The three phase pwm inverter engineering essay

Engineering

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Department of Engineering and Design,

BEng (Hons) Electrical/Electronic Engineering

Power Systems, Energy converters & Drives Report

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Aims:

To investigate the operation of the three phase pulse width modulated inverterTo understand the fundamental process of the power conversion in inverter circuitTo identify some possible problems encountered when using this type of inverter

Objectives:

To observe the supply current and voltage waveforms, determine the power factor and investigate the harmonic content of the supply currentTo measure the crest factor and determine the peak currentTo determine if the harmonic current affects the supply voltageTo observe the inverter output current and voltageTo investigate the change in output voltage and current with frequencyTo determine the frequency of the inverter

Introduction:

These days most of the inverters available in the market utilises the Pulse Width Modulation technology. The inverters based on PWM are superior in many factors compared to the other existing inverters designed using conventional technologies. The PWM inverters use Mosfets in the output switching stage. Power inverters are a circuit that is used to convert Direct current to Alternating Current. The inverter can use a DC source or a rectified AC source as it's input, there are two main types for switch mode voltage source inverters such as square wave and pulse width modulation. Square wave inverters are simple to implement although the harmonics are close to the fundamental frequency. The PWM inverters function by comparing a sinusoidal control signal at a desired frequency output with a triangle carrier signal at switching the frequency. The harmonic of the PWM inverters are located at the multiples of the carrier signal frequency which will be in the KHz range. [1]The inverter used in this exercise is a three phase pulse width modulation type with a variable output frequency, the load connected is a squirrel cage induction motor. The function of the PWM inverter is to shape and control the output voltage in magnitude and frequency in order to minimise harmonic current in the load. Although the output voltage waveform is chopping the resulting current waveform when the load is inductive, in this case for the motor, resulting sine wave is fairly good with some higher frequency ripple. Unless the inverter is powered by a battery or a DC source, the supply to the inverter is either a single or three phase AC, in this exercise single phase is used which is then rectified and smoothed, the initial conversion from AC to DC has its own problems.

Experimental Process:

The inverter is powered is powered from a single phase AC supply which is then rectified by using a bridge rectifier, and the resulting DC it smoothed by two electrolytic capacitors. The DC is then converted to three phase AC with the frequency which can be varied. In this particular inverter the switching pulses required to produce a three phase pulse width modulated output waveform, are generated on a circuit board that plugs into the main power board. The switching pulses are fed to the drive circuit of the six Gate-turn-off Thyristors. The main transformer has been removed from the board and the low voltage power required to operate is obtained from the boxed transformer giving an output of 15-0-15 volts. The main power to drive the motor is supplied via an isolating step down transformer and an auto transformer which varies the supply voltage. The transformer isolated the circuit from the supply so that the circuit is floating with respect to ground. A current clamp is used to observe the supply and load currents and it also provides isolation between the oscilloscope and the circuit.

Inverter supply side:

The first step of this experiment is to look at the supply input to the inverter, the circuit is connected up as shown in fig 1 below. Fig 1 . Connection of supply terminal [2]The auto transformer is set to zero output voltage and switched on, meanwhile the supply voltage is increased to 41 volts. The speed of the motor can be varied by turning the potentiometer knob. The motor speed is set to maximum, fig 2 below shows the supply voltage and current waveform. voltagecurrentFig 2 supply voltage and current waveformsThe following table shows the measurements is taken from the

Voltech power analyser. Input voltage40. 47 VoltsCurrent0. 44 AmpsPower10. 21 WattsVA17. 36Power factor0. 59The table below is the harmonic measurements of the supply current. Fundamental0. 2562nd harmonic8. 31%0. 0213rd harmonic91%0. 2335th harmonic73. 94%0. 1897th harmonic50%0. 128At maximum speed the 3rd harmonic of the supply voltage is measured which gives 0. 84% of 40. 47 V this equals to 0. 339. The speed is then reduced to zero and measured the same harmonic again this time it shows 0. 67% of 40. 47 V which equals to 0. 271. The crest factor of the current waveform measured using the analyser give 3. 070, this is confirmed by using the crest factor ratio Ipeak/Irms formula, the Ipeak is 1. 35A and the Irms is 0. 44A therefore the crest factor equals 1. 35/0. 44 = 3. 068.

Inverter output side:

Fig 3 Load side connection [2]The auto transformer is set to zero output voltage and switched back on, the supply voltage is increased to 41 volts and the motor speed is at its maximum output voltage therefore there is a maximum frequency. Fig 4 shows the output voltage and current waveforms. F: powerpower pwmTEK0001. BMPFig 4 Output voltage and current waveformsThe output voltage is pulse width modulated however due to the time base setting of the oscilloscope not all of the pulses are viable, so in order to see the pulses the output frequency is reduced to approximately 25Hz and the time base is also reduced. Fig 5 and fig 6 below show the voltage and current waveforms at a time base of 2. 5ms and 1ms. F: powerpower pwmTEK0002. BMPFig 5 voltage and current waveforms at 2. 5ms time baseF: powerpower pwmTEK0003. BMPFig 6 voltage and current waveforms at 1ms time baseThe inverter is set to maximum speed and connected to the star point in order to observe the red phase voltage, fig 7 shows the voltage and current waveform of the red phase, F: powerpower pwmTEK0004. BMPFig 7 phase voltage and current waveformsSame as before not all of the pulses are visible therefore the time base is reduced to 2. 5ms and 1ms, fig 8 and 9 shows the waveform pulses at time base of 2. 5ms and 1ms. F: powerpower pwmTEK0006. BMPFig 8 phase voltage and current waveforms at 2. 5ms time baseF: powerpower pwmTEK0007. BMPFig 9 phase voltage and current waveform at 1ms time baseA basic three-phase inverter consists of three single-phase inverter switches each connected to one of the three load terminals. The operation of the three switches is coordinated so that one switch operates at each 60 degree point of the fundamental output waveform. This creates a line-to-line output waveform that has six steps. The six-step waveform has a zero-voltage step between the positive and negative sections of the square-wave such that the harmonics that are multiples of three are eliminated as described above. When carrier-based PWM techniques are applied to six-step waveforms, the basic overall shape of the waveform is retained so that the 3rd harmonic and its multiples are cancelled.

The Inverter Efficiency:

The efficiency of the inverter output is 2. 8 X 3 = 8. 4, the input is 10watts. There are a few main power losses in the inverter which is due to the losses through the diode and the switching components.

The relationship between the inverter output voltage, current and frequency.

The output voltage, current and frequency values are measured from 10Hz to 50Hz in increments of 5Hz. The table and fig 10 and 11 below shows the inverter output voltage and current plotted against the frequency. FrequencyOutput VoltageOutput CurrentHzvoltsamps1010. 970. 341513. 630. 42015. 940. 432517. 940. 453019. 650. 463521. 350. 474022. 950. 474524. 180. 4850250. 46Fig 10 output voltage vs. frequencyFig 11 output current vs. frequencyThe table and graph in Fig 10, 11 shows as the frequency reduces the voltage also reduces in order to keep the same ratio. It is also necessary to reduce the inverter output voltage as the frequency falls, so that the output current does not rise to high.

Conclusion:

In this experiment I have learnt that a pulse width modulation is a process of modifying the width of the pulses in a pulse train directly proportional to a small control signal, the resulting pulses will be wider if the control voltage is greater. By using sinusoid of the desired frequency as the control voltage for the PWM circuit to produce a high power waveform which an average waveform varies in a sinusoidal manner which is suitable for driving an ac squirrel cage induction motors.