DESIGN AND CONSTRUCTION OF FIRING CIRCUIT FOR THREE-PHASE THYRISTER BRIDGE CONVERTER[+]

Fadhil Yasin Ahmed[*]

Abstract

This paper presents design and construction of firing circuit for three-phase bridge converter. The turns on thyristers are line commatated. Discrete components are used to build the circuit. Integrated circuits are used to generate the firing pulses, which are synchronized with the source voltages. The firing pulses can be varied linearly with the control voltage of the comparator.

The various waveforms of firing circuit obtained theoretically and experimentally are in good agreement. Also this circuit can be connected to a microproccer in order to construct closed loop system.

المستخلص

يتناول البحث تصميم وبناء دائرة قدح لمقوم ثايرستوري ثلاثي الطور.يتم إخماد الثايرسورات عن طريق فولتية الخط.تم استخدام مكونات منفصلة لبناء الدائرة.كما استخدمت دوائر متكاملة لتوليد نبضات القدح المتزامنة مع المصدر وقد تم الحصول على مدى لزوايا القدح من (0-180^0) عن طريق التحكم بفولتية السيطرة لدائرة مقارن الفولتية.تمت مقارنة الأشكال الموجية لدائرة القدح عمليا"ونظريا" وقد وجد توافق دقيق بينهما.فضلا عن ذلك بالإمكان ربط هذه الدائرة الى معالج دقيق لبناء منظومة تحكم مغلقة.

1-Introduction

The proper design of firing circuits yields precise, reliable and stable operation of the system.Simplicity, small size, minimum number of components and lower cost are generally the most important factors that determine a good design.

Different methods are commonly used to construct firing circuits for triggering thyristers. Each method has advantages and disadvantages [1,2,3,4,5].

The firing circuit that is introduced in [1] does not meet with all requirements for good design. Minimum components and synchronized control are used in circuit [3], but the disadvantage of this circuit is that it uses a single chip as decoder so that any damage in the decoder will make the circuit fail to supply firing pulses, as well as the firing angle is not vary linearly with the dc control voltage. The proposed controller for thyrsiter control, which is produced in [5], is in agreement with the requirements for good design, but it is used for single-phase circuit.In this work good circuit design is introduced where less components are used, linear relationship between triggering angle and the control voltage, besides synchronized with the supply voltage. The firing circuit is designed, assembled, and tested. The firing angle can be varied from 0 to 180 by changing the control voltage from 0 to 70 mv.

2-Firing Circuit Description And Design

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[*] **Technical Institute of Karbalaa,Karbalaa,Iraq**

The main object of the converter circuit under consideration is to deliver three gate pulses separated by 120^0 to the thyristers gates with sufficient width time in order to turn on, also synchronism with the supply voltages, and can be varied along the positive half cycle of the thyrister anode cathode voltages.

Fig. (1) illustrates the block diagram of the firing circuit, it mainly consists of five stages. Square wave generator, ramp generator, voltage comparator, pulse splitter, and pulse isolator. The schematic of the complete firing circuit is shown in fig. (2), with its typical waveforms for different stages shown in Fig. (3).The square wave generator comprises three step-down transformers connected as shown in Fig.(2),in order to get reference voltages at a,b,c.The firing pulses to th_1 will be explained below in details.

The secondary voltage of transformer v_{ag} is compared with zero level voltage using IC741 op amp. The output of this comparater i.e. point (d) is fed to stage two ramp generator, it consists of RC integrator with pnp transistor switch across capacitor for sharp discharge.

Values of R and C must be chosen large enough to give approximately linear rise for the ramp. However with larger values of R and C the maximum value of capacitor voltage will be low during the charging interval which is taken 10 msec width.

The output ramp function at point (e) is fed to stage three i.e. voltage comparator in order to permits variation of firing angle with respect to controlled voltage V_R.In stage four the output pulses at point (f) is frequency modulated using pulse splitter IC7411 and IC555 timer to generator pulses at frequency $2kh_z$ .The aim of injecting high frequency pulses is to make the firing signal exists for a time enough to ensure reailable turn on and without excessive gate power despation.

Finally the frequency-modulated pulses at point (g) is applied to the thyrister gate through an opto-coupler IC CNY48 in stage six.

3-Experimental Results

The firing circuit shown in Fig.(2) is assembled and tested.Waveforms are photographed for different positions. Fig.(4) illustrates the waves at points(a,d) while Fig.(5) shows the waves at points(d,e).Fig.(6) shows combination of all the waveforms at different points of the firing circuit.It is easy to compare the relative phase difference between the different waveforms.

This firing circuit is tested for a three phase half controlled bridge rectifier to control the speed of dc motor. The firing angle can be varied from (0-180^0) by adjusting the control voltage V_R from (0-70) mV. Fig.(7) shows the experimental firing angle verses the control voltage curve.Fig.(8) illustrates the firing angle verses motor speed characteristics of the dc motor.

4-Conclusion

The firing circuit for three-phase thyrister bridge rectifier have been designed and controlled in laboratory. The firing angle can be varied from (0-180^0) according to change in control voltage of the comparator. Various waveforms of the firing circuit are obtained in laboratory and oscillagraphed. Finally this circuit can be connected to a microproccer in order to construct closed loop control.

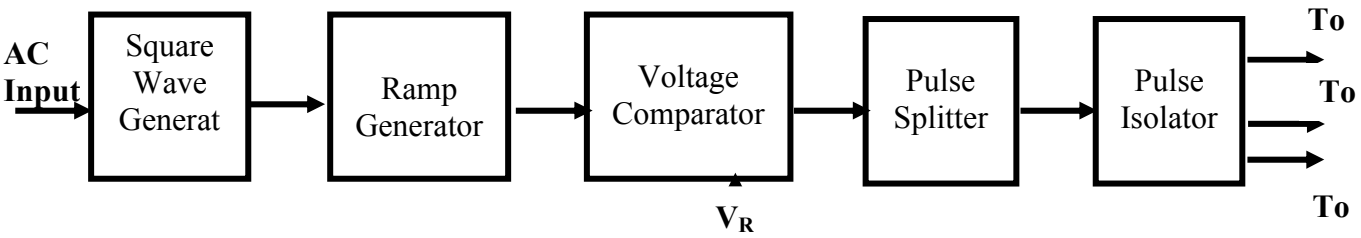


Fig. (1) : Schematic block diagram ot the firing circuit.

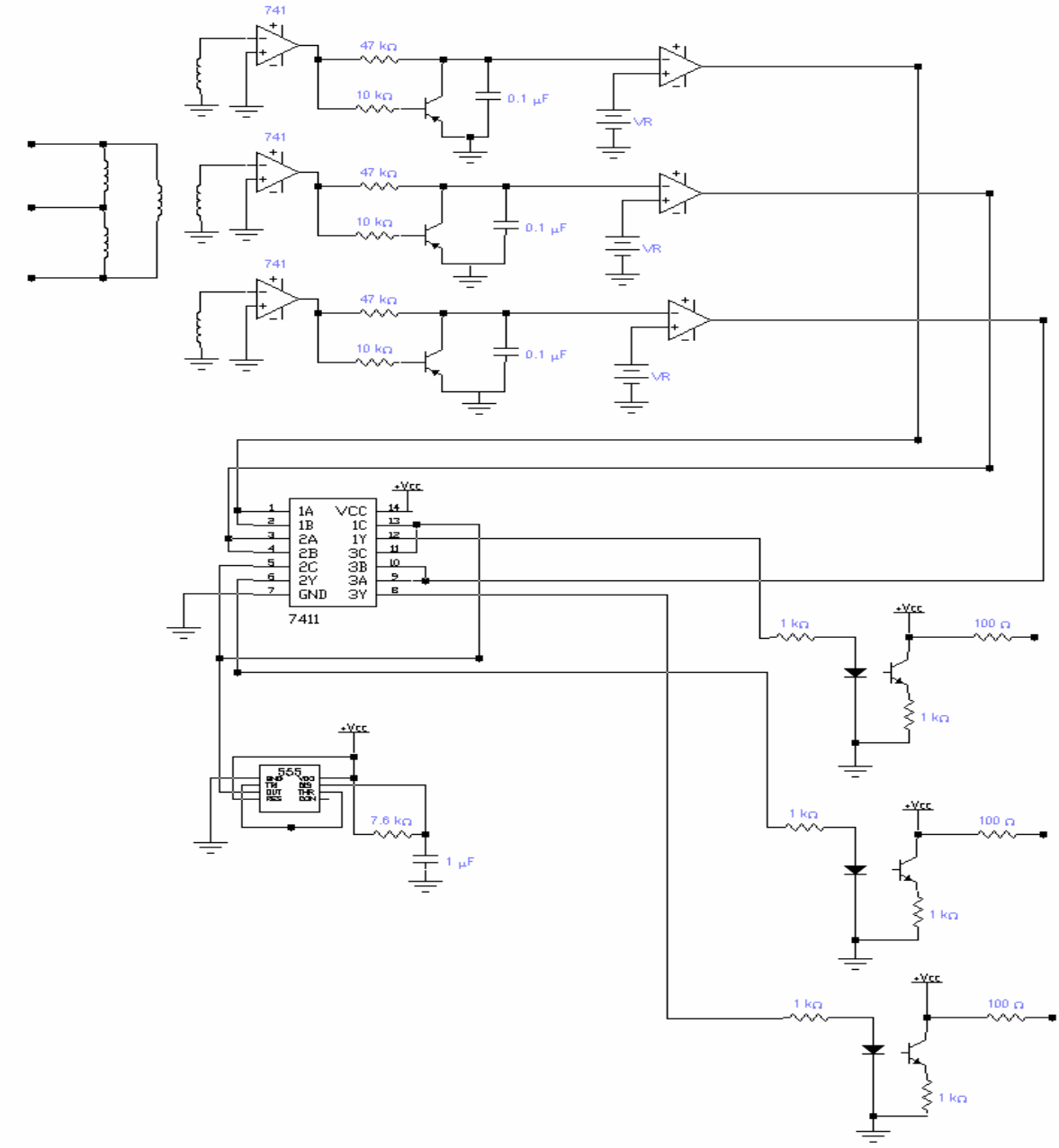


Fig. (2) : The complete circuit diagram of the firing circuit.

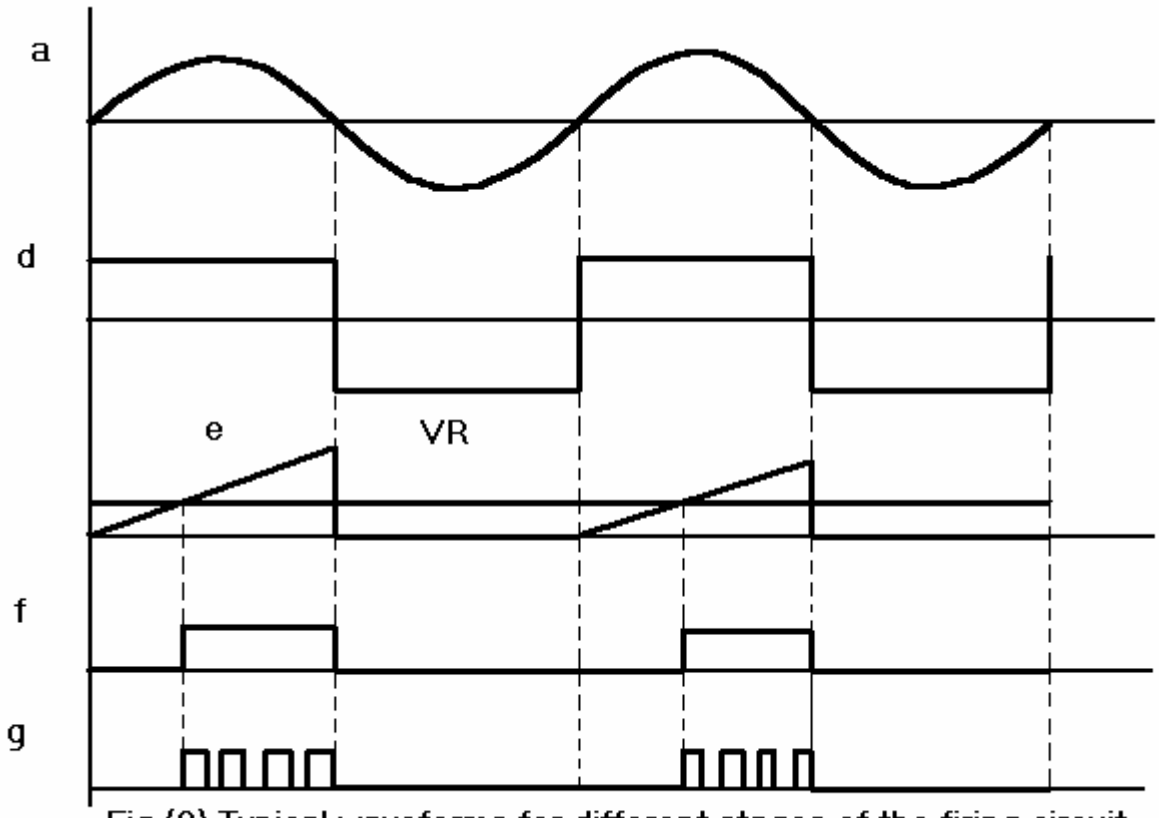
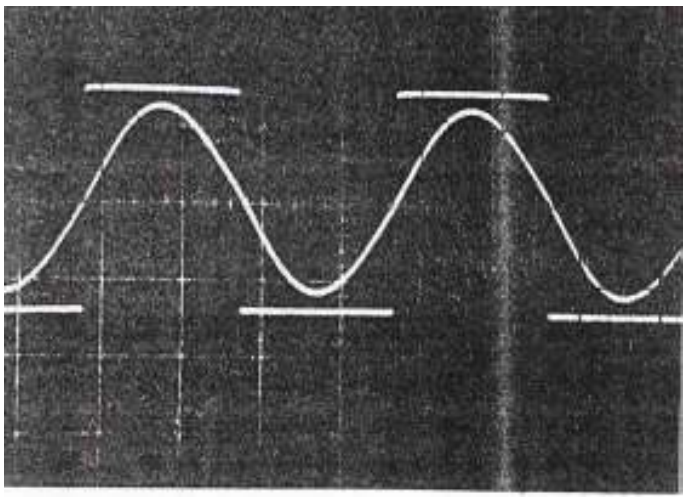
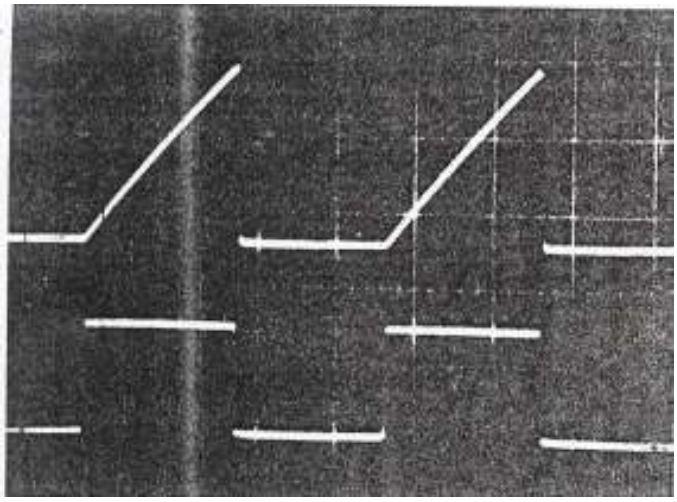


Fig.(3) Typical waveforms for different stages of the firing circuit



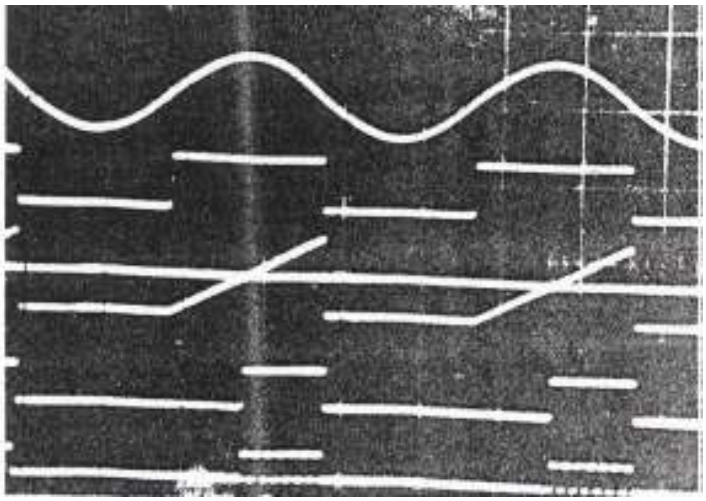
Ver. Sine 5v/div. Square 2vldiv. Hor. 5ms/div.

Fig. (4) :Voltages waveforms for stage one.
Input sine waveform at point (a).
Output square waveform at point (d).



Ver. Ramp 2v/div. Square 2v/div. Hor. 5ms/div.

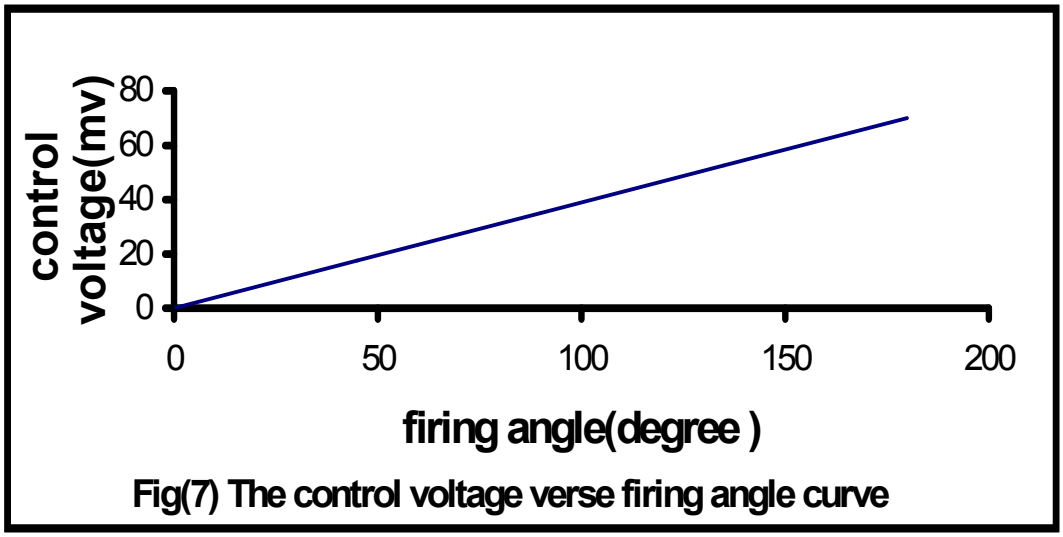
Fig. (5) :Voltage waveforms for stage two.
Input square waveform at point (d)
Output ramp waveform at point (e).



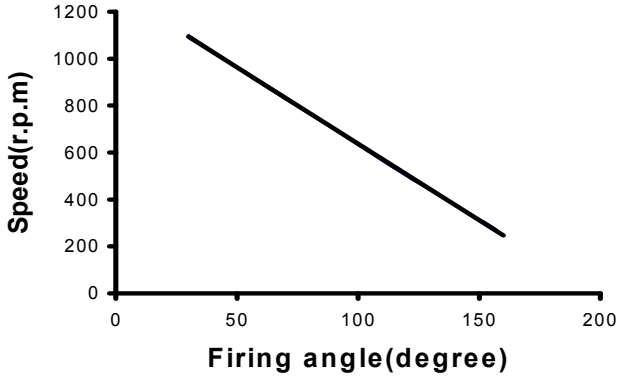
Ver. 2v/div. Hor. 5ms/div.

Fig. (6) :Voltage waveforms at points (a, d, e,f,g).

(a) Input sine waveform.
(d) Square waveform.
(e) Ramp waveform together with variable voltage.
(f) Rectangular waveform.
(g) Gate signal output waveform.



Fig(7) The control voltage verse firing angle curve



Fig(8).Firing angle verses motor speed

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