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VOLUME 13

ISSUE 3

VERSION 1.0



GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: F
ELECTRICAL AND ELECTRONICS ENGINEERING

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ELECTRICAL AND ELECTRONICS ENGINEERING

VOLUME 13 ISSUE 3 (VER. 1.0)

OPEN ASSOCIATION OF RESEARCH SOCIETY

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GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING
ELECTRICAL AND ELECTRONICS ENGINEERING
Volume 13 Issue 3 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

An Investigation Study of Total Harmonic Distortion in a Flying Capacitor Multilevel Inverter With / Without Closed-Loop Feedback Schemes

By Shanmuga Priyan.S & Dr. Ramani.K

K.S.Rangasamy College of Technology, Tamilnadu

Abstract - This paper focuses on the investigation study of Total Harmonic Distortion (THD) in a seven-level Flying Capacitor Multilevel Inverter (FCMLI) with / without closed-loop feedback schemes. For that, a closed-loop model is designed for the existing FCMLI through this paper. Conventionally full bridge and half bridge inverter configurations are used for certain applications where DC-AC conversion is needed. But the main drawbacks of these inverters are high harmonic content and used only for limited power applications. In order to overcome this, a novel approach called closed-loop FCMLI will be proposed, which significantly increases the level number of the output waveform and thereby dramatically reduces the low-order harmonics and THD. The proposed system consists of a DC-DC power converter and a DC-AC multilevel inverter. In order to achieve low cost, easy control, high efficiency, and high reliability, a capacitor clamped DC-DC boost converter using minimal devices is introduced to interface the low-voltage Photovoltaic (PV) module.

Keywords : capacitor clamped DC-DC boost converter; flying capacitor multilevel inverter (FCMLI); phase disposition – pulse width modulation (PD-PWM); photovoltaic (PV); total harmonic distortion (THD).

GJRE-F Classification : FOR Code: 671503, 090699



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An Investigation Study of Total Harmonic Distortion in a Flying Capacitor Multilevel Inverter With / Without Closed – Loop Feedback Schemes

Shanmuga Priyan.S^α & Dr. Ramani.K^σ

Abstract - This paper focuses on the investigation study of Total Harmonic Distortion (THD) in a seven-level Flying Capacitor Multilevel Inverter (FCMLI) with / without closed-loop feedback schemes. For that, a closed-loop model is designed for the existing FCMLI through this paper. Conventionally full bridge and half bridge inverter configurations are used for certain applications where DC-AC conversion is needed. But the main drawbacks of these inverters are high harmonic content and used only for limited power applications. In order to overcome this, a novel approach called closed-loop FCMLI will be proposed, which significantly increases the level number of the output waveform and thereby dramatically reduces the low-order harmonics and THD. The proposed system consists of a DC-DC power converter and a DC-AC multilevel inverter. In order to achieve low cost, easy control, high efficiency, and high reliability, a capacitor clamped DC-DC boost converter using minimal devices is introduced to interface the low-voltage Photovoltaic (PV) module. In this paper, a Phase Disposition – Pulse Width Modulation (PD-PWM) technique, applicable for proposed FCMLI is presented. With the use of multilevel inverter, resolution is increased and also the harmonics is highly reduced. The proposed seven level FCMLI not only achieves high power ratings, but also enables the use of renewable energy sources in an efficient manner. In order to justify the merits of the proposed system, it is interfaced with the single phase lamp load and analysed through simulation investigations.

Keywords : capacitor clamped DC-DC boost converter; flying capacitor multilevel inverter (FCMLI); phase disposition – pulse width modulation (PD-PWM); photovoltaic (PV); total harmonic distortion (THD).

1. INTRODUCTION

In Recent years, there has been an increasing interest in electrical power generation from renewable-energy sources, such as photovoltaic (PV) or wind-power systems [1], [2]. The benefits of power generation from these sources are widely accepted. They are essentially inexhaustible and environmentally friendly. Among the

different renewable-energy sources possible to obtain electricity, solar energy has been one of the most active research areas in the past decades, both for grid-connected and stand-alone applications [3]–[4].

Multilevel inverter is based on the fact that sine wave can be approximated to a stepped waveform having large number of steps. The steps being supplied from different DC levels supported by series connected batteries or capacitors. The unique structure of multilevel inverter allows them to reach high voltages and therefore lower voltage rating device can be used. As the number of levels increases, the synthesized output waveform has more steps, producing a very fine stair case wave and approaching very closely to the desired sine wave. It can be easily understood that as motor steps are included in the waveform the harmonic distortion of the output wave decrease, approaching zero as the number of levels approaches infinity.

Hence Multi- level inverters offer a better choice at the high power end because the high volt- ampere ratings are possible with these inverters without the problems of high dv/dt and the other associated ones [5].

Nowadays different topologies have been reported for multi-level inverters. They are named as neutral point clamped (diode-clamped) inverter, flying capacitor (capacitor-clamped) inverter and cascaded multi-cell with separated dc source inverter [6]. Among them, the FCMLI does not require isolated DC sides and additional clamping diodes, the snubberless operation is possible and it is easy to be expanded to the multi-level. The FCMLI offers a great advantage with respect to the availability of voltage redundancies.

This inverter uses capacitors to limit the voltage of the power devices. They are defined as different combinations of capacitors allowing the charging or discharging of the individual flying capacitors in order to produce the same phase leg voltage. This advantage provides the special opportunity for controlling the individual voltage on flying capacitors [6]–[7]. Many studies have shown that under certain conditions, a simple open loop control guarantees natural balancing of the flying capacitor.

Author α : PG Scholar – Final Year, Power Electronics & Drives/EEE, K.S.Rangasamy College of Technology, Tiruchengode, Tamilnadu, India. E-mail : arunaipriyan@gmail.com

Author σ : Associate Professor, Power Electronics & Drives/EEE, K.S.Rangasamy College of Technology, Tiruchengode, Tamilnadu, India. E-mail : kreee82@gmail.com

In this paper, Proportional-Integral-Derivative (PID) controllers based closed loop system for seven level flying capacitor multilevel inverter and for capacitor clamped DC-DC boost converter have been proposed. This scheme maintains the output voltage stability, reducing the harmonic content in the output there by improving the overall system performance. This paper has been designed using a seven level flying capacitor multilevel inverter with the appropriate closed loop schemes there by THD can be significantly reduced which is confirmed through simulation investigation.

II. PROPOSED TOPOLOGY OF CLOSED LOOP SYSTEM

a) Architecture of Proposed System

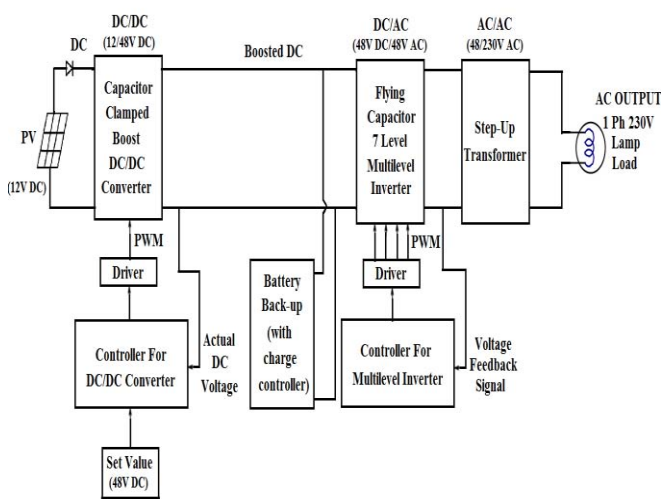


Figure 1 : Overall Block Diagram of Proposed System

For this proposed topology, DC input to the system is a solar energy which is harvested from the Sun based on the irradiation and insolation level. In this system a single stand-alone PV module of 12V capacity is used to obtain the DC voltage. Then this obtained DC voltage is given as the input to the Capacitor Clamped DC-DC Boost Converter. By the boost DC-DC converter topology, the 12V DC is boosted into 48V DC.

In order to maintain the constant DC voltage from the boost converter, a closed loop block is designed in which the actual DC voltage is compared with the 48V DC set value. Based on the error signal from the comparator, the PID controller produces the control signal to the PWM pulse generator block.

Then based upon the specified switching frequency of MOSFET, switching pulses are given to the single switch in the boost converter. Then the boosted DC voltage is given as the input to the seven level FCMLI which is used for 48V DC to 48V AC conversion.

For controlling the FCMLI, a closed loop block is designed which consists of voltage measurement, voltage controller - PID controller and Sin generator block. With the help of these blocks, a closed loop design is achieved for proposed FCMLI. Then this low

voltage AC signal of 48V AC is given to the step-up transformer for stepping up the voltage level to 230V AC. Finally a resistive load – single phase lamp load is connected across the 230V AC output terminals.

b) System Composition

The described system in this paper is a standalone system which consisting of the following individual systems:-

- For generating the DC voltage signal, a suitable stand-alone PV module is used.
- For boosting up the generated DC voltage, an appropriate Capacitor Clamped DC-DC boost converter is used.
- For maintaining the constant DC output from boost converter, a closed loop controller is used for DC-DC converter.
- For converting the boosted DC voltage into appropriate AC voltage, a FCMLI is used.
- For improving the performance of MLI, a closed loop controller is used for FCMLI.
- For stepping up the generated AC voltage from MLI, a suitable step-up transformer is used.
- For connecting the developed system to the resistive load, a single phase lamp load is used.

c) System Specification

Table 1 : Technical Specification of a Proposed System

System Stages	Technical Specification
DC Input	PV Module – 12V DC
DC - DC Conversion	Capacitor Clamped DC-DC Boost Converter (12/48V DC)
DC Storage	Battery back-up of 48V – Series connection of 4 batteries (12V each)
DC - AC Conversion	Seven Level FCMLI 48V DC/48V AC Stepped Waveform
AC - AC Conversion	Step-up Transformer (48/230V AC) Nearly Sinusoidal Waveform
Connected Load	Single Phase 230V AC Lamp Load

d) Simulation Model of Proposed System

The overall Simulation diagram of the proposed closed loop system for FCMLI is shown in Figure 2.

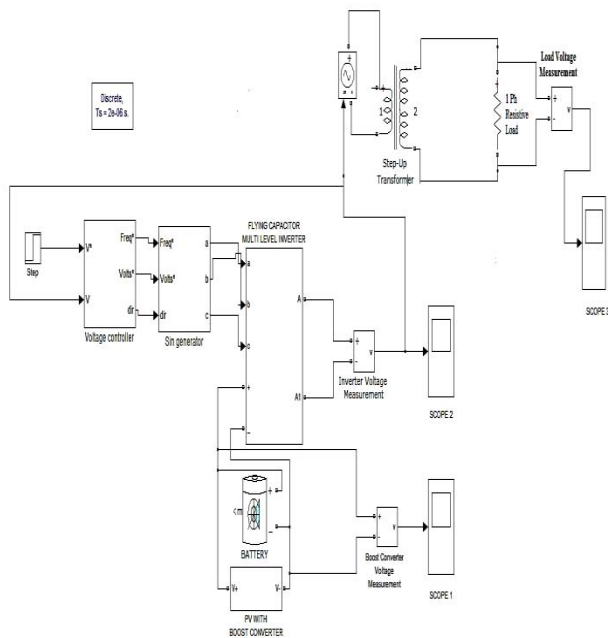


Figure 2 : Overall Simulation Model of Proposed System

III. CAPACITOR CLAMPED DC-DC BOOST CONVERTER

a) Significance of Usage

A Capacitor Clamped DC-DC Boost Converter with single switching element - MOSFET is proposed in this paper. Instead of using two or more than two number of switching devices as in the case of conventional half-bridge or full-bridge DC-DC converters, the proposed topology uses only one switching device there by fast switching with less switching loss is possible with this type of converter.

b) Basic Configuration

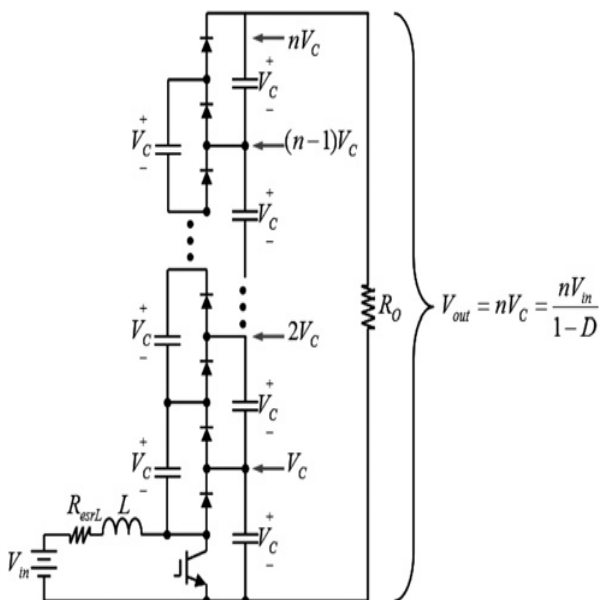


Figure 3 : Basic Configuration of DC-DC MBC for Nx or N+1 levels

The proposed circuit is based on the multilevel converter principle, where each device blocks only one voltage level achieving high-voltage converters with low-voltage devices. It is a Nx DC-DC converter based on one driven switch, 2N+1 diodes and 2N+1 capacitors. One advantage of the topology is that the number of levels can be extended by only adding capacitors and diodes and the main circuit does not need to be modified.

c) Circuit Description

The DC-DC Multilevel Boost Converter (MBC) is a PWM based DC-DC converter, which combines the boost converter and the switched capacitor function to provide different output voltages and a self-balanced voltage using only one driven switch, one inductor, 2N-1 diodes and 2N-1 capacitors for an Nx MBC.

The difference between the MBC and the conventional one is that in the MBC, the output is Vc times N, where N+1 is the converter's number of levels taking into account the zero level as shown in Figure 3. This behavior is achieved, thanks to the voltage multiplier in the boost converter's output that is driven by the only switch in the converter.

IV. FLYING CAPACITOR MULTILEVEL INVERTER (FCMLI)

a) Basic Configuration

The FCMLI requires a large number of capacitors to clamp the device (switch) voltage to one capacitor voltage level. Provided all the capacitors are of equal value, the size of the voltage increment between two consecutive legs of the clamping capacitors defines the size of voltage steps in the output waveform, if the voltage of the main dc-link capacitor is Vdc the voltage of the innermost capacitor clamping the innermost two devices is Vdc/ (n-1).

The voltage of the next innermost capacitor will be Vdc/(n-1) + Vdc/ (n-1) = 2 Vdc/(n-1) and so on. Each next clamping capacitor will have the voltage increment of Vdc/(n-1) from its immediate inner one. The voltage levels and the arrangements of the flying capacitors in the FCMLI structure assures that the voltage stress across each main device is same and is equal to Vdc/(n-1) for an n- level inverter.

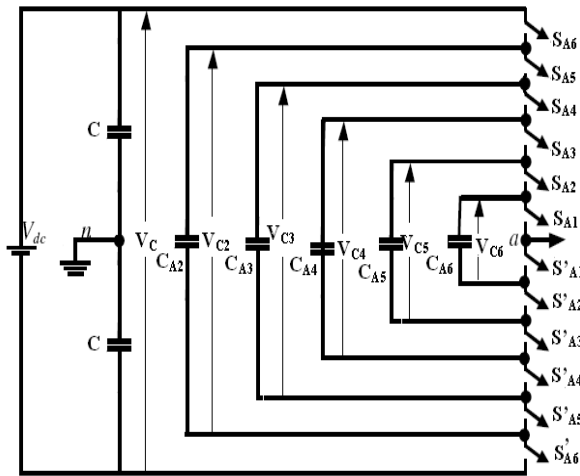


Figure 4 : One Phase Leg of a Seven Level Flying Capacitor Multilevel Inverter

A one phase leg of seven-level inverter as shown in Figure 4. For a three phase inverter, two more legs of same construction are coupled to the same dc-link battery V_{dc} . In this figure each switch SA_1 to SA_6 and SA_1' to SA_6' consists of a power semiconductor device (e.g. GTO, IGBT) and an anti-parallel diode. Voltages V_C , V_{C2} , V_{C3} , V_{C4} , V_{C5} , and V_{C6} are V_{dc} , $5/6 V_{dc}$, $2/3 V_{dc}$, $V_{dc}/2$, $V_{dc}/3$, and $V_{dc}/6$ respectively, as $n = 7$.

b) Features of FCMLI

The FCMLI has the following features.

- Voltage stresses across the devices are equal.
- Switching combination chosen affects the current rating of the capacitor
- Redundancy of switching combinations.
- Single capacitor voltage regulating circuit is required.

V. RESULTS AND ANALYSIS

The proposed topology of closed loop system for Flying Capacitor Multilevel Inverter (FCMLI) consists of various models. They are

- Photovoltaic Generation Model.
- Capacitor Clamped DC-DC Boost Converter Model.
- Open Loop FCMLI Model.
- Closed Loop FCMLI Model.

a) Photovoltaic Generation Model

The Simulation diagram for the PV Generation by a single stand-alone 12V PV module is shown in Figure 5.

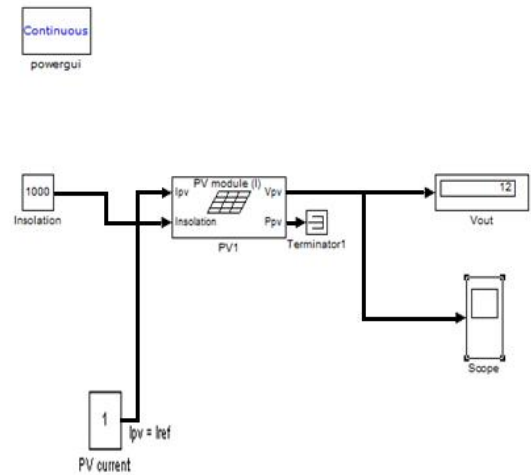


Figure 5 : MATLAB Model of Photovoltaic Generation

It consists of Insolation block, Single PV module block for DC voltage generation and display & scope blocks for displaying the output in numerical and graphical form respectively. The technical specifications of the PV module used in the proposed system are listed in the TABLE II.

Table 2 : Technical Specifications of Pv Module

S. No	Parameters	Specifications	Units
1	Short Circuit Current (I_{sc})	5.45A	Amperes
2	Open Circuit Voltage (V_{oc})	12V	Voltage
3	Current at P_{max}	4.95A	Amperes
4	Voltage at P_{max}	17.2V	Voltage
5	Insolation	1000 W/m ² (Constant)	Watts / metre ²

The Simulated output is taken for 1000 watts/m² of Insolation and 25°C of Temperature under Standard Test Condition (STC).

The corresponding output voltage waveform of 12V PV Panel is shown in the Figure 6.

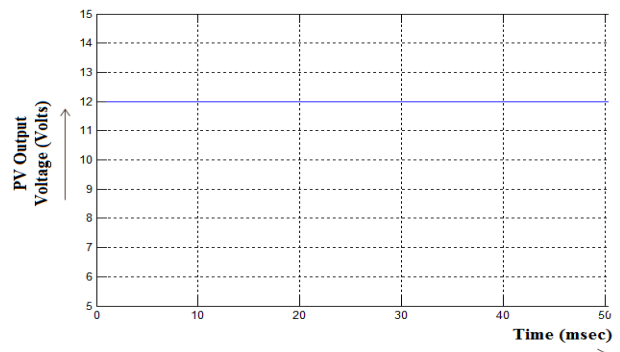


Figure 6 : Output Voltage Waveform of PV Module

Thus from the PV Panel, a 12V DC of Unidirectional Voltage is produced. Then this low value of DC voltage is given to the Boost converter for achieving desired DC voltage for giving input to the Multilevel Inverter.

b) Capacitor Clamped Dc-Dc Boost Converter Model

From the PV module a 12V DC voltage is obtained. This unidirectional DC voltage is then given to the Capacitor Clamped DC-DC Boost Converter for boosting up the voltage up to 48V DC.

The Simulation diagram of the Capacitor Clamped DC-DC Boost Converter is shown in Figure 7.

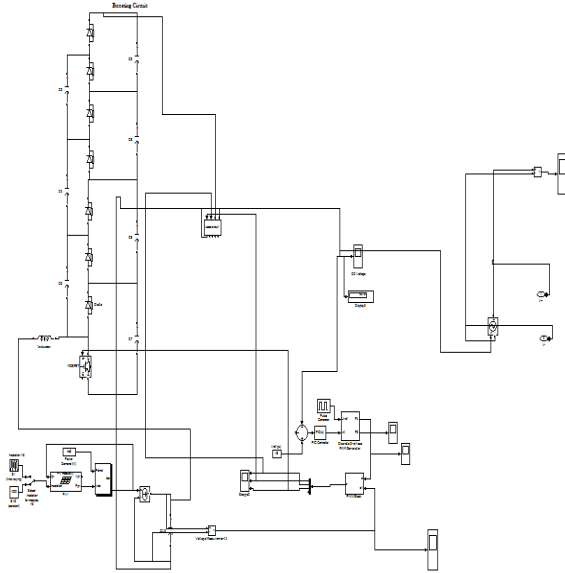


Figure 7 : MATLAB Model of Capacitor Clamped Boost Converter

It consists of various circuit elements such as Boost Inductor, MOSFET, Clamping Capacitor and free-wheeling diodes for boosting up the DC voltage from PV panel – 12V DC into 48V DC. It also consists of a comparator, PID controller, pulse generator and PWM block for producing pulses for MOSFET.

The corresponding output voltage waveform of the proposed Capacitor Clamped DC-DC Boost Converter is shown in Figure 8.

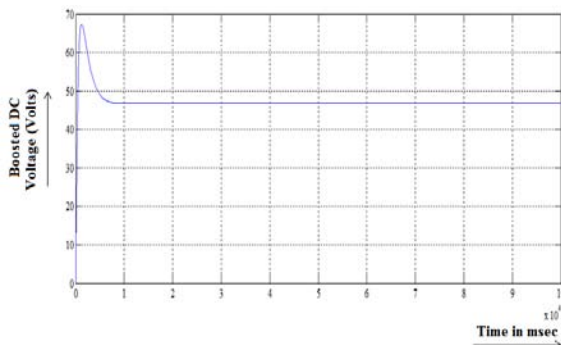


Figure 8 : Output Voltage Waveform of Boost Converter Model

From the above output, the main inference is initially the voltage signal is raised to nearly 60V DC and then it is settled down to the 48V of DC. The reason behind that is because of the presence of the boosting inductor in the initial stage of boost converter, the voltage raise takes place and after that based on the set value in comparator it falls to actual pre-defined value.

c) Open Loop FCMLI Model

From the Boost Converter Model, a 48V of DC is given to the Seven Level FCMLI for converting a DC voltage into stepped output waveforms.

The Figure 9 shows the corresponding overall simulation model of proposed Multilevel Inverter which includes the Inverter model and pulse generation model.

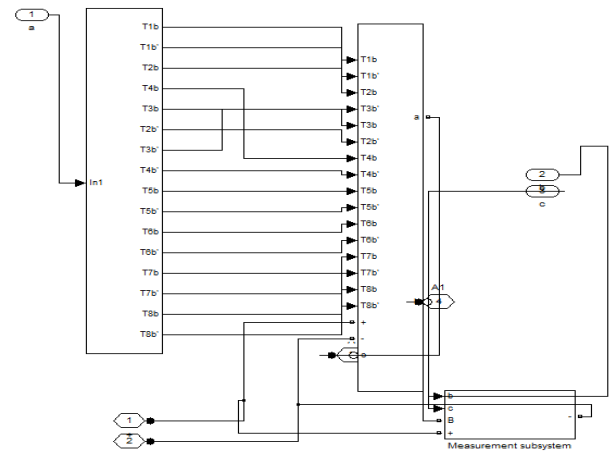


Figure 9 : MATLAB Model of FCMLI

The proposed Seven Level FCMLI will produce the seven levels of stepped AC output waveforms at its output. The switching sequence of various switches used in the Inverter model are determined by the PWM pulses from the pulse generation model. In this Pulse Generation Model, there are six number of carrier signals which are produced by Repeating sequence concept and these signals are compared with the Sinusoidal signal with the help of the relational operator ($>=$).

Here Multicarrier PWM in turn PD-PWM technique is employed for generating appropriate PWM pulse signals for respective switches in the MLI.

The Figure 10 shows the Pulse Generation Model Using Multicarrier PWM – PDPWM technique for Seven Level FCMLI.

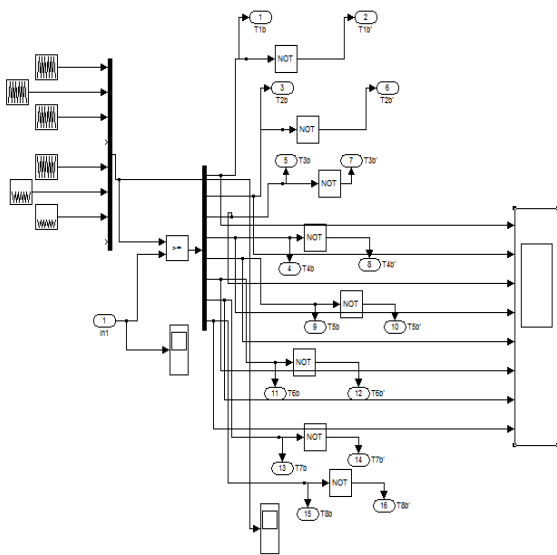


Figure 10 : Pulse Generation Model for Multilevel Inverter Using Multicarrier (PDPWM) Technique

The Figure 11 shows the six number of carrier signals in PD-PWM Pulse Generation Model.

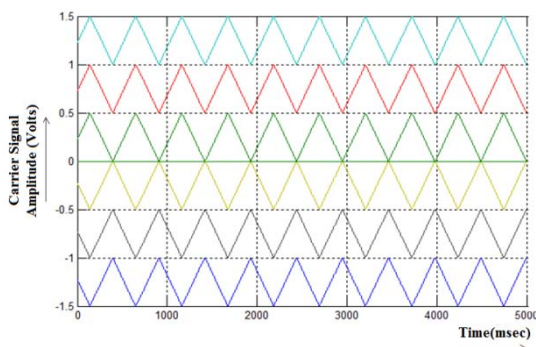


Figure 11 : Carrier Signals Used in Pulse Generation Model

The six carrier signals used in pulse generation model are generated based on the repeating sequence concept which is listed in the Table III.

Table 3 : Carrier Signal Generation For Pulse Generation Model

S. No	Carrier Signals	Time Values (Sec)	Output Values (Volts)
1	1 st Carrier	[0 0.005/20 0.01/20 0.015/20 0.02/20]	[0 .5 0 .5 0]
2	2 nd Carrier	[0 0.005/20 0.01/20 0.015/20 0.02/20]	[.5 1 .5 1 .5]
3	3 rd Carrier	[0 0.005/20 0.01/20 0.015/20 0.02/20]	[1 1.5 1 1.5 1]
4	4 th Carrier	[0 0.005/20 0.01/20 0.015/20 0.02/20]	[0 -.5 0 -.5 0]
5	5 th Carrier	[0 0.005/20 0.01/20 0.015/20 0.02/20]	[-.5 -1 -.5 -1 -.5]
6	6 th Carrier	[0 0.005/20 0.01/20 0.015/20 0.02/20]	[-1.5 -2 -1.5 -2 -1.5]

The Figure 12 shows the comparison of six number of carrier signals and the sinusoidal modulating signal. In which the sinusoidal signal is superimposed

over the carrier signals for generating appropriate PWM pulses.

The Figure 12 shows the comparison of six number of carrier signals and the sinusoidal modulating signal. In which the sinusoidal signal is superimposed over the carrier signals for generating appropriate PWM pulses.

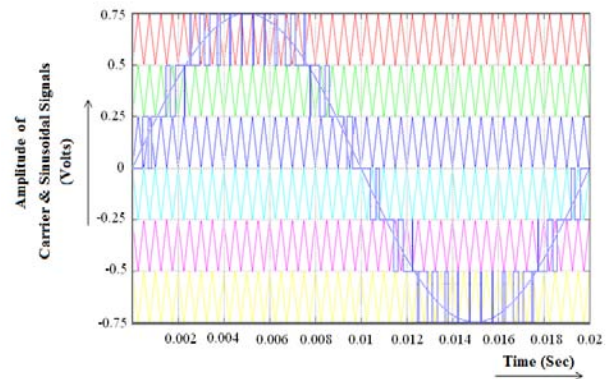


Figure 12 : PDPWM Modulation Scheme

The corresponding open loop output voltage waveform of proposed Multilevel Inverter is shown in Figure 13.

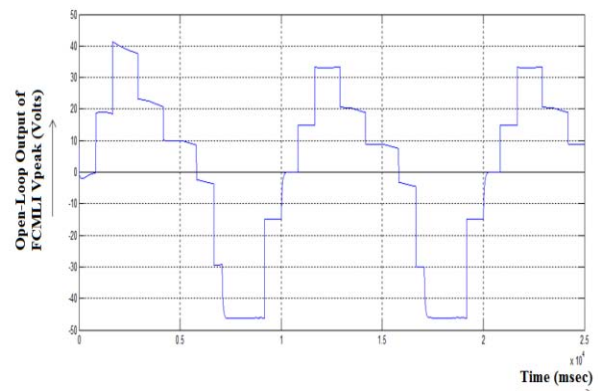


Figure 13 : Open Loop AC Output Voltage Waveform of FCMLI

From the Open loop output, it is observed that seven level stepped output waveform with the magnitude of nearly 48V is achieved but it is slightly distorted. Because of this the Total Harmonic Distortion (THD) of open-loop output is having more percentage values. Thus in order to reduce the THD level of Multilevel Inverter output and to improve the performance of the system, a closed-loop design is essential for Multilevel Inverter. By implementing the closed-loop system, the THD level can be reduced to certain extend.

d) Closed Loop FCMLI Model

i. Voltage Controller Model

For designing closed-loop system for proposed MLI, various blocks such as Voltage Controller block, Sin Generator block are used.

The Figure 14 shows the voltage controller – PID controller model for closed-loop design of Seven Level FCMLI.

The various blocks used in the voltage controller model are Zero-order Hold, gain, Abs - absolute, comparator, discrete-time integrator, saturation and rate transition blocks.

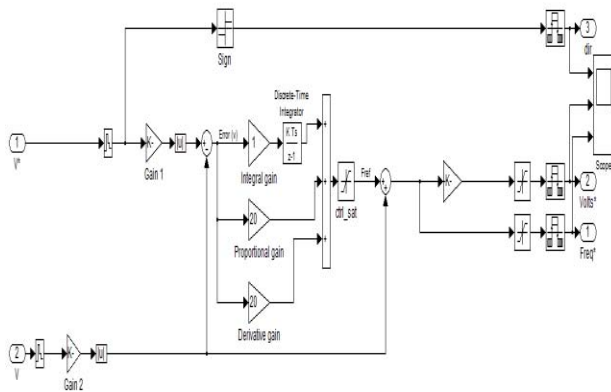


Figure 14 : Simulation Model of Voltage Controller in Closed-loop System

ii. Sin Generator Model

The output of the voltage controller model is given as the three input parameters of sin generator model. This model is used to produce the sinusoidal modulating signal which is used in pulse generation model for producing PWM output pulses.

The Figure 15 shows Sin Generator model for closed-loop design of Seven Level FCMLI.

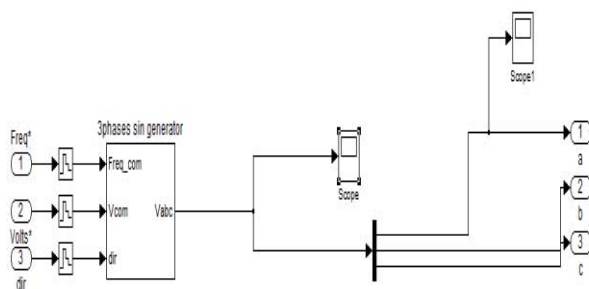


Figure 15 : Simulation Model of Sin Generator in Closed-loop System

The corresponding single phase sinusoidal outputs of Sin Generator Model are shown in the Figure 16.

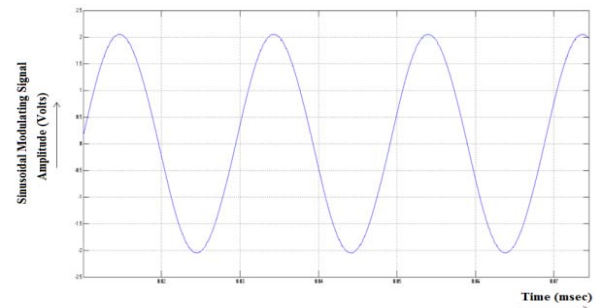


Figure 16 : Single Phase Sinusoidal Output of Sin Generator For Pulse Generation Model

Thus after the comparison of Sinusoidal modulating signal and generated carrier signals using PDPWM Technique in Pulse Generation Model, the appropriate PWM switching pulses are generated. These pulses are used to trigger the switching devices in proposed MLI in a proper sequence to produce the stepped AC waveform from the output of MLI.

In order to reduce the THD level of MLI output a closed-loop model is developed and its corresponding output voltage is shown in Figure 17.

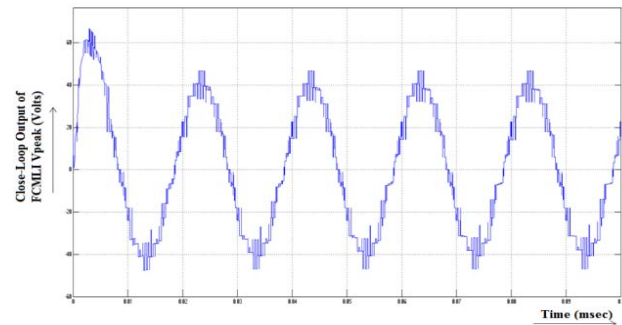


Figure 17 : Closed Loop AC Output Voltage Waveform of FCMLI

e) Load Voltage Waveform

For connecting a Single Phase resistive lamp load, the 48V AC stepped output waveform from the MLI is given to the 48/230V AC step-up transformer.

The Figure 18 shows the corresponding output voltage waveform of a step-up transformer (48/230V AC). This AC voltage is fed to the Single Phase Lamp Load.

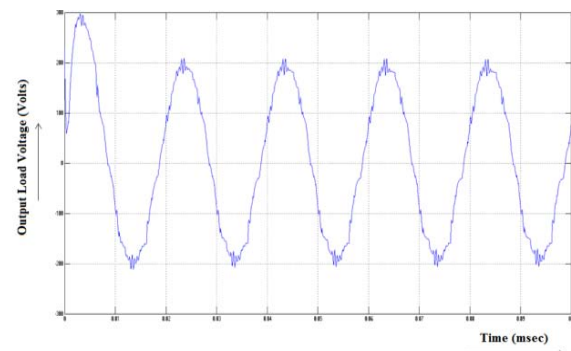


Figure 18 : Output Load Voltage Waveform

f) Total Harmonic Distortion

The Total Harmonic Distortion (THD) is used to characterize the linearity of audio systems and the power quality of electric power systems.

The formula below shows the calculation for THD on a voltage signal. The end result is a percentage comparing the harmonic components to the fundamental component of a signal. The higher the percentage, the more distortion that is present on the mains signal.

$$THD = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \dots + V_n^2}}{V_1} * 100\% \quad (1)$$

The results of THD analysis performed for both open-loop and closed-loop systems are shown in the Figures 19 and 20.

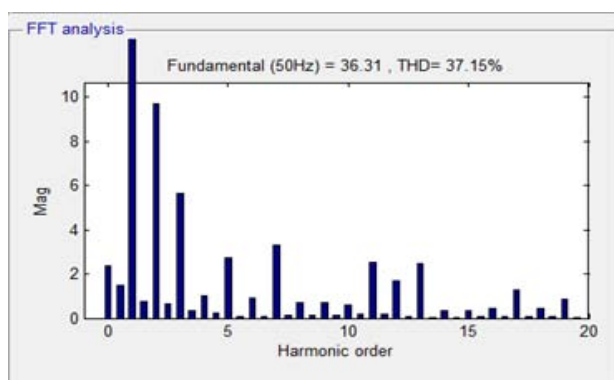


Figure 19 : Open Loop THD Result of Seven Level FCMLI

From the Figure 19, it is observed that THD value of **37.15%** is obtained for Open-Loop Multilevel Inverter. This value can be reduced by Closed-Loop design.

The result of THD analysis performed for closed-loop systems is shown in Figure 20.

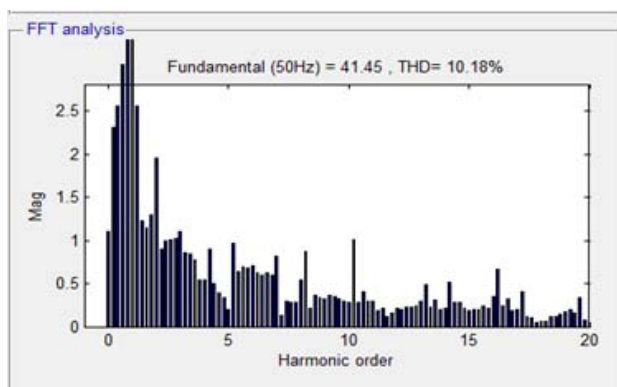


Figure 20 : Closed Loop THD Result of Seven Level FCMLI

From the Figure 18, it is observed that THD value of **10.18%** is obtained for Closed-Loop Multilevel Inverter. This is comparatively lesser value than the THD obtained in Open-Loop system.

VI. CONCLUSION

Thus the investigation study for seven level FCMLI was performed with / without closed-loop feedback schemes.

In the proposed method, a closed-loop system was implemented for a Seven Level FCMLI. The newly developed design will improve the system performance and maintains the voltage stability there by stable operation can be ensured without more disturbances. The closed loop controller is also designed for Capacitor Clamped DC-DC Boost Converter there by constant output voltage at the output of the boost converter can be achieved.

The performance was verified through simulation models by using MATLAB software tool. From the simulation study, the important conclusions are,

- From the output of Stand-alone single PV Module, a unidirectional DC voltage of 12V DC was produced based on the panel parameters and Insolation level.
- From the output of Capacitor Clamped DC-DC Boost Converter, a boosted DC voltage of 48V DC is produced with the help of single switching device there by switching loss and circuit complexity are reduced.
- From the output of FCMLI, an AC output voltage of 48V AC stepped signals are obtained. There by THD level is reduced.

Investigation Report:

Seven Level Flying Capacitor Multilevel Inverter		
Feedback Schemes	With Closed-Loop Scheme	Without Closed-Loop Scheme
Total Harmonic Distortion (THD) in percentage	10.18%	37.15%

The main inference from the proposed concept is, for the developed Seven Level FCMLI system the THD value of open-loop model is 37.15% and for the closed-loop model is 10.18%. Thus the percentage of THD value can be minimized by implementing the closed-loop control for FCMLI there by better performance in its output can be achieved.

REFERENCES RÉFÉRENCES REFERENCIAS

- J. M. Carrasco, L. G. Franquelo, J. T. Bialasiewicz, E. Galvan, R. C. Portillo Guisado, M. A. M. Prats, J. I. Leon, and N. Moreno-Alfonso, "Power-electronic systems for the grid integration of renewable energy sources: A survey," *IEEE Trans. Ind. Electron.*, vol. 53, no. 4, pp. 1002–1016, Jun. 2006.
- F. Blaabjerg, Z. Chen, and S. B. Kjaer, "Power electronics as efficient interface in dispersed power generation systems," *IEEE Trans. Power Electron.*, vol. 19, no. 5, pp. 1184–1194, Sep. 2004.

3. E. Roman, R. Alonso, P. Ibanez, S. Elorduizaparietxe, and D. Goitia, "Intelligent PV module for grid-connected PV systems," IEEE Trans. Ind. Electron., vol. 53, no. 4, pp. 1066–1073, Jun. 2006.
4. R.-J. Wai, W.-H. Wang, and C.-Y. Lin, "High-performance stand-alone photovoltaic generation system," IEEE Trans. Ind. Electron., vol. 55, no. 1, pp. 240–250, Jan. 2008.
5. Kapil Jain, and Pradyumn Chaturvedi, "Matlab - based Simulation & Analysis of Three - level SPWM Inverter," International Journal of Soft Computing and Engineering (IJSCE), vol. 2, issue. 1, pp. 56-59, March 2012.
6. K.Ramani and Dr.A.Krishnan, "High performance Flying Capacitor based Multilevel Inverter fed Induction Motor," International Journal of Recent Trends in Engineering, vol. 2, no. 2, pp. 7-9, Nov 2009.
7. D. W. Kang, B. K. Lee, J. H. Jeon, T. J. Kim and D. S. Hyun, "Asymmetrical carrier technique of CRPWM for voltage balance method of flying capacitor multilevel inverter," IEEE Trans. Ind. Electronics, vol. 52, no. 3, pp. 879-888, June 2005.
8. Rong-Jong Wai, Wen-Hung Wang and Chung-You Lin, "High-Performance Stand-Alone Photovoltaic Generation System," IEEE Trans. on Ind. Electronics, vol.55, no.1, pp. 240-250, Jan 2008.
9. Shuai Jiang, Dong Cao, Yuan Li and Fang Zheng Peng, "Grid-Connected Boost-Half- Bridge Photovoltaic Microinverter System Using Repetitive Current Control and Maximum Power Point Tracking," IEEE Trans. Power Electronics, vol.27, no.11, pp. 4711-4722, Nov 2012.
10. T. Meynard, H. Foch, P. Thomas, J. Courault, R. Jakob and M. Nahrstaedt, "Multicell converters: basic concepts and industry applications," IEEE Trans. Ind. Electronics, vol. 49, no. 5, pp. 955-964, Oct. 2002.
11. Pablo Lezana and Roberto Aceiton, "Hybrid Multicell Converter : Topology and Modulation," IEEE Trans. on Ind. Electronics, vol.58, no.9, pp. 3938-3945, Sep 2011.
12. M. H. Rashid, Power Electronics Handbook, Academic Press, London, 2001.

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GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING
ELECTRICAL AND ELECTRONICS ENGINEERING
Volume 13 Issue 3 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Analysis of FWM Effect in Multichannel Optical Communication System

By B.K.Mishra, Lochan Jolly & Karishma Mhatre

Thakur College of Engg and Technology, India

Abstract - Long haul multichannel optical communication system is extremely affected by crosstalk due to Four wave mixing (FWM). The FWM effect depends on channel separation and number of channels. The paper presents the design and performance analysis of FWM effect on bit error rate, Q-factor, output spectrums and eye opening by varying channel spacing and number of channels. Results show that FWM effect reduces with increase in channel spacing and decrease in number of channels. Further it can be reduced by unequal channel spacing.

Keywords : four wave mixing, wavelength division multiplexing, bit error rate.

GJRE-F Classification : FOR Code: 090605, 100506



Strictly as per the compliance and regulations of :



Analysis of FWM Effect in Multichannel Optical Communication System

B.K.Mishra^α, Lochan Jolly^σ & Karishma Mhatre^ρ

Abstract - Long haul multichannel optical communication system is extremely affected by crosstalk due to Four wave mixing (FWM). The FWM effect depends on channel separation and number of channels. The paper presents the design and performance analysis of FWM effect on bit error rate, Q-factor, output spectrums and eye opening by varying channel spacing and number of channels. Results show that FWM effect reduces with increase in channel spacing and decrease in number of channels. Further it can be reduced by unequal channel spacing.

Keywords : four wave mixing, wavelength division multiplexing, bit error rate.

I. INTRODUCTION

Optical fibers in telecommunication systems now carry more channels and higher optical powers than ever before. Systems are operating in which the fiber carries such a high optical power density that signals can modify the transmission properties of the fiber. An optical channel can then affect how it and other channels propagate through the fiber - leading to nonlinear effects. By the term nonlinear, we mean that the optical signal leaving the fiber at a given wavelength no longer increases linearly with the input power at that wavelength.

In order to meet the huge capacity demands imposed on the core transmission network by the explosive growth in data communications the number of optical channels in dense-WDM optical networks is being increased. Since the gain bandwidth of EDFAs is limited, these requirements for a very large number of channels mean that the channel spacing will have to be small. The current ITU grid specifies 100 GHz channel spacing, but systems are being considered with 50 GHz to 25GHz channel spacing. At these spacing, the non-linear effects of the optical fiber can induce serious system impairments. Four-Wave-Mixing (FWM) is another non linear effect that can limit the performance of WDM systems [1].

When high power optical signal is launched into a fiber Linearity of optical response is lost. Four-wave

is due to changes in the refractive index with optical mixing power called optical Kerr effect. Four-wave mixing (FWM) is a parametric process in which different frequencies interact and by frequency mixing generate new spectral components. When new frequencies fall in the transmission window of original frequency it causes severe cross talk between channels propagating through an optical fiber. Degradation becomes very severe for large number of WDM channels with small spacing. In this paper, we have simulated the effect of FWM products in WDM environment by varying the channel spacing and number of channels.

II. FOUR WAVE MIXING

Four-wave mixing (FWM) is a type of optical Kerr effect, and occurs when light of two or more different wavelengths is launched into a fiber. Fig.1 is a schematic diagram that shows four-wave mixing in the frequency domain. As can be seen, the light that was there from before launching, sandwiching the two pumping waves in the frequency domain, is called the probe light (or signal light). The idler frequency f_{idler} may then be determined by

$$f_{idler} = f_{p1} + f_{p2} - f_{probe} \quad (1)$$

Where f_{p1} and f_{p2} are the pumping light frequencies, and f_{probe} is the frequency of the probe light [3]. This condition is called the frequency phase-matching condition.

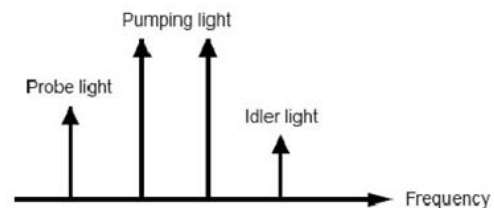


Fig. 1 : Two channel pump wave

FWM can have important deleterious effects in optical fiber communications, particularly in the context of wavelength division multiplexing where it can cause cross-talk between different wavelength channels, and/or an imbalance of channel powers [4].

FWM can transfer data to a different wavelength. A continuous wave pump beam is launched into the fiber together with the signal channel. Its wavelength is chosen half-way from the desired shift.

Author^α: Principal, Thakur College of Engg and Technology, Mumbai, India. E-mail : drbk.mishra@thakureducation.org

Author^σ: Department of Electronics and Telecommunication, Thakur College of Engg and Technology, Mumbai, India. E-mail : lochan.jolly@thakureducation.org

Author^ρ: Department of Electronics and Telecommunication, Thakur College of Engg and Technology, Mumbai, India. E-mail : mhatrekarishma@yahoo.co.in

FWM transfers the data from signal to the idler beam at the new wavelength [5, 7, 9].

Applications of FWM:

- Parametric amplification.
- Optical phase conjugation.
- Demultiplexing of OTDM channels.
- Wavelength conversion of WDM channels.
- Super-continuum generation.

Four-wave mixing (FWM) (also called four-photon mixing) is one of the major limiting factors in WDM optical fiber communication systems that use the low dispersion fiber or narrow channel spacing. Normally, multiple optical channels passing through the same fiber interact with each other very weakly. In the FWM effect, three co-propagating waves produce nine new optical sideband waves at different frequencies. When this new frequency falls in the transmission window of the original frequencies, it causes severe cross talk between the channels propagating through an optical fiber.

The number of the side bands due to the FWM increases geometrically, as shown in Fig.2.

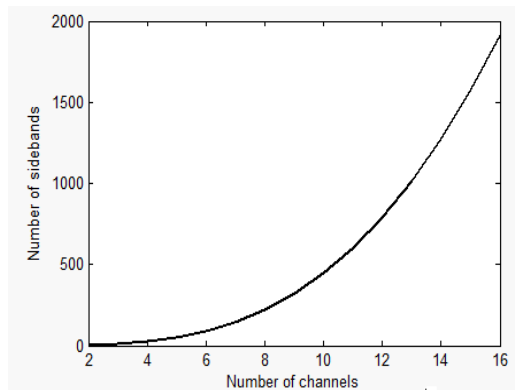


Fig. 2: Number of FWM sidebands

III. SCHEMATIC MODEL

The transmitter section consists of a laser, modulator driver, pn-sequence generator i.e. data source and modulator. The wavelength of various channels is set by keeping the difference equal to the spacing required. Then all these transmitted signals are combined/multiplexed together. Then the combined signal is amplified so that it can be transmitted over long distances without its degradation. Then the signal is transmitted over the non linear fiber which adds the nonlinearities into the signal. At the receiver side, the signal is demultiplexed. The receiver consists of a photodiode and a filter.

IV. SIMULATION AND DESCRIPTION

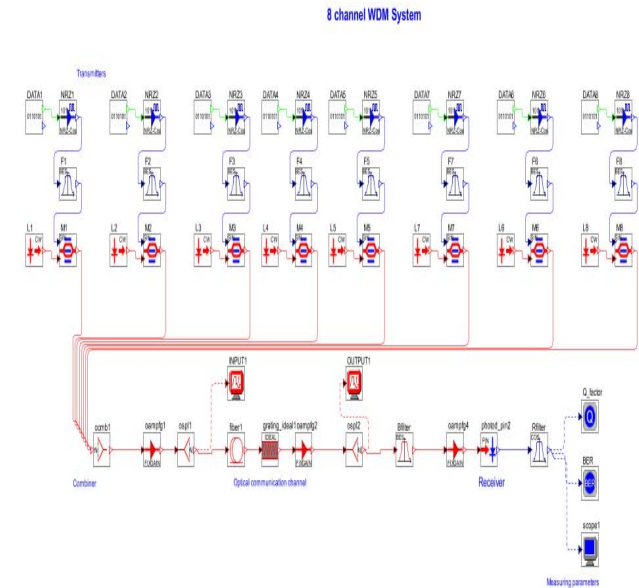


Fig. 4: Schematic model for WDM system

The simulation setup for showing the effect of changing spacing between the input channels on four-wave mixing is shown in Fig 4. The continuous wave laser is used to create the carrier signal. In this setup, eight users are taken in account whose wavelengths have a specific difference i.e. spacing between them. The data source is used to generate the random input data bit sequence at the rate of 10 Gbps. The light signal modulates the input data. The modulator is driven by the modulator driver which decides the input data format. The input data format used here is NRZ raised cosine. The modulated data from all the users is combined using a combiner. The post amplifier amplifies the signal before allowing it to enter into the fiber to avoid losses. Then this signal is sent over the fiber. At the receiver, the signal is demultiplexed by using optical splitter which splits this signal into the same number of signals as were transmitted. The photodiode is used for optical to electrical conversion. Then the signal is passed through the Raised cosine filter and the final output signal is received. An optical scope is attached at the output of combiner to examine the input signal. Another optical scope is placed at the output of splitter to examine the four wave mixing effect in frequency spectrum. An electrical scope is kept at the receiver output to examine the eye diagram. Initially the four wave mixing effect has been compared for different values of channel spacing and the performance has been evaluated in terms of output spectrums, eye diagrams, BER, eye opening and Q-factor. Here, all the channels are spaced evenly but at different values like 20 GHz, 30GHz, 50GHz, 70 GHz, 75 GHz, 90GHz and 95GHz.

Also FWM effect is analyzed for unequal channel spacing and by varying the number of channels in WDM system.

V. RESULTS AND DISCUSSION

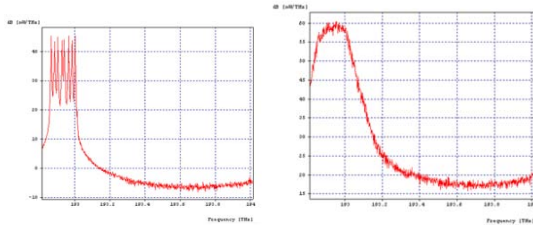


Fig. 5 (a) : Input pattern for 20GHz channel spacing and

Fig 5 (b) : Output Pattern

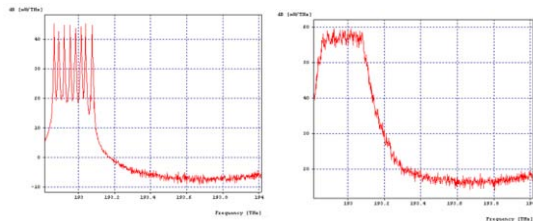


Fig. 6(a) : Input pattern for 30GHz channel spacing and

Fig. 6 (b) : Output Pattern

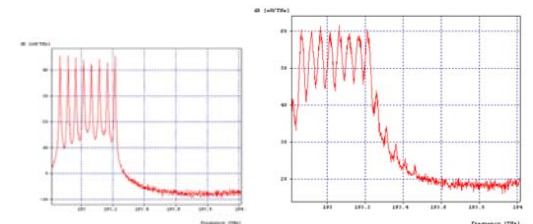


Fig. 7(a) : Input pattern for 50GHz channel spacing and

Fig. 7 (b) : Output Pattern

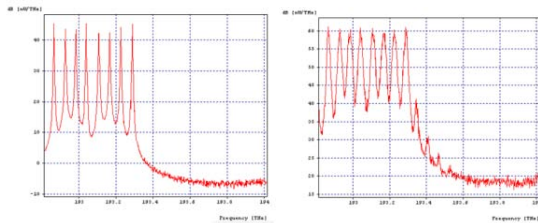


Fig. 8 (a) : Input pattern for 60GHz channel spacing and

Fig. 8 (b) : Output Pattern

Using simulation setup, the value of BER, Q-factor, eye diagrams, input and output optical spectrums are measured. Optical scope measures the input and output wavelength spectrums. BER, eye diagrams and Q-factor is measured at the receiver output by using an electrical scope, Q estimator and BER estimator.

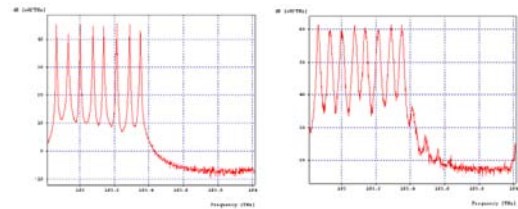


Fig. 9(a) : Input pattern for 70GHz channel spacing and

Fig. 9 (b) : Output Pattern

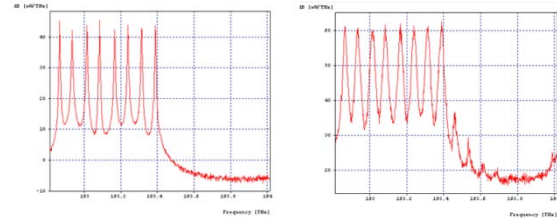


Fig. 10 (a) : Input pattern for 75GHz channel spacing and

Fig. 10 (b) : Output Pattern

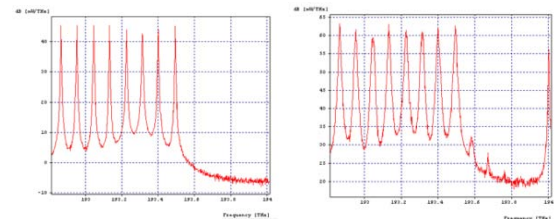


Fig. 11 (a) : Input pattern for 90GHz channel spacing and

Fig. 11 (b) : Output Pattern

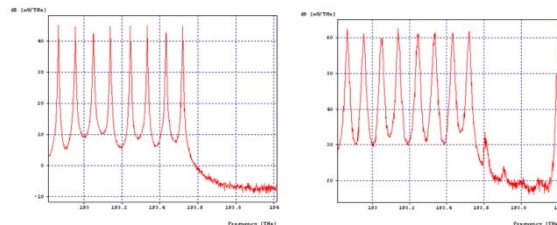


Fig. 12 (a) : Input pattern for 95GHz channel spacing and

Fig. 12 (b) : Output Pattern

Fig 5(a) shows the input optical spectrum for the spacing of 20 GHz between input channels. On changing the spacing between the different users, the peaks get shifted to the frequencies as specified in the laser. It is observed that there are no unnecessary side peaks at the input of the fiber. There are eight input channels so eight peaks appear in the input spectrum. Fig 5 to Fig 12 represents the input and output spectrum for the various values of spacing between the input users. The four wave mixing effect is clearly seen in the above output spectrum for 20GHz spacing as unnecessary peaks at various frequencies are occurring at the sides of the input spectrum. Moreover, the peaks at the input frequencies have also diminished due to four wave mixing occurred after crossing the non linear fiber.

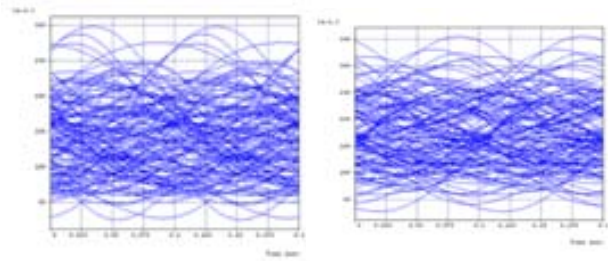


Fig. 13 (a) : Eye pattern for 20GHz channel spacing,
Fig. 13 (b) : Eye pattern for 30GHz channel spacing

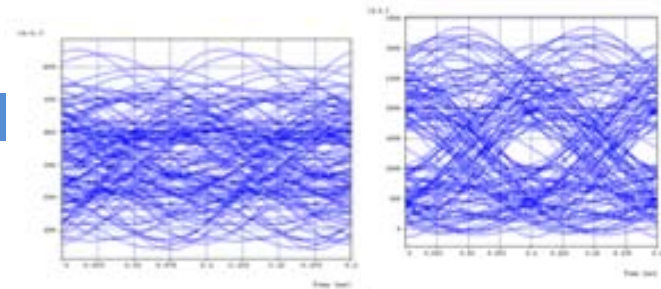


Fig. 14 (a) : Eye pattern for 50GHz channel spacing,
Fig. 14 (b) : Eye pattern for 60GHz channel spacing

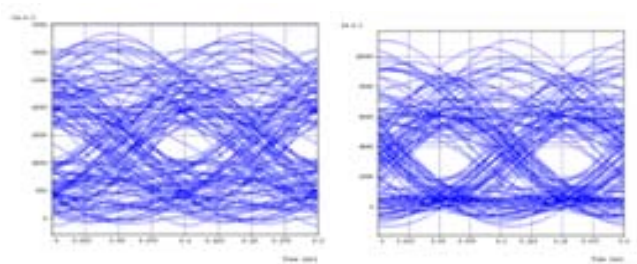


Fig. 15 (a) : Eye pattern for 70GHz channel spacing,
Fig. 15 (b) : Eye pattern for 75GHz channel spacing

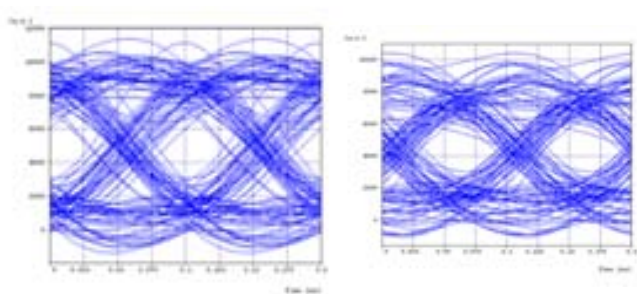


Fig. 16 (a) : Eye pattern for 90GHz channel spacing,
Fig. 16 (b) : Eye pattern for 95GHz channel spacing

The above spectrums shows that as the spacing between the input channels increases, the four wave mixing effect goes on decreasing. The unwanted peaks are more when the spacing is 20GHz and are less when the spacing is 95GHz. This shows that lesser the spacing between different input channels, more is

the interference between the input frequencies i.e. more is the four wave mixing effect. On increasing the spacing between the input channels, the four wave mixing decreases.

Fig 13 to Fig 16 shows the eye diagrams for the various values of channel spacing. The above eye diagrams show that the eye diagram clarity goes on increasing with the increasing spacing between the input channels. This shows that the interference between the input frequencies and hence the four wave mixing effect decreases with the increasing channel spacing.

Fig 17 shows the variation of BER on the basis of spacing between the input channels. The Fig shows that BER goes on decreasing with the increasing spacing.

Fig 18 shows the variation of Q-factor with the spacing between the input channels. The graph shows that the Q-factor increases as the channel spacing increases. It is highest when the channel spacing is 95 GHz and is lowest when the channel spacing is 20 GHz.



Fig.17 : BER factor Vs channel spacing

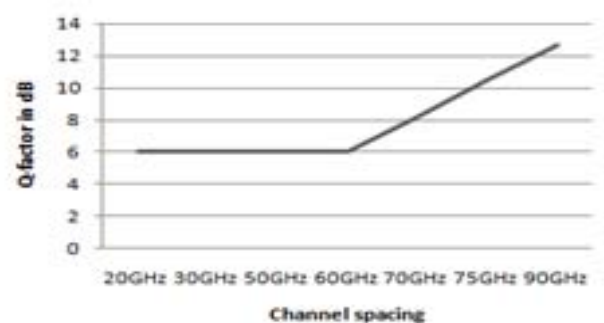


Fig.18 : Q factor Vs channel spacing

The comparative study of all the measured parameters for different channel spacing is as given in Table 1.

In a WDM system if channels are equally spaced, the new waves generated by FWM will fall at channel frequencies and thus will give rise to crosstalk.

Also much channel spacing is blocked by bandwidth constraints so channel spacing must be optimized.

Table 1 : Comparative Study of Measured Parameters

Para-meter	Channel spacing in GHz					
	50	60	70	75	90	95
Q-factor (linear)	2.00000	2.00000	2.58070	3.34055	4.30506	4.34502
Q-factor (dB)	6.02060	6.02060	8.23474	10.47636	12.67959	12.75983
BER	0.22750 E-01	0.22750 E-01	0.52921 E-02	0.37681 E-03	0.83581 E-05	0.86281 E-05
Eye opening	0.22340 E+03	0.46430 E+03	0.16669 E+04	0.59204 E+04	0.71059 E+04	0.75052 E+04

Hence we have change the channel spacing and for three different cases Q factor and BER is measured as shown in Fig. 19 and Fig 20.

As discussed earlier, FWM effect increases as number of channels increases. Hence the same is analyzed for varying number of channels and change in Q factor and BER has been observed as shown in Fig 21 and Fig 22.

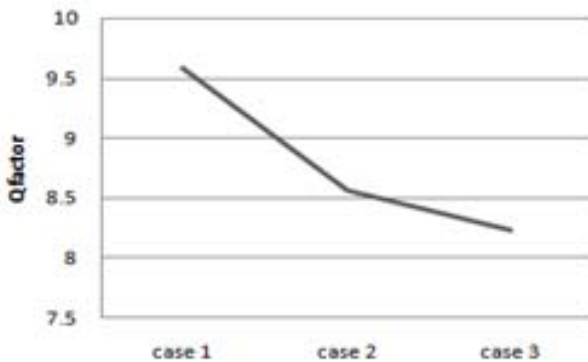


Fig. 19 : Q factor measured with unequal channel spacing

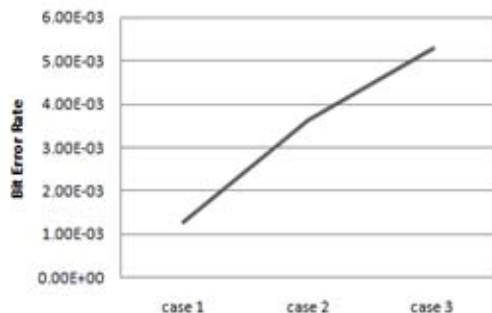


Fig. 20 : BER measured with unequal channel spacing

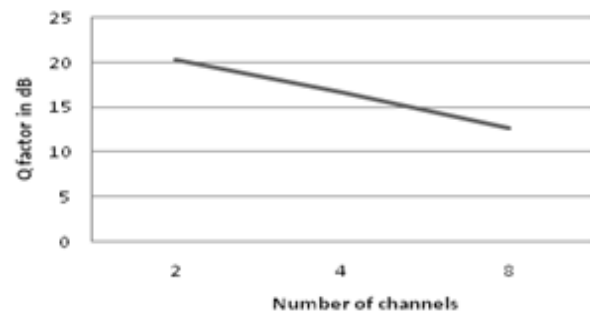


Fig. 21 : Q factor Vs number of channels

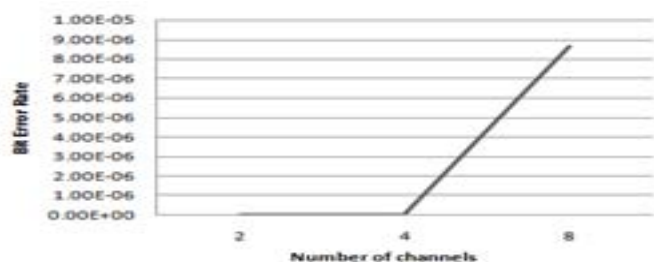


Fig. 22 : Q factor Vs number of channels

VI. CONCLUSION

In this paper, the design, implementation and performance analysis of four waves mixing in optical communication system on the basis of channel spacing and number of channels is presented. The comparison of four wave mixing effect at various values of channel spacing revealed that 95 GHz spacing has the edge over 20 GHz spacing in optical communication system. It is found that spacing of 95GHz has the lowest BER and better system performance.

Also FWM effect increases as number of channels increases. Hence, the higher spacing values between the input channels are recommended for long distance transmission without four wave mixing. It can be seen from the graphs of BER, Q-factor and eye opening that higher channel spacing gives the best performance as compared to lower channel spacing. Hence, it is concluded that higher channel spacing is best suitable to be employed in the optical communication systems minimizing the four wave mixing effect. Also further improvement in FWM effect can be achieved by unequal channel spacing. The results are in accordance with the study reported in [3,8].

In the transmission of dense wavelength-division multiplexed (DWDM) signals, FWM is to be avoided, but for certain applications, it provides an effective technological basis for fiber-optic devices. A tradeoff between advantages and disadvantages of FWM effect can be achieved by proper system design to utilize its potential to the fullest.

REFERENCES RÉFÉRENCES REFERENCIAS

1. J.S. G. P Agarwal, "Fiber Optic communication systems", John Wiley and Sons, Inc., 1992.
2. M. Wu and W. I. Way, "Fiber nonlinearity limitations in ultra-dense WDM systems," *J. Lightw. Technol.*, Vol22, no. 6, pp. 1483–1498, Jun. 2004.
3. G. P. Agrawal, "Nonlinear Fiber Optics", 3rd ed. San Diego, CA: Academic, 2001.
4. J. Toulouse, "Optical Nonlinearities in Fibers: Review, Recent Examples, and Systems Applications", *J. Lightw. Technol.*, Vol. 23, no. 11, November 20.
5. Osamu Aso, Masateru Tadakuma and Shu Namiki, "Four-Wave Mixing in Optical Fibers and Its Applications", WP Team, Opto-technology Lab., R & D Div.
6. Spector, Kai Song, MalinPremaratne, "Effects of SPM, XPM, and Four-Wave-Mixing in L-Band EDFAs on Fiber-Optic Signal Transmission", *IEEE Photon. Technol. Lett.*, Vol. 12, no. 11, pp. 1630–1632, December 2000.
7. Jianxin Ma, Jianjun Yu, Chongxiu Yu, ZhenshengJia, Xinzhu Sang, Zhen Zhou, Ting Wang, and Gee Kung Chang, "Wavelength Conversion Based on Four-Wave Mixing in High-Nonlinear Dispersion Shifted Fiber using a Dual-Pump Configuration", *J. Lightw. Technol.*, Vol. 24, no. 7, pp. 2851-2859, July 2006.
8. M.Z.Rahman, M.S.Islam, T. Rahman, S.M.A.Islam, "Effect of chromatic dispersion on Four wave mixing in WDM Optical Transmission System", *International Journal on Internet and Distributed Computing Systems (IJIDCS)*, Vol. 1, no.02, pp. 324-331, 2011.
9. Nazmi A. Mohammed, Mahmoud M. Ragab, Moustafa H. Aly, "Four wave mixing based wavelength conversion using different types of fibers", *International Journal of Engineering Science and Technology (IJEST)*, Vol. 4, no.01, pp. 324-331 January 2012.



GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING
ELECTRICAL AND ELECTRONICS ENGINEERING
Volume 13 Issue 3 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Implementation of Closed Loop System for Diode Clamped Multilevel Inverter with Stand-Alone Photovoltaic Input

By Venus.V & K.Ramani

K.S.Rangasamy College of Technology

Abstract - Multilevel inverter is as one of the most recent and popular type of advances in power electronics. It synthesizes desired output voltage waveform from several dc sources used as input for the multilevel inverter. This paper describes a diode-clamped five-level inverter-based battery/super capacitor direct integration scheme for photovoltaic energy systems. The study is carried out for three cases. In the first case, one of the two dc-link capacitors of the inverter is replaced by a battery bank and the other by a super capacitor bank. In the second case, dc-link capacitors are replaced by two battery banks. In the third case, ordinary dc-link capacitors are replaced by two super capacitor banks. The first system is supposed to mitigate both long-term and short-term power fluctuations while the last two systems are intended for smoothening long-term and short-term power fluctuations, respectively. These topologies eliminate the need for interfacing dc-dc converters and thus considerably improve the overall system efficiency. The major issue in aforementioned systems is the unavoidable imbalance in dc-link voltages. An analysis on the effects of unbalance and a space vector modulation method, which can produce undistorted current even in the presence of such unbalances, are presented in this paper. Simulation work is done using the MATLAB software which validates the proposed method and finally THD comparison is presented for analysis.

Keywords : *diode-clamped five-level inverter, direct integration of battery energy storage systems, space vector modulation, unbalanced operation of diode-clamped five-level inverter.*

GJRE-F Classification : *FOR Code: 090699*



Strictly as per the compliance and regulations of :



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Abstract - Multilevel inverter is as one of the most recent and popular type of advances in power electronics. It synthesizes desired output voltage waveform from several dc sources used as input for the multilevel inverter. This paper describes a diode-clamped five-level inverter-based battery/super capacitor direct integration scheme for photovoltaic energy systems. The study is carried out for three cases. In the first case, one of the two dc-link capacitors of the inverter is replaced by a battery bank and the other by a super capacitor bank. In the second case, dc-link capacitors are replaced by two battery banks. In the third case, ordinary dc-link capacitors are replaced by two super capacitor banks. The first system is supposed to mitigate both long-term and short-term power fluctuations while the last two systems are intended for smoothening long-term and short-term power fluctuations, respectively. These topologies eliminate the need for interfacing dc-dc converters and thus considerably improve the overall system efficiency. The major issue in aforementioned systems is the unavoidable imbalance in dc-link voltages. An analysis on the effects of unbalance and a space vector modulation method, which can produce undistorted current even in the presence of such unbalances, are presented in this paper. Simulation work is done using the MATLAB software which validates the proposed method and finally THD comparison is presented for analysis.

Keywords : diode-clamped five-level inverter, direct integration of battery energy storage systems, space vector modulation, unbalanced operation of diode-clamped five-level inverter.

I. INTRODUCTION

Multilevel converters are mainly utilized to synthesis a desired single or three-phase voltage waveform. The desired multi staircase output voltage is obtained by combining several dc voltage sources. Solar cells, fuel cells, batteries and ultra capacitors are the most common independent sources used. The intermittent nature of renewable energy sources can create serious system stability issues, especially at increased levels of penetration [1], [2]. Renewable energy resources will be an

Increasingly important part of power generation in the new millennium. Besides assisting in the reduction of the emission of greenhouse gases, they add the much-needed flexibility to the energy resource mix by decreasing the dependence on fossil fuels. Recently, batteries and super capacitors have emerged as leading energy storage devices [3]-[6]. Furthermore, the combination of battery and super capacitor provides an excellent match that can cover a wide range of power and energy requirements [5],[15].

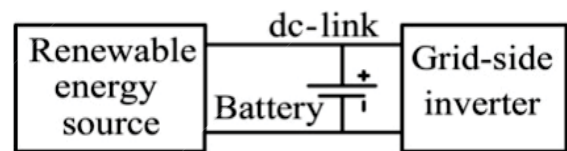


Fig. 1 (a) : Direct connection to the dc link

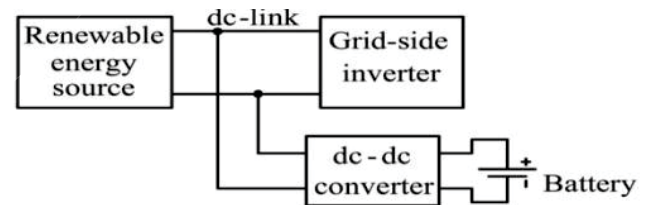


Fig. 1 (b) : Connection to the dc link through a dc-dc converter

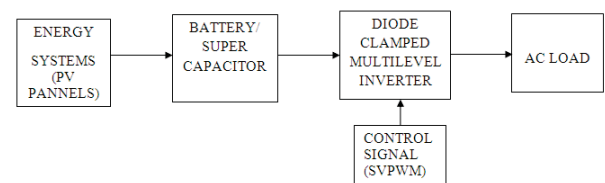


Fig. 1 (c) : Proposed battery/super capacitor five level inverter direct integration scheme

The simplest way of adding a battery (or a super capacitor) bank is the direct connection to the dc link of the grid side inverter, as shown in Fig. 1(a). But it suffers from several drawbacks such as large internal resistance, fixed current distribution governed by internal resistors, and lack of control over the power flow [8]. Effects of these issues can somewhat be reduced if an intermediate dc-dc converter is placed between the

Author : PG Scholar – Final Year, Power Electronics & Drives /EEE, K.S.Rangasamy College of Technology, Tiruchengode, Tamilnadu, India. E-mail : venuseee1989@gmail.com

Author : Associate Professor, Power Electronics & Drives/EEE, K.S.Rangasamy College of Technology, Tiruchengode, Tamilnadu, India. E-mail : kreee82@gmail.com

battery (or the super capacitor) bank and the dc link as shown in Fig. 1(b). But the disadvantage of this topology is the increased number of components, cost, and power losses.

Therefore, the possible alternative ways of connection to avoid additional dc-dc converter while maintaining the control flexibility. The result is the simple configuration shown in Fig. 1(c). In the figure, the dc-link capacitors of a standard diode-clamped five-level inverter are replaced by a battery bank and a super capacitor bank. Latter part of this paper discusses two more cases: one with two super capacitor banks and the other with two battery banks. If a change in the source or the load happens, the power imbalance will be compensated by the battery bank and/or super capacitor bank.

The main issue with this particular topology is the imminent imbalance of the neutral point potential which is due to unequal states of charge of the battery bank and the super capacitor bank. Comprehensive analysis on capacitor voltage unbalance and balancing techniques used in diode-clamped inverters can be found in the literature [1], [8]. A new Space Vector Modulation (SVM) method has been developed for diode-clamped five-level inverters with variable dc-link voltages. Furthermore, full controllability over small vector selection is available in the proposed SVM method. Relevant equations and diagrams are given in Section III with a detailed analysis. The proposed SVM technique involves more computations compared to simplified SVM techniques proposed in the literature. The THD values for the Traditional, Conventional and proposed inverters are compared and analysed.

II. UNBALANCED DC-LINK VOLTAGES EFFECTS

For the diode-clamped Five-level inverter, shown in Fig. 1(c), line-to-ground voltages can be derived from switching states S_a , S_b , and S_c , and the results are given in Table I. If the inverter is connected to a balanced three-phase load, corresponding phase voltages can be derived from line-to-ground voltages using (1). Then, these phase voltages are transformed into the dq reference frame by (2).

$$\begin{bmatrix} v_{as} \\ v_{bs} \\ v_{cs} \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix} \begin{bmatrix} v_{ag} \\ v_{bg} \\ v_{cg} \end{bmatrix} \quad (1)$$

Table 1 : Switching States And Line-To-Ground Voltages

Switching state S_a, S_b, S_c	IGBT Switching Sequence of the leg (Top to Bottom)	Line to ground Voltages v_{ag}, v_{bg}, v_{cg}
0	0011	0
1	0110	V_L
2	1100	$V_L + V_U$

$$\begin{bmatrix} v_{ds} \\ v_{qs} \\ V_0 \end{bmatrix} = \frac{2}{3} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} v_{as} \\ v_{bs} \\ v_{cs} \end{bmatrix} \quad (2)$$

The locations of small and medium vectors vary with dc-link voltages as shown in Fig. 2. However, locations of large vectors (2 0 0, 2 2 0, 0 2 0, 0 2 2, 0 0 2, and 2 0 2) depend only on the total dc-link voltage and would remain unchanged if the total voltage is constant. When capacitor voltages are balanced, positive and negative small vectors (2 1 1, 2 2 1, 1 2 1, 1 2 2, 1 1 2, 2 1 2, 1 0 0, 1 1 0, 0 1 0, 0 1 1, 0 0 1, and 1 0 1) coincide and only one inner hexagon is formed as shown in Fig. 2(b). Furthermore, medium vectors (2 1 0, 1 2 0, 0 2 1, 0 1 2, 1 0 2, and 2 0 1) reach midpoints of the outer hexagon. If an unbalance is present, small vectors split and two separate inner hexagons appear as shown in Fig. 2(a) and (c). In addition to that, medium vectors move toward large vectors. The size of the inner hexagon formed with negative small vectors depends on the battery voltage, which is nearly constant in the proposed system. Similarly, the size of the inner hexagon formed with positive small vectors varies with the super capacitor voltage. The circles marked with dotted lines in Fig. 2 represent the path of the reference voltage vector. In the proposed method, the super capacitor voltage is allowed to vary in a way that this circle will always remain within the outer hexagon and middle inner hexagon. If the normal SPWM with two equal carriers, as shown in Fig. 3(b),

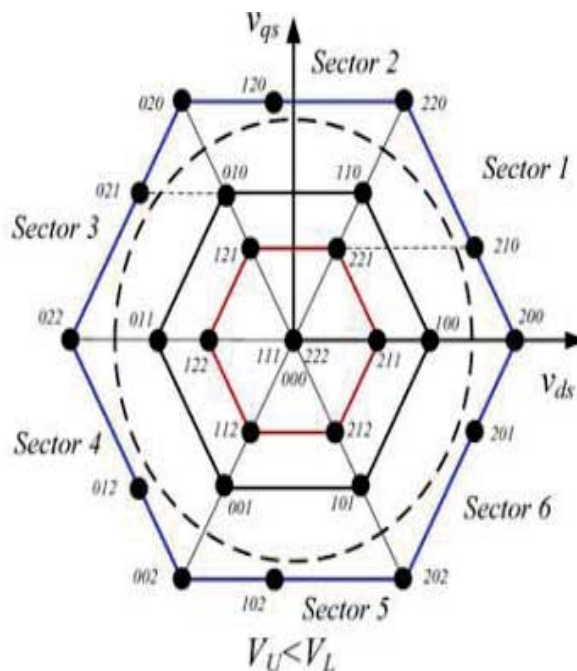


Fig. 2 (a) : Space vector diagram for $V_U < V_L$


$$A_U = \frac{2V_U}{V_U + V_L} \quad (3)$$

$$A_L = \frac{2V_L}{V_H + V_L} \quad (4)$$

description of the proposed SVM technique is given in Section III.

III. IMPLEMENTATION OF SVM TECHNIQUE

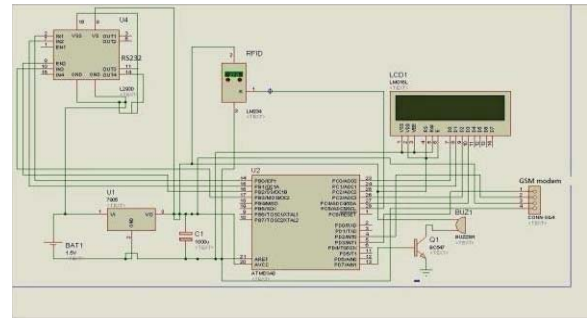


Fig. 3 : Block diagram of the proposed technique

The diagram shows a coordinate system with \$v_{qs}\$ on the vertical axis and \$v_{ds}\$ on the horizontal axis. A large red triangle connects points 000, 200, and 220. Other points labeled include 120, 110, 210, 221, 211, 100, and 200. Vectors are drawn from the origin (000) to various points. A dashed arc centered at the origin passes through points 100 and 210. A dashed line segment connects point 210 to the \$v_{ds}\$ axis at point 100. Angles \$\theta_1\$ and \$\theta_2\$ are indicated near the origin. Horizontal distances along the \$v_{ds}\$ axis are labeled \$x\$ and \$y\$. The angle between the \$v_{ds}\$ axis and the dashed line segment is labeled \$\alpha\$.

Fig.4 (a) : Limit Angles for Triangles Formed with Lower Small Vectors

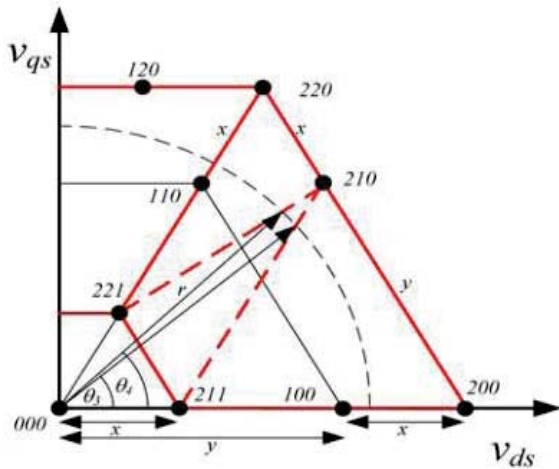


Fig. 4 (b) : Limit Angles for Triangles Formed with Upper Small Vectors

$$x = \frac{2}{3}V_U, \quad y = \frac{2}{3}V_L \quad (5)$$

$$\alpha = \sin^{-1} \left(\frac{\sqrt{3}y}{2\sqrt{(x+y)^2 - 3xy}} \right) \quad (6)$$

$$\theta_1 = \alpha - \sin^{-1} \left(\frac{\sqrt{3}y^2}{2r\sqrt{(x+y)^2 - 3xy}} \right) \quad (7)$$

$$\theta_2 = \sin^{-1} \left(\frac{\sqrt{3}y}{2r} \right) \quad (8)$$

$$\theta_3 = \frac{\pi}{3} - \sin^{-1} \left(\frac{\sqrt{3}x}{2r} \right) \quad (9)$$

$$\theta_1 = \alpha - \frac{\pi}{3} - \sin^{-1} \left(\frac{x}{r} \sin \left(\alpha - \frac{2\pi}{3} \right) \right) \quad (10)$$

$$z = d_1V_1 + d_2V_2 + d_3V_3 \quad (11)$$

$$d_1 + d_2 + d_3 = 1 \quad (12)$$

The limit angles given in (7)–(10) are valid only for sector 1. Once the limit angles are calculated, the triangle and corresponding three vectors can easily be derived. After finding the three vectors, the next step is to determine switching times. According to the well-known volt-second balancing principle, a given reference vector can be synthesized by three adjacent vectors. Equations (11) and (12) provide the mathematical description of this process. Equations (13)–(16) are used to calculate corresponding switching times $d_1 - d_3$ that are expressed as fractions of the sampling time.

$$\Delta = (x_1y_2 - x_2y_1) + (x_2y_3 - x_3y_2) + (x_3y_1 - x_1y_3) \quad (13)$$

$$d_1 = \frac{(x_0(y_2 - y_3) + y_0(x_3 - x_2)) + (x_2y_3 - x_3y_2)}{\Delta} \quad (14)$$

$$d_2 = \frac{(x_0(y_3 - y_1) + y_0(x_1 - x_3)) + (x_3y_1 - x_1y_3)}{\Delta} \quad (15)$$

$$d_3 = \frac{(x_0(y_1 - y_2) + y_0(x_2 - x_1)) + (x_1y_2 - x_2y_1)}{\Delta} \quad (16)$$

Where $(x_n, y_n) n = 0, \dots, 3$ are the coordinates of vector points.

IV. SIMULATION AND RESULTS

The five level diode clamped multilevel inverter simulation results and analysis describe in this section. It has described open loop and closed loop output of DCMLI phase voltage of DCMLI,

a) Simulation Diagram for PV System

The simulation diagram for five levels DCMLI with PV is shown in the Figure 5. The PV is used as the input source. The PV simulation model diagram is given below with clearly. In this two Panels are connected.

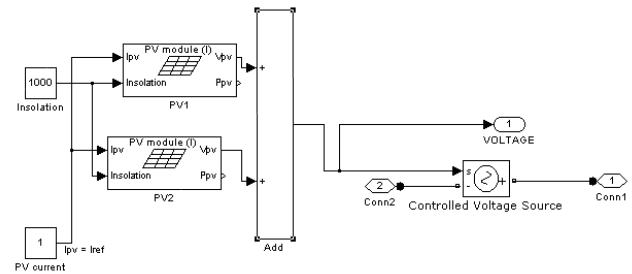


Fig 5 : Simulation Diagram for PV System

b) Simulation Diagram for Open Loop Diode Clamped Multilevel Inverter

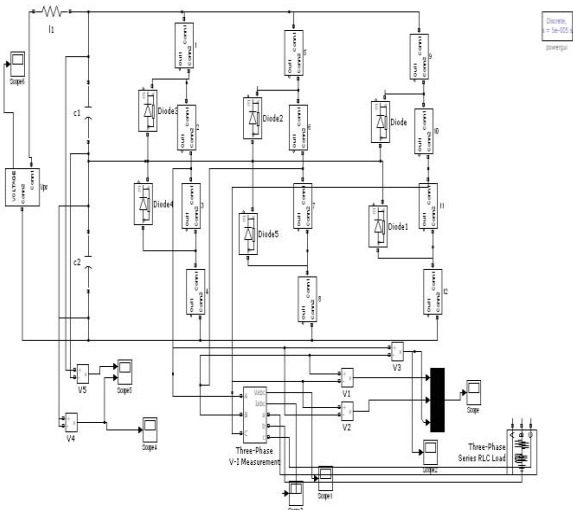


Fig 6 : Simulation Diagram for Open Loop Diode Clamped Multilevel Inverter

The simulation diagram for open loop DCMLI with PV is shown in the Figure 6. The modeling of five levels DCMLI inverter has been developed by using MATLAB. The simulation model parameters are given in

table 3. With the use of this proposed method harmonics are eliminated. Therefore the efficiency of inverter is increased.

c) Simulation Diagram for Space Vector Modulation

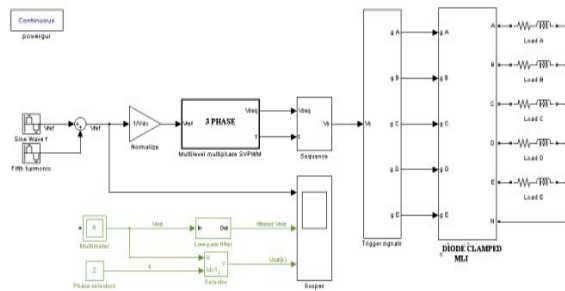


Fig. 7 : Simulation Diagram for SVPWM Techniques

The simulation diagram for space vector Modulation is shown in Figure 7. With the use of this proposed method harmonics are eliminated. Therefore the efficiency of the inverter is increased. Some soft switching method can be used for multilevel inverter to reduce the switching loss and to increase the efficiency.

d) Simulation Diagram for DCMLI with SVPWM

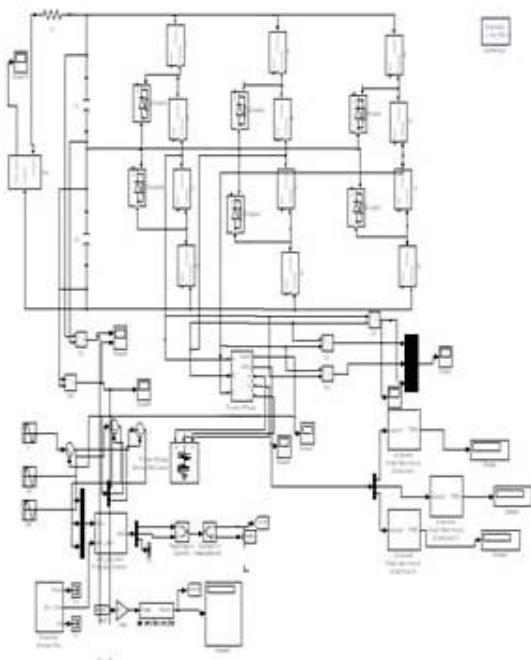


Fig. 8 : Simulation Diagram for DCMLI with SVPWM

The simulation of DCMLI with SVPWM is shown in the figure.8. This is done by using space vector PWM. A reference signal is compared with two triangular carrier signals that are phase shifted by 90 degree. The resulting PWM signals control the corresponding switches. This control strategy is used to get accurate five level stepped outputs for Diode clamped multilevel inverter.

V. RESULT AND ANALYSIS

a) Simulation Waveform for Photovoltaic System

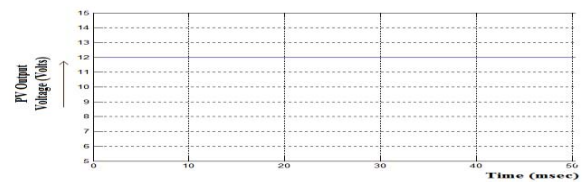


Fig. 9 : Input Voltage from Solar Panel

An input voltage of 12V is shown in the Figure 9. An accurate PV module electrical model is presented based on the Shockley diode equation. The general model was implemented on MATLAB scrip file, and accepts irradiance and temperature as variable parameters and outputs the I-V characteristic.

b) Simulation Waveform for Open Loop

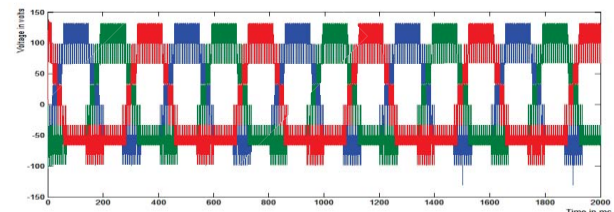


Fig. 10 : Output Voltage Waveform for Open Loop

The output of DCML Phase voltage is shown in Figure 10. It has 100V, 50 Hz frequency. The phase voltage has three levels, positive half cycle of hundred volts and negative half cycle of hundred voltages. The five level output are in stepped waveform the X-axis consists of time period in milliseconds and Y- axis consists of voltage in volts.

c) Simulation Waveform for Space Vector Modulation

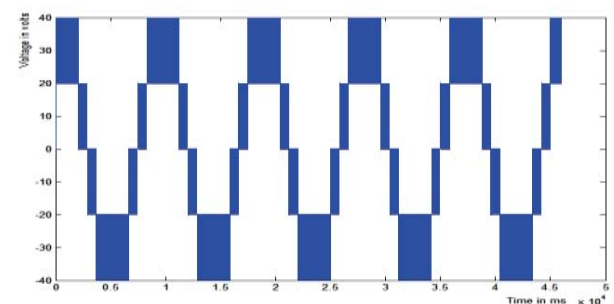


Fig. 11 : Space Vector Modulation Output Voltage

The Space Vector Modulation Output Voltage is shown in Figure 11. It has 40V, 50 Hz frequency. The phase voltage has five levels, positive half cycle of forty volts and negative half cycle of forty voltage. The five level output are in stepped waveform the X-axis consists of time period in milliseconds and Y- axis consists of voltage in volts.

d) *Line Voltage Waveforms of the Diode Clamped Multilevel Inverter Output*

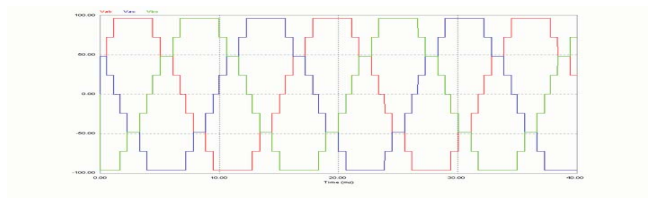


Fig. 12 : Line Voltage Waveforms of the DCMLI

The Figure 12 is the Line Voltage Waveforms of the Diode Clamped Multilevel Inverter Output.

It has 100V, 50 Hz frequency. The phase voltage has five levels, positive half cycle of hundred volts and negative half cycle of hundred voltages. The five level output are in stepped waveform the X-axis consists of time period in milliseconds and Y- axis consists of voltage in volts.

e) *Simulation Waveform for DCMLI with SVPWM*

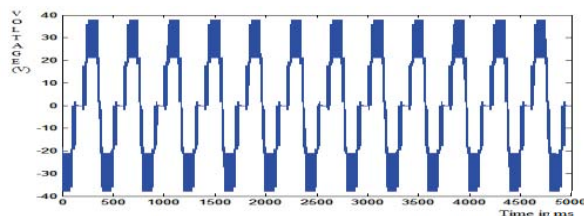


Fig. 13 : Closed Loop Inverter Output Voltage

The output of Diode clamped multilevel inverter with space vector modulation phase voltage closed loop inverter output voltage is shown in Figure 13. It has 40V, 50 Hz frequency. The phase voltage has five levels, positive half cycle of hundred volts and negative half cycle of hundred voltages. The five level output are in stepped waveform the X-axis consists of time period in milliseconds and Y- axis consists of voltage in volts.

f) *Total Harmonics Distortion Analysis*

The Total Harmonics Distortion for open loop system is given figure 14.

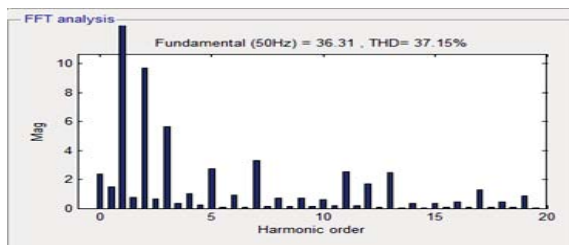


Fig. 14 : THD Analysis for Open Loop System

The figure 14 Total Harmonics Distortion for open loop system. The Total harmonic distortion of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. THD is used to characterize the

linearity of audio systems and the power quality of electric power systems.

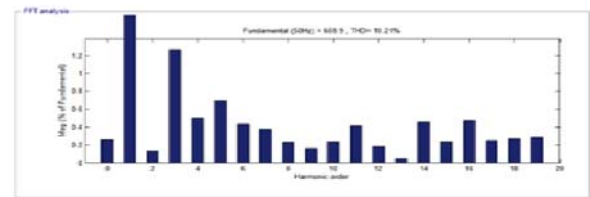


Fig. 15 : Total Harmonics' Distortions waveform for Closed Loop System with SVM

The figure 15 Total Harmonics Distortion for closed loop system. In power systems, lower THD means reduction in peak currents, heating, emissions, and core loss in motors. The output voltage THD is less than 12%. Thus by using the proposed scheme THD and switching losses are reduced.

Table 2 : THD comparison

Kind of the MLI	2 Level MLI	3 Level MLI	5 Level Propose d MLI
THD	58.84%	53.84%	10.16%

From the table 3 different inverter THD values are compared. The proposed inverter THD value is obtained as 10.16%, which is the best among all. This shows that quality of the five level inverter is improved.

V. CONCLUSION

This paper is the first step to develop a complete solar photovoltaic power electronic conversion system in simulation. The Proposed topologies eliminate the need for additional dc-dc converters by connecting two battery banks, two super capacitor banks or a battery bank, and a super capacitor bank directly across dc links of a diode clamped five-level inverter. Unavoidable dc-link voltage imbalance is the major issue with these topologies. This problem is handled by a novel space vector modulation technique. Further work is needed to improve the efficiency by reducing THD and the hardware will be designed for different power levels. The THD values for the Traditional, Conventional and proposed inverters are compared and analysed.

REFERENCES RÉFÉRENCES REFERENCIAS

1. AlirezaNami, and FiruzZare,[2011] "A Hybrid Cascade Converter Topology with Series-Connected Symmetrical and Asymmetrical Diode-Clamped H Bridge Cells" IEEE Transactions on Power Electronics, Vol. 26, No.1,PP: 51-65.
2. Anshuman Shukla, and Arindam Ghosh, [2010] "Flying-Capacitor-Based Chopper Circuit for DC Capacitor Voltage Balancing in Diode-Clamped Multilevel Inverter" IEEE Transactions on Industrial Electronics, Vol. 57, No. 7,PP: 2249-2261.

3. Arash A. Boora and AlirezaNami,[2010] "Voltage-Sharing Converter to Supply Single-Phase Asymmetrical Four-Level Diode-Clamped Inverter with High Power Factor Loads. IEEE Transactions on Power Electronics, Vol. 25, No. 10, PP: 2507-2520.
4. AshishBendre and Slobodan Krstic, [2005] "Comparative Evaluation of Modulation Algorithms for Neutral-Point-Clamped Converters" IEEE Transactions on Industry Applications, Vol. 41, No. 2, PP: 634-643.
5. BehzadVafakhah and Jeffrey Ewanchuk,[2011] "Multicarrier Interleaved PWM Strategies for a Five-Level NPC Inverter Using a Three-Phase Coupled Inductor" IEEE Transactions on Industry Applications, Vol. 47, No. 6,PP: 2549-2558.
6. Berkouk, and C. Saudemont, September [2007] "DC Link Capacitor Voltage Balancing in a Three-Phase Diode Clamped Inverter Controlled by a Direct Space Vector of Line-to-Line Voltages" IEEE Transactions on Power Electronics, Vol. 22, PP: 1636-1648.
7. GaminiJayasinghe, and D.MahindaVilathgamuwa, [2011]"Diode-Clamped Three-Level Inverter-Based Battery/Super capacitor Direct Integration Scheme for Renewable Energy Systems. IEEE Transactions on Power Electronics, Vol. 26, No. 12, PP: 3720-3729.
8. EnginOzdemir, and SuleOzdemir, [2009] "Fundamental-Frequency-Modulated Six-Level Diode-Clamped Multilevel Inverter for Three-Phase Stand-Alone Photovoltaic System" IEEE Transactions on Industrial Electronics, Vol. 56, No. 11, PP: 4407-4415
9. Hirofumi Akagi and Kazunori Hasegawa,[2011] "A New DC-voltage-Balancing Circuit Including a Single Coupled Inductor for a Five-Level Diode-Clamped PWM Inverter" IEEE Transactions on Industry Applications, Vol. 47, No. 2,PP: 841-852.
10. Huafeng Xiao, and ShaojunXie,[2012] "Transformer Less Split-Inductor Neutral Point Clamped Three-Level PV Grid-Connected Inverter" IEEE Transactions on Power Electronics, Vol. 27, No. 4,PP: 1799-1808.
11. Jeffrey Ewanchuk, and John Salmon,[2011] "A Five-/Nine-Level Twelve-Switch Neutral-Point-Clamped Inverter for High-Speed Electric Drives" IEEE Transactions on Industry Applications, vol. 47, no. 5,PP: 2145-2153.
12. Jose I. Leon and Sergio Vazquez,[2009] "Three-Dimensional Feed Forward Space Vector Modulation Applied to Multilevel Diode-Clamped Converters" IEEE Transactions on Industrial Electronics, Vol. 56, No. 1,PP: 101-109.
13. Kazunori Hasegaw and Hirofumi Akagi,[2011] "A New DC- voltage-Balancing Circuit Including and Single Coupled Inductor for a Five -Level Diode Clamped PWM Inverter" IEEE Transactions on Industry Applications, Vol. 47, No. 2,PP: 841-852.
14. Kazunori Hasegawa and Hirofumi Akagi, [2012] "Low Modulation – Index Operation of a Five Level Diode Clamped PWM Inverter with DC-voltage-Balancing circuit for a motor drive" IEEE Transactions on Power Electronics, Vol. 27, No. 8,PP: 3495-3504
15. Masaaki Takagi and Yumiko Iwafune, [2012] "Economic Value of PV Energy Storage Using Batteries of Battery-Switch Stations" IEEE Transactions on Sustainable Energy, PP: 1-10.





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A Qualitative Segmentation of Drinking Water Market in Tunisia: Regional Diversification

By Ali Bouchrika & Dr. Fakhri Issaoui

Université de la Manouba, Tunisie

Abstract - How does the Tunisian consumer react to drinking water quality? This question is still unexplored because quality was always assumed to be homogeneous while it is not. This paper provides answers and allows us to test the importance of the variable "quality" as a key determinant of global and regional drinking water demand function (Greater Tunis, Sousse and Gabes).

Design / methodology / approach : We have used, through an exploratory survey of a sample of 1200 households, econometric estimates to determine the weight that Tunisian consumers ascribe to the variable quality in their water demand functions.

Results : The estimated demand functions in the regions of Greater Tunis, Sousse and Gabes, revealed the importance of quality as a fundamental determinant of quantities requested by consumers. The empirical analysis has shown that in Greater Tunis water quality is not a constraint on demand. However, in the regions of Sousse and Gabes, water quality is an important factor in determining consumer behaviour.

Research limitations / implications : The empirical results depend on the 2004 survey.

Keywords : *drinking water management - drinking water quality - demand function - consumer preferences - social equity.*

GJRE-F Classification : *FOR Code: A11-Q20-Q56*



A QUALITATIVE SEGMENTATION OF DRINKING WATER MARKET IN TUNISIA REGIONAL DIVERSIFICATION

Strictly as per the compliance and regulations of :



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Originality / value : In most developing countries, we notice absence of real drinking water markets which did not lead to a true and fair valuation of drinking water. The integration of the variable quality to estimate regional demand functions allows Tunisian policymakers to rethink current drinking water management. Market segmentation based on qualities will create a fairer market where the consumer pays a fair price consistent with the quality received.

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1. INTRODUCTION

There is no doubt that water is vital for both humans and for other species. Thus, according to Frederico Mayor [1999] "Water is first a natural and ecological good that plays an important role in the biosphere and whose functions are useful to mankind. It can not be reduced to that of a raw material exploitable and expendable at will. It is a social and economic good whose uses by humans are regulated by law."

However, despite the importance of this resource, we notice that it exists in limited quantities and is unevenly distributed in the world. Moreover, very large spatial and regional disparities in the quality of fresh water are recorded. To this shortage is added a quantitative mismanagement which is explained by many factors (patterns of unsustainable development, population growth, drought, ecological imbalances etc.).

The figures show that more than a billion people do not always have access to clean and safe water. The problem of quality is one of the leading causes of death and disease in the world. Climate change and pollution threaten drinking water which represents only 3% of the world's water.

Faced with this multidimensional challenge (political, socio-economic and ecological), the World Bank, in recent statistics, estimated that water supply would require \$ 180 billion a year for developing countries in the next 25 years, while the current investment is around 70 to 80 billion. Henceforth, it is necessary to review current use patterns of this resource in terms of production and consumption so that any water use is done while preserving the interests of future generations.

Tunisia, like many countries in the world, can be classified as a disadvantaged geographical area where available water resources continue to decline and where reserves have reached their threshold. The relative scarcity of this resource is one of the major challenges facing the Tunisian decision-makers for a more effective and efficient management of the said resource.

The current principle of water management depends, in a large measure, on recorded rainfall. In other words, the surplus in years of high rainfall must be used and operated in low rainfall years. But as long as these resources are often limited, random and unevenly distributed across the country, this solution remains inadequate and highly risky. Indeed, a policy of sustainable development should be based on stable water resources in order to promote the productive sectors (agriculture, tourism, agribusiness, etc.).

Urbanization, migration to the capital (Tunis) and coastal governorates and climate change have created an imbalance between water supply and demand. The adjustment to be done is primarily quantitative and the central constraint to take into account. It is that of satisfying global demand. However, this quantitative water resources management did not often integrate water quality as a decision variable in pricing policy. That quality is considered homogeneous by SONEDE despite the huge variation in the physico-chemical nature of water distributed within and across regions.

Thus, the underlying objective of this paper is to study the influence of the variable quality on the structure of the global and spatial drinking water

demand in Tunisia. The variable "quality" that was excluded in the policy of SONEDE may present a critical factor in changing consumer preferences.

The remainder of this paper is organized as follows: the second section presents an analysis of drinking water quality. The third section will describe the empirical methodology checking for the quality problem in water resources management. The fourth section gives the estimation results of the econometric models and their interpretation. The last section concludes the paper.

II. DEFINITION AND ANALYSIS OF THE QUALITY OF DRINKING WATER IN TUNISIA

In a crude way, quality of drinking water needs to satisfy two basic criteria. The first takes into account the enforced national and international standards determining the physico-chemical characteristics that water should meet in order to be a drinking water (taste, clarity, smell ... etc.). The second criterion relates to the quality of different services and facilities necessary to ensure efficient production and a continuous distribution.

In Tunisia, the issue of water quality is always raised as we easily notice that this good is not homogeneous either within or across regions. By way of illustration and not exclusive, treatment of surface waters in the North of Tunisia offers water quality that complies with that required by international standards. However, this quality can cause problems especially in Centre and in the South of the country. Although the Tunisian strategy recommends nationally serving water salinity less than 1.5 g / l. This objective is not fully achieved between different regions of the country and even within the same region.

While aware of this problem, in the context of an approach aimed at improving quality of services to its customers, "the SONEDE conducted a satisfaction survey in April 2003 and had two fundamental objectives. First, assess current quality of service provided by SONEDE and secondly to measure level of quality expected by customers. The selected sample covered 2100 subscribers (in domestic drinking water) spread over 33 districts and centres and including all social levels. The results indicate that 19% of customers believe that quality of supplied water is excellent, 30% judge it as good, 32% consider it average, while the rest (19%) consider it bad."³

Low levels of satisfaction are recorded especially in the South where salinity is relatively high. These results confirm bacteriological studies and analyzes by samples that showed evolution (in percentage) of filthy water (i.e. quality of drinking water is a consumption problem for users) for the whole of Tunisia, reaching 1.5% in 2009 and ranged from a

minimum of 0.4% recorded in the northern regions to a maximum of 1.7% recorded in the South.

It follows from what has been mentioned above that quality of drinking water is a serious problem in the Tunisian context which makes its current management inefficient and unfair especially that the constraints faced by decision-makers are numerous (scarcity, unequal distribution, quality heterogeneity etc.). In other words, variability of water quality within and across regions needs a price discrimination policy that takes into account scarcity of the resource and financial resources of users.

III. EMPIRICAL METHODOLOGY

To analyze the problem of drinking water quality in Tunisia, we used a study of a statistical survey conducted on a sample of 1,200 households. The underlying thinking behind this study is to cover and represent all professional categories of consumers who are served water from the SONEDE. Variation in consumer preferences is detected by the personal assessment of households questioned about their drinking water consumption (taste, smell, clarity, etc.).

a) Presentation of the Survey

As already mentioned, the survey we conducted during 2004, allowed us to better understand households behaviour with respect to their consumption of drinking water and their reactions towards a set of independent variables of strategies of consumption. To meet the ratio of 10% of the population base as minimum size of the sample, the total size of the sample is 1200 households. To involve all socio-professional categories we had recourse to a stratified sampling design which allowed us to ensure their representativeness. Each stratum includes a definite socio-professional category and classified according to a given number of individuals. Finally, each stratum is distributed in their appropriate cities.

The questions of the questionnaire are designed to clarify two distinct problems. First, how consumers feel they current water management and secondly, how they know to evaluate the water quality they consume. The basic unit of our sample is the "household" while the independent variables of demand function are household income, quality of drinking water, the quantity of bottled water consumed, existence of alternative sources, type of occupied residency, household size and education level (Point (1993) and Howe (1982)).

b) Functions of Global and Regional Demand

Research focusing on estimating water demand function are scarce and mostly exploratory in nature, since consumed water quantity is often independent of current costs incurred by distribution companies. According to Point [1993] analysis of drinking water

demand is primarily focused on the needs. Quantity of water consumed and prices depend on the particular evolution of population as well as their lifestyle.

Among the few studies that have focused on estimating drinking water demand function include those of Howe [1982] and Point [1993]. The first has linked consumption and price through a cross-sectional analysis. Point [1993] focused on the problem of sharing water resources between different users. To do this, the author took into account three categories of use; commercial, industrial and domestic. The results indicate that price elasticity is around -0.167 compared to average price for the department of Gironde in France (such a study is conducted to estimate drinking water demand, throughout Tunisia and for "domestic use" category in 2004, which reached an elasticity approaching - 0.42 compared to the average).

Like in several countries of the world and Tunisia, the demand function model does not include water quality as a variable. This variable can be fixed in advance by the supervisory authority as in France where it offers a multitude of water agencies available to consumers. In other countries such as Tunisia quality is considered, or rather assumed, as a homogeneous entity, although it is not.

Therefore, the introduction of the variable quality in the demand function model aims at anticipating changes in consumer preferences due to a change in the nature of quality offered. Indeed, these variations can be explained by the negative or positive effect that the variable quality may have on the quantities consumed by households expressed by the amount of the bill. To achieve this goal, drinking water demand function model should take the following form:

$$y_i = \alpha_0 + \alpha_1 x_i + \alpha_2 z_i + e_i$$

Where y_i represents the amount spent by a household to purchase drinking water, x_i represents a vector of variables related to water management and z_i represents a vector of variables related to households' socio-economic characteristics.

Therefore, according to the followed empirical procedure, this model will be estimated in various ways. At first, demand function estimation will include all observations in the sample, and this to see and understand the inter-regional impact and how quality varies from one region to another. In a second step, estimation of demand function is done separately in three major geographical areas of Tunisia, namely Greater Tunis, Sousse and Gabes, to infer intra-regional information on drinking water management.

IV. RESULTS AND DISCUSSION

a) Descriptive Analysis

Through a rough view of the information gathered from the questionnaire, we can draw the following conclusions:

- i. The most frequent quarterly amount of the bill is 30 dinars. This amount is spent by 138 households which represent 11.5% of our sample.
- ii. Availability of drinking water is not generally a problem for the Tunisian consumer given that this resource is distributed continuously throughout the year (359.11 / d 365) and given a rate of availability approaching 98.6%. The few disturbances and interruptions are recorded during summer season.
- iii. Households with higher incomes are more likely to put at risk current water quality and this because they have the means to substitute it. The figures confirm the hypothesis that the proportion of households (86.4%), who had a poor evaluation (to an average limit) of water quality provided by SONEDE mostly belongs to the class of rich households.
- iv. Most respondents have no idea about SONEDE pricing policy. Those who know pricing (16.9%) generally have a secondary second cycle or higher education level.
- v. Analysis also indicates that 24% of households have alternative sources (Magin, Well, others ...) in favour of domestic consumption. This category of consumers is assumed to be in search of new water sources substitutable to SONEDE water especially if that category believes that drinking water quality is bad.
- vi. According to the results of the survey, 57.1% of households use bottled water. This type of good is indeed an effective solution for a broad class of consumers, especially in the case where drinking water quality poses problems in terms of consumption. Most respondents believe that bottled water is a necessity especially for those who have some diseases (renal failure, etc.) or who have fear of having them. Faucet water and irrespective of its quality is assumed to have a lower quality than that of bottled water. We note that in average each household consumes 5.19 liters per week.
- vii. Most respondents felt that drinking water quality is bad or average at most (86.4%) while only 13.6% consider it satisfactory.

b) Econometric Analysis

Data processing of the statistical survey indicates that water demand depends on a complex structure of variables which are alternative sources, household size, how consumers evaluate faucet water quality, occupation of housing and income level. These

variables have a significant effect on determining consumer behaviour towards demanded water quantity.

The econometric analysis aims at estimating the coefficients of these variables based on econometric methods appropriate for estimating evaluation functions in order to have highly significant results, which may be consistent with economic intuition, and useful to the design and implementation of all appropriate policies for sustainable management of a resource that is becoming dramatically scarce.

In this context, the main objective of the various econometric estimation is to determine the variables that are capable of influencing consumer behaviour. Then, the variables retained the in various econometric regressions are given by:

- i. MFEPT : Amount of Quarterly Water Bill
- ii. SAE : an alternative water source of household.
- iii. Achat : amount spent on the purchase of bottled water.
- iv. LIT : number of liters of bottled water consumed per week.
- v. Qualité : quality of tap water.

$$MFEPT_i = 7,870 + 4,009 Taille_{1i} + 0,0123 Revenu_{2i} - 21,400 SAE_{3i} - 0,305 LIT_{4i} + 1,125 Qualité_{5i} \quad (1)$$

(5,553) (20,406) (14,918) (-21,408) (-4,130) (1,692)

$$R^2 = 0,523 \quad \bar{R}^2 = 0,521$$

Indeed, it is observed that the size variable has a positive and significant coefficient with an error risk of 1%, which means that water consumption increases with number of people who constitute the household. The coefficient on household income is also positive and significant at an error risk of 1%. This result is consistent with economic predictions as long as the richer the household is the more water it consumes. Thus, a household with a high income had to pay a higher MFEPT.

The variable SAE coefficient is negative and significant at the 1% level. This means that when the household has alternative water sources, drinking water consumption decreases. This confirms the economic theory that states that a demand for a good decreases when the consumer makes use of perfect or near perfect substitutes.

The coefficient on LIT is negative and significant at the 1% level. Indeed, as consumers use mineral water they spend less on purchasing drinking water delivered by SONEDE.

$$MFEPT_i = 6,737 + 4,691 Taille_{1i} + 19,588 Revenu_{2i} - 0,00677 SAE_{3i} \quad (2)$$

(3,381) (13,348) (-10,627) (5,176)

$$R^2 = 0,560 \quad \bar{R}^2 = 0,556$$

The estimated model indicates that the coefficients of size and household income are positive

vi. Prop: a variable for the legal nature of housing occupation (1 if owner is 0 otherwise).

vii. Taille: household size.

viii. Nivist: educational level of the interviewee.

ix. Nbdac: number of people in the household.

x. Prof: occupation of the interviewee.

xi. Revenu: household income.

Construction of econometric models resulted in a mixed set of independent variables; in this case we speak of covariance models. The goodness of fit of these models also depends on the choice of predictors. It is desirable to select a limited number of variables, non-redundant and with predictive power. The most common technique used to select the most explanatory variables is the Forward Stepwise Regression method⁴.

i. Global Demand Function

Applying a "Forward Stepwise Regression" allows us to overcome problems encountered in a multicollinearity model. Therefore, the model chosen (after testing normality of errors) and corrected of all the problems of heteroskedasticity and autocorrelation of errors allowed us to obtain the following results:

The coefficient of the variable "faucet water quality" is positive and statistically significant at the 10% level. This implies that amount of bill varies with the level of quality estimated by households (good - average - poor). Therefore, amount of bill is low in case of poor quality especially if the household has an alternative source.

ii. Spatial Demand Function

In this section we try to estimate demand function in the regions of Greater Tunis, Sousse and Gabes to know the specifics of consumption structure and consumer behaviour in each of them. To this end, we will introduce permanent and fundamental variables in the construction of a valid econometric model for each region.

a. The Greater Tunis Area

For this region the estimated model has the following results:

and significant with an error risk of 1%. These results are perfectly logical because large families or who have high

incomes consume more water. In addition, the variable SAE coefficient is negative and significant at an error risk of 1%, which means that consumption decreases with the existence of alternative sources, in which case consuming SONEDE water becomes smaller.

$$\text{MFEPT}_i = 41,761_{(12,183)} - 1,553_{(-2,881)} \text{Taille}_{i1} + 0,00451_{(2,464)} \text{Revenu}_{2i} + 4,827_{(2,194)} \text{Qualité}_{3i} \quad (3)$$

$$R^2 = 0,228 \quad \bar{R}^2 = 0,220$$

In this region, the coefficient on Taille (Size) is negative and significant at an error risk of 1%. This result is not consistent with reality, since in principle water consumption increases with household size. Can we say that there is some correlation between family size and household wealth? A priori, the answer is positive, which means that a small family is probably richer and therefore it consumes more water.

The coefficients on income and water quality

$$\text{MFEPT}_i = 11,454_{(3,352)} + 2,436_{(3,291)} \text{Taille}_{i1} + 0,00949_{(3,886)} \text{Revenu}_{2i} - 15,975_{(-4,868)} \text{SAE}_{3i} - 0,663_{(-2,387)} \text{LIT}_{4i} + 2,074_{(1,779)} \text{Nbdac}_{5i} \quad (4)$$

$$R^2 = 0,355 \quad \bar{R}^2 = 0,338$$

The coefficients on Size, SAE and income are significant at the 1% risk level. Size and income have positive coefficients but SAE has a negative coefficient. The coefficient of the variable Nbdac is positive and significant at the 10% risk level, which means that when the number of people in a household increases there will probably be a wealth effect that is created and encourage the said household to consume more drinking water, resulting on a positive effect on MFEPT. The coefficient on LIT is negative and significant at an error risk of 5%. This means that in this region, there's a general movement towards consuming bottled water to replace SONEDE water especially for drinking.

V. CONCLUSION

The estimation of water demand function indicated that the dependent variable (MFEPT) in the different models is influenced by many variables that need to be integrated in water management. The most important variable is the quality variable which essential in household consumption structure. The estimation of regional demand functions in the areas of Greater Tunis, Sousse and Gabes showed that variation of the variable MFEPT is mainly due to household size, income, SAE and especially the variable quality which differs significantly between these three regions. In Greater Tunis, this variable is not problematic while in the other two regions of Sousse and Gabes, the situation becomes more complicated. In these two regions faucet water quality is a dominant factor in explaining consumer behaviour. Indeed, in the region of Sousse bill

b. The Sousse Area

In this region the linear regression estimated is given by:

are positive and significant at the 5% level. As household income increases, more water is consumed. Moreover, when drinking water quality improves then consuming water increases, thereby increasing the amount spent by consumers.

c. The Gabes Region

The linear regression estimated in this region gave the following results:

amount varies directly with the level of quality offered, while in the region of Gabes this variation is explained by the fact that consumers are looking for substitutable goods (SAE, LIT).

However, despite its importance in water management, the variable quality is still neglected by decision-makers. Should we rethink SONEDE pricing policy and restructure it so that it is fairer and more effective? The answer is, a priori, positive because the current strategy of drinking water management in Tunisia has reached almost its limits. Thus, it would be wiser to recognize heterogeneity in the quality of water distributed and price according to the quality offered taking into account households' socio-economic status and this to ensure their right to healthy and pure water consumption.

FOOTNOTES

1. Assistant at the Institute of Management of Gabes, Gabes University, PO Box 37, ISG Gabes Street Al Habib Jilani, 6000, Gabes, Tunisia. E-mail: ali.bouchrika@yahoo.fr
2. Assistant Professor in Economics; researcher in contemporary philosophy. Graduate School of Business la Manouba Tunis, Manouba University, Tunisia. E-mail: fakhrissaoui@yahoo.fr
3. **Bouchrika, A ; Issaoui, F and Charfeddine L.** (2012) "La qualité de l'eau potable et les préférences de consommateurs : cas de la Tunisie"

in Global business and Management research vol 4 n°2.

4. When the number of variables is important and to avoid multicollinearity problem between the independent variables, it is necessary to have methods for the automatic selection of variables: forward stepwise regression, back ward stepwise regression or a combination of both methods.

REFERENCES RÉFÉRENCES REFERENCIAS

1. Amigues, J-P ; Bonnieux F ; Legoffe P and Point P. (1995), Valorisation des usages de l'eau. Economica.
2. Anne, B. (2004), Fondements théorique pour une tarification de l'eau en Afrique subsaharienne : une revue de la littérature, VI^{ème} Journées Scientifiques Réseau «Analyse économique et développement » : le financement du développement et réduction de la pauvreté. Agence Universitaire de la Francophonie.
3. Bahri, A. (2002), Water Reclamation and Reuse in Tunisia, Manuscrit, National Institute for Research on Agricultural Engineering Water, And Forestry, Tunis.
4. Bouchrika, A; Issaoui, F and Thabet, K. (2012), Le Management de l'eau potable dans le long terme (vers une gestion plus efficace: Application au cas Tunisien), Global Journal of Management and business research GJMBR, Volume 4 Issue 3.
5. Bouchrika, A ; Issaoui, F and Charfeddine L. (2012), La qualité de l'eau potable et les préférences de consommateurs : cas de la Tunisie" in Global business and Management research vol 4 n°2.
6. Bruno, R. (1994), The sustainable management of water resources in rural areas: the role of water in land planning, Revue of economic urban regional N°4.
7. Desvougues, W.S; Smith V.K. and McGivney M.P. (1983), Comparison of Alternative Approaches for Estimating Recreation and Related Benefits for Water Quality Improvements, U.S. Environmental Protection Agency.
8. Howe, C.W. (1982), Impact of price residential water demand: new insights, Water Resources Research 18, 713-716.
9. Jaglin, S. (2001), L'eau potable dans les villes en développement : les modèles marchands face à la pauvreté, In : les nouvelles politiques de l'eau : enjeux urbains, ruraux, régionaux », Revue Tiers Monde. N° 166.
10. Lionel, P. (2004), Enquête sur le consentement à payer pour maintenir le caractère maritime du Mont-Saint-Michel, Coastman Working papers N°14.
11. Mayor, F. (1999), Un monde nouveau, Paris Editions Odile Jacob, 530 PP.
12. Marcel, B and Serge, G. (2004), Régulation et mode de gestion : une étude économétrique sur les prix et la performance dans le secteur de l'eau potable, (Version préliminaire). Université de Montréal. Laboratoire GEA, ENGREF Montpellier France.
13. Marielle, M. (2004), La structure de la tarification de l'eau potable et de l'assainissement en France. Éléments de réponse à travers d'une enquête nationale, Cemagref et École nationale du Génie de l'eau et de l'environnement de Strasbourg.
14. Matoussi, M. S and Branzini, A. (1998), Environmental and water resource, Academy international of the Environment; Geneva; Switzerland. Working paper.
15. Nauges, C and Raymond, A. (2001), Estimation de la demande d'eau potable en France, Revue Economique vol 52. N°1.
16. Nieswiadomy, M.L. and Molina, D.J. (1991), A note on Price Perception in Water Demand Models, Land Economics. 67 pp 352-359.
17. Point, P. (1993), Partage de la ressource en eau et demande d'alimentation en eau potable, Revue Économique N°4. 849-862.
18. Razafindralambo, R (2001), Valeur économique de l'alimentation en eau urbaine. Cas de la ville de Fianarantsoa, Université d'Antananarivo.
19. Serge, G ; Lise, B and Laetitia, G. (2003), «La régulation des services publics d'eau et d'assainissement : pertinence d'un observatoire européen sur la délégation », Les cahiers de recherche GEA N°1.
20. Smets, H. (2001), «Solidarité pour l'eau potable », Revue Quart Monde, N° 180.
21. Spiller, PT and William D. S. (1999), spilled water institutional commitment in the provision of water services. Washington: Inter – American Development Bank.
22. Sylvestre G. (2005), "Effect of price information on residential water demand", Forth coming in applied econometrics.
23. Taylor, L.D. (1975), "The demand for Electricity: A Survey", the Bell Journal of Economics. N° 6, PP 74-110.
24. Vincent I. (2003). Le prix de l'eau pour les pauvres : comment concilier droit d'accès et paiement d'un service ? Afrique contemporaine N° 205. P 119-134.
25. Webb, M and D, ehrhardt. (1998). Improving water services through competition. Public Policy for the Private sector N° 164. The world Bank Group.
26. OCDE (2000), "Examen des performances environnementales études par pays ».
27. World Bank, (1995), A strategy of management water in the middle east and North Africa.
28. DGCCRF (2001). Enquête sur le prix de l'eau 1995/2000. Site web Ministère des finances (<http://www.finances.gouv.fr/DGCCRF/eau/index-d.htm>)

APPENDIX 1

❖ Phase 1 : questions relatives à la gestion de l'eau.

Q1 : Pouvez vous m'indiquer le montant de votre facture d'eau trimestrielle ?
Combien ?.....

Q2 : Avez-vous une idée sur la tarification de l'eau potable ?

Non ☐ Oui ☐

Q3 : Quel est le nombre de jours pendant lesquels l'eau est régulièrement disponible dans l'année ?...../365.

Q4 : Avez-vous des sources alternatives d'eau (magin, puits, autres...)

Non ☐ Oui ☐

Q5 : Achetez-vous de l'eau en bouteilles ?

Non ☐ Oui ☐

Q5 a: Combien de litre par semaine ?.....

❖ Phase 2 : questions relatives à la qualité de l'eau potable.

Q6 : Que pensez-vous de la qualité de l'eau de robinet ?

Bonne ☐ Moyenne ☐ Mauvaise ☐

Q7 : Quelles sont les raisons de cette appréciation ?

Son goût Oui ☐ Non ☐

Sa limpidité Oui ☐ Non ☐

Son odeur Oui ☐ Non ☐

❖ Phase 3 : questions relatives aux caractéristiques socioéconomiques.

Q8 : Genre : Homme ☐ Femme ☐

Q9 : Etes vous locataire ☐ Propriétaire ☐

Q10 : Quelle est la taille de votre ménage ?

.....personnes.

Q11 : Quel est votre niveau d'instruction ?

Analphabète ☐ Secondaire 2eme cycle ☐

Primaire ☐ Supérieur ☐

Secondaire 1^{er} cycle ☐

Q12 : Quel est le nombre d'actifs dans votre ménage ?.....

Q13 : Quelle est votre profession

Journalier ☐ Ouvrier ☐ Indépendant agricole ☐

Indépendant industriel ☐ Indépendant commercial ☐ Cadre ☐

Q14 : Quel est le montant total des revenus mensuels nets de votre ménage?

Combien ?.....

APPENDIX 2

Analyse statistique du questionnaire

Tableau 1 : Connaissance de la tarification					Tableau 2 : Sources alternatives d'eau potable				
		Fréquence	Pourcentage	Pourcentage valide			Fréquence	Pourcentage	Pourcentage valide
Valide	Non	997	83,1	83,1	Valide	Non	911	75,9	76,0
	Oui	203	16,9	16,9		Oui	289	24,0	24,0
	Total	1200	100,0	100,0		Total	1200	99,9	100,0

Tableau 3 : Qualité de l'eau de robinet					
		Fréquence	Pourcentage	Pourcentage valide	Pourcentage cumulé
Valide	Mauvaise	561	46,8	46,8	46,8
	Moyenne	476	39,7	39,7	86,4
	Bonne	163	13,6	13,6	100,0
	Total	1200	100,0	100,0	

Tableau 4 : Consommation d'eau embouteillée				
		Fréquence	Pourcentage	Pourcentage valide
Valide	Non	515	42,9	42,9
	Oui	685	57,1	57,1
	Total	1200	100,0	100,0

Tableau 5 : Genre				
		Fréquence	Pourcentage	Pourcentage valide
Valide	Féminin	473	39,4	39,4
	Masculin	727	60,6	60,6
	Total	1200	100,0	100,0

Tableau 6 : Occupation du logement				
		Fréquence	Pourcentage	Pourcentage valide
Valide	Locataire	326	27,2	27,2
	Propriétaire	874	72,8	72,8
	Total	1200	100,0	100,0

Tableau 7 : Niveau d'instruction du chef de ménage					
		Fréquence	Pourcentage	Pourcentage valide	Pourcentage cumulé
Valide	Néant	128	10,7	10,7	10,7
	Primaire	179	14,9	14,9	25,6
	Secondaire 1er cycle	165	13,8	13,8	39,3
	Secondaire 2ème cycle	245	20,4	20,4	59,8
	Supérieur	483	40,3	40,3	100,0
	Total	1200	100,0	100,0	

Tableau 8 : Profession du chef du ménage				
		Fréquence	Pourcentage	Pourcentage valide
Valide	Journalier	139	11,6	11,6
	Ouvrier	216	18,0	18,0
	Ind. agricole	134	11,2	11,2
	Ind. Industriel.	274	22,8	22,8
	Ind. commercial	178	14,8	14,8
	Cadres	259	21,6	21,6
	Total	1200	100,0	100,0

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

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

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

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

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

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

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

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

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

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

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

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



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

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

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

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

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

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

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

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

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

Final Points:

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

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



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

General style:

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

To make a paper clear

- Adhere to recommended page limits

Mistakes to evade

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

In every sections of your document

- Use standard writing style including articles ("a", "the," etc.)
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- Align the primary line of each section
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- Use present tense to report well accepted
- Use past tense to describe specific results
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- Shun use of extra pictures - include only those figures essential to presenting results

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Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript-- must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

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- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
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- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
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- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

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- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
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- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

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

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
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- Leave out information that is immaterial to a third party.

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

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently. You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.



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- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
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What to stay away from

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

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

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- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.



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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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ISSN 9755861

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