Induction Motor and drives

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Abstract

The principle operation of pulse width modulation (PWM) method is depending upon mathematical relationships between the voltage and the frequency to decrease the harmonics that take exists place due to the modulation process. This mathematic relationship is calculated in the main program where the storage in personal computer (PC). The control signal of PWM inverters is generated by comparing a reference sinusoidal wave and a triangular signal.

Introduction :

All the steps of process of generated PWM are implemented by using simulation PC. In this project the unipolar modulation technique is presented to overcome many problems. The generated pulses are fed to a six-pulses bridge inverter consisting of six MOSFET transistors. The operation frequency to control the inverter output voltage is varying from 2Hz up to 50Hz. The number of samples is chosen to be 1024 samples for each half cycle, to get a resolution is 0.17578125 .The operation of each speed value is analyzed theoretically by a simulation program [1].

Induction motor control system :

A variable voltage and frequency three-phase supply for the a.c. induction motor can be generated by the use of a pulse width modulated (PWM) inverter. A schematic diagram of the system is shown in Fig.(1) . The system consists of a rectified single-phase a.c. supply, which is usually smoothed to provide the d.c supply rails for the main switching devices. Alternate devices in each inverter leg are switched at a high carrier frequency in order to provide the applied voltage waveforms to the motor. During each switching cycle the motor current remains approximately constant due to the inductive nature of the AC motor load [1,2].

In the circuit of Fig.(1) the main switching devices are MOSFETs and each MOSFET has a freewheeling diode connected in anti-parallel. The motor load current is determined by the circuit conditions. When the load current in a particular phase is flowing into the motor then conduction alternates between the top MOSFET and the bottom freewheel diode in that inverter leg. When the load current is flowing from the motor then the bottom MOSFET and top diode conduct alternately. Fig.(2) shows a typical sinusoidal PWM voltage waveform for one motor phase.

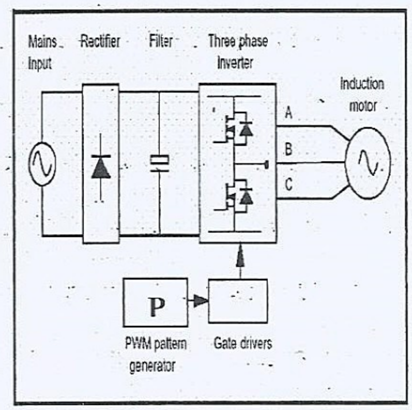


Fig.(1): PWM inverter, block

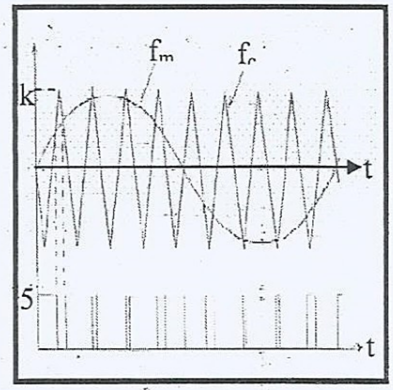


Fig.(2): Sinusoidal-PWM

The three phases are maintained at 120° relative to each other. Both the frequency and amplitude of the fundamental component of the output voltage waveform can be varied by controlling the timing of the switching signals to the inverter (MOSFET) devices. A dedicated i.e. is usually used to generate the switching signals in order to maintain the required V/f ratio for a particular system [2].

The PWM algorithm introduces a delay between the switching signal applied to the MOSFETs in each inverter leg which allows for the finite switching times of the devices and thus protects the system from shoot-through conditions [3].

The principal idea of pulse-width modulation (PWM) is to compare the required signal (modulating signal) with another higher frequency signal (carrier signal). The result of the comparison is a train of pulses with widths proportional to the amplitude of the modulating signal [2,3].

Conventionally, to generate a sinusoidal PWM signal, ideal modulating wave $f_m(t)$ is compared with a triangular carrier wave $f_c(t)$ as shown in Fig.(2) . The frequency of inverter output is determined by frequency of the modulating wave, and its amplitude is determined by the ratio of $f_m(t)$ peak amplitude to the $f_c(t)$ peak amplitude. This ratio is called depth of modulation (M).

Fig.(2) represents a single-phase PWM. Three–phase PWM can be generated by direct comparison between the three phases of the modulating wave and a single carrier wave. However, the three-phase PWM can also be generated from single–phase PWM depending on the fact that the angle between each two phases is 120 electrical. This can be achieved simply by generating a single–phase PWM, then shifts the generated waveform by 120 and 240 electrical to produce the other two phases.

Frequency ratio (FR) is the ratio of the carrier frequency (f_c) to the modulating frequency (f_m). The high value of FR reduces the effective low harmonics in the output and consequently, the output voltage waveform becomes closer to the sinusoidal shape. However, the highest value of FR (maximum switching frequency) is restricted by the switching capability of the devices used and its switching losses [2,4,5].

In this work the main program that was used to achieve the required functions in the Personal Computer (PC) is executed are written in Visual Basic language. Fig.(2) .

Personal Computer is used for monitoring and display waveforms and tables of trigger pulses (Fig.(3) shows the main flowchart). Initially the main program required initial speed and frequency ratio, after input FR and speed, then the PC will generate PWM. The PWM is generated by an intersection between sine wave and triangular wave and then generate samples coincident with intersection points.

Fig.(4) shows the flowchart of PWM generation, by intersecting sine wave and carrier (Triangular) wave, an intersection points will set. From these intersection points, the appropriate pulses will be obtained. The widths of pulses depend upon the value of speed and the mathematic relationship that is shown in the Flowchart. The width of pulses is directly related with the value of speed and the number of pulses increased when the frequency ratio is increased.

The first equation for the reference signal which is a sine wave and the second one is for the unipolar triangular carrier signal. The carrier signal is written by using Fourier series extension.

$$f(t)=\frac{K}{2}-\frac{16K}{\pi^2}\left[\frac{1}{4}\cos(\frac{2\pi t}{L})+\frac{1}{36}\cos(\frac{6\pi t}{L})+\frac{1}{100}\cos(\frac{10\pi t}{L})+\frac{1}{196}\cos(\frac{14\pi t}{L})+\frac{1}{324}\cos(\frac{18\pi t}{L})+....\right] \qquad ...(1)$$

Where:

$$B=\frac{1}{4}\cos(\frac{2\pi t}{L})+\frac{1}{36}\cos(\frac{6\pi t}{L})+\frac{1}{100}\cos(\frac{10\pi t}{L})+\frac{1}{196}\cos(\frac{14\pi t}{L})+\frac{1}{324}\cos(\frac{18\pi t}{L})+....$$

$L=\frac{\pi}{R_1.W}$, $R_1 =$ Frequency ratio (12)., W =Number of cycles (1).

K= The amplitude of carrier (50)., f= Frequency ($f = N/30$)., N= The speed of motor., V= Line voltage ($V = 8f$).

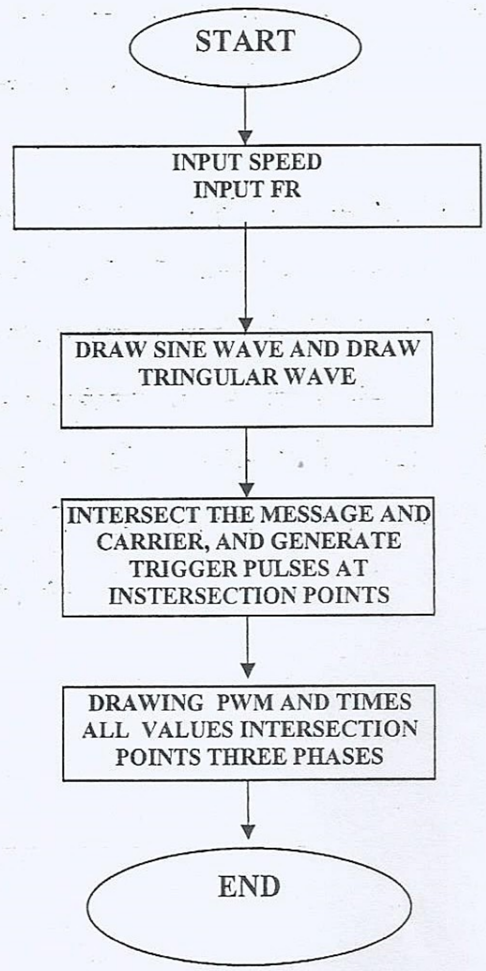
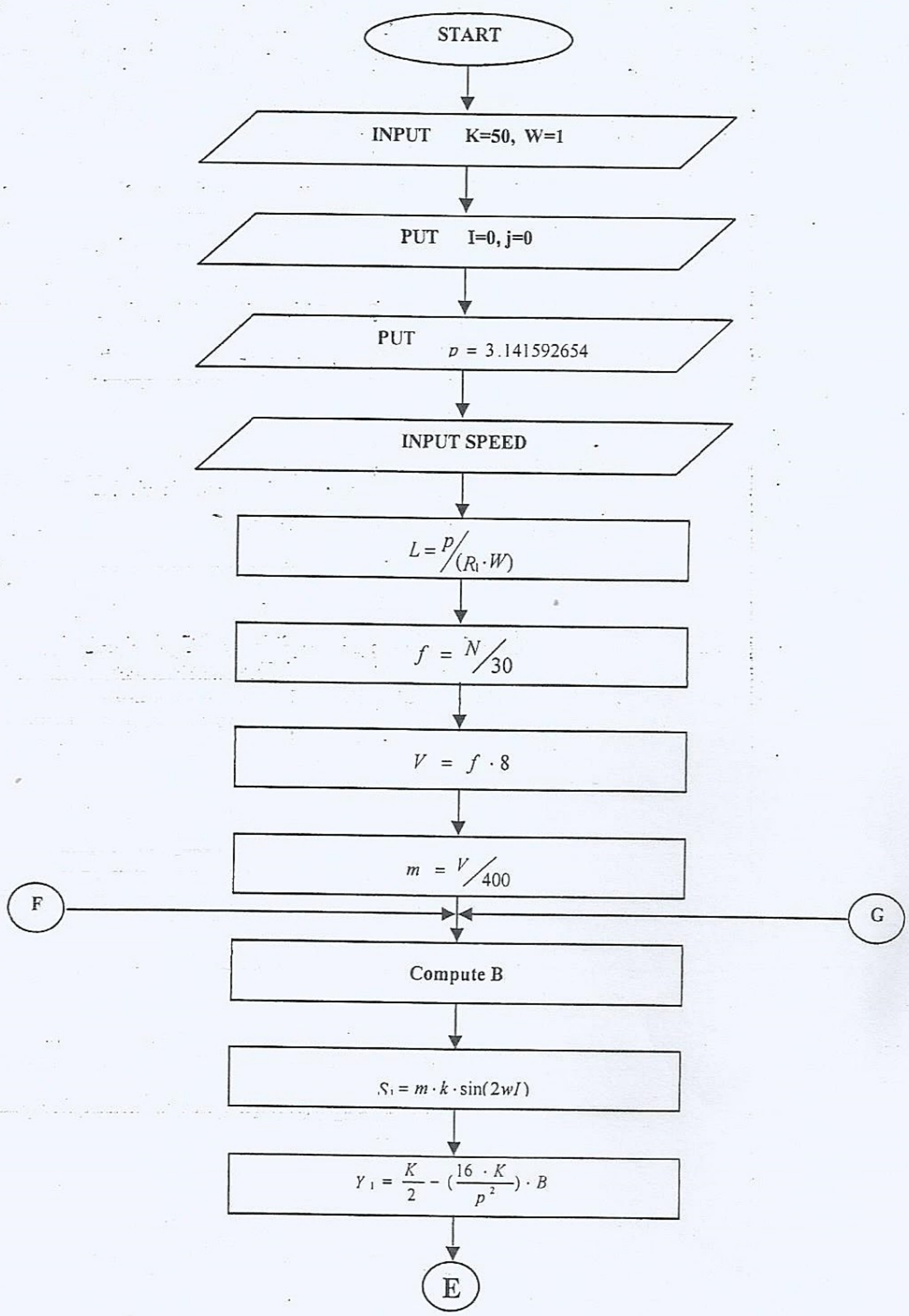


Fig.(3): Flowchart of main program package


START
INPUT K=50, W=1
PUT I=0, j=0
PUT p = 3.141592654
INPUT SPEED
$L = p/(R_1 \cdot W)$
$f = N/30$
$V = f \cdot 8$
$m = V/400$
F
G
Compute B
$S_1 = m \cdot k \cdot \sin(2wI)$
$Y_1 = \frac{K}{2} - (\frac{16 \cdot K}{p^2}) \cdot B$
E

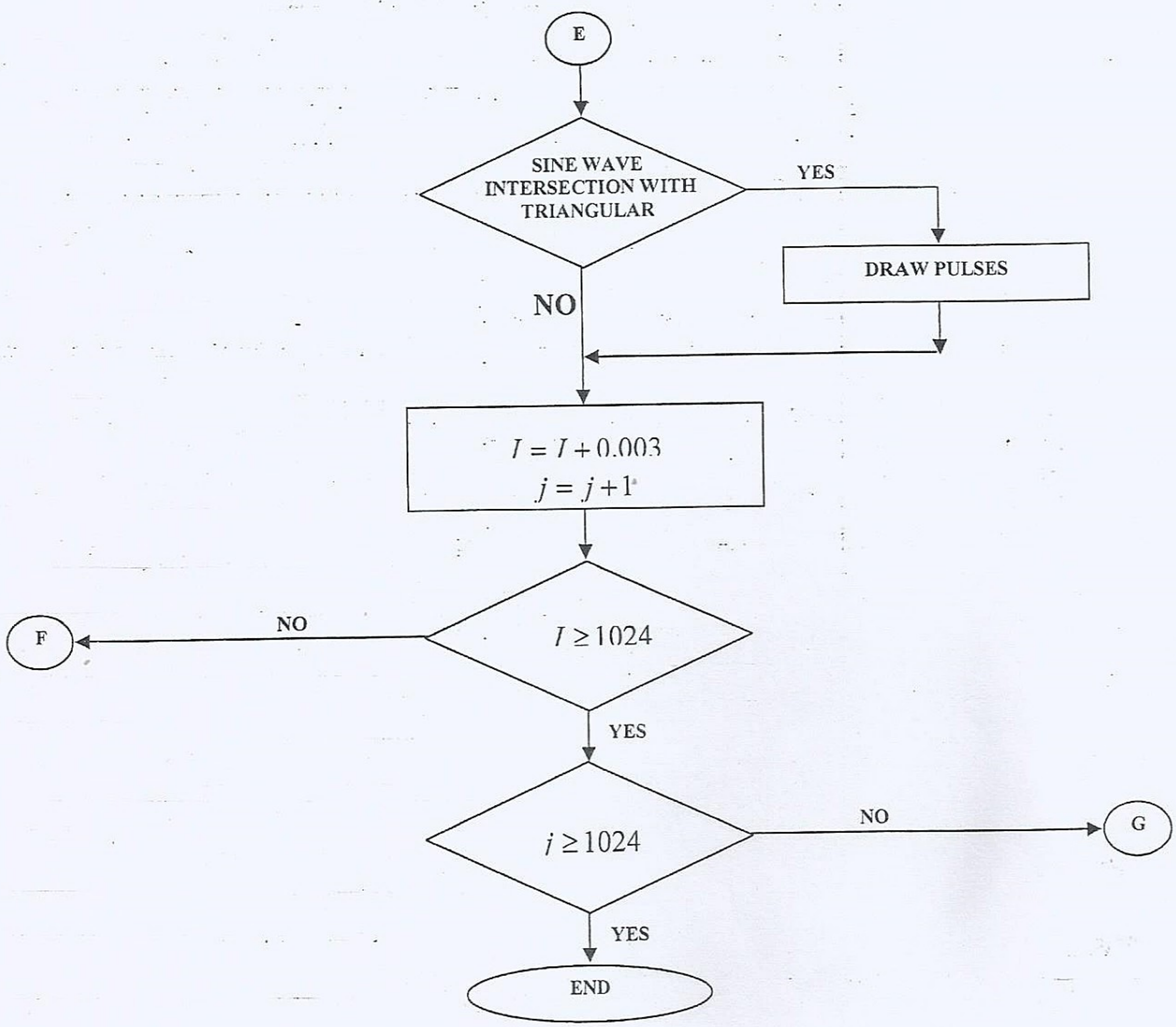


Fig.(4): Flowchart of PWM generation

The effect of varying the modulation index:

The ratio between the amplitude of the reference signal and the constant amplitude of the triangular carrier signal is modulation index (M) [6].

The effect of varying the modulation index on the output waveform is shown in Fig.(5) . These waveforms are drawing by using a visual basic program.

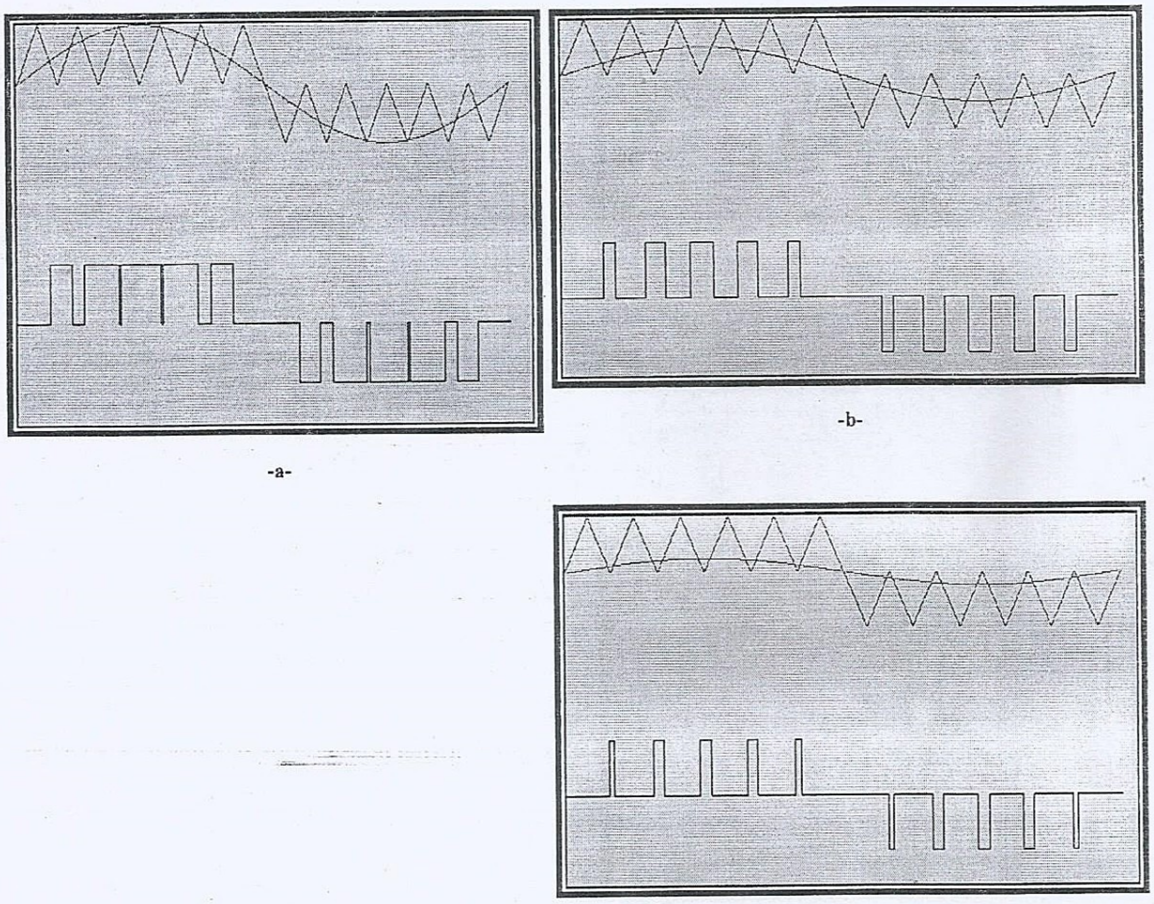


Fig.(5): The effect of varying the modulation index on the output waveform (a) m=1, (b) m=0.5 (c) m=0.24

It has been found that there is a linear relationship between the fundamental voltage magnitude and the modulation index. The fundamental line-to-neutral voltage amplitude is given by:

$$V_1 = M\frac{V_d}{2} \quad \text{for} \quad 0 \le M \le 1 \quad \ldots\ldots(2)$$

Where V_d is the dc-link voltage.

The effect of varying the frequency ratio:

To achieve a low harmonic content in the output waveform of the PWM, the reference and the carrier waves have to be synchronized [7].

The ratio between the carrier and reference frequency is called the frequency ratio (FR).

$$FR = \frac{f_c}{f_r} \quad \ldots\ldots(3)$$

For the unipolar carrier [8].

$$f_c = 6.N.f_r \quad , \quad N=1, 2, 3,\ldots\ldots(4)$$

By increasing the frequency ratio, the number of switching in one cycle increased. Fig.(6) shows the resulting output waveform at R=12 and R=24 (for a constant M). This figure is drawing by using a visual basic program.

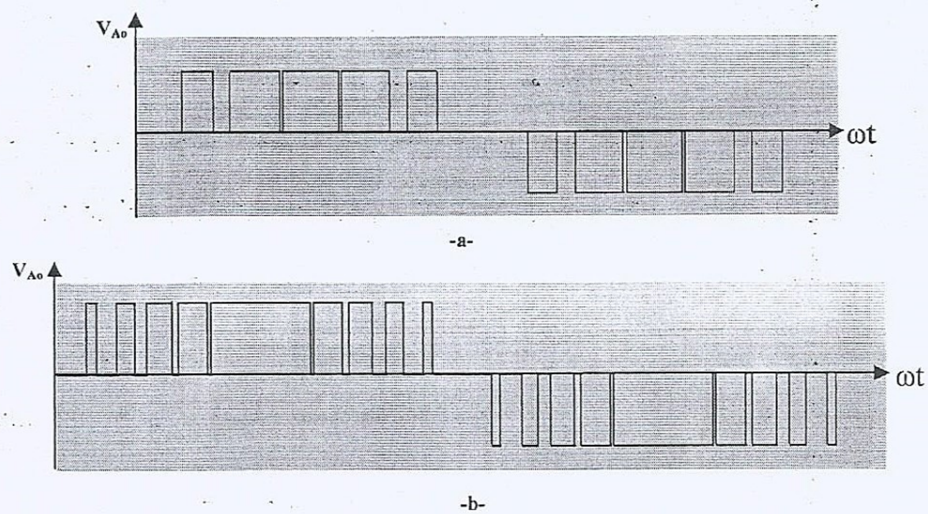


Fig.(6): The resulting output waveform for constant M: (a) at R=12 and (b) at R=24

Conclusions:

- Six- Trigger pulses is generated by using a PWM strategy to give acceptable results. Where the DC-link is kept constant, while modulation index is variable.
- The number of samples is choose 1024 samples for each half cycle, to get a resolution is 0.17578125.
- The method that used to generate the PWM by using a microcontroller gives:

1- Reduced the harmonic
2- Low cost and efficient
3- Easy to maintains
4- Fast response

Future works:

At this stage of work, the module can be developed to include future facilities and capabilities, for future work.

- To use a microcontroller 8951, to achieve flexibility, simplicity and low cost.
- These tables are stored in the internal ROM of microcontroller.

- The process controller can be connected to an PC through the port, either to communicate with other controller or to change the control parameters.
- The microcontroller can provide many other tasks such as self-tests, start/stop sequencing and checking faults.
- The PC is connected with microcontroller via serial link by using RS-232 and RS-485.

References

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