NORMALIZATION OF CONTROL VARIABLES IN INVERSE-PARALLEL POWER CONTROLLER SCHEME

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ABSTRACT

This paper examines the controlled variation of the r.m.s value of the alternating voltage applied to a load through an inverse parallel thyristor pair. Analyses of the first fundamental component of the Fourier series of the load current from the laboratory test results are present. Other dependent variable such as distortion factor, displacement factor and displacement angle were examined using a firing angle (α) or 30^0 for the thyristors. The thyristor used was TIC 106M, with current rating (IT(ava) Max). of 3.3A and a gating voltage (VGT) of 1.2V. the results obtained were used to plot curves of normalized fundamental harmonic load current (I_{Lnorm}) Versus α, an output normalized current (I_{Lnorm}) versus α , the distortion factor versus α, the displacement factor versus α, and the displacement angle versus α. These analyses are intended to assist an industrial engineer to determine the appropriate angle to fire a thyristor, depending on the load current demand, in order to minimize power loss.

KEY WORDS: Power Thyristor, Diode, Load, Normalized Variables Fourier series, Fundamental Component).

INTRODUCTION:

Tremendous advance have been made in the field of power electronics following the advent of the state art of semiconductor advice-thyristor in 1957. This semiconductor switch has revolutionized the field of electrical power control and conversion. The internal feedback makes the thyristor an extremely efficient and fast switching device. It can be used in the control of highly powered load, since the reverse-biased junction can be made to withstand many hundreds of volts. With suitably large junctions, thousands of amperes can be handled with a drop of about one volts across the thyristor. This combination of high breakdown voltage and high effective current gain is impossible to achieve in a power transistor. For these reasons, high power control applications the thyristor is most suitable. These are wide areas of application of thyristor in industries. Which includes, lighting control, speed control of induction motors, variation of supply, frequency of a power source. This paper examined the use of thyristor as an a.c. voltage controller, and of all number of thyristors based a.c. voltage controller configuration available, the inverse-parallel thyristor pairs was considered and analyzed because of its wide usage.

Fig.1 shows the circuit diagram of an a.c power controller using inverse parallel thyristor pair. The inverse parallel connected thyristor pair is used to regulate the r.m.s value of a.c voltage supply to a load, by connecting the controller load. To transmit power to the load, each thyristor is made to conduct during the appropriate half-cycle, by means of gating pulse signals applied to the gate. The firing angle (α) determines the amount of power transmitted to the load.

In this work, two inverse-parallel configurations are analyzed. These two schemes are the Thyristor- Thyristor pair for fully control and the Thyristor-Diode pair for half control.

The controlled variables for these schemes were normalized for it's convenient. A plot of the normalized value versus the firing angle α was made.

The information provided in this paper will assist in providing efficient control of power to load by triggering the gate of the thyristors at the appropriate firing angle depending on the load requirement. This will help in conserving power without wastage.

This paper will equally be vital to all Engineers in the field of control, electrical power and machine and electronics, industrially, the knowledge in this paper will be useful to silicon control rectifier manufacturers and devices requiring input voltage control.

MATERIALS AND METHOD

The materials need for the inverse parallel controller configuration are;

Constant Ac- Voltage Source.

Thyristor-Thyristor configuration

Thyristor- Disode configuration

Triggering Circuit

Load

Ammeter, Voltmeter

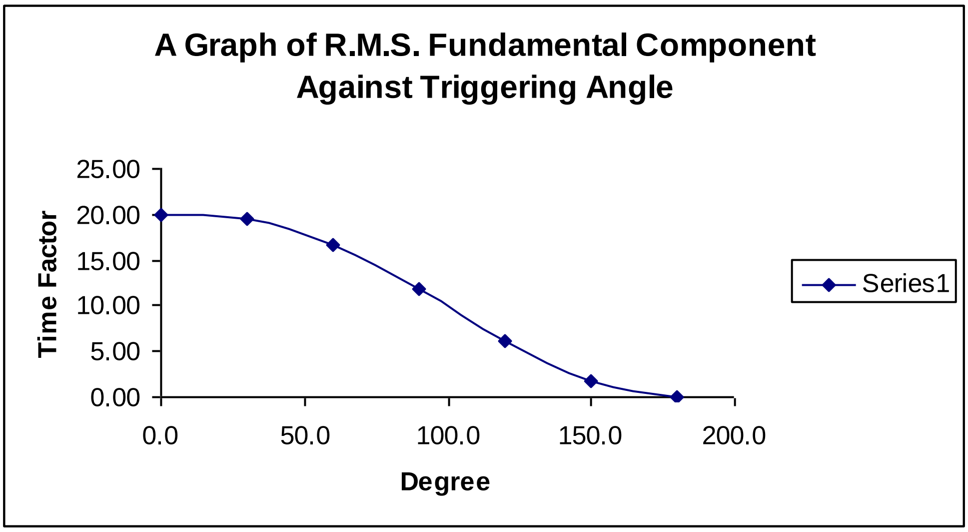
Oscilloscope

Connecting Wires

EXPERIMENTAL PROCEDURE

The solid state device (controller is connected between the constant voltage source and the load. The triggering circuit is connected to the gates of the thyristors to provide the pulse required to fore the gate at various delay angle α. Fig (1) show the circuit diagram for the inverse parallel Thyristor connection, while fig 2 shows the wave form for the various section of the circuit under operation.

Fig 3 and fig 4. respectively show that of the Thyristor-Diode configuration.



R.M.S. LOAD CURRENT. From the view point of power transfer the electrical parameter of interest are the **r.m.s** voltage V_L and **r.m.s**. Load current I_L.

From Ohm's Law the relationship between voltage and current is

$$I_L = \frac{V_L}{R} \quad (1)$$

The constant ac source voltage is

$$V_S = \sqrt{2}\ V_{rms} SinWt \quad (2)$$

Due to symmetry fig (2), the voltage across the load is

$$V_L = \left[\frac{1}{\pi} \int_0^{\pi} V_S^{\ 2} (wt) dwt \right]^{1/2} \quad (3)$$

$$V \left[\tfrac{1}{2} \pi (Sin 2\alpha + 2(\pi - \alpha) \right]^{1/2} \quad (4)$$

Similarly, Applying Fourier series to equation (3)

$$a_1 = \frac{\sqrt{2}V}{2\pi R}(Cos2\alpha - 1) \qquad (5)$$

$$b_1 = \frac{\sqrt{2}V}{2\pi R}(Sin2\alpha + 2(\pi - \alpha) \qquad (6)$$

and

$$\frac{a_0}{2} = 0 \qquad (7)$$

Hence in terms of load current equation (4) becomes

$$I_L = \frac{V_L}{R}\left[\frac{1}{2\pi}(Sin2\alpha + 2(\pi - \alpha)\right]^{1/2} \qquad (8)$$

NORMALIZED CONTROL VARIABLE

It is convenient to scale thyristor controlled variables in normalized value. The normalized value of the fundamental component of the controller variable is defined as the ratio of the value of the variable of a given firing angle α to the value of the variable at full thryristor conduction α =0

The normalized load current is

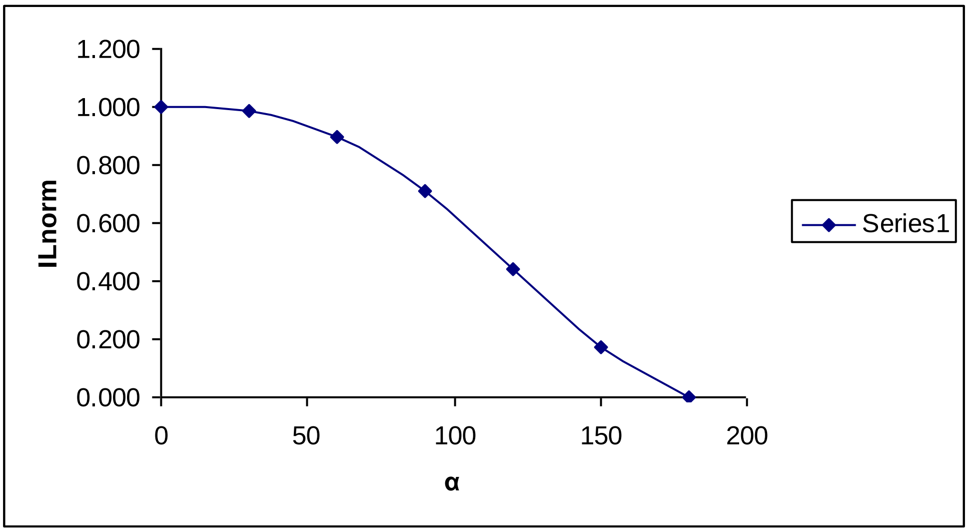
$$I_{L\,\text{norm}} = \frac{\frac{V}{R}\left[\frac{1}{2\pi}(Sin2\alpha + 2(\pi - \alpha)\right]^{1/2}}{\frac{V}{R}\left[\frac{1}{2\pi}(Sin0\alpha + 2(\pi - 0)\right]^{1/2}} \qquad (9)$$

$$= \left[\frac{1}{2\pi}(Sin2\alpha + 2(\pi - \alpha)\right]^{1/2} \qquad (10)$$

Substituting for α =0,30^0,60^0,90^0,120^0,150^0 and 180^0. in equation (10). The corresponding normalized load current are obtained and tabulated as shown in table (1)

α	0	30	60	90	120	150	180
I_1/I_L	1	0.986	0.896	0.707	0.442	0.170	0.00

Plot of I_{Lnorm} against α is shown in fig 6.



THYRISTOR –DIODE CONFIGURATION

For the thyristor- Diode configuration the same procedure were repeated. Fig… shows the circuit diagram of the configuration and fig- shows the wave forms.

Apply Fourier series to the load voltage

V_L= [ ]

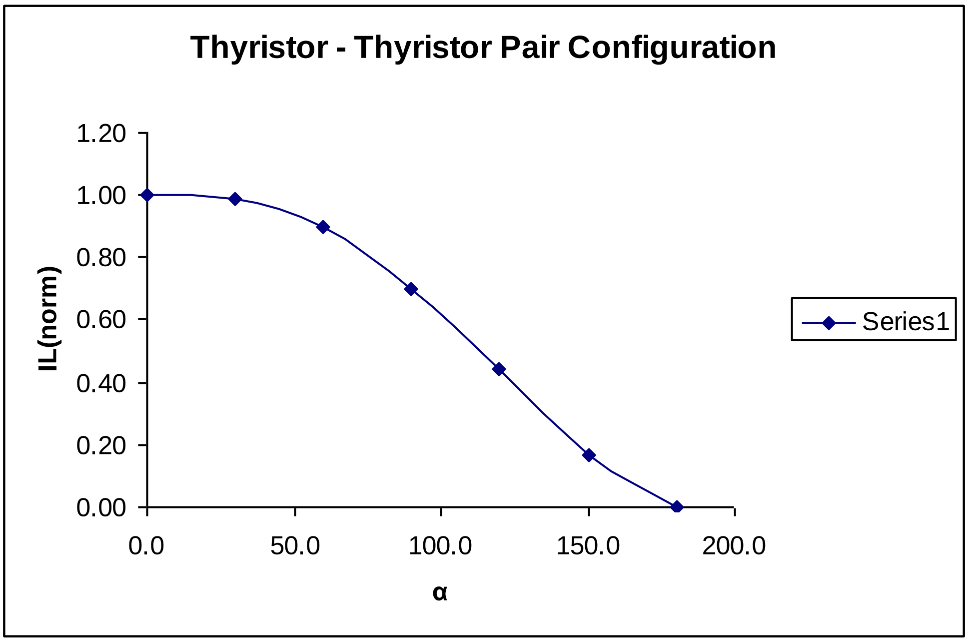
Therefore the load current.

$I_L = \frac{V_L}{R}$ [ ]

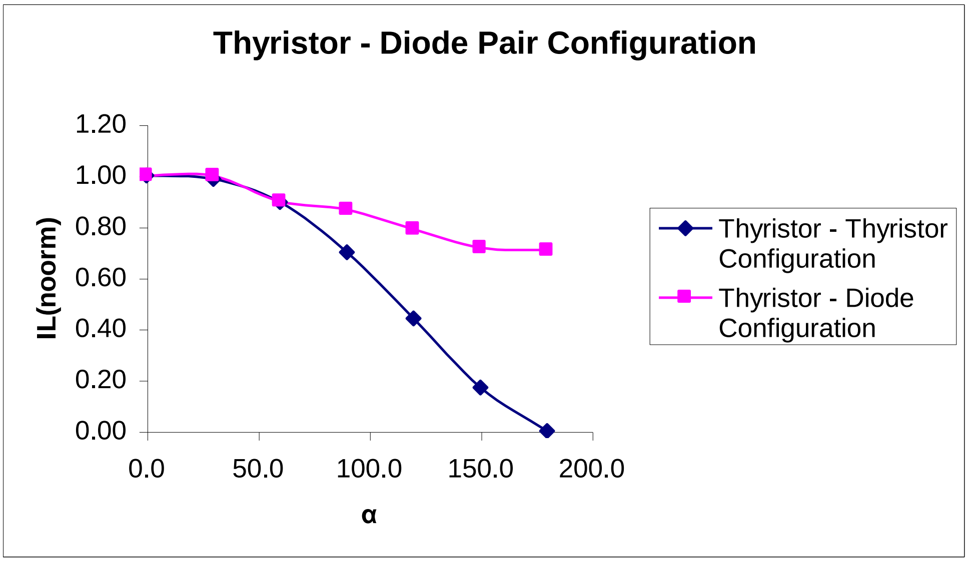
The normalized load current

I_L = [ ]

The corresponding values of the normalized load current for $\alpha = 0^0, 30^0, 60^0, 90^0, 120^0, 150^0$ and 180^0 were tabulated table 2. A plot of I_{Lnorm} against α was obtained shown in fig.



The normalized values of the two schemes at various firing angle α were plotted on the same scale for comparison



RESULTS AND DISCUSSION.

The two configuration analyzed shows a clear distinction of fully control for inverse parallel connected thyristors and half control for the thyristor-diode pair. It also showed that the amount of power applied to a load depends on the (delay) firing angle. Eva thought the circuit is energized from the supply source.

The value of the normalized load current drop from 1.0 to 0 as α varies from 0^0 to 180^0 as shown in fig… for the inverse parallel connected thyristor, but in fig…. the curve for the thyistor-diode par show that the normalized load current does not drop from 1. to 0 as α varies from 0^0 to 180^0. at 180^0, I_L normalized is …..which is a cheer indication of half control of power to the load.

Since α can be varied from 0^0 to 180^0, it is clear that effective control of the power to a load from a constant ac voltage source can be achieved by applying the triggering pulse to the thyristor of the appropriate firing angle α. Since the firing angle is a function of time, hence the putting pulse which will affect control can be delay cd according to the desired objective.

The graphical illustration shown the power transfer to a load and its control can be pre-determined choosing appropriate firing angle α which corresponding to a particular normalized load current.

CONCLUSION

Since the demand for electrical energy is high for both domestic and industrial usage and the supply is grossly in adequate worldwide, there is the need to regulate the power consumed at the consumer and using appropriate power controller schemes which have been presented in this work for effective control and operation of device which minimum power consumption.

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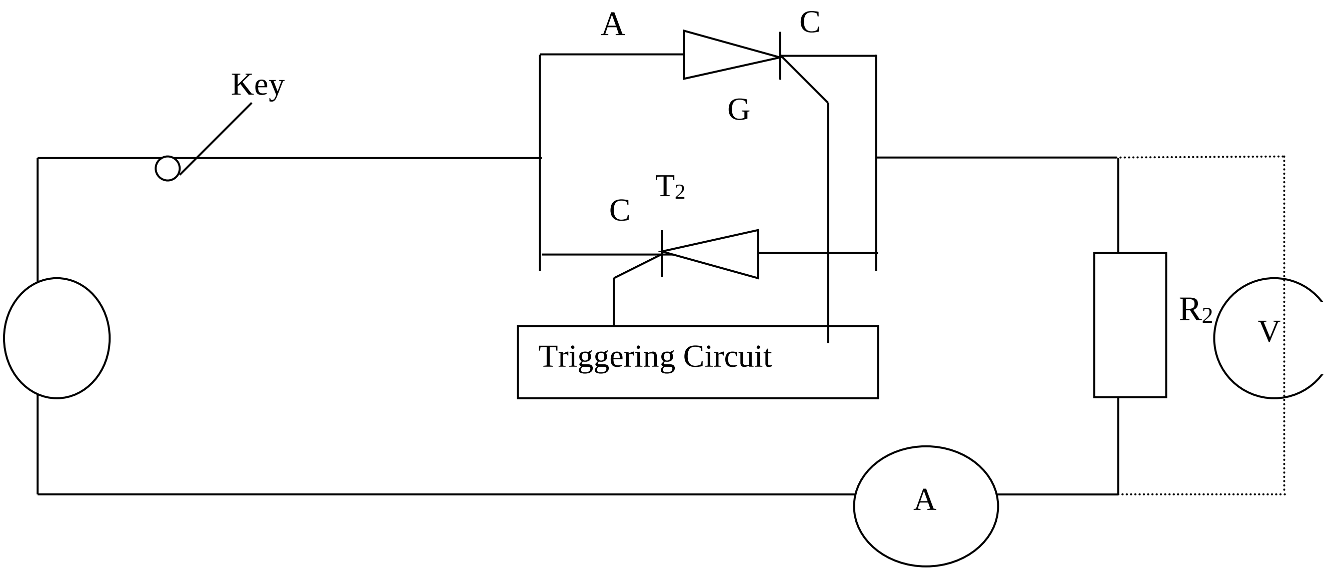
A
C
Key
G
T2
C
R2
V
Triggering Circuit
A