SINGLE-PHASE, TWO-PULSE ELECTRONIC FIRING CIRCUIT FOR AC TO AC OR AC TO DC CONVERTER CIRCUITS APPLICATIONS

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Abstract. As a part of a final year project, this paper presents a simple single-phase, two-pulse electronic firing circuit for triggering the essential controlled semiconductor(s) required in the application of AC to AC or AC to DC converter circuits, for Ac or DC loads. The proposed electronic firing circuit can deliver two shifted by 180^{o} pulses with adequate amplitude and duration for triggering one, two or four controlled semiconductors required in the single-phase AC to AC or AC to DC converter circuits. Complete simulation results obtained from the simulated circuit model are obtained and represented. Some results, from an experimental set up constructed, operated, and tested in the laboratory, obtained from the proposed electronic firing circuit are presented to verify the simulation results.

Keywords: Two-pulse, Firing Circuit, Controlled Converters

INTRODUCTION

AC to AC and AC to DC controlled circuits are semiconductor power electronics converters used extensity in controlling the flow of power from AC power supply to AC or DC loads [1, 2]. For controlling the semiconductor devices of the converters such as Thyristors or Triacs, additional circuits are required. These circuits are called triggering or firing circuits. In the following two sections detailed information will be given concerning the converter circuits and their essential firing circuits.

AC TO AC VOLTAGE REGULATORS (AC TO AC CONVERTERS)

AC regulators are used to control the flow of power from AC power supply to feed AC loads such as AC motors. In such converters, Thyristors or Triacs can be used. The converters can be classified mainly into [1, 2]:

a. Single – Phase converters
b. Three – Phase converters

The suggested firing circuit for this paper, can be used for a single- phase converters to control the quantity of power which could be provided to a light bulb or to an AC single phase motor, which is consider as an inductive load.

Thus, the converter can use either a single Triac unit, as shown in Fig. 1 (a, and b), or two back to back antiparallel connected Thyristors, as shown in Fig. 2.

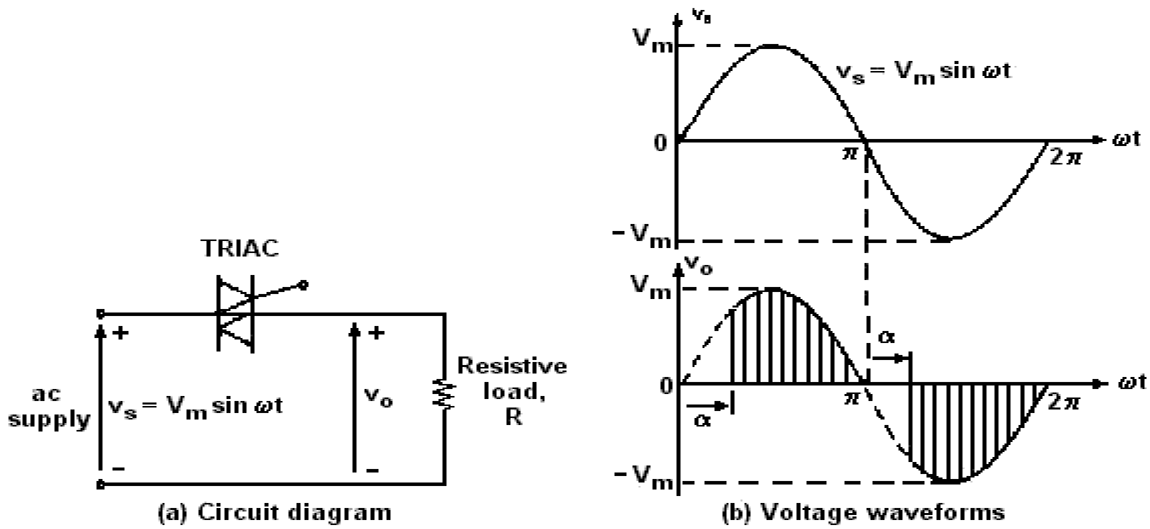


Fig. 1: Single – Phase converter using single Triac unit

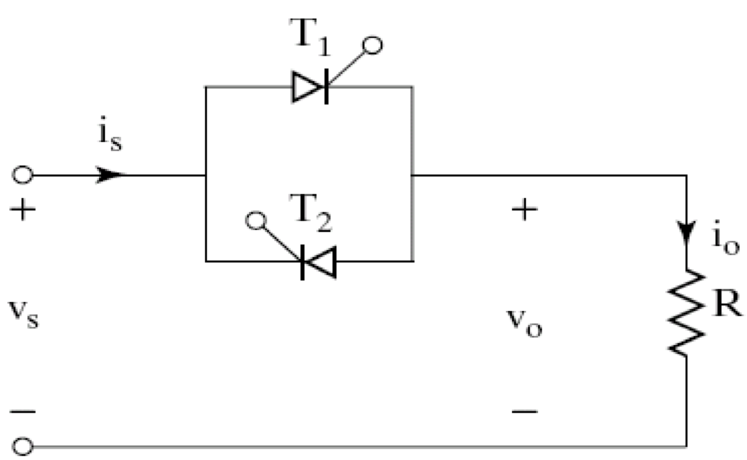


Fig. 2: Single – Phase converter using single Triac unit

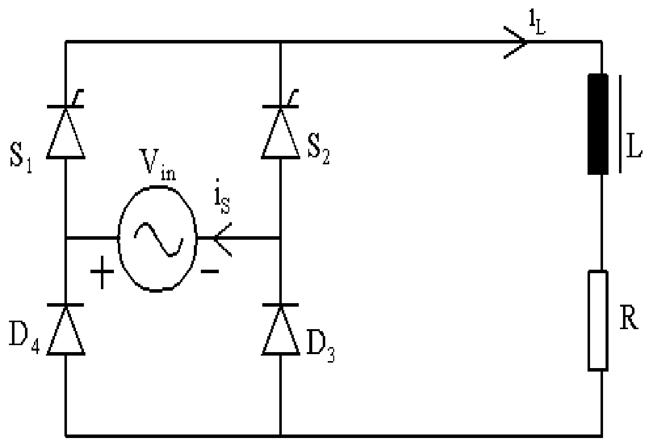
AC TO DC CONTROLLED RECTIFIERS (AC TO DC CONVERTERS)

AC to DC controlled rectifier is used to control the flow of power from AC power supply to feed DC loads such as DC motors. In such converters, Thyristors and diodes or only Thyristors can be used. The converters can be classified mainly into [1, 2]:

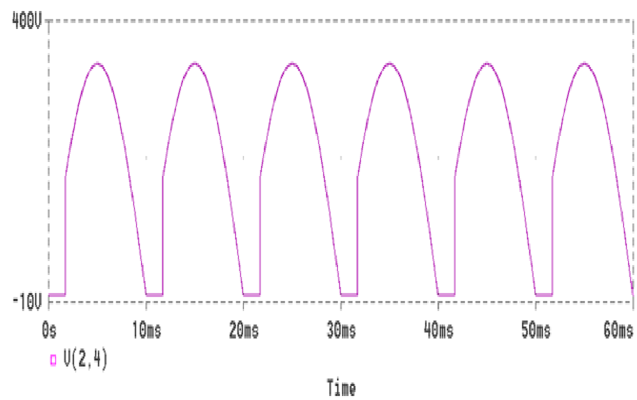
a. Single – Phase converters, (Semi controlled, or Fully controlled rectifier)
b. Three – Phase converters, (Semi controlled , or Fully controlled rectifier)

The suggested firing circuit for this paper can be used for a single- phase converters to control the power flow from AC source to a DC loads which could be DC motor.

The two converters configrations with part of the expected output voltage waveforms are shown in Fig. 3 and 4.



(a) Circuit diagram



(b) Voltage waveforms

Fig. 3: Single – Phase AC/DC Semi - controlled rectifier

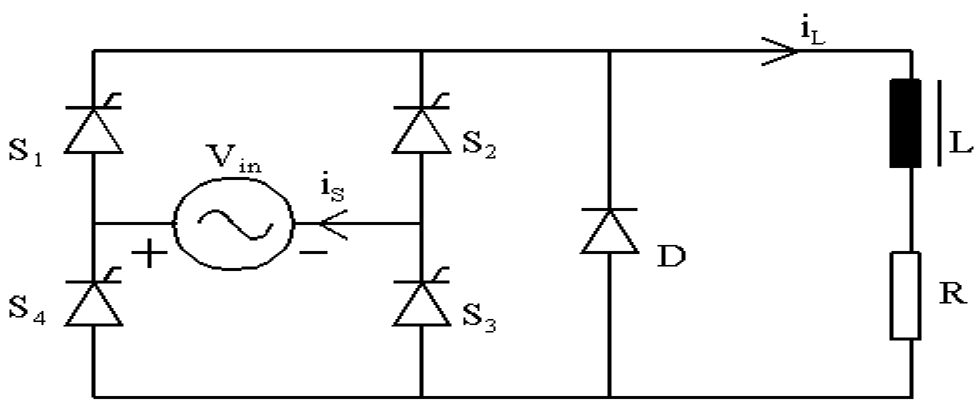


Fig. 4: Single – Phase AC/DC Fully-controlled rectifier

PRINCIPLE OF PHASE CONTROL TECHNIQUE

The principle of phase control technique which is used in the AC to AC regulators and AC to DC controlled rectifier can be explained with reference to Figs. 1-4, [1, 2].

The power flow to the load is controlled by delaying the firing angle of the Triac of Fig. 1(a) or of the two Thyristors, S1 and S2, of Fig. 3(a) or the four Thyristors S1, S2, S3, and S4, Fig.4.

Thus, during the positive half-cycle of input voltage, the power flow is controlled by varying the delay angle of either the Triac, Fig. 1(a), or Thyristor S1; Fig.3 (a), or S1 and S3, Fig. 4, with relevant to the type of converter used . Afterward, and with 180^o phase shift, Thyristor S2, of Fig. 3 or S2 and S4, of Fig.

4 controls or control the power flow during the negative half-cycle of input voltage, whereas, the Triac converter, Fig. 1 needs only one pulse.

SINGLE-PHASE, TWO-PULSE ELECTRONIC FIRING CIRCUIT

5.1. CIRCUIT'S SCHEMATIC DIAGRAM

The suggested electronic firing circuit for AC and DC loads is shown in Fig. 5. The circuit is designed and constructed from simple electronics elements such as comparators, 555-timer, AND circuits, diodes, capacitors, resistors, pulse transformers as insulators, 220/10 V transformer, and variable DC source. Its functional mechanism can be explained briefly by the following section, [3, 4].

5. 2 CIRCUIT'S FUNCTIONAL MECHANIZM AND SIMULATION

The two 180^o phase shifted pulses required for triggering the required controlled semiconductors of the converters can be achieved in the following successive steps, [3, 4]:

- Initial sine wave signal of 10 V rms from 220V rms transformer is used, →
- Changed to cosine wave by using integrator circuit for the top leg of the circuit, Fig.6 →
- Inverse cosine is obtained for the bottom leg of the circuit, →
- The two cosine and cosine inverse signals are applied to two comparators in top and bottom legs and compare with a DC voltage to obtain two 180^o phase shifted pulses. The initial instant of the generated pulses depend on the value of the DC voltage in compare with the instant values of the two cosine and cosine inverse signals, Fig. 7→
- The two generated 180^o phase shifted pulses are applied to two AND circuits in top and bottom legs and added to the signal comes from the 555-Timer for generating two train of 180^o phase shifted pulses, Fig.8→
- The two train pulses that shifted by 180^o are amplified, isolated and then applied through the output of the firing circuit to the semiconductors of the required controlled converters, Fig. 9.

4th

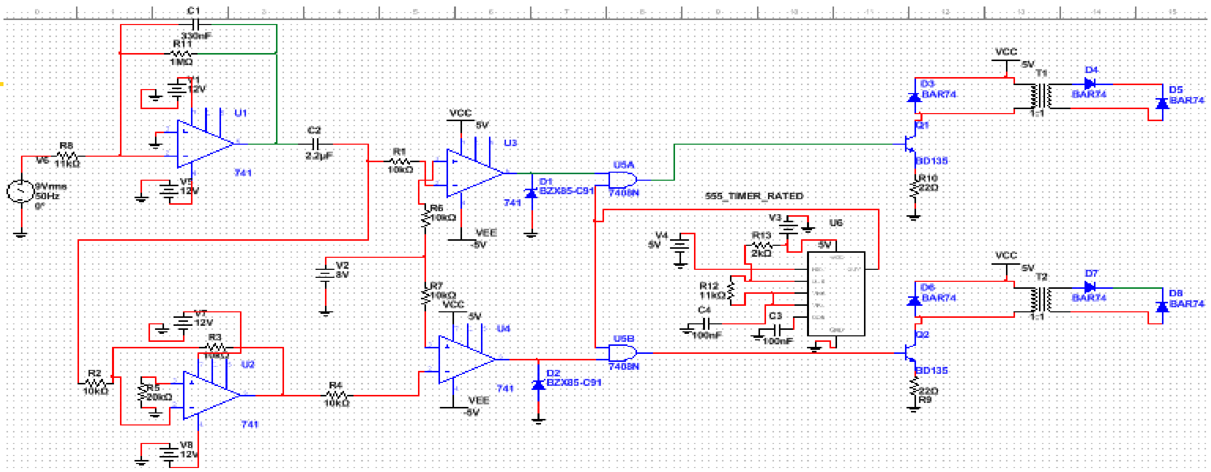


Fig. 5: Single-Phase, Two-Pulse Electronic Firing Circuit

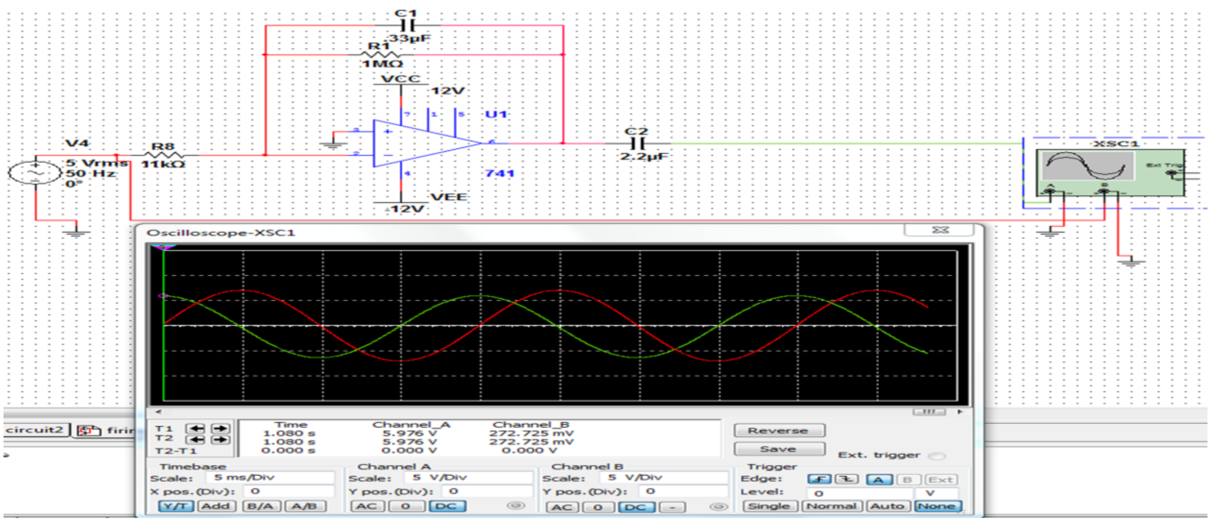


Fig. 6: Input and output signal of an integrator circuit

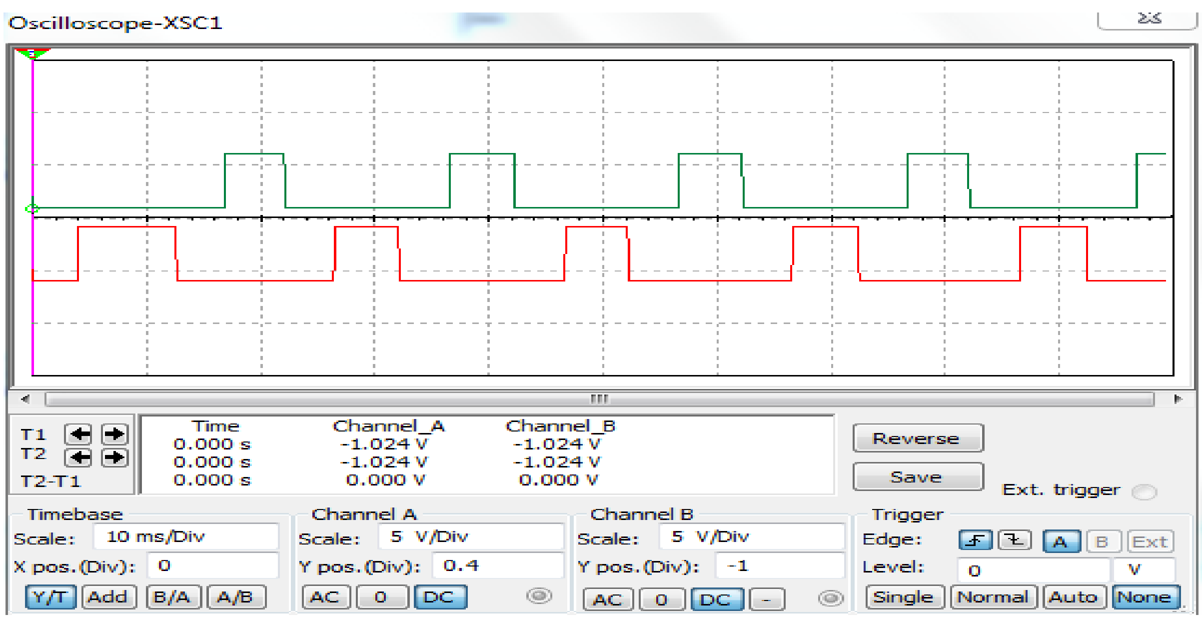


Fig. 7: Two 180° phase shifted pulses

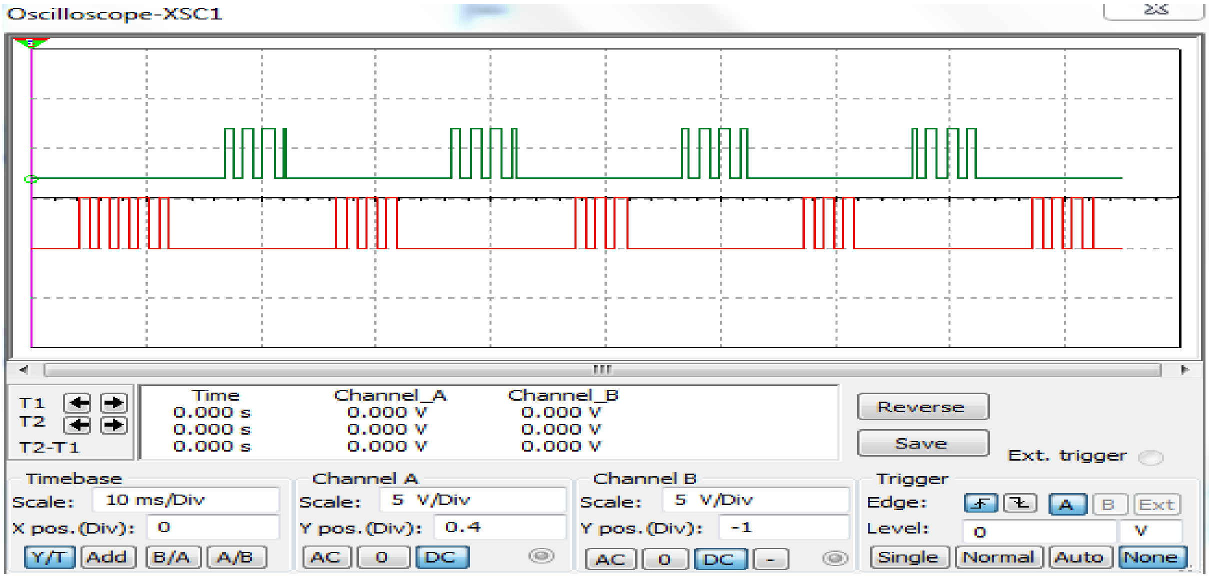


Fig. 8: Two train of 180° phase shifted pulses

Fig. 9: Final form for the two 180° phase shifted pulses

CONCLUSION

As a part of the final year project, the paper demonstrated the electronic simulation of a simple electronic circuit. The circuit is used for generating two 180^o phase shifted pulses with an amplitude and duration quit enough for ensuring the triggering of one or two semiconductor devices required to control the power flow from AC to AC or to DC loads. The simulation results were as expected.

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