

Software to Determine the Optimal Value of Resistance by Current Measurements for TRIACs and SCRs Control

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Abstract—In some electronics devices, such as SCRs and TRIACs, it is necessary that a current flows through its gate in order to control them. To limit this current, a resistor is used in the gate (RG) to provide the TRIAC with the necessary current to control it. This current should not be so large to avoid damaging the device. In practice these resistors are not calculated, they are proposing, this produces insufficient or dangerous currents, which causes in time and money losses. In this work, a designed apparatus solves this problem which consists on a test bank with a PIC18F452 microcontroller and its software allows calculating the RG value automatically in a short time and without damaging the TRIAC. This is possible because the prototype contains a graphic interface and a data acquisition interface which allow the user to introduce the desired current value. The system varies its internal resistance by means of resistors arrangements and it measures the value of the current. If the measured current and the wanted current are different, then the system varies its internal resistance again, this process is repeated until both currents are same; offering to the user the value of the best resistance for the wanted current.

Index Terms—Software, current measurement, microcontroller, TRIAC, SCR.

I. INTRODUCTION

Power devices such as TRIAC (Triode for Alternating Current) and SCR (Silicon Controlled Rectifier) are fundamental for diverse power electronic applications. Such applications often need a low voltage control system (five volts typically). Mixing control signals with power signals is complicated, since in occasions the power signals alter the control signals or in other cases the control signals do not provide the necessary current to trigger power devices [1]. To control the TRIAC or the SCR, a current flows through its gate [1, 2]. The magnitude of this current is determined by the gate resistance. In most cases the precise currents for these circuits do not exceed 200 mA. If this current is surpassed these devices can be damaged, which is translated in economic losses and time consumption.

Diverse methods exist to calculate the value of the best resistance for the TRIAC; the simplest is the Ohm law and the theorem of Meshes and Nodes. However, in practice power devices (SCR and TRIAC) do not behave ideally like passive devices and the calculation of this resistance can be

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incorrect. In other cases the alternating current is varying in time and it can present picks that can damage the TRIAC.

In this work, equipment able to calculate the resistance (RG) is presented. This equipment assures triggering the TRIAC and the SCR and contains an interface which allows the user to introduce the value of the wanted current or the maximum pick current by means of a keyboard. The system varies its internal resistance by means of resistors arrangements and measures the value of the current. If the measured current and the desired current are different, then the system varies its internal resistance again. This process is repeated until both currents are the same; offering to the user the value of the best resistance for the wanted current.

II. METHODOLOGY

A. Hardware

The microcontroller used is the PIC18F452, which possesses an integrated digital analogical convertor [3]. It is possible to program it in "C" language by means of the MPLAB compiler and the C18 C Compiler library.

For the analog to digital converter (ADC) it is necessary to use an appropriate voltage reference to the voltage that will measure. The employed integrated Circuit (CI) is the ISL21032 which gives an output reference voltage of 0.6 volts [4], since the maximum voltage to measure is of 0.200 Volts. Fig. 1 shows the diagram of the designed system.

The analogical switch ADG1419 it is used in the resistors bank to obtain the wanted series arrangements. Nine resistors of 100 ohms and nine resistors of 1000 ohms were used in the resistors bank. The range from 100 ohms to 9900 ohms with increments of 100 ohms is implemented using the switches. Fig. 2 shows this configuration.

The logical one ("1") closes each of the switches (S) and the logical zero ("0") opens them. A final equivalent resistance is obtained thanks to this procedure.

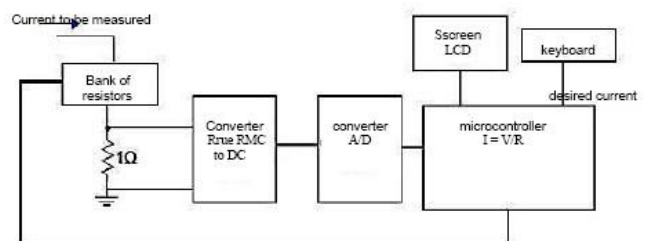


Fig. 1. Block diagram of the designed electronic circuit that obtains the optimal resistance for the TRIAC.

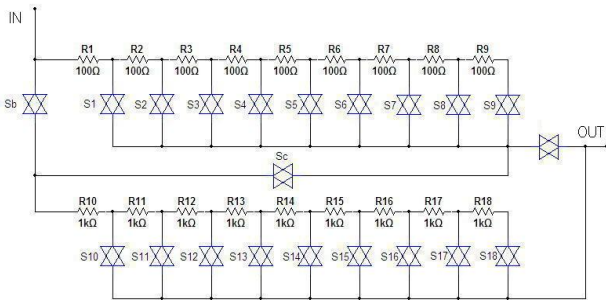


Fig. 2. Resistors bank diagram.

To control the analogical switches (S), 21 digital outputs are required. The use of 21 microcontroller pins was avoided by implementing a 74HC154 decoder with 4 inputs and 16 outputs which control the switches S1 to S9. Another decoder, with the same characteristics, controls the switches S10 to S18, and finally, 3 microcontroller pins were used to control Sa, Sb and Sc (see Fig. 2). The AD736 integrated-circuit converts the RMS voltage in CD voltage. This circuit measures the current that will flow through the 1 ohm resistor.

Fig. 3 shows the components that were connected to each microcontroller port. The arrows indicate the sense of the data circulating in each stage.

B. Software

The fundamental tool for programming the PIC18F452 Microchip’s microcontrollers is the MPLAB integrated development environment (IDE). This software allows compiling the program to be recorded in the microcontroller. Fig. 4 shows the main program implemented in the MPLAB. The general description of the main program is the following one:

The first step in the program is the declaration of the variables called *current_value* and *current_obtained*. Then, the ports are initialized according to their function (input or output) with the function *Initialization_of_ports()*. Later the analogical-digital convertor is configured with the *converter_configuration_AD()* function. Once done this, it is necessary to prepare the LCD for its operation. For this, we use the *initialization_LCD()* function that configures the LCD [5], next one enters to an infinite cycle by means of the iterative control instruction called *while(1)* where will stay, the following instruction reads, captures and ponders the digits that are reading from the keyboard by means the *read_keyboard()* function, the result is stored in the *value_of_the_variable_current* that is the value that the user wants to obtain of current, after this one enters in another infinite cycle by means of the second *while(1)* where the value from the analogical-digital convertor is read by means of the *read_converter_AD()* function, the read value is stored in the *current-obtained* variable, after this the wanted current is compared with the measure, through the next condition: “if (*current_value == current_obtained*)”, which indicates that if the value of the wanted current and the measured current are same, then the wanted current was found, therefore the second infinite cycle finish by means of the *break*, and it is ready to make the routine again, if not be the value of the

wanted current, then the resistance is changed and it returns to compare until verifying that they are same.

The “C” language allows dividing to the main program in specific work groups called functions. The functions implemented to control the keyboard and the LCD screen will not be explained since they are not the purpose of this work.

The microcontroller’s D port was used as information output to control the LCD, while the B port controlled the keyboard.

The C port is programmed only as output, since it is connected to two decoders 74HC154 in order to control the analog switches. The E port was enabled as output for controlling the switches Sa, Sb and Sc.

The configuration of the ports described previously was programmed like it is shown next:

```
void Initialization_of_ports(void)
{
    LATB=0;
    TRISB= 0b11110000; //Port B, 4 pins as output

    LATD=0;
    TRISD=0; //Port D as output

    LATC=0;
    TRISC=0; // Port C as output

    LATE=0;
    ADCON1=0x07;
    TRISE=0; // Port E as output
}
```

One of the most important functions is called *converter_configuration_AD()* because the correct current measurement depends on it.

The converter allows the conversion from an analog signal to a 10 bit digital number [3]. In additions, also it also has 8 different frequencies of conversion. In this case a frequency of (4MHz / 8), where 4MHz is the crystal frequency denoted as FOSC and was set to obtain bits aligned to the right. Another aspect to configure was channel CH0 (microcontroller’s pin 2) to read the analog signal. The external reference voltages of 0.6 volts and to disable the interrupts are also part of the configuration of the ADC. This configuration is shown in *converter_configuration_AD()* function:

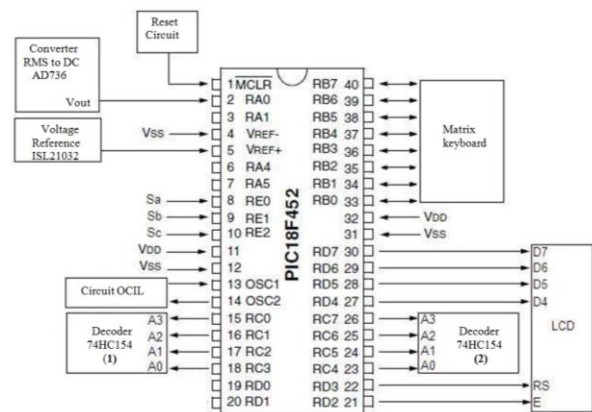


Fig. 3. Connection of components to the microcontroller.

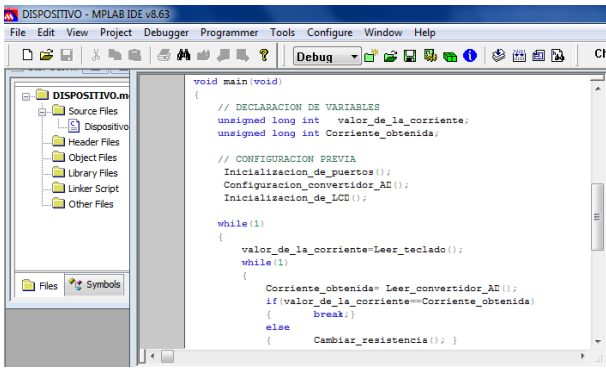


Fig. 4. Main program for obtaining of the best resistance.

```

Void converter_configuration_AD (void)
{
    OpenADC( ADC_FOSC_8 & ADC_RIGHT_JUST &
            ADC_2ANA_IREF, ADC_CH0 & ADC_INT_OFF );
}
    
```

To measure the current an analog to digital converter is required. Since the converter's lecture can vary, it is necessary to take several samples and average the result for further processing.

The ADC() function asks if the voltage conversion into a digital number was completed, then the function sends "1" when a conversion is not completed and it sends "0" when this was finished. This function allows the converter to extract the value at the right time. The readadc() function reads the value from the converter and returns it in a variable of type unsigned long int. The reference voltage is 0.600 volts. To obtain the current, this voltage has to be divided by the resistance values where the voltage is measured. Since this resistance is 1 ohm, the division always gives the same result. In turn, in the program, 1 mA is 1000, so the maximum range of 0.6 volts is 600 mA and in the program will be 600000. The value obtained in the converter is not expressed in mA, Because the analog signal is converted into a 10-bit number, there are 1024 (2¹⁰) binary combinations to represent, ranging from 0 to 1023 so this value will be multiplied by 600000 and divided by 1023 which is equivalent to the maximum value of the conversion in decimal; in this form was obtained the value of the measured current. The function that allows the measurement of current is called read_converter_AD and is shown below:

```

unsigned long int read_converter_AD (void)
{
    unsigned long intvalue_obtenida=0;
    intsuma=0,i;
    for(i=0;i<100;i++)
    {
        Delay10TCYx(5);
        ConvertADC();
        while(BusyADC());
        value_obtenida = ReadADC();
        sum += value_obtenida;
    }
    Value_obtenida = (unsignedlongint)(suma/100.0);
    Value_obtenida = ((value_obtenida*600000.0)/1023.0);
    return(value_obtenida);
}
    
```

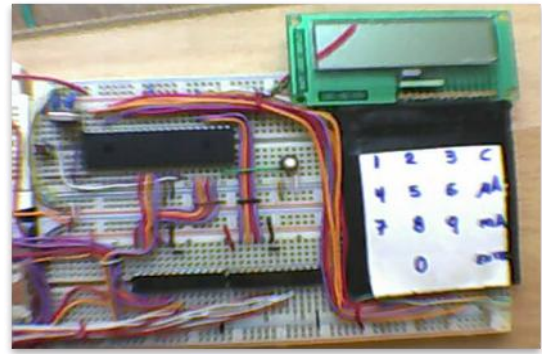


Fig. 5. Implemented system for obtaining the optimal resistance.

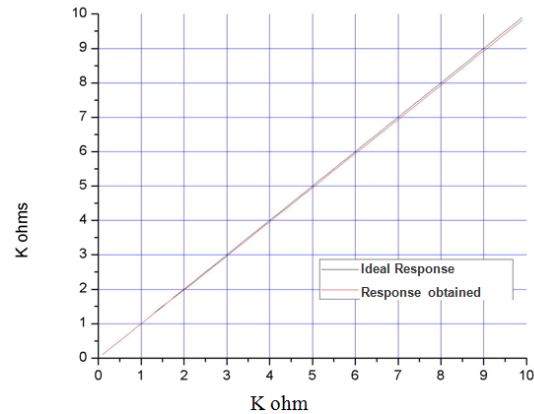


Fig. 6. Obtained values from the measured resistance arrangements compared whit expected ideal values.

III. RESULTS AND DISCUSSION

The main circuit of the implemented system is shown in Fig. 5.

It was proceeded to give appropriate control signals to the analog switches to be closed or open and get the expected values of equivalent proposed resistance. The result was optimal for small resistance values and the error increased when the required resistance value was higher.

The resistors arrangements in Fig. 2 were assembled with precision resistors of $\pm 1\%$. Error, were found to have more variation in the resistors of 1 Kohm therefore error was increasing with the increase of quantity of ohms in the circuit.

The resistance values obtained was compared with the ideal values of the resistors arrangements. The results of this comparison are shown in Fig. 6.

IV. CONCLUSIONS

The response in the digital design with Microchip PIC18F452 microcontroller was feasible since it avoids problems in the management of digital and analog systems together. Furthermore, it allows an optimal speed and programming in C language allowed easy debugging of errors. The program is easy to understand because it was divided into functions.

More precise resistors are required to make this system highly effective. However, with the features shown, the prototype is a very efficient option since it can save time and money for the design of electronic circuits.

REFERENCES

- [1] R. L. Boylestad and L. Nashelsky, *Electrónica: Teoría de Circuitos y dispositivos Electrónicos*, 10th ed. Mexico, 2009.
- [2] T. L. Floyd, *Dispositivos Electrónicos*, 8th ed. México, 2008.
- [3] PIC 18F452 Datasheet [Online]. Available: <http://www.datasheetcatalog.org/datasheet/microchip/39564b.pdf>
- [4] Precision 0.600V Low Voltage FGA ISL21032 Datasheet. [Online]. Available: <http://www.intersil.com/content/dam/Intersil/documents/fn62/fn6239.pdf>
- [5] JulyanIlet, How to use intelligent L.C.D.s part one, Constructional Feature. [Online]. Available: <http://www.epemag.wimborne.co.uk/lcd2.pdf>.



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