PSoC Based Tyristorised Bridge Inverter

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Abstract- *The Programmable system on chip (PSoC) is a reconfigurable, embedded, mixed signal system- on-chip from Cypress Semiconductor. In addition to all the standard elements of 8-bit microcontrollers, PSoC features analog and digital programmable blocks, which themselves allow implementation of a large number of peripherals. PSoC can replace tradition fixed function ICs (Integrated Circuits), ASICs (Application Specific Integrated Circuits) and microcontrollers in many applications today. Digital blocks consist of smaller programmable blocks that can be configured to allow different development options. Analog blocks are used for development of analog elements. Depending on the microcontroller family, PSoC (1, 3 or 5) have 4–16 digital blocks and 3–12 analog programmable blocks. PSoC1 is based on 8-bit microcontroller known as M8C.*

Keywords- Programmable system on chip (PSoC), ASICs (Application Specific Integrated Circuits), Analog blocks

I. INTRODUCTION

It consists of a Central Processing Unit (CPU) that executes the instructions and controls the interaction among the different blocks. The reset controller helps to restore the microcontroller to its initial state, frequency generator generates clock signals of various frequencies that can be selected based on application requirement, watchdog timer to handle deadlock situations, sleep timer to make microcontroller wake up at regular periodic intervals from power saving modes, Input/ Output pins to communicate between CPU and programmable blocks as well as for I/O operations.

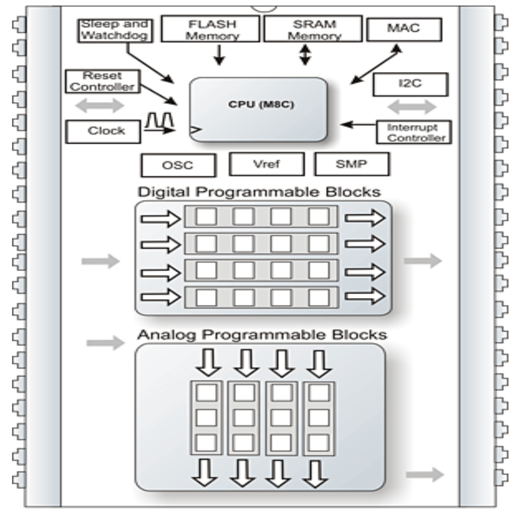

Figure 1. PSoC Architecture

PSoC also consists of digital and analog programmable blocks like filters, Analog-to-Digital Converter (ADC) and Digital-to-Analog Converter (DAC)s, inverting, non-inverting and operational amplifiers, counters, timers etc.. It also supports Inter integrated circuit (I2C), Serial Peripheral Interconnect (SPI), Universal Asynchronous Receiver Transmitter (UART), Universal Serial Bus (USB) communications along with Radio Frequency (RF). The programming language is C or assembly. Both can be used at the same time. An important part of the software development package is basic set of libraries including floating point math, strings, and proprietary libraries. The “Strings” unit is traditionally the weakest part of C. Code from older projects is reusable. Rewriting software libraries from scratch is very time consuming. If you run a project, the engineering question stands: “how can I get from A to B, without wasting time”? Two compilers are supported. Just recently, a new embedded system C compiler from HI-TECH was released. During operation, the unused blocks can be put asleep. External trigger can wake up particular block, or the whole device. There is also a section taking care of the program security. Particular memory sections can be encrypted. Specific software tasks can use the advantage of dedicated hardware multiplier. The CPU clock has optional frequency multiplier by two, based on PLL (Phase Lock Loop). The minimized PLL loop filter spares the real estate space on the silicon chip. Sensitivity to RF EMI radiation was found, causing slight clock skew. From functional point of view, the device can bring major system improvements, replacing large portfolio of hardware state machines. It can run the laundry washing machine, it can supervise the brewing process, or provide data acquisition, signal processing, and data encryption. A desktop frequency counter burning few Watts of power can shrink to a handheld device with temperature controlled frequency standard. PSoC is an interesting stand-alone engineering tool.

The gate terminal connects directly to the base of the lower transistor; it may be used as an alternative means to latch the thyristor. By applying a small voltage between gate and cathode, the lower transistor will be forced on by the resulting base current, which will cause the upper transistor to conduct, which then supplies the lower transistor's base with current so that it no longer needs to be activated by a gate voltage. The necessary gate current to initiate latch-up, of course, will be much lower than the current through the SCR from cathode to anode, so the Thyristor does achieve a measure of amplification. This method of securing Thyristor conduction is called triggering.

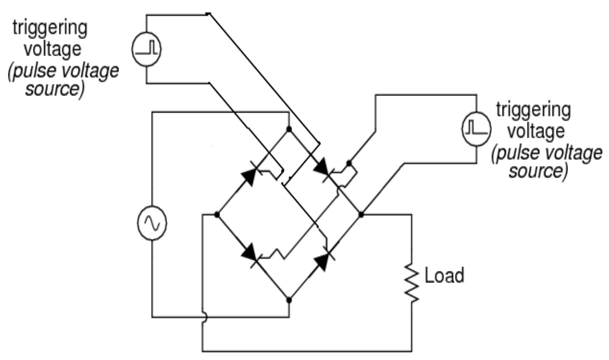

Figure 2. Thyristorised Rectifier Bridge

In power electronics one of the needs is the conversion of AC voltage to DC voltage. One of the devices used in energy conversion is the rectifier bridge, which converts an alternating voltage into a DC voltage, and has been used with new approaches. The average output voltage (VLmed), of a thyristorised rectifier bridge, is obtained with (1), where Vo is the RMS input voltage and the firing angle.

$$V_{Lmed} = 0{,}45.V_o.(1+\cos\alpha). \qquad (1)$$

There are two ways to characterize the firing angle, through the comparison of the control voltage Vc and a reference voltage Vref, with a saw-tooth or a cosine wave characteristic. Through the second method of comparison it is possible to obtain a linear relationship between the firing angle and the average voltage output, which results in a better response of the converter. Because of this ch aracteristic, this type of comparison was implemented on this work. The relationship between the control voltage and the firing angle can be seen in (2), where VM is the cosine maximum reference voltage.

$$\frac{V_{Lmed}}{0{,}9.V_o} = \left(1 - \frac{V_c}{V_M}\right). \qquad (2)$$

II. HISTORY & BACKGROUND

One needs existing in the electrical systems is the conversion of an alternating voltage into a DC voltage. For this task it is common to use rectifier bridges, which produce a variable output voltage. The control system of a rectifier bridge uses different integrated circuits (ICs), as well as auxiliary circuits, to convert the signals from each part of the circuit. The system developed by, among some applications of the rectifier bridge, uses the MC6809 microprocessor to perform the control of a three-phase rectifier bridge, which feeds a DC motor. Additionally, some discrete components and integrated circuits are used, such as the timer VIA6522, which is responsible for generating the trigger pulse of the thyristors. The reference presents a dual converter feeding a DC motor. The control system of the dual converter uses a smaller number of external circuits, since a great number of functions are performed by the 68HC11 microcontroller. However, the trigger pulse generation system depends on extra components such as: counter, comparator and demultiplexer.

A control system for a three-phase induction motor is considered. Although it used a circuit suitable for the driving of controllable devices, such as thyristors and triacs, the TCA780, resulting in a considerable decrease in the number of external components, the control system is accomplished through analog PI controllers. The search for cost reduction due to the decrease or the efficient use of raw materials leads the researches for the production of optimized systems (fewer components, lower power consumption, etc.). Following this trend, the System-on-Chip - integrated circuits that incorporate different features, configurable and programmable, in an integrated circuit - are available on the market. Thus, this work presents the implementation of a thyristorised rectifier with constant current output, using a System-on-Chip, i.e. the PSoC (Programmable System-on-Chip developed and produced by Cypress Semiconductor Corp.). The use of PSoC reduces the amount of discrete circuitry of the conversion system and consequently has a lower system cost, flexibility (change of functions), among other features. The system developed in this study took into account the circuits used in applications previously mentioned, noting the advantages and disadvantages of each approach in order to evaluate the parts of the circuit that could be integrated in the PSoC, thus reducing the total number of external circuits. In this project, the PSoC was chosen because it provides useful resources for the intended application, such as timers, which will be used to generate the trigger pulses for the thyristors, analog to digital (A/D) converters used in converting the output current, amplifiers and filters, responsible for the signal conditioning.

III. PROBLEM STATEMENT

One needs existing in the electrical systems is the conversion of an alternating voltage into a DC voltage. For this task it is common to use rectifier bridges, which produce a variable output voltage. The control system of a rectifier bridge uses different integrated circuits (ICs), as well as auxiliary circuits, to convert the signals from each part of the circuit. The existing systems are bulky and require many external interfaces thereby increasing the cost of the system and making the systems expensive. In order to obtain a controlled bridge rectifier system with reduced cost we use PSoC(Programmable system on chip). In this project, the PSoC was chosen because it provides useful resources for the intended application, such as timers, which will be used to generate the trigger pulses for the thyristors, analog to digital (A/D) converters used in converting the output current, amplifiers and filters, responsible for the signal conditioning.

IV. PROPOSED SYSTEM

The need for cost reduction by the efficient use of raw materials for the production of optimized systems with fewer components, lower power consumption, etc is the main objective of the project. For this, the System-on-Chip - integrated circuits that incorporate different features, configurable and programmable, in an integrated circuit is used Thus, this work presents the implementation of a thyristorised rectifier with constant current output, using a System-on-Chip, i.e. the PSoC (Programmable System-on-Chip developed and produced by Cypress Semiconductor Corp.). The use of PSoC reduces the amount of discrete circuitry of the conversion system and consequently has a lower system cost, flexibility (change of functions), among other features. In order to perform the controlling operation PSoC is used to reperesent the control system. The changes in load and input voltages are given as inputs to PSoC as a feed back system. Then through the control system implemented on Psoc the driver circuits are provided with the trigger pulse so as to maintain the output current constant.

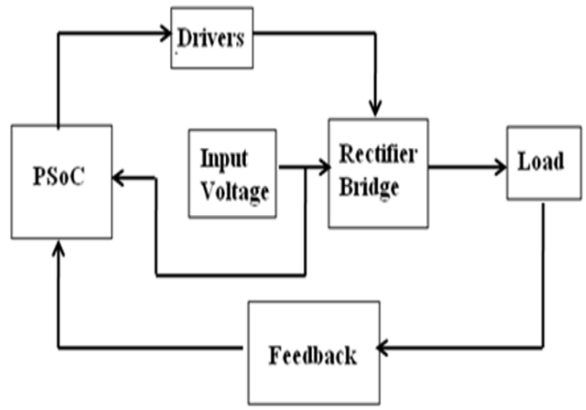

Figure 3. Rectifier Bridge Contolled Through Psoc

The implementation of the system in PSoC can be given as shown in Figure 3. The pulses that will trigger the thyristors will be generated by the PSoC through its internal timers, as illustrated in Figure 3. The timers outputs are connected through AND functions to the output of a PWM block with a frequency of 10 kHz. To get the average voltage at the Hall sensor output, which is proportional to the output current of the circuit, an internal low-pass filter was used, as shown in Figure 3. To convert the value of the analog voltage, which is proportional to the output current and is obtained at the output of the low pass filter, it will be accomplished through the A/D converter internal to the PSoC. The data conversion is performed using the incremental method, where the input and reference signals are integrated in each stage of the clock. This converter eliminates the need for external components, simplifying adjustments, reducing the interferences and the final cost of the project. To calculate the control voltage Vc, which will be used later to obtain the firing angle , a PI controller for the current control loop, was used. The control is implemented on the PSoC, allowing rapid adjustment of parameters, when compared with analog control circuits and due to the resources of the microcontroller, such as MAC (Multiply Accumulate 32-bit), the controller calculus are performed in a small amount of time.

IV. RESULTS

For voltage =1V

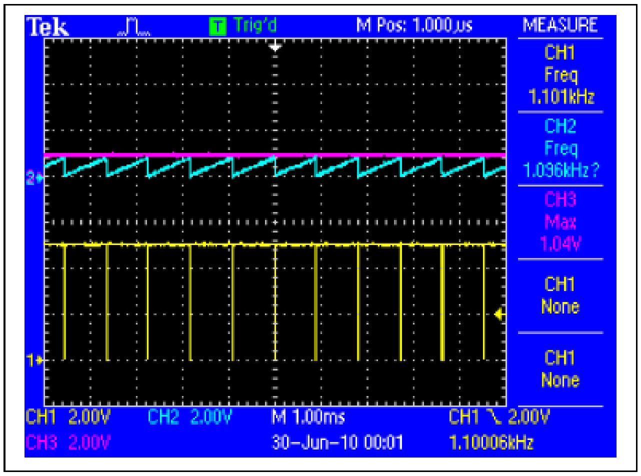

Figure 4.

For voltage =3V

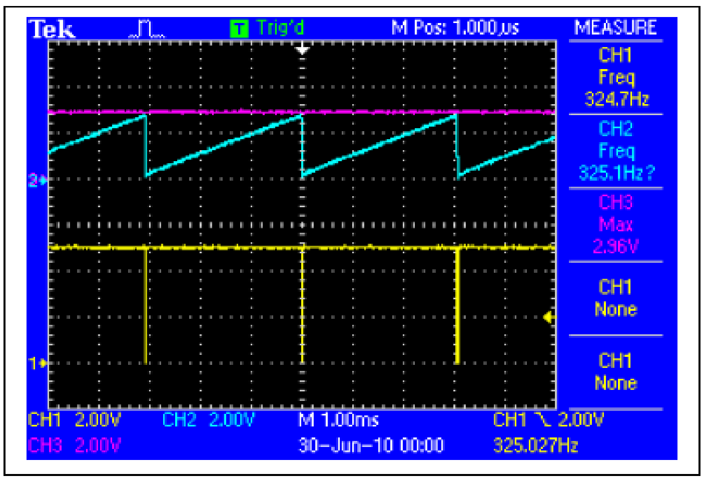

Figure 5.

V. CONCLUSION

In this system, the design and implementation of a control system for a thyristorised rectifier bridge has been proposed. The voltage controlled oscillator part has been implemented on PSoC. The advantage was the considerable decrease in external circuitry. Compared to other methods, a 40% reduction of the external circuitry was obtained .In addition to the benefits of circuit dimension reduction; there is the lowest energy consumption, increased power density and higher efficiency of the structure, which allows using this type of solution in a large number of applications. It should also be noted the ease of modification of the project, as the circuits integrated in the PSoC, can be changed or reconfigured dynamically.

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