Sensor less Dust and Speed Controlling of Motor Using Micro Controllers

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ABSTRACT
This paper implements a new technology for identifying dust particles in industrial motors and to increase motor efficiency. Present modern industries are highly sophisticated industries. The use of advanced technologies, including satellite communications, automation, smart sensors, and robotics is widespread. Computers and microprocessors are responsible for making big machines reliable and efficient, and for assisting exploration, mine operations, and mineral processing adapt to new competitive environments in a safe and environmentally sound manner. Now a day's the use of autonomous mobile transportation equipment is increasing worker safety and reducing industry costs. Using sensor less position detection to form feedback loop, the control system can realize high precise position and speed servo control following the motion command input. An AVR Micro Controller is used which is a single chip processor (SCP) with the implementation on an AT90PWM3 of an induction motor speed control loop using a natural pulse-width modulation (PWM) technique.
Keywords: **AVR Micro controller, PWM technique, vector control method.**

I. INTRODUCTION

It's difficult to stop the entire running system of industry may be motor disorder is due to variation in internal fields or external fields. Internal fields like torque, voltage variation which can be controlled by vector control methods, and external fields like dust particles, brush disorder, decrease in life span of the brushes etc., we can identify this dust content by measuring the speed of the motor. There are some sensors to measure speed like KMI 15/X and KMI 16/X [1]. The next generation of electrical drives will include some type of sensor less control; Controlled induction motor drives without speed sensors have the attractions of low cost and high reliability due to the absence of the mechanical component and its sensor cable. Speed estimation schemes that allow high dynamic performances are based on vector control of induction machines. A more sophisticated approach using a space vector PWM instead of the natural PWM technique [2] is known to provide lower energy consumption and improved transient responses. The control algorithms in AVR micro controller have been implemented on the AT90PWM3 [3], a low-cost low-power single-chip microcontroller, achieving up to 16 MIPS and suitable for the control of DC-DC buck-boost converters, permanent magnet synchronous machines, three-phase induction motors and brushless DC motors.

II. PROPOSED SYSTEM

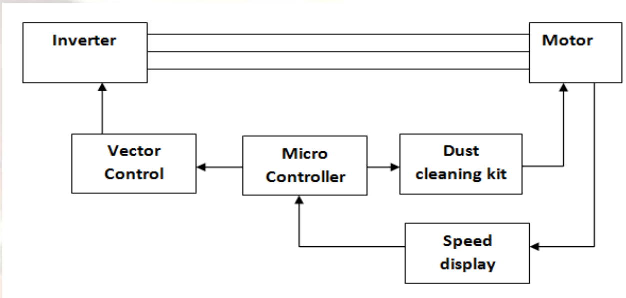

Fig.1. Proposed System.

III. WORKING

In this system there is a feedback loop from motor to controller as shown in the fig.1. If there is dust in the machine, there may be speed variation in the motor. So speed is continuously monitored and displayed in the speed display by using some techniques like open loop slip calculations [4, 5, 10], Extended Kalman Filters [6] and Luenberger observers[7]. When there is reduction in speed, AVR controller set dust cleaning kit active to clean the motor internally by making speed minimum for specific time period till dust was cleaned. Then after Vector control method [9] drives motor to required speed. This makes motor clean and increases efficiency avoiding human interference.

3.1. The 3-phase Inverter:

The structure of a typical 3-phase power inverter [10] is shown in Fig. 2, where V_A, V_B, V_C are the voltages applied to the star-connected motor windings, and where V_{DC} is the continuous inverter input voltage.

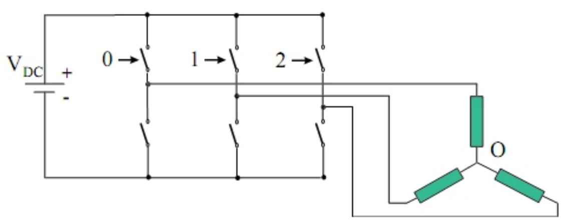

Fig. 2: Basic scheme of 3-phase inverter and AC-

motor.

The six switches can be power BJT, GTO, IGBT etc. The ON-OFF sequence of all these devices must respect the following conditions:

- Three of the switches must always be ON and three always OFF.
- the upper and the lower switches of the same leg are driven with two complementary Pulsed signals. In this way no vertical conduction is possible, providing care is taken to ensure that there is no overlap in the power switch transitions.

3.2. The Space Vector Pulse Width Modulation (SVPWM):

Space Vector PWM supplies the AC machine with the desired phase voltages. The SVPWM method of generating the pulsed signals minimizes the harmonic contents and fits the above requirements. Note that the harmonic contents determine the copper losses of the machine which account for a major portion of the machine losses. Taking into consideration the two constraints quoted above there are eight possible combinations for the switch commands. These eight switch combinations determine eight phase voltage configurations. The diagram below depicts these combinations.

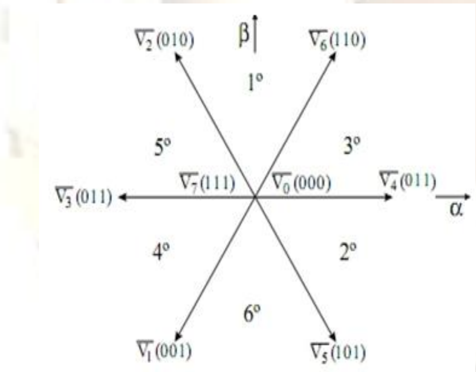

Fig. 3: SVPWM, vectors and sectors.

S_{a+}	S_{b+}	S_{c+}	S_i	V_{ab}	V_{bc}	V_{ca}	V_{an}	V_{bn}	V_{cn}	V_α	V_β	V_i
0	0	0	S_0	0	0	0	0	0	0	0	0	V_0
0	0	1	S_1	0	-E	E	-E/3	-E/3	+2E/3	-E/2	$-E\sqrt{3}/2$	V_5
0	1	0	S_2	-E	E	0	-E/3	+2E/3	-E/3	-E/2	$E\sqrt{3}/2$	V_3
0	1	1	S_3	-E	0	E	-2E/3	-E/3	-E/3	-E	0	V_4
1	0	0	S_4	E	0	-E	+2E/3	-E/3	-E/3	E	0	V_1
1	0	1	S_5	E	-E	0	E/3	-2E/3	E/3	E/2	$-E\sqrt{3}/2$	V_6
1	1	0	S_6	0	E	-E	E/3	E/3	-2E/3	E/2	$E\sqrt{3}/2$	V_2
1	1	1	S_7	0	0	0	0	0	0	0	0	V_7

Table 3-1. Switching configurations and output voltages of a 3-phase inverter

The vectors divide the plan into six sectors. Depending on the sector that the voltage reference is in, two adjacent vectors are chosen. The binary representations of two adjacent basic vectors differ in only one bit, so that only one of the upper transistors switches when the switching pattern moves from one vector to the adjacent one. The two vectors are time weighted in a sample period T to produce the desired output voltage.

Assuming that the reference vector V_{ref} is in the 3 degree sector, we have the following situation:

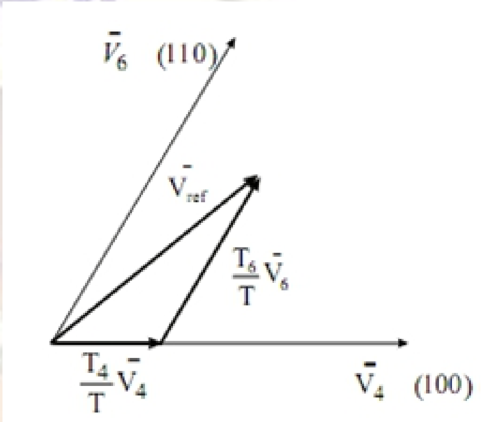

Fig. 4: Reference vector as a combination of adjacent vectors.

Where T_4 and T_6 are the times during which the vectors V_4 and V_6 are applied and T_0 the time during which the zero vectors are applied. When the reference voltage (output of the inverse Park transformation) and the sample periods are known, the following system makes it possible to determine the uncertainties T_4 ,T_6 and T_0.

$$\begin{cases} T = T_4 + T_6 + T_0 \\ \bar{V}_{ref} = \frac{T_4}{T}\bar{V}_4 + \frac{T_6}{T}\bar{V}_6 \end{cases}$$

Under these constraints the locus of the reference vector is the inside of a hexagon whose vertices are formed by the tips of the eight vectors.

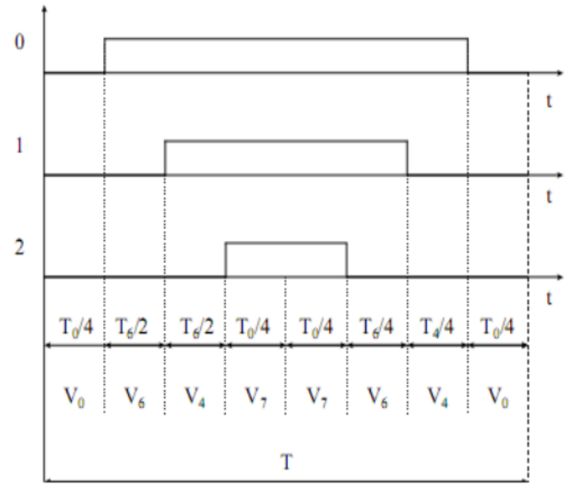

Fig. 5: Pattern of SVPWM.

The generated space vector PWM waveforms are symmetrical with respect to the middle of each PWM period. Fig. 5 shows the waveforms in the example presented above.

The following diagram shows the pattern of SVPWM for each sector:

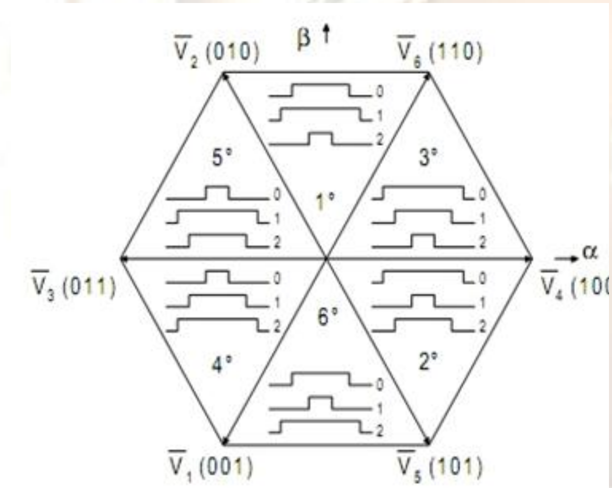

Fig. 6: Hexagon of SVPWM, pattern.

Sector Number	θ	d_k	d_{k+1}
1	$\left[0,\frac{\pi}{3}\right]$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(\frac{\pi}{3}-\theta)$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(\theta)$
2	$\left[\frac{\pi}{3},\frac{2\pi}{3}\right]$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(\frac{\pi}{3}+\theta)$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(\frac{5\pi}{3}+\theta)$
3	$\left[\frac{2\pi}{3},\pi\right]$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(\theta)$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(\frac{4\pi}{3}+\theta)$
4	$\left[\pi,\frac{4\pi}{3}\right]$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(\frac{5\pi}{3}+\theta)$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(2\pi-\theta)$
5	$\left[\frac{4\pi}{3},\frac{5\pi}{3}\right]$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(\frac{4\pi}{3}+\theta)$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(\frac{2\pi}{3}+\theta)$
6	$\left[\frac{5\pi}{3},2\pi\right]$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(2\pi-\theta)$	$\frac{2}{\sqrt{3}}\frac{V_s}{E}\sin(\frac{\pi}{3}+\theta)$

Table 3-2. Expressions of the duty cycles in each sector

In conclusion, the inputs for the SVPWM are the reference vector components (v_{α}, sr, v_{α},sr) and the outputs are the times to apply each of the relevant sector limiting vectors.

3.2.1. Simulation in MATLAB:

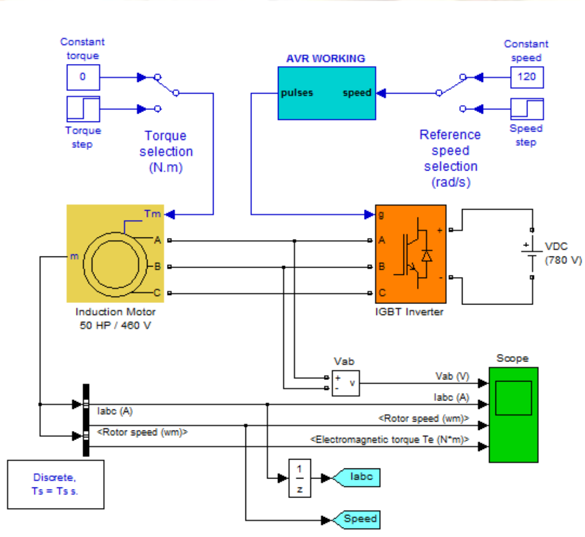

Fig. 7: Simulation in MATLAB

3.2.2. Simulation Results:

Start the simulation. Observe the motor current, voltage, and speed during the starting on the scope. At the end of the simulation time (3 s), the system has reached its steady-state.

Response to a change in reference speed and load torque is discussed:

The initial conditions state vector `Initial' to start has been saved in the 'power_acdrive_init.mat' file. This file is automatically loaded in your workspace when you start the simulation (See Model Properties). In order to use these initial conditions you have to enable them. Check the Simulation/Configuration Parameters menu, then select "Data Import/Export" and check "Initial state".

Now, double click the two Manual Switch blocks to switch from the "Constant speed" and "Constant torque" blocks to the Step blocks. Restart the simulation and observe the drive response to successive changes in speed reference and load torque.

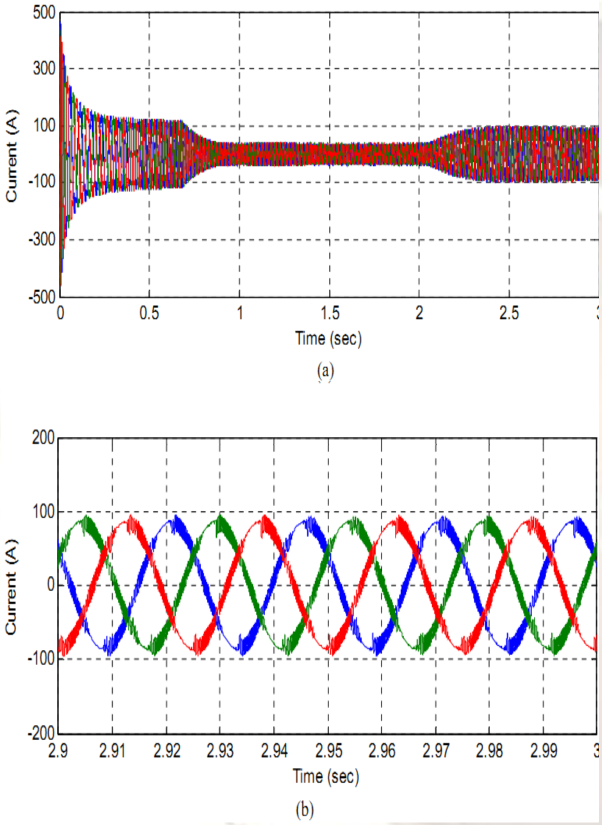

Fig. 8: (a),(b). Motor current

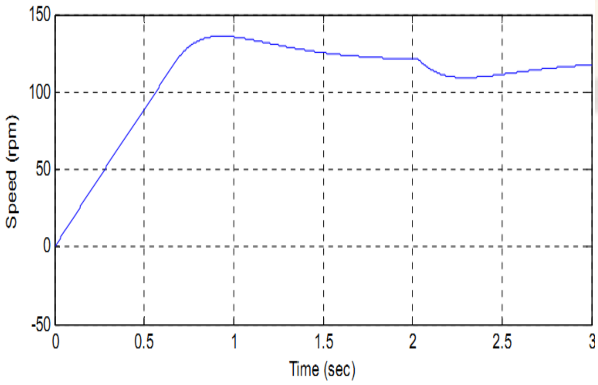

Fig. 9: Speed changes.

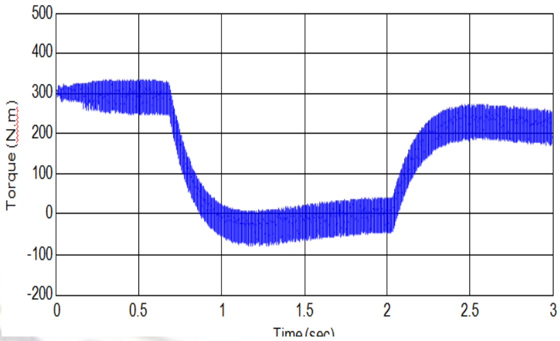

Fig. 10: Torque changes.

A simple generalized Matlab/Simulink model is presented to implement SVPWM for a three phase VSI. In this work, a three-level inverter using space vector modulation strategy has been modelled and simulated. The results obtained by simulation show the feasibility of the proposed strategy. Through the simulations, it is confirmed that the proposed SVPWM technique, has good drive response to successive changes in speed reference and load torque.

3.3. AVR Micro Controller

In a previous application note [AVR494], the implementation on an AT90PWM3 of an induction motor speed control loop using the constant Volts per Hertz principle and a natural pulse-width modulation (PWM) technique was described. A more sophisticated approach using a space vector PWM instead of the natural PWM technique is known to provide lower energy consumption and improved transient responses. The aim of this application note is to show that this approach, though more computationally intensive, can also be implemented on an AT90PWM3.

3.3.1. AT90PWM3 Key Features

The control algorithms have been implemented on the AT90PWM3[3], a low-cost low- power single-chip microcontroller, achieving up to 16 MIPS and suitable for the control of DC-DC buck- boost converters, permanent magnet synchronous machines, three-phase induction motors and brushless DC motors. This device integrates.

- 8-bit AVR advanced RISC architecture microcontroller (core similar to the ATmega 88)
- 8K Bytes of In-System-Programmable Flash memory
- 512 Bytes of static RAM to store variables and lookup tables dedicated to the application program
- 512 bytes of EEPROM to store

configuration data and look-up tables
- one 8-bit timer and one 16-bit timer
- 6 PWM channels optimized for Half-Bridge Power Control
- an 11-channel 10-bit ADC and a 10-bit DAC
- 3 on-chip comparators
- a programmable watchdog timer with an internal oscillator

Figure 11. Shows the speed response and the stator voltages obtained with the microcontroller for speed reference steps between +700 and -700 rpm. These experimental results were obtained with a 750 W induction machine. This figure shows that the desired speed is reached after a 1.2s long transient, and that when the stator frequency ωs obtained at the output of the PI regulator nears zero, the stator voltage magnitude is equal to the boost voltage. These figures also confirm that transient obtained with a space vector PWM is smoother but also longer.

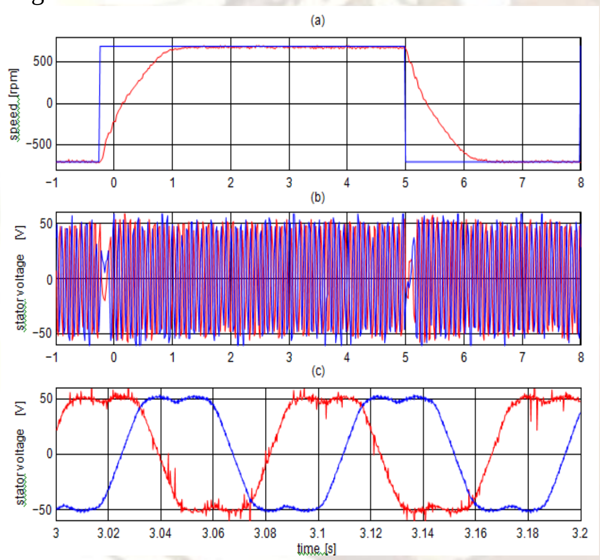

Fig.11: Measured speed (in rpm) and line-to-neutral stator voltage (in Volts) obtained with the microcontroller during speed reference steps.

IV. CONCLUSION:

This paper has been shown that an AVR micro controller with SVPWM methodology can control speed an induction motor in industries by cleaning the dust in the motors. It is confirmed that the proposed SVPWM technique, has good drive response to successive changes in speed reference and load torque through the simulation. Also confirm that transient obtained with a space vector PWM is smoother and also longer. The results obtained by simulation show the feasibility of the proposed strategy.

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