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Handheld All-In One Electronic Laboratory For Education And Research

M.Praveenkumar
Department of ECE, Jaya Engineering College, Chennai, India
Mrs.Sujatha
Department of ECE, Jaya Engineering College, Chennai, India

Abstract:
This paper gives a idea to make a cost efficient wireless communication laboratory using ARM cortex that is inexpensive and available worldwide. To make it possible we have include complete transmission, reception, probing capabilities and channel emulation. This project is targeted especially for budding engineer, used to learn Visual real-time demonstration in wireless communication system. The Ultimate objective of this project is to give a low cost and effective laboratory device for developing country like India. In India still using conventional method of laboratory tools. A survey that were collected from two classes of student taught by the author in a university in Columbia, south America and which show the effectiveness of the laboratory in teaching wireless communication

Key words: *ARM CORTEX*

1.Introduction

This idea for creating this paper is, due to the circumstance and necessity rather than forethought and planning. The total cost for made this project is only $200. Needless to say, the aforementioned budgetary constraints posed a significant challenge when the author wished to engage in teaching and research in wireless Communication. While software simulations are useful and could be employed, there is Nonetheless and experimental verification of both teaching and researchHowever, due to the aforementioned financial constraints, the only budget that could be allocated, at great effort, was approximately $1200 for the purchase of six Xilinx Spartan-3A starter kit boards. Faced with this high budget, forced author to develop new efficient verilog programming techniques to cram the wireless communications structure inside the ARM cortex, resulting in several theoretical and practical breakthroughs.

In this project author describe about the wireless communications laboratory. Another aim is to make the project kit within $200. The only additional equipment that required is a computer to interface to the board and optionally a keyboard and VGA moniter to transform the lab into a completely autonomous facility. The laboratory presented here is fully suitable to accompany under-graduate course wireless communications and is powerful enough to useful in academic research in wireless communication. Moreover, since the same unmodified using ARM cortex can also used in courses for digital design, computer architecture, and networking and embedded system, the investment needed for the laboratory can be reduced to a pittance by spreading the cost among various courses and research projects. Such an extreme cost-conscious approach is essential in order to allow for wireless communications teaching and research in resource-limited developing countries.

2.Physical Platform

2.1.Digital Signal Oscilloscope

Used to monitor signals acquisitioned through the inbuilt 12-bit A to D converter. This device is single channel, 100 KHz bandwidth. The signals will be shown in color waveforms in a nice 65K Color QVGA Touch screen TFT Graphical LCD Display. Waveform Storage and Playback – used to save the acquired signals for analyzing and viewing. The storage medium is a 2GB MicroSD memory card.

2.2.Frequency Generator

used to generate pulses at variable frequencies with added pulse width control

2.3.Logic Analyzer

used to analyze serial protocols such as UART.

2.4.Voltmeter

used to measure the input DC voltage.

2.5.Ammeter

used to measure the input DC current using current shunt resistor drop.

2.6.Ohmmeter

used to find the resistor values, short circuits and components such as diodes.

2.7.Tachometer

used to measure the speed of the rotating shaft of the motor using the Rotary Encoder.

2.8.Audiometer

used to monitor the audible frequency signals sensed via Microphone circuitry.

2.9.3-axis Motion Monitor

used to measure acceleration or tilt or motion on all three axis using 3-Axis MEMS Accelerometer.

2.10.Light Meter

used to measure the brightness of the incident light in terms of Luminosity using Light Sensor.

2.11.Temperature Probe

used to measure the temperature or heat of atmosphere or an object in degree Celsius.

2.12.Calculator

used to perform math calculations using touch screen keypad.

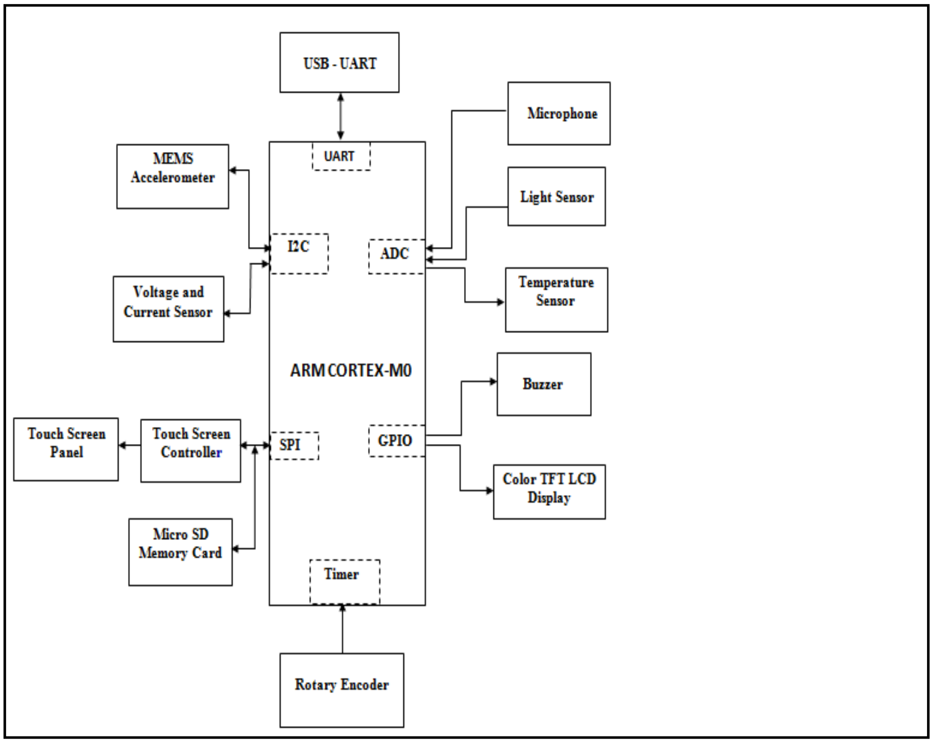

Figure 1: low cost one touch interface laboratory equipment

3.Software Used

The software uses Graphics Library and the user interacts with the device using touch screen buttons and menus. The device has a USB-UART bridge circuit that gives USB connectivity for Desktop/Laptop communication for data logging the measured quantities. The logged data can be used for further analysis. This process can be fully controlled by the user from the device UI. It also helps to easily upgrade the firmware of the device from a desktop/Laptop. The device is controlled by LPC1114, a powerful 32-bit ARM Cortex-M0 microcontroller from NxP Semiconductors.

4.ARM Cortex-M3

The ARM Cortex™-M3 processor is the industry-leading 32-bit processor for highly deterministic real-time applications and has been specifically developed to enable partners to develop high-performance low-cost platforms for a broad range of devices including microcontrollers, automotive body systems, industrial control systems and wireless networking and sensors. The processor delivers outstanding computational performance and exceptional system response to events while meeting the challenges of low dynamic and static power constraints. The processor is highly configurable enabling a wide range of implementations from those requiring memory protection and powerful trace technology through to extremely cost sensitive devices requiring minimal area.

5.Components Interfaced With Arm Cortex

5.1.I2C Protocol

I²C is a multi-master serial computer bus invented by Philips that is used to attach low-speed peripherals to a motherboard, embedded system, or cell phone. The name stands for Inter-Integrated Circuit and is pronounced *I-squared-C* and also, incorrectly, *I-two-C*. I²C uses only two bidirectional open-drain lines, Serial Data (SDA) and Serial Clock (SCL), pulled up with resistors. The I²C reference design has a 7-bit address space with 16 reserved addresses, so a maximum of 112 nodes can communicate on the same bus. The maximum number of nodes is obviously limited by the address space, and also by the total bus capacitance of 400 pF.

5.2.LPC1300

The LPC1311/13/42/43 is ARM Cortex-M3 based microcontrollers for embedded applications featuring a high level of integration and low power consumption. The ARMCortex-M3 is a next generation core that offers system enhancements such as enhanced debug features and a higher level of support block integration.

The LPC1311/13/42/43 operates at CPU frequencies of up to 72 MHz. The ARMCortex-M3 CPU incorporates a 3-stage pipeline and uses Harvard architecture with separate local instruction and data buses as well as a third bus for peripherals. The ARM Cortex-M3 CPU also includes an internal pre fetch unit that supports speculative branching.

The peripheral complement of the LPC1311/13/42/43 includes up to 32 kB of flash memory, up to 8 KB of data memory, USB Device (LPC1342/43 only), one Fast-mode Plus I2C-bus interface, one UART, four general purpose timers, and up to 42 general purpose I/O pins.

5.3.Seial Peripheral Interface

Serial Peripheral Interface is a simple interface which enables to communicate microcontroller and peripheral chips or intercommunicate between two or more microcontrollers. Serial Peripheral Interface bus sometimes called four wire interfaces may be used to interface such chips or devices like: LCD, sensors, memories, ADC, RTC. The range of usage is huge.

SPI Bus uses synchronous protocol, where transmitting and receiving is guided by clock signal generated by master microcontroller. SPI interface allows connecting several SPI devices while master selects each of them with CS (Chip Select) signal – (Underline means that active is LOW).

5.4.USART Asynchronous Mode

In this mode, the USART uses standard non-return-to zero (NRZ) format (one start bit, eight or nine data bits, and one stop bit). The most common data format is 8 bits. An on-chip, dedicated, 8-bit baud rate generator can be used to derive standard baud rate frequencies from the oscillator. The USART transmits and receives the LSB first. The USART's transmitter and receiver are functionally independent, but use the same data format and baud rate.

The baud rate generator produces a clock either x16 or x64 of the bit shift rate, depending on bit BRGH (TXSTA<2>). Parity is not supported by the hardware, but can be implemented in software (and stored as the ninth data bit). Asynchronous mode is stopped during SLEEP. Asynchronous mode is selected by clearing bit SYNC (TXSTA<4>). The USART Asynchronous module consists of the following important elements.

5.5.USART Asynchronous Transmitter

The USART transmitter block diagram is shown in fig. The heart of the transmitter is the transmit (serial) shift register (TSR). The shift register obtains its data from the read/write transmit buffer, TXREG. The TXREG register is loaded with data in software. The TSR register is not loaded until the STOP bit has been transmitted from the previous load. As soon as the STOP bit is transmitted, the TSR is loaded with new data from the TXREG register (if available). Once the TXREG register transfers the data to the TSR register (occurs in one TCY), the TXREG register is empty and flag bit TXIF (PIR1<4>) is set. This interrupt can be enabled/disabled by setting/clearing enable bit TXIE.

6.Academic Teaching Examples

This section gives examples of typical lab usage in a university setting for teaching wireless communications. A low-end Tektronics oscilloscope to measure time signals and an evaluation version of a commercial PC-audio spectrum analyzer are used. Freeware programs for computer-audio based oscilloscope and spectrum analysis measurements could just as well be used. Since only one board was available for the class and the user interface was still in development, only the professor (the author) operated the laboratory during class, as the need arose

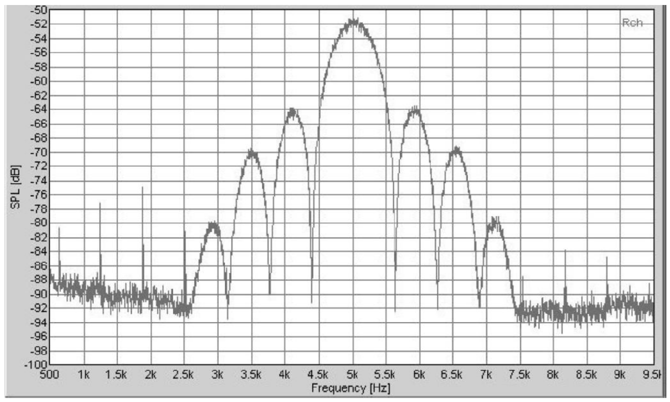

Figure 2: Spectrum of the modulated QPSK signal after transmission filter

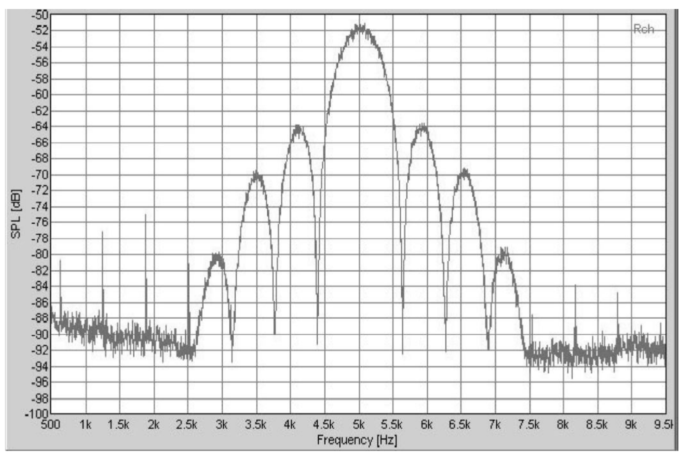

Figure 3: Demodulator (before the matched filter) when the carrier is locked. Symbol SNR is 12 dB (the I and Q spectrums are essentially the same).

7.Other Results And Experiments

A wide variety of experiments can be carried out using the Laboratory, with only a standard (or computer-based) oscilloscope and a (computer-audio based) spectrum analyzer. These Include, but are not limited to the following:

• Investigating the nonlinear behavior of the synchronization

PLLs, including pull-in and cycle-slip behavior;

• Investigating the cross-interaction of the various PLLs and AGC control loops;

• Investigating the interaction between PLL performance and BER;

• Investigating and comparing waveforms throughout the transmitter's and receiver's signal chains for various modulations and signal-to-noise ratios;

• Optimizing receiver and PLL parameters;

• Performing eye-diagram measurements;

• Making BER and symbol error rate (SER) performance

8.Conclusion

This paper presented an ultra low-cost wireless communications laboratory based upon an inexpensive ARM Cortex processor. The cost of the laboratory can be further reduced if the cost of this general-purpose FPGA card is spread out among several courses or projects for which this board is suited. The laboratory allows easy probing and control of internal signals and parameters and is thus useful for teaching and research of wireless communications, especially in a university setting. In particular, the low cost of the laboratory makes it ideal for universities in the developing world.

9.Reference

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