



# Conversion of Single Phase AC to Three Phase AC Supply

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## ABSTRACT

This paper presents a simple converter topology for driving a load with a single-phase AC supply. Using only six active switch IGBT's(FGH40N60SFD). The converter supplies balanced output voltages at rated frequency, the proposed control approaches are supported by test results. The convertor takes single phase supply and converts it into three phase supply with the help of thyristors. The single phase supply is first converted into dc supply by using rectifier again dc supply of rectifier is given to inverter where IGBT's are used and converts the dc supply again into three phase ac supply. In the proposed scheme, Arduino Uno/Mega ADK microcontroller interfaced with Scilab(5.5.2) is used to produce PWM signals. The PWM signals generated is given to IC FAN7392(driver IC) which drives the thyristors. Three phase machines can be run on this by converting single phase to three phase AC supply wherever three phase AC supply is absent. Three phase induction motor can be used as load for testing of the hardware. For example, electric vehicles. The experimental result showed that PWM pulses produced remained approximately constant and the hardware have satisfactorily converted the single phase power to three phase power supply.

**Keywords :** Single Phase AC to Three Phase AC supply, IGBTs, drive system.

## I. INTRODUCTION

In the past, single-phase to three-phase conversion systems were made possible by the connection of passive elements capacitors and reactors with autotransformer converters. Such kind of system presents well know disadvantages and limitations. So to overcome from this disadvantages the newly adopted thyristors and power electronics devices were used mainly thyristors like SCRs, MOSFETs, IGBTs etc.

Both have the advantages of simple structure and reasonably low cost. The project is about 'single phase to three phase conversion system using **IGBTs**. Since the beginning of the solid state power electronics, the semiconductor devices were the major technology used to drive the power processors. Looking at the semiconductor devices used in the former controlled rectifiers and comparing them with the new technologies it makes possible to figure out the astonishing Development. Beyond the improvement related to power switches, it was also identified a great activity in terms of the circuit topology innovations in the field of three-phase to three-phase, single phase to single phase and three-phase to single phase conversion systems. The single-phase induction motor drives by the three-phase

induction motor drives in some low-power industrial applications. When the three phase induction motor is driven by a single phase induction motor by rotary phase converters and autotransformer capacitor phase converters, this causes more loss as compared to the new this method. Motor drives constitute a predominant load for the agricultural sector. As most rural communities in the India are supplied with single-phase ac power, these drives have to be realized with single-phase motors, or with three phase motors (Induction Motors) driven by phase converters. Autotransformer capacitor phase converters, however, cannot easily obtain balanced output voltage with reasonable cost, and rotary converters are heavy and have significant no-load losses, also both topologies have high inrush current during motor start up.

The three-phase induction motors have some advantages in the machine efficiency, power factor, and torque ripples compared to their single-phase counterparts. Though the precise control of single phase induction motor is less complex in comparison to the three phase induction motor, but when the torque requirement is considered then three phase induction motor is the best choice. The applications for these motors cover almost

every stage of manufacturing and processing. It is not surprising to find that among all type of electric motors, Induction motor is so popular, when one considers its simplicity, reliability, and low cost.

Therefore, it is desirable to replace the single-phase induction motor drives by the three-phase induction motor drives in some low-power industrial applications in some rural areas where only a single-phase utility is available, we should convert a single-phase to a three-phase supply. This paper proposes an alternative solution for phase conversion with very low overall cost, moderate motor performance during start up and high steady-state performance at line frequency.

Here we are using 16-bit Arduino microcontroller which yields enhanced operations, fewer system components, lower system cost and increased efficiency. The system is designed for driving medium power (1.5hp), 3-phase AC induction motors. Our work consist of a full bridge rectifier, a split capacitor dc bus, six active devices (IGBTs), Driver circuit (FAN 7392 IC) which drives the six thyristors, Arduino module interfaced with *scilab* to give the three phase controlled PWM output to the driver circuit. The developed hardware can be tested on a 3-phase, 415V, 50Hz Induction motor or the inverted output and graph/waveforms are analyzed and studied on Digital Storage Oscilloscope.

Scilab is an interpreted language. This generally allows to get faster development processes, because the user directly accesses a high-level language, with a rich set of features provided by the library. By this way, external libraries can be used as if they were a part of Scilab built-in features. Scilab also interfaces Arduino.

## II. BLOCK DIAGRAM AND ITS EXPLANATION

### A. System Overview

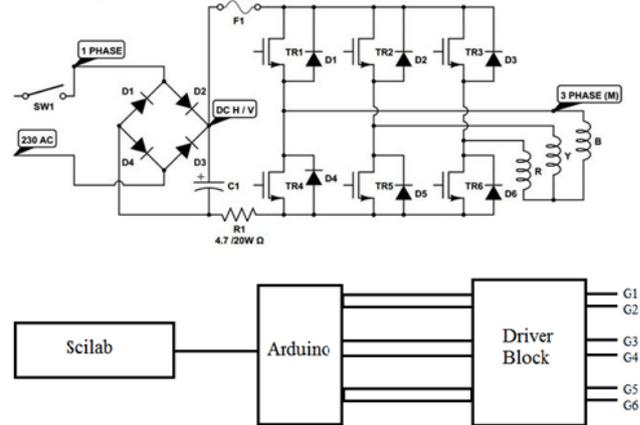


Figure 1- Block diagram of the system

All the electronics or electrical components need power supply of AC supply. So, we are converting power from single phase into three phase AC supply. Using these three phase power supply, we can drive any motor. Block diagram of converting single phase to three phase power supply consist of input, rectifier, filter, inverter, load, driving stage, microcontroller, scilab and power supply as shown in figure 1. As we seen from the block diagram the first stage is input, input is given in two circuits, first one is given to rectifier and further towards the other and the second input is given to controller stage Since the input is first works in rectifier which converts the ac supply into pulsating dc but after rectification also having some ac contain. So to remove that filters are used consisting of inductors and capacitors which helps to eliminate the ac contain and gives nearly pure dc. Further the supply is given to inverter where IGBT's are connected. In addition with main power supply again energising stage is there which use to energise IGBT's i.e. DRIVING STAGE comprises of micro controller interfaced with scilab where simulations are made accordingly and supply is given to inverter stage as per the programmer's and circuit requirement. Afterwards the dc supply which is fed to inverter is converted into ac supply in the form of three wire i.e. three phase supply. After the conversion the three phase supply is given to load which is motor. In the sense of load the load may be a motor or any three phase load.

## B. Power circuit design

The power circuit designed contains full bridge rectifier with split capacitors assembly, full bridge inverter assembly. Single phase 230V, 50Hz AC supply is applied to the full bridge rectifier and IGBT. IGBT switches are protected against surge voltages using snubber circuit. This full bridge rectifier converts single phase AC input into DC which is filtered by capacitor. The pure DC supply is applied to the full bridge inverter which is made up of six IGBT switches. The output of the 3-phase inverter is given to induction motor. The energy that a switching power converter delivers to a motor is controlled by Pulse Width Modulated (PWM) signals applied to the gates of the switches. PWM signals are pulse trains with fixed frequency and magnitude and variable pulse width. The power circuit design is shown in figure 2.

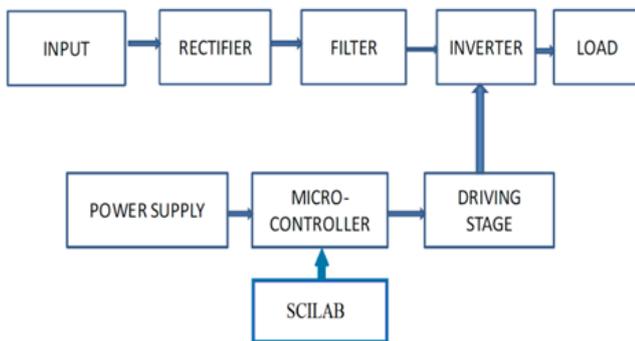


Figure 2- Power circuit diagram

## C. Driver Circuit Block

The FAN 7392 is a monolithic high and low side gate driver IC, that can drive high speed MOSFET and IGBTs that operate up to +600V it has a buffered output stage with all NMOS transistors designed for high pulse current driving capability and minimum cross conduction. This processes high voltage and common mode noise cancelling techniques provide stable operation of the high side driver under high dv/dt noise circumstances. An advanced level shift circuit offers high side gate driver operation up to  $V_s=9.8V$  (typical) for  $V_{BS}=15V$ . Logic inputs are compatible with standard CMOS or LSTTL output, down to 3.3V logic. The high current and low output voltage drop feature makes this

device suitable for half and full bridge inverters, like switching mode power supply and high power DC-DC converter applications. Figure 3 shows the pin diagram for 14 pin and 16 pin IC. This IC can controls two thyristor gates.

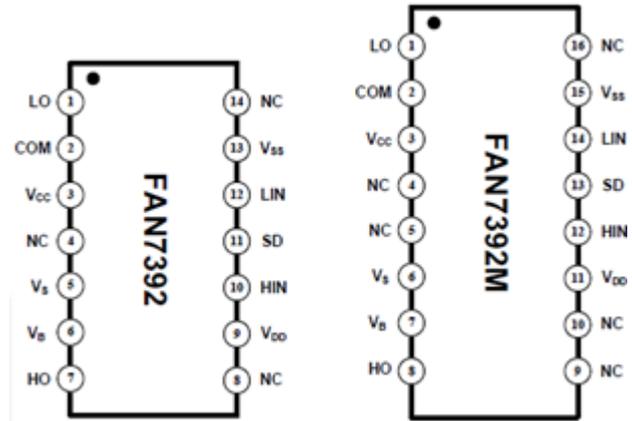


Figure 3- Pin diagram of FAN 7392/7392M

Figure 4 and figure 5 shows the internal block diagram of FAN 7392 and FAN 7392M.

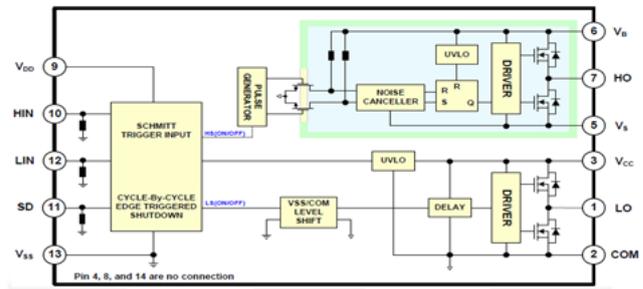


Figure 4- Internal block diagram of FAN 7392

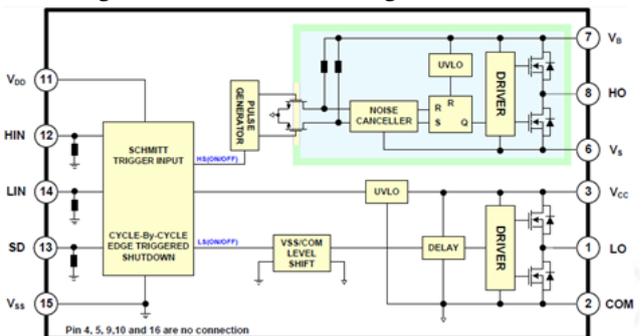


Figure 5- Internal block diagram of FAN 7392M

## D. Scilab Simulation

Download the following files from: [HTTPS://ATOMS.SCILAB.ORG/](https://atoms.scilab.org/)

1. serial\_0.4.1\_5.5-1.bin.

2. arduino\_1.1-1.bin.x64.windows (suitable for your system).
3. toolbox\_arduino\_v3 (from: [https://github.com/fizcris/Scilab\\_Xcos\\_arduino\\_toolbox\\_david\\_MPU6050/blob/master/toolbox\\_arduino\\_v3/toolbox\\_arduino\\_v3.ino](https://github.com/fizcris/Scilab_Xcos_arduino_toolbox_david_MPU6050/blob/master/toolbox_arduino_v3/toolbox_arduino_v3.ino))

3. Relationalop: This tool compares the triangular wave form and the sine wave which results in PWM.
4. Arduino Setup: Arduino card is choosed and the port number is setup.
5. Arduino Digital Write Pin: The PWM is given to the respective Arduino pins.

Load toolbox\_arduino\_v3 to Arduino software. Also load serial\_0.4.1\_5.5-1.bin and arduino\_1.1-1.bin.x64.windows in scilab console window and run the program.

Figure 6 shows the simulation circuit that generates PWM needed Trigger the IGBT's gate.

### III. RESULTS AND DISCUSSION

The output of the simulation is shown in figure 7 and 8 that is given to driving circuit which drives the IGBTs at phase difference of 120° for three phase.

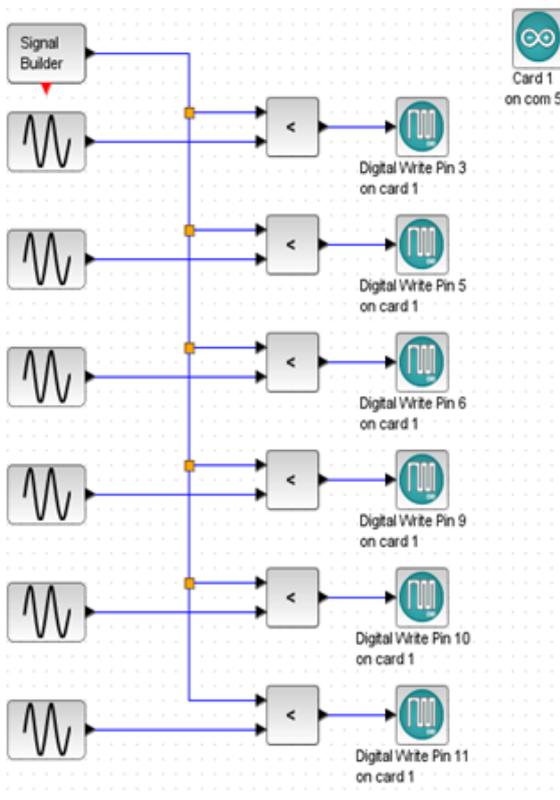


Figure 6- Circuit for generation of PWM

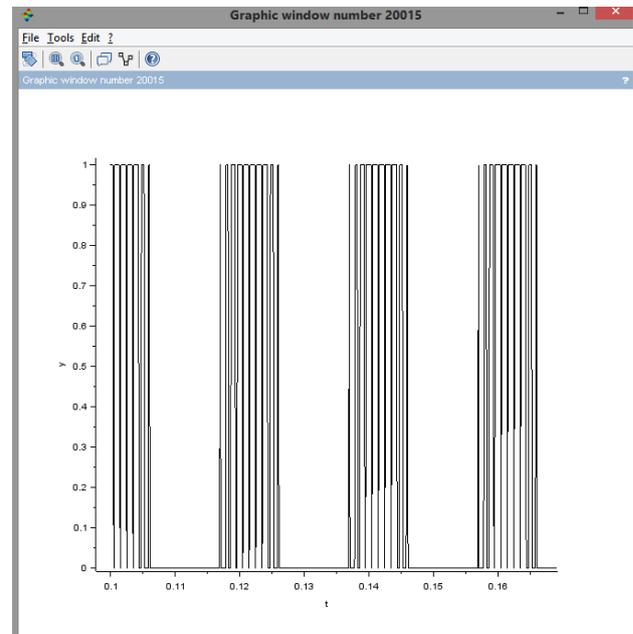
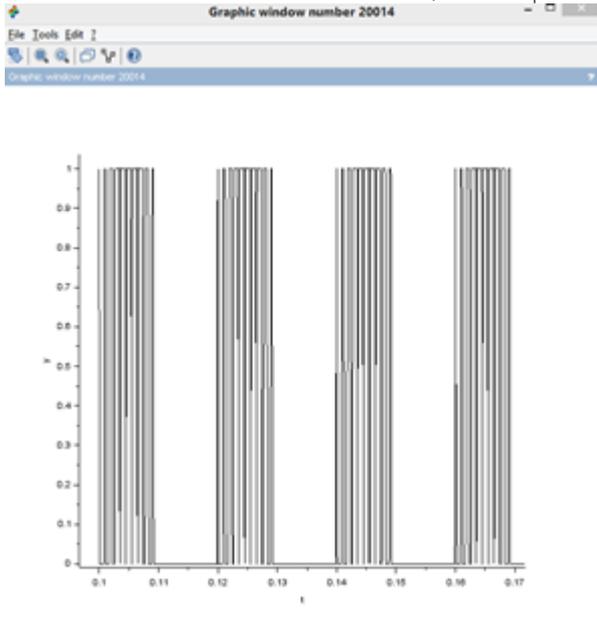


Figure 7- Generated PWM for positive cycle

#### Used tools:

All the tool are taken from the xcos palette.

1. Signal Builder: This is used to generate triangular waveform of preferred frequency and amplitude. The specification can be changed according to the requirement.
2. Sine wave generator: This generates a sine wave of preferred frequency and amplitude. The specification can be changed according to the requirement. Here we are giving comparing six sine wave generator at 60° phase angle.



**Figure 8-** Generated PWM for negative cycle

We can see a  $30^\circ$  phase shift between positive and negative cycle. The output is shown for single phase. Similarly, three phase PWM can be generated.

#### IV. CONCLUSION

Three phase asynchronous induction motors are widely used in industrial applications due to their features of low cost, high reliability and less maintenance. Due to the need for three-phase electricity in today's remote areas for agriculture work where three phase power is not available easily, in those areas these single phase to three phase converters are use full. Operating a three phase induction motor using single phase supply has been presented.

The developed system is useful in remote areas where three phase supply is not available easily.

Applications of single phase to three phase converter are:

- Electric Vehicle.
- In Irrigation Pumps for Agriculture purpose.
- Rural Area Water Supply.

#### V. REFERENCES

- [1]. Chingchi Chen, "A Hybrid Inverter/cylcoconverter-Based Variable-Speed Three-phase Induction Motor Drive for Single-phase Inputs" IEEE Tran. on Industry application, Vol.31.no.3,may/june 1995 .
- [2]. P. N. Enjeti and A. Rahman, "A new single-phase to three-phase converter with active input current shaping for low cost ac motor drives,"IEEE Trans. Ind. Applicar., vol. 29, no. 4, pp. 80C813 July/Aug. 1993.
- [3]. Shivanagouda.B.Patil, M. S. Aspalli, "Operating Three Phase Induction Motor Connected to Single Phase Supply", 2012, International Journal of Emerging Technology and Advanced Engineering,(Nov 2012), ISSN 2250-2459.
- [4]. M. Khan, I. Husain, and Y. Sozer, "Integrated electric motor drive and power electronics for bidirectional power flow between the electric vehicle and dc or ac grid," Power Electronics, IEEE Transactions on,vol. 28, no. 12, pp. 5774–5783, Dec 2013.
- [5]. Dong-Choon Lee, Member, IEEE, and Young-Sin Kim," Control of Single-Phase-to-Three-Phase AC/DC/AC PWM Converters for Induction Motor Drives," IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 54, NO. 2, APRIL 2007.
- [6]. Shivanagouda.B.Patil, M. S. Aspalli," Operating Three Phase Induction Motor Connected to Single Phase Supply ," International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 2, Issue 11, November 2012.
- [7]. Arvind K.Yadav, Nayan Wadgure, Pavan kamdi, "CONVERSION OF SINGLE PHASE TO THREE PHASE SUPPLY" International Journal of Research in Advent Technology (E-ISSN: 2321-9637), "ICATEST 2015", 08 March 2015.
- [8]. M. A. Kumar and S. Lakshminarayanan, "Cost effective gate drive circuit for MLI with constant number of conducting switches," 2016 IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), Bangalore, 2016, pp. 617-622. doi: 10.1109/RTEICT.2016.7807896.