Designers of digital circuits now more and more rely on the FPGA (Field Programmable Gate Array) technology. The technology itself is not very new, but it becomes widely used with lower prices of circuits and especially with acceptable prices of development tools (some of them are even free of charge). Now these circuits are mainly used in prototyping as well as in the low and middle volume production, where they replace the ASICs.

The use of FPGAs brings several advantages to the designer as well as the producer and even the end user of the final product. The hardware design is very simple, as whole or substantial part of the digital design consists of one or more FPGA circuits. Probably the biggest advantage is the hardware re-programmability of FPGAs that allows designer to change the hardware behavior without redesigning the PCB layout. For the volume production FPGAs offer similar distinction, which allows making the hardware behavior changes (e.g. errors correction) only by replacing the FPGA content. It usually requires no changes in the hardware design, and can be done quickly and without any demands for manufacturing process. End user can again profit from this re-programmability, which e.g. allows adding new hardware features into the product without the necessity to buy the new one.

The paragraph above focuses on the advantages of FPGA technology, but there is at least one disadvantage too. Standard MSI, LSI or VLSI circuits provide pre-defined functionality and offer no possibility to change it. When they are included into the digital design and all the requirements they have for their neighborhood are satisfied, these circuits should work properly. Using the FPGA circuits we have either to synthesize all the functionality we want to implement or to use already created IP (intellectual property) functions, provided either by the design tool or by third party companies. The hardware design is then “reduced” to the programming the internal circuitry behavior. This programming requires for designer to know and understand one or more high-level programming languages (e.g. VHDL, Verilog or AHDL) that are used for this purpose. Nevertheless it is not enough; designer is responsible for the functionality of basic blocks that replace the MSI, LSI or VLSI circuits used in traditional designs. Most of these designs are available as IP functions, but their price is usually not acceptable for low and sometimes even middle volume production. Designer is then responsible for the proper design of these blocks, which is not easy and very time consuming.

When starting with FPGA technology, user has usually some free development tools available, provided by the FPGA circuit manufacturers to support the sale of their chips. These tools allow to design and simulate the hardware design functionality, but simulation can never replace the test in the real hardware environment. In this phase the universal breadboards are used for the pilot implementation and test before the final PCB layout is designed. There are number of such boards provided directly by the FPGA circuit manufacturers, but the limited features they provide limit their use. In the next paragraph we describe the breadboard designed and developed for testing the basic and simple designs of beginners as well as quite complex designs of advanced users.

The board is designed with Altera’s ACEX family of FPGA circuit. It accepts all circuits from the simplest 1K10 up to the largest 1K100 (they all share the same PCB footprint).
These circuits provide enough internal capacity for large designs and they are still very cost effective. The FPGA chip can either be programmed using the special programming instrument (Byte Blaster) connected to the parallel port of the PC or using a standard serial memory (socket is available). It allows the fast circuit reprogramming during the development phase and easy programming with final design.

Besides the FPGA itself the breadboard contains several other circuits that allow testing designs without additional hardware. For the basic designs the four LED and four pushbuttons are connected to FPGA as well as the four digit LED display (in multiplex arrangement). The connected buzzer allow for simple acoustic indication, whereas analog amplifier supplied from the low-pass filter, connected to the FPGA digital output, allows designer to experiment with sound processing. The serial interface (RS 232) is available as well for testing of designs focused on communication. The keyboard (PS/2) and VGA interfaces allow designing the simple user interface.

The second heart of the breadboard is the AT89C52 microprocessor in configuration with the internal monitor program, which allows downloading the application program into the external RAM memory, executing and debugging it using the serial interface. FLASH memory is connected to the microprocessor too. In the advanced designs the processor can use the peripherals implemented inside the FPGA circuit and user can debug both parts together. Both the memories (RAM and FLASH) can also be used directly by the FPGA.

The external clock generator (25 MHz) supplies the FPGA chip. Using the external clock inputs or internal PLL circuit user can establish arbitrary clock frequencies.

The breadboard is equipped with its own power supply, which provides +9 V, ±5 V, +3.3 V and +2.5 V. The first voltage supplies the analog amplifier, +5 V supplies the digital circuits and together with –5 V are intended for potential external analog circuits. The latter two voltages are intended for the FPGA.

The breadboard offers 32 general I/O pins, 8 dedicated inputs and dedicated clock inputs for the interconnection with external circuits.

Using the described board several designs were particularly tested, e.g. the PCI interface, ARINC controller, CAN generator and others.

References:


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