations of such conversions. Indications of this are located already in the law of the Faraday induction. Let us write down Faraday:

$$\oint \vec{E}' d\,\vec{l}' = -\frac{d\,\Phi_B}{d\,t} \qquad (2.1)$$

As is evident in contrast to Maxwell equations in it not particular and substantive (complete) time derivative is used.

The substantional derivative in relationship (2.1) indicates the independence of the eventual result of appearance emf in the outline from the method of changing the flow, i.e. flow can change both due to the local time derivative of the induction of and because the system, in which is measured , it moves in the three-dimensional changing field . The value of magnetic flux in relationship (2.1) is determined from the relationship

$$,\Phi_B = \int \vec{B}\, d\,\vec{S}' \qquad (2.2)$$

where the magnetic induction $\vec{B} = \mu \vec{H}$ is determined in the fixed coordinate system, and the element $d\,\vec{S}'$ is determined in the moving system. Taking into account (2.2), we obtain from (2.1)

$$\oint \vec{E}' d\,\vec{l}' = -\frac{d}{d\,t}\int \vec{B}\, d\,\vec{S}', \qquad (2.3)$$

and further, since $\frac{d}{d\,t} = \frac{\partial}{\partial\,t} + \vec{v}\;grad$, let us write down [3-6]

$$\oint \vec{E}' d\,\vec{l}' = -\int \frac{\partial\,\vec{B}}{\partial\,t}\, d\,\vec{S} - \int \left[\vec{B} \times \vec{v}\right] d\,\vec{l}' - \int \vec{v}\; d\,\dot{v}\; \vec{B}\; d\,\vec{S}' \qquad (2.4)$$

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In this case contour integral is taken on the outline $d\vec{l}'$, which covers the area $d\vec{S}'$. Let us immediately note that entire following presentation will be conducted under the assumption the validity of the Galileo conversions, i.e., $d\vec{l}' = d\vec{l}$ and $d\vec{S}' = d\vec{S}$. From relationship (2.6) follows

$$\vec{E}' = \vec{E} + \left[\vec{v} \times \vec{B}\right]. \qquad (2.5)$$

If both parts of equation (2.6) are multiplied by the charge, then we will obtain relationship for the Lorentz force

$$\vec{F}_L' = e\,\vec{E} + e\left[\vec{v} \times \vec{B}\right]. \qquad (2.6)$$

Thus, Lorentz force is the direct consequence of the law of magnetoelectric induction.

For explaining physical nature of the appearance of last term in relationship (2.5) let us write down $\vec{B}$ and $\vec{E}$ through the magnetic vector potential $\vec{A}_B$:

$$\vec{B} = rot\,\vec{A}_B, \qquad \vec{E} = -\frac{\partial\,\vec{A}_B}{\partial\,t}. \qquad (2.7)$$

Then relationship (2.5) can be rewritten

$$\vec{E}' = -\frac{\partial\,\vec{A}_B}{\partial\,t} + \left[\vec{v} \times rot\,\vec{A}_B\right] \qquad (2.8)$$

and further

$$\vec{E}' = -\frac{\partial\,\vec{A}_B}{\partial\,t} - \left(\vec{v}\,\nabla\right)\vec{A}_B + grad\,\left(\vec{v}\,\vec{A}_B\right) \qquad (2.9)$$

The first two members of the right side of equality (2.9) can be gathered into the total derivative of vector potential on the time, namely:

$$\vec{E}' = -\frac{d\,\vec{A}_B}{d\,t} + grad\,\left(\vec{v}\,\vec{A}_B\right). \qquad (2.10)$$

From relationship (2.9) it is evident that the field strength, and consequently also the force, which acts on the charge, consists of three parts.

First term is obliged by local time derivative. The sense of second term of the right side of relationship (2.9) is also intelligible. It is connected with a change in the vector potential, but already because charge moves in the three-dimensional changing field of this potential. Other nature of last term of the right side of relationship (2.9). It is connected with the presence of potential forces, since. potential energy of the charge, which moves in the potential field $\vec{A}_B$ with the speed $\vec{v}$, is equal $e\left(\vec{v}\,\vec{A}_{\mathbf{B}}\right)$. The value $e\,grad\,\left(\vec{V}\,\vec{A}_B\right)$ gives force, exactly as gives force the gradient of scalar potential.

Taking rotor from both parts of equality (2.10) and taking into account that $rot\;grad \equiv 0$, we obtain

$$rot\,\vec{E}' = -\frac{d\,\vec{B}}{d\,t}. \qquad (2.11)$$

If there is no motion, then relationship (2.11) is converted into the Maxwell first equation. Relationship (2.11) is more informative than Maxwell equation

$$rot\,\vec{E} = -\frac{\partial\,\vec{B}}{\partial\,t}.$$

Since in connection with the fact that $rot\;grad \equiv 0,$ in Maxwell e quation there is no information about the potential forces, designated through $e\;grad\,\left(\vec{v}\,\vec{A}_B\right)$.

Let us write down the amount of Lorentz force in the terms of the magnetic vector potential:

$$\vec{F}_L{}' = e\,\vec{E} + e\,[\vec{v} \times ro\,t\vec{A}_B] = e\,\vec{E} - e(\vec{v}\,\nabla)\vec{A}_B + e grad\,(\vec{v}\,\vec{A}_B) \qquad (2.12)$$

Is more preferable, since the possibility to understand the complete structure of this force gives.

Faraday law (2.2) is called the law of electromagnetic induction, however this is terminological error. This law should be called the law of magnetoelectric induction, since the appearance of electrical fields on by a change in the magnetic caused fields on.

However, in the classical electrodynamics there is no law of magnetoelectric induction, which would show, how a change in the electrical fields on, or motion in them, it leads to the appearance of magnetic fields on. The development of classical electrodynamics followed along another way. Ampere law was first introduced:

$$\oint \vec{H}\,d\,\vec{l} = I\,, \qquad (2.13)$$

where I is current, which crosses the area, included by the outline of integration. In the differential form relationship (2.13) takes the form:

$$rot\,\vec{H} = \vec{j}_\sigma\,, \qquad (2.14)$$

where j_σ is current density of conductivity.

Maxwell supplemented relationship (2.14) with bias current

$$rot\ \vec{H} = \vec{j}_\sigma + \frac{\partial\ \vec{D}}{\partial\ t}. \qquad (2.15)$$

If we from relationship (2.15) exclude conduction current, then the integral law follows from it

$$\oint \vec{H} d\ \vec{l} = \frac{\partial\ \Phi_D}{\partial\ t}, \qquad (2.16)$$

where $\Phi_D = \int \vec{D}\ d\vec{S}$ the flow of electrical induction.

If we in relationship (2.16) use the substantional derivative, as we made during the writing of the Faraday law, then we will obtain [1-10]:

$$\oint \vec{H}' d\ \vec{l}' = \int \frac{\partial\ \vec{D}}{\partial\ t} d\ \vec{S} + \oint [\vec{D} \times \vec{v}] d\ \vec{l}' + \int \vec{v}\ d\ i\!v\ \vec{D}\ d\ \vec{S}'. \qquad (2.17)$$

In contrast to the magnetic fields, when $div\vec{B} = 0$, for the electrical fields on $div\vec{D} = \rho$ and last term in the right side of relationship (2.8) it gives the conduction current of and from relationship (2.7) the Ampere law immediately follows. In the case of the absence of conduction current from relationship (2.17) the equality follows:

$$\vec{H}' = \vec{H} - [\vec{v} \times \vec{D}]. \qquad (2.18)$$

As shown in the work [2], from relationship (2.18) follows and Bio-Savara law, if for enumerating the magnetic fields on to take the electric fields of the moving charges. In this case the last member of the right side of relationship (2.17) can be simply omitted, and the laws of induction acquire the completely symmetrical form [6]

$$\begin{gathered} \oint \vec{E}' dl' = -\int \frac{\partial \vec{B}}{\partial t} d\vec{s} + \oint \left[\vec{v} \times \vec{B} \right] dl' \vec{H} \\ \oint \vec{H}' dl' = \int \frac{\partial \vec{D}}{\partial t} d\vec{s} - \oint \left[\vec{v} \times \vec{D} \right] dl' \vec{H}' \end{gathered}, \qquad (2.19)$$

or

$$\begin{gathered} rot\vec{E}' = -\frac{\partial \vec{B}}{\partial t} + rot\left[\vec{v} \times \vec{B} \right] \\ rot\vec{H}' = \frac{\partial \vec{D}}{dt} - rot\left[\vec{v} \times \vec{D} \right] \end{gathered}. \qquad (2.20)$$

For dc fields on these relationships they take the form:

$$\begin{gathered} \vec{E}' = \left[\vec{v} \times \vec{B} \right] \\ \vec{H}' = -\left[\vec{v} \times \vec{D} \right] \end{gathered}. \qquad (2.21)$$

In relationships (2.19-2.21), which assume the validity of the Galileo conversions, prime and not prime values present fields and elements in moving and fixed inertial reference system (IS) respectively. It must be noted, that conversions (2.21) earlier could be obtained only from the Lorenz conversions.

The relationships (2.19-2.21), which present the laws of induction, do not give information about how arose fields in initial fixed IS. They describe only laws governing the propagation and conversion fields on in the case of motion with respect to the already existing fields.

The relationship (2.21) attest to the fact that in the case of relative motion of frame of references, between the fields $\vec{E}$ and $\vec{H}$ there is a cross coupling, i.e. motion in the fields $\vec{H}$ leads to the appearance fields on $\vec{E}$ and vice versa. From these relationships escape the additional consequences, which were for the first time examined in the work.

The electric field $E = \frac{g}{2\pi\varepsilon r}$ outside the charged long rod with alinear density g decreases as $\frac{1}{r}$, where r isdistance from the centralaxis of the rodto the observation point.

If we in parallel to the axis of rod in the field E begin to move with the speed Δv another IS, then in it will appear the additional magnetic field $\Delta H = \varepsilon E \Delta v$. If we now with respect to already moving IS begin to move third frame of reference with the speed Δv, then already due to the motion in the field ΔH will appear additive to the electric field $\Delta E = \mu\varepsilon E(\Delta v)^2$. This process can be continued and further, as a result of which can be obtained the number, which gives the value of the electric field $E'_v(r)$ in moving IS with reaching of the speed $v = n\Delta v$, when $\Delta v \to 0$, and $n \to \infty$. In the final analysis in moving IS the value of dynamic electric field will prove to be more than in the initial and to be determined by the relationship [7]:

$$E'(r, v_\perp) = \frac{gch\frac{v_\perp}{c}}{2\pi\varepsilon r} = Ech\frac{v_\perp}{c}.$$

If speech goes about the electric field of the single charge e, then its electric field will be determined by the relationship:

$$E'(r, v_\perp) = \frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r^2},$$

where $v_\perp$ is normal component of charge rate to the vector, which connects the moving charge and observation point.

Expression for the scalar potential, created by the moving charge, for this case will be written down as follows:

$$\varphi'(r,v_\perp)=\frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r}=\varphi(r)ch\frac{v_\perp}{c}, \qquad (2.22)$$

where $\varphi(r)$ is scalar potential of fixed charge. The potential $\varphi'(r,v_\perp)$ can be named scalar-vector, since it depends not only on the absolute value of charge, but also on speed and direction of its motion with respect to the observation point. Maximum value this potential has in the direction normal to the motion of charge itself. Moreover, if charge rate changes, which is connected with its acceleration, then can be calculated the electric fields, induced by the accelerated charge.

During the motion in the magnetic field, using the already examined method, we obtain:

$$H'(v_\perp)=Hch\frac{v_\perp}{c}.$$

where $v_\perp$ is speed normal to the direction of the magnetic field.

If we apply the obtained results to the electromagnetic wave and to designate components fields on parallel speeds IS as $E_\uparrow$, $H_\uparrow$, and $E_\perp$, $H_\perp$ as components normal to it, then with the conversion fields on components, parallel to speed will not change, but components, normal to the direction of speed are converted according to the rule

$$\vec{E}'_\perp = \vec{E}_\perp ch\frac{v}{c} + \frac{v}{c}\vec{v}\times\vec{B}_\perp sh\frac{v}{c},$$

$$\vec{B}'_\perp = \vec{B}_\perp ch\frac{v}{c} - \frac{1}{vc}\vec{v}\times\vec{E}_\perp sh\frac{v}{c}, \qquad (2.23)$$

where c is speed of light.

Conversions fields (2.23) they were for the first time obtained in the work [8].

However, the iteration technique, utilized for obtaining the given relationships, it is not possible to consider strict, since its convergence is not explained Let us give a stricter conclusion in the matrix form [7].

Let us examine the totality IS of such, that IS K_1 moves with the speed Δv relative to IS K, IS K_2 moves with the same speed Δv relative to K_1 , etc. If the module of the speed Δv is small (in comparison with the speed of light c), then for the transverse components fields on in IS K_1, K_2,…. we have:

$$\vec{E}_{1\perp} = \vec{E}_\perp + \Delta\vec{v}\times\vec{B}_\perp \qquad \vec{B}_{1\perp} = \vec{B}_\perp - \Delta\vec{v}\times\vec{E}_\perp / c^2$$

$$\vec{E}_{2\perp} = \vec{E}_{1\perp} + \Delta\vec{v}\times\vec{B}_{1\perp} \qquad \vec{B}_{2\perp} = \vec{B}_{1\perp} - \Delta\vec{v}\times\vec{E}_{1\perp} / c^2 \qquad (2.24)$$

Upon transfer to each following IS of field are obtained increases in $\Delta\vec{E}$ and $\Delta\vec{B}$

$$\Delta\vec{E}=\Delta\vec{v}\times\vec{B}_\perp, \qquad \Delta\vec{B}=-\Delta\vec{v}\times\vec{E}_\perp/c^2, \qquad (2.25)$$

where of the field $\vec{E}_\perp$ and $\vec{B}_\perp$ relate to current IS. Directing Cartesian axis x along $\Delta\vec{v}$, let us rewrite (4.7) in the components of the vector

$$\Delta E_y=-B_z\Delta v, \qquad \Delta E=B_y\Delta v, \qquad \Delta B_y=E_z\Delta v/c^2. \qquad (2.26)$$

Relationship (2.26) can be represented in the matrix form

$$\Delta U = AU\Delta v \qquad \begin{pmatrix} 0 & 0 & 0 & -1 \\ 0 & 0 & 1 & 0 \\ 0 & 1/c^2 & 0 & 0 \\ -1/c^2 & 0 & 0 & 0 \end{pmatrix} \qquad U = \begin{pmatrix} E_y \\ E_z \\ B_y \\ B_z \end{pmatrix}$$

If one assumes that the speed of system is summarized for the classical law of addition of velocities, i.e. the speed of final IS $K'=K_N$ relative to the initial system K is $v=N\Delta v$, then we will obtain the matrix system of the differential equations of

$$\frac{dU(v)}{dv}=AU(v), \qquad (2.27)$$

with the matrix of the system v independent of the speed A . The solution of system is expressed as the matrix exponential curve $\exp(vA)$:

$$U'\equiv U(v)=\exp(vA)U, \qquad U=U(0), \qquad (2.28)$$

here U is matrix column fields on in the system K, and U' is matrix column fields on in the system K'. Substituting (2.28) into system (2.27), we are convinced, that U' is actually the solution of system (2.27):

$$\frac{dU(v)}{dv}=\frac{d[\exp(vA)]}{dv}U=A\exp(vA)U=AU(v).$$

It remains to find this exponential curve by its expansion in the series:

$$\exp(va)=E+vA+\frac{1}{2!}v^2A^2+\frac{1}{3!}v^3A^3+\frac{1}{4!}v^4A^4+...$$

where E is unit matrix with the size 4×4. For this it is convenient to write down the matrix A in the unit type form

$$A=\begin{pmatrix}0 & -\alpha\\ \alpha/c^2 & 0\end{pmatrix},\qquad \alpha=\begin{pmatrix}0 & 1\\ -1 & 0\end{pmatrix},\qquad 0=\begin{pmatrix}0 & 0\\ 0 & 0\end{pmatrix}.$$

then

$$A^2=\begin{pmatrix}-\alpha^2/c^2 & 0\\ 0 & -\alpha/c^2\end{pmatrix},\quad A^3=\begin{pmatrix}0 & \alpha^3/c^2\\ -\alpha^3/c^4 & 0\end{pmatrix},$$

$$A^4=\begin{pmatrix}\alpha^4/c^4 & 0\\ 0 & \alpha^4/c^4\end{pmatrix},\quad A^5=\begin{pmatrix}0 & -\alpha^5/c^4\\ \alpha^5/c^6 & 0\end{pmatrix}.....$$

And the elements of matrix exponential curve take the form

$$[\exp(vA)]_{11}=[\exp(vA)]_{22}=I-\frac{v^2}{2!c^2}+\frac{v^4}{4!c^4}-....,$$

$$[\exp(vA)]_{21}=-c^2[\exp(vA)]_{12}=\frac{\alpha}{c}\left(\frac{v}{c}I-\frac{v^3}{3!c^3}+\frac{v^5}{5!c^5}-.....\right),$$

where I is the unit matrix 2×2. It is not difficult to see that $-\alpha^2=\alpha^4=-\alpha^6=\alpha^8=....=I$, therefore we finally obtain

$$\exp(vA)=\begin{pmatrix}Ich\ \ v/c & -c\alpha sh\ \ v/c\\ (\alpha sh\ \ v/c)/c & Ich\ \ v/c\end{pmatrix}=$$

$$\begin{pmatrix}ch\ \ v/c & 0 & 0 & -csh\ \ v/c\\ 0 & ch\ \ v/c & csh\ \ v/c & 0\\ 0 & (ch\ \ v/c)/c & ch\ \ v/c & 0\\ -(sh\ \ v/c)/c & 0 & 0 & ch\ \ v/c\end{pmatrix}.$$

Substituting there $\exp(vA)$, we find

$$E'_y=E_y ch\ \ v/c-cB_z sh\ \ v/c,\qquad E'_z=E_z ch\ \ v/c+cB_y sh\ \ v/c,$$

$$B'_y=B_y ch\ \ v/c+(E_z/c)\,sh\ \ v/c,\qquad B'_z=B_z ch\ \ v/c-(E_y/c)\,sh\ \ v/c$$

or in the vector record

$$\vec{E}'_\perp=\vec{E}_\perp ch\ \frac{v}{c}+\frac{v}{c}\vec{v}\times\vec{B}_\perp sh\frac{v}{c},$$
$$\vec{B}'_\perp=\vec{B}_\perp ch\ \frac{v}{c}-\frac{1}{vc}\vec{v}\times\vec{E}_\perp sh\frac{v}{c},\qquad (2.29)$$

This is conversions (2.23).

III. Unipolar Induction in the Concept of the Scalar-Vector Potential

Let us examine the case, when there is a single long conductor, along which flows the current. We will as before consider that in the conductor is a system of the mutually inserted charges of the positive lattice g^+ and free electrons g^-, which in the absence current neutralize each other (Fig.1).

The electric field, created by rigid lattice depending on the distance r from the center of the conductor, that is located along the axis z it takes the form

$$E^+=\frac{g^+}{2\pi\varepsilon r}. \qquad (3.1)$$

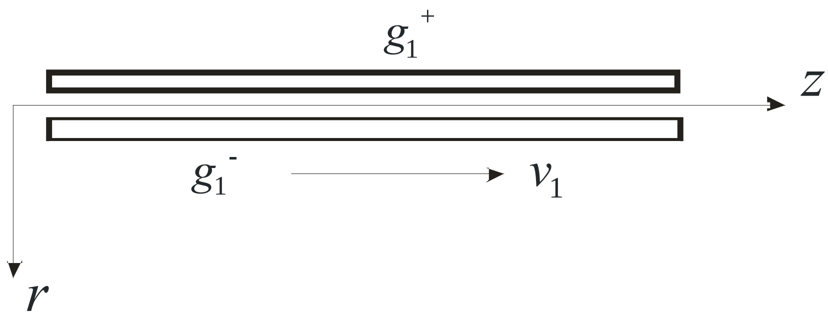

Fig. 1 : Section is the conductor, along which flows the current.

We will consider that the direction of the vector of electric field coincides with the direction r. If electronic flux moves with the speed, then the electric field of this flow is determined by the equality

$$E^- = -\frac{g^-}{2\pi\varepsilon r} ch\frac{v_1}{c} \cong -\frac{g^-}{2\pi\varepsilon r}\left(1+\frac{1}{2}\frac{v_1^2}{c^2}\right). \tag{3.2}$$

Adding (3.1) (3.2), we obtain:

$$E^- = -\frac{g^- v_1^2}{4\pi\varepsilon c^2 r}.$$

This means that around the conductor with the current is an electric field, which corresponds to the negative charge of conductor. However, this field has insignificant value, since in the real conductors. This field can be discovered only with the current densities, which can be achieved in the superconductors, which is experimentally confirmed in works.

Let us examine the case, when very section of the conductor, on which with the speed v_1 flow the electrons, moves in the opposite direction with speed v (Fig. 2). In this case relationships (3.1) and (3.2) will take the form

$$E^+ = \frac{g^+}{2\pi\varepsilon r}\left(1+\frac{1}{2}\frac{v^2}{c^2}\right), \tag{3.3}$$

$$E^- = -\frac{g^-}{2\pi\varepsilon r}\left(1+\frac{1}{2}\frac{(v_1-v)^2}{c^2}.\right) \tag{3.4}$$

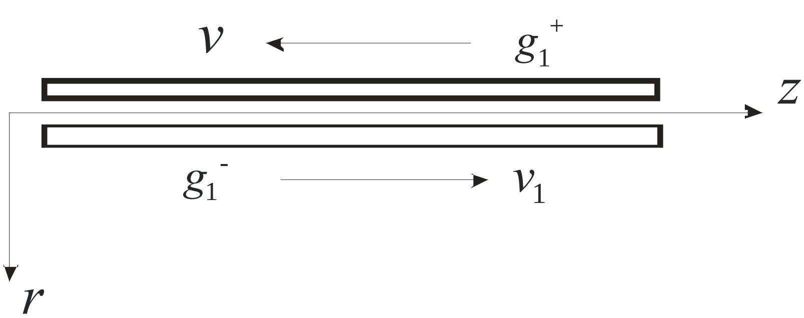

Fig. 2 : Moving conductor with the current.

.Adding (3.3) and (3.4), we obtain:

$$E^+ = \frac{g}{2\pi\varepsilon r}\left(\frac{v_1 v}{c^2} - \frac{1}{2}\frac{v_1^2}{c^2}\right). \tag{3.5}$$

In this relationship as the specific charge is undertaken its absolute value. since the speed of the mechanical motion of conductor is considerably more than the drift velocity of electrons, the second term in the brackets can be disregarded. In this case from (3.5) we obtain

$$E^+ = \frac{g v_1 v}{2\pi\varepsilon c^2 r}. \tag{3.6}$$

The obtained result means that around the moving conductor, along which flows the current, with respect to the fixed observer is formed the electric field, determined by relationship (3.6), which is equivalent to appearance on this conductor of the specific positive charge of the equal

$$g^{+} = \frac{g v_1 v}{c^2}.$$

If we conductor roll up into the ring and to revolve it then so that the linear speed of its parts would be equal v, then around this ring will appear the electric field, which corresponds to the presence on the ring of the specific charge indicated. But this means that the revolving turn, which is the revolving magnet, acquires specific electric charge on wire itself, of which it consists. During the motion of linear conductor with the current the electric field will be observed with respect to the fixed observer, but if observer will move together with the conductor, then such fields will be absent.

As is obtained the unipolar induction, with which on the fixed contacts a potential difference is obtained, it is easy to understand from Fig. 3.

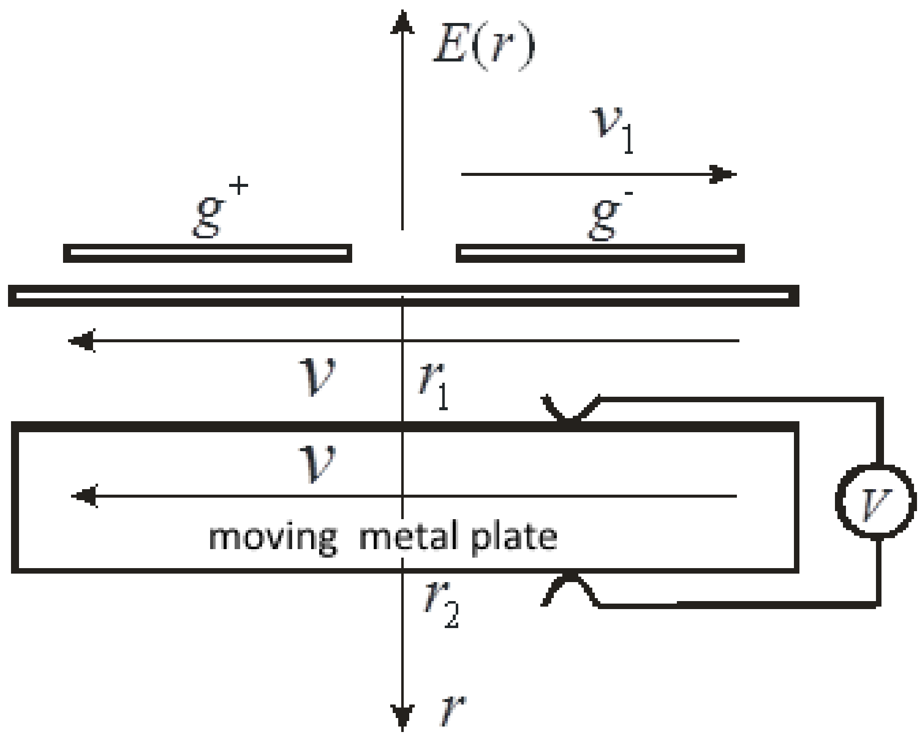

Fig. 3 : Diagram of formation emf. unipolar induction.

We will consider that r_1 and r_2 of the coordinate of the points of contact of the tangency of the contacts, which slide along the edges of the metallic plate, which moves with the same speed as the conductor, along which flows the current. Contacts are connected to the voltmeter, which is also fixed. Then, it is possible to calculate a potential difference between these contacts, after integrating relationship (3.6):

$$U = \frac{g v_1 v}{2\pi\varepsilon c^2}\int_{r_1}^{r_2}\frac{dr}{r} = \frac{g v_1 v}{2\pi\varepsilon c^2}\ln\frac{r_2}{r_1}.$$

But in order to the load, in this case to the voltmeter, to apply this potential difference, it is necessary sliding contacts to lock by the cross connection, on which there is no potential difference indicated. But since metallic plate moves together with the conductor, a potential difference is absent on it. It serves as that cross connection, which gives the possibility to convert this composite outline into the source emf with respect to the voltmeter.

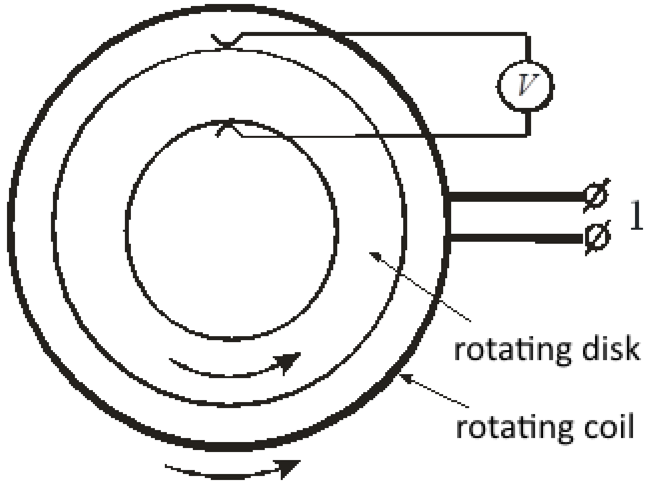

Fig. 4 : Schematic of unipolar generator with the revolving turn with the current and the revolving conducting ring.

Now it is possible wire to roll up into the ring (Fig. 4) of one or several turns, and to feed it from the current source [9-11]. Moreover contacts 1 should be derived on the collector rings, which are located on the rotational axis and to them joined the friction fixed brushes. Thus, it is possible to obtain the revolving magnet. In this magnet should be placed the conducting disk with the opening, which revolves together with the turns of the wire, which serves as magnet, and with the aid of the fixed contacts, that slide on the generatrix of disk, tax voltage on the voltmeter. As the limiting case it is possible to take continuous metallic disk and to connect sliding contacts to the generatrix of disk and its axis. Instead of the revolving turn with the current it is possible to take the disk, magnetized in the axial direction, which is equivalent to turn with the current, in this case the same effect will be obtained.

Different combinations of the revolving and fixed magnets and disks are possible.

The case with the fixed magnet and the revolving conducting disk is characterized by the diagram, depicted in Fig. 5, if the conducting plate was rolled up into the ring.

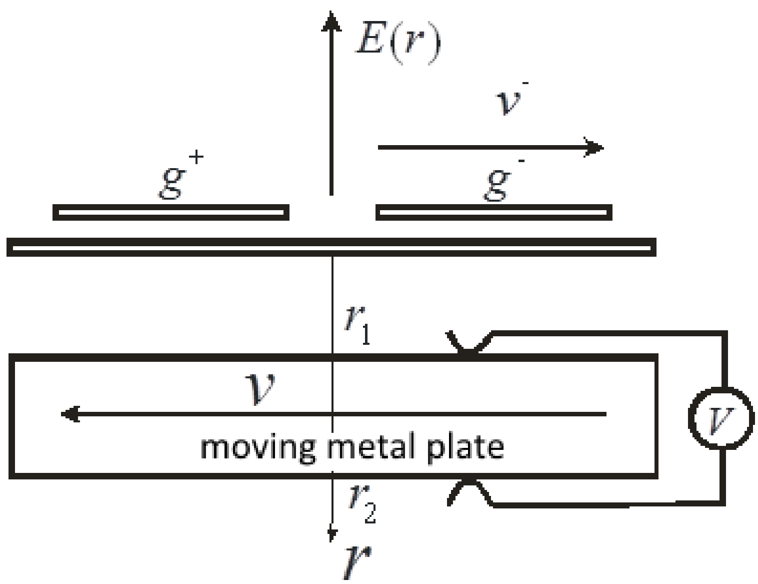

Fig. 5 : Case of fixed magnet and revolving disk.

In this case the following relationships are fulfilled:

The electric field, generated in the revolving disk by the electrons, which move along the conductor, is determined by the relationship

$$E^- = -\frac{g^-}{2\pi\varepsilon r} ch\frac{v_1 - v}{c} = -\frac{g^-}{2\pi\varepsilon r}\left(1 + \frac{1}{2}\frac{(v_1 - v)^2}{c^2}\right),$$

and by the fixed ions

$$E^+ = \frac{g^+}{2\pi\varepsilon r} ch\frac{v}{c} = \frac{g^-}{2\pi\varepsilon r}\left(1 + \frac{1}{2}\frac{v^2}{c^2}\right).$$

The summary tension of electric field in this case will comprise

$$E_{\Sigma} = \frac{g}{2\pi\varepsilon r}\left(\frac{vv_1}{c^2}\right),$$

and a potential difference between the points r_1 and r_2 in the coordinate system, which moves together with the plate, will be equal

$$U = \frac{g(r_2 - r_1)}{2\pi\varepsilon r}\left(\frac{vv_1}{c^2}\right).$$

Since in the fixed with respect to the magnet of the circuit of voltmeter the induced potential difference is absent, the potential difference indicated will be equal by the electromotive force of the generator examined. As earlier moving conducting plate can be rolled up into the disk with the opening, and the wire, along which flows the current into the ring with the current, which is the equivalent of the magnet, magnetized in the end direction.

Thus, the concept of scalar-vector potential gives answers to all presented questions.

IV. Conclusion

The unipolar induction was discovered still Faraday almost 200 years ago, but in the classical electrodynamics of final answer to that as and why work some constructions of unipolar generators, there is no up to now. Let us show that the concrete answers to all these questions can be obtained within the framework the concept of scalar-vector potential. This concept, obtained from the symmetrical laws of induction, assumes the dependence of the scalar potential of charge and pour on it from the charge rate. The symmetrization of the equations of induction is achieved by the way of their record with the use by substantial derivative. Different the schematics of unipolar generators are given and is examined their operating principle within the framework of the concept of scalar-vector potential.

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Modified Modulation Techniques for Cascaded Multilevel Inverter Fed Induction Motor Drive

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Keywords: cascaded multilevel inverter, SVPWM, offset voltage.

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MODIFIEDMODULATIONTECHNIQUESFORCASCADEDMULTILEVELINVERTERFEDINDUCTIONMOTORDRIVE

Strictly as per the compliance and regulations of:

Modified Modulation Techniques for Cascaded Multilevel Inverter Fed Induction Motor Drive

Ch. Lokeshwar Reddy α, P. Satish Kumar σ & M. Sushama ρ

Abstract- This paper presents modified Space Vector Pulse Width Modulation (SVPWM) techniques for Cascaded Multilevel Inverter. In the proposed SVPWM technique the reference signals are generated by adding offset voltage to the reference phase voltages. This SVPWM technique does not involve region identification, sector identification or look up tables for switching vector determination as are required in the conventional multilevel SVPWM technique It is also reduces the computation time compared to the conventional space vector PWM technique. The modulation signals are generated by comparing the reference phase voltages with triangular carrier signals. Cascaded multilevel inverter fed with Induction Motor and RL load is simulated for various carrier PWM techniques like PDPWM, PODPWM, APODPWM and PSCPWM. The simulation results are analysed and compared. Among the various modulation techniques, PDPWM is the most efficient one and has better spectral performance and better induction motor performance.

Keywords: cascaded multilevel inverter, SVPWM, offset voltage.

I. Introduction

Many different PWM methods are available to achieve these aims: wide linear modulation range, reduced switching loss, lesser total harmonic distortion in the spectrum of switching waveform, easy implementation, less memory space and computation time on implementing digital processors. The most widely used PWM schemes for Multi-level inverters are the carrier based PWM (sine-triangle PWM or SPWM) and space vector based PWM. These modulation techniques have been studied extensively and compared for the performance parameters for two level inverters [1,2].

The SPWM techniques are more flexible and simple to implement, but the maximum peak of the fundamental component in the output voltage is limited to 50% of the DC link voltage and the extension of the SPWM techniques into over- modulation range is difficult [2].

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The SVPWM technique presented for multi-level inverters can also work in the over-modulation range. The SVPWM technique gives more fundamental voltage and better harmonic performance compared with SPWM technique [3-5].The maximum peak of the fundamental component in the output voltage obtained with space vector pulse width modulation is 15% more than with the sine-triangle modulation technique [2,3]. But the conventional space vector PWM technique requires sector identification and look-up tables to determine the timings for various switching vectors of the inverter in all the sectors [3,4].This makes the implementation of the SVPWM technique is complicated.

Based on the arrangement of carrier waves, the PWM techniques can be classified as Phase Disposition (PD), Phase Opposition Disposition (POD), Alterative Phase Opposition Disposition (APOD), Phase Shifted Carrier PWM (PSCPWM). PD, POD and APOD are level shifted carrier PWM methods whereas; PSCPWM is the phase shifted carrier method.

This paper focuses on different control strategies and suitable modulation strategy is selected based on the outputs obtained through the simulations for cascaded multi-level inverters.

a) *Phase Disposition (PD)*

This technique requires (m-1) carrier waveforms for an m-level phase waveform. All the carriers are in same phase and level shifted equally. The Fig. 1 shows the arrangement of carriers for eleven level cascaded multilevel inverter. The ten carrier signals with same phase but level shifted equally are compared with reference signal.

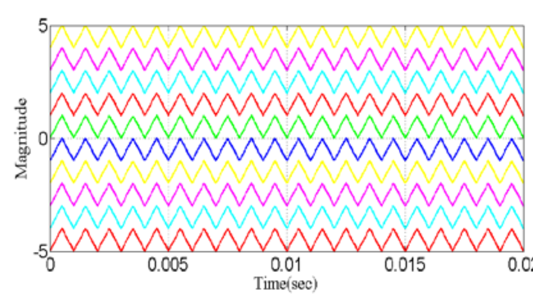

Fig.1 : Arrangement of carriers for PD Technique.

b) Phase Opposition Disposition (POD)

This technique requires (m-1) carrier waveforms for an m-level phase waveform. Half of the carrier waveforms above and below are in phase, but there is 1800 phase shift between the above and below half as shown in Fig. 2. The significant harmonics are located around the carrier frequency fc for both the phase and line voltage waveforms.

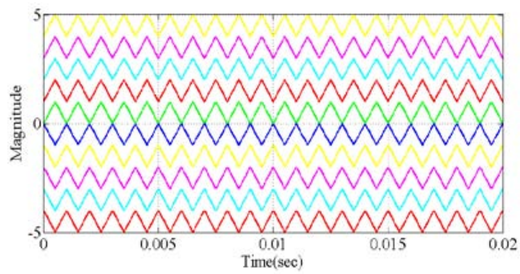

Fig.2 : Arrangement of carriers for POD Technique.

c) Alterative Phase Opposition Disposition (APOD)

This technique requires (m-1) carrier waveforms for an m-level phase waveform. The carriers are phase displaced each other by 1800 alternatively as shown in Fig. 3. The most significant harmonics are centered as sidebands around the carrier frequency fc and therefore no harmonics occur at fc.

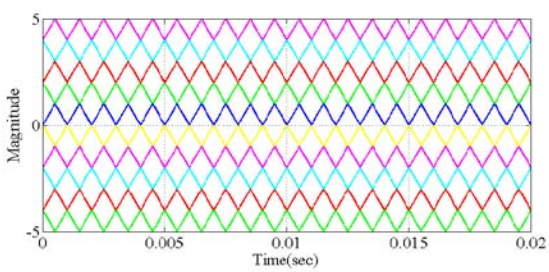

Fig.3 : Arrangement of carriers for APOD Technique.

d) Phase Shifted Carrier (PSCPWM)

In this technique all the carriers are phase shifted by an angle 3600/N (where N is number of single phase inverter cells used in a phase leg). This strategy leads to the cancellation of all carrier and associated sideband harmonics up to 2Nth carrier group[6]. Fig. 4 shows the arrangement of carriers for an eleven level cascaded multilevel inverter.

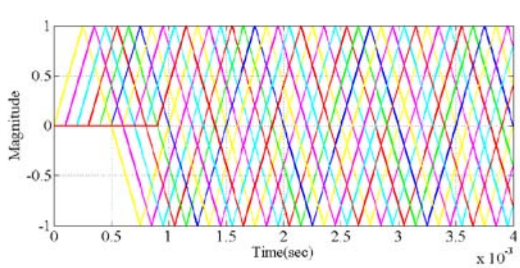

Fig. 4 : Arrangement of carriers for PSC PWM Technique.

For APOD, the first set of sideband harmonics is centered about the carrier frequency, while for PSCPWM the first set of sideband harmonics is centered about the 2Nth multiple of carrier frequency, where N is the number of h-bridges in each cascaded inverter phase leg.[7]. The total number of switch transitions for PSCPWM is exactly 2N times the number of switch transitions for APOD.

II. Modified SVPWM

The conventional SVPWM for multilevel inverters involves mapping of the outer sectors to an inner sub hexagon sector, to determine the switching time duration, for various inverter vectors. Then the switching inverter vectors corresponding to the actual sector are switched, for the time durations calculated from the mapped inner sectors. It is obvious that such a scheme, in multilevel inverters will be very complex, as large number of sectors and inverter vectors are involved. This will also considerably increase the computation time for real time implementation.

A carrier based PWM scheme has been presented [8], where sinusoidal references are added with a proper offset voltage before being compared with carriers, to achieve the performance of a SVPWM. The offset voltage computation is based on a modulus function depending on the DC link voltage, number of levels and the phase voltage amplitudes.

A modulation scheme is presented where a common mode voltage of suitable magnitude is added to the reference phase voltage throughout the duration [4,5]. A modulation technique is presented in [7], where a fixed common mode voltage is added to the reference phase voltage throughout the modulation range. It has shown [9] that this common mode addition will not result in a SVPWM like performance, as it will not centre the middle inverter vectors in a sampling interval. The common mode voltage to be added in the reference phase voltages, to achieve SVPWM like performance is a function of the modulation index for multilevel inverters [9]. A simplified method, to determine the correct offset times for centering the time durations of the middle inverter vectors, in a sampling interval is presented [10].

To obtain the maximum possible peak amplitude of the fundamental phase voltage in linear modulation, the procedure for this is given in [11-13] an offset time, T_{offset}, is added to the reference phase voltages where the magnitude of T_{offset} is given by

$$T_a = \frac{V_a * T_s}{V_{dc}} \tag{1}$$

$$T_b = \frac{V_b * T_s}{V_{dc}} \tag{2}$$

$$T_c = \frac{V_c * T_s}{V_{dc}} \tag{3}$$

T_a , T_b and T_c are the imaginary switching time periods proportional to the instantaneous values of the reference phase voltages

$$T_{offset} = [\frac{T_0}{2} - T_{\min}] \tag{4}$$

$$T_0 = [T_s - T_{effect}] \tag{5}$$

$$T_{effect} = T_{\max} - T_{\min} \tag{6}$$

$T_{\max} =$ Maximum magnitude of the three sampled reference phase voltages, in a sampling interval.

$T_{\min} =$ Minimum magnitude of the three sampled reference phase voltages, in a sampling interval.

The addition of offset voltage to the reference phase voltages results in the active inverter switching vectors being centered in a sampling interval, making the SPWM technique equivalent to the SVPWM technique. Fig. 5 shows the generated reference signals for the proposed technique.

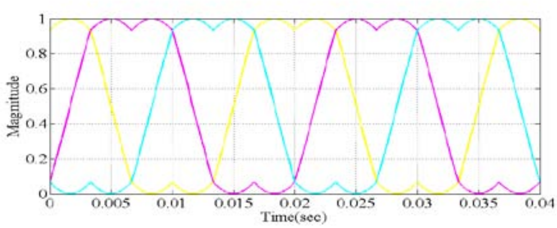

Fig.5 : Generation of Reference Phase Voltages.

This proposed SVPWM signal generation does not involve region identification, sector identification or look up tables for switching vector determination required in the conventional multilevel SVPWM technique. This scheme is computationally efficient when compared to conventional multilevel SVPWM scheme.

III. Simulation Results and Comparison

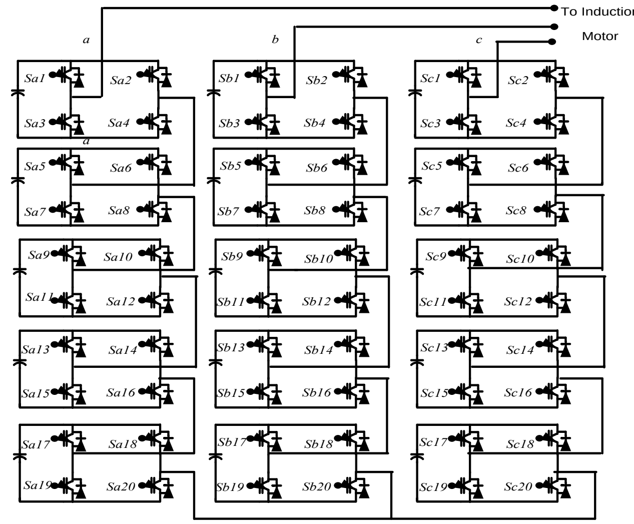

Fig.6 : Cascaded 11 level Multilevel Inverter.

An eleven level cascaded multilevel inverter fed with Induction motor shown in Fig. 6 and for RL load is simulated. The carrier frequency fc is 1 kHz. The modulating pulses are generated by the comparing the reference wave with the triangular waves. For m level cascaded multilevel inverter m-1 carrier waves required.

It is simulated for different carrier modulating techniques PDPWM, PODPWM, APODPWM and PSCPWM. Fig. 7 shows the generation of PWM pulses for Eleven Level Cascaded Multilevel Inverter by using PDSVPWM. Fig. 8 shows the generation of PWM pulses for Eleven Level Cascaded Multilevel Inverter by using PODSVPWM. Fig. 9 shows the generation of PWM pulses for Eleven Level Cascaded Multilevel Inverter by using APODSVPWM and Fig. 10 shows the generation of PWM pulses for Eleven Level Cascaded Multilevel Inverter by using PSCSVPWM. Here reference wave is generated by modified SVPWM technique.

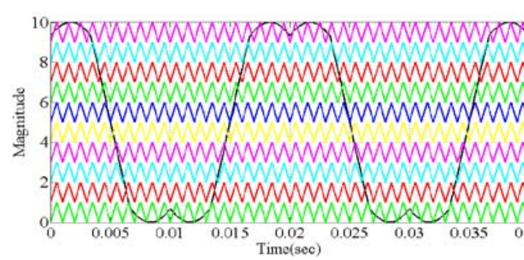

Fig.7 : Generation of PWM pulses by PDSVPWM.

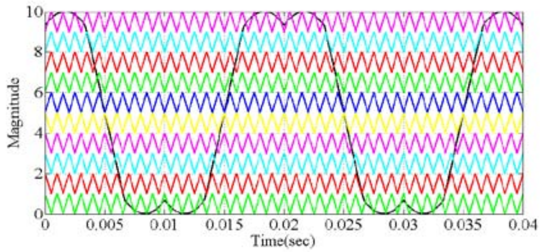

Fig.8 : Generation of PWM pulses by PODSVPWM.

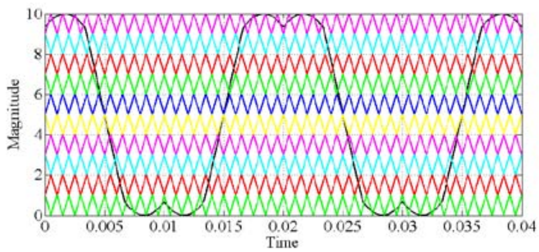

Fig.9 : Generation PWM pulses by APODSVPWM.

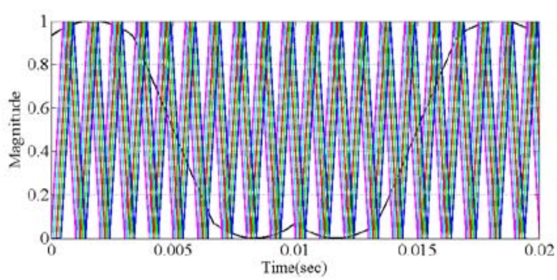

Fig.10 : Generation PWM pulses by PSCSVPWM for half cycle.

Fig. 11 shows the harmonic spectrum of line voltage for PSCSPWM. Fig. 12 shows the harmonic spectrum of line voltage for PDSPWM. Fig. 13 shows the harmonic spectrum of line voltage for PODSPWM and Fig. 14 shows the harmonic spectrum of line voltage for APODSPWM. It is observed that PDSPWM technique produces fewer harmonic with respect to other techniques.

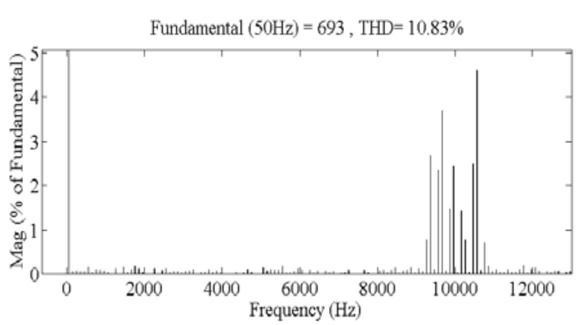

Fig.11 : Frequency Spectrum of 11level CMLI with PSCSPWM.

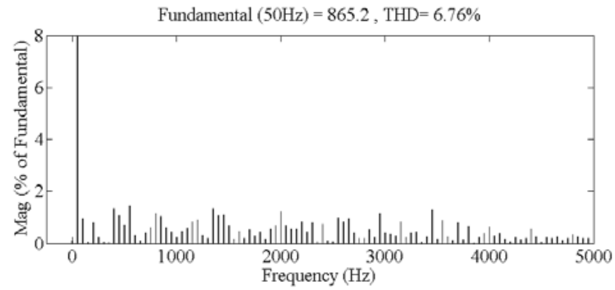

Fig.12 : Frequency Spectrum of 11level CMLI with PDSPWM.

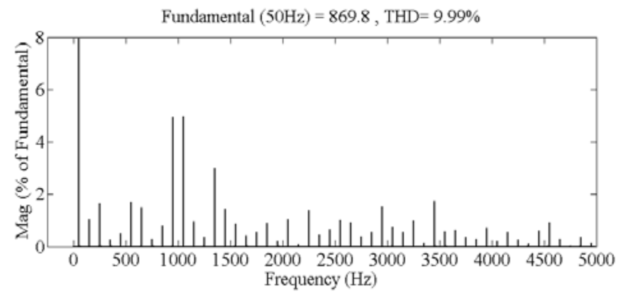

Fig.13 : Frequency Spectrum of 11level CMLI with PODSPWM.

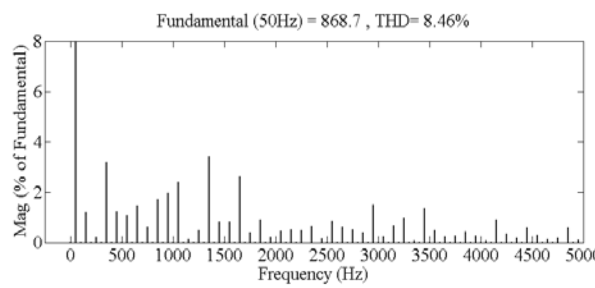

Fig.14 : Frequency Spectrum of 11level CMLI with APODSPWM.

Fig. 15 shows harmonic spectrum of line voltage for an eleven level Cascaded Multilevel Inverter by using PDSVPWM technique. Fig. 16 shows harmonic spectrum of line voltage for an eleven level Cascaded Multilevel Inverter by using PODSVPWM technique. Fig. 17 shows harmonic spectrum of line voltage for an eleven level Cascaded Multilevel Inverter by using APODSVPWM technique and Fig. 18 shows harmonic spectrum of line voltage for an eleven level Cascaded Multilevel Inverter by using PSCSVPWM technique.

From Fig. 16, it is observed that the significant harmonics are located around the carrier frequency fc for the line voltage waveform in PODSVPWM.

From Fig. 17, it is observed that the most significant harmonics are centered as sidebands around the carrier frequency fc and therefore no harmonics occur at fc for APODSVPWM.

From Fig. 18, it is observed that the PSCPWM strategy leads to the cancellation of all carrier and associated sideband harmonics up to 2Nth carrier group.

For APOD and POD , no harmonic exists at pulse number P due to odd symmetry of their PWM wave forms. For PD, the wave forms is asymmetric and the harmonic at P is relatively high only for single phase, but for three phase the triplen harmonics of voltage will be eliminated, thus harmonics at P is eliminated if P is chosen as a multiple of three. So PD is more convenient due to very little values of other harmonics.

It is observed that the total harmonic distortion is less in PDSVPWM technique with comparison to other SVPWM techniques and all other SPWM techniques.

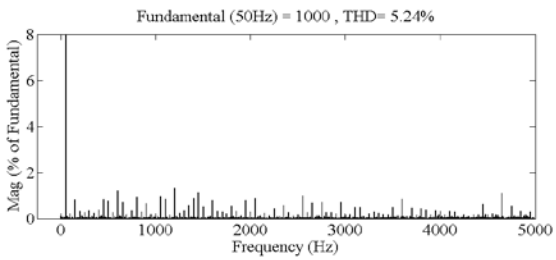

Fig.15 : Frequency Spectrum of CMLI with PDSVPWM.

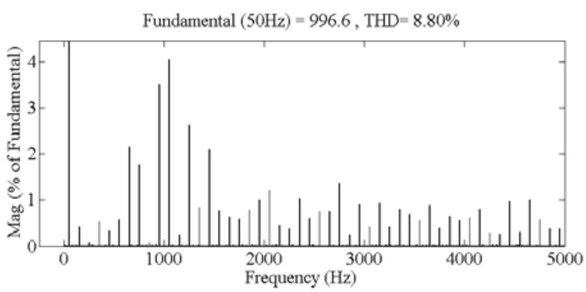

Fig.16 : Frequency Spectrum of CMLI with PODSVPWM.

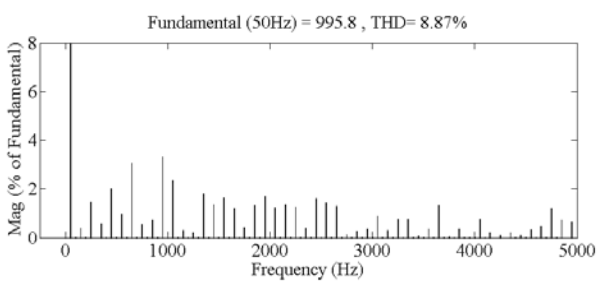

Fig.17 : Frequency Spectrum of 11level CMLI with APODSVPWM.

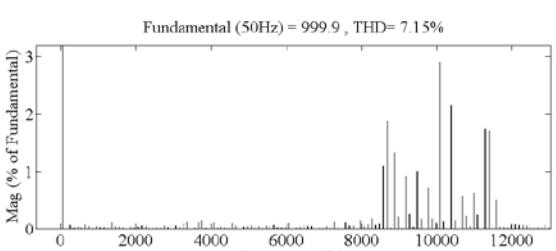

Fig.18 : Frequency Spectrum of CMLI with PSCSVPWM.

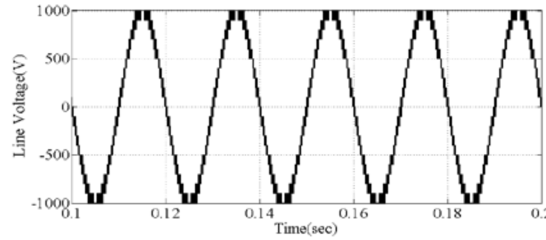

Fig.19 : Line Voltage for 11level Inverter.

Table 1 : Comparison Between Different PWM Techniques.

S.No	Type of PWM	% THD	Magnitude of Fundamental
I. SPWM With RL Load			
1	PDSPWM	6.79	865.7
2	APODSPWM	8.57	864.7
3	PODSPWM	9.36	860.7
4	PSCSPWM	10.81	692.5
II. Modified SVPWM with RL load			
1	PDSVPWM	5.51	999.4
2	PSCSVPWM	7.31	998.6
3	APODSVPWM	8.51	1005
4	PODSVPWM	8.85	996.4
III. SPWM With IM load			
1	PDSPWM	6.76	865.2
2	PSCSPWM	1083	693
3	APODSPWM	8.46	868.6
4	PODSPWM	9.99	869.8
IV. Modified SVPWM with IM load			
1	PDSVPWM	5.24	1000
2	PSCSVPWM	7.15	999.9
3	APODSVPWM	8.87	995.8
4	PODSVPWM	8.80	996.7

Table 1 shows the Line voltage harmonic comparison of an eleven level cascaded multilevel inverter connected to RL and Induction motor loads for all the PWM techniques. It is observed from the table that PDSVPWM technique generates fewer harmonic with respect to all other methods.

In this simulation the induction motor used is 1.5 Kw, 1500rpm, 4-pole, 3-phase induction motor having the following parameters:

Rr = 7.55Ω, Rs = 7.83 Ω, Lm = 0.4535H, Ls = 0.4751H,

Lr = 0.4751H,J =0.06 Kg.m2 and B = 0.01 N-m.sec/rad.

Fig. 19 shows the line voltage output for cascaded multilevel inverter. Fig. 20 shows Induction Motor torque waveform for the Sinusoidal PWM technique PSCSPWM. Fig. 21 shows Induction Motor torque waveform for the Sinusoidal PWM technique PDSPWM. Fig. 22 shows Induction Motor torque waveform for the Sinusoidal PWM technique PODSPWM and Fig. 23 shows Induction Motor torque waveform for the Sinusoidal PWM technique APODSPWM technique. In this simulation the load torque is varied from 0 to 10 at 1sec. It is observed that the torque reaches to steady state faster in PDSPWM technique, but PODSPWM and APODSPWM techniques gives almost similar response. The PSCSPWM technique takes more time to reach motor torques to steady state.

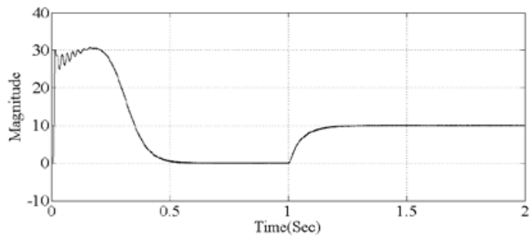

Fig.20 : Motor Torque for PSCSPWM technique.

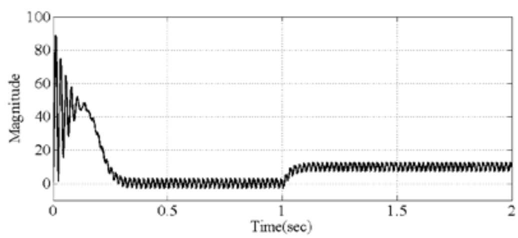

Fig.21 : Motor Torque for PDSPWM technique.

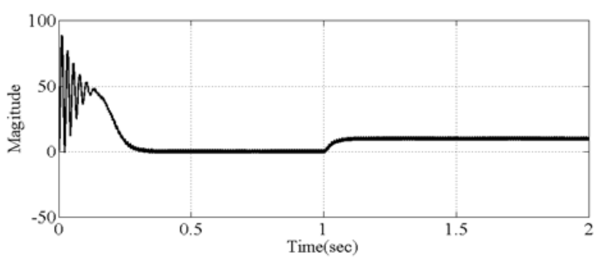

Fig.22 : Motor Torque for PODSPWM technique.

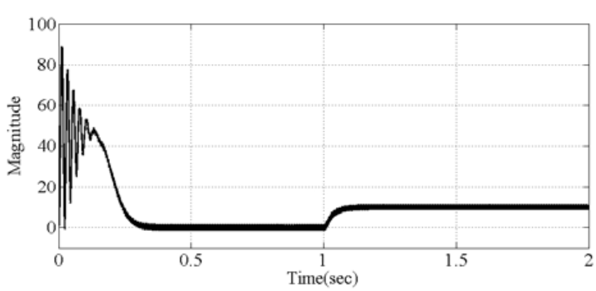

Fig.23 : Motor Torque for APODSPWM technique.

Fig. 24 shows Induction Motor torque waveform for the Space Vector PWM technique PSCSVPWM. Fig. 25 shows Induction Motor torque waveform for the Space Vector PWM technique PDSVPWM. Fig. 26 shows Induction Motor torque waveform for the Space Vector PWM technique PODSVPWM and Fig. 27 shows Induction Motor torque waveform for the Space Vector PWM technique APODSVPWM. Here the load torque is varied from 0 to 10 at 1 sec. It is observed that the motor torque reaches to steady state quickly by using various modified SVPWM techniques.

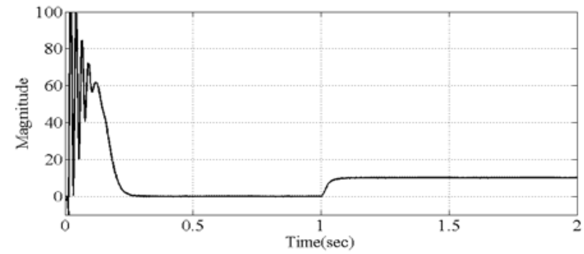

Fig.24 : Motor Torque for PSCSVPWM technique.

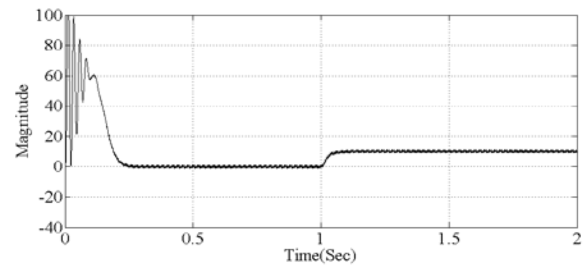

Fig.25 : Motor Torque for PDSVPWM technique.

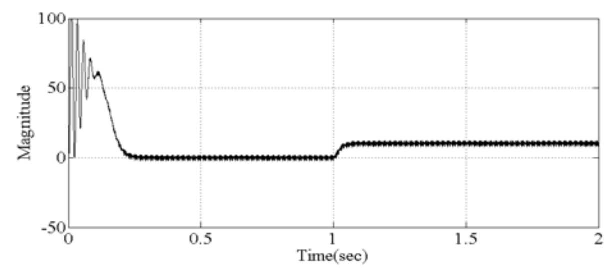

Fig.26 : Motor Torque for PODSVPWM Technique.

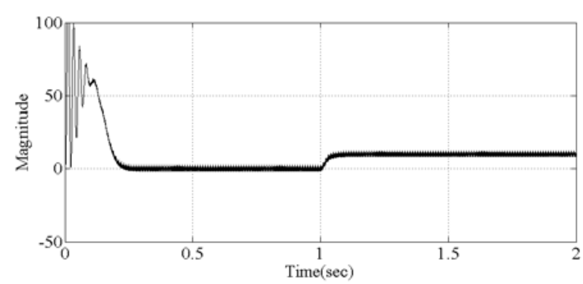

Fig.27 : Motor Torque for APODSVPWM technique.

Fig. 28 shows Induction Motor speed waveform for the Sinusoidal PWM technique PSCSPWM. Fig. 29 shows Induction Motor speed waveform for the Sinusoidal PWM technique PDSPWM. Fig. 30 Induction Motor speed waveform for the Sinusoidal PWM technique PODSPWM and Fig. 31 shows Induction Motor speed waveform for the Sinusoidal PWM technique APODSPWM. Here the load torque is varied from 0 to 10 at 1 sec.

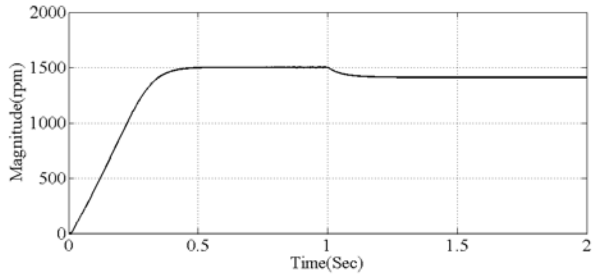

Fig.28 : Motor Speed for PSCSPWM technique.

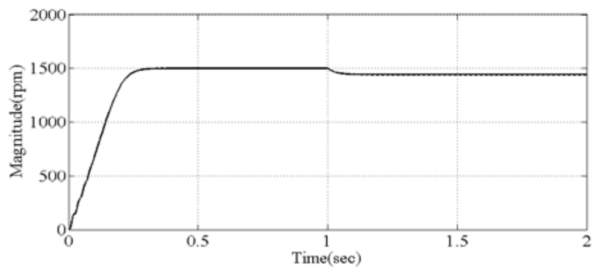

Fig.29 : Motor Speed for PDSPWM technique.

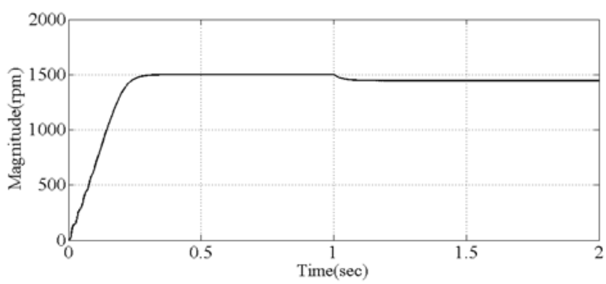

Fig.30 : Motor Speed for PODSPWM technique.

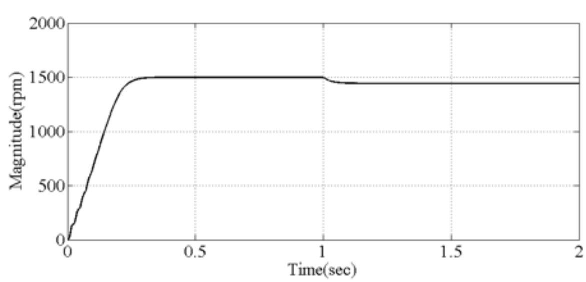

Fig.31 : Motor Speed for APODSPWM technique.

Fig. 32 shows Induction Motor speed waveform for the Space Vector PWM technique PSCSVPWM. Fig. 33 shows Induction Motor speed waveform for the Space Vector PWM technique PDSVPWM. Fig. 34 shows Induction Motor speed waveform for the Space Vector PWM technique PODSVPWM and Fig. 35 shows Induction Motor speed waveform for the Space Vector PWM technique APODSVPWM. Here the load torque is varied from 0 to 10 at 1 sec. It is observed that speed reaches to steady state quickly in modified SVPWM technique.

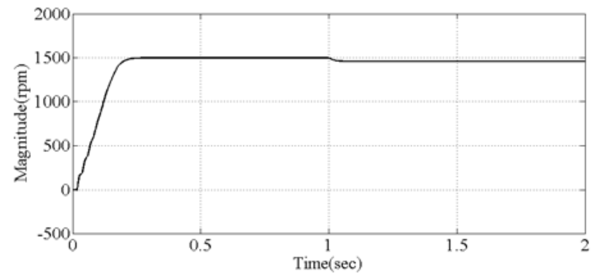

Fig.32 : Motor Speed for PSCSVPWM technique.

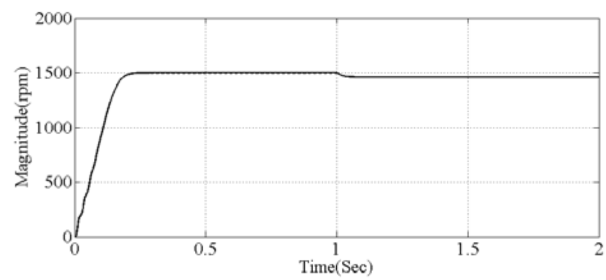

Fig.33 : Motor Speed for PDSVPWM technique.

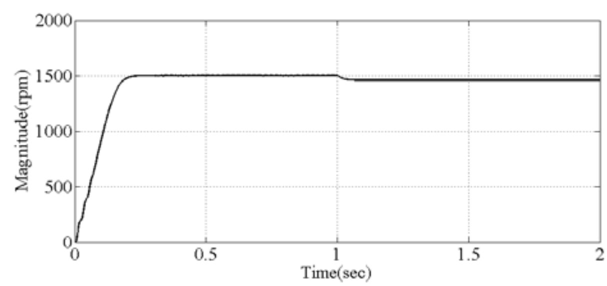

Fig.34 : Motor Speed for PODSVPWM technique.

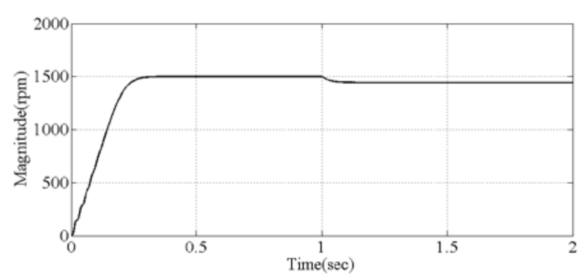

Fig.35 : Motor Speed for APODSVPWM technique.

IV. Conclusion

The reference signals are generated by using modified SVPWM techniques. This method does not involve region identification, sector identification or look up tables for switching vector determination required in conventional SVPWM technique. Simulation studies have been carried out on Cascaded multilevel inverter fed Induction motor and RL load for different PWM techniques. It is observed that Modified SVPWM technique has given better torque and speed performance of the motor, and it is also noticed that one of the modified SVPWM techniques is PDSVPWM technique which produces less harmonic distortion with respect to all other PWM techniques.

V. Acknowledgment

We thank the University Grants Commission (UGC), New Delhi, for providing support to carryout research on Multilevel Inverters under the Major research project.

VI. Future Scope

This modified SVPWM technique does not involve region identification, sector identification or look up tables for switching vector determination as are required in the conventional multilevel SVPWM technique, and reduces the computation time compared to the conventional space vector PWM technique. The hardware implementation with this SVPWM technique will also be easily possible for higher levels.

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Harmonics Cancellation and Alleviation of Ripple Content from AC-DC Uncontrolled Rectifier by Pulse-Multiplication Technique using Phase-Shifting Transformer

By MD Nasmus Sakib Khan Shabbir, Fatiha-Tul Jannat, Md. Atiqur Rahman, Md. Shohel Rana & Kajal Chakrabarty

Bangladesh University of Business and Technology, Bangladesh

Abstract- Harmonic distortion is a huge problem for the power systems. But harmonic distortion can be controlled using some unique methods with the utility systems. This paper discusses the impact of using 12- pulse and 24-pulse rectifier circuit. The 24-pulse topology is generally more expensive, but produces the least Input current harmonics. In this paper pulsemultiplication technique is used to mitigate the harmonic distortion from the input line current. Phase-shifting transformers are used to produce 24-pulse from 12- pulse. A comparison between 12-pulse and 24-pulse rectifier also shown in this paper. Operation of the circuits is verified through computer simulations.

Keywords: diodes, phase-shifting transformer, 12-pulse and 24-pulse rectifier.

GJRE-F Classification: FOR Code: 290901

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MD Nasmus Sakib Khan Shabbir [α], Fatiha-Tul Jannat [σ], Md. Atiqur Rahman [ρ], Md. Shohel Rana [Ѡ] & Kajal Chakrabarty [¥]

Abstract- **Harmonic distortion is a huge problem for the power systems. But harmonic distortion can be controlled using some unique methods with the utility systems. This paper discusses the impact of using 12-pulse and 24-pulse rectifier circuit. The 24-pulse topology is generally more expensive, but produces the least Input current harmonics. In this paper pulse-multiplication technique is used to mitigate the harmonic distortion from the input line current. Phase-shifting transformers are used to produce 24-pulse from 12-pulse. A comparison between 12-pulse and 24-pulse rectifier also shown in this paper. Operation of the circuits is verified through computer simulations.**

Keywords: diodes, phase-shifting transformer, 12-pulse and 24-pulse rectifier.

I. Introduction

Development of our technology in recent years, the direction of research has shifted to power electronics from power systems to produce the most efficient energy conversion. The power electronics is giving us the opportunity to shape and control large amounts of power with better efficiency. Low cost, smaller size and high energy efficiency are possible because of power electronics. Within the next 30 years, power electronics will shape and condition the electricity somewhere in the transmission network between its generation and all its users.[1] Diode is called the first solid state electronic device. Now-a-days it becomes a weighty part of power electronic era. Diode rectifiers are used in several power systems. Diode bridge is specially used in high-power applications. Only diode contain some magnificent characteristics such as availabile, light weight, compact, high efficiency, robust for fault high current, less emission noises and etc. Three phase diode bridge constructed with six diodes. It can operate with or without transformer.

Like other non-linear devices diode also affected by harmonics. Harmonics are multiples of the

Like other non-linear devices diode also affected by harmonics. Harmonics are multiples of the

fundamental frequency. The deviation from perfect sine wave isknown as harmonic distortion. Harmonic is acceptablewithin limit. Increase in core losses due to increased iron losses in transformers occured by harmonic currents at harmonic frequencies. It also increased copper losses and stray flux losses result in additional heating, and winding insulation stresses, especially if high levels of *dv/dt* (i.e., rate of rise of voltage) are present. Temperature cycling and possible resonance between transformer winding inductance and supply capacitance, line notching problems are produced by harmonics. [2]

Several harmonic mitigation procedure are available using diode rectifiers. Some of them provide fine uncontrolled dc voltage without harmonic pollution . Every configurations cannot fullfill the demand like auto-transformer based schemes fails due to higher rating magnetic, higher number of bridges, resulting in enhancement of capital cost. [3]

This paper work with the three-phase multi-pulse AC to DC conversion system employing a phase-shifting transformer and a three-phase uncontrolled bridge rectifier between the supply and load side of the system. Every such converter provides 6-pulse ripple components on the output voltage, so in order to produce more sets of 6-pulse systems, a uniform phase-shift is required and hence with proper phase-shifting angle, 12, 18, 24, 30, and higher pulse systems can be produced.[4] Phase shifting transformer based configurations are really cost effective and reliable than others. In this paper we design a ac-dc converter with limited harmonic distortion with the help of phase shifting transformer. This paper represent an unique 24-pulse converter with bridge rectifier which is able to control harmonic distortion and provide best ripple factor in the output. This can be achieved by applying pulse-multiplication technique.

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II. Circuit Topology

a) Pulse Circuit schemes

Fig 3.1 shows a simplified circuit diagram of a three-phase twelve-pulse diode rectifier. The resistor and inductance RLin is the total inductance including the line inductance, transformer reactance, and line reactor between the utility and the rectifier. A single unit 3-phase rectifier is called 6-pulse rectifier. Thus, a 12-pulse rectifier have 2x6-pulse rectifier. Phase-shifting not only reduce the harmonic input current but also reduces the ripple on the DC output of the rectifier. Three phase full wave rectification diodes D1, D2, D3, D4, D5, D6 are numbered in order of conduction sequences and each one conduct for 120^0. The conduction sequence for diodes is D1D2, D3D2, D3D4, D5D4, D5D6 and D1D6.

When phase voltage V_{ab} starts D1D6 conduct for 60^0 and for V_{ba} the negative phase voltage starts D3D4 conduct with the supply. Similarly V_{bc} and V_{cb} phase voltage converted to dc at the supply side by connecting D3D2 and D5D6 that time. Lastly Vca and Vac converted to dc using sequence D1D2 and D5D4. The average output voltage is found:

$$V_0 = \frac{2}{\frac{2\pi}{6}} \int_0^{\frac{\pi}{6}} \sqrt{3} V_m \cos \omega t \, d(\omega t)$$

$$= 1.654 V_m; \text{-----------------------------} (1.1)$$

Where Vm is the peak value of rms voltage.

When load is purely resistive the rms value of the diode current is :

$$I_{rms} = \left[\frac{4}{2\pi} \int_0^{\pi/6} I_m^2 \cos^2 \omega t \, d(\omega t)\right]^{\frac{1}{2}}$$

$$= 0.5518 I_m \text{-----------------------------} (1.2)$$

Supply the three phases are symmetrical and are Y-connected.

The 3-phase voltage sources are defined as:

$$V_a = V_{rms} * \sqrt{2/3} \sin(\omega t + \theta * \pi/180)$$

$$V_b = V_{rms} * \sqrt{2/3} \sin(\omega t + \theta * \pi/180 - 2\pi/3)$$

$$V_c = V_{rms} * \sqrt{2/3} \sin(\omega t + \theta * \pi/180 + 2\pi/3)$$

Here line-to-line rms voltage Vrms of the three-phase source in V. The resistances and inductances of the three-phase branches are equal. The initial currents are zero.

In 12-pulse converter Y-Y and Y-Δ transformer presents the resistance and inductance values of the secondary winding are referred to the primary side. The relationship between the referred values and the real secondary winding values is:

$$Rs = Rs\_real\_value * (Np/Ns)^2$$

$$Ls = Ls\_real\_value * (Np/Ns)^2$$

The transformer has a 3-leg core, with 1 primary winding and 1 secondary winding on each leg. Primary and secondary winding ratio for Y-Y is 1 and for Y- Δ is 0.577 The nodes at the bottom are the neutral points of the Y connections.

The resistances are in Ohm and the inductances are in H.

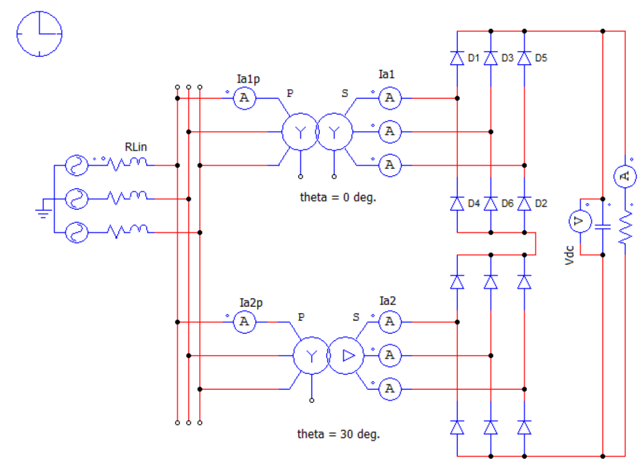

Figure 1 : 12- pulse technique with Diode Bridge

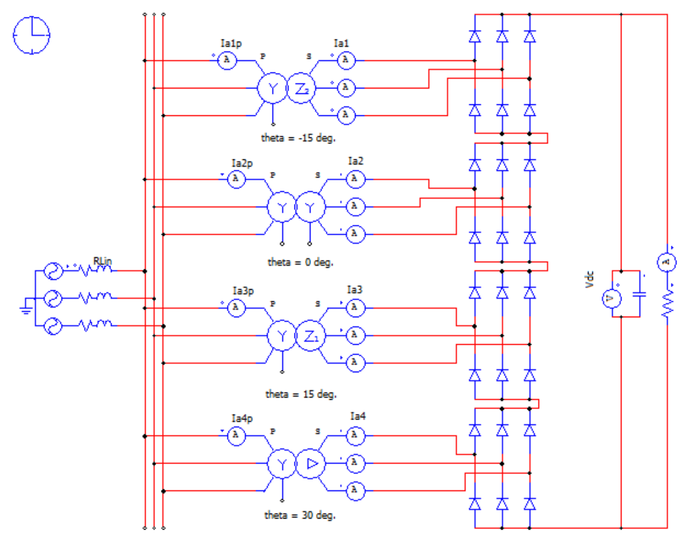

Figure 2 : 24- pulse technique with Diode Bridge

III. Parameters

A **Phase-Shifting Transformer** is a device for controlling the power flow through specific lines in a complex power transmission network. The basic function of a **Phase-Shifting Transformer** is to change the effective phase displacement between the input voltage and the output voltage of a transmission line, thus controlling the amount of active power that can flow in the line.

To degrade harmonics from input minimum phase shift calculation is as follows:

Phase shift= 60^0 /no. of converters

So 30^0 phase shift required for the 12-pulse converter. For obtaining a 12-pulse ac-dc conversion the

So 30^0 phase shift required for the 12-pulse converter. For obtaing a 12-pulse ac-dc conversion the phase shift between the two sets of voltages should be either 0° to 30° or +15° to -15° with respect to supply voltage. In this paper phase shift is used for the 0° to 30° phase shift is use for the transformer along with the pulse multiplication technique.

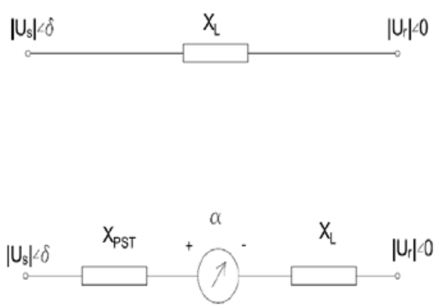

Figure 3 : Model of a transmission line with and without a PST The phase shift is controllable within certain limits

24-pulse diode rectifier operate with four 6-pulse diode rectifier. For obtaing a 24-pulse ac-dc conversion the phase shift among four sets of voltages should be -15° to 0° and 15° to 30° with respect to supply voltage.

This transformers provide a phase shift of 0 to -30° between the secondary and primary windings. Let Θ be the angle difference between the secondary line voltage V_{ab} and the primary line voltage V_{AB}. The relationship between the angle and the winding turns are:

$$Ns2 / (Ns1 + Ns2) = \sin(30^o - |\Theta|) / \sin(30^o + |\Theta|)$$

$$Np / (Ns1 + Ns2) = 1 / (2*\sin(30^o + |\Theta|)) * V_{AB}/V_{ab} ;$$

where $-30^o <= \Theta <= 0$

Here,

Np (Primary winding): 1 (Number of turns of the primary winding.

Ns1(Secondary winding): 0.8966 (Number of turns of the 1st secondary winding)

Ns2(Secondary winding): 0.5176 (Number of turns of the 2nd secondary winding)

V_{AB}: Primary line voltage

V_{ab} : Secondary line voltage

To calculate phase shifting angle :

$$\sin(30^o - |\Theta|) / \sin(30^o + |\Theta|) = 0.5176 / (0.8966 + 0.5176) \qquad \text{------------------------ (1.3)}$$

Using above equation we calculate the phase shift angle (Θ) for 24-pulse rectifier is 15^0.

Transformer secondary current waveform for 12-pulse and 24-pulse rectifier with phase shifting.

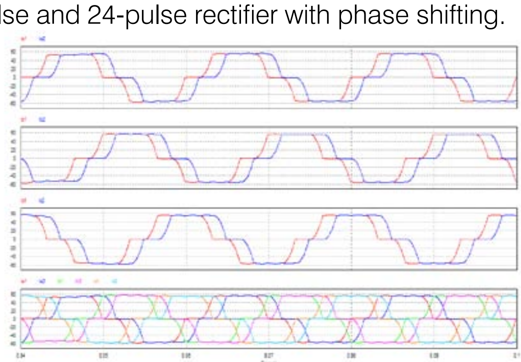

Figure 4 : 12-pulse input current waveform

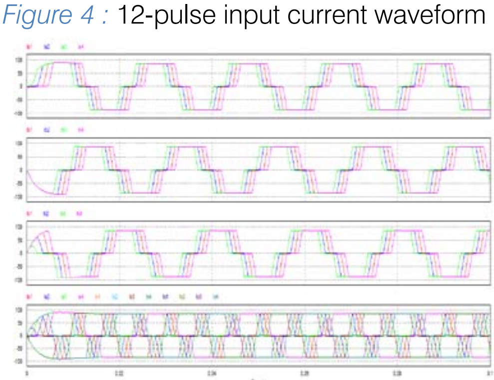

Figure 5 : 24-pulse input current waveform

THD Calculation from input current waveform:

12-pulse and 24 pulse Input current in frequency domain shown below:

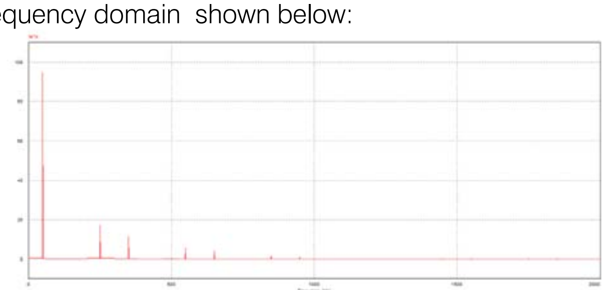

Figure 6 : 12-pulse primary current for THD calculation

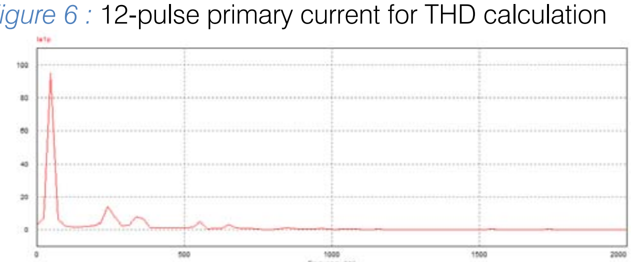

Figure 7 : 24- pulse primary current for THD calculation%

THD from 12-pulse rectifier is 20.44% whereas 24-pulse contain only 17.45% harmonic distortion. Increasing pulse number decrease 17^{th} and 22^{th} harmonics component are eliminated from 24-pulse converter.

IV. Filter Deisgn

When the instantaneous voltage Vs is higher than the instantaneous capacitor voltage Vc, the diodes conduct; and the capacitor is then charged from the supply. If the instantaneous supply voltage falls below Vs the instantaneous voltage Vc, the diodes are reverse biased and the capacitor Ce discharges through the load resistance R.

In practice, the ripple factor can be found from

$$RF = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} \qquad \text{------------------------ (1.4)}$$

From single phase ripple factor calculation assuming RF as 3% then is

$$C = \frac{1}{4fR}\left(1 + \frac{1}{\sqrt{2}\times.03}\right) \qquad \text{------------------------- (1.5)}$$

from above calculation we 12.2m capacitance for 3% RF in single phase.

Using capacitor filter in 12-pulse rectifier Vdc is shown in figure

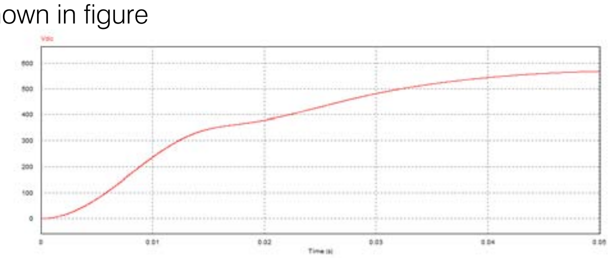

Figure 8 : 12- pulse output voltage with capacitor filter

From equation (1.4) RF calculation for 12-pulse rectifier with filter

Here,

Vrms=422.04 volt and Vdc= 385.49 volt

so, RF= 0.441 or 44.1%

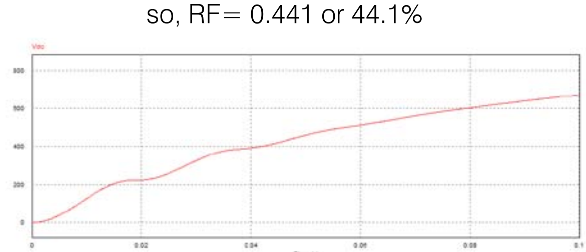

Figure 9 : 24-pulse output voltage with capacitor filter

Similarly, RF calculation for 24-pulse,

Here,

Vrms=460.07 volt and Vdc= 418.94 volt

So, RF=0.453 or 45.3%

The capacitor absorbs energy during the pulse and delivers this energy to the load between pulses, the output voltage can never fall to zero. However, if the resistance of the load is small, a heavy current will be drawn by the load and the average output voltage will fall. Also, the filter capacitor acts like a short circuit across the rectifier while the capacitor is being charged. Due to these reasons, a simple capacitor filter is not suitable for rectifiers in higher power applications.

V. Simulation Results

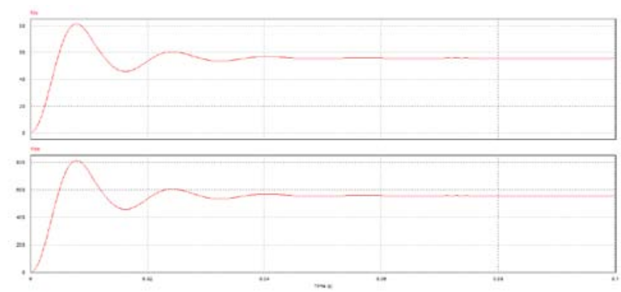

Figure 10 : 12- pulse output current and voltage without filte rRF calculation for 12-pulse without filter,

Here,

Vrms=556.31 volt and Vdc= 554.04 volt

So, RF=0.0906 or 9.06%

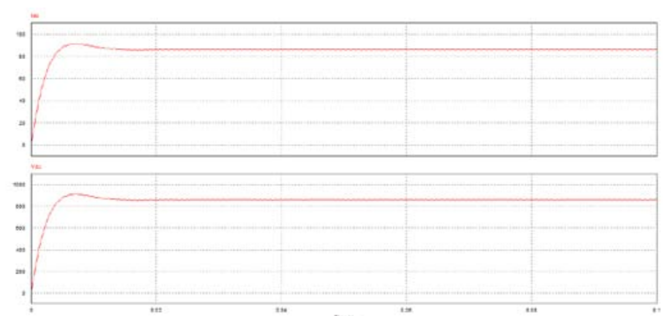

Figure 11 : 24- pulse output current and voltage without filter

Similarly, RF calculation for 24-pulse,

Here,

Vrms=854.54 volt and Vdc= 852.75 volt

So, RF=0.0648 or 6.48%

12-pulse and 24-pulse AC-DC converter with RL and RLC load:

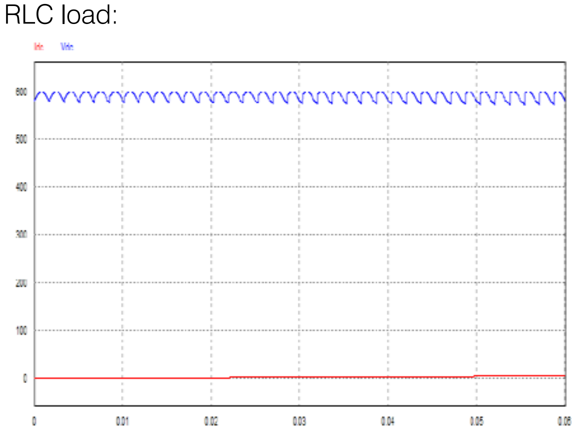

Figure 12 : 12-pulse with RL Load

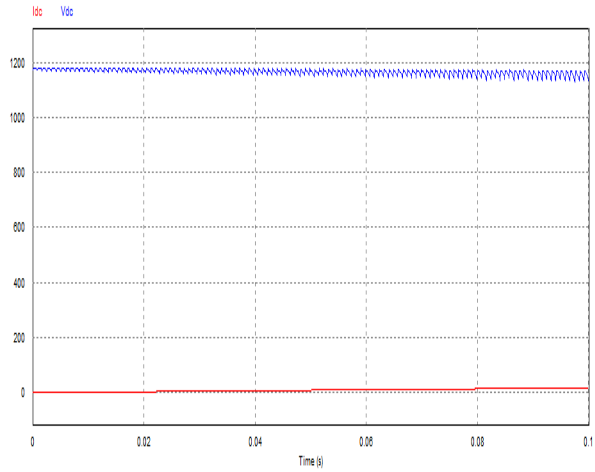

Figure 13 : 24- pulse with RL load

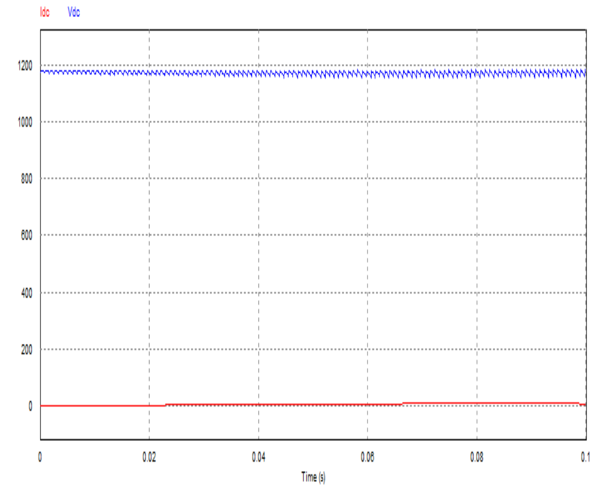

Figure 15 : 24- pulse with RLC load

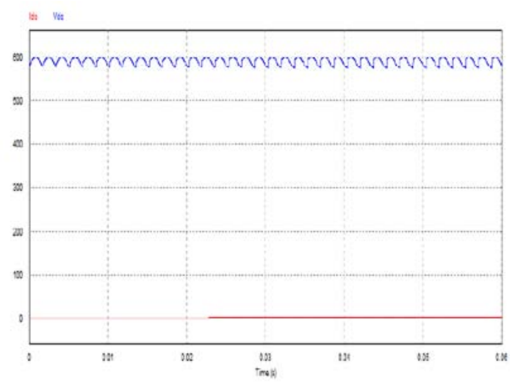

Figure 14 : 12- pulse with RLC load

Table I : Comparison Between 12-Pulse And 24-Pulse AC-DC Conversion

Properties	12-pulse rectifier			24-pulse rectifier		
	R	RL	RLC	R	RL	RLC
PF	1	.86	.88	1	.87	.92
Real Power, P(KW)	30.68	1.6	1.47	73.04	10	7.84
Vrms (Volt)	556.31	590.30	590.6	854.54	1160	1175
Irms (A)	55.3	3.14	2.82	85.45	10.2	7.31
%THD	20.44			17.45		
%RF	9.06			6.48		

VI. Conclusions

This paper present the comparison between 12-pulse and 24-pulse rectifier. After finishing necessary calculation we have seen 24-pulse contain less harmonic content in input current. It improves power factor with inductive and capacitive load.

Although detail analysis has not been described in this paper, but every inevitable information are given. The desirable features of the modified diode rectifier, such as compact, economical, efficient and reliable are added with the new 24-pulse rectifier. Some new features are joined with this configuration such as lower Ripple component and higher power factor.

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Problem of Lorentz Force and its Solution

By F. F. Mende & A. S. Dubrovin

Abstract- In the article is developed the concept of scalarvector potential, based on the symmetrization of the equations of induction, during record of which is used the substantional derivative. The physical causes of molding of Lorentz force are examined. is shown that the dependence of the scalar potential of charge on the speed is the physical cause of Lorentz force. The examination of power interaction of the current carrying systems is carried out and it is shown that with the low speeds of charges the concept of scalar- vector potential gives the same results as the concept of magnetic field. It is shown that the Lorentz force is connected with the gradient of scalar potential. This potential form the charges, which move in the field of the vector potential of magnetic field, which, is in turn the consequence of the dependence of the scalar potential of charge on the speed.

Keywords: magnetic field, lorentz force, equation of induction, maxwell equation, scalar-vector potential, vector potential.

GJRE-F Classification: FOR Code: 290903

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Strictly as per the compliance and regulations of:

Problem of Lorentz Force and its Solution

F. F. Mende [α] & A. S. Dubrovin [σ]

Abstract- In the article is developed the concept of scalar-vector potential, based on the symmetrization of the equations of induction, during record of which is used the substantional derivative. The physical causes of molding of Lorentz force are examined. is shown that the dependence of the scalar potential of charge on the speed is the physical cause of Lorentz force. The examination of power interaction of the current carrying systems is carried out and it is shown that with the low speeds of charges the concept of scalar- vector potential gives the same results as the concept of magnetic field. It is shown that the Lorentz force is connected with the gradient of scalar potential. This potential form the charges, which move in the field of the vector potential of magnetic field, which, is in turn the consequence of the dependence of the scalar potential of charge on the speed.

Keywords: magnetic field, lorentz force, equation of induction, maxwell equation, scalar-vector potential, vector potential.

I. Introduction

All past century is marked by the most great when for the change to the materialist understanding of physical processes is alien scholastic mathematics, which itself began to develop its own physical laws. The introduction was a typical example of such approaches the concept the frequency dispersion of such the material parameters as the dielectric and magnetic constant of material media. These approaches have given rise to the whole direction in electrodynamics physical environments. These approaches gave birth to entire direction in the electrodynamics of material media. General with the theorists, for me it repeatedly was necessary to observe, that them usually little interests physics of processes, mathematics is god for them and if with mathematics all in the order, then theory is accurate. But this approach has its underwater stones. Thus it occurred also with the dielectric constant of dielectrics when, after entangling concepts, they began to consider that this permeability depends on frequency. Even in Large Soviet Encyclopedia it is written, that this dependence is located.

The special feature of contemporary physics is its politicization and creation of the transnational clans, which took into their hands and authority in the science, and the financial flows, and they uncontrolled by them manage. These negative phenomena gave birth to the personality cult of individual scientists, when they canonize, in contrast to the church, not only corpses, but also living. A typical example of this cult are Einstein and Hoking.

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Still one whip of science is its bureaucratization, when to the foreground in the science leave not true scientists, but bureaucrats from the science. Are especially well visible the results of this scientific activity based on the example to the USSR. That command-administrative system, which ruled in the national economy of the country, was extended also to the science, when the director of any large scientific establishment in the required order became academician.

The science, chained into the shackles of the yellow press, when on the covers of popular periodicals were depicted brilliant cripples, causes surprise. All this gave birth to the most severe crisis in the science. But this state of affairs cannot continue eternally. Now situation in physics greatly resembles that, which preceded the fall of the system of Ptolemy. But if we speak about the wreck of the old become obsolete ideas, then this cannot occur without the appearance of new progressive ideas and directions, which will arrive for the change to decrepit dogmas.

The special theory of relativity (SR) in its time arose for that reason, that in the classical electrodynamics there were no conversions fields on upon transfer of one inertial reference system into another. This theory, by the way of introduction into physics of known postulates, explained several important experimental results and in connection with this was obtained the acknowledgement.

Being based on the ideas of Maxwell about the calculation of total derivatives during the writing of the laws of induction, it is possible to obtain such laws of electrodynamics, which explain the existing electrodynamic phenomena and give the possibility within the framework of Galileo conversions to write down the rules of conversion fields on upon transfer of one inertial system (IS) to another. It follows from such laws that the main basic law of electrodynamics, from which follow its all the remaining dynamic laws, is the dependence of the scalar potential of charge on its relative speed. And this is the radical step, which gives the possibility to obtain a number of the important systematic and practical results, which earlier in the classical electrodynamics are obtained be they could not. This approach made possible not only to create on the united basis one-piece electrodynamics, but also to explain power interaction of the current carrying systems without the use of a postulate about the Lorentz force, or to describe the phenomenon of phase aberration and the transverse Doppler effect.

This article depicts an example of that how the problem of Lorentz force can be solved on the basis of new ideas. Still from the times of Lorenz and Poincare this force was introduced as experimental postulate and there was no that physical basis, which appears it would explain this phenomenon.

II. Maxwell Equations and Lorentz Force

The laws classical electrodynamics they reflect experimental facts they are phenomenological. Unfortunately, contemporary classical electrodynamics is not deprived of the contradictions, which did not up to now obtain their explanation. In order to understand these contradictions, and to also understand those purposes and tasks, which are placed in this work, let us briefly describe the existing situation.

The fundamental equations of contemporary classical electrodynamics are Maxwell equation [1]. They are written as follows for the vacuum:

$$rot\ \vec{E} = -\frac{\partial \vec{B}}{\partial t}, \tag{2.1}$$

$$rot\ \vec{H} = \frac{\partial \vec{D}}{\partial t}, \tag{2.2}$$

$$div\ \vec{D} = 0, \tag{2.3}$$

$$div\ \vec{B} = 0, \tag{2.4}$$

where $\vec{E}$, $\vec{H}$ are tension of electrical and magnetic field, $\vec{D} = \varepsilon_0 \vec{E}$, $\vec{B} = \mu_0 \vec{H}$ are electrical and magnetic induction, μ_0, ε_0 are magnetic and dielectric constant of vacuum. From these equations follow wave equations for the electrical and magnetic fields

$$\nabla^2 \vec{E} = \mu_0 \varepsilon_0 \frac{\partial^2 \vec{E}}{\partial t^2}, \tag{2.5}$$

$$\nabla^2 \vec{H} = \mu_0 \varepsilon_0 \frac{\partial^2 \vec{H}}{\partial t^2}, \tag{2.6}$$

these equations show that in the vacuum can be extended the plane electromagnetic waves, the velocity of propagation of which is equal to the speed of light

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \tag{2.7}$$

For the material media of Maxwell's equation they take the following form:

$$rot\ \vec{E} = -\tilde{\mu}\mu_0 \frac{\partial \vec{H}}{\partial t} = -\frac{\partial \vec{B}}{\partial t}, \tag{2.8}$$

$$rot\ \vec{H} = ne\vec{v} + \tilde{\varepsilon}\varepsilon_0 \frac{\partial \vec{E}}{\partial t} = ne\vec{v} + \frac{\partial \vec{D}}{\partial t}, \tag{2.9}$$

$$div\ \vec{D} = ne, \tag{2.10}$$

$$div\ \vec{B} = 0, \tag{2.11}$$

where $\tilde{\mu}$, $\tilde{\varepsilon}$ are the relative magnetic and dielectric constants of the medium and n, e, $\vec{v}$ are density, value and charge rate.

The equation (2.1 - 2.11) are written in the assigned IS, and in them there are no rules of passage of one IS to another. The given equations also assume that the properties of charge do not depend on their speed, since in first term of the right side of equation (2.9) as the charge its static value is taken. The given equations also assume that the current can flow as in the electrically neutral medium, where there is an equal quantity of charges of both signs, so also to represent the self-contained flow of the charged particles, moreover both situations are considered equivalent.

In Maxwell equations are not contained indication that is the reason for power interaction of the current carrying systems; therefore to be introduced the experimental postulate about the force, which acts on the moving charge in the magnetic field. This the so-called magnetic part of the Lorentz force

$$\vec{F}_L = e\left[\vec{v} \times \mu_0 \vec{H}\right] \tag{2.12}$$

However in this axiomatics is an essential deficiency. If force acts on the moving charge, then in accordance with Newton third law the reacting force, which balances the force, which acts on the charge, must occur and to us must be known the place of the application of this force. In this case the magnetic field comes out as a certain independent substance and comes out in the role of the mediator between the moving charges, and if we want to find the force of their interaction, then we must come running to the services of this mediator. In other words, we do not have law of direct action, which would give immediately answer to the presented question, passing the procedure examined, i.e., we cannot give answer to the question, where are located the forces, the compensating action of magnetic field to the charge.

The relationship (2.12) from the physical point sight causes bewilderment. The forces, which act on the body in the absence of losses, must be connected either with its acceleration, if it accomplishes forward motion, or with the centrifugal forces, if body accomplishes rotary motion. Finally, static forces appear when there is the gradient of the scalar potential of potential field, in which is located the body. But in relationship (2.12) there is nothing of this. Usual rectilinear motion causes the force, which is normal to the direction motion. What some new law of nature? To this question there is no answer also.

The magnetic field is one of the important concepts of contemporary electrodynamics. Its concept consists in the fact that around any moving charge appears the magnetic field. This field determines Ampere law.

The Ampere law, expressed in the vector form, determines magnetic field at the point x, y, z [2]

$$\vec{H} = \frac{1}{4\pi}\int \frac{Id\vec{l} \times \vec{r}}{r^3} \tag{2.13}$$

where I is current in the element $d\vec{l}$, $\vec{r}$ is vector, directed from $d\vec{l}$ to the point x, y, z. This law is introduced by phenomenological means and there is no physical basis under it. Consequently there is no physical basis, also, under the relationship (2.12), determining Lorentz force.

But, unfortunately, there is a number of the physical questions, during solution of which within the framework the concepts of magnetic field, are obtained paradoxical results. Here one of them.

Using relationships (2.12) and (2.13) not difficult to show that with the unidirectional parallel motion of two like charges, or flows of charges, between them must appear the additional attraction. However, if we pass into the inertial system, which moves together with the charges, then there magnetic field is absent, and there is no additional attraction. This paradox does not have an explanation.

The force with power interaction of material structures, along which flows the current, are applied not only to the moving charges, but to the lattice, but in the concept of magnetic field to this question there is no answer also, since. in equations (2.1-2.13) the presence of lattice is not considered. At the same time, with the flow of the current through the plasma its compression (the so-called pinch effect), occurs, in this case forces of compression act not only on the moving electrons, but also on the positively charged ions. And, again, the concept of magnetic field cannot explain this fact, since in this concept there are no forces, which can act on the ions of plasma.

The solution of the problems indicated and the physical explanation of Lorentz force can be obtained within the framework the concept of scalar-vector potential, which assumes the dependence of the scalar potential of charge and fields on it from the speed.

III. Concept of Scalar-Vector Potential

The Maxwell equations do not give the possibility to write down fields in the moving coordinate systems, if fields in the fixed system are known [1]. This problem is solved with the aid of the Lorenz conversions, however, these conversions from the classical electrodynamics they do not follow. Question does arise, is it possible with the aid of the classical electrodynamics to obtain conversions fields on upon transfer of one inertial system to another, and if yes, then, as must appear the equations of such conversions. Indications of this are located already in the law of the Faraday induction. Let us write down Faraday:

$$\oint \vec{E}' d\,\vec{l}' = -\frac{d\,\Phi_B}{d\,t}. \tag{3.1}$$

As is evident in contrast to Maxwell equations in it not particular and substantive (complete) time derivative is used.

The substantional derivative in relationship (3.1) indicates the independence of the eventual result of appearance emf in the outline from the method of changing the flow, i.e. flow can change both due to the local time derivative of the induction of and because the system, in which is measured , it moves in the three-dimensional changing field . The value of magnetic flux in relationship (3.1) is determined from the relationship

$$\Phi_B = \int \vec{B}\, d\,\vec{S}', \tag{3.2}$$

where the magnetic induction $\vec{B} = \mu\,\vec{H}$ is determined in the fixed coordinate system, and the element $d\,\vec{S}'$ is determined in the moving system. Taking into account (3.2), we obtain from (3.1)

$$\oint \vec{E}' d\,\vec{l}' = -\frac{d}{d\,t}\int \vec{B}\, d\,\vec{S}', \tag{3.3}$$

and further, since $\frac{d}{d\,t} = \frac{\partial}{\partial\,t} + \vec{v}\ grad$, let us write down [4-7]

$$\oint \vec{E}' d\,\vec{l}' = -\int \frac{\partial\,\vec{B}}{\partial\,t}\, d\,\vec{S} - \int \left[\vec{B} \times \vec{v}\right] d\,\vec{l}' - \int \vec{v}\, d\,\mathbf{v}\,\vec{B}\, d\,\vec{S}' \tag{3.4}$$

In this case contour integral is taken on the outline $d\vec{l}'$, which covers the area $d\vec{S}'$. Let us immediately note that entire following presentation will be conducted under the assumption the validity of the Galileo conversions, i.e., $d\vec{l}' = d\vec{l}$ and $d\vec{S}' = d\vec{S}$. From relationship (3.6) follows

$$\vec{E}' = \vec{E} + \left[\vec{v} \times \vec{B}\right]. \qquad (3.5)$$

If both parts of equation (3.6) are multiplied by the charge, then we will obtain relationship for the Lorentz force

$$\vec{F}_L' = e\,\vec{E} + e\left[\vec{v} \times \vec{B}\right]. \qquad (3.6)$$

Thus, Lorentz force is the direct consequence of the law of magnetoelectric induction.

For explaining physical nature of the appearance of last term in relationship (3.5) let us write down $\vec{B}$ and $\vec{E}$ through the magnetic vector potential $\vec{A}_B$:

$$\vec{B} = rot\,\vec{A}_B, \qquad \vec{E} = -\frac{\partial \vec{A}_B}{\partial t}. \qquad (3.7)$$

Then relationship (3.5) can be rewritten

$$\vec{E}' = -\frac{\partial \vec{A}_B}{\partial t} + \left[\vec{v} \times rot\,\vec{A}_B\right] \qquad (3.8)$$

and further

$$\vec{E}' = -\frac{\partial \vec{A}_B}{\partial t} - \left(\vec{v}\,\nabla\right)\vec{A}_B + grad\,\left(\vec{v}\,\vec{A}_B\right). \qquad (3.9)$$

The first two members of the right side of equality (3.9) can be gathered into the total derivative of vector potential on the time, namely:

$$\vec{E}' = -\frac{d\,\vec{A}_B}{d\,t} + grad\,\left(\vec{v}\,\vec{A}_B\right) \cdot \qquad (3.10)$$

From relationship (3.9) it is evident that the field strength, and consequently also the force, which acts on the charge, consists of three parts.

First term is obliged by local time derivative. The sense of second term of the right side of relationship (3.9) is also intelligible. It is connected with a change in the vector potential, but already because charge moves in the three-dimensional changing field of this potential. Other nature of last term of the right side of relationship (3.9). It is connected with the presence of potential forces, since. potential energy of the charge, which moves in the potential field $\vec{A}_B$ with the speed $\vec{v}$, is equal $e\left(\vec{v}\,\vec{A}_{\mathbf{B}}\right)$. The value $e\;grad\;\left(\vec{V}\,\vec{A}_B\right)$ gives force, exactly as gives force the gradient of scalar potential.

Taking rotor from both parts of equality (3.10) and taking into account that $rot\;grad \equiv 0$, we obtain

$$rot\,\vec{E}' = -\frac{d\,\vec{B}}{d\,t}. \qquad (3.11)$$

If there is no motion, then relationship (3.11) is converted into the Maxwell first equation. Relationship (3.11) is more informative than Maxwell equation

$$rot\,\vec{E} = -\frac{\partial\,\vec{B}}{\partial\,t}.$$

Since in connection with the fact that $rot\;grad\;\equiv 0$, in Maxwell equation there is no information about the potential forces, designated through $e\;grad\;\left(\vec{v}\,\vec{A}_B\right)$.

Let us write down the amount of Lorentz force in the terms of the magnetic vector potential:

$$\vec{F}_L{}' = e\,\vec{E} + e\,[\vec{v} \times rot\,\vec{A}_B] = e\,\vec{E} - e(\vec{v}\,\nabla)\vec{A}_B + e grad\,(\vec{v}\,\vec{A}_B). \qquad (3.12)$$

Is more preferable, since the possibility to understand the complete structure of this force gives.

Faraday law (3.2) is called the law of electromagnetic induction, however this is terminological error. This law should be called the law of magnetoelectric induction, since the appearance of electrical fields on by a change in the magnetic caused fields on.

However, in the classical electrodynamics there is no law of magnetoelectric induction, which would show, how a change in the electrical fields on, or motion in them, it leads to the appearance of magnetic fields on. The development of classical electrodynamics followed along another way. Ampere law was first introduced:

$$\oint \vec{H}\,d\,\vec{l} = I, \qquad (3.13)$$

where *I* is current, which crosses the area, included by the outline of integration. In the differential form relationship (3.13) takes the form:

$$rot\,\vec{H} = \vec{j}_\sigma, \qquad (3.14)$$

where $\vec{j}_\sigma$ is current density of conductivity.

Maxwell supplemented relationship (3.14) with bias current

$$rot\,\vec{H} = \vec{j}_\sigma + \frac{\partial\,\vec{D}}{\partial\,t}. \qquad (3.15)$$

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If we from relationship (3.15) exclude conduction current, then the integral law follows from it

$$\oint \vec{H} d\vec{l} = \frac{\partial \Phi_D}{\partial t}, \qquad (3.16)$$

where $\Phi_D = \int \vec{D}\, d\vec{S}$ the flow of electrical induction.

If we in relationship (3.16) use the substantional derivative, as we made during the writing of the Faraday law, then we will obtain [4-6]:

$$\oint \vec{H}' d\vec{l}' = \int \frac{\partial \vec{D}}{\partial t} d\vec{S} + \oint [\vec{D} \times \vec{v}] d\vec{l}' + \int \vec{v}\, d\,\dot{v}\, \vec{D}\, d\vec{S}' \qquad (3.17)$$

In contrast to the magnetic fields, when $div\vec{B} = 0$, for the electrical fields on $div\vec{D} = \rho$ and last term in the right side of relationship (2.8) it gives the conduction current of and from relationship (2.7) the Ampere law immediately follows. In the case of the absence of conduction current from relationship (3.17) the equality follows:

$$\vec{H}' = \vec{H} - [\vec{v} \times \vec{D}]. \qquad (3.18)$$

As shown in the work [3], from relationship (2.18) follows and Bio-Savara law, if for enumerating the magnetic fields on to take the electric fields of the moving charges. In this case the last member of the right side of relationship (3.17) can be simply omitted, and the laws of induction acquire the completely symmetrical form [7]

$$\begin{aligned} \oint \vec{E}' dl' &= -\int \frac{\partial \vec{B}}{\partial t} d\vec{s} + \oint \left[\vec{v} \times \vec{B}\right] dl' \vec{H}, \\ \oint \vec{H}' dl' &= \int \frac{\partial \vec{D}}{\partial t} d\vec{s} - \oint \left[\vec{v} \times \vec{D}\right] dl' \vec{H}' \end{aligned} \qquad (3.19)$$

or

$$\begin{aligned} rot\vec{E}' &= -\frac{\partial \vec{B}}{\partial t} + rot\left[\vec{v} \times \vec{B}\right] \\ rot\vec{H}' &= \frac{\partial \vec{D}}{dt} - rot\left[\vec{v} \times \vec{D}\right] \end{aligned}. \qquad (3.20)$$

For dc fields on these relationships they take the form:

$$\begin{aligned} \vec{E}' &= \left[\vec{v} \times \vec{B}\right] \\ \vec{H}' &= -\left[\vec{v} \times \vec{D}\right] \end{aligned}. \qquad (3.21)$$

In relationships (3.19-3.21), which assume the validity of the Galileo conversions, prime and not prime values present fields and elements in moving and fixed inertial reference system (IS) respectively. It must be noted, that conversions (3.21) earlier could be obtained only from the Lorenz conversions.

The relationships (3.19-3.21), which present the laws of induction, do not give information about how arose fields in initial fixed IS. They describe only laws governing the propagation and conversion fields on in the case of motion with respect to the already existing fields.

The relationship (3.21) attest to the fact that in the case of relative motion of frame of references, between the fields $\vec{E}$ and $\vec{H}$ there is a cross coupling, i.e. motion in the fields $\vec{H}$ leads to the appearance fields on $\vec{E}$ and vice versa. From these relationships escape the additional consequences, which were for the first time examined in the work.

The electric field $E = \frac{g}{2\pi\varepsilon r}$ outside the charged long rod with alinear density g decreases as $\frac{1}{r}$, where r isdistance from the centralaxis of the rodto the observation point.

If we in parallel to the axis of rod in the field E begin to move with the speed Δv another IS, then in it will appear the additional magnetic field $\Delta H = \varepsilon E \Delta v$. If we now with respect to already moving IS begin to move third frame of reference with the speed Δv, then already due to the motion in the field ΔH will appear additive to the electric field $\Delta E = \mu\varepsilon E (\Delta v)^2$. This process can be continued and further, as a result of which can be obtained the number, which gives the value of the electric field $E'_v(r)$ in moving IS with reaching of the speed $v = n\Delta v$, when $\Delta v \to 0$, and $n \to \infty$. In the final analysis in moving IS the value of dynamic electric field will prove to be more than in the initial and to be determined by the relationship [8]:

$$E'(r, v_\perp) = \frac{g ch \frac{v_\perp}{c}}{2\pi\varepsilon r} = E ch \frac{v_\perp}{c}.$$

If speech goes about the electric field of the single charge e, then its electric field will be determined by the relationship:

$$E'(r, v_\perp) = \frac{e ch \frac{v_\perp}{c}}{4\pi\varepsilon r^2},$$

where $v_\perp$ is normal component of charge rate to the vector, which connects the moving charge and observation point.

Expression for the scalar potential, created by the moving charge, for this case will be written down as follows:

$$\varphi'(r,v_\perp)=\frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r}=\varphi(r)ch\frac{v_\perp}{c}, \qquad (3.22)$$

here $\varphi(r)$ is scalar potential of fixed charge. The potential $\varphi'(r,v_\perp)$ can be named scalar-vector, since it depends not only on the absolute value of charge, but also on speed and direction of its motion with respect to the observation point. Maximum value this potential has in the direction normal to the motion of charge itself. Moreover, if charge rate changes, which is connected with its acceleration, then can be calculated the electric fields, induced by the accelerated charge.

During the motion in the magnetic field, using the already examined method, we obtain:

$$H'(v_\perp)=Hch\frac{v_\perp}{c}.$$

where $v_\perp$ is speed normal to the direction of the magnetic field.

If we apply the obtained results to the electromagnetic wave and to designate components fields on parallel speeds IS as $E_\uparrow$, $H_\uparrow$, and $E_\perp$, $H_\perp$ as components normal to it, then with the conversion fields on components, parallel to speed will not change, but components, normal to the direction of speed are converted according to the rule

$$\begin{aligned}\vec{E}'_\perp &= \vec{E}_\perp ch\ \frac{v}{c}+\frac{v}{c}\vec{v}\times\vec{B}_\perp sh\frac{v}{c},\\ \vec{B}'_\perp &= \vec{B}_\perp ch\ \frac{v}{c}-\frac{1}{vc}\vec{v}\times\vec{E}_\perp sh\frac{v}{c},\end{aligned} \qquad (3.23)$$

where c is speed of light.

Conversions fields (3.23) they were for the first time obtained in the work [9].

However, the iteration technique, utilized for obtaining the given relationships, it is not possible to consider strict, since its convergence is not explained.

Let us give a stricter conclusion in the matrix form [8]. Let us examine the totality IS of such, that IS K_1 moves with the speed Δv relative to IS K, IS K_2 moves with the same speed Δv relative to K_1, etc. If the module of the speed Δv is small (in comparison with the speed of light c), then for the transverse components fields on in IS K_1, K_2,…. we have:

$$\begin{aligned}\vec{E}_{1\perp} &= \vec{E}_\perp+\Delta\vec{v}\times\vec{B}_\perp & \vec{B}_{1\perp} &= \vec{B}_\perp-\Delta\vec{v}\times\vec{E}_\perp/c^2.\\ \vec{E}_{2\perp} &= \vec{E}_{1\perp}+\Delta\vec{v}\times\vec{B}_{1\perp} & \vec{B}_{2\perp} &= \vec{B}_{1\perp}-\Delta\vec{v}\times\vec{E}_{1\perp}/c^2\end{aligned} \qquad (3.24)$$

Upon transfer to each following IS of field are obtained increases in $\Delta\vec{E}$ and $\Delta\vec{B}$

$$\Delta\vec{E}=\Delta\vec{v}\times\vec{B}_\perp, \qquad \Delta\vec{B}=-\Delta\vec{v}\times\vec{E}_\perp/c^2, \qquad (3.25)$$

where of the field $\vec{E}_\perp$ and $\vec{B}_\perp$ relate to current IS. Directing Cartesian axis x along $\Delta\vec{v}$, let us rewrite (3.24) in the components of the vector

$$\Delta E_y=-B_z\Delta v, \qquad \Delta E=B_y\Delta v, \qquad \Delta B_y=E_z\Delta v/c^2. \qquad (3.26)$$

Relationship (3.26) can be represented in the matrix form

$$\Delta U=AU\Delta v \qquad \begin{pmatrix}0&0&0&-1\\0&0&1&0\\0&1/c^2&0&0\\-1/c^2&0&0&0\end{pmatrix} \qquad U=\begin{pmatrix}E_y\\E_z\\B_y\\B_z\end{pmatrix}.$$

If one assumes that the speed of system is summarized for the classical law of addition of velocities, i.e. the speed of final IS $K'=K_N$ relative to the initial system K is $v=N\Delta v$, then we will obtain the matrix system of the differential equations of

$$\frac{dU(v)}{dv}=AU(v) \qquad (3.27)$$

with the matrix of the system v independent of the speed A. The solution of system is expressed as the matrix exponential curve $\exp(vA)$:

$$U'\equiv U(v)=\exp(vA)U, \qquad U=U(0) \qquad (3.28)$$

here U is matrix column fields on in the system K, and U' is matrix column fields on in the system K'. Substituting (3.28) into system (3.27), we are convinced, that U' is actually the solution of system (3.27):

$$\frac{dU(v)}{dv}=\frac{d[\exp(vA)]}{dv}U=A\exp(vA)U=AU(v).$$

It remains to find this exponential curve by its expansion in the series:

$$\exp(va)=E+vA+\frac{1}{2!}v^2A^2+\frac{1}{3!}v^3A^3+\frac{1}{4!}v^4A^4+...$$

where E is unit matrix with the size 4×4. For this it is convenient to write down the matrix A in the unit type form

$$A=\begin{pmatrix}0&-\alpha\\\alpha/c^2&0\end{pmatrix}, \qquad \alpha=\begin{pmatrix}0&1\\-1&0\end{pmatrix}, \qquad 0=\begin{pmatrix}0&0\\0&0\end{pmatrix}.$$

then

$$A^2=\begin{pmatrix}-\alpha^2/c^2&0\\0&-\alpha/c^2\end{pmatrix}, \quad A^3=\begin{pmatrix}0&\alpha^3/c^2\\-\alpha^3/c^4&0\end{pmatrix},$$

$$A^4=\begin{pmatrix}\alpha^4/c^4&0\\0&\alpha^4/c^4\end{pmatrix}, \quad A^5=\begin{pmatrix}0&-\alpha^5/c^4\\\alpha^5/c^6&0\end{pmatrix}.....$$

And the elements of matrix exponential curve take the form

$$[\exp(vA)]_{11}=[\exp(vA)]_{22}=I-\frac{v^2}{2!c^2}+\frac{v^4}{4!c^4}-....,$$

$$[\exp(vA)]_{21}=-c^2[\exp(vA)]_{12}=\frac{\alpha}{c}\left(\frac{v}{c}I-\frac{v^3}{3!c^3}+\frac{v^5}{5!c^5}-.....\right),$$

where I is the unit matrix 2×2. It is not difficult to see that $-\alpha^2=\alpha^4=-\alpha^6=\alpha^8=....=I$, therefore we finally obtain

$$\exp(vA)=\begin{pmatrix} Ich\ \ v/c & -c\alpha sh\ \ v/c \\ \left(\alpha sh\ \ v/c\right)/c & Ich\ \ v/c \end{pmatrix}=$$

$$\begin{pmatrix} ch\ \ v/c & 0 & 0 & -csh\ \ v/c \\ 0 & ch\ \ v/c & csh\ \ v/c & 0 \\ 0 & \left(ch\ \ v/c\right)/c & ch\ \ v/c & 0 \\ -\left(sh\ \ v/c\right)/c & 0 & 0 & ch\ \ v/c \end{pmatrix}.$$

Substituting there $\exp(vA)$, we find

$$E'_y = E_y ch\ \ v/c - cB_z sh\ \ v/c, \qquad E'_z = E_z ch\ \ v/c + cB_y sh\ \ v/c,$$

$$B'_y = B_y ch\ \ v/c + \left(E_z/c\right) sh\ \ v/c, \qquad B'_z = B_z ch\ \ v/c - \left(E_y/c\right) sh\ \ v/c\ ,$$

or in the vector record

$$\vec{E}'_\perp = \vec{E}_\perp ch\ \ \frac{v}{c} + \frac{v}{c}\vec{v}\times\vec{B}_\perp sh\frac{v}{c}, \qquad (3.29)$$

$$\vec{B}'_\perp = \vec{B}_\perp ch\ \ \frac{v}{c} - \frac{1}{vc}\vec{v}\times\vec{E}_\perp sh\frac{v}{c},$$

This is conversions (3.23).

IV. Power Interaction of the Current Carrying systems

It was already said, that Maxwell equations do not include information about power interaction of the current carrying systems. In the classical electro-dynamics for calculating such an interaction it is necessary to calculate magnetic field in the assigned region of space, and then, using a Lorentz force, to find the forces, which act on the moving charges. Obscure a question about that remains with this approach, to what are applied the reacting forces with respect to those forces, which act on the moving charges.

The concept of magnetic field arose to a considerable degree because of the observations of power interaction of the current carrying and magnetized systems. Experience with the iron shavings, which are erected near the magnet poles or around the annular turn with the current into the clear geometric figures, is especially significant. These figures served as occasion for the introduction of this concept as the lines of force of magnetic field. In accordance with third Newton's law with any power interaction there is always a equality of effective forces and opposition, and also always there are those elements of the system, to which these forces are applied. A large drawback in the concept of magnetic field is the fact that it does not give answer to that, counteracting forces are concretely applied to what, since. magnetic field comes out as the independent substance, with which occurs interaction of the moving charges.

Is experimentally known that the forces of interaction in the current carrying systems are applied to those conductors, whose moving charges create magnetic field. However, in the existing concept of power interaction of the current carrying systems, based on the concepts of magnetic field and Lorentz force, the positively charged lattice, which is the frame of conductor and to which are applied the forces, it does not participate in the formation of the forces of interaction.

Let us examine this question on the basis of the concept of scalar- vector potential [11-12]. We will consider that the scalar- vector potential of single charge is determined by relationship (3.22), and that the electric fields, created by this potential, act on all surrounding charges, including to the charges positively charged lattices.

Let us examine from these positions power interaction between two parallel conductors (Fig. 1), over which flow the currents. We will consider that g_1^+, g_2^+ and g_1^-, g_2^- present the respectively fixed and moving charges, which fall per unit of the length of conductor.

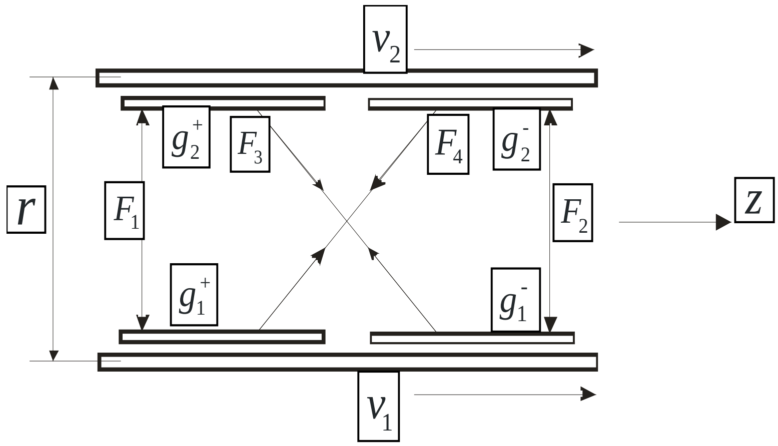

Fig. 1 : Schematic of power interaction of the current carrying wires of two-wire circuit taking into account the positively charged lattice.

The charges g_1^+, g_2^+ present the positively charged lattice in the lower and upper conductors. We will also consider that both conductors prior to the start of charges are electrically neutral, i.e., in the conductors there are two systems of the mutually inserted opposite charges with the specific density to g_1^+, g_1^- and g_2^+, g_2^-, which electrically neutralize each other. In Fig. 1 these systems for larger convenience in the examination of the forces of interaction are moved apart along the axis of z . Subsystems with the negative charge (electrons) can move with the speeds v_1, v_2. The force of interaction between the lower and upper conductors we will search for as the sum of four forces, whose designation is understandable from the figure.

The repulsive forces F_1, F_2 we will take with the minus sign, while the attracting force F_3, F_4 we will take with the plus sign.

For the single section of the two-wire circuit of force, acting between the separate subsystems, will be written down

$$F_1 = -\frac{g_1^+ g_2^+}{2\pi\varepsilon r},$$

$$F_2 = -\frac{g_1^- g_2^-}{2\pi\varepsilon r} ch\frac{v_1 - v_2}{c},$$

$$F_3 = +\frac{g_1^- g_2^+}{2\pi\varepsilon r} ch\frac{v_1}{c},$$

$$F_4 = +\frac{g_1^+ g_2^-}{2\pi\varepsilon r} ch\frac{v_2}{c}. \qquad (4.1)$$

Adding all force components, we will obtain the amount of the composite force, which falls per unit of the length of conductor,

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\left(ch\frac{v_1}{c} + ch\frac{v_2}{c} - ch\frac{v_1 - v_2}{c} - 1 \right) \qquad (4.2)$$

In this expression as g_1, g_2 are undertaken the absolute values of charges, and the signs of forces are taken into account in the bracketed expression. For the case $v << c$, let us take only two first members of expansion in the series $ch\frac{v}{c}$, i.e., we will consider that $ch\frac{v}{c} \cong 1 + \frac{1}{2}\frac{v^2}{c^2}$. From relationship (4.2) we obtain

$$F_{\Sigma 1} = \frac{g_1 v_1 g_2 v_2}{2\pi\varepsilon c^2 r} = \frac{I_1 I_2}{2\pi\varepsilon c^2 r}, \qquad (4.3)$$

where as g_1, g_2 are undertaken the absolute values of specific charges, and v_1, v_2 take with its signs.

Since the magnetic field of straight wire, along which flows the current of I, we determine by the relationship

$$H = \frac{I}{2\pi r},$$

From relationship (4.2) we obtain

$$F_{\Sigma 1} = \frac{I_1 I_2}{2\pi\varepsilon c^2 r} = \frac{H_1 I_2}{\varepsilon c^2} = I_2 \mu H_1,$$

where H_1 is the magnetic field, created by lower conductor in the location of upper conductor.

Itisanalogous

$$F_{\Sigma 1} = I_1 \mu H_2,$$

where H_2 is the magnetic field, created by upper conductor in the region of the arrangement of lower conductor.

These relationships completely coincide with the results, obtained on the basis of the concept of magnetic field.

The relationship (4.3) represents the known rule of power interaction of the current carrying systems, but is obtained it not by the phenomenological way on the basis of the introduction of phenomenological magnetic field, but on the basis of completely intelligible physical procedures, under the assumption that that the scalar potential of charge depends on speed. In the formation of the forces of interaction in this case the lattice takes direct part, which is not in the model of magnetic field. In the model examined are well visible the places of application of force. The obtained relationships coincide with the results, obtained on the basis of the concept of magnetic field and by the axiomatically introduced Lorentz force. In this case is undertaken only first member of expansion in the series $ch\frac{v}{c}$. For the speeds $v \sim c$ should be taken all terms of expansion. In terms of this the proposed method is differed from the method of calculation of power interactions by the basis of the concept of magnetic field. If we consider this circumstance, then the connection between the forces of interaction and the charge rates proves to be nonlinear. This, in particular it leads to the fact that the law of power interaction of the current carrying systems is asymmetric. With the identical values of currents, but with their different directions, the attracting forces and repulsion become unequal. Repulsive forces prove to be greater than attracting force. This difference is small and is determined by the expression

$$\Delta F = \frac{v^2}{2c^2} \frac{I_1 I_2}{2\pi\varepsilon c^2 \varepsilon},$$

but with the speeds of the charge carriers of close ones to the speed of light it can prove to be completely perceptible.

Let us remove the lattice of upper conductor (Fig. 1), after leaving only free electronic flux. In this case will disappear the forces F_1, F_3, and this will indicate interaction of lower conductor with the flow of the free electrons, which move with the speed v_2 on the spot of the arrangement of upper conductor. In this case the value of the force of interaction is defined as:

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\left(ch\frac{v_2}{c} - ch\frac{v_1 - v_2}{c} \right) \qquad (4.4)$$

Lorentz force assumes linear dependence between the force, which acts on the charge, which moves in the magnetic field, and his speed. However, in the obtained relationship the dependence of the amount of force from the speed of electronic flux will be nonlinear. From relationship (4.4)it is not difficult to see that with an increase in v_2 the deviation from the linear law increases, and in the case, when $v_2 >> v_1$, the force of interaction are approached zero. This is very meaningful result. Specifically, this phenomenon observed in their known experiments Thompson and Kauffmann, when they noted that with an increase in the velocity of electron beam it is more badly slanted by magnetic field. They connected the results of their observations with an increase in the mass of electron. As we see reason here another.

Let us note still one interesting result. From relationship (4.3), with an accuracy to quadratic terms, the force of interaction of electronic flux with the rectilinear conductor to determine according to the following dependence:

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\left(\frac{v_1 v_2}{c^2} - \frac{1}{2}\frac{v_1^2}{c^2} \right) \qquad (4.5)$$

from expression (4.5) follows that with the unidirectional electron motion in the conductor and in the electronic flux the force of interaction with the fulfillment of conditions $v_1 = \frac{1}{2} v_2$ is absent.

Since the speed of the electronic flux usually much higher than speed of current carriers in the conductor, the second term in the brackets in relationship (4.5) can be disregarded. Then, since

$$H_1 = \frac{g_1 v_1}{2\pi\varepsilon c^2 r}$$

will obtain the magnetic field, created by lower conductor in the place of the motion of electronic flux:

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\frac{v_1 v_2}{c^2} = g_2 \mu v_2 H.$$

In this case, the obtained value of force exactly coincides with the value of Lorentz force. Taking into account that

$$F_\Sigma = g_2 E = g_2 \mu v_2 H,$$

it is possible to consider that on the charge, which moves in the magnetic field, acts the electric field E, directed normal to the direction of the motion of charge. This result also with an accuracy to of the quadratic terms $\frac{v^2}{c^2}$ completely coincides with the results of the concept of magnetic field and is determined the Lorentz force, which acts from the side of magnetic field to the flow of the moving electrons.

As was already said, one of the important contradictions to the concept of magnetic field is the fact that two parallel beams of the like charges, which are moved with the identical speed in one direction, must be attracted. In this model there is no this contradiction already. If we consider that the charge rates in the upper and lower wire will be equal, and lattice is absent, i.e., to leave only electronic fluxes, then will remain only the repulsive force F_2.

Thus, the moving electronic flux interacts simultaneously both with the moving electrons in the lower wire and with its lattice, and the sum of these forces of interaction it is called Lorentz force. This force acts on the moving electron stream.

Regularly does appear a question, and does create magnetic field most moving electron stream of in the absence compensating charges of lattice or positive ions in the plasma. The diagram examined shows that the effect of power interaction between the current carrying systems requires in the required order of the presence of the positively charged lattice. Therefore most moving electronic flux cannot create that effect, which is created during its motion in the positively charged lattice.

Let us demonstrate still one approach to the problem of power interaction of the current carrying systems. The statement of facts of the presence of forces between the current carrying systems indicates that there is some field of the scalar potential, whose gradient ensures the force indicated. But that this for the field? Relationship (4.3) gives only the value of force, but he does not speak about that, the gradient of what scalar potential ensures these forces. We will support with constants the currents I_1, I_2, and let us begin to draw together or to move away conductors. The work, which in this case will be spent, and is that potential, whose gradient gives force. After integrating relationship (4.3) on r, we obtain the value of the energy:

$$W=\frac{I_1 I_2 \ln r}{2\pi\varepsilon c^2}.$$

This energy, depending on that to move away conductors from each other, or to draw together, can be positive or negative. When conductors move away, then energy is positive, and this means that, supporting current in the conductors with constant, generator returns energy. This phenomenon is the basis the work of all electric motors. If conductors converge, then work accomplish external forces, on the source, which supports in them the constancy of currents. This phenomenon is the basis the work of the mechanical generators of emf.

Relationship for the energy can be rewritten and thus:

$$W=\frac{I_1 I_2 \ln r}{2\pi\varepsilon c^2}=I_2 A_{z1}=I_1 A_{z2},$$

where

$$A_{z1}=\frac{I_1 \ln r}{2\pi\varepsilon c^2}$$

is Z - component of vector potential, created by lower conductor in the location of upper conductor, and

$$A_{z2}=\frac{I_2 \ln r}{2\pi\varepsilon c^2}$$

is Z - component of vector potential, created by upper conductor in the location of lower conductor.

The approach examined demonstrates that large role, which the vector potential in questions of power interaction of the current carrying systems and conversion of electrical energy into the mechanical plays. This approach also clearly indicates that the Lorentz force is a consequence of interaction of the current carrying systems with the field of the vector potential, created by other current carrying systems. This is clear from a physical point of view. The moving charges, in connection with the presence of the dependence of their scalar potential on the speed, create the scalar field, whose gradient gives force. But the creation of any force field requires expenditures of energy. These expenditures accomplishes generator, creating currents in the conductors. In this case in the surrounding space is created the special field, which interacts with other moving charges according to the special vector rules, with which only scalar product of the charge rate and vector potential gives the potential, whose gradient gives the force, which acts on the moving charge. Thisis a Lorentz force.

In spite of simplicity and the obviousness of this approach, this simple mechanism up to now was not finally realized. For this reason the Lorentz force, until now, was introduced in the classical electro-dynamics by axiomatic way.

V. Conclusion

In the article is developed the concept of scalar- vector potential, based on the symmetrization of the equations of induction, during record of which is used the substantional derivative. The physical causes of molding of Lorentz force are examined. is shown that the dependence of the scalar potential of charge on the speed is the physical cause of Lorentz force. The examination of power interaction of the current carrying systems is carried out and it is shown that with the low speeds of charges the concept of scalar- vector potential gives the same results as the concept of magnetic field. It is shown that the Lorentz force is connected with the gradient of scalar potential.

This potential form the charges, which move in the field of the vector potential of magnetic field, which, is in turn the consequence of the dependence of the scalar potential of charge on the speed.

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Laws of the Electro-Electrical Induction

By F. F. Mende & A. S. Dubrovin

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Keywords: maxwell equation, scalar-vector potential, dipole moment, dipole emission, ampere law, helmholtz theorem.

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F. F. Mende [α] & A. S. Dubrovin [σ]

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I. Introduction

Maxwell equations attest to the fact that in the free space the transverse electromagnetic waves can exist [1, 2]. Together with the boundary conditions these equations give the possibility to solve the problems of reflection and propagation of such waves in the locked and limited structures. With the aid of Maxwell equations it is possible to solve the problems of emission. But since the equations indicated are phenomenological, physics of such processes thus far remains not clear. Similar problems can be solved, also, with the use of potentials. This approach opens greater possibilities, but physics of the vector potential of magnetic field also up to now remained not clear. The development of the concept of scalar- vector potential, which dedicated a number of works [3-10], it made it possible to open the physical essence of a number of the fundamental laws of electrodynamics, charges connected with the motion. This concept assumes the dependence of the scalar potential of charge on its relative speed. It is obtained by the way of the symmetrization of the laws of induction with the use by the substantial derivative. This approach made possible to explain such phenomena as the phase aberration of electromagnetic waves, transverse Doppler effect, power interaction of the current carrying systems and nature of Lorentz force. In this article the new law of electro-electrical induction, which explains nature of dipole emission, will be examined on the basis of the concept of scalar-vector potential.

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II. Law of the Electro-Electrical Induction

In the works [3-10] is developed the concept of scalar vector potential, from which it follows that the scalar potential depends on speed. This dependence is determined by relationship.

$$\varphi(r,t)=\frac{g\ ch\frac{v_\perp}{c}}{4\pi\ \varepsilon_0 r},$$

where $v_\perp$ is component of the charge rate g, normal to to vector $\vec{r}$, connecting charge with the observation point.

Since pour on any process of the propagation of electrical and potentials it is always connected with the delay, let us introduce the being late scalar- vector potential, by considering that the field of this potential is extended in this medium with a speed of light [1, 2]:

$$\varphi(r,t)=\frac{g\ ch\frac{v_\perp\left(t-\frac{r}{c}\right)}{c}}{4\pi\ \varepsilon_0 r} \qquad (2.1)$$

where $v_\perp\left(t-\frac{r}{c}\right)$ is component of the charge rate of g, normal to

to the vector $\vec{r}$ at the moment of the time $t'=t-\frac{r}{c}$, r is distance between the charge and the point, at which is determined the field, at the moment of the time t.

Using a relationship of $\vec{E}=-grad\ \varphi(r,t)$, let us find field at point 1 (Fig. 1) The gradient of the numerical value of a radius of the vector of $\vec{r}$ is a scalar function of two points: the initial point of a radius of vector and its end point (in this case this point 1 on the axis of x and point 0 at the origin of coordinates). Point 1 is the point of source, while point 0 - by observation point. With the determination of gradient from the function, which contains a radius depending on the conditions of task it is necessary to distinguish two cases:

1) the point of source is fixed and $\vec{r}$ is considered as the function of the position of observation point.
2) observation point is fixed and $\vec{r}$ is considered as the function of the position of the point of source.

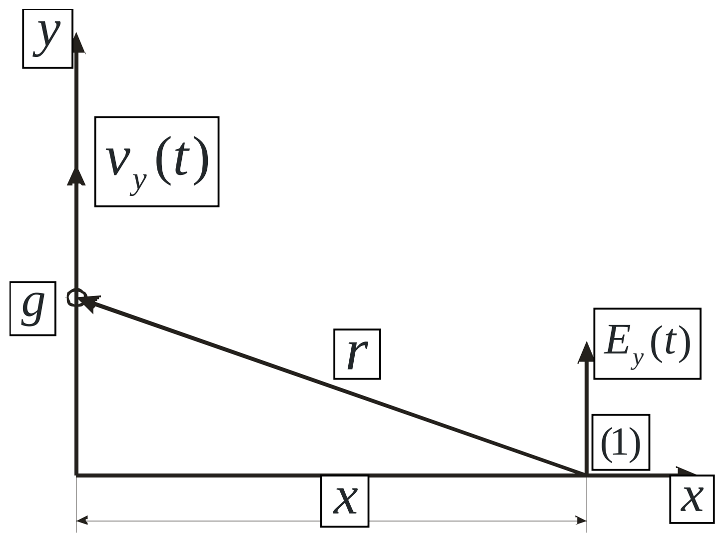

Fig. 1 : Diagram of shaping of the induced electric field.

We will consider that the charge of e accomplishes fluctuating motion along the axis of y, in the environment of point 0, which is observation point, and fixed point 1 is the point of source and $\vec{r}$ is considered as the function of the position of charge. Then we write down the value of electric field at point 1:

$$E_y(1) = -\frac{\partial \varphi_\perp(r,t)}{\partial y} = -\frac{\partial}{\partial y}\frac{e}{4\pi\varepsilon_0 r(y,t)}\, ch\frac{v_y\left(t-\frac{r(y,t)}{c}\right)}{c}$$

When the amplitude of the fluctuations of charge is considerably less than distance to the observation point, it is possible to consider a radius vector constant. We obtain with this condition:

$$E_y(x,t) = -\frac{e}{4\pi\varepsilon_0 cx}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial y} sh\frac{v_y\left(t-\frac{x}{c}\right)}{c} \qquad (2.2)$$

where x is some fixed point on the axis x.

Taking into account that

$$\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial y} = \frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t}\frac{\partial t}{\partial y} = \frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t}\frac{1}{v_y\left(t-\frac{x}{c}\right)}$$

we obtain from (2.2)

$$E_y(x,t) = \frac{e}{4\pi\varepsilon_0 cx}\frac{1}{v_y\left(t-\frac{x}{c}\right)}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t} sh\frac{v_y\left(t-\frac{x}{c}\right)}{c} \qquad (2.3)$$

This is a complete emission law of the moving charge.

If we take only first term of the expansion of $sh\frac{v_y\left(t-\frac{x}{c}\right)}{c}$, then we will obtain from (2.3):

$$E_y(x,t) = -\frac{e}{4\pi\varepsilon_0 c^2 x}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t} = -\frac{ea_y\left(t-\frac{x}{c}\right)}{4\pi\varepsilon_0 c^2 x} \qquad (2.4)$$

where $a_y\left(t-\frac{x}{c}\right)$ is being late acceleration of charge. This relationship is wave equation and defines both the amplitude and phase responses of the wave of the electric field, radiated by the moving charge.

If we as the direction of emission take the vector, which lies at the plane xy, and which constitutes with the axis y the angle α, then relationship (2.4) takes the form:

$$E_y(x,t,\alpha) = -\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x} \qquad (2.5)$$

The relationship (2.5) determines the radiation pattern. Since in this case there is axial symmetry relative to the axis y, it is possible to calculate the complete radiation pattern of this emission. This diagram corresponds to the radiation pattern of dipole emission.

Since $\frac{ev_z\left(t-\frac{x}{c}\right)}{4\pi x} = A_H\left(t-\frac{x}{c}\right)$ is being late vector potential, relationship (2.5) it is possible to rewrite

$$E_y(x,t,\alpha) = -\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x} = -\frac{1}{\varepsilon_0 c^2}\frac{\partial A_H\left(t-\frac{x}{c}\right)}{\partial t} =$$

$$= -\mu_0\frac{\partial A_H\left(t-\frac{x}{c}\right)}{\partial t}$$

Is again obtained complete agreement with the equations of the being late vector potential, but vector potential is introduced here not by phenomenological method, but with the use of a concept of the being late scalar- vector potential. It is necessary to note one important circumstance: in Maxwell's equations the electric fields, which present wave, vortex. In this case the electric fields bear gradient nature.

Let us demonstrate the still one possibility, which opens relationship (2.5). Is known that in the electrodynamics there is this concept, as the electric dipole and the dipole emission, when the charges, which are varied in the electric dipole, emit electromagnetic waves. Two charges with the opposite signs have the dipole moment:

$$\vec{p} = e\vec{d}, \qquad (2.6)$$

where the vector $\vec{d}$ is directed from the negative charge toward the positive charge. Therefore current can be expressed through the derivative of dipole moment on the time

$$e\vec{v} = e\frac{\partial \vec{d}}{\partial t} = \frac{\partial \vec{p}}{\partial t}$$

Consequently

$$\vec{v} = \frac{1}{e}\frac{\partial \vec{p}}{\partial t},$$

and

$$\vec{a} = \frac{\partial \vec{v}}{\partial t} = \frac{1}{e}\frac{\partial^2 \vec{p}}{\partial t^2}.$$

Substituting this relationship into expression (2.5), we obtain the emission law of the being varied dipole.

$$\vec{E} = -\frac{1}{4\pi r\varepsilon_0 c^2}\frac{\partial^2 p(t-\frac{r}{c})}{\partial t^2} \qquad (2.7)$$

This is also very well known relationship [1].

In the process of fluctuating the electric dipole are created the electric fields of two forms. First, these are the electrical induction fields of emission, represented by equations (2.4), (2.5) and (2.6), connected with the acceleration of charge. In addition to this, around the being varied dipole are formed the electric fields of static dipole, which change in the time in connection with the fact that the distance between the charges it depends on time. Specifically, energy of these pour on the freely being varied dipole and it is expended on the emission. However, the summary value of field around this dipole at any moment of time defines as superposition pour on static dipole pour on emissions.

The laws (2.4), (2.5), (2.7) are the laws of the direct action, in which already there is neither magnetic pour on nor vector potentials. I.e. those structures, by which there were the magnetic field and magnetic vector potential, are already taken and they no longer were necessary to us.

Using relationship (2.5) it is possible to obtain the laws of reflection and scattering both for the single charges and, for any quantity of them. If any charge or group of charges undergo the action of external (strange) electric field, then such charges begin to accomplish a forced motion, and each of them emits electric fields in accordance with relationship (2.5). The superposition of electrical pour on, radiated by all charges, it is electrical wave.

If on the charge acts the electric field of , then the acceleration of charge is determined by the equation:

$$a = -\frac{e}{m} E'_{y0} \sin \omega t.$$

Taking into account this relationship (2.5) assumes the form

$$E_y(x,t,\alpha) = \frac{e^2 \sin\alpha}{4\pi\varepsilon_0 c^2 mx} E'_{y0} \sin\omega(t - \frac{x}{c}) = \frac{K}{x} E'_{y0} \sin\omega(t - \frac{x}{c}) \qquad (2.8)$$

where the coefficient $K = \frac{e^2 \sin\alpha}{4\pi\varepsilon_0 c^2 m}$ can be named the coefficient of scattering (re-emission) single charge in the assigned direction, since it determines the ability of charge to re-emit the acting on it external electric field.

The current wave of the displacement accompanies the wave of electric field:

$$j_y(x,t) = \varepsilon_0 \frac{\partial E_y}{\partial t} = -\frac{e \sin\alpha}{4\pi c^2 x} \frac{\partial^2 v_y\left(t - \frac{x}{c}\right)}{\partial t^2}.$$

If charge accomplishes its motion under the action of the electric field of , then bias current in the distant zone will be written down as

$$j_y(x,t) = -\frac{e^2\omega}{4\pi c^2 mx} E'_{y0} \cos\omega\left(t - \frac{x}{c}\right). \qquad (2.9)$$

The sum wave, which presents the propagation of electrical pour on (2.8) and bias currents (2.9), can be named the electrocurent wave. In this current wave of displacement lags behind the wave of electric field to the angle equal $\frac{\pi}{2}$. For the first time this term and definition of this wave was used in the works [3, 4].

In parallel with the electrical waves it is possible to introduce magnetic waves, if we assume that

$$\vec{j} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} = rot\vec{H} \qquad (2.10),$$

$$div\vec{H} = 0.$$

Introduced thus magnetic field is vortex. Comparing (2.9) and (2.10) we obtain:

$$\frac{\partial H_z(x,t)}{\partial x} = \frac{e^2\omega \sin\alpha}{4\pi c^2 mx} E'_{y0} \cos\omega\left(t - \frac{x}{c}\right).$$

Integrating this relationship on the coordinate, we find the value of the magnetic field

$$H_z(x,t) = \frac{e^2 \sin\alpha}{4\pi cmx} E'_{y0} \sin\omega\left(t - \frac{x}{c}\right). \qquad (2.11)$$

Thus, relationship (2.8), (2.9) and (2.11) can be named the laws of electrical-electrical induction, since. They give the direct coupling between the electric fields, applied to the charge, and by fields and by currents induced by this charge in its environment. Charge itself comes out in the role of the transformer, which ensures this prozess. The magnetic field, which can be calculated with the aid of relationship (2.11), is directed normally both toward the electric field and toward the direction of propagation, and their relation at each point of the space is equal:

$$\frac{E_y(x,t)}{H_z(x,t)} = \frac{1}{\varepsilon_0 c} = \sqrt{\frac{\mu_0}{\varepsilon_0}} = Z,$$

where Z is wave drag of free space

Wave drag determines the active power of losses on the single area, located normal to the direction of propagation of the wave:

$$P = \frac{1}{2} Z E^2{}_{y0}.$$

Therefore electrocurent wave, crossing this area, transfers through it the power, determined by the data by relationship, which is located in accordance with Poynting theorem about the power flux of electromagnetic wave. Therefore, for finding all parameters, which characterize wave process, it is sufficient examination only of electrocurent wave and knowledge of the wave drag of space. In this case it is in no way compulsory to introduce this concept as magnetic field and its vector potential, although there is nothing illegal in this. In this setting of the relationships, obtained for the electrical and magnetic field, they completely satisfy Helmholtz's theorem. This theorem says, that any single-valued and continuous vectorial field $\vec{F}$, which turns into zero at infinity, can be represented uniquely as the sum of the gradient of a certain scalar function φ and rotor of a certain vector function $\vec{C}$, whose divergence is equal to zero:

$$\vec{F} = grad\varphi + rot\vec{C},$$

$$div\vec{C} = 0.$$

Consequently, must exist clear separation pour on to the gradient and the vortex. It is evident that in the expressions, obtained for those induced pour on, this separation is located. Electric fields bear gradient nature, and magnetic is vortex.

Thus, the construction of electrodynamics should have been begun from the acknowledgement of the dependence of scalar potential on the speed. But nature very deeply hides its secrets, and in order to come to this simple conclusion, it was necessary to pass way by length almost into two centuries. The grit, which so harmoniously were erected around the magnet poles, in a straight manner indicated the presence of some power pour on potential nature, but to this they did not turn attention; therefore it turned out that all examined only tip of the iceberg, whose substantial part remained invisible of almost two hundred years.

Taking into account entire aforesaid one should assume that at the basis of the overwhelming majority of static and dynamic phenomena at the electrodynamics only one formula (2.1), which assumes the dependence of the scalar potential of charge on the speed, lies. From this formula it follows and static interaction of charges, and laws of power interaction in the case of their mutual motion, and emission laws and scattering. This approach made it possible to explain from the positions of classical electrodynamics such phenomena as phase aberration and the transverse Doppler effect, which within the framework the classical electrodynamics of explanation did not find. After entire aforesaid it is possible to remove construction forests, such as magnetic field and magnetic vector potential, which do not allow here already almost two hundred years to see the building of electrodynamics in entire its sublimity and beauty.

Let us point out that one of the fundamental equations of induction (2.4) could be obtained directly from the Ampere law, still long before appeared Maxwell equations. The Ampere law, expressed in the vector form, determines magnetic field at the point x, y, z

$$\vec{H} = \frac{1}{4\pi}\int \frac{I d\vec{l} \times \vec{r}}{r^3}$$

where I is current in the element $d\vec{l}$, $\vec{r}$ is vector, directed from $d\vec{l}$ to the point x, y, z.

It is possible to show that

$$\frac{[d\vec{l}\vec{r}]}{r^3} = grad\left(\frac{1}{r}\right)\times d\vec{l}$$

and, besides the fact that

$$grad\left(\frac{1}{r}\right)\times d\vec{l} = rot\left(\frac{d\vec{l}}{r}\right) - \frac{1}{r} rot\ d\vec{l}\ .$$

but the rotor $d\vec{l}$ is equal to zero and therefore is final

$$\vec{H} = rot\int I\left(\frac{d\vec{l}}{4\pi r}\right) = rot\ \vec{A}_H$$

where

$$\vec{A}_H = \int I\left(\frac{d\vec{l}}{4\pi r}\right) \qquad (2.12)$$

the remarkable property of this expression is that that the vector potential depends from the distance to the observation point as $\frac{1}{r}$. Specifically, this property makes it possible to obtain emission laws.

Since $I = gv$, where g the quantity of charges, which falls per unit of the length of conductor, from (2.12) we obtain:

$$\vec{A}_H = \int \frac{gv\ d\vec{l}}{4\pi r}.$$

For the single charge of e this relationship takes the form:

$$\vec{A}_H = \frac{e\vec{v}}{4\pi r},$$

and since

$$\vec{E} = -\mu\frac{\partial \vec{A}}{\partial t},$$

that

$$\vec{E} = -\mu\int \frac{g\frac{\partial v}{\partial t}\ d\vec{l}}{4\pi r} = -\mu\int \frac{ga\ d\vec{l}}{4\pi r}, \qquad (2.13)$$

where a is acceleration of charge.

This relationship appears as follows for the single charge:

$$\vec{E} = -\frac{\mu e\vec{a}}{4\pi r} \qquad (2.14)$$

If we in relationships (2.13) and (2.14) consider that the potentials are extended with the final speed and to consider the delay of $\left(t-\frac{r}{c}\right)$, and assuming $\mu = \frac{1}{\varepsilon_0 c^2}$, these relationships will take the form:

$$\vec{E} = -\mu\int \frac{ga(t-\frac{r}{c})\ d\vec{l}}{4\pi r} = -\int \frac{ga(t-\frac{r}{c})\ d\vec{l}}{4\pi\varepsilon_0 c^2 r}, \qquad (2.15)$$

$$\vec{E} = -\frac{e\vec{a}(t-\frac{r}{c})}{4\pi\varepsilon_0 c^2 r} \qquad (2.16)$$

The relationship (2.15) and (2.16) represent, it is as shown higher (see (2.4)), wave equations. Let us note that these equations - this solution of Maxwell's equations, but in this case they are obtained directly from the Ampere law, not at all coming running to Maxwell equations. To there remains only present the question, why electrodynamics in its time is not banal by this method.

Given examples show, as electrodynamics in the time of its existence little moved. The phenomenon of electromagnetic induction Faraday opened into 1831 and already almost 200 years its study underwent practically no changes, and the physical causes for the most elementary electrodynamic phenomena, until now, were misunderstood. Certainly, for his time Faraday was genius, but that they did make physics after it? There were still such brilliant figures as Maxwell and Hertz, but even they did not understand that the dependence of the scalar potential of charge on its relative speed is the basis of entire classical electrodynamics, and that this is that basic law, from which follow the fundamental laws of electrodynamics.

III. Conclusion

Maxwell equations attest to the fact that in the free space the transverse electromagnetic waves can exist. Together with the boundary conditions these equations give the possibility to solve the problems of reflection and propagation of such waves in the locked and limited structures. With the aid of Maxwell equations it is possible to solve the problems of emission. But since the equations indicated are phenomenological, physics of such processes thus far remains not clear. Similar problems can be solved, also, with the use of potentials. This approach opens greater possibilities, but physics of the vector potential of magnetic field also up to now remained not clear. The development of the concept of scalar-vector potential, which dedicated a number of works [3-10], it made it possible to open the physical essence of a number of the fundamental laws of electrodynamics, charges connected with the motion. This concept assumes the dependence of the scalar potential of charge on its relative speed. It is obtained by the way of the symmetrization of the laws of induction with the use by the substantional derivative. This approach made possible to explain such phenomena as the phase aberration of electromagnetic waves, transverse Doppler effect, power interaction of the current carrying systems and nature of Lorentz force. In this article the new law of electro-electrical induction, which explains nature of dipole emission, will be examined on the basis of the concept of scalar-vector potential.

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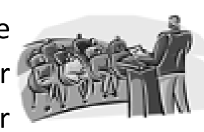

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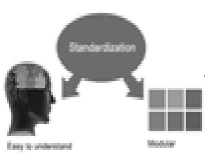

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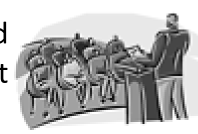

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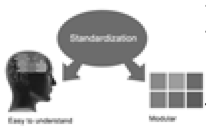

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Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

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

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin 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 research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

Tables, Figures and Figure Legends

Tables: Tables should be few in number, 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. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. 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.

Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.

6. AFTER ACCEPTANCE

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

6.1 Proof Corrections

The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded

(Free of charge) from the following website:

www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

6.2 Early View of Global Journals Inc. (US) (Publication Prior to Print)

The Global Journals Inc. (US) are enclosed by our publishing's Early View service. Early View articles are complete full-text articles sent in advance of their publication. Early View articles are absolute and final. They have been completely reviewed, revised and edited for publication, and the authors' final corrections have been incorporated. Because they are in final form, no changes can be made after sending them. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the conventional way.

6.3 Author Services

Online production tracking is available for your article through Author Services. Author Services enables authors to track their article - once it has been accepted - through the production process to publication online and in print. Authors can check the status of their articles online and choose to receive automated e-mails at key stages of production. The authors will receive an e-mail with a unique link that enables them to register and have their article automatically added to the system. Please ensure that a complete e-mail address is provided when submitting the manuscript.

6.4 Author Material Archive Policy

Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

6.5 Offprint and Extra Copies

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You must strictly follow above Author Guidelines before submitting your paper or else we will not at all be responsible for any corrections in future in any of the way.

Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. 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.

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

6. Use of computer is recommended: As you are doing research in the field of Computer Science, then this point is quite obvious.

7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

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

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

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. 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 to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

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

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

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

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After 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 though which your research is going to be in print to 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 in 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 criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of 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 the 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 evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

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

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing 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 approach 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. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than 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 maintain the initial two items to no more than one ruling each.

- Reason of the study - 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 quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness 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 to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled 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 with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose 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 sound written Procedures segment allows a capable scientist to replacement 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 for the least amount of information that would permit another capable scientist to spare 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 object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text 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:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not 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 - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in 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 a 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. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise 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 in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to 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 part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a 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 implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly 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 with prospect, and let it drop at that.

- Make a decision if each premise is supported, 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 the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One 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 available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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

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 Inc. (US).

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

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