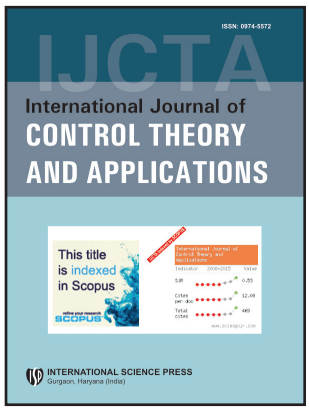

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PV Array Based HERIC Inverter Topology for Irrigation Pump

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Abstract: This paper presents an inverter topology to drive a single phase induction motor (SPIM) using photovoltaic (PV) modules. The HERIC inverter topology with fuzzy controller logic is proposed. The pulses to the inverter are controlled using a fuzzy controller. The advantages of this logic are that the information is divided in partially overlapping clusters and the controller is able to compute the control action and to describe it in the same language. The proposed design incorporates higher efficiency and less switching losses. In the irrigation field, the system which has been developed will help to solve the energy crisis to an extent and can be used throughout the year. The model is implemented using MATLAB/Simulink.

Keywords: HERIC Inverter, Single Phase Induction Motor (SPIM), Fuzzy Controller, Photovoltaic Module (PV).

1. INTRODUCTION

In general, this paper focuses on the application of underground water pumping using solar power. The overall requirements to implement the proposed system is a solar photovoltaic system (solar PV panels), DC-AC inverter, fuzzy controller and SPIM. The motor uses pump as a load. The major sources of world's electricity generation are Fossil fuels such as coal, petroleum, natural gas etc. but these are facing a number of challenges such as rising prices, shortage of these resources, growing environmental concerns over the climate change etc. [1]-[2]. Because of these challenges various alternative energy sources and new technologies for electricity generation are being developed. Among these renewable sources of electricity, solar power is of great interest for researchers and developers. "Maximum Power Point Technique (MPPT) is used to extract maximum power from solar panel" [3]. The Highly Efficient and Reliable Inverter Concept (HERIC) topology that gives the higher efficiency and less switching losses are used in the proposed system [4]-[5]. At one time only 2 switches are active so due to this technique it provides higher efficiency and less conduction losses [6]-[7].

Fuzzy control system is knowledge based non-linear systems [8]-[9]. It is a technique in computer science which solve the problem as quickly like a human brain. This technique is also used to control the pulses of converter. It does not have any precise mathematical equation but it achieves the accurate, stable and fast

response. The accuracy of the system depends upon the numbers of inputs and fuzzy rule table [10]-[11]. The output of this system is adjusted by rule which make the output as near to zero. The idea of this system is to implement the simpler and faster method and reduce the computational burden. This system is divided in several states. The concept of fuzzy logic (FL) can be used for low cost, better features and high performance. The methodology has now been widely used in many scientific and industrial applications [12]-[13].This paper attempts to integrate solar and HERIC with fuzzy controller. The load is considered as an AC Motor (water pump) [14]-[15].

2. PROPOSED SYSTEM

The system block diagram consist of a solar panel as input source, an inverter which converts DC-AC and water pump which is used for agriculture irrigation is shown in Figure 1. The main source of energy which is available to the system is the Solar panel. Figure 2 depicts the model of the solar panel. The internal impedance as shown in Figure consists mainly of a diode. The ideal operating point is determined by the internal impedance (series and shunt resistance) and the diode which has a non-linear circuit element and makes the I-V characteristic of a solar panel non-linear. There are several factors in which the MPP of a solar panel is dependent. They are the amount of irradiance, the temperature and the shading of the panel. The location of the MPP is affected by all these factors. Thus, the MPP of a solar panel changes constantly and maximum power output has to be obtained by MPPT.

The HERIC based inverter circuit includes six switches with four MOSFET in each arm of H-bridge and two switches connected anti-parallel at the output of the H-bridge. For every half wave are 2 different MOSFET´s of the H-bridge switched with PWM. The MOSFET's at the output are turned on/off during the corresponding half-wave. The transformer in solar photovoltaic inverters can be eliminated to reduce the overall size and losses of the system. The inverter topology and control strategy, both affects the leakage current. HERIC topology has advantages like low leakage current level and high efficiency among the existing inverters. The additional branch of switches of the circuit is active during half-wave period of the output voltage. The path for the freewheeling current is provided by this bridge by eliminating the circulation of reactive power and increasing the efficiency and voltage. Table 1 represents the inductor and capacitor value which is used in simulation as filter parameters.

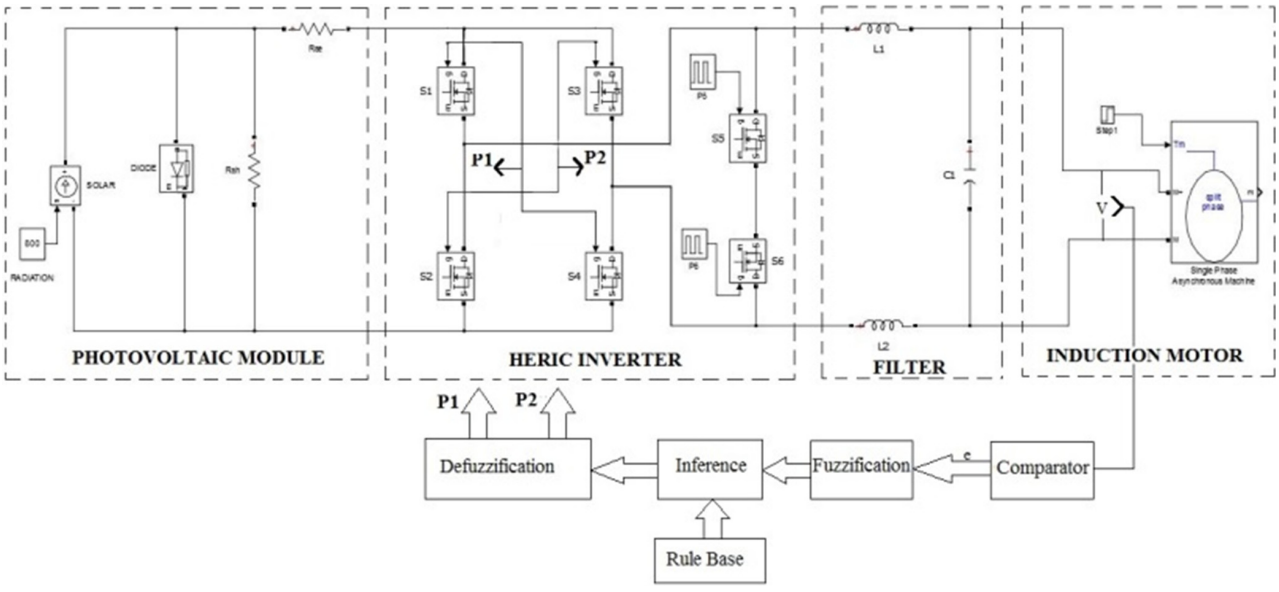


Figure 1: System Model

Table 1
Simulation Parameter Of Filter

Simulation parameter	*Rating*
Inductor 1 (L1)	3.0 mH
Inductor 2 (L2)	3.0 mH
Capacitor	1000μF

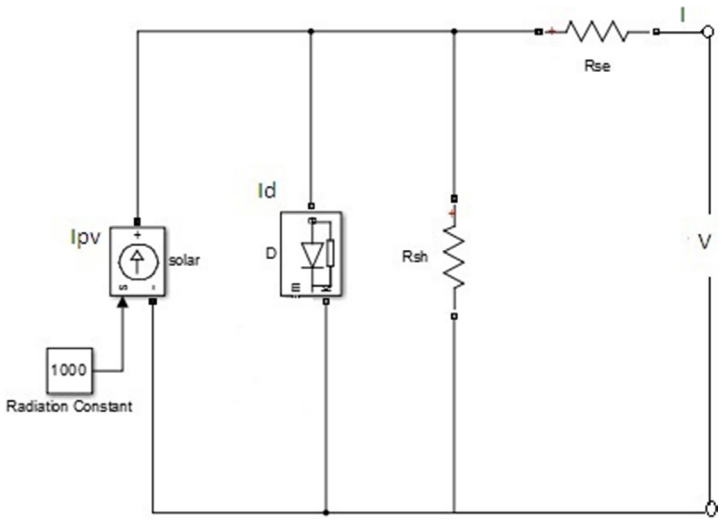
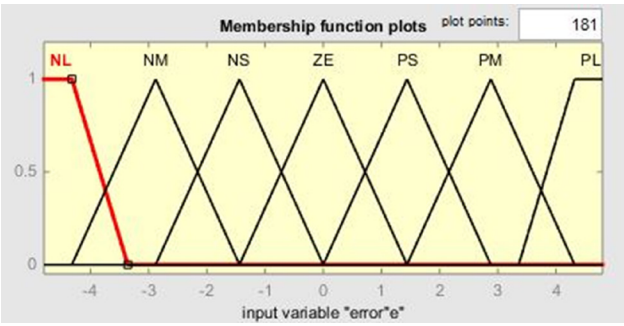


Figure 2: Equivalent Model of Solar Panel

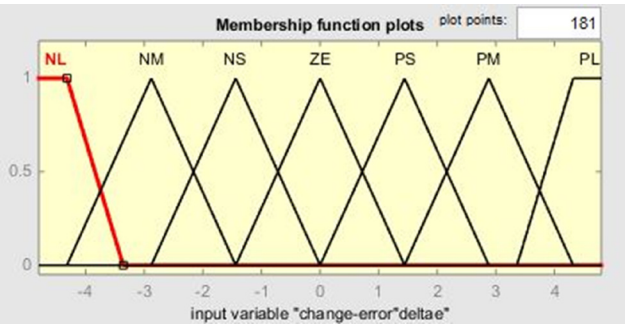
3. FUZZY LOGIC SYSTEM

Among all the popular techniques in soft computing, the fuzzy logic controller is a system which does not require any accurate model of the plant. It is an algorithm which computes the "degrees of truth" other than the "true or false". A number of partial truths can be formed by aggregating the data, and further aggregates into higher truths. It has special case in which fuzzy logic can be seen as the way of reasoning and binary or Boolean logic.

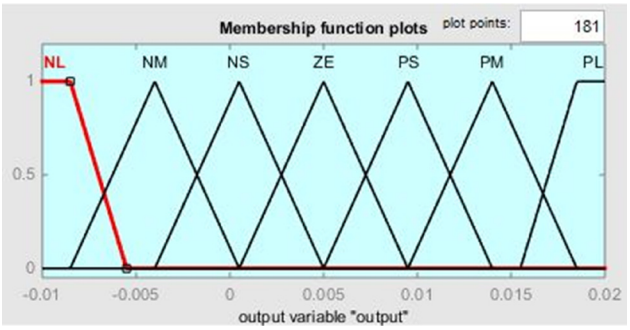
The output voltage of HERIC converter is measured and compared with reference voltage through comparator. The controller block gets the difference between the output voltage and the reference value which generates the error signal. The change in error is also generated. The error and change in error is fuzzified. The fuzzification is a method to transform the crisp input value to linguistic value of fuzzy. The variable of fuzzification is fuzzy variable and can be represented by a membership function. In these process two inputs has been chosen that is error and change in error and one output as shown in Figure 3(a) to 3(c).



(a)



(b)



(c)

Figure 3: Membership Function: (a) input (error); (b) input (change in error); (c) output

The membership function is a technique which is used to solve the empirical problems based on experience only. The construction of this function is designed based on available histogram and other probability. The range of membership function is 0 to 1. It has some special features such as core, support, boundary to characterize the membership function. The output of fuzzification is fed to inference. The inference is a method to perform the deductive reasoning, so the inference is depending upon the fuzzy rule. By adjusting the value of table the error will adjust. The input value of fuzzy MH, MM, MS, Z, PL, PM, PB stands for minus high, minus medium, minus small, zero, positive small, positive medium, positive big respectively. The Table 2 states the rule which is the input values of fuzzy. Defuzzifier uses the membership function to convert the fuzzy inference engine output to crisp input value which is analogous to the ones used by the fuzzifier. The output of this controller is used to generate the PWM pulses which are triggers the switch S1 and S4.

Table 2
Fuzzy Table Rule

Δe \ e	*MH*	*MM*	*MS*	*Z*	*PS*	*PM*	*PB*
MH	MS	PB	PB	PB	PB	PM	Z
MM	PB	PB	PM	PM	PM	Z	MS
MS	PB	PM	PS	PS	PS	MS	MM
Z	PB	PM	PS	Z	MH	MM	MH
PS	PM	PH	MS	MS	MS	MM	MH
PM	PS	Z	MM	MM	MM	MH	MH
PB	Z	MS	MH	MH	MH	MH	PS

4. SIMULATION RESULTS

The overall implemented mat lab simulation file is shown in Figure 4. The pulses for switch 1, 4 and for switch 2 and 3 generated from the defuzzification output are shown in Figure 5. By feeding this pulses into switch, the output voltage and current of inverter obtained for a single phase induction motor load. The peak voltage and current of inverter is 315 V and 7.2 A is shown in Figure 6 respectively. The parameter of 1 HP SPIM considered is given in table 3. Simulated results obtained for the motor parameter listed in table 3, the main winding current, rotor current torque and constant speed at 3000 rpm is shown in Figure 7.

5. HARDWARE RESULTS

The hardware model of the proposed circuit developed and the output voltage obtained from the inverter of 5V RMS is as shown in Figure 8. and 9.

Table 3
Machine Parameter

Specification	*Rating*	*Rating*	*Specification*	*Rating*
Main stator winding	Rs = 4Ω	Lls = 0.0203 H	Nominal Power	746 W
Main rotor winding	Rr = 3.6Ω	Llr = 0.0304 H	Nominal Voltage	220 V
Auxiliary stator winding	Rs' = 6.5Ω	Lls' = 0.0211H	Frequency	50 Hz
Mutual inductance (main)	Lms = 0.1954 H		Inertia	0.0147 J

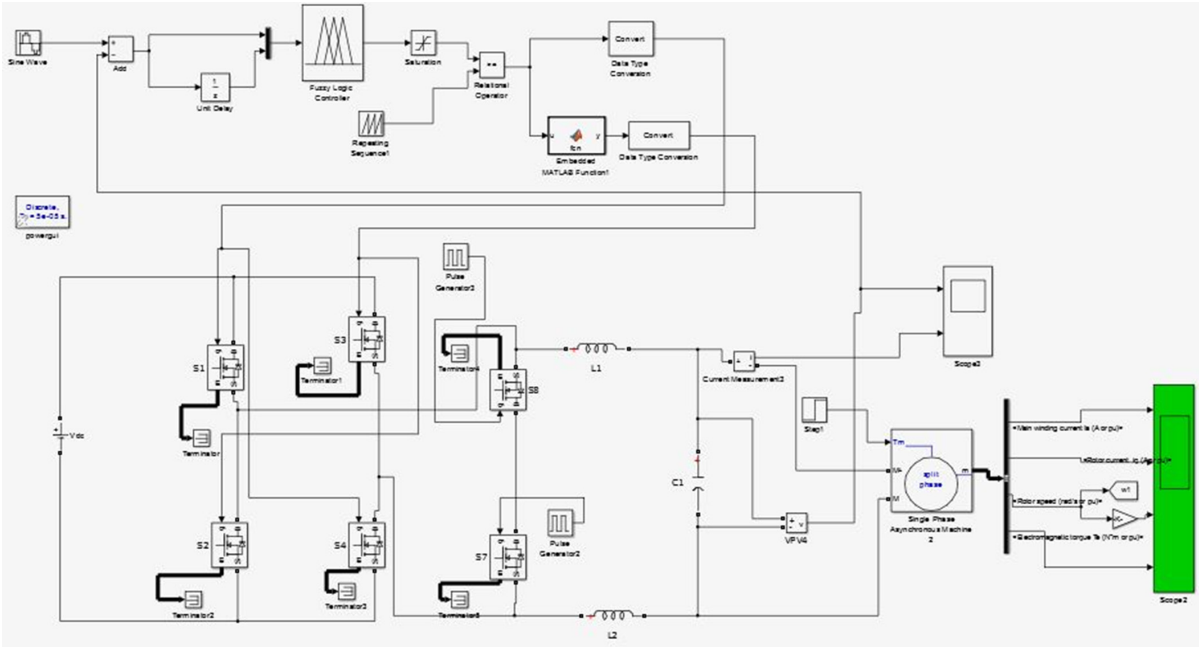


Figure 4: Simulation File

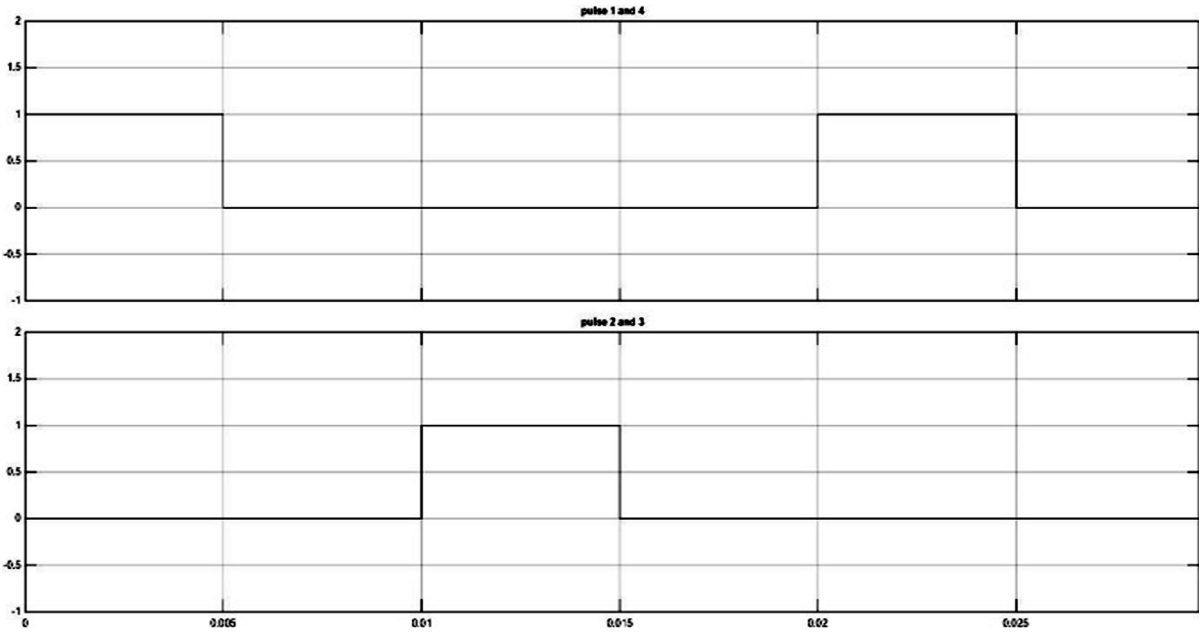


Figure 5: Switching Pulse through Fuzzy Controller

6. CONCLUSION

The proposed HERIC inverter topology incorporates the higher efficiency because at single instant less switch conduction happens and less switching losses occurs. Fuzzy logic controller gives fast response with minimum THD. The water pump depends upon the output behavior of induction motor. The speed of induction motor is controlled as a constant value at 3000 rpm. The MATLAB Simulink model was used for obtaining simulation result and a hardware demo model result is also presented.

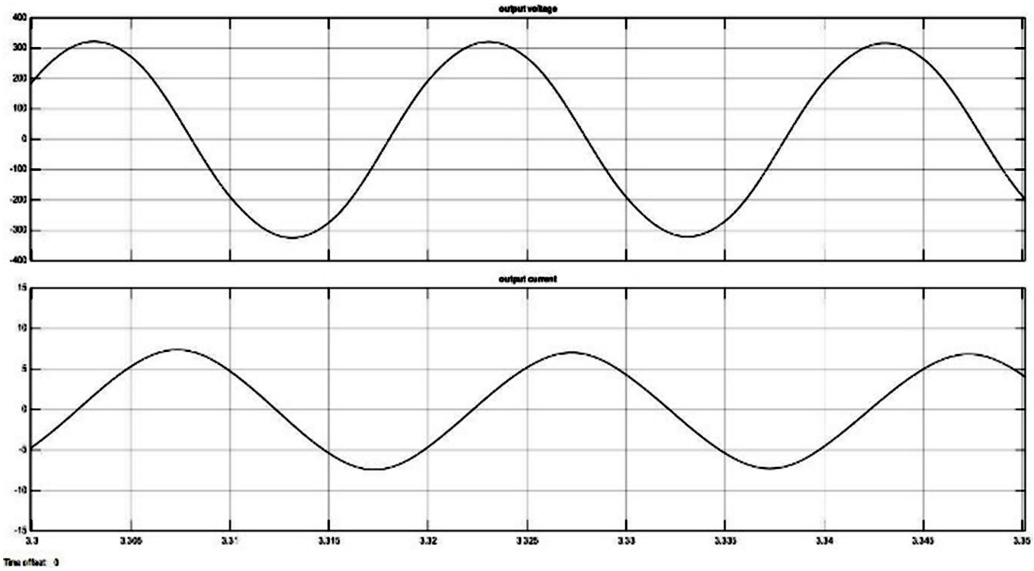


Figure 6: Output showing voltage and current of inverter

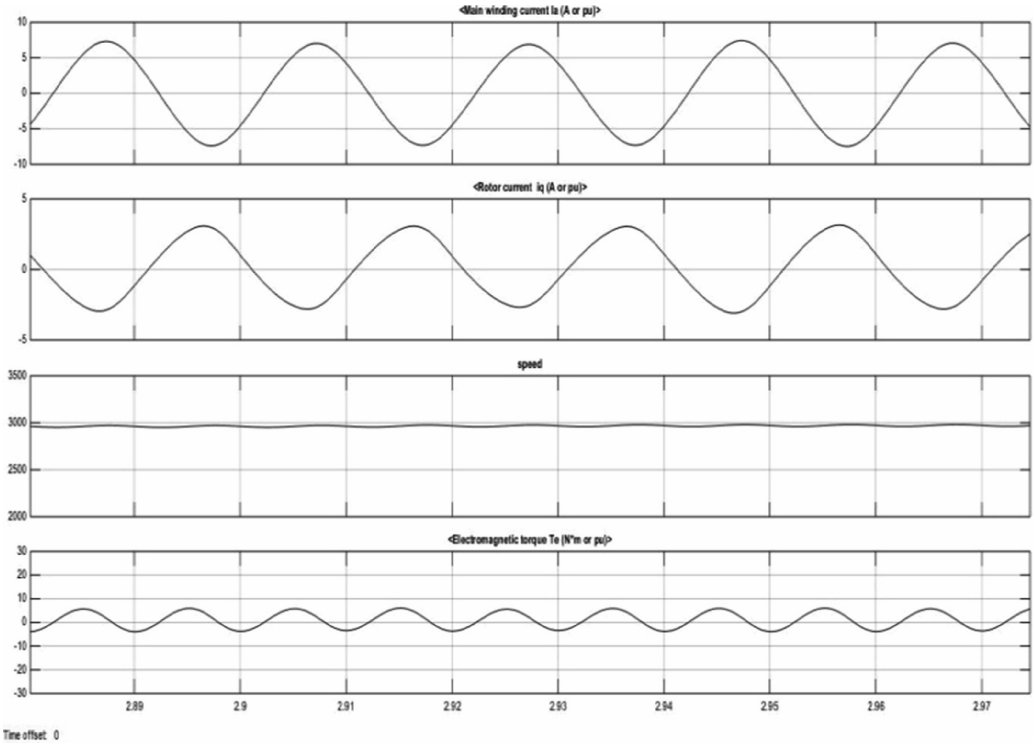


Figure 7: Output of the Induction Motor

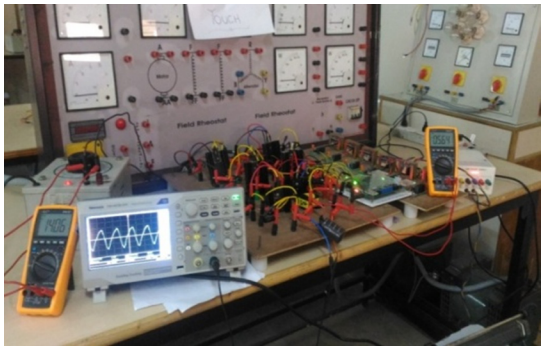


Figure 8: Hardware prototype of the proposed converter

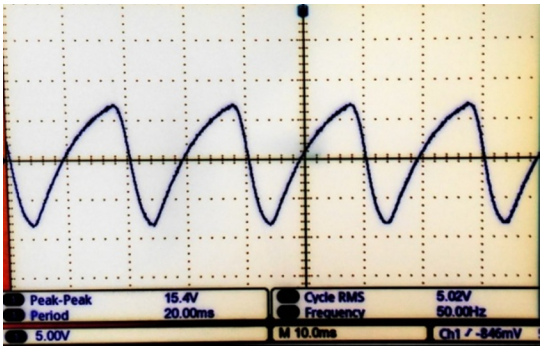


Figure 9: Output of the inverter

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