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Research Article

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Electrical Power Generation from Inverter for Domestic Usage in Nigeria: A Means of Youth Empowerment

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Abstract Nigeria had suffered an unprecedented setback in world economy due to inadequate and inconsistent power generation and supply. This had led to geometrical increase in crime waves, which resulted from youthful exuberances and social menace. The present study is basically on production of photovoltaic system in which solar cell or module is used to power an inverter, this serves as a means of empowering our youth for nation's socio-economic development through alternative power generation. The system consists of solar modules, solar charge controller, 12V.d.c battery and an inverter (0.5 HP). Solar modules serve as source of charger through solar charge controller to the battery and inverter are used in converting the direct current into an alternating current for the domestic appliance. Self-charging inverter is more economical, noiseless, emission free, portable, rugged and uninterrupted alternate source of electricity which requires less maintenance and no fossil fuel. The estimated energy cost is comparable and competitive with the other inverters and renewable energy sources for both commercial power companies and technology suppliers. The 2KVA inverter with the alternator was able to power a table top refrigerator, Air-conditioning system, plasma TV, and ten 60watts bulbs for 7 hours continuously, before recharged.

Keywords Power generation, Inverter, Alternating Current, Direct Current

Introduction

Energy crisis and its solutions have been in the fore front agenda of any responsible government in the whole world. The supply of basic amenities of which electricity is part, has become a major challenge to most government especially that of the developing countries. These challenges were attributed to the unstable global oil prices, natural disaster, industrial strike embark upon by workers, vandalizing of equipment etc. In Nigeria, this has caused increase in the demand for many amenities, among those for which there has been high demand in electricity. In order to solve the high demand for electricity in the country, a hydro power station was started in 1964 and was completed in 1968. The total cost was estimated at $209 million and many substations. The aim of this was to supply electricity to every house hold in the country at affordable rate.

However, the first process in the delivery of electricity to consumers is the electricity generation. Others include electric power transmission and electricity distribution. The importance of dependable electricity generation was revealed when it became apparent that electricity was useful for providing heat, light and power for human needs [1]. Electricity has been generated for the purpose of powering human technologies for at least 120 years from various sources of energy [2]. The first power plants were run on wood, while today, we rely mainly on petroleum, natural gas, coal, hydroelectric and nuclear power and a small amount of hydrogen, solar energy, tidal harness, wind generators and geothermal sources.

Thus, whenever there is power outage, heavy down pour or a severe storm, electrical power interruptions are normally encountered in every place. In response to this power outage, a more economical, noiseless and emission free, alternative source of electricity -surpassing the use of the generators, solar and more recently the inverters is both the self-charging inverter [3]. Both the generators and inverters come with their adverse problems such as cost of fuelling, the noise, emissions and the need to recharge the inverter's batteries after use. This present study aimed at developing a 2 kVA inverter which powered from the source of 12V battery and this was achieved via designing, building, installing and testing a 2 kVA power inverter as a means of self empowerment.

Solar Energy

Solar energy is the energy transmitted from the sun in the form of electromagnetic radiation, which requires no medium for its transmission [4]. In solar energy, sun has been worshipped as life-giver to our planet since ancient times. The energy supply from the sun is truly enormous on average's the Earth's surface receives about 1.2 x 1017W of solar power [5]. This means that in less than one hour enough energy is supplied to the Earth to satisfy the entire energy demand of the human population over the whole year. Indeed, it is the energy of sunlight assimilated by biological organisms over millions of years that has made possible the industrial growth as we know it today. Most of the other renewable means of power generation also depend on the sun as the primary source: hydroelectric, wind and wave power all have the same origin. Energy source such as photovoltaic are needed to help reduce the levels of green house gases in the atmosphere and alleviate this global warming.

Inverter

According to the Authoritative Dictionary of IEEE Standards Terms (2000) [6], inverter is an electrical power converter that changes direct current (DC) to alternating current (AC). The converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits. The inverter performs the opposite function of a rectifier. The electrical inverter is a high-power electronic oscillator. It is so named because early mechanical AC to DC converters was made to work in reverse, and thus was "inverted", to convert DC to AC. Inverters do not suffer much from all these except that the batteries are consumed very fast as the load increases calling for constant recharging of the batteries after each use [3].

Classifications of inverters

The earliest electronic inverters produced a square wave, which can be seen as a sine wave sampled twice per cycle. This is *Nyquist limit.* There are several types of power inverter available in different categories. The common ones are the true sine wave power inverter and the modified sine wave type. According to Abatan *et al*, (2013) [3], the true sine wave type produces utility grade power. These inverters are very expensive and can power almost anything including laser printers fax machines, fans, television set, computers etc.

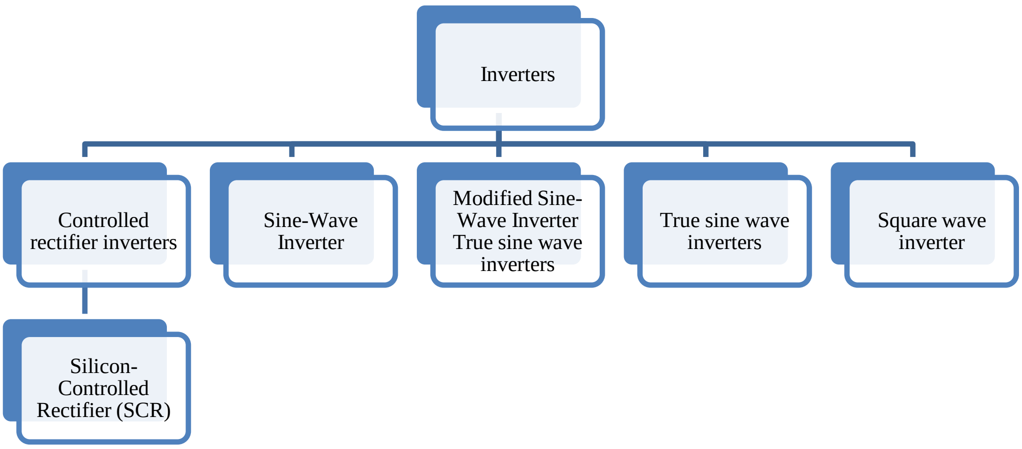

Figure 1: Classifications of Inverters

A sine wave inverter is recommended to operate higher electronic equipment. Modified sine wave inverter on the other hand can adequately power most household appliances and power tools. It is more economical, but may present certain compromises with some loads such as microwave ovens, laser printers, clocks and cordless tool chargers. The big advantage of the modified sine wave is that it has the same peak-to-RMS voltage ratio as a true sine wave, i.e., sqrt(2) = 1.414, while being as easy to generate as a square wave. This has made MSW inverters very popular. Thus, the classifications of inverters are presented in fig 1.

Applications of Inverters

Simple inverters make use of oscillators driving a transistor to create a square wave, which in turn is fed through a transformer to produce the required output voltage, while advanced inverters have started using more advanced forms of transistors of similar devices such as thysistors. Inverters are used in a wide range of applications. From small power supplies form computer large industrial applications to transport bulk power. The applications and uses of a power inverter which are as follows:

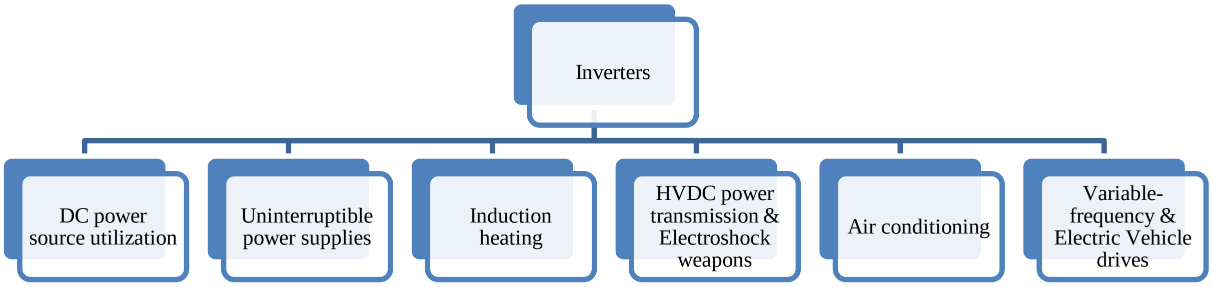

Figure 2: Applications of Inverters

Inverter Ratings

The ratings that one should look at when buying an inverter (depending on the type) are:

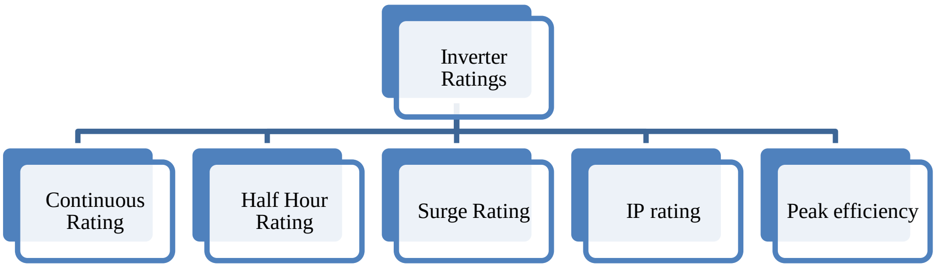

Figure 3: Ratings of Inverters

Methodology

Self-Charging Inverter Process

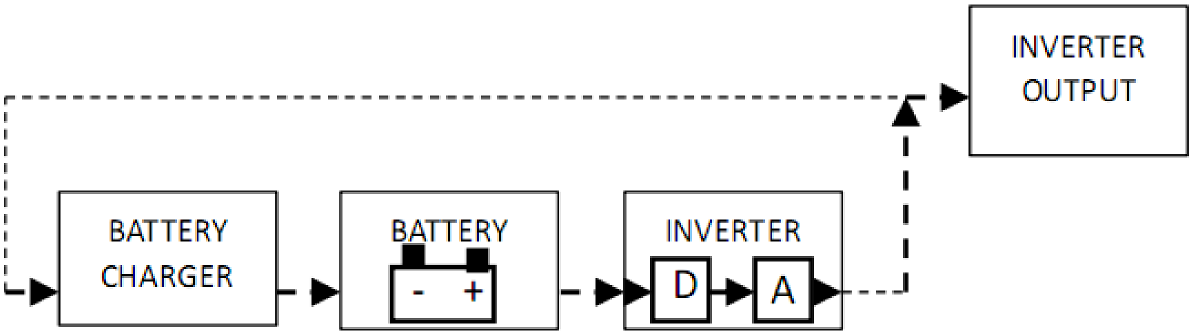

Figure 4: Block diagram of a practical self-charging inverter [8]

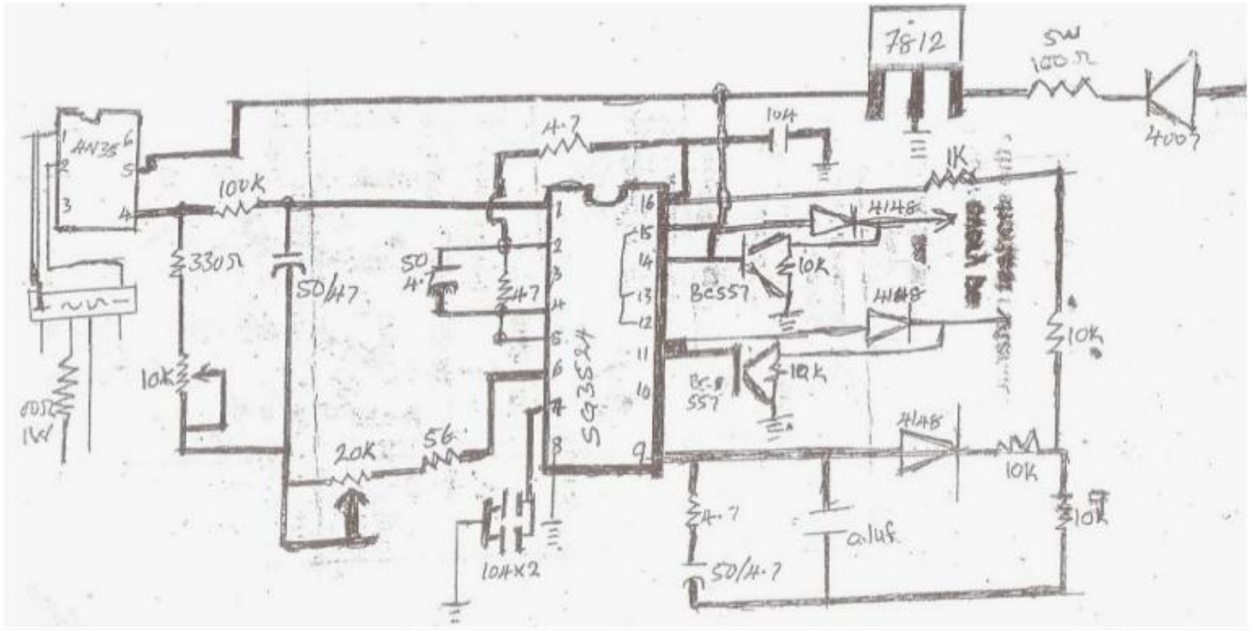

Figure 5: Circuit diagram for a 2kVA Inverter [9]

The block diagram of a practical self-charging inverter and circuit diagram for 2kVA are presented below. The self-charging inverter is an electronic device that produces an alternating output from a direct current input or supply from 12V battery. When inverter is connected to the power supply, the AC voltage is converted to DC by bridge rectifier circuit which is used to change the 12V battery. The 12V DC from a fully charged battery connected to the inverter switches to oscillating stage where the oscillator generates a sinusoidal sine wave of frequency 50Hz. The oscillator converts the output voltage from the charging stage to alternating current as an output voltage which is 12V AC.

Material Selection

The four main functional components of the improved self-charging inverter power are:

a) **Battery**: The battery mode is 12volts, 100AH and its size is 347 x 184 x 260mm^3. It has a gross weight of 31kg, Net Weight of 30kg and the quantity is one.

b) **Inverter**

The inverter has the capacity of 2000watts with the following features

i. ***Overload protection:*** this is to turn the inverter off automatically when the electric appliance is overloaded.

ii. ***Overvoltage protection:*** this will enable the power inverter to turn off automatically when the voltage of storage batter is over 15.5v.

iii. ***Voltage starvation protection:*** when the voltage of storage battery is below 9.5v, the inverter power will shut off automatically.

iv. ***Voltage starvation alarm:*** when the voltage of the storage battery goes down to 10.5V, the inverter will sound the alarm.

In one simple inverter circuit, DC power is connected to a transformer through the center tap of the primary winding. A switch is rapidly switched back and forth to allow current to flow back to the DC source following two alternate paths through one end of the primary winding and then the other. The alternation of the direction of current in the primary winding of the transformer produces alternating current (AC) in the secondary circuit [4]. The electromechanical version of the switching device includes two stationary contacts and a spring supported moving contact. The spring holds the movable contact against one of the stationary contacts and an electromagnet pulls the movable contact to the opposite stationary contact. The current in the electromagnet is interrupted by the action of the switch so that the switch continually switches rapidly back and forth. This type of electromechanical inverter switch, called a vibrator or buzzer, was once used in vacuum tube automobile radios. A similar mechanism has been used in door bells, buzzers and tattoo machines. As they became available with adequate power ratings, transistors and various other types of semiconductor switches have been incorporated into inverter circuit designs. Certain ratings, especially for large systems (many kilowatts) use thyristors (SCR). SCRS provide large power handling capability in a semiconductor device, and can readily be controlled over a variable firing range [10]. Base provides chambers and appropriate position of all other components to sit. The angle iron is used to fabricate the seating of inverter, motor, battery and alternator. The mild steel mesh is used to allow adequate ventilation. On top there is a cover that can be locked with pad lock to prevent a playing child's hands getting inside the casing.

Assembly

The assembly is shown in Fig. 6. The battery is connected to the inverter which is connected to the house. The motor terminal is then plugged into wall socket inlet. As the motor takes power from the source, it turns therefore start driving the alternator which consequently begins to charge the battery. At this juncture, the lost charges from the battery will be replaced constantly.

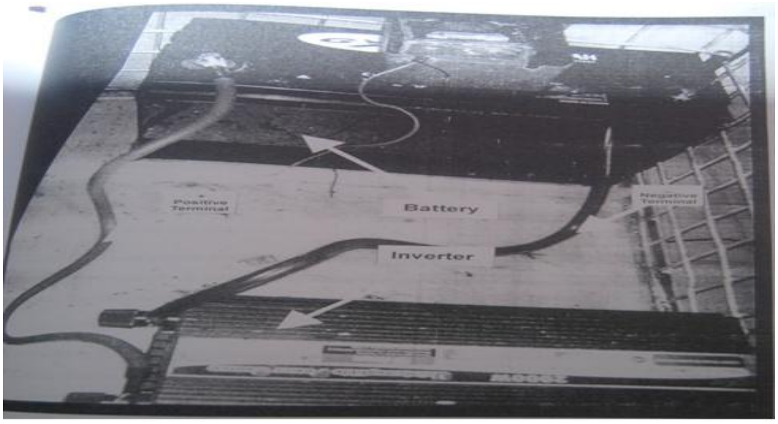

Figure 6: The Assembly of the Inverter and Battery

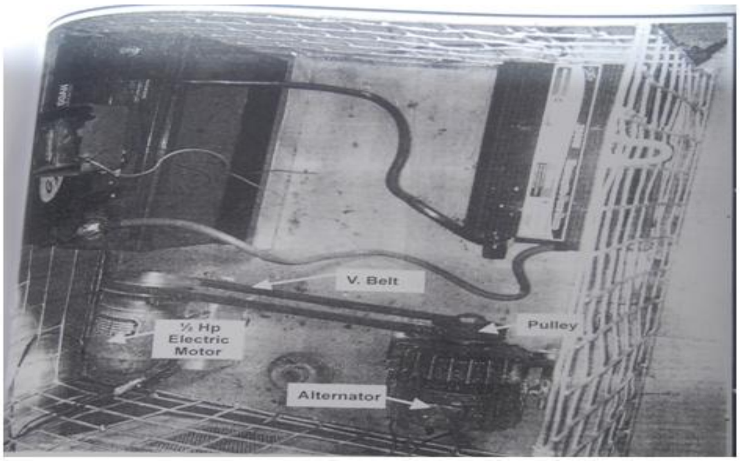

Figure 7: The Assembly of the Inverter and other Components

Testing and Evaluation

The switch in the simple inverter described in Fig. 6, when not coupled to an output transformer, produces a square voltage waveform due to its simple off and on nature as opposed to the sinusoidal waveform that is the usual waveform of an AC power supply. Using Fourier analysis, periodic waveforms are represented as the sum of an infinite series of sine waves. The sine wave that has the same frequency as the original waveform is called the fundamental component [11]. Other sine waves, called *harmonics*, which are included in the series, have frequencies that are integral multiples of the fundamental frequency. The quality of the inverter output waveform can be expressed by using the Fourier analysis data to calculate the total harmonic distortion (THD). The total harmonic distortion (THD) is the square root of the sum of the squares of the harmonic voltages divided by the fundamental voltage:

$$THD = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \cdots + V_n^2}}{V_1}$$

The quality of output waveform that is needed from an inverter depends on the characteristics of the connected load. Some loads need a nearly perfect sine wave voltage supply to work properly. Other loads may work quite well with a square wave voltage.

To receive normal incident sunlight, the solar panels aligned were placed outside and connected to the charging circuit, wired to the battery. Trickle charge was initiated and observation was made with constant value of current throughout testing. The battery read 12.5V before connection and then read 13.6V once a connection was made. It increased potentially for the next 7 hours until the voltage stopped at 12V. AC Output voltage from the inverter is 220V, the waveform is sine wave and the frequency is 50 Hz respectively as shown in figs. 8 and 9.

Table 1: Measurement and testing of an inverted and solar cell

S/N	Measurement	Specified	Achieved
1	V_{output} (Solar Cell)	60V	60V
2	P_{output} (Solar Cell)	150 Watts	150 Watts
3	V_{output} (Inverter)	220-240V	220-240V
4	I_{output} (Inverter)	9A	9A
5	P_{output} (Inverter)	2kVA	1.98kVA
6	Frequency	50 Hz	50 Hz
7	Waveform	Sine wave	

Table 2: Loading on the photovoltaic system

S/N	Appliances	Units	Power/Wattage	Runtime
1	1.5 hp A/C	1	1125	5 Hours
2	Laptop	4	120.08	7 Hours
3	Bulbs	6	60	7 Hours
4	Fan (ceiling)	1	20	7 Hours
5	Television set		100	4 Hours

This rated output is when the battery and the inverter are being used alone. When connected to electric motor, the load will have to be reduced to accommodate the necessary input to the electric motor.

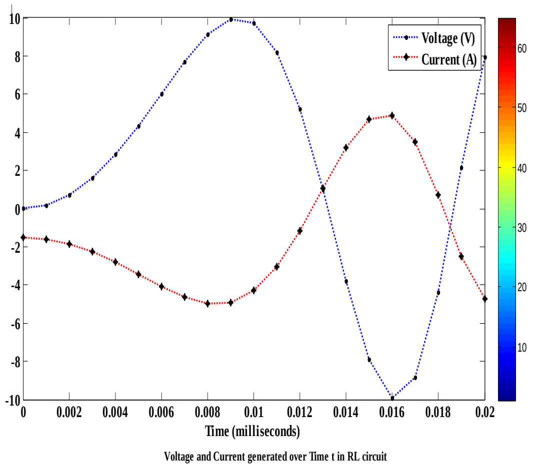

Figure 8: Sine wave plot for RL circuit at lower amplitude

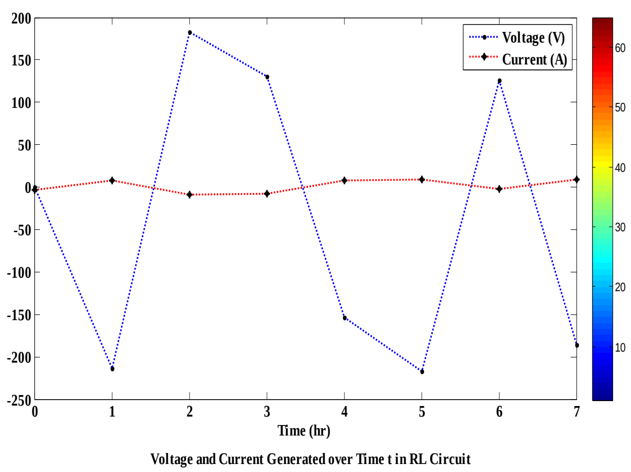

Figure 9: Sine wave plot for RL circuit at higher amplitude

Conclusion

Inverter and other components could be an appropriate alternative power supply in this energy crippled environment. The improved inverter power generation unit is a straight forward unit. It is however discovered that even with all precautions taken in order to ensure proper operation of the unit, certain problems still surfaced during the testing period as stated earlier.In addition, it was discovered that the 2KVA inverterwas able to carry one Air conditioning system, one radio set and six 60watt lighting bulbs, television set, computer set, standing or ceiling fan. The loading was ON for only 7hrs before the battery discharges and therefore call for charging again. However, it was discovered that the 2KV (2000W) inverter used for this study could not power the ½ horse power electric motor. Therefore it is recommended that a 3.5KVA be used to enhance its performance and efficiency.

References

[1]. Coker, J. O and Ogunji, B. A (2013). Design and construction of an inverter using solar cell as a source of charger, Journal of Applied and Natural Science (JANS), 5 (1): 30-36.

[2]. Markvart. T. (2001). Solar Electricity 2nd Edition.Unesco Energy Engineering series Energy Engineering Learning/Package.

[3]. Abatan O.A., Adewale A.O., Alabi A.A (2013) Constant Electricity Generation From Self-Charging Inverter, International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 12; pp 694-698.

[4]. Coker, J.O. (2004).Solar energy and its applications in Nigeria. Global Journal of Pure and Applied Sciences 10: 223 – 225.

[5]. Kreider J.F. and Kreith, F.(1977). Solar heating and cooling engineering, practical design and economics, 2nd Edition Hemisphere Publishing Corporation Washington, D.C.

[6]. The Authoritative Dictionary of IEEE Standards Terms (2000) Seventh Edition, IEEE Press, ISBN0-7381-2601-2, p588.

[7]. Walding, R., Rapkins, G. and Rossiter, G (1999) *New Century Senior Physics*. Melbourne, Australia: Oxford University Press. ISBN 0-19-551084-4.

[8]. Abraham, K.B and Tylor M. (2009) Switching power supply design, third edition McGraw Hill ISBN 0-07-148272-5

[9]. Barry G.W (1984) Practical Electroncis, United Kingdom McGraw Hill Book Company UK Ltd. Pp 789 – 802.

[10]. Ito, Akihito; Oikawa, Takehisa (2004)."Global Mapping of Terrestrial Primary Productivity and Light-Use Efficiency with a Process-Based Model." in Shiyomi, M. et al. (Eds.) *Global Environmental Change in the Ocean and on Land.* pp. 343–358.

[11]. Ristinen, R.A and Kraushaar, J.J (2006) Energy and the Environment. New York: John Wiley & Sons, Inc.

Appendix

The Sine Wave block provides a sinusoid. The block can operate in either time-based or sample-based mode.

Time-Based Mode

The output of the Sine Wave block is determined by

Y = Amplitude * sin (frequency * time + phase) + bias

Time-based mode has two submodes: continuous mode or discrete mode. The value of the

Sample-Based Mode

Sample time parameter determines whether the block operates in continuous mode or discrete mode:

- `0` (the default) causes the block to operate in continuous mode.
- `>0` causes the block to operate in discrete mode.

A. Matlab Script for RL circuit at lower amplitude

```
% RL circuit
% current i(t) and voltage v(t) are generated; t is time in milliseconds
>> t=(0:1E-3:20E-3);
>> f = 50; % frequency in Hertz
>>pi=180;
>> A = 10;
>> B = 5;
>>a_rad = (60*pi/180); % angle in radians
>> ω = 2*pi*f*t; % angular speed in radians per seconds
>> ω = 2*pi*f*t;
>> v = A*sin(ω.*t);
>> i = B*sin(ω.*t + a_rad);
>>plot(t, v, '.', t, i, '*')
>>title('Voltage and Current Generated over Time t in RL Circuit')
```

B. Matlab Script for RL circuit at higher amplitude

```
% RL circuit
% current i(t) and voltage v(t) are generated; t is time in hours
>> t=(0:1:7);
>> f = 50; % frequency in Hertz
>>pi=180;
>> A = 220;
>> B = 9;
>>a_rad = (60*pi/180); % angle in radians
>> ω = 2*pi*f*t; % angular speed in radians per seconds
>> ω = 2*pi*f*t;
>> v = A*sin(ω.*t);
>> i = B*sin(ω.*t + a_rad);
>>plot(t, v, '.', t, i, '*')
>>title('Voltage and Current Generated over Time t in RL Circuit')
```

C.

```
functioncreatefigure(X1, YMatrix1)
%CREATEFIGURE(X1,YMATRIX1)
%  X1:  vector of x data
%  YMATRIX1:  matrix of y data

%  Auto-generated by MATLAB on 21-Mar-2017 20:24:21
% Create figure
figure1 = figure('PaperSize',[20.98 29.68]);
% Create axes
axes1 = axes('Parent',figure1,'Position',[0.128 0.1544 0.707 0.815],...
'FontWeight','bold',...
'FontSize',12,...
'FontName','Times New Roman');
box(axes1,'on');
hold(axes1,'all');
% Create multiple lines using matrix input to plot
plot1 = plot(X1,YMatrix1,'Parent',axes1,'MarkerFaceColor',[0 0 0],...
'MarkerEdgeColor',[0 0 0],...
'LineWidth',2,...
```

```
'LineStyle',':');
set(plot1(1),'Marker','.','DisplayName','Voltage (V)');
set(plot1(2),'Marker','*','Color',[1 0 0],'DisplayName','Current (A)');
% Createxlabel
xlabel('Time (hr)','FontWeight','bold','FontSize',12,...
'FontName','Times New Roman');
% Create title
title('Voltage and Current Generated over Time t in RL Circuit',...
'FontWeight','bold',...
'FontSize',12,...
'FontName','Times New Roman');
% Createcolorbar
colorbar('peer',axes1);
% Resize the axes in order to prevent it from shrinking.
set(axes1,'Position',[0.128 0.1544 0.707 0.815]);
% Create legend
legend(axes1,'show');
```