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Journal of Electrical Engineering and Modern Technology

Aims and Scope

Journal of Electrical engineering and Modern Technology, publishes original research papers in the fields of Electrical and Electronic Engineering and in related disciplines. Areas included (but not limited to) are electronics and communications engineering, electric energy, automation, control and instrumentation, computer and information technology, and the electrical engineering aspects of building services and aerospace engineering, Journal publishes research articles and reviews within the whole field of electrical and electronic engineering, new teaching methods, curriculum design, assessment, validation and the impact of new technologies and it will continue to provide information on the latest trends and developments in this ever-expanding subject.

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Contents

Circuit Protection Using Thermal Imaging and its Processing Techniques

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A B S T R A C T

Protection is always an essential parameter of an electrical circuit system. As per electrical fundamental rules, short circuit occurs due to high current passes through an electrical connection. This high called an over current may burnout further circuitry or may blast an important and expensive instruments connected to it. So, it is always mandatory to solve this problem by detecting over current before any harmful incident. Actually, an over current passing through any wire or any component will increase temperature of surrounding areas. If we can detect that high temperature then it is possible to protect the whole circuits and also connected instruments further by removing its supply. To do the same, images acquired from thermal imaging camera can be used to detect temperature of an area and also it helps to solve this problem without coming into the contact. In this paper, I have tried to protect electrical circuit using different but simple image processing techniques using machine vision system. I have used electrical circuit images acquired from thermal imaging camera. By means of different image processing techniques, I have found overheated area in an image due to over current flows in a circuit. After successful detection and analysis of an overheated area, one can easily save and protect the circuit by making off the partial or whole supply to the circuit.

Keywords: Infrared Thermal imaging, Thresholding, Image processing technique, Electrical circuit protection, overheated.

1. INTRODUCTION

For any human being, it is difficult to measure high temperature of surrounding area near any live electrical connection or temperature of surrounding area of a running motor or actuator without coming into contact. Hence it is also difficult to continuously track the temperature of this type of system. Now, in this type of system, if any problem exists at certain time then it is yet difficult but needed to take quick action to overcome any damage. In [1] Jibu Vargese et al. used thermal image analysis technique to find out loading condition of PCB based on thermal camera image. In [2] TANG Qingju et al., compared and analyzedant colony algorithm and canny operator to extract required parameter from infrared thermal images. In [3] TANG Qingju et al., discussed about fusion of morphology and canny algorithm in Infrared image edge detection. In [4] Aleksandra Pavlovid et al. discussed about fusion of visual and thermal image to find area of interest from thermal images. In [5] S. Harishkumar et al., has worked on hot spot occurs due to transformer heating. So, Inspired from the above papers published based on thermal camera in this paper, I have tried to track temperature continuously using thermal camera. I have used two images having area of normal temperature and high temperature. I have drawn out area of interest using image processing technique discussed below.

2. PROBLEM DEFINITION

An Industry comprises of many expensive instruments, products etc. In today's era, anything related to an industry or house hold instruments or products has to deal with electrical parameters such as current, voltage, power etc. The current passing through an instrument plays major role in electrical parameters and it should be within limited range. If it is more than a maximum limited range then this may create unexpected damage to the product or major blast in an industry. To save the instrument or to protect an industry from an unexpected electrical damage, one has to sense the overcurrent problem flows through the circuit. It is possible to sense overcurrent and cutoff further circuitry of an instrument. In this paper, not only over current but, I have also tried to find exact wire or connection from which overcurrent or beyond limit current is flowing. The current passing through the circuit of an instrument will increase the power consumed by the wire and ultimately the instrument. The more power consumed by the wire will increase surrounding temperature which is quite differ from ambient temperature.

It is not possible to find overheated area of circuit from an image taken by normal camera as shown in Figure 1. But temperature difference can be sensed or detected in an image taken by thermal imaging camera as shown in Figure 2. It can be easily seen that one of the wire shown in Figure 2 carries more current as compare to others. By using an image from thermal imaging camera, I have used remote sensing type technique to sense the temperature rise due to overcurrent flow. After certain image processing steps followed described as under, a user can easily detect overcurrent flow. To resolve it, user can eitherswitch off the supply or do necessary action to limit the temperature or current within defined range

Figure 1: Image taken by Normal Camera

Figure 2: Image taken by Infrared Thermal Imaging Camera

(source:http://www.cheyenneelectric.com/thermographic-scanning-service)

3. IMAGE PROCESSING TECHNIQUES AND OTHER METHOD USED

I have used below mention image processing related techniques to solve the sudden rise in surrounding temperature of an electrical circuitry.

3.1 Infrared Thermal Imaging

Thermal imaging is a method of improving visibility of objects in a dark environment by detecting the objects' infrared radiation and creating an image based on that information. Night vision technologies that are most commonly used are near-infrared illumination, low- light imaging and thermal imaging. Thermal imaging works in environments without any ambient light. Fog, haze and smoke can be penetrated by thermal imaging just like near- infrared illumination [1].

All objects emit infrared energy as a function of their temperature. Heat signature is the infrared energy produced by an object. More radiation is been emitted as the object becomes hotter. Tiny differences in temperature can be detected using a heat sensor called as thermal camera. Infrared radiation is collected by the device from objects in the scene and creates an electronic image based on temperature differences information. Thermal camera can detect each object distinctly and can give a distinctive image as the objects that are closer very rarely have precisely same temperature. Grayscale images are obtained using a thermal camera. Cold and hot objects look black and white respectively whereas variation between two is indicated by depth of gray. Different temperatures are indicatedby different colors in some thermal cameras [1]. Different temperature colors can be seen in Figure 3.

3.2 Channels in color image

In RGB color model, each colour appears in its primary spectral components of red, green and blue. The colour of a pixel is made up of three components; red, green, and blue (RGB), described by their corresponding intensities. Colour components are also known as colour channels or colour planes (components). In the RGB colour model, a colour image can be represented by the intensity function [8] I_{RGB}.

$$I_{RGB} = F_R, F_G, F_B \qquad (1)$$

Where FR(x,y) is the intensity of the pixel (x,y) in the red channel, FG(x,y) is the intensity of pixel (x,y) in the green channel, and FB(x,y) is the intensity of pixel (x,y) in the blue channel. The intensity of each colour channel is usually stored using eight bits, which indicates that the quantization level is 256 [6]. I have extracted red channel image from an infrared thermal image.

3.3 Threshold selection [7]

Thresholding is the simplest method of image segmentation. From a grayscale image, thresholding can be used to create binary images.

The key parameter in the thresholding process is the choice of the threshold value. Several different methods for choosing a threshold exist; users can manually choose a threshold value, or a thresholding algorithm can compute a value automatically, which is known as automatic thresholding.

In a noiseless image with uniform background and object values, the mean or median will work well as the threshold, however, this will generally not be the case. A more sophisticated approach might be to create a histogram of the image pixel intensities and use the valley point as the threshold. The histogram approach assumes that there is some average value for the background and object pixels, but that the actual pixel values have some variation around these average values [7].

Global (single) thresholding method is also used when there the intensity distribution between the objects of foreground and background are very distinct. When the differences between foreground and background objects are very distinct, a single value of threshold can simply be used to differentiate both objects apart. Thus, in this type of thresholding, the value of threshold depends solely on the property of the pixel and the grey level value of theimage. Some most common used global thresholding methods are Otsu method, entropy based thresholding, etc [8].

Thresholding is the simplest segmentation method [9].The pixels are partitioned depending on their intensity value. I have used Global thresholding, using an appropriate threshold T given by below equation.

$$a(x,y) = \begin{cases} 1, & if\ f(x,y) > T \\ 0, & if\ f(x,y) \leq T \end{cases} \qquad (2)$$

3.4 Region of interest

A region of interest (ROI) is a portion of an image that has to be processed and analyzed. An ROI is defined by masks. The concept of an ROI is used in many application areas such as, in medical imaging, thermal imaging etc., to find the boundaries of an object. Region of interest can be selected manually or automatically [10]. This method is not mandatory in our case but user may use this to get better result.

3.5 Temperature color graph

The temperature color graph is shown in Figure 3 below for certain infrared thermal imaging sensor. By seeing this graph, one can easily find the temperature of corresponding color in an image as per Figure 3. This figure is shown as per reference. The temperature varies according to infrared thermal imaging sensors. In that graph the range of red color shows high temperature regions. So whenever infrared thermal imaging sensor senses red color, it means that area has got very high temperature can be called overheated area and else will be considered as normally heated area. I have concentrated on red color and beyond that to find out overheat area in an image.

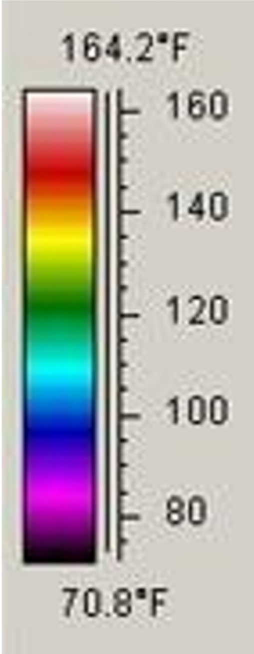

Figure3. Temperature color Graph

4. ALGORITHM/METHOD USED

Table-I will define the steps or methods to resolve the problem discussed above

Table-I

Steps	Method used
1	Acquire an Image of an electrical circuit from thermal imaging camera as shown in Figure 2.
2	Cropped Figure 2 and extract two different images defined overheated image area as shown in Figure 4 and normally heated image area as shown in Figure 5.
3	Extract red channel images of both overheated and normally heated images as shown in Figure 6 and Figure 7 using color separation technique.
4	Apply global thresholding to both Red channel Images with well- defined threshold level as shown in Figure 8 and Figure 9.
5	The user can also skip step 2 to step 4 by selecting region of interest in thermal image shown in Figure 2 to find overheated area and normally heated area.
6	After thresholding, an image will be divided in binary levels or black and white levels as shown in Figure 8 and Figure 9.
7	Once binary images are extracted, then it is possible to find area filled by two different colors such as black and white in terms of pixels as shown in Table II by using function of region props in MATLAB.
8	Normalization and simple arithmetic conversion method helps to find the areas extracted in terms of pixels into the form of percentage of images shown in Figure 8 and Figure 9.
9	After Having final maximum limit area covered for overheated temperature in an image, user can easily decide whether temp is normal or overheated. In our case above 40% area covered by white region is known as overheated.

Figure 4. Overheated area of an image

Figure 5. Normal heated area of an image

Figure 6. Red Channel image of an Overheated image area

Figure 7. Red Channel image of an normally heated image area

Figure 8. Thresholded image of an Overheated image area

Figure 9. Thresholded image of normally heated image area

Table-II

Sr. No.	Areas found							
	Total Area	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Decision
1	1840.8 (InPixel)	8	25	2	2	1	1	Normal heat (Low Temp)
	100(In %)	0.4388	1.3713	0.1097	0.1097	0.0549	0.0549	
2	1840.8 (In Pixel)	**915**	1	26	---	---	---	Overheat (High Temp.)
	100(In %)	**49.706**	0.0543	1.4124	---	---	---	

5. RESULT

After applying certain image processing and thresholding technique, I have found images shown in Figure 8 and Figure 9having two different areas filled with black and white color. In those images white area describes temperature rise in that area and black means normal or below maximum limit temperature is maintained. Region finding technique will provide you information regarding filled area in terms of pixels as shown in Table II. Filled area interms of percentage as shown in Table-II will be found by using normalization and simple arithmetic conversion method.

6. CONCLUSION

One should be aware about relation of current and temperature rise in particular wire or component to protect circuitry. Whenever current rises it will increase the temperature in that particular surrounding area. So, to differentiate between normal temperature area and overheated area user should observe thresholded image as shown in figure. First, the user must decide about certain limit of maximum level of area affected from high temperature. So I am finding the area in terms of percentage which is overheated due to temperature and ultimately due to overcurrent drawn from circuit. After seeing Table-II, one can easily decide about normal temperature area and overheated area shown in terms of pixel and in percentage as well. Now, user can easily find area from which overcurrent is drawn in circuit and take necessary action to resolve it.

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Statistical Studies of Energy in Iran Vs World

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ABSTRACT

Iran is increasing domestic demand for electricity has created supply shortfalls during times of peak energy demand. Iran recently increased electricity prices, which is a component of its energy subsidy reform, in hopes to limit demand growth. Iran holds the world's fourth-largest proved crude oil reserves and the world's first-largest natural gas reserves. Despite the country's abundant reserves, Iran's oil production has substantially declined over the past few years, and natural gas production growth has slowed. International sanctions have profoundly affected Iran's energy sector. Sanctions have prompted a number of cancellations or delays of upstream projects, resulting in declining oil production capacity. The aim of the present study is to identify capacity of various source of energy in Iran compared with world and potential of Iran to become top 10 energy producing countries in the world.

Keywords: Energy scenario; Primary energy consumption; Non-conventional energy; Million Tonnes oil equivalent (MTOE);

1. INTRODUCTION

Any physical activity in the world whether by human beings or by nature is caused due to flow of energy in one form to other. Energy is required to do any kind of work the work output depends on the energy input. The capability to do work depends on the amount of energy one can control and utilize. We cannot see energy, only its effects, we cannot make it, only use it; and we cannot destroy it, only waste it through inefficient use. The energy is most basic infrastructure input required for economic growth and development of a country. A systematic study of various forms of energy and energy transformation, including human experience and observations is called 'Energy Science'. The applied part of energy science useful to human society, nation and individual is called 'Energy Technology'.

1.1: ENERGY : ITS DEFINITION

To discuss energy in a useful way, it is necessary to arrive at a definition of energy and ascribe to it physical units, so that the concept of energy can be discussed quantitatively and quantitative calculations can be performed. In physics, energy is defined as „capacity for doing work'. The word work is used with many different associations, but in physics, it has a very definite meaning: Work = Force x Displacement along the direction of force. To perform this work, energy must be available. In case of a person pushing a thing, the energy may be in the form of food calories. In another case, in which the force is exerted by an electrical device, the electrical energy used may be from electrical energy generating sources.

1.2: VARIOUS FORM OF ENERGY

In a sense, energy is simply the capacity for doing work. Energy may be transformed from one type to another and hence, much of the discussion of energy is related to the transformation of energy from one form to another so that it can do useful work. There is an important principle stating that the total amount of energy in a closed system remains constant. Energy may change from one form to another, but the total amount in any closed system remains constant. This principle, known as „Conservation of Energy' is extremely important for understanding a variety of phenomena. Energy can still be changed from some useful form to some other form that for all practical purposes is useless, even though, formally energy is conserved in the process. Thevarious forms of energy and transformations of energy from one form to another are listed below.

a) Kinetic energy: Energy of motion is called kinetic energy. If an object has a mass, m and velocity v. then its kinetic energy is, KE = 1/2 mv2.

b) Potential energy: The energy that an object possesses as a result of its elevation in a gravitational field is called potential energy and is expressed as, PE= mgh, where m is mass, g is the gravitational acceleration, h is the height.

c) Chemical energy: Chemical energy arises out from the atoms in the form of heat as they combine or separate. When certain chemicals combine, energy is released usually in the form of heat. It is the chemical energy in coal, natural gas, oil, wood etc. use to generate electricity. Also it is the chemical energy in the food we eat that provides the energy we need for daily life.

d) Electrical energy: Electrical energy arises out due to moving electrons in the form of heat, electro-magnetic radiation and magnetic field. If wires are connected to the battery and are connected to a light bulb or resistor, the energy contained in the battery is transferred through the wires and dissipated as heat in the resistor. There are number of sources of electrical energy besides batteries.

e) Heat energy: Heat energy is the kinetic energy of molecules. In daily life, we frequently refer to the heat content of bodies. It is also called the thermal energy.

f) Radiant energy: Radiant energy is the energy in transit through space. It is emitted by electrons as they change orbit and by atomic nuclei during fission and fusion. Such energy appears ultimately as heat. Only radiant heat can exist alone; all other forms require the presence of matter.

g) Nuclear (Mass) energy: Nuclear energy arises out of the elimination of all or part of the mass of atomic particles. As a consequence of special theory of relativity, it can be shown that when the mass of some system is reduced by an amount Δm, as in nuclear reaction, then the amount of energy released is, $En = \Delta mc^2$.

1.3 : CLASSIFICATION OF VARIOUS SOURCES:

Energy sources can be classified in the following ways.

1) Based on usability of energy:

a) Primary sources: Energy sources available in nature in raw form are called primary energy resources (fossil fuels, uranium, and hydrogen). This form of energy cannot be used as such. These are converted to a form as required by the consumer.

b) Intermediate sources: Energy sources which are obtained from primary energy sources by one or more steps of transformation are intermediate resources.

c) Secondary sources: The form of energy, which is finally supplied to the consumer for utilization, is known as secondary or usable energy (electric energy, thermal energy, chemical energy).

2) Based on long-term availability:

a) Non-renewable sources: Energy sources which are finite and do not get refill after their consumption, are called non-renewable (fossil fuels, uranium).

b) Renewable sources: Energy sources which are renewed by nature again and again and their supply is not affected by the rate of their consumption are called renewable (solar, wind, biomass, ocean, geothermal, hydro).

Outlet is called non-commercial resource, e.g. wood, animal dung cake, crop residue, etc.

3) Based on origin:

The different types of energy based on their origin are as follows:

a) Fossil fuels energy b) Nuclear energy

c)Hydro energy d)Solar energy

e) Wind energy f)Biomass energy

g) Geothermal energy h) Tidal energy

I) Ocean thermal energy j) Ocean wave energy and many more……

1.4 : ENERGY SCENARIO OF WORLD (AT END OF 2013)

1.4.1 (A): Primary energy sources

1) Coal: The proven global coal reserve was estimated to be 891,531 million tonnes (MT) by end of 2013. The USA had the largest share of the global reserve (237,295 MT, 26.6 %) followed by Russian Federation (157,010 MT, 17.6 %) and China (114,500 MT, 12.8 %). Middle East is negligible with 0.1 %, 1122 MT of coal reservoir. (Iran less than 0.05 %) With the current reserve-to-production ratio coal reserves will last for 113 years.

2) Oil: Total global proven oil reserve was estimated to be 1687.9 thousand billion barrels (TMB) (One Barrel = 158.98 Lit.). Venezuela has largest share (17.7 %, 298.3 TMB) of oil reserve followed by Saudi. Arabia (15.8 %, 265.9 TMB), Canada (10.3 %, 174.3 TMB) and Iran (9.3 %, 157.0 TMB).Top 10 countries in the world with proven oil reserve listed in Table 1.1. With current reserve-to-production ratio world"s oil reserves will last for another 53.3 years.

Table 1.1: World"s top countries with proven oil reserve at end of 2013

Position	Country	% share Of world	Proven oil reserve	% of production share	% of Consumption n share
				Thousand barrels daily	Thousand barrrels daily
1	Venezuela	17.70%	298.3 TMB	3.30%	0.90%
2	S. Arabia	15.80%	265.9 TMB	13.10%	3.20%
3	Canada	10.30%	174.3 TMB	4.70%	2.50%
4	Iran	9.30%	157.0 TMB	4.00%	2.20%
5	Iraq	8.90%	150.0 TMB	3.70%	Less than 0.2 %
6	Kuwait	6.00%	101.5 TMB	3.70%	0.50%
7	United Arab	5.80%	97.8 TMB	4.00%	0.90%
8	Russian Federation	5.50%	93.0 TMB	12.90%	3.70%
9	Libya	2.90%	48.5 TMB	1.10%	Less than 0.1%
10	US	2.60%	44.2 TMB	10.80%	19.90%

3) Natural gas: Global proven gas reserve was estimated to be 185.7 trillion cubic metres (TCM)(One Trillion = 1018). The Iran has the largest share of the reserve with almost 18.2 % (33.8 TCM) followed by Russian Federation and Qatar having total share of 16.8 % (31.3 TCM) and 13.3 % (24.7 TCM) respectively. The world"s natural gas reserves will last for another 55.1 years.

4) Nuclear Energy: There are around 437 nuclear power plants in the world in 31 countries based on U235 generating total power generation 372 GW (563.2 MTOE) which is about1/6th of world's electricity. The world"s top 10 countries nuclear energy consumption is shown in Table 1.2.

Table 1.2: World"s top countries with nuclear energy consumption at end of 2013

Position	Country	% of share	Proven oil reserve
1	USA	33.40%	187.9 MTOE
2	France	17.00%	95.9 TMTOE
3	Russian Federation	6.90%	39.1 MTOE
4	South Korea	5.60%	31.4 MTOE
5	China	4.40%	25.0 MTOE
6	Canada	4.10%	23.1 MTOE
7	Germany	3.90%	22.0 MTOE
8	Ukraine	3.30%	18.8 MTOE
8	United Kingdom	2.80%	16.0 MTOE
9	Sweden	2.70%	15.1 MTOE
10	Spain	2.30%	12.8 MTOE

The USA has the largest share of the consumption with almost 33.4 % (187.9 MTOE) followed by France 17.0 % (95.9 MTOE) and Russian Federation 6.9 % (39.1 MTOE). Uranium reserves in the world are small and expected to last hardly for 50 years. Concentrated deposits of uranium are not available. Major sources of uranium are available in USA, Canada and Australia. Thorium reserves are expected to be more than those of uranium.

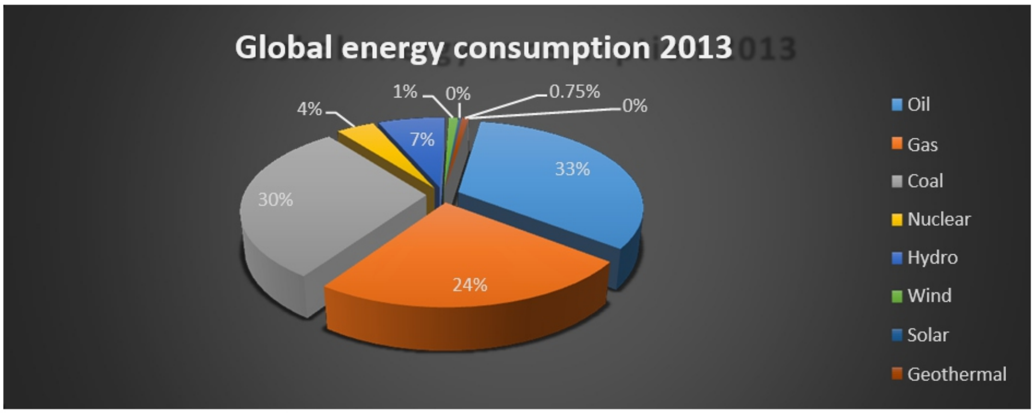
5) Hydroelectricity: Among all renewables, hydropower is the most established source of electric power. Due to requirement of huge capital investment and strong environmental concerns about large plants, only 20 % potential has been taped so far. The global installed generating capacity of hydropower is about 855.8 MTOE, which account 23 % of the world's total installed electric power generation capacity and 7 % of the world's primary energy supply.

Table 1.3: World"s top countries with hydro-electric energy consumption

Position	Country	% of share	Proven oil reserve
1	China	24.10%	206.3 MTOE
2	Canada	10.40%	88.6 MTOE
3	Brazil	10.20%	87.2 MTOE
4	USA	7.20%	61.5 MTOE
5	Russian Federation	4.80%	41.0 MTOE
6	India	3.50%	29.8 MTOE
7	Norway	3.40%	29.2 MTOE
8	Venezuela	2.20%	19.0 MTOE
9	Japan	2.20%	18.6 MTOE
10	France	1.80%	15.5 MTOE

Biggest hydroelectric power station is located in China, at in Hubei. Its capacity is 22,500 MW. The dam is 1045 km^2.The world‟s top 10 countries hydro-electric energy consumption is shown in Table 1.3.As seen in the figure, the China is the biggest hydro-electric consumer in the world with 206.3 MTOE which is 24.1 % of globe‟s hydro-electric consumption. This is followed by Canada with 88.6 MTOE (10.4 %) and Brazil with 87.2MTOE (10.2 %) respectively.

It is interesting to note that the about 87 % of world's energy supply comes mainly from fossil fuels i. e. from oil, natural gas and coal whereas the remaining 13 % of the world's energy supply comes mainly from nuclear and hydro-electric energy.



1.4.1(B): Global Primary Energy Consumption

The global primary energy consumption at the end of 2013 was equivalent to 12730.4MTOE. The primary energy consumption for few countries is shown in Table 1.4.

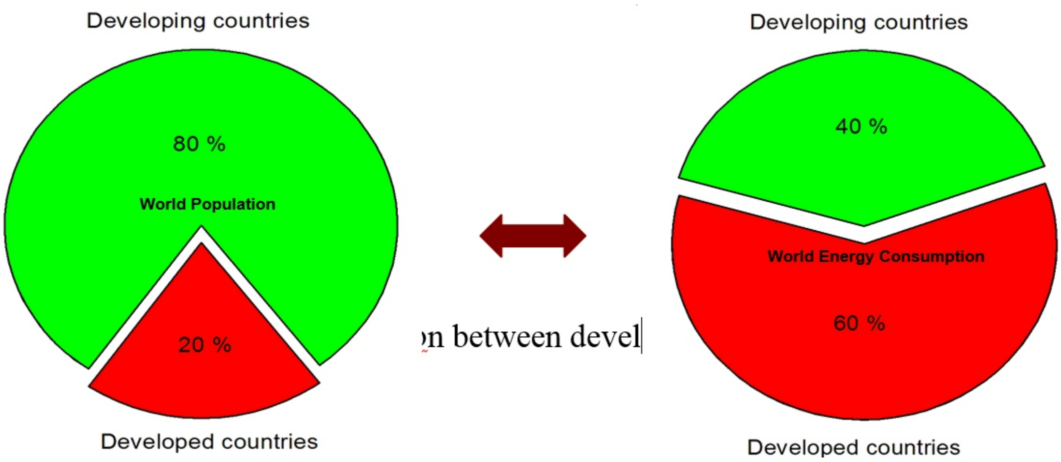
Table 1.4: Primary Energy Consumption by Fuel, 2013

Country	Oil	Gas	Coal	Nuclear	Hydro	Renewables	Total (MTOE)
China	507.4	145.5	1925.3	25	206.3	42.5	**2265.8**
USA	831	671	455.7	187.9	61.5	58.6	**2265.8**
Russian Federation	153.1	372.1	93.5	39.1	41	0.1	**699**
India	175.2	46.3	324.3	7.5	29.8	11.7	**595**
Japan	208.9	105.2	128.6	3.3	18.6	9.4	**474**
Canada	103.5	93.1	20.3	23.1	88.6	4.3	**332.9**
Germany	112.1	75.3	81.3	22	4.6	29.7	**325**
Brazil	132.7	33.9	13.7	3.3	87.2	13.2	**284**
South Korea	108.4	47.3	81.9	31.4	1.3	1	**271.3**
France	80.3	38.6	12.2	95.9	15.5	5.9	**248.4**
Iran	92.9	146	0.7	0.9	3.4	0.1	**243.9**
TOTAL WORLD	**4185.1**	**3020.4**	**3826.7**	**563.2**	**855.8**	**279.3**	**12730.4**

The China is largest primary energy consumer in the world followed by USA and Russian federation. Iran is 11th largest primary energy consumer in the world.

1.4.1(C): Energy distribution between developed and developing countries

Although 80 % of the world"s population resides in the developing countries, their energy consumption amounts to only 40 % of the world total energy consumption (See figure 1.2).



The high standards of living in the developed countries are attributable to high-energy consumption levels. Also, the rapid population growth in the developing countries has kept the per capita energy consumption low compared with highly industrialized developed countries.

The world average energy consumption per person is equivalent to 2.2 Tonnes of coal. In industrialized countries, a person uses 4-5 times more than the world average and 9 times more than the average for the developing countries. An American uses 2.2 times more energy than an Iranian.

1.4.2: Non-conventional energy sources

Non-conventional technologies are under growth stage and their share is very small.

1) Solar energy: Solar photovoltaic (PV) is a method of generating electrical power by converting solar radiation into electricity On an average earth receives solar power of 22,25,04,000 TW, which is about 13,000 times the current world's energy consumption. World"s total installed PV power is 136GW(as of the 2013).The International Energy Agency (IEA) estimates the total global solar power capacity will grow from 98 GW in 2012 to 308 GW in 2018.Large-scale photovoltaic power plants in the world are listed in Table 1.5.

Table 1.5: Large-scale photovoltaic power plants in the world

Position	PV Power Station	Country	Capacity
1	Longyangxia Hydro-solar PV Station	China	320 MWp
2	Agua Caliente Solar Project	USA	250 MWp
3	California Valley Solar Ranch	USA	250 MWp
4	Charanka Park PV power plant	India	214 MWp
5	Golmud PV power plant, Golmud	China	200 MWp
6	Gonghe Industrial Park Phase I	China	200 MWp
7	Centinela Solar	USA	170 MWp

8	Solarpark Meuro	Germany	166 MWp
9	Mesquite Solar I	USA	150 MWp
10	Solarpark Neuhardenberg	Germany	145 MWp
11	Catelina Solar Project	USA	143.2 MWp
12	Campo Verde Solar Project	USA	139 MWp
13	Solarpark Templin	Germany	128 MWp
14	Arlington Valley Solar Energy	USA	139 MWp
15	Centrale solaire de Toul-Rosières	France	115 MWp
16	Perovo I-V PV power plant	Ukraine	105.56 MWp
17	Chengde PV Project Phase I and II	China	100 MWp
18	Jiayuguan PV power plant	China	100 MWp
19	Xitieshan I,II,III PV power plant	China	100 MWp
20	Sarnia PV power plant	Canada	97 MWp

2)Wind energy: The wind power potential is estimated 1.6 x 107 MW, but harnessed so far is 318.137 GW. It is most economical among all renewable energy sources and is expanding at a rate of 30 % per year. Top 10 countries by wind power installed capacity are listed in Table 1.6.

Table 1.6: Installed wind power as on June 2013

Position	Country	Capacity
1	China	91,424 MW
2	United States of America	61,091 MW
3	Germany	34,250 MW
4	Spain	22,959 MW
5	India	20,150 MW
6	United Kingdom	10,531 MW
7	Italy	8,552 MW
8	France	8,254 MW
9	Canada	7,803 MW
10	Denmark	4,772 MW
…….	Iran	Around 100 MW

There has been remarkable growth of wind power installation in the world. Wind power installations worldwide have crossed 318,137 MW (installed capacity). China is the world leader in wind power with installed capacity of 91,424 MW.

3) Biomass energy: Energy resources available from animal and vegetation are called biomass energy resources. This is an important resource for developing countries, especially in rural areas. Principal biomass resources are,

I) Trees (wood, leaves and forest industry waste)

ii) Algae and other vegetation from ocean and lake

iii) Urban waste (municipal and industrial waste)

iv) Rural waste (agricultural and animal waste, crop residue, etc.)

Solar energy absorbed by plants (through photosynthesis process) is estimated to be 2x1021 J /year. Biomass material may be transformed by chemical or biological processes to produce intermediate bio-fuels such as biogas (methane), ethanol and charcoal, etc. At present there is millions of biogas plants in the world, most of them are in China.

4) Geothermal energy: Geothermal energy is derived from a huge amount of stored thermal energy in the interior of the earth. However, its economic recovery is not feasible everywhere onthe surface of the earth. Its overall contribution in total energy requirement is negligible. However, it is a very important resource locally. World's total present (end of year 2013) installed electrical power generating capacity from geothermal resource is about 11,765 MW (in 24 countries). Globally, geothermal power is growing steadily at a rate of about 8.5 % per year. The island of Hawaii derives 25 % of its electricity from geothermal resources.

Table 1.7:10 topperInstalled geothermal capacity up to 2013

Position	Country	Capacity
1	United States of America	3,389 MW
2	Philippines	1,894 MW
3	Indonesia	1,333 MW
4	Mexico	980 MW
5	Italy	901 MW
6	New Zealand	895 MW
7	Iceland	664 MW
8	Japan	537 MW
9	Kenya	215 MW
9	Costa Rica	208 MW
10	El Salvador	204 MW

5) Ocean tidal energy: The potential in ocean tides resource estimated is nearly 45,000 MW. It is in the developing stage. There are at present only few operational tidal power plants. The first and the biggest 254 MW tidal plant was built in Sihwa Lake Tidal Power Station, South Korea. Second one with capacity of 240 MW tidal plant was built in 1966 in France at the mouth of La Rance river, near St. Malo on the Brittany coast. The 240MW Swansea Bay Tidal Lagoon project, to be built at Swansea Bay in the UK, is the world's biggest tidal power project and will become the world's third biggest tidal power project upon completion.

Table 1.8: World"s operational tidal power plants

Position	Country	Station	Capacity (MW)
Under construction	South Korea	Incheon Tidal Power Station	818 or 1,320
1	South Korea	Sihwa Lake Tidal Power Station	254
2	France	Rance Tidal Power Station	240
3	UK	Swansea Bay Tidal Lagoon	240
4	Scotland	MeyGen Tidal Energy	86
5	Canada	Annapolis Royal Generating Station	20
6	China	Jiangxia Tidal Power Station	3.2
7	Russia	Kislaya Guba Tidal Power Station	1.7
8	South Korea	Uldolmok Tidal Power Station	1.5
9	UK	Strangford Lough SeaGen Station	1.2

1.5:ENERGY SCENARIO OF IRAN

1.5. (A): Primary energy sources in Iran

1) Oil Supply: Iran"s proven oil reserve is 157TMB (9.3 %) of total oil reserves. The country"s annual crude oil production is peaked at about 3558 Thousand Barrels/day (4%) against the peak demand of about 92.9 million tones. In the current scenario, the oil production of Iran is 3558 thousand barrels per day against the consumption of 2002 Thousand Barrels/day. Thus the net export of the oil is 1556 Thousand Barrels/day. It has been estimated that with the current reserve to production ratio the oil reserve will last for more than 100 years.(at the end of 2013)

2) Coal Supply: Iranhas less than 0.05 % of proven recoverable reserves of coal in the world. It may last for about 15 -20 years at the current reserve-to-production ratio. In contrast, the world"s proven coal reserves are expected to last only for 113 years at the current reserve-to-production ratio.

3) Natural Gas Supply: Iran"s proven natural gas reserve is 18.2 % (33.8 TCM) of world"s total natural gas reserves. The current natural gas production rate is 166.6 Billion cubic meters/yearagainst the consumption rate 162.2 BCM/year at the end of 2013. Thus the net export of thegas is about 4.4 BCM of natural gas per year and this demand is expected to increase in future.

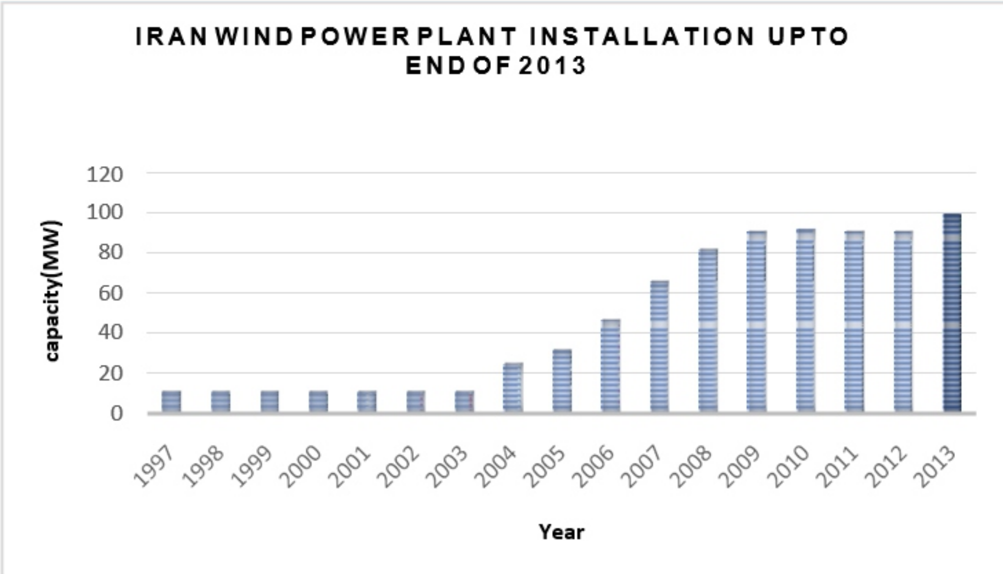
4) Nuclear Power Supply: Nuclear power is 3th largest source of electricity in Iran after thermal, hydroelectric. The Iranian government took control over the management of the plant in late 2013, around the same time the nuclear power plant began commercially producing power at its full capacity of 1,000 megawatts (MW), according to BMI. Two additional units are planned at Bushehr, each with a planned capacity of 1,000 MW, according to the World Nuclear Association. Iran plans to generate 23,000 MWh of electricity through nuclear technology by 2025 to meet its increasing demand for energy.

5) Hydro Power Supply: Iran is endowed with a vast and viable hydro potential for power generation. Iran stands 32th in the list of nations with hydro resources. Total share is 3.4 MTOE at the end of 2013(11 GW).

1.5. (B): Non-Conventional Energy Sources in Iran

Iran located in the region, is endowed with large renewable energy resources i. e. solar, wind and biomass including agricultural residue. Harnessing these resources is best suited to meet the energy requirement in rural areas in a decentralized manner. Iran has potential of generating more than 100,000 MW from non-conventional resources. Up to March 2013, the electrical power generation by non-conventional resource has reached only 0.1 MTOE (323 MW), which is about less than 1 % of total electrical power generation

1) Wind energy: Iran has the potential to generate 20 to 30 GW of wind energy. That is half of the total energy consumption needs of the country.



2) Solar photovoltaic energy: Iran's unique geographical position means 90% of the country has enough sun to generate solar power 300 days a year. According to PressTV Iran has 520 watts per hour per square meter of solar radiation every day.

3) Biomass energy: A large quantity of biomass is available in Iran(20 Million Tonnes per year) in the form of dry waste like agro residues, fuel wood, etc. and wet wastes like cattle dung, sugarcane bagasse, banana stem etc. Biomass power generation in Iran has a potential ranges from 5000 MW to 10000 MW.

4) Geothermal energy: Iran has the potential to become the 9th largest geothermal energy producer. The first geothermal electricity generation station in Meshkinshahr, Ardebil with capacity of 250 MW installed in 2010.

5) Ocean wave and tidal energy: The global tidal range energy potential is estimated to be about 200 TWh/y, about 1 TW being available at comparable shallow waters. Within the European Union, France and the UK have sufficiently high tidal ranges of over 10 meters. Beyond the EU, Canada, the CIS, Argentina, Western Australia and Korea have potentially interesting sites. Additionally for Iran, there is a wide range of potentially interesting sites for tidal ranges.

CONCLUSIONS:

Currently, Iran is the 11th largest energy consumer in the world and the country's energy consumption is expected to increase in the near future. In the past, Iran has derived most of its energy from gas and oil but recently the country has been making efforts to extract energy from other sources. However, fossil fuels still remain the largest energy source. Iran has become self-sufficient in designing, building and operating dams and power plants and it has won a good number of international bids in competition with foreign firms, so our target should be promotion of renewable energy with support of investors by legislation of correct energy policy against world.

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Reducing The Output Harmonics and The Number Components in High Frequency Distribution System by Using A Switched-capacitor-based Cascaded Multilevel Inverter

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A B S T R A C T

The increase of frequency in AC transmission system has more advantages than low- or medium frequency distribution systems. In high-frequency ac Power Distribution System the high-Frequency inverter serves as source. Here the high frequency inverter is obtained with a switched-capacitor-based cascaded multilevel inverter is proposed in this work. The inverter is constructed by a combination of switched-capacitor and H Bridge inverter. The the conversion of series and parallel connections, the switched capacitor increases the number of voltage levels in the output. The harmonics in the output and the number of components can be significantly reduced by the increasing number of voltage levels in the output waveform. The symmetrical triangular waveform modulation with analog implementation is used in this circuit topology. The mathematical analysis, determination of circuit parameters is examined. The computer simulation results confirm the feasibility of proposed multilevel inverter.

Keywords: Cascaded H-Bridge inverter, high-frequency ac, multilevel inverter, switched capacitor

1. INTRODUCTION

In previous technique DC to AC conversion technique process the output has high amount of harmonics, in order to reduce this harmonics we develop a new project; in this a novel switched capacitor is introduced for the purpose in increase the voltage levels. In addition to this the H bridge also used. In this project we generate the gate pulses by using PWM technique. The switched capacitor situated at the front end and the H bride at back end. By using this project the harmonics are significantly reduced from high level to low level. In this project the efficiency of the out voltage is increased to certain level. To overcome the above problem of two methods we are going for cascaded multi level inverter based on switched capacitor for high frequency AC power distribution system. In this project we want to increase the levels of output voltage at any cost without problem discussed above. We used two cascaded H-Bridge inverters and capacitors which, used increase the output voltage more than input voltage. By using this total harmonics are reduced because of the increased levels in the output voltage.

High-Frequency AC Power Distribution System becomes an alternative to dc distribution due to the lesser components and lower cost. The present inverter applications can be found in computer, telecom, electric vehicle and renewable energy micro grid [[1],[2]. However high-frequency AC Power Distribution System has to confront the challenges from large power capacity, high Electromagnetic Interference, and severe power losses [3]. In order to increase the power capacity, the most popular method is to connect the inverter output in series or in parallel. However, it is impractical for high-frequency inverter, because it is complicated to simultaneously synchronize both amplitude and phase with high frequency dynamics. Multilevel inverter is an effective solution to increase power capacity without synchronization consideration, so the higher power capacity is easy to be achieved by multilevel inverter with lower switch stress. Non polluted sinusoidal waveform with the lower Total Harmonic Distortion (THD) is critically caused by long track distribution in HFAC PDS. The higher number of voltage levels can effectively decrease total harmonics content of staircase output, thus significantly simplifying the filter design [4]. HF power distribution is applicable for small-scale and internal closed electrical network in Electric vehicle (EV) due to moderate size of distribution network and effective weight reduction [5]. The consideration of operation frequency has to make compromise between the ac inductance and resistance [6], so multilevel inverter with the output frequency of about 25 kHz is a feasible trial to serve as power source for high-frequency EV application. The traditional topologies of multilevel inverter mainly are diode-clamped and capacitor-clamped type [7], [8]. In this project the efficiency of the out voltage is increased to certain level. To overcome the above problem of two methods we are going for cascaded multi level inverter based on switched capacitor for high frequency AC power distribution system. In this project we want to increase the levels of output voltage at any cost without problem discussed above. We used two cascaded H-Bridge inverters and capacitors which, used increase the output voltage more than input voltage. By using this total harmonics are reduced because of the increased levels in the output voltage.

2. FAULT DIAGNOSIS IN MULTILEVEL CONVERTERS

Since a multilevel converter is normally used in medium to high power applications, the reliability of the multilevel converter system is very important. For instance industrial drive applications in manufacturing plants are dependent upon induction motors and their inverter systems for process control. Generally,

the conventional protection systems are passive devices such as fuses, overload relays, and circuit breakers to protect the inverter systems and the induction motors. The protection devices will disconnect the power sources from the multilevel inverter system whenever a fault occurs, stopping the operated process. Downtime of manufacturing equipment can add up to be thousands or hundreds of thousands of dollars per hour, therefore fault detection and diagnosis is vital to a company's bottom line. In order to maintain continuous operation for a multilevel inverter system, knowledge of fault behaviors, fault prediction, and fault diagnosis are necessary. Faults should be detected as soon as possible after they occur, because if a motor drive runs continuously under abnormal conditions, the drive or motor may quickly fail.

3. CASCADED NINE LEVEL INVERTER WITH NINE-LEVEL OUTPUT.

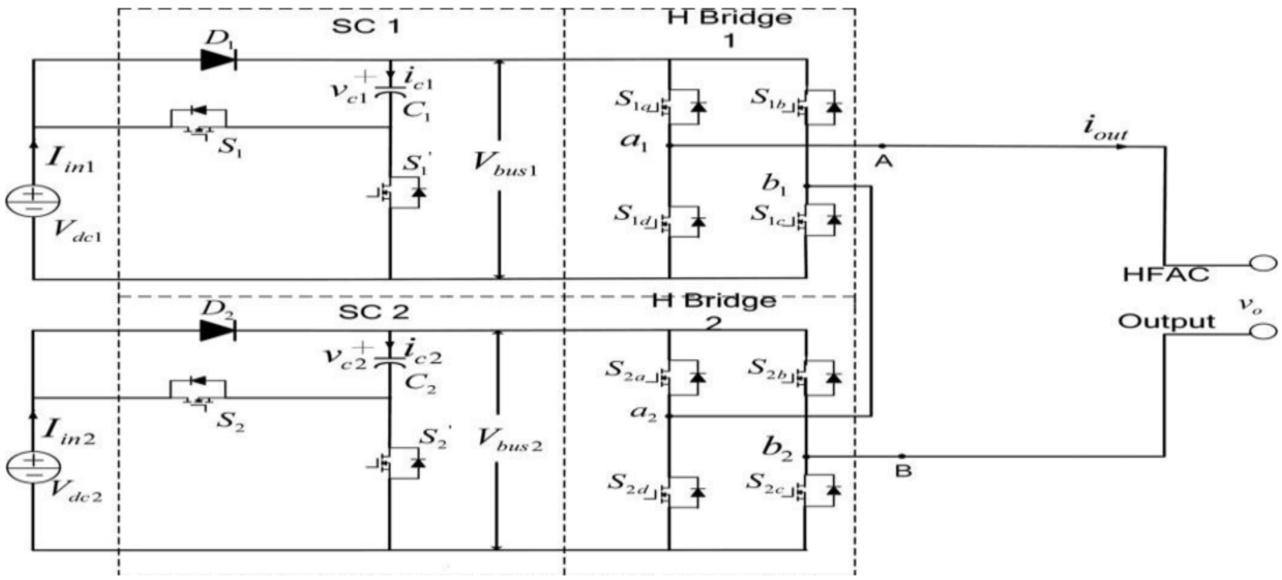

Fig .1 Nine Level Inverter for nine level output

The proposed circuit is made up of the switched capacitor and cascaded H-Bridge inverter. If the numbers of voltage levels obtained by switched capacitor and cascaded H-Bridge inverte are N1 and N2 , then the number of voltage levels is 2 ×N1×N2+1 in the entire operation cycle. Fig 1 shows the circuit topology of nine-level inverter (N1 =2, N2 = 2), where S1, S2, S^1 , S^2 as the switching devices of switched capacitor circuits (SC1 and SC2) are used to convert the series or parallel connection of C1 and C2 . S1a, S1b, S1c, S1d, S2a, S2b, S2c, S2dare the switching devices of cascaded H-Bridge. Vdc1 and Vdc2 are input voltage. D1 and D2 are diode to restrict the currents direction. I_{out} and vo are the output current and the output voltage, respectively. Vc is the triangular carrier, and Vpp is the peak value of Vc. The modulation signals of triangular carrier are Vm 1c, Vm 1b, Vm 2c and Vm 2b . Vm 1b and Vm 2b are used to control phase-shift angles of H-Bridge 1 and H-Bridge 2, respectively, and δi is the duration of voltage levels

controlled by them. Vm 1c and Vm 2c are used to control the alternative operations of SC1 and SC2, respectively, and αi is the duration of voltage levels controlled by them. Thus, the drive signals of H-Bridge switches (S1a, S1b, S1c, S1d, S2a, S2b, S2c, S2d) are phase-shifted pulse signals, while the drive signals of SC switches (S1, S2, S_1 , S_2)are complementary pulse signals.

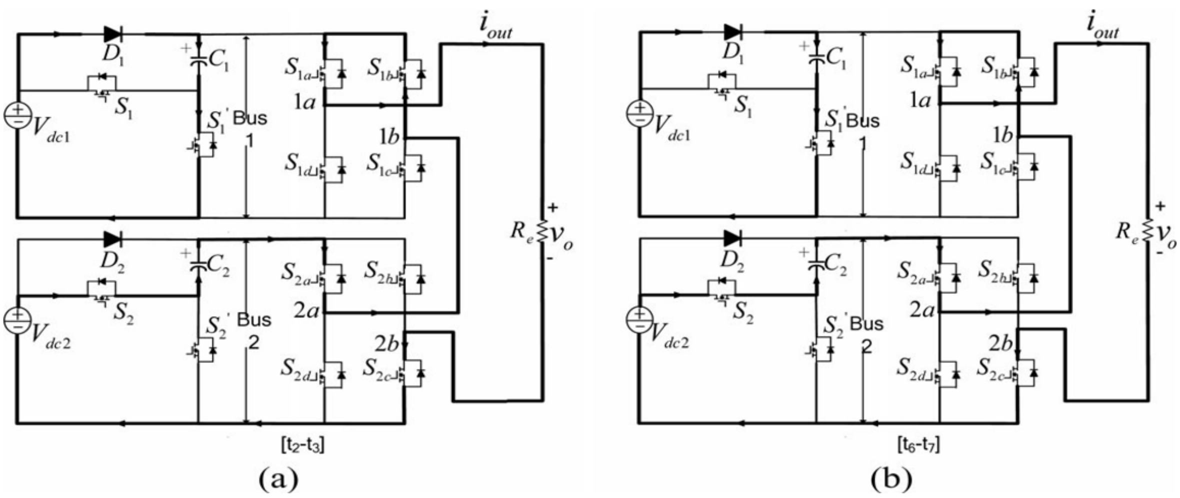

Fig . 2. Active circuits for different operation intervals in the operational modes

.The operations H-Bridge 1 is in freewheeling state, and H-Bridge 2 is in Fig. 2. Output voltage equals 2Vin because S1 and S2 are on, the capacitor C1 keeps charged to Vin and capacitor C2 is discharged. The voltages on Bus 1 and Bus 2 are Vin and 2Vin , respectively. The current flow of this time intervals shown in Fig(a). Similarly, the active circuit of t6 ≤ t <t7is shown in Fig (b) that has the same operations as t2 ≤ t <t3 . The second half-cycle (from t8 on) has the similar active circuits as the first half-cycle (t1 − t8), but the current will be circulated in the opposite direction to provide the negative output voltage. The relations of on-state switches and output voltage level are described in Table I, as well as operations of two modes are compared closely. Table I has ten working states for nine voltage levels. When the operation enters a new state from an adjacent state, only one power switch changes between on and off. The device stress in switching devices of H-bridge circuit is higher than that in SC circuit. It can also be found that the output voltage in Mode 1 is more stable than Mode 2 due to less discharging period of switching capacitor. Along with the up-down movement of modulation signals (Vm 1c, Vm 1b, Vm 2c, Vm 2b), the output voltage of the proposed inverter is a controllable nine-level staircase. The duration of each voltage level is determined by the duty-cycle of SC circuit and the phase-shifted angle of H- Bridge circuit.

Table.1 Relations of on-state switches and output voltage

Mode 1			Mode 2		
On-state switches	Output voltage	Capacitor State	On-state switches	Output voltage	Capacitor State
$S_{1a}, S_{1c}, S_{2a}, S_{2c}, S_1, S_2$	$4V_{in}$	C_1, C_2 Discharging	$S_{1a}, S_{1c}, S_{2a}, S_{2c}, S_1, S_2$	$4V_{in}$	C_1, C_2 Discharging
$S_{1a}, S_{1c}, S_{2a}, S_{2c}, S_1', S_2$	$3V_{in}$	C_2 Discharging	$S_{1a}, S_{1c}, S_{2a}, S_{2c}, S_1', S_2$	$3V_{in}$	C_2 Discharging
$S_{1a}, S_{1c}, S_{2a}, S_{2c}, S_1' S_2'$	$2V_{in}$	C_1, C_2 Charging	$S_{1a}, S_{1b}, S_{2a}, S_{2c}, S_1' S_2$	$2V_{in}$	C_2 Discharging
$S_{1a}, S_{1b}, S_{2a}, S_{2c}, S_1' S_2'$	V_{in}	C_1, C_2 Charging	$S_{1a}, S_{1b}, S_{2a}, S_{2c}, S_1' S_2'$	V_{in}	C_1, C_2 Charging
$S_{1a}, S_{1b}, S_{2a}, S_{2b}, S_1' S_2'$ or $S_{1c}, S_{1d}, S_{2c}, S_{2d}$	0	C_1, C_2 Charging	$S_{1a}, S_{1b}, S_{2a}, S_{2b}, S_1' S_2'$ or $S_{1c}, S_{1d}, S_{2c}, S_{2d}$	0	C_1, C_2 Charging
$S_{1c}, S_{1d}, S_{2b}, S_{2d}, S_1' S_2'$	$-V_{in}$	C_1, C_2 Charging	$S_{1c}, S_{1d}, S_{2b}, S_{2d}, S_1' S_2'$	$-V_{in}$	C_1, C_2 Charging
$S_{1b}, S_{1d}, S_{2b}, S_{2d}, S_1' S_2'$	$-2V_{in}$	C_1, C_2 Charging	$S_{1c}, S_{1d}, S_{2b}, S_{2d}, S_1' S_2$	$-2V_{in}$	C_2 Discharging
$S_{1b}, S_{1d}, S_{2b}, S_{2d}, S_1', S_2$	$-3V_{in}$	C_2 Discharging	$S_{1b}, S_{1d}, S_{2b}, S_{2d}, S_1', S_2$	$-3V_{in}$	C_2 Discharging
$S_{1b}, S_{1d}, S_{2b}, S_{2d}, S_1, S_2$	$-4V_{in}$	C_1, C_2 Discharging	$S_{1b}, S_{1d}, S_{2b}, S_{2d}, S_1, S_2$	$-4V_{in}$	C_1, C_2 Discharging

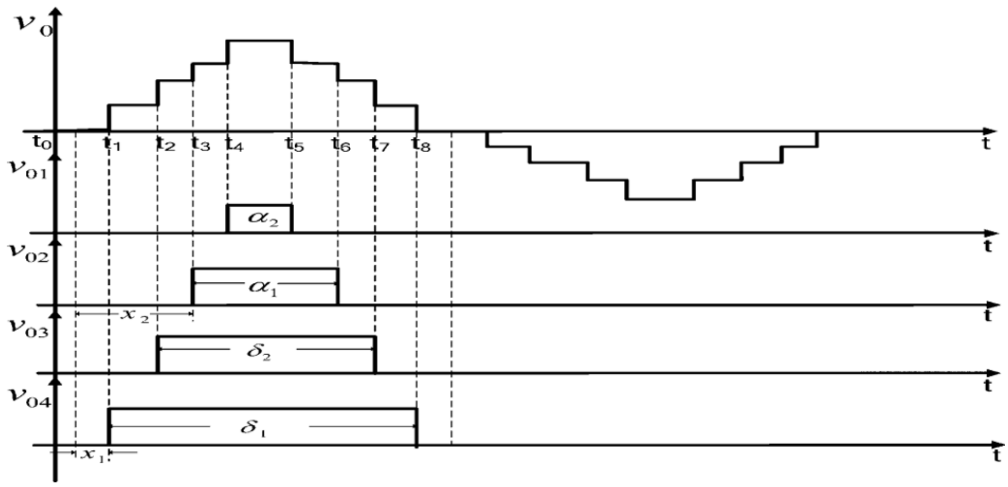

Fig. 3. Output voltage decomposition for Fourier analysis in mode 1.

The numerical benchmark and THD optimization will be examined in the future study, and a fixed ratio (k1 = k2 = 0.5, x1 = π/8, x2 = π/4) is adopted to evaluate output harmonics in subsequent simulation and experiment. If the proposed dc–ac inverter is used as second stage of ac–ac conversion, an ac–dc controlled rectifier is introduced a preceding stage of ac–ac conversion. Power factor correction (PFC) implemented by dc–dc converter can improve the power factor in ac–dc conversion. In this case, both SC and H-bridge generate the optimized pulse width to minimize output THD. The magnitude regulation of output voltage can be performed by controllable ac–dc stage in input side. The minimized THD is achieved by this two- stage power circuit, namely, ac–dc stage is used to regulate magnitude, and dc–ac stage formed by the proposed inverter is used to minimize THD.

Table.2 Components Comparison Of Proposed Inverter And Cascaded H-Bridge:

Inverter type	Proposed inverter enhanced by SC n×2 topology	Proposed inverter enhanced by H-Bridge 2×n topology	Cascaded H-Bridge
Switching device	2n+8	6n	8n
Capacitor	2n-2	n	0
Diode	4n-6	n	0
DC bus	2	n	2n
Power losses	$(2n-2)loss_{cap}+(4n-6)loss_{diode}+(2n+8)loss_{switch}$	$nloss_{cap}+nloss_{diode}+6nloss_{switch}$	$8nloss_{switch}$

An n × 2 topology needs 2n – 2 capacitors, 2n + 8 switches, and 2 dc inputs; 2×n topology needs n capacitors, 6n switches, and n dc inputs. The traditional cascaded H-Bridge needs 8n switches and 2n dc inputs. With the same number of voltage levels, the proposed inverter needs less switching devices and inputs than the traditional cascaded H-Bridge. The fundamental frequency is 25 kHz that is the same as output frequency. It can be observed that the fundamental harmonic is significantly higher than the other harmonics. The magnitude of fundamental component is below 40 V for nine-level inverter.

The calculated THD is 19.1% for 9-level inverter .It can be estimated that the harmonics can be further cut down along with the increasing number of voltage levels. Thus, the proposed inverter produces near sinusoidal staircase output, and two methods can make it more sinusoidal. One is to optimize the duration of voltage levels; the other one is to increase the number of voltage levels.

4. COMPUTER SIMULATION RESULTS

Simulink is a software add-on to matlab which is a mathematical tool developed by The Math works,(http://www.mathworks.com) a company based in Natick. Matlab is powered by extensive numerical analysis capability. Simulink is a tool used to visually program a dynamic system (those governed by Differential equations) and look at results. Any logic circuit, or control system for a dynamic system can be built by using standard building blocks available in Simulink Libraries.

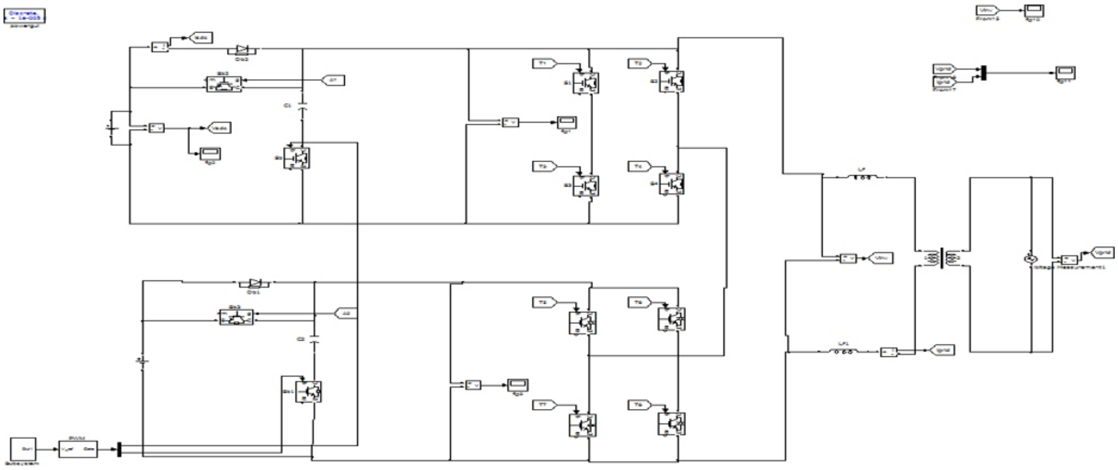

Fig.4 simulation circuit of nine level inverter

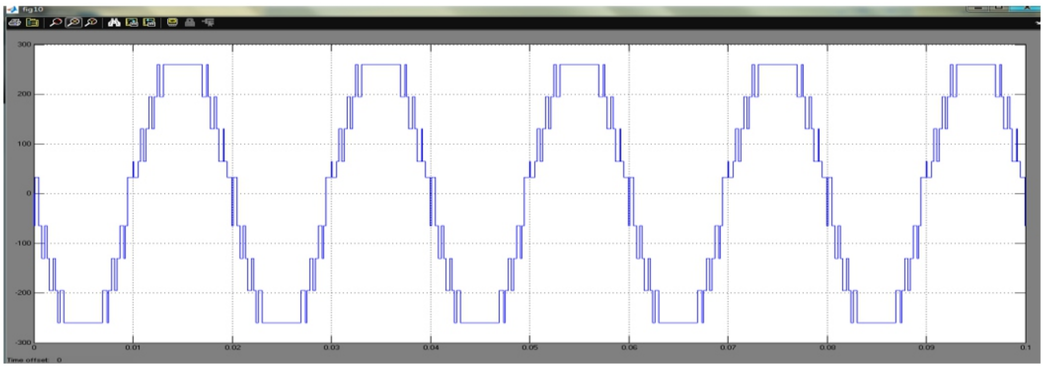

Fig 5. Nine level inverter output voltage waveform

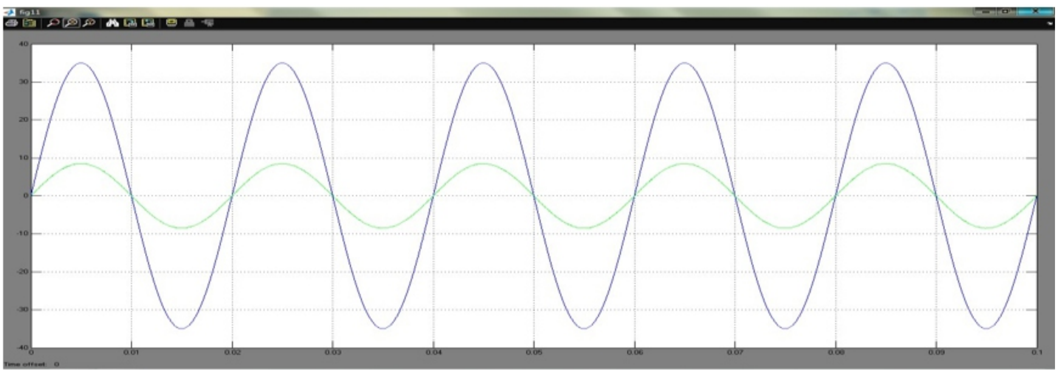

Fig .6. Output voltage and current waveforms at Grid

5. CONCLUSION

In this proposed work, a switched capacitor based cascaded multilevel inverter with reduced total harmonic component was proposed. The nine level output compared with conventional cascaded multilevel inverter, the proposed inverter can decrease the number of switching components. A single carrier modulation technique with the low switching frequency was presented. The simulation results obtained confirms the feasibility of proposed circuit and modulation method. Comparing with cascade H-bridge, the number of voltage levels can be further increased by this method. The number of voltage levels increases two times in half cycle of nine level converter output. With the increase in the number of voltage levels, the harmonics are significantly reduced in the staircase output. Meanwhile, the magnitude control can be achieved by pulse width regulation of voltage level, so the proposed multilevel inverter can serve as HF power source with controlled magnitude and lesser harmonics. In this proposed work the nine level inverter was analyzed. The proposed inverter can be applied to grid-connected photovoltaic system and electrical network of EV, because the multiple dc sources are available easily from solar panel, batteries ,Ultra capacitors, and fuel cells.

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Cascaded H-bridge Multilevel Inverter Using Spwm

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ABSTRACT

This paper presents the concert of flying capacitor multilevel inverter and cascaded H-bridge multilevel inverter. To improve the performance of Flying Capacitor Multilevel Inverter (FCMLI) the switching pattern selection scheme is used. By this scheme the capacitor voltage fluctuation is reduced without using voltage feedback. The elimination of harmonics in a cascaded multilevel inverter (MLI) by taking the unequal of separated DC source is presented. DC sources may be batteries, solar cells, etc. A fundamental switching scheme is used, which achieves the fundamental in the output voltage while eliminating the lower order harmonics and to produce a nearly sinusoidal output. The FFT spectrums for the outputs are presented to study the reduction in the harmonics. The circuit is simulated using MATLAB/SIMULINK. The simulation results are verified.

Keywords: Embedded Controller, MATLAB/SIMULINK, H-bridge Multilevel Inverter, THD, Unequal Voltage Sources.

1. INTRODUCTION

Multilevel inverters have very important development for high power medium voltage AC drives. Quite a lot of topologies have found industrial approval;

a Neutral Point Clamped Multilevel Inverter.

b. Flying capacitor Multilevel Inverter.

c. Cascaded Multilevel Inverter.

Maynard and Foch introduced a flying-capacitor-based inverter in 1992. The structure of this inverter is similar to that of the diode-clamped inverter except that instead of using clamping diodes, the inverter uses capacitors in their place. The cascaded multilevel inverters offer more than two voltage levels. A desired output voltage waveform can be synthesized from the multiple voltage levels with less distortion, at low switching frequency, higher efficiency, and lower voltage rating devices. An important question in designing an effective multilevel inverter is to ensure that, the total harmonic distortion (THD) in the output voltage waveform is small. A complete solution is obtainable for computing all possible switching angles that achieve the required fundamental voltages and eliminate the lower order harmonics [1]. On the other hand, it was assumed that the dc sources were all equal, which will probably not be the case in applications even if the sources are nominally unequal. Here, it is shown how the method in [2] can be extended to two unequal dc source inverter. Particularly, eliminating harmonics in a multilevel converter in which the separate dc sources do not have equal voltage levels is measured. Normally each phase of a cascaded multilevel converter requires n DC sources for 2n + 1 level. For many applications, to get several separate DC sources is difficult, and too many DC sources will be necessary many long cables and might lead to voltage unbalance among the DC sources. To reduce the number of DC sources necessary while the cascaded H-bridge multilevel converter is applied to a motor drive, a scheme is proposed in [3] that allow the use of two unequal DC sources to generate five level equal step multilevel inverter output. In this paper, the lower order harmonics are eliminated using two unequal DC voltages for H-bridges.

II. FLYING CAPACITOR MULTILEVEL INVERTER

Fig. 1 shows a FCMLI, in this type of inverter uses a ladder structure of dc side capacitors where the voltage on each capacitor differs from that of the next capacitor. n^{-1} capacitors in the dc bus are needed to generate n-level staircase output voltage. Every phase-leg has an indistinguishable structure. The size of the voltage increment between two capacitors decides the size of the voltage levels in the output waveform of the inverter.

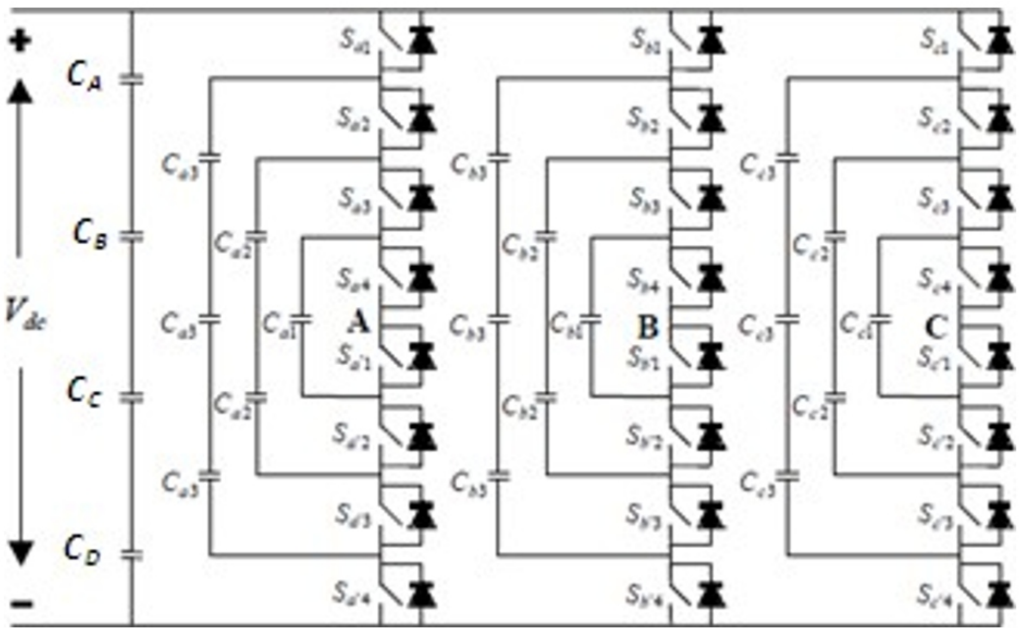

Fig. 1 Three phase flying capacitor multilevel inverter.

It is clear that three inner-loop balancing capacitors for phase leg A, C_{a1}, C_{a2}, and C_{a3} are independent from those for phase leg B. Every phase legs segregate the same dc link capacitors, C_A to C_D. Table I shows the possible switch combinations to generate the five level output waveform.

The voltage synthesis in a five-level flying capacitor converter has more flexibility than a diode-clamped converter [4]. The voltage of the five-level phase-leg A output with respect to the neutral point o, V_{Ao}, can be synthesized by the different switch combinations.

TABLE I SWITCHING STATES OF FIVE LEVEL MULTI LEVEL INVERTER

Output Voltage	Switching States Of MLI							
VAO	Sa1	Sa1	Sam-1	Sam	Sa'1	Sa'2	Sa'm-1	Sa'm
$V_5=V_{dc}$	1	1	1	0	0	0	0	0
$V_4=3V_{dc}/4$	1	1	1	0	0	0	0	1
$V_3=V_{dc}/2$	1	1	0	0	0	0	1	1
$V_2=V_{dc}/4$	1	0	0	0	0	1	1	1
$V_1=0$	0	0	0	0	1	1	1	1

III. CASCADED H-BRIDGE MULTILEVEL INVERTER

The cascaded multilevel inverter consists of a series of H-bridge inverter. The general purpose of this multilevel inverter is to synthesize a desired voltage from several separate dc sources, like batteries, fuel cells, solar cells, and ultra capacitors. Fig. 2 shows a single- phase structure of a cascade inverter with separate dc sources [5]. Each separate dc source is connected to a single-phase full-bridge inverter.

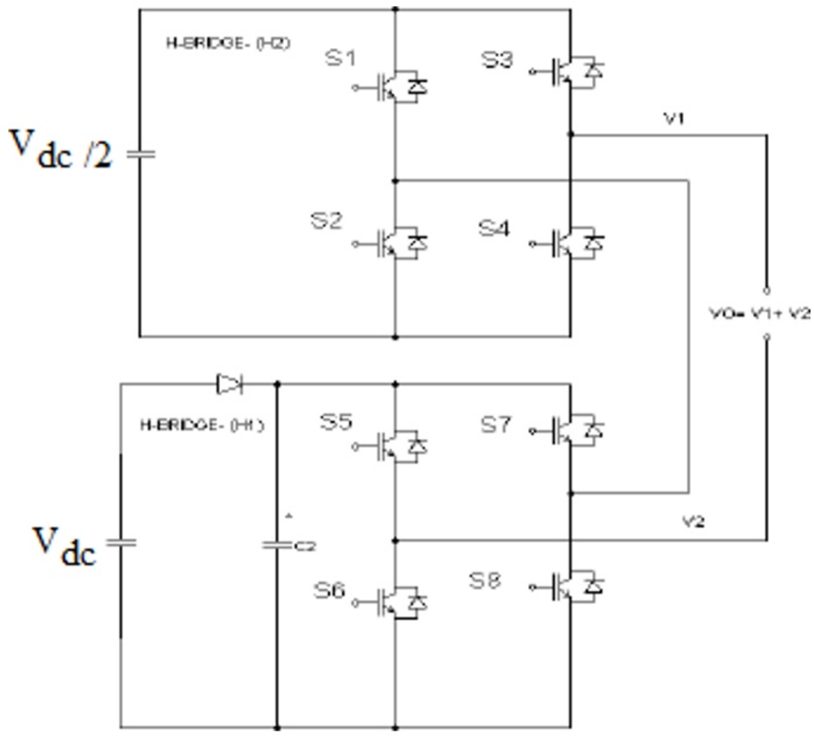

Fig. 2 Topology of a five level H-bridge cascaded multilevel inverter.

The topology offered in this paper employs two unequal dc sources to generate an equal step five level output. The proposed inverter consists of two H-bridges as shown in Fig.2. The main H - bridge (H1) is connected to a dc source of Vdc and the second bridge (H2) is connected to a dc source of 0.5Vdc. By suitably opening and closing the switches of H1, the output voltage v1 can be made equal to $-V_{dc}$, 0, or $+V_{dc}$ similarly the output voltage of H_2 can be made equal to $-0.5V_{dc}$, 0, or $0.5V_{dc}$ and the cascaded output is shown in Fig.3. Therefore, the output voltage of the converter can have five possible values V_{dc}, $0.5V_{dc}$, 0, $-0.5V_{dc}$, and $-V_{dc}$

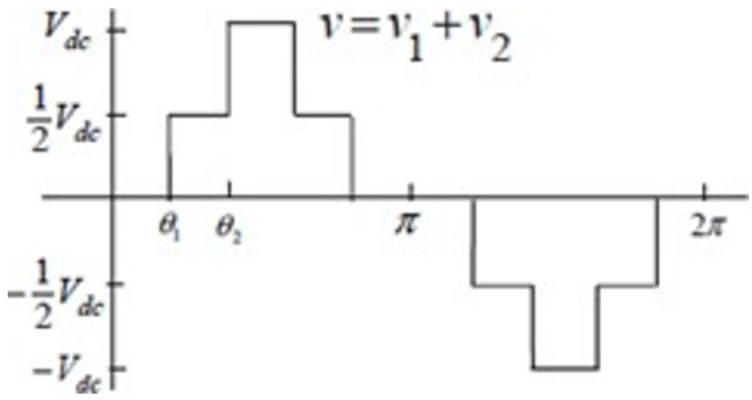

Fig. 3 Fundamental frequency waveform.

The DC source for the first H-bridge (H_1) is a dc source with an output voltage of V_{dc}, whereas the dc source for the second H-bridge (H_2) is a DC source voltage to be held at $V_{dc}/2$. The output voltage of the first H-bridge is denote by v1 and the output of the secondH-bridge is denote by v_2. Hence the output of this two dc sources cascaded H-bridge multilevel inverter is $v = v_1+v_2$. By opening and closing the switches of H_1 suitably, the output voltage v_1 can be made equal to V_{dc}, 0, or else $-V_{dc}$ when the output voltage of H_2 can be made equal to $V_{dc}/2$, 0, or else $-V_{dc}/2$ by opening and closing its switches suitably. Therefore, the output voltage of the inverter may have the values V_{dc}, $V_{dc}/2$, 0, $-V_{dc}/2$, and $-V_{dc}$ which are five levels. The output voltage of the cascaded multilevel inverter is

$$v = v_1 + v_2 \qquad (1)$$

i) Harmonics

The switching angles of the waveform will be adjusted to obtain the lowest output voltage THD. The harmonics orders and magnitude are depends up on the type of inverter and the control techniques. For example in single phase VSI, the output voltage waveform typically consists only of odd harmonics. The even harmonics are not present due to the half wave symmetry of the output voltage harmonics. The harmonic spectra depend on the switching frequency and the control method [6].

ii) Switching control of the inverters

There are number of modulation control techniques such as sinusoidal PWM method (SPWM) [7-11], space vector PWM method (SVPWM), selective harmonic elimination method (SHE) [12-14], and active harmonic elimination method [15], and they all can be used for inverter modulation control. For the proposed inverter control, a sensible modulation control method is the fundamental frequency switching control for high output voltage and Sinusoidal PWM control for low output voltage. In this paper, fundamental frequency switching control is used in H-bridge MLI [16].

IV. SIMULATION OF FCMLI AND CASCADED H-BRIDGE MULTILEVEL INVERTER

The performance of the proposed Flying capacitor multilevel inverter is verified through the simulation results.

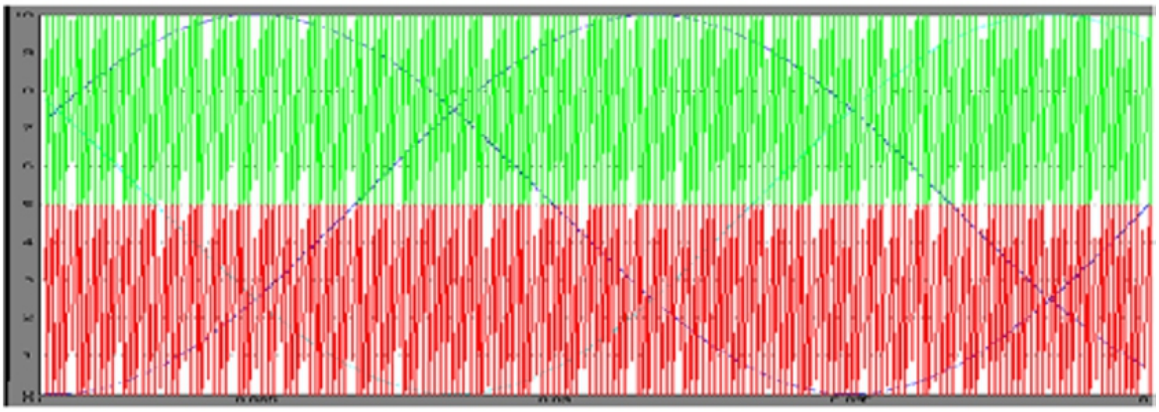

Fig. 4 Sinusoidal PWM signals for FCMLI.

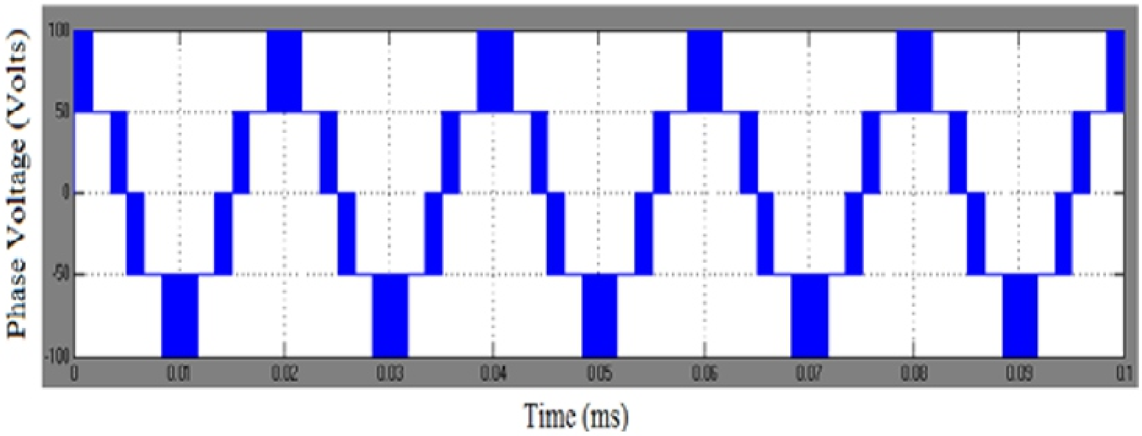

Fig. 5 Phase voltage of FCMLI.

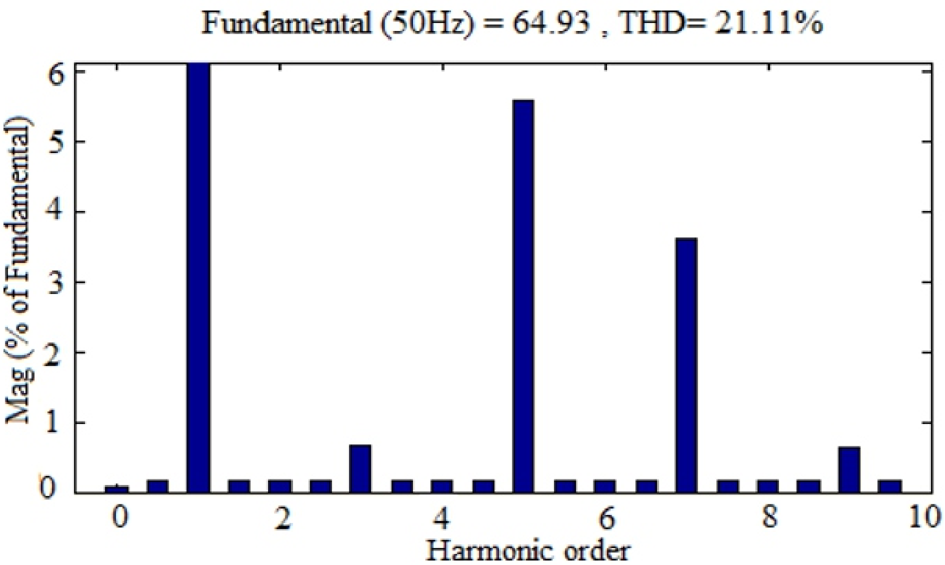

Fig. 6 FFT analysis of FCMLI voltage.

The Fig. 4 shows the sinusoidal PWM control for low output voltage. Fig. 5 and Fig. 6 show the FCMLI phase voltage, and FFT analysis of voltage respectively.

The performance of the proposed H-bridge multilevel inverter is verified through the simulation results. Fig. 7 shows the phase voltage of cascaded H-bridge multilevel inverter. Fig.8 shows the FFT analysis of voltage.

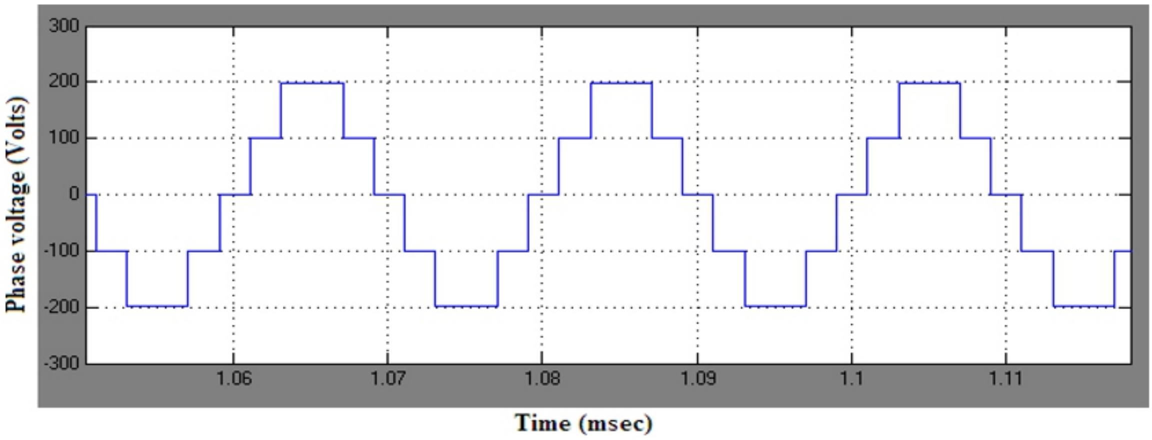

Fig. 7 Phase voltage of cascaded H-bridge multilevel inverter.

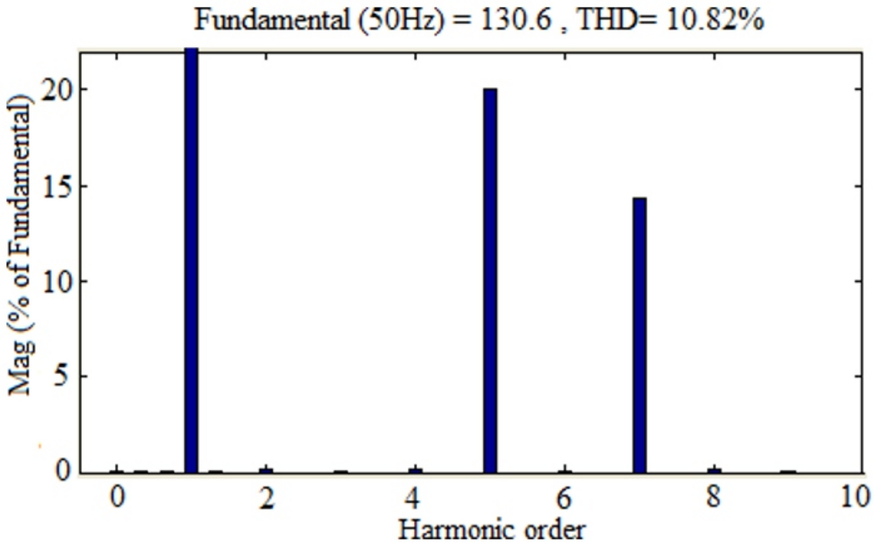

Fig. 8 FFT analysis of Cascaded H-Bridge MLI voltage.

TABLE II PERFORMANCE PARAMETERS OF FIVE LEVEL FCMLI AND H-GRIDGE MULTILEVEL INVERTER

Perameter	FCMLI	H-Bridge MLI
THD %	21.11%	10.82%

Table II shows the THD performance of five level FCMLI and cascaded H-bridge multilevel inverter. Comparing both MLI cascaded H-bridge multilevel inverer gives the less value of THD (10.82%).

V. CONCLUSION

The flying capacitor multilevel inverter uses a ladder structure of dc side capacitors where the voltage on each capacitor differs from that of the next capacitor. The sinusoidal PWM scheme is used for modulation control. In cascaded H-bridge multilevel inverter separated unequal DC sources are used to generate sinusoidal output. A fundamental switching scheme is used and produces a nearly sinusoidal output. This cascaded inverter design is to get the improved sinusoidal output of an inverter and gives reduced THD%. The elimination of harmonics in a cascade H-bridge multilevel inverter by considers the inequality of separated dc source. FFT spectrum shows the reduction in the harmonics in the output voltage.

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Ac Conductivity of Polyaniline – Nickel Oxide Composite

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ABSTRACT

Polyaniline –NiO composite have been prepared by using ammonium persulphate. The prepared composites were characterized for structural and morphology studies by FTIR and SEM. Further the ac conductivity was carried by two probe method. It is found that the conductivity increases with increase in frequency. Among, all composites 25 wt% shows high conductivity due to space charge polarization.

Keywords: Composite, Ac conductivity, FTIR, Scanning electron microscopy

1. INTRODUCTION

As a typical highly conjugated conductive polymer, polyaniline (PANI) has the unique properties of ease of preparation, high environmental stability, and a special doping mechanism [1] and has potential applications in polymeric conducting molecular chemical sensors, supporting material for catalysts, light-emitting and electronic devices, and so forth [2]. Recently, the morphology of PANI has aroused considerable interest and has been widely studied for its influence on physical properties. Zeolite, porous alumina, and polymer fibers have been used as hard templates to synthesize PANI nanotubes and nanofibers. Organized molecular assemblies of micelles, inverse micelles, and lamellar liquid crystals have been applied as soft templates to obtain various morphologies of PANI, such as nanotubes, nanorods, nanofibers, and hollow microspheres. Wan and Li also proposed a template-free method for fabricating microtubes of PANI in the presence of b-naphthalene sulfonic acid as a dopant. The preparation of PANI composites with inorganic particles has also aroused great interest because of their multifunctionality. PANI/TiO_2 and PANI/Fe_3O_4 composite nanotubes [3] have been reported by a self assembly process.

Nickel oxide is one of the important materials in the application of electrochemical capacitor, battery electrode, catalysis and in electromagnetic device. This metal oxide could be prepared by different methods like sol-gel, combustion, SPCR, Hydrothermal and solvothermal technique etc. Here we have report, synthesis, characterization and conductivity of polyaniline –NiO composites at various weight percentages.

EXPERIMENTS

Materials and method

All Chemicals used were analytical grade (AR). The monomer aniline was doubly distilled prior to use. Ammonium persulphate ($(NH_4)_2S_2O_8$), Nickel oxide (NiO), hydrochloric acid (HCl) were procured and were used as received.

Preparation of polyaniline

Ammonium persulphate (0.1 mole aqueous solutions in protonic acid) is added drop wise to a stirred solution of 0.1 mole aniline dissolved in 1 mole of aqueous solution of hydrochloric acid, pre cooled to 3 – 5^0 C. Ammonium persulphate solution is added very slowly to prevent the warming of the solution. After completion of the addition, stirring is continued for 2 hours by suing a mechanical stirred to ensure the completion of reaction. The timeof initial coloration on mixing of reactants depends upon the temperature and protonic acid. During the polymerization reaction, HCl is used as a protonic acid and a temperature of 0 -5^0 C is maintained by using a freezing mixture. The end product of green color precipitate is obtained. The precipitate was filtered, washed with deionised water and finally dried in an oven for 24 hrs to achieve a constant weight.

Synthesis of Polyaniline / NiO Composites

0.1 mol of aniline was dissolved in 1 M HCl to form aniline hydrochloride. Nickel oxide (NiO), is added in the weight percent of 10, 20, 30, 40 and 50 to aniline hydrochloride solution with vigorous stirring in order to keep the NiO, suspended in the solution. To this reaction mixture, 0.1 M of ammonium persulphate [$(NH_4)_2S_2O_8$] which acts as the oxidant was added slowly with continuous stirring for 4 – 6 hours at 0 – 5^0 C. The precipitate powder recovered ware vacuum filtered and washed with water and acetone. Finally the resultant precipitate was dried in an oven for 24 hours to achieve a constant weight. In this way 5 different polyaniline NiO composites with different wt% of NiO (05, 10, 15, 20 and 25) in polyaniline have been synthesized.

The IR spectra of all the samples are recorded on Perkin Elmer (model 783) IR spectrometer in KBr medium at room temperature. For recording IR spectra, powders are mixed with KBr in the ratio 1:25 by weight to ensure uniform dispersion. The mixed powders are pressed in a cylindrical dye to obtain clean discs of approximately 1 mm thickness. The samples were sputtered with gold and then the surface morphology of the composites was investigated by scanning electron microscope (SEM, JEOL/EO JSM-6360). DC conductivity was carried out by using Kelvin two probes and the resistance was measured using Keithley meter.

RESULTS AND DISCUSSION

Figure 2 shows the IR spectra of PANI/ NiO composite (25 % wt of NiO in PANI). The IR transmission spectra of powder using KBr pellets having different weight percentage of NiO in PANI were recorded in the range 450 – 4000 cm^{-1} to confirm polymerization of polyaniline. The spectra for all the samples showed strong bands in the region 500 – 1600 cm^{-1} that are the characteristics of PANI.

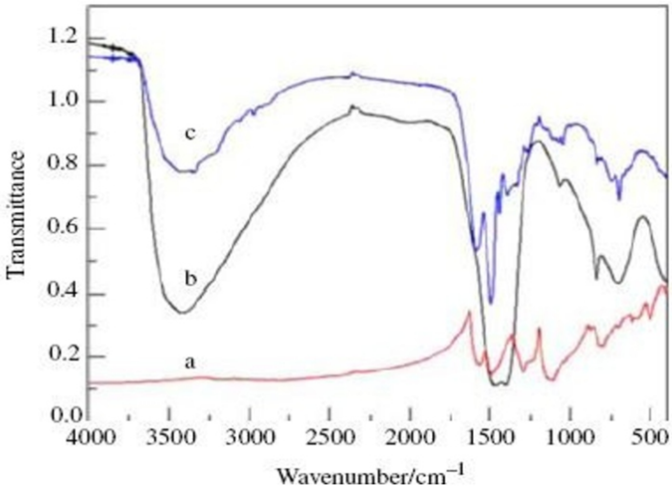

Figure 1 FTIR spectra of (a) Polyaniline, (b) NiO and (c) Polyaniline

NiO composite (25 wt %) Similar stretching frequencies can also be found in other composites but intensity of metal oxygen peak increases as the weight present of NiO is increased [4]. The important peaks that are observed in this composite in IR spectra are observed at 1648 cm^{-1}, 1564 cm^{-1}, 1488 cm^{-1}, 1394 cm^{-1}, 1303 cm^{-1}, 1252 cm^{-1}, 1118 cm^{-1}, 882 cm^{-1}, 804 cm^{-1}, 595 cm^{-1} and 512 cm^{-1}. It is found from the FTIR spectra that some of the characteristic stretching frequencies are considerably shifted towards higher frequency side. The typical peaks observed are at 1564 cm^{-1}, 1488 cm^{-1}, 1303 cm^{-1}, 801 cm^{-1} and 512 cm^{-1}, which may be attributed due to the weak interaction between NiO and PANI chain.

The SEM image of pure NiO is shown in figure 2 (a) and it is observed to have the rectangular like shape. The average length is found to be of 392.1 nm. These structures play an important role in enhancing the electrical property of the composites. The SEM micrograph of polyaniline / NiO composite with 25 wt% of TiO_2 in polyaniline is shown in figure 2 (b). High magnification SEM image reveals the presence of NiO particles uniformly distributed throughout the composite sample.

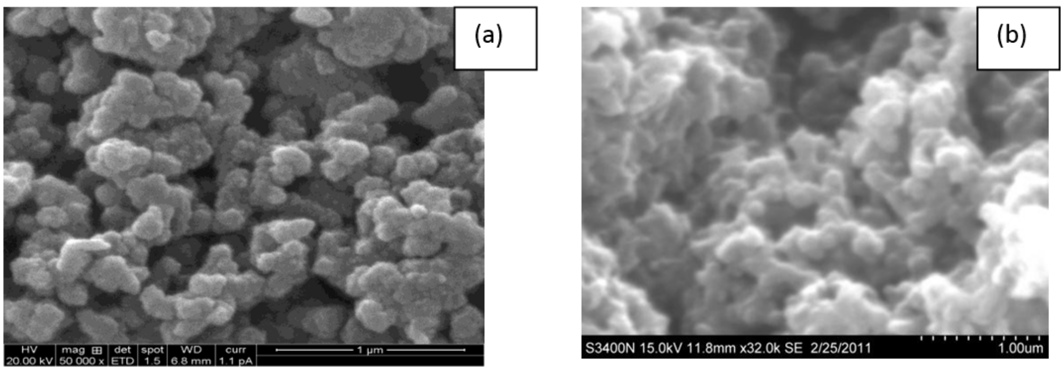

Figure 2 (a, b) SEM Micrograph of polyaniline and polyaniline – NiO composite

A small variation in the particle dimensions of NiO so dispersed in polyaniline has been observed. Also fibrillar morphology is observed in the composite. The size of these crystallite is around 356.5 nm. The contrast in the image is due to the difference in scattering from different surface areas as a result of geometrical differences between polyaniline and NiO. Since structure property correlation plays a significant role, a correlation between dimension of NiO used for composite preparation and its effect on electrical properties.

AC CONDUCTIVITY

Figure 3 shows the variation of ac conductivity as a function of frequency for polyaniline – NiO composites (different wt %). It is observed that in all the cases, σ_{ac} remains constant up to 10^5 Hz. The maximum value of conductivity is observed for 25 wt% at 10^5Hz. This behaviour is attributed to addition of NiO in polymer matrix. It is observed that in all the composites the conductivity increases at 05 & 20 wt of NiO in polyaniline. This may be due to the extended chain length of polyaniline which facilitate the polarization of charge carriers.

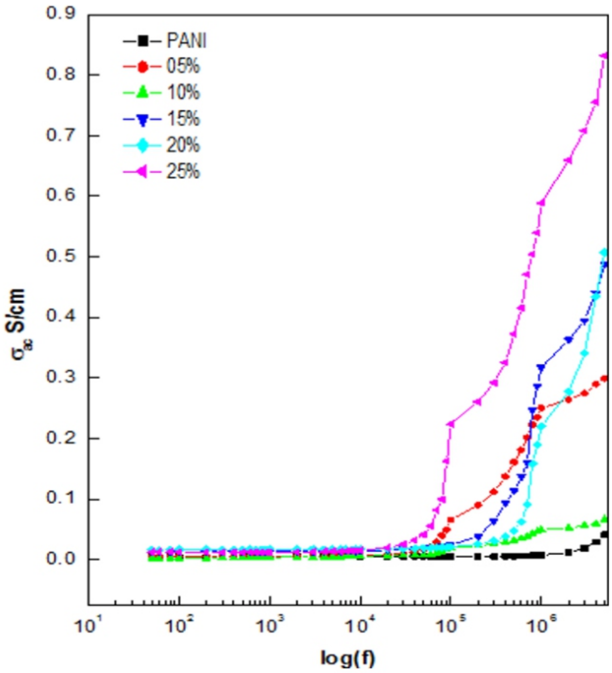

Figure 3 shows the ac conductivity of polyaniline – NiO composites

CONCLUSION

Nickel oxide doped polyaniline composites have been prepared by in situ polymerization. The prepared composite was characterized for structural studies by FTIR, indicates the 1564 cm^{-1}, 1488 cm^{-1}, 1303 cm^{-1}, 801 cm^{-1} and 512 cm^{-1}, which may be attributed due to the weak interaction between NiO and PANI chain. SEM image revels that the particles size decreases with increase in NiO weight percentage. The ac conductivity increases with increase in frequency. Among, all composites 25 wt% shows high conductivity due to space charge polarization.

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4. Scientific critique or forum (discussion on a particular scientific topic, based exclusively on management argumentation) and commentaries. Exceptionally, in particular areas, a scientific paper in the Journal can be in a form of a monograph or a critical edition of scientific data (historical, archival, lexicographic, bibliographic, data survey, etc.) which were unknown or hardly accessible for scientific research.

Professional articles:

1. Professional paper (contribution offering experience useful for improvement of professional practice but not necessarily based on scientific methods);
2. Informative contribution (editorial, commentary, etc.);
3. Review (of a book, software, case study, scientific event, etc.)

Language

The article should be in English. The grammar and style of the article should be of good quality. The systematized text should be without abbreviations (except standard ones). All measurements must be in SI units. The sequence of formulae is denoted in Arabic numerals in parentheses on the right-hand side.

Abstract and Summary

An abstract is a concise informative presentation of the article content for fast and accurate Evaluation of its relevance. It is both in the Editorial Office's and the author's best interest for an abstract to contain terms often used for indexing and article search. The abstract describes the purpose of the study and the methods, outlines the findings and state the conclusions. A 100- to 250-Word abstract should be placed between the title and the keywords with the body text to follow. Besides an abstract are advised to have a summary in English, at the end of the article, after the Reference list. The summary should be structured and long up to 1/10 of the article length (it is more extensive than the abstract).

Keywords

Keywords are terms or phrases showing adequately the article content for indexing and search purposes. They should be allocated heaving in mind widely accepted international sources (index, dictionary or thesaurus), such as the Web of Science keyword list for science in general. The higher their usage frequency is the better. Up to 10 keywords immediately follow the abstract and the summary, in respective languages.

Acknowledgements

The name and the number of the project or programmed within which the article was realized is given in a separate note at the bottom of the first page together with the name of the institution which financially supported the project or programmed.

Tables and Illustrations

All the captions should be in the original language as well as in English, together with the texts in illustrations if possible. Tables are typed in the same style as the text and are denoted by numerals at the top. Photographs and drawings, placed appropriately in the text, should be clear, precise and suitable for reproduction. Drawings should be created in Word or Corel.

Citation in the Text

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Footnotes

Footnotes are given at the bottom of the page with the text they refer to. They can contain less relevant details, additional explanations or used sources (e.g. scientific material, manuals). They cannot replace the cited literature.
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