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Proposed Nine-Switch Ac/Ac Converter Fed Three Phase Induction Motor with Volts per Hertz Control

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***Abstract*-In this project presents design and analysis of a three phase induction motor drive using proposed nine-switch ac/ac converter with volts per hertz (V/F) in closed loop using PIC16F877 as a controller. A nine-switch converter having two-set of output terminals was recently proposed in place of traditional back to back converter that uses twelve switches in total. This converter features sinusoidal inputs and outputs, unity power factor and more importantly, low manufacturing cost due to its reduced number of active switches. A PIC16F877 microcontroller is a 16bit high performance digital signal controller. A 1HP, 3 phases, 415 V, 50 HZ induction motor is used as load for the converter. PC Lab view 8.2 is used to record and analyze the various waveforms. The experimental result for V/F control of three phase induction motor using PIC16F877 chip clearly shows constant volts per hertz and converter output voltage.**

***Index Terms*- Ac/Ac converter, proposed nine-switch converter, volts per hertz control**

I. INTRODUCTION

The In the present time, in the most of the applications, AC machines are preferable over DC machines due to their simple and most robust construction without any mechanical commentators'. Induction motors are the most widely used motors for appliances like industrial control, and automation; hence, they are often called the workhorse of the motion industry. Although various induction motor control techniques are in practice today, the most popular control technique is by generating variable frequency supply, which has constant voltage to ratio frequency ratio. This technique is popularly known as V/F control. This work describes the design of a 3-phase AC induction motor drive with volt per hertz control in closed loop (V/F) using 16-bit High-Performance PIC Microcontrollers. The 3-phase induction motor drive contains an single stage integrated nine switch converter as a drive system with volt per hertz control in closed loop using 16 bit PIC Microcontrollers. The proposed nine switch converter with two set of output terminals instead of using twelve switch back to back converters and it was recommended for dual motor drives, rectifier-inverter system and uninterruptible power supplies. The system is designed as motor control system for driving 3-phase AC induction motor. The PIC16F877 device contains extensive Microcontroller (MC) functionality within high-performance 16-bit microcontroller (MCU) architecture. According to the requirement, a software program is written and is fed to the MC (PIC16F877) for the necessary action.

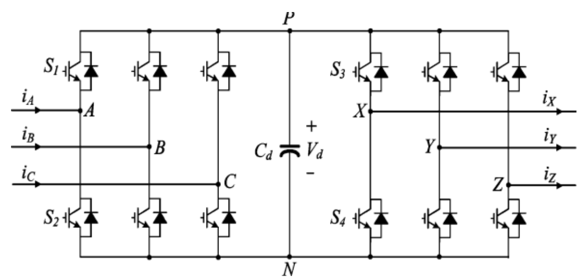

Fig.1. *Back to Back converter*

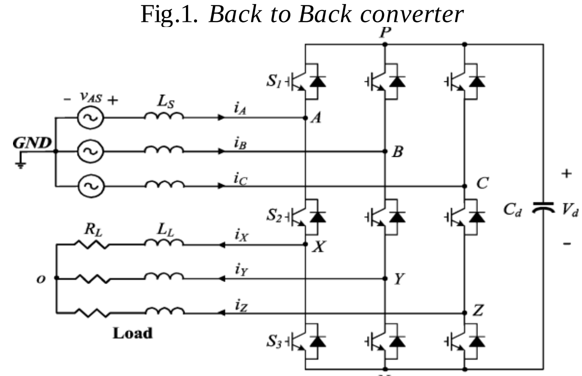

Fig. 2. *Main circuit of Proposed Nine-Switch Converter*

The controller circuit essentially takes the reference speed and actual speed of the motor into account. Depending upon the difference between the reference speed and actual speed, the MC decides the frequency of gate pulse of MOSFET"s. The conventional approach of motor control is to first convert the line voltage into DC. DC is again converted to single/three phase AC as per load requirements. The output voltage, frequency or both of inverter can be controlled by the application of power electronics and microcontroller. A closed loop control is normally required to satisfy the steady state and transient performance specifications of ac drives.

II. EXISTING SYSTEM

The most popular topology of multilevel converter is the twelve switch back to back converter. In the Twelve switch back to back converter in fig.1 consist simply of a forced commutated rectifier and a forced commutated inverterConnect with common Dc link. The DC link voltage is roughly equal to 1.35 times the line voltage and the DC link voltage is regulated by controlling the power flow to the AC grid, the inverter operates on the boosted DC link, it is possible to increase output power flow of a connected machine over its rated power. An important property of the back to back converter is the possibility of the power flow.

III. PROPOSED SYSTEM

In this project, a new proposed nine–switch power converter fed 3-phase induction motor with volt per hertz control in closed loop using 16 bit High-Performance PIC Microcontrollers. The proposed topology is obtained by replaces shunt and series converter found in conventional twelve switch back to back converter, there are powered by a common DC link capacitor. This topology formed by using three semiconductor switches like MOSFET's, IGBT's per phases, giving a total of nine for all the three phases. The proposed conditioner uses a nine-switch converter with two sets of output terminals in fig.2, instead of the usual 12 switch back-to back converter and was recommended for dual motor drives, rectifier–inverter systems, and uninterruptible power supplies. Despite functioning as intended, these applications are burdened by the limited phase shift and strict amplitude sharing enforced between the two terminal sets of the nine-switch converter.

More importantly, a much larger DC-link capacitance and voltage need to be maintained, in order to produce the same ac voltage amplitudes as for the back-to-back converter. The larger DC-link voltage would overstress the semiconductor switches unnecessarily, and might to some extent overshadow the saving of three semiconductor switches made possible by the nine-switch topology. This feature improves the reliability of the circuit. A 3-phase induction motor is run with the proposed topology for the full modulation range. The effectiveness of the microcontrollers based balancing algorithm is tested for the full range of speed and during the sudden acceleration of the motor.

IV. OPERATING PRINCIPLE

When the three phase supply given to the nine switch converter it converts ac to dc and then convert dc to ac supply and given to the three phase induction motor. The nine-switch converter is formed by tying three semiconductor switches per phase, giving a total of nine for all three phases. The nine switches are powered by a common dc link, which can either be a micro source or a capacitor depending on the system requirements under consideration. Like most reduced component topologies, the nine-switch converter faces limitations imposed on its assumable switching states, unlike the fully decoupled back-to-back converter that uses 12 switches. The switching states are found from table(1) which, it is clear that the nine-switch converter can only connect its two output terminals per phase to either Vdc or 0 V, or its upper terminal to the upper dc rail P and lower terminal to the lower dc rail N . The last combination of connecting its upper terminal to N and lower terminal to P is not realizable; imposing this basic rule of thumb on reference placement then results in those gating signals drawn in Fig.4. For the three switches of S1, S2, and S3 per phase.

$$S_1 = !S_1' = \begin{cases} \text{ON}, & \text{if upper reference is larger than carrier} \\ \text{OFF}, & \text{otherwise} \end{cases}$$

$$S_3 = !S_3' = \begin{cases} \text{ON}, & \text{if lower reference is smaller than carrier} \\ \text{OFF}, & \text{otherwise} \end{cases}$$

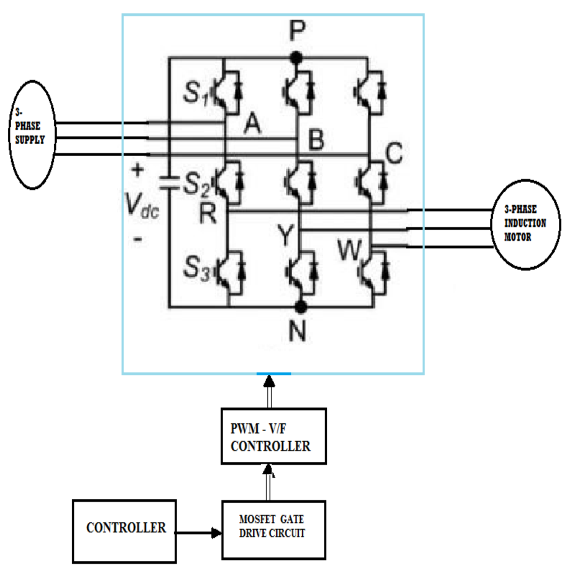

Fig.3. Circuit Diagram of Proposed Nine Switch Converter with 3-phase Induction Motor

$$S_2 = S_1' \oplus S_3' \tag{1}$$

where $\oplus$ is the logical XOR operator. Signals obtained from S2 when applied to the nine-switch converter, then lead to those output voltage transitional diagrams drawn in Fig.5.1 for representing VAN and VRN per phase. Together, these voltage transitions show that the forbidden state of VAN = 0V and VRN = Vdc is effectively blocked off. These references are for the two output terminal sets of the nine-switch converter, tied to separate motors operating at approximately the same rated voltage but at different frequencies. Such motor operating criteria would force the references to share the common carrier range equally; the maximum modulation ratio allowed is therefore 0.5 × 1.15 per reference.

The output voltage of the converter is given to the three phase induction motor. The gate pulses are obtained by sinusoidal PWM technique where PIC microcontroller drives the gate circuit to generate gate pulses. The speed of the induction motor is sensed by proximity sensor and feed back to the controller, where controller compares with its ref speed and to generate appropriate gate pulses.

V. PWM TECHNIQUE

A .Single-Pulse-Width-Modulation

In single pulse width modulation control, there is only one pulse per half cycle and the output rms voltage is changed by varying the width of the pulse. The gating signals and output voltages of single pulse-width modulation are shown in fig 5. The gating signals are generated by comparing the rectangular control signal of amplitude V_c with triangular carrier signal V_{car}. The frequency of the control signal determines the fundamental frequency of ac output voltage. The amplitude modulation index is defined as:

$$m_a = \frac{V_c}{V_{car}} \tag{2}$$

The RMS ac output voltage,

$$V_o = \left\{ \frac{2}{T} \int_{\left(\frac{T}{4} - \frac{t_{on}}{2}\right)}^{\left(\frac{T}{4} + \frac{t_{on}}{2}\right)} V_s^2 \, dt \right\}^{1/2} = V_s \sqrt{\frac{2 t_{on}}{T}} = V_s \sqrt{2\delta} \tag{3}$$

$$\delta = \text{duty ratio} = \frac{t_{on}}{T} \tag{4}$$

By varying the control signal amplitude V_c from 0 to V_{car} the pulse width ton can be modified from 0 secs to T/2 secs and the rms output voltage V_o from 0 to V_s. In multiple PWM control, instead of having a single pulse per half cycle, there will be multiple numbers of pulses per half cycle, all of them being of equal width.

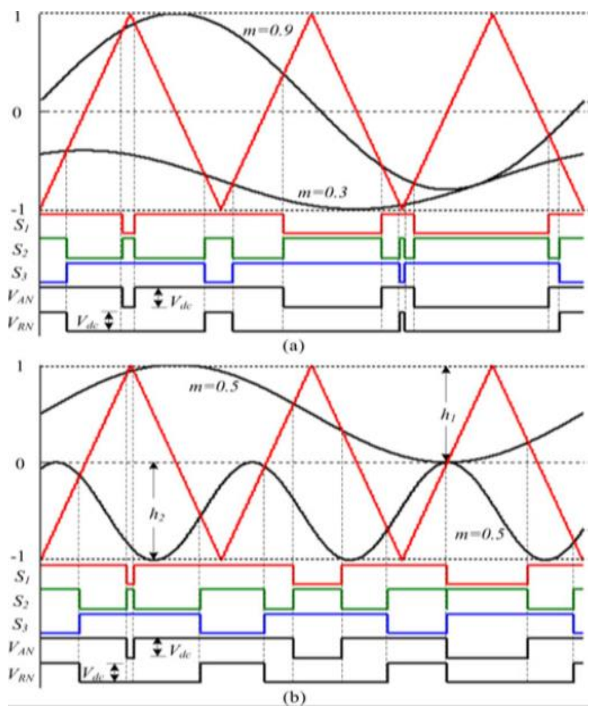

Fig. 4. Arrangements of references having (a) the same frequency but different amplitudes, and (b) different frequencies but the same amplitude.

TABLE I SWITCH STATES AND OUTPUT VOLTAGES PER PHASE

S_1	S_2	S_3	V_{AN}	V_{RN}
ON	ON	OFF	V_{dc}	V_{dc}
ON	OFF	ON	V_{dc}	0
OFF	ON	ON	0	0

TABLE II COMBINATION OF PULSES APPLIED TO VARIOUS SWITCHES

Pulse	Switches	
P_1	S_4	
P_2	S_1	S_7
P_3	S_5	
P_4	S_2	S_8
P_5	S_6	
P_6	S_3	S_9

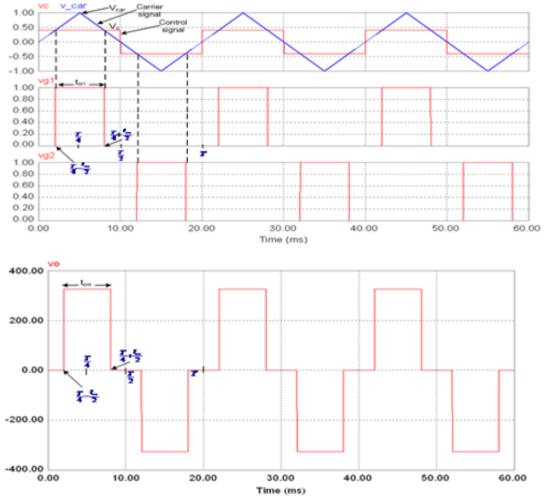

Fig. 5. *Gating signals and output voltage of Single pulse-width modulation*

V. MODULATION SCHEMES

A. Modulation scheme for CF-mode operation

Taking SPWM as an example, Fig.6. Illustrates the modified scheme for CF-mode operation, where mr and mi are the rectifier and inverter modulation indexes.

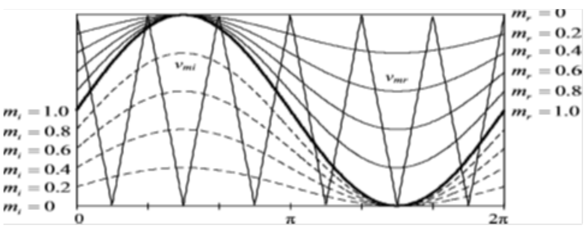

Fig. 6. SPWM scheme for CF-mode operation.

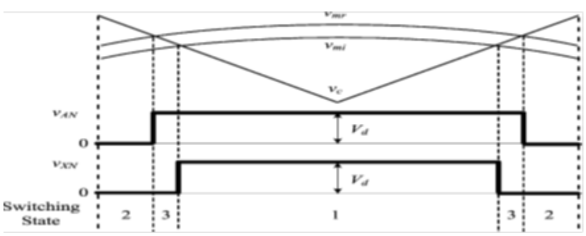

Fig.7 illustrates the generalized carrier-based modulation scheme in a single switching period for the nine-switch con-both magnitude and frequency of the inverter output voltage is vertex. The rectifier modulating wave Vmr and the inverter mode adjustable. The CF-mode operation is particularly suitable formulating wave Vmi are arranged such that Vmr is not lower than applications in UPS, whereas the VF mode can be applied to Vmi at any instant of time. These two modulating waveforms are variable-speed drives.

VI. SIMULATION

A. Introduction Lab VIEW

Lab VIEW is a graphical programming language in principle capable of the same utility that programming in C or C++ can provide. Some capabilities of C++ are more difficult to obtain, but for the purposes of control systems. Lab VIEW is an exceptionally convenient programming language. This is for two primary reasons:

1. Lab VIEW enables programming that mirrors that graphical analysis tools (such as block diagrams) that we use to analyze control systems;
2. Lab VIEW seamlessly (well, at least ideally seamlessly) incorporates \hardware-in-the-loop" needs into code.

Lab VIEW (short for Laboratory Virtual Instrumentation Engineering Workbench) is a platform and development environment for a visual programming language from National Instruments. The graphical language is named "G". Originally released for the Apple Macintosh in 1986, Lab VIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various flavours of Linux, and Mac OS X.

B. *Control and Simulation*

Control design is a process that involves developing mathematical models that describe a physical system, analyzing the models to learn about their dynamic characteristics, and creating a controller to achieve certain dynamic characteristics.

Simulation is a process that involves using software to recreate and analyze the behaviour of dynamic systems. You use the simulation process to lower product development costs by accelerating product development. You also use the simulation process to provide insight into the behaviour of dynamic systems you cannot replicate conveniently in the laboratory.

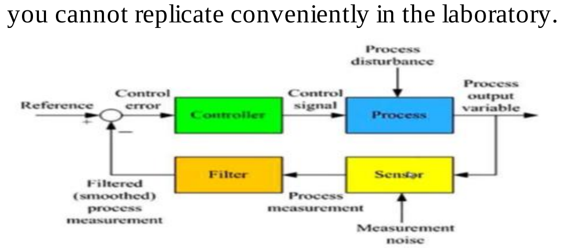

Fig 8. A Closed-Loop Feedback Control System

A. *Control and Simulation in Lab VIEW*

Lab VIEW has several additional modules and Toolkits for Control and Simulation purposes, e.g., “Lab VIEW Control Design and Simulation

Module", "Lab VIEW PID and Fuzzy Logic Toolkit", "Lab VIEW System Identification Toolkit" and "Lab VIEW Simulation Interface Toolkit". Lab VIEW Math Script is also useful for Control Design and Simulation.

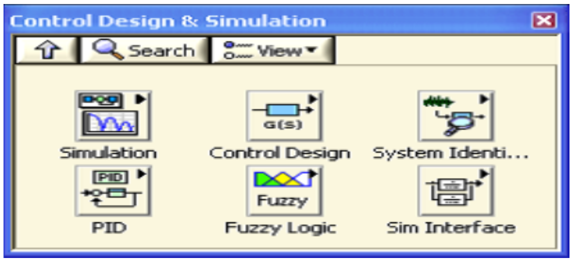

Fig 9. Additional Modules and Toolkits for Control and Simulation Purposes

C. *Lab VIEW Control Design and Simulation Module*

With Lab VIEW Control Design and Simulation Module you can construct plant and control models using transfer function, state-space, or zero-pole-gain. Analyze system performance with tools such as step response, pole-zero maps, and Bode plots. Simulate linear, nonlinear, and discrete systems with a wide option of solvers. With the NI Lab VIEW Control Design and Simulation Module, you can analyze open-loop model behaviour, design closed-loop controllers, simulate online and offline systems, and conduct physical implementations.

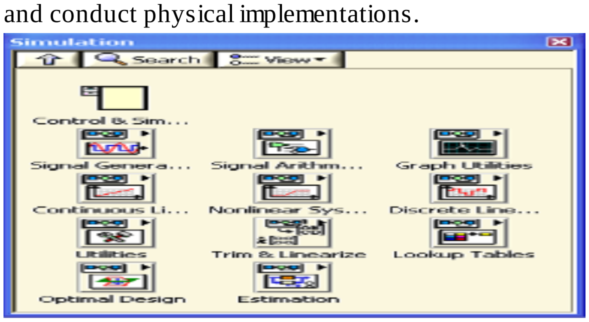

Fig 9. The Simulation Palette in Lab VIEW

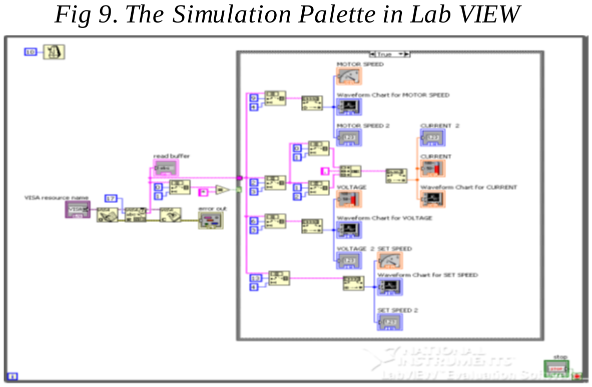

Fig 10. Lab VIEW Simulation diagram When interface with hyper terminal

VII. SIMULATION RESULTS

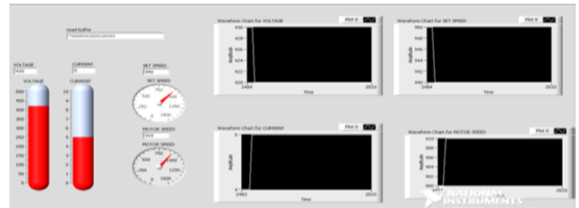

Fig 10. Simulation Result of Motor Input Voltage, Current, Set Speed and Motor Speed

VIII. CONCLUSION

In this paper, a new integrated nine –switch power converter fed 3-phase induction motor with volt per hertz control in closed loop using 16 bit High-Performance PIC Microcontrollers. The proposed topology is obtained by replaces shunt and series converter found in conventional twelve switch back to back converter, there are powered by a common DC link capacitor. The key advantages of this topology compared to the conventional topologies include reduced number of devices and simple control. An important feature of this is the reduces switching losses, reduced size of DC link capacitor. Another advantage of this converter is that reduced semiconductor cost. This feature of the converter improves the reliability of the system. The proposed configuration has been analyzed and experimentally verified for various modulation indexes and frequencies by running a 3-phase squirrel cage induction motor in V/f control mode. A new generation PIC approach for the V/F control of three-phase induction motor has been presented. This complete system is developed and tested in power electronics laboratory. Speed control of motor is acquired with the accuracy of ±15 rpm. Hence in this work 98% accuracy of speed control is recorded. The variation of stator voltage and frequency is done proportionally, such that V/F ratio is constant. The inverter line to line voltage recoded is very stable and very smooth with the use of filter. PC Lab VIEW 8.6 is helpful to real time monitoring motor performance. Hence this three-phase induction motor V/F control by DSC is more stable, efficient and economical.

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