Design and Implementation of Triangular Waveform and Pulse Generators for Three-Phase PWM Inverter Feeding Induction Motor

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Abstract- Many circuits require different waveform as input. Sinusoidal and pulse waveform are examples of such signals. There are different generators which are specifically designed to produce such S signals. However, there are specific needs where a customized circuit may be required. This paper presents a design and implementation of Sinusoidal and pulse waveform generators which is used in firing circuit of Pulse Width Modulated Inverter to feed an induction motor. The design procedure involved determining the input power requirement. The main component used is ICL 8038 IC. The design was built and tested. The concept was used in developing a three-phase Pulse Width Modulated Inverter which was used to feed an induction motor.

Indexed Terms- Inverter, waveform, Induction motor, Pulse Width Modulation.

I. INTRODUCTION

Adjustable frequency operator of the Pulse Width Modulator (PWM) inverter is achieved by simultaneously varying the frequencies of the carriers and references waveforms while preserving synchronization and maintain the correct phase relationship. These conditions are readily satisfied when both waveforms are generated by a common reference oscillator. (Aphiratsakun, .2005).

A set of 3 sine wave reference voltages of adjustable amplitude is required, and each wave is compared with a common fixed amplitude triangular wave. The modulation index is varied linearly with the frequency of the reference wave to give a fundamental output voltage that is proportional to output frequency. (Aziz, 2004).

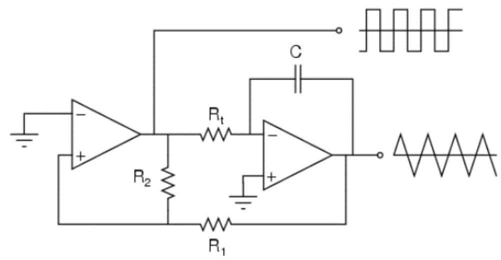

Fig.1.0 Typical triangular generator circuit

The sine wave PWM inverter operates with a fixed dc link voltage, which offers a number of advantages. A constant link voltage can be provided by an uncontrolled diode rectifier bridge, and the absence of delayed firing means that the fundamental power factor presented to the a.c. utility supply is always high (of the order of 0.96) and is independent of motor power factor. (A constant drive requires approximately constant motor current at all speeds). The sinusoidal pulse width modulation (SPWM) method popularly used in the industry was adopted with a unique phase shifting technique. The implementation was done using analog method to generate the firing pulses for the three-phase circuit. The pulse width modulation was achieved by feeding the sine and triangular wave into a comparator. A set of three phase reference sine waves with common triangular wave were used. A phase shifting network was employed to obtain the three phase from single phase supply.

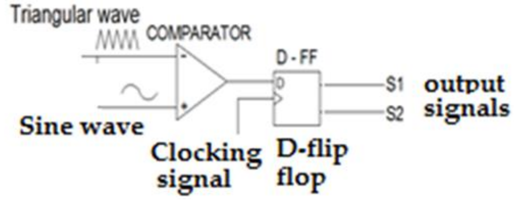

Fig. 2.0: Modulation scheme for pulse generator

More often, circuits that produce an output, which varies its amplitude with time without any external input signal are common. The output may be sinusoidal, square, pulse, triangular or saw tooth. They are referred to as oscillators and form the basic element of all ac signal sources and generates sinusoidal signal of known frequency and amplitude. Most electrical electronic measurement circuits; be it analog or digital make use of oscillator in different ways. (Liaw, 2005). They are used as clocks or to convert signals from a physical parameter like temperature, sound etc. to frequency.

Oscillators can be constructed using components that exhibit a negative resistance characteristic. The common examples are Unijunction Transistors (UJT) and tunnel diode. However, the large majority of Oscillators circuit is based on an amplifier with positive feedback loop. If a portion of an amplifier is feedback in phase with the amplifier is fed back in phase with the input, the effective input is increased and so the overall gain.

The requirements for a circuit to produce oscillation continuously are: (i) Amplification to maintain oscillation (ii) Positive feedback (iii) A frequency determine network (iv) A source of D.C power. (Shukla, 2007). Fig 1 shows a generalized block diagram of an Oscillator.

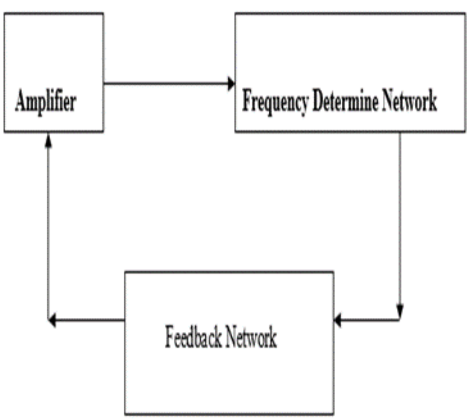

Fig 3.0: Block diagram of oscillator

There exists a vast ranging oscillator and they all have various application and advantages over each other and waveforms they generate. Advancements in electronics have made it possible for oscillation to be generated using ICs on a single loop. IC oscillators are designed to reduce the cumbersome nature to discrete oscillator circuit. Examples of the IC oscillators used in this are the 55timers, ICL 8038. Most IC oscillators like ICL8038 used in this project are design to generate multiple waveforms like triangular, sinusoidal square waveform.

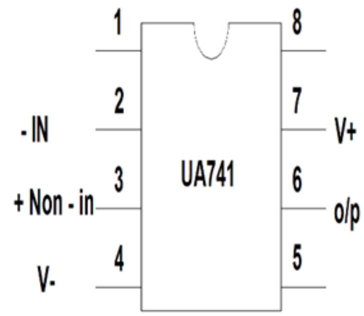

Fig 4.0.10 Pin configuration for UA741 amplifier

Table.1.0: 8038 (Triangle wave generator) Pin layout

Pin #	Symbol	Type	Description
1	SA1	I	Wave Form Adjust Input 1.
2	SWO	O	Sine Wave Output.
3	TWO	O	Triangle Wave Output.
4	DCA1	I	Duty Cycle Adjustment Input.
5	DCA2	I	Duty Cycle Adjustment Input.
6	V_{CC}		Positive Power Supply.
7	FMBI	I	Frequency Modulation Input.
8	FMSI	I	Frequency Sweep Input.
9	SQO	O	Square Wave Output.
10	TC	I	Timing Capacitor Input.
11	V_{EE}		Negative Power Supply.
12	SA2	I	Wave Form Adjust Input 2.
13	NC		No Connect.
14	NC		No Connect.

An OP-AMP is a direct coupled differential amplifier with an extraordinarily high open voltage gain. It is one of the most versatile and widely used electronic devices as they are very easy to use and cheap. Negative feedback circuits are employed in OP-AMPs to control the gain when precise gain values are needed. The OP-AMP was originally developed for use with analog computer, but now found application in all area of electronics design.

It has three terminals: an inverting (-), non-inverting (+) and output terminal. The input impedance of the ideal OP-AMP is infinite while the output voltage is function of the difference between the voltages at the input terminals. If V_1, V2 and $V_{0\ \text{represent}}$ the respective terminal voltage. It can be stated that, the output voltage is related to the input voltage by:

$V_0 = A (V_2-V_1)$
Where, A is the amplifier gain.
The ideal OP-AMP has Infinite: (i) voltage gain (ii) input resistance and (iii) band width.

In practice, however, there is deviation from the ideal condition. The actual characteristics of UA741 OP-AMP are: (i) Voltage gain – 10^6dB (numerical gain=2000000) (ii) Input impedance = 1MΩ (iii) Output impedance = 7.5KΩ (iv) Bandwidth – up to 1MHZ.

OP-amp has also power supply terminals. Some have dual voltage (for positive or negative) e.g. UA741 has $\pm$15. There are many application of the Op amp such as integrator, differentiator, buffer comparator etc.

In order to obtain 50Hz from the D-flip flop, it has to be clocked by a signal. The clocking signal used in this project is SG3524. It incorporates on a single monolithic chip all the function required for the construction of regulating power supplies inverters or switching regulators. They can also be used as the control element for high power-output applications. The SG3524 family was designed for switching regulators of either polarity, transformer-coupled dc to-dc converters, transformer less voltage doublers and polarity converter applications employing fixed-frequency, pulse-width modulation techniques. The dual alternating outputs allows either single-ended or push-pull applications. Each device includes an on-ship reference, error amplifier, programmable oscillator, pulse-steering flip flop, two uncommitted output transistors, a high-gain comparator, and current-limiting and shut-down circuitry. The pin configuration is shown in fig 2.

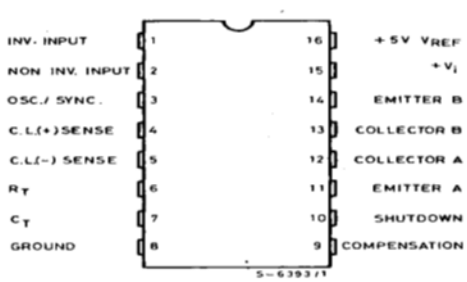

Fig. 5.0 Pin configuration for SG3524

The SG3524 contains an on-board 5V regulator that serves as a reference as well as powering the SG3524's internal control circuitry and is also useful in supplying external support functions. The oscillator controls the frequency of the SG3524 and is programmed by RT and CT according to the approximate formula:

$$f = \frac{1.18}{R_T C_T}$$

Where R_T is in kΩ; C_T is in µF and f is in kHz.
The frequency required is 100Hz (0.1 kHz), since the reference wave is 50Hz. That is, the clocking signal is twice the reference signal. The value of C_T selected was 0.1µF; therefore

$$R_T = \frac{1.18}{f C_T}$$

R_T =118 kΩ
A value of 120 kΩ was therefore used

II. EXPERIMENTAL IMPLEMENTATION AND RESULTS

The design was first simulated on an electronic bench to validate the design. The laboratory experimentation was finally carried out. The design is then built and tested, and resistor or capacitor values are trimmed as necessary to provide the exact frequency of oscillation desired.

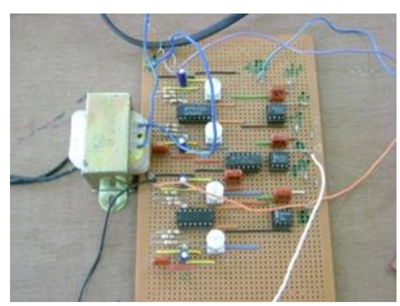

Fig. 6.0: Experimental board

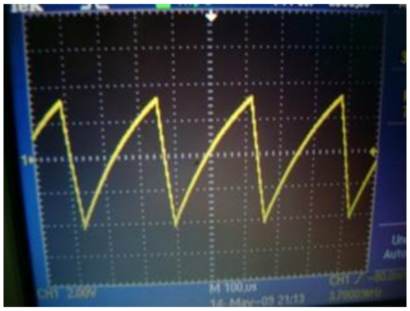

Fig. 7.0: Triangular waveform

Fig. 8.0 Generated pulses

The generated pulses were used in pulse width modulation scheme for three phase inverter fed induction motor. Phase shift technique was used to obtain the three-phase. The results of simulation show that the design's concept is correct. They can also be applied to other application with proper modification.

CONCLUSION

This paper has described a simple easy to implement triangular and pulse generators often used in many application. More often, circuits that produce an output, which varies its amplitude with time without any external input signal are common. The output may be sinusoidal or pulse (square, triangular or sawtooth) wave. They are referred to as oscillators and form the basic element of all a.c. signal sources and generates sinusoidal signal of known frequency and amplitude. Most electrical and electronics measurement circuits; be it analog or digital make use of oscillator in different ways. They are used as clocks to convert signals from a physical parameter like temperature, sound etc. to frequency.

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