Implementation of Continuous power supply system for irrigation using Solar based SPWM Inverter and Diesel generator

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Abstract- In this paper describe details of fully automatic system that implemented for continuous power supply for water irrigation . In which solar power, supply mains and diesel generator use as source .System gives output on the predefined priority. First priority is set on solar power , second priority is set on the supply mains and last one is on diesel power. For converting solar DC power in AC power SPWM inverter uses. For the SPWM inverter microcontroller ATmega16 uses, which generate SPWM gate pulses for inverter. Performance of SPWM inverter fed induction motor is described in detail .

Keywords :-SPWM inverter, Induction motor, Solar power.

1-Introduction

Solar power is energy from the Sun. It is renewable and environmental pollution free. Solar power battery charged systems provide power supply for a day irrespective of bad weather. By adopting the appropriate technology for the concerned geographical location, we can use large amount of power from solar radiations. More over solar energy is expected to be the most promising alternate source of energy. The global search and the rise in the cost of conventional fossil fuel is making supply-demand of electricity product almost impossible especially in some remote areas. Generators which are often used as an alternative to conventional power supply systems are known to be run only during certain hours of the day and the cost of fueling them is increasingly becoming difficult if they are to be used for commercial purposes. Normally in remote areas water irrigation is done by either supply mains or by solar power but in bad weather condition solar power is not only sufficient for irrigation purpose, So other option is supply mains but if both sources are unavailable at a time so for water irrigation, diesel powered generation system is alternative choice but presently irrigation is done by manual system so there is problem with continuous water irrigation at remote location. For resolving these problems implemented "**Continuous power supply system for irrigation using Solar based SPWM Inverter and Diesel generator**". In which load is automatic shifted from one source to another source on the basic of predefined priority and also control battery charging and discharging process. Solar power is first priority for water irrigation because it is renewable, non-polluted energy source. Second priority is set on supply mains and last priority is on diesel powered generator .Table 01 shows output priority of supply for load with in different cases. In the table '0' represent unavailability of source and '1' represent availability of source. For converting DC power in to AC power output ATmega16 microcontroller based SPWM inverter is use. Operational amplifier based automatic battery charging system also available to avoid battery from overcharging and deep discharging.

TABLE-01:- PRIORITY SELECTION FOR LOAD WITH DIFFERENT CASES.

Case	Solar Power	Supply Mains	Diesel Generator	Output Priority
01	0	0	0	No source
02	0	0	1	D/G set
03	0	1	0	Supply mains
04	0	1	1	Supply mains
05	1	0	0	Solar power
06	1	0	1	Solar power
07	1	1	0	Solar power
08	1	1	1	Solar power

2-Generation Of SPWM Controlling Signals For Inverter Using Atmega16 Microcontroller.

In sine pulse width modulated inverter,ATmega16 microcontroller is used for generation of gate pluses for inverter bridge. ATmega16 is 40pin AVR microcontroller. It have 16kb flash memory, 32 Programmable I/O pins,8 channel for 10-bit ADC and 3 timer i.e. Timer 0, Timer 1, Timer 2 . Timer 0 and Timer 2 is of 8 bit timer. These timer use for generation of SPWM pluses. For generation of SPWM controlling signals, Timer 0 and Timer 2 set in fast PWM mode at 1 MHz clock frequency by using timer counter control register(TCCRx).Figure-01 shows timer counter control register of timer-0(TCCR0). Bits D0,D1,D2 of TCCR0 are used for clock presale setting. Table-02 shows different setting for clock presale setting of TIMER 0.

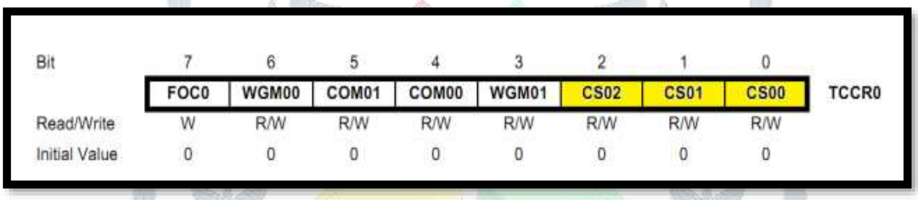

Figure-01 Timer/Counter control register

Table-03 shows different mode of operation of TIMER0. With the help of bit D6 and D3 of control register controller work in different mode . For fast PWM mode bit D6 and D3 set to high. Both timer set in fast PWM mode with 1Mhz clock frequency by given setting.

TCCR0|=(1<<WGM00)|(1<<COM01)|(1<<WGM01)|(1<<CS00); **Control register Setting of timer 0**

TCCR2|=(1<<WGM20)|(1<<COM21)|(1<<WGM21)|(1<<CS20); **Control register Setting of timer 2**

TABLE-02:- FOR CLOCK SETTING IN TIMER

CS02	CS01	CS00	Description
0	0	0	No clock source (Timer/Counter stopped).
0	0	1	$clk_{I/O}$/(No prescaling)
0	1	0	$clk_{I/O}$/8 (From prescaler)
0	1	1	$clk_{I/O}$/64 (From prescaler)
1	0	0	$clk_{I/O}$/256 (From prescaler)
1	0	1	$clk_{I/O}$/1024 (From prescaler)
1	1	0	External clock source on T0 pin. Clock on falling edge.
1	1	1	External clock source on T0 pin. Clock on rising edge.

TABLE-03:- TIMER MODE SELECTION

WGM00 (D6)	WGM01 (D3)	MODE
0	0	Normal
0	1	CTC(clear timer on compare match)
1	0	PWM , phase correct
1	1	Fast PWM

For generate 50Hz output frequency TIMER 0 is on for 10ms than TIMER 2 is on for next 10ms continuously. With the change value from 0 to 255 of OCRX (X=0,1,2) output voltage increases from 0 to 5v at timer output port. For SPWM generation value of OCRX register change with respect to time as same as sine curve value increases with respect to time. For positive half cycle timer 0 activated for 10ms and for negative half cycle timer 2 activated for 10ms.Figure02 shows output wave form of SPWM gate pluses from microcontroller.

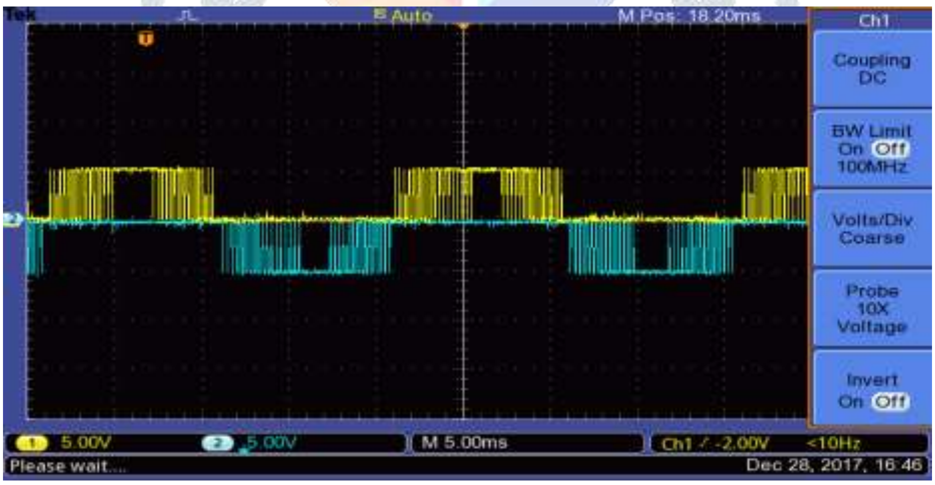

Figure-02 SPWM firing pluses for inverter.

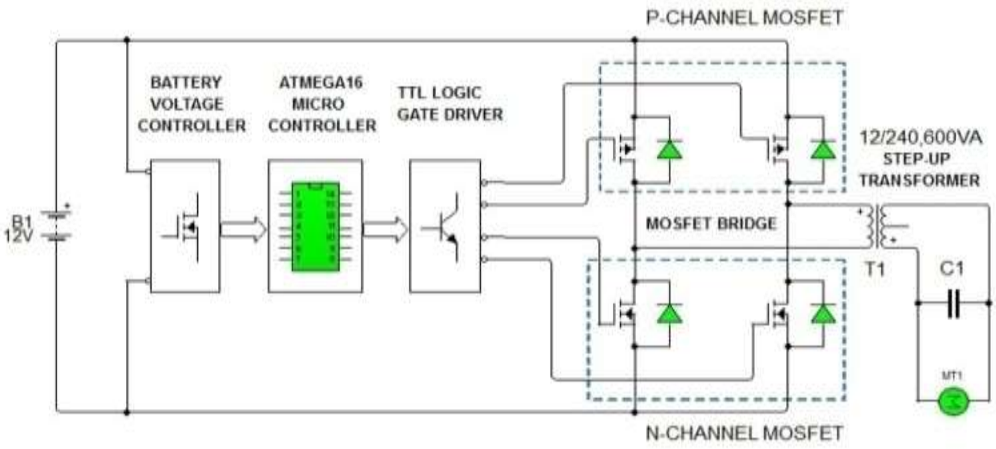

Figure-03 Model of SPWM inverter

Figure 03 shows model of atmega16 microcontroller based SPWM inverter. In the model battery voltage controller use for automatic inverter shutdown during low battery voltage. ATmega16 microcontroller is heart of the SPWM inverter because it generate SPWM gate pluses for inverter bridge . Output of the microcontroller is connected to TTL based gate driving circuit and output signal of TTL driver connected to MOSFET based inverter bridge. In the MOSFET bridge P-channel MOSFET use in upper leg and N-channel MOSFET use in lower leg. 12/230,600VA transformer is used for step up voltage level.Figure-04 shows implemented hardware of MOSFET based inverter and TTL logic gate driving circuit.

Figure-04 Implemented Model of SPWM Inverter

3- Proposed system

In figure 05, complete block diagram of "Continuous power supply system for irrigation using solar based SPWM inverter and diesel generator" is shown, in which solar panel is connected to charging current controller. Output of charging current controller is connected to battery voltage

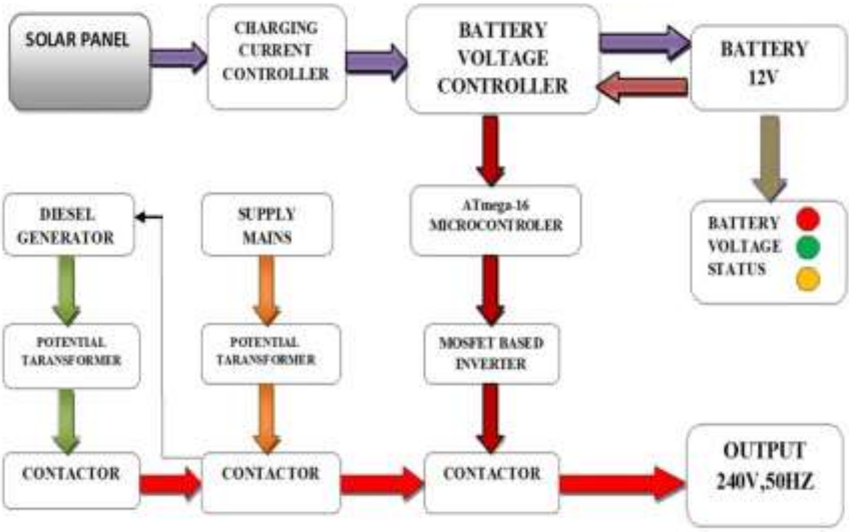

Figure-05 Block diagram of the system

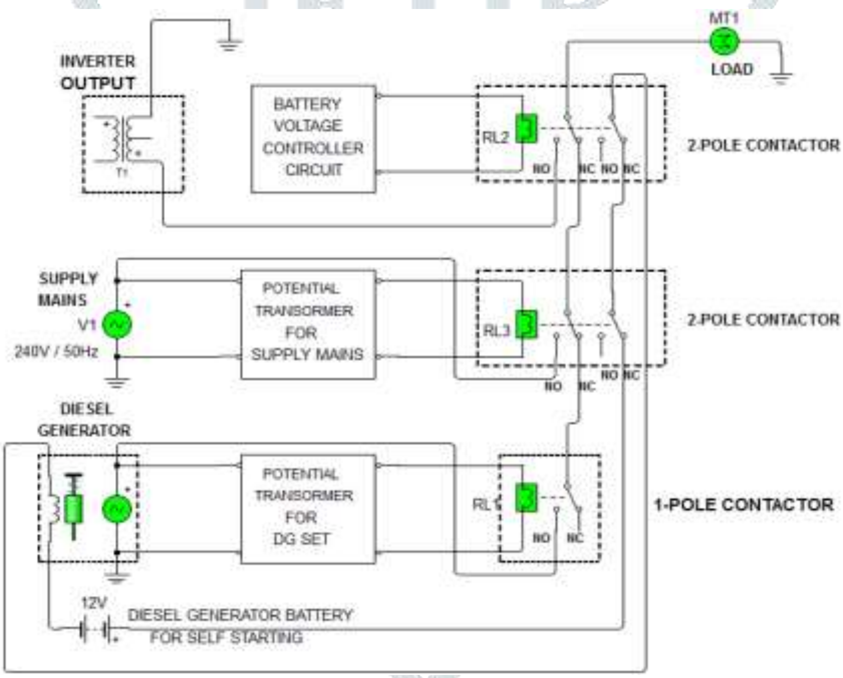

Figure-06 Contactor connection for priority selection

controller, which controls battery charging process as battery voltage reaches at preset maximum value so controller automatically turn off battery charging process. For better performance of battery and inverter, charging voltage controller automatically disconnect the load as battery voltage is low. Battery level indicator also used for indicating the battery voltage level. Main function of system is maintain continuity of output supply .For continuous power supply 3 different electrical sources use. That sources are solar panel, supply mains and diesel generator . With the help of contactors setting first priority set on solar based SPWM inverter, second priority set on supply main and last priority set on diesel generator. ATmega16 microcontroller is connected to MOSFET based inverter. Microcontroller is use for generating SPWM firing plus for bridge inverter. Output of inverter is connected step up transformer for step up voltage level from 11volt to 230volt . transformer output is connected to DPDT contactor. Output of diesel generator and supply mains terminal is connected to potential transformer for voltage measurement .If voltage is in safe range so contactor is activated. with the help of proper switching sequence between NO, NC and COMMAN terminal of the contactors set priority of source voltage. Figure-06 shows connection of contactors for priority setting .In priority selection circuit a SPDT contactor and 2 DPDT contactors use. Implemented hardware of automatic battery voltage controller and priority selection circuit shown in figure 07.In the circuit MOSFET is use for charging voltage controller and another MOSFET is use for auto shutdown inverter during low input battery voltage and automatic load shift on the supply mains by using priority selector contactors.

Figure-07 Implemented battery voltage controller and priority selector circuit

4-Analysis Of Performance Parameter & Results

Results are obtained with solar powered SPWM single phase 600VA MOSFET based inverter with 12v,150AH battery bank connected to 4 different load. For analysis of output and input parameter with 4 different load ,system connection shown in figure-08. In this setup a 12v,150ah battery use as a DC source for SPWM inverter ,SPWM inverter have MOSFET bridge. Output of the inverter is connected to primary winding of step-up transformer and secondary winding is connected to load with voltmeter, Ammeter, Watt meter, and DSO. Constant losses of the transformer is 38 watts. For analysis of current wave in DSO, series resistance R1 1Ω,5watt is use with load. Analysis of voltage waveform resistance R2 and R3 connected parallel with load for voltage division.

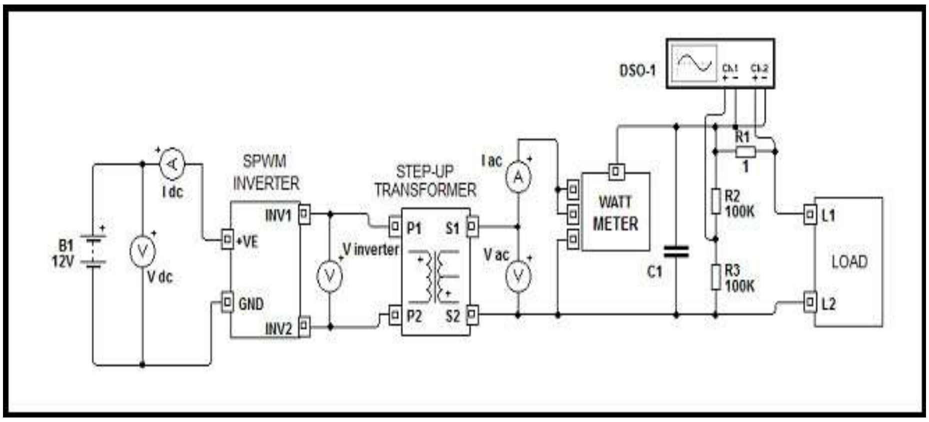

Figure-08 Circuit configuration for testing

TABLE-04:- SPECIFICATIONS OF APPARATUS

S.NO	Name of apparatus	Range	Type
01	Volt meter	0-32V	Moving coil
02	Ammeter	0-50A	Moving coil
03	voltmeter	0-30V	Moving iron
04	Volt meter	0-300V	Moving iron
05	Ammeter	0-3A	Moving iron
06	Watt meter	0-750W	Dynamometer
07	Digital oscilloscope	0-50v/div max	Tektronix 100mhz,2GS/s

In SPWM inverter gate pulse generated by Atmega16 microcontroller by using PWM mode of timer0 and timer2, port PB3 and port PD7 of microcontroller is use for drive MOSFET inverter bridge. Figure-09 shows waveform of gate pulse .For analysis of performance parameter, inverter connected to different load various parameter found that shown in table 05.

TABLE-05:-OUTPUT PARAMETER WITH IN DIFFERENT CASES

Case	Vdc	Idc	Wdc	Vin	Vout	Iout	Wout
01	8.5V	16.0A	136.00W	8.2	215	.48A	90W
02	9.9V	11.5A	113.85W	8.8	242	.39A	65W
03	9.0V	17.0A	153.00W	8.1	205	.51A	95W
04	8.1V	23.0A	186.50W	6.8	140	.80A	100W

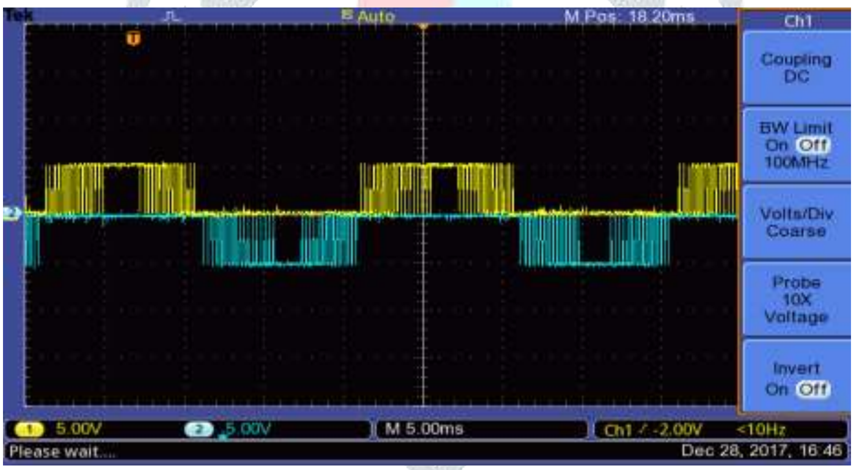

Figure-09 SPWM firing pulse for inverter

Case 1:- 100w lamp load connected to inverter

If 100w lamp load connected to inverter with 12v,150ah battery bank. , DSO voltage setting is 50v/division for channel 01 and 1v/division for channel 02 And time scale set 50ms/division for both channels , channel 01 is use for load voltage measurement and channel 02 is use for load current measurement, output voltage wave form shown in figure 10 and output current wave form shown in figure-11.

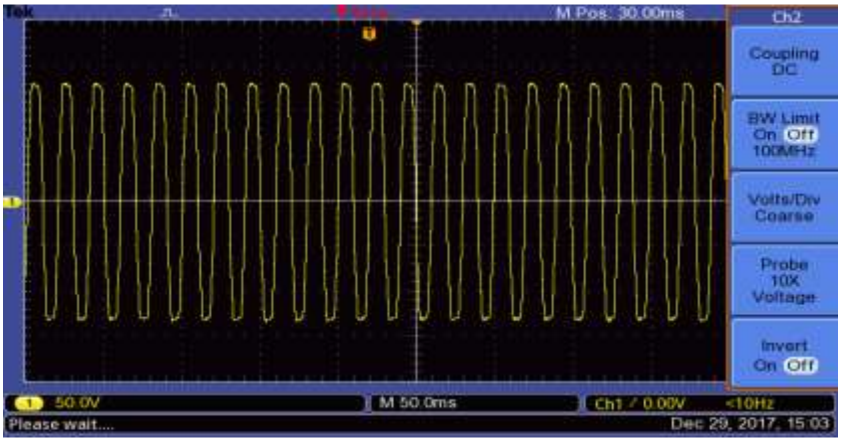

Figure -10 Voltage wave form under 100w lamp load

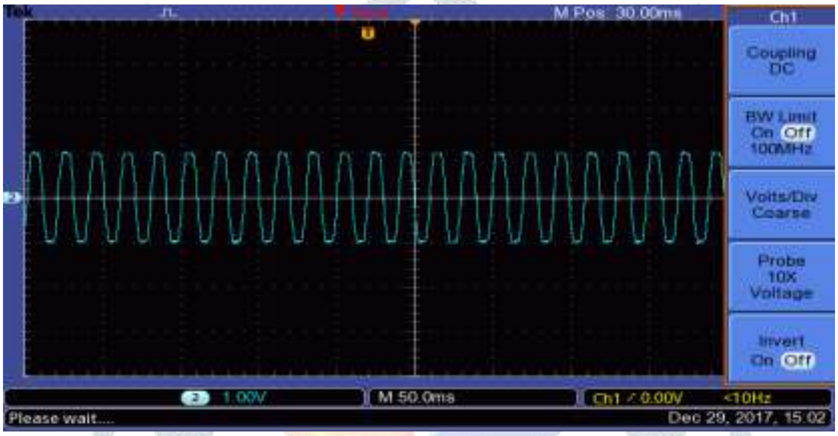

Figure-11 Current wave-form at 100w lamp load

***Case 2*:-** 105watt induction fan motor connected to inverter

105watt induction fan motor connected to inverter with 12v,150ah battery bank. , DSO voltage setting is 50v/division for channel 01 and 1v/division for channel 02 and time scale setting is 10ms/division, channel 01 is use for load voltage measurement and channel 02 is use for load current measurement. Output voltage and current wave form shown in figure 12.

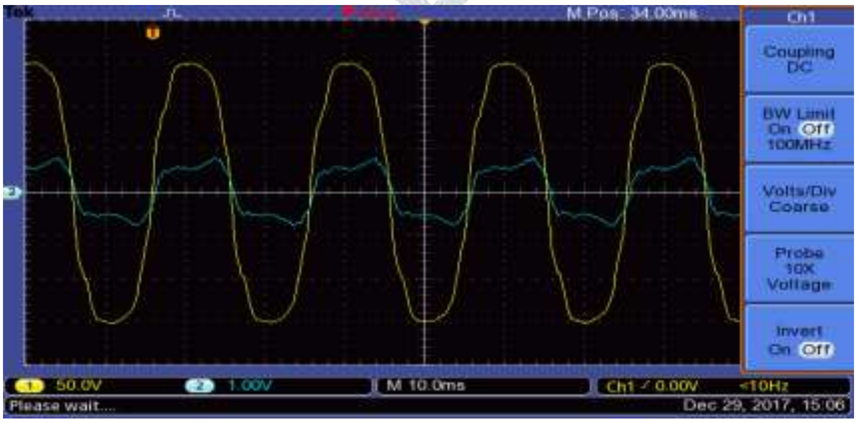

Figure -12 Voltage and current wave-form at 105w induction motor at no-load

***Case 3*:-** 120 watt induction water pump at no load connected to inverter:-

120 watt induction water pump at no load connected to inverter with 12v,150ah battery bank . DSO voltage setting is 50v/division for channel 01 and 1v/division for channel 02 and time scale setting is 5ms/division, output voltage and current wave form shown in figure 13.

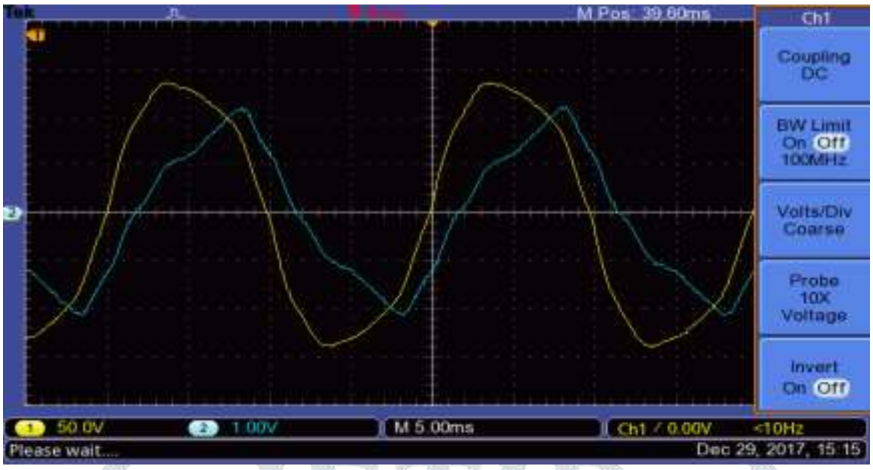

Figure -13 Voltage and current wave form of induction water pump at no-load

Case 4: 120 watt induction water pump at 10 fit water head connected to inverter:-

120 watt water pump connected to inverter with 10 feet water head, DSO voltage setting is 50v/division for channel 01 and 1v/division for channel 02 and time scale setting is 10ms/division, output voltage wave-form shown in figure-14 , current wave-form shown in figure-15 and voltage and current wave form shown in figure-16.

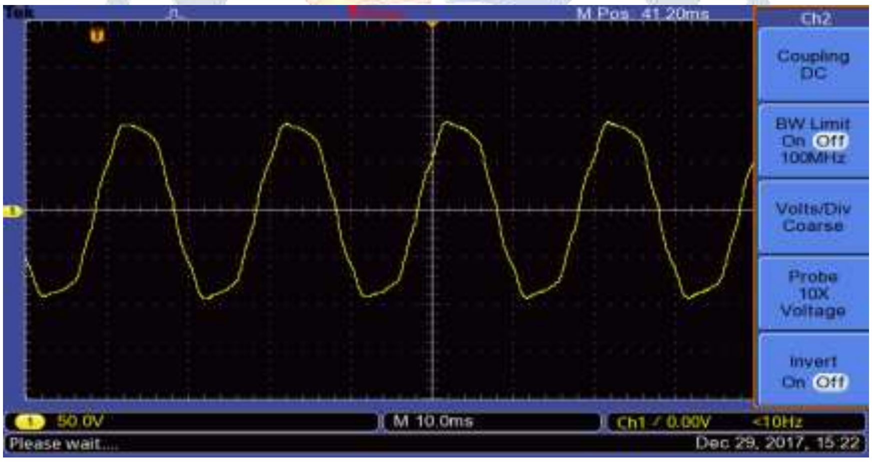

Figure -14 Voltage wave form of induction water pump at 10 feet head

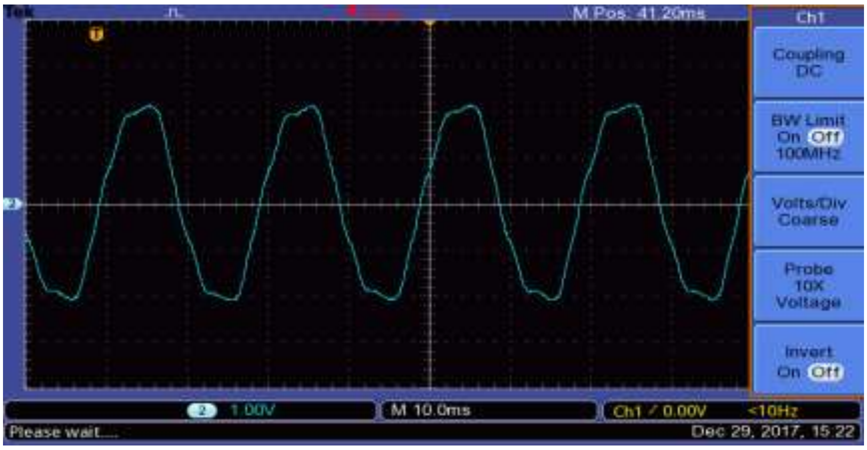

Figure -15 Current wave form of induction water pump at 10 feet head

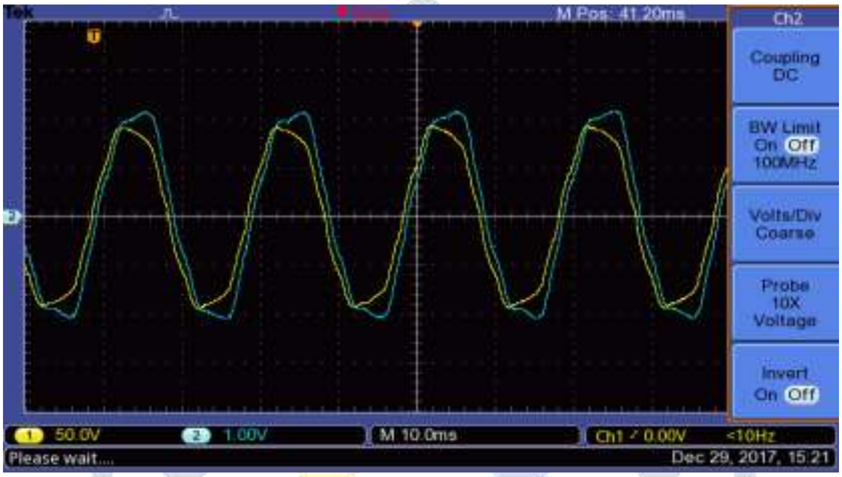

Figure -16 Voltage and current wave form of induction water pump at 10 feet head

5-Conclusion

The developed system is Simple and cost effective than most other systems present in the market. It is fully automatic system for continuous power supply. First source priority set on solar power next one is on supply mains and last one is on diesel generator. For converting DC power in to AC power, microcontroller based SPWM voltage source inverter has been design and developed . SPWM inverter produces sine wave output .Which reduces harmonics content and power losses at load side. SPWM inverter (220V,50Hz ,600VA) design and developed by using ATmega16 microcontroller ,this setup tested successfully with single phase mono-block 220volt ,50hz, 120watt water pump and also tested with various resistive and inductive load . It is found that the complete designed system working well and giving desired output results. The novelty of designed system is that, batteries are directly charged from the solar panel so DC power is available throughout 24 hours. Apart from irrigation some light sources can be used in night. By implementing this type system there are various benefits for the government and the farmers. For the government a solution for energy crisis is proposed. The excess energy produced using solar panels can also be feed-back to the grid with small modifications in the system circuit, which can be a source of the revenue for the farmer, thus encouraging farming in India and same time giving a solution for energy crisis.

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