

## Three Phase Inverting using Pulse Width Modulation controlled by 6802 Motorola Microprocessor

### Abstract

Different types of voltage sources are available in the market, but the point is how to convert any voltage to our desired waveform? For example; if we have a DC voltage source (like battery or dc generator) and we need to run AC motor (one phase or three phases) or run DC motor with special voltage, or we have an AC source (one phase or three phases) and need to run AC machine with special voltage and special frequency or run DC machine with special voltage. In simple meaning we need a connector between the sources and loads to match between them. But it should pass this conditions; efficiency, mobility, size, weight, range of operation, simple with using and cost. This paper focuses on designing and producing a true sinewave inverter that provides premium power which is identical to (or even better than) the power supplied by the utility company with multi output. On this work we will give an explanation for type of inverter depend on output and function for it.

### 1. Introduction

The electric converter system (ECS) contains five major block units and a transformer as viewed in Figure 1.

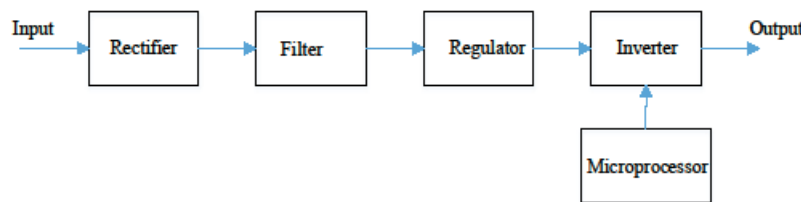


Figure 1: ECS system

And they are:

- a) Rectifier circuit; for rectifying the single phase or three phase to (DC) direct current and to union the direction of output current if the input is (DC).
- b) Filter; for rippling the output of rectifier, to make it easy for regulating in the next step.
- c) Regulator; for regulating output to become pure (DC).
- d) Inverter; for convert (DC) to (AC 3 $\phi$ ) and controlling by PWM wave form.
- e) Microprocessor; that is the brain of system where it connect with inverter.

### 2. EXPERIMENTAL SETUP

#### 2.1. MICROCONTROLLER

As shown in Figure 2, we used microprocessor 6802 Motorola that has 16 bit address bus, 8 bit data bus and control bus that separated from each other and it connected with crystal oscillator 2MHz as clock. Data bus goes from microprocessor to quadruple bus transceiver (74LS243) where it used to neglect noise and protected the micro. Then the data bus distribute to the erasable programmable read only memory (EPROM), random access memory (RAM) and parallel interface adapter (PIA).

- a. RAM 6810 128 byte.
- b. EPROM 2732 4096 byte.
- c. PIA 6821. Used as interface between microprocessor and peripheral device.

Address bus goes from microprocessor to octal bus buffer (74HCT241) then the address bus distribute to the RAM & EPROM.

We used decoder (74HC138) to enable or **disable** the peripheral device of the microprocessor depend on the address bus [1]. In general the program that we design has six control line outputs that controlled the MOSFET.

## 2.2. INVERTER CIRCUIT

The six control lines that carry pulse width modulation, where it's input for power MOSFET to control the inverter to get three phases, 50 Hz, 380 V<sub>L-L</sub>. By drive MOSFET (TC4427) that used to step up the control voltage where the V<sub>gs</sub> of power MOSFET activate at 10V [2, 3]. As shown in Figure 3 we used IRF460LC MOSFET that has:

- Drain current 20A.
- Breakdown voltage 500V.
- Resistance 0.27Ω.
- The average time is between (18 – 77) ns.

In general the inverter consists of six power MOSFET, three drive MOSFET and cooling plats, where the input is DC at 311V and the output is three phases 380V<sub>L-L</sub> at 50 Hz frequency [4, 5].

## 2.3. RECTIFIER & FILTER CIRCUIT

As shown in Figure 4 we used S25120 power diode has:

- Forward current 25A.
- Breakdown voltage 1200V.
- Resistance 0.025Ω.

And we used capacitor as low pass filter where it's capacity 940μF to minimize the ripple from rectification circuit. In general the rectifier circuit consists of six power diode and two capacitors connected in parallel where the input is single phase 220Vrms at 50 Hz and the output is the input of the inverter [6]. The overall setup is shown in Figure 5.

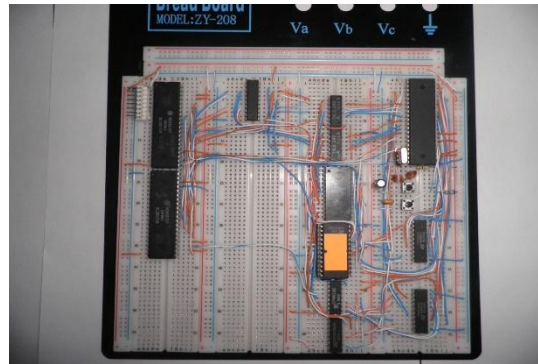


Figure 2: The micro, ROM, PIA, RAM and other component of microcontroller.

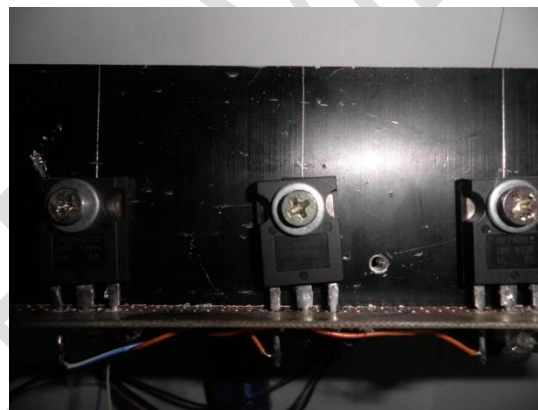


Figure 3: Three powers MOSFET.



Figure 4: The rectifier and filter circuit.

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### 3. RESULTS AND DISCUSSION

In this paper, MATLAB software is used to insure that the circuits are correctly operated and compare the outputs of simulation with the practical work.

Figure 6 shows the simulation electrical circuits for ECS with single phase voltage supply  $311V_p$  50Hz and connected with induction motor by DC link, in this link we connect a bridge rectifier to convert AC input to DC voltage with ripple then we filtered this wave to minimize ripple by low pass filter (parallel capacitor with the rectifier circuit) then to the full bridge inverter that makes the AC voltage, controlling by microcontroller that shown in Figure 6, this controller is the microprocessor 8602 in practical operation that gives 36 PWM in the periodic time to get the required amplitude, frequency and phases degree in the simulation of the MATLAB we consider this microprocessor as a pulse generator that gives 21 pulse in the periodic time and gives us 3 phase 50 Hz as an output of the circuit.

In the Figure 7, we have  $311V_p$  50Hz coming from the source and rectification to DC as shown in the next steps. The magnitude of the voltage is 311V with the ripple 10V, and in transient the tolerance of voltage is (240 to 311) V, when the system goes to the steady state the tolerance is (305 to 311) V. The low-pass filter in this circuit is a capacitor 940  $\mu F$ , which by charge and discharge contained in capacitor. As we see; by charge and discharge in capacitor. The magnitude of current will be down from 90.62 A in the transient to steady state consequently in the rectification circuit to 50.12 A after passing the low-pass filter as shown in below Figure 8.

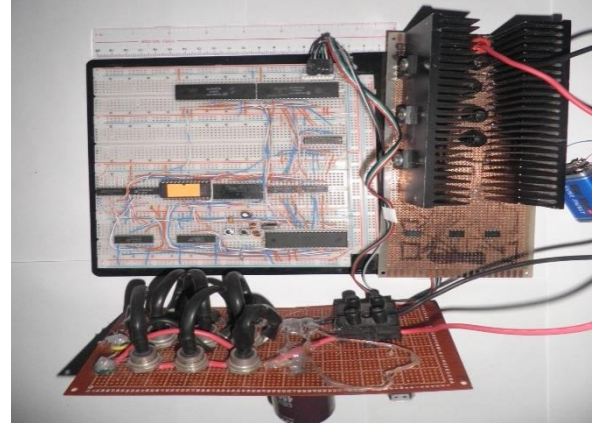


Figure 5: Picture for all devices connecting together

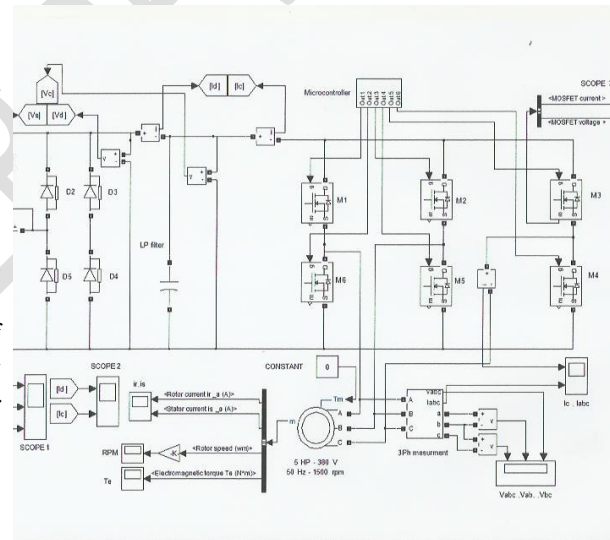


Figure 6: Simulation circuit

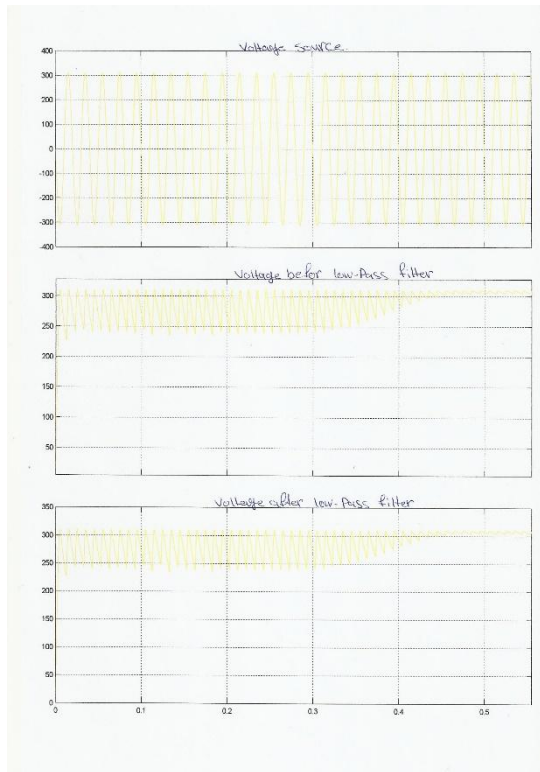


Figure 7: (1) voltage source (single phase). (2) Output voltage from the rectifier. (3) Output voltage after low-pass filter.

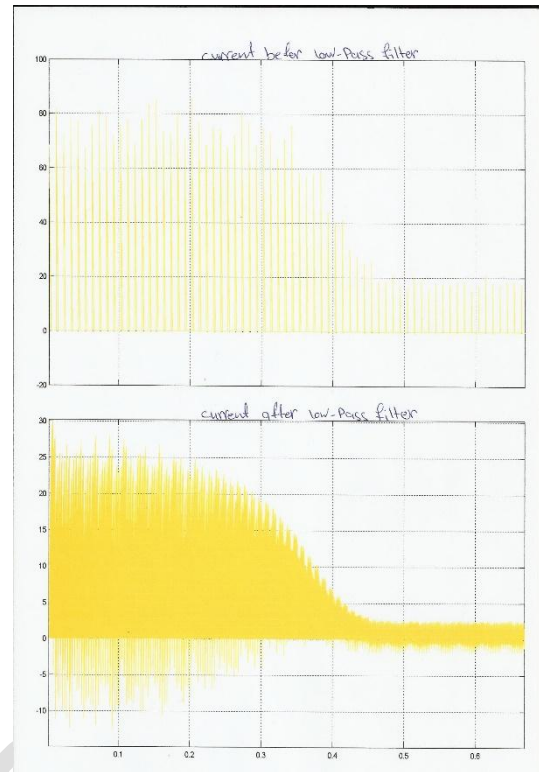


Figure 8 : (1) current before low-pass filter (2) current after low-pass filter.

In Figure 9, the input voltage of the MOSFET about 311V as pulses and current is 4A as pulses this is because of the microcontroller gives the pulse to the MOSFET to be operation and from the data sheet the maximum current and voltage is 20A, 500V Respectively. As shown in In Figure 10 and 11, this is the line current that output from the DC link between the single phase input voltage and the three output voltage that connected to the load (induction motor [6, 7, 8]) the line current is 25A and 3A in transient and steady states, respectively. As shown we have a good starting for the induction motor, and we have natural current with magnitude of  $(-2 \times 10^{-19})$  produce by the harmonic. As shown in the Figure 12, we see the electric torque on the motor, but we have distortion at the steady-stat that happened because of the switching the power MOSFET. Not that the electrical torque on the motor depend on the load that effected to the motor ( $T_m$ ) and as shown in figure the mechanical torque that we applied on motor is zero. The speed of motor is 1490 rpm because the losses, and the rise time very smooth is about 0.44s and its steady state after this time, the overshoot as we see is zero, see Figure 13 and 14.

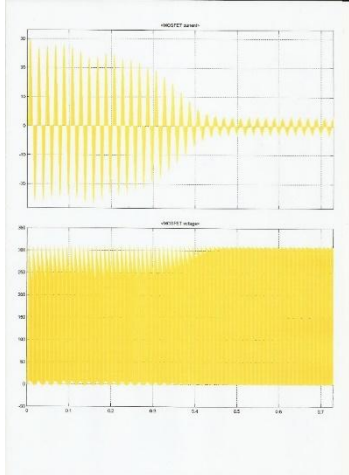


Figure 9: The current pass & voltage applied on the MOSFET.

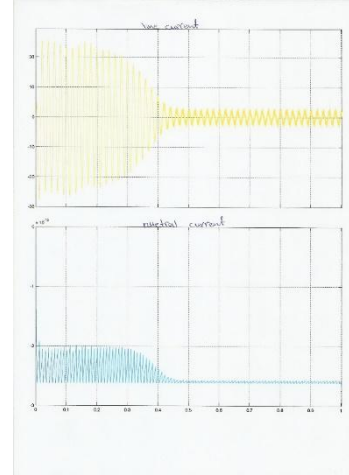


Figure 10: Line current & current in the neutral.

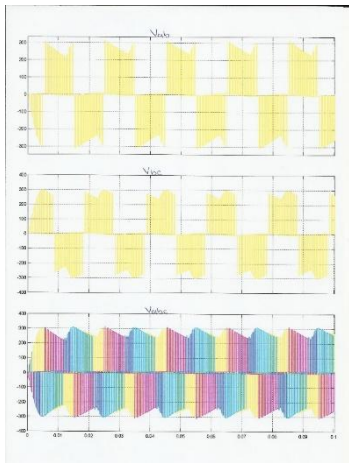


Figure 11: line-line voltage  $V_{ab}$ ,  $V_{bc}$  & 3 phases voltage

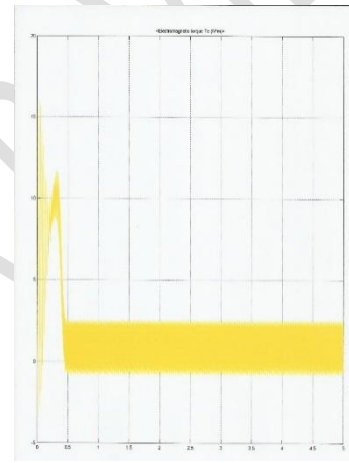


Figure 12: the electrical torque

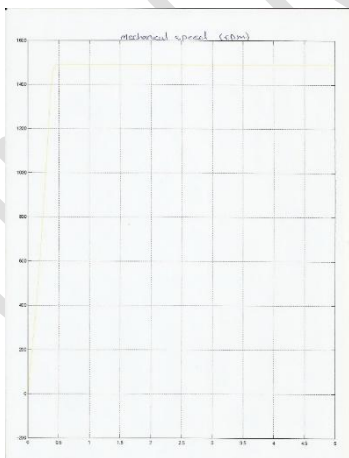


Figure 13: the speed of motor

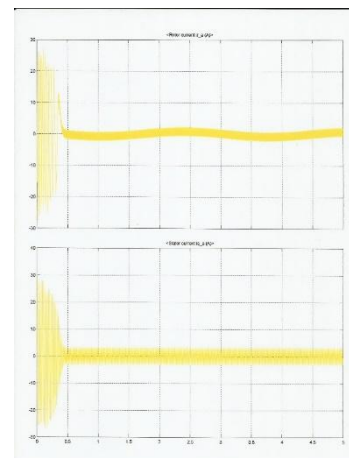


Figure 14: the rotor current & the stator current

#### 4. CONCLUSION

A true sinewave inverter is designed and built to provide premium power, identical to the power supplied by the utility company. The MATLAB software is used in the design and optimization of the system's components to insure its best performance. The experimental results show that the performance of the built system is the same as those obtained from the MATLAB simulation, emphasizing that the built system operate at its best state, making it a suitable candidate for providing the required power.

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