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Microprocessor controlled static converter

This paper wants to demonstrate a way of implementing a microcontroller into an DC motor speed control loop. The static power converter is a fully controlled rectifier bridge, using standard SCR's. The bridge's control signals are supplied by the microcontroller and are phase-angle or burst types. The automation loop contains a software PI-style regulator. All the experimental results shows that this approach is flexible enough to be used on a large scale.

1. Introduction

The static converter used is a fully controlled tri-phase rectifier bridge made from normal thyristors and it's used to control the rotation speed of an DC electric motor.

This control loop is realized around 2 inner loops with limiting to manage the current through the rotor of the motor.

Control of the rectifier bridge is made by the means of a PIC16C74 microcontroller in a FC-36M model control board.

2. Modeling

This three phase microprocessor based firing circuit is primarily designed for the control of thyristors and has a wide range of selectable features. The signal control options can be analogue or digital input. The module incorporates phase angle and burst firing modes, or a combination of both. Installation phase wiring is kept to a minimum, with no necessity for external phasing transformers.

The microprocessor board is universally acceptable for DC resistive or inductive loads. Controller gives smooth proportional-integral control to all types of industrial processes

The total transfer function of the microprocessor module is:

$$H_{PR} = \frac{K_0}{1 + \sigma \cdot s} \quad (1)$$

Figure 1 presents the bloc diagram of the controller.

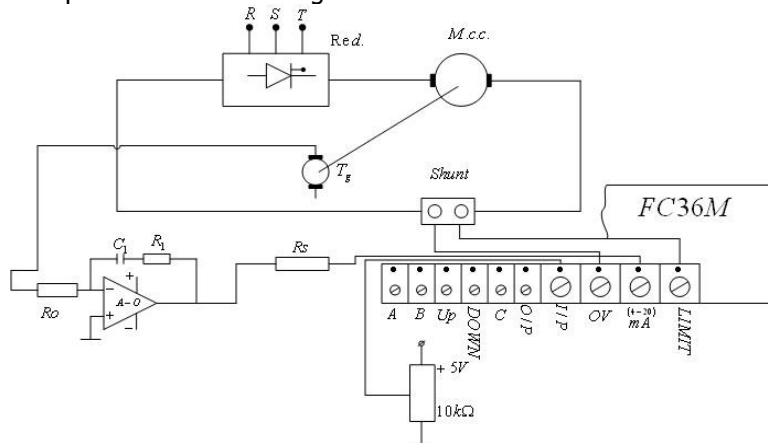


Figure 1. Bloc diagram of the controller

The PIC microprocessor is generating six controlled thyristor gate pulses nominally displaced by 60° . It can be controlled from either a 0 to 5V or 4-20mA analogue signal or by two logic signals. The logic inputs provide also a soft start function. Figure 2 shows the layout of the FC-36M board made by United Automation Ltd.

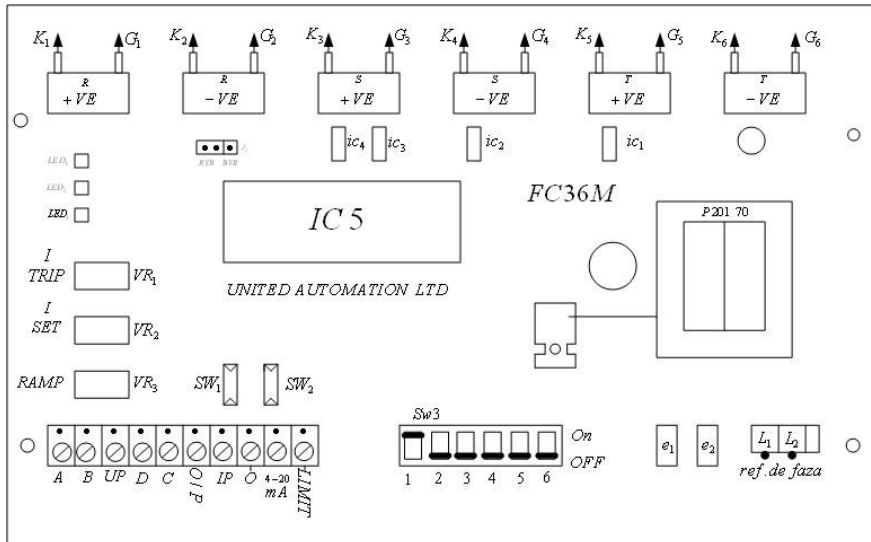


Figure 2. Layout of the board

3. Experimental results

Experiments have been made in laboratory with a 5kW, 1000rpm DC motor. The recordings were made using LabVIEW software. Figure 3 represents the gate pulse for one of the thyristors, showing the impulse and the burst command mode.

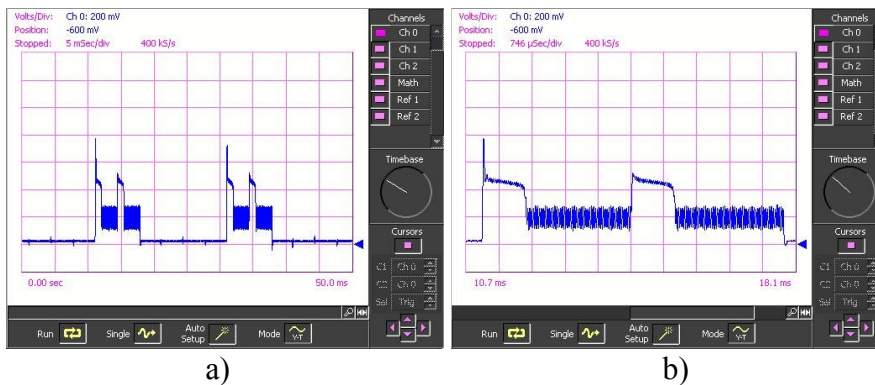
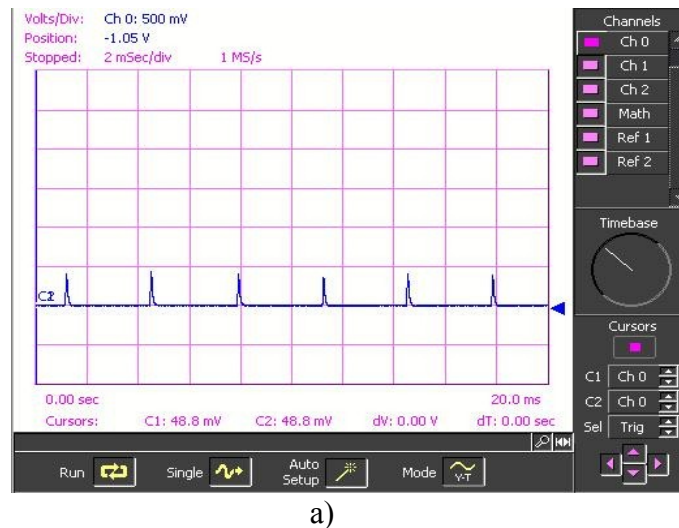
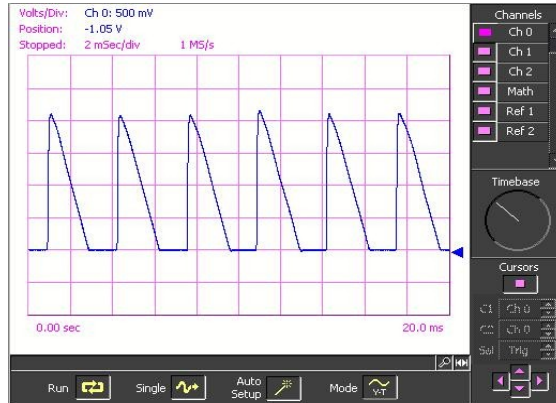


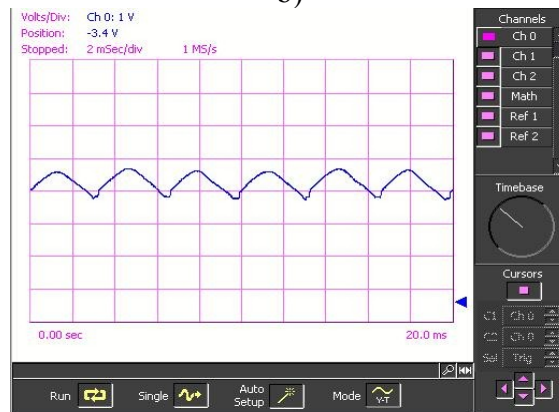
Figure 3. Gate pulses for one thyristor. a) two impulses and b) detail for impulse

The maximum voltage obtained from the rectifier bridge, supplied from a three-phase reduction transformer was about 81V and the maximum current available from the device was 500A. Figure 4 shows the waveform of the voltage at the load in three different command angles.





b)



c)

Figure 4. Load voltage waveform a) 88° , b) 42° and c) 11° firing angle

Figure 5 represents the indicial response in speed of the DC motor shaft.

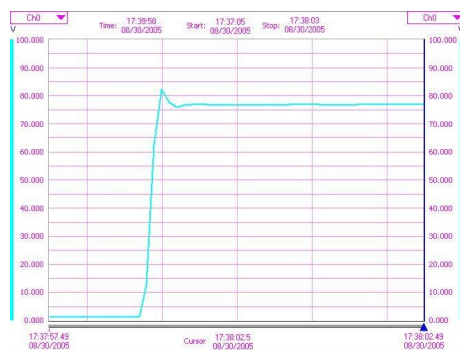


Figure 5. Indicial response of DC motor supplied from rectifier

4. Conclusions

After the experimentation some conclusions were drawn:

- The whole equipment is very sturdy and has great fiability.
- The system is fast, stabile and capable of very large load variation control.
- Because of it's simplicity, the converter is scalable from 1A to 5000A current and 1V to 2000V and it is useful in a very large number of industrial applications.
- The end price is reasonable.

References

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- [3] National Instruments Corp. – *Data Acquisition Board PCI-MIO-16E-1. User Manual*, Austin, TX 1999.
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