AC 2012-3720: SENIOR DESIGN PROJECTS USING C-STAMP MICRO-CONTROLLERS

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Antonio Soares was born in Luanda, Angola, in 1972. He received a bachelor's of science degree in electrical engineering from Florida Agricultural and Mechanical University in Tallahassee, Fla., in Dec. 1998. He continued his education by obtaining a master's of science degree in electrical engineering from Florida Agricultural and Mechanical University in Dec. of 2000 with a focus on semiconductor devices, semiconductor physics, optoelectronics, and integrated circuit design. Soares then worked for Medtronic as a full-time Integrated Circuit Designer until Nov. 2003. Soares started his pursuit of a doctorate of philosophy degree at the Florida Agricultural and Mechanical University in Jan. 2004 under the supervision of Dr. Reginald Perry. Upon completion of his Ph.D., Soares was immediately hired as an Assistant Professor (tenure-track) in the Electronic Engineering Technology Department at FAMU. Soares has made many contributions to the department, from curriculum improvements, to ABET accreditation, and more recently by securing a grant with the Department of Education for more than half a million dollars.

Senior Design Projects Using C-Stamp Microcontrollers

In the EET program at Florida A&M University, two microprocessor courses are offered. The first course is *CET 2123 Microprocessor Fundamentals*, which is a required course. In the course, basic concepts in the microprocessor, including the assembly language and the hardware architecture are introduced. The second course of *CET 4149 Microprocessor Interfacing* is offered as an elective course. This course covers more advanced topics and concepts, such as ADC (Analog to Digital Converter), serial port communication, timers, etc. In both courses, PIC18 microcontroller is used as the main microcontroller. We switched to PIC microcontrollers a few years ago. The reason behind it is mainly that Microchip PIC microcontrollers have become a significant player in industry as well as among hobbyists. Its popular 8 bit microcontroller providing embedded control solutions have been incorporated into many products globally.

PIC Microcontroller

In 1989, Microchip Technology Corporation introduced an 8-bit microcontroller called the PIC, which stands for Peripheral Interface Controller. The microcontroller had small amounts of data RAM, a few hundred bytes of on-chip ROM for the program, one timer, and a few pins for I/O ports, all on a single chip with only 8 pins. It is amazing that a company that began with such a humble product became one of the leading suppliers of 8-bit microcontrollers in less than a decade. [1] Now Microchip is the number one supplier of 8-bit microcontrollers in the world. Since the introduction of the PIC16xxx, they have introduced an array of 8-bit microcontrollers, including the PIC families of 10xxx, 12xxx, 14xxx, 16xxx, 17xxx and 18xxx. PIC 18xxx is available in 18 to 80 pin packages, which make it an ideal choice for new designs. PIC has some of the following advantages in terms of architecture.

- Small instruction set
- RISC architecture
- Built in oscillator with selectable speeds
- Easy entry level, in circuit programming plus in circuit debugging
- Inexpensive microcontrollers
- Wide range of interfaces including I²C, SPI, USB, USART, A/D, programmable comparators, PWM, LIN, CAN, PSP, and Ethernet.

Because of these advantages, plus their low cost, wide availability, large user base, extensive collection of application notes, low cost of free development tools, and serial programming (and re-programming with flash memory) capability, PICs are becoming more and more popular with both industrial developers and hobbyists alike.

In the two courses taught at EET program, the students have a chance to do some hardware labs as well as software labs. The PICkit 2 Starter Kit [2] and PIC18/PIC16 Trainer board [3] are used for the lab. The IDE used is MPLAB form Microchip [2] .The following are some examples of the labs.

- MPLAB assembler and simulator
- Examine the flag
- Arithmetic operations
- ASCII and BCD conversion
- Microchip C18 programming
- Data transfer
- Testing PIC I/O ports
- Interfacing an LCD to PIC
- PIC serial port programming
- ADC programming in the PIC
- Interfacing a sensor to PIC
- Event counter programming

In the EET program, every senior student needs to take *EET 4914 Senior Design Project* before they graduate. This capstone experience will give the students a chance to put what they have learned in EET program into practice. It starts with need analysis, literature review, design proposal, simulation, prototyping, testing, trouble shooting, etc. And it finishes with a final working "product", nicely assembled and packaged. The students are given the freedom to choose their own projects. In selecting the design topic, a lot of students are interested in doing microcontroller based projects. But although in CET 2123 and CET 4149, the students have finished a lot of labs, which strengthened what they have learned in the class, since each lab usually focuses only on one topic, they don't have a chance to take up an integrated design project, including the software and the hardware. Therefore some students have to give up the idea because they are afraid they can't start from scratch and finish in time.

Still some students chose to go along with their ideas and used some third party development board, such as C Stamp, as the basis of their design. Since these development boards provide a pre-assembled hardware platform, which include common peripheries. They also provide the library for programming. These benefits make the students' learning curve much shorter and most of their projects are satisfactory.

C Stamp microcontroller platform

The C Stamp microcontroller platform is developed by A-WIT [4]. Each C Stamp comes with a microcontroller chip that contains the C Stamp Operating System, internal memory (RAM, EEPROM, and Flash), a 5-volt regulator, a number of general-purpose I/O pins (TTL-level and Schmitt Trigger inputs, and 0-5 Volts outputs), communication and other peripherals, analog functions, and a set of library function commands for math, pin operations, and much more. C Stamp modules are capable of running many thousand instructions per second and are programmed with a subset of the C programming language, called WC. WC is a simple, easy way to learn language, and it is highly optimized for embedded system. It includes many specialized functions. The manual includes an extensive section devoted to each of the available functions. Table 1 provides the specifications of the CS110000 C Stamp module [5]. Figure 1 shows how the pins of the CS 110000 C Stamp module are numbered.

Table 1 Specification of CS110000 C Stamp Module

Features/Attributes	
Package	48-pin DIP
PACKAGE SIZE (L x W x H)	2.4" x 1.0" x 0.4"
PINS ATTACHMENT METHODOLOGY	Through Hole
ENVIRONMENT	-40 to 85 deg. C (-40 to 185 deg. F)
MICROCONTROLLER	MICROCHIP PIC18F6520
PROCESSOR SPEED	40 MHz
PROGRAM EXECUTION SPEED	~10,000,000 instructions/sec
RAM SIZE	2K Bytes
SCRATCH PAD RAM	2K Bytes
PROGRAM MEMORY SIZE	32K Bytes, ~16,000 inst
NUMBER OF I/O PINS	41 + 2 Dedicated Serial
VOLTAGE REQUIREMENTS	5 - 24 V DC
CURRENT DRAW @ 5V	19 mA Run / 0.7 uA Sleep
SOURCE/SINK CURRENT PER I/O	25 mA / 25 mA
SOURCE/SINK CURRENT PER MODULE	100 mA / 100 mA per 4 I/O pins
PC PROGRAMMING INTERFACE	Serial (57600 baud)
C STAMP™ INTEGRATED PROGRAMMING ENVIRONMENT	MPLAB IDE (v7.22 and up)
EEPROM (DATA) SIZE	1K Byte
INTERRUPTS	4
DIGITAL TO ANALOG CONVERTERS	2 channels (10 bits) single ended
OTHER COMMUNICATION INTERFACES	3-wire SPI™, I 2 C Master and Slave
PARALLEL SLAVE PORT	8 bits
ANALOG TO DIGITAL CONVERSION	12 channels (10 bits) single ended
ANALOG COMPARATORS	2

Board of Learning

The C Stamp is complemented by the CS310X00 (µC 101) Microcontroller Fundamentals Board of Learning (BOL) [5] .The Microcontroller Fundamentals Board of Learning (BOL) is a complete, high performance, low cost development platform designed for those interested in learning and using A-WIT's C Stamp module. Its size, rich feature set, and low price make it an ideal tool for the student and educator. The µC101-BOL is a great tool with which to get started with A-WIT's C Stamp modules. For educators, the µC101-BOL provides a clean and efficient platform to teach students the basics of microcontrollers, where they can easily plug in parts, and perform A-WIT provided projects or educator developed C Stamp based curriculum.

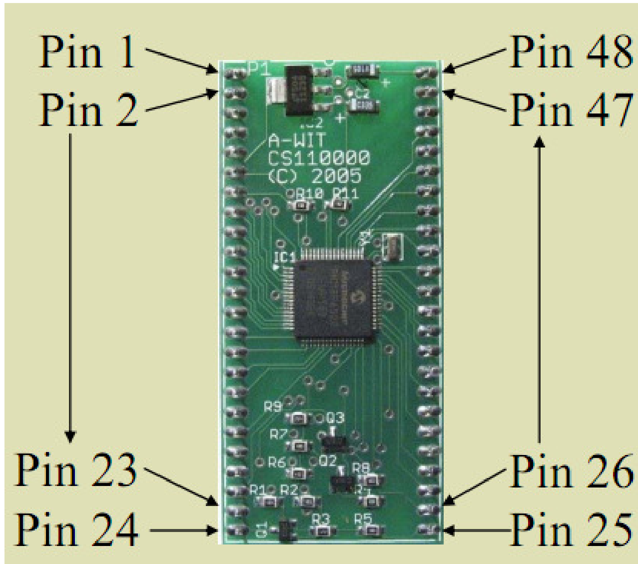

Figure 1 CS 110000 C Stamp module

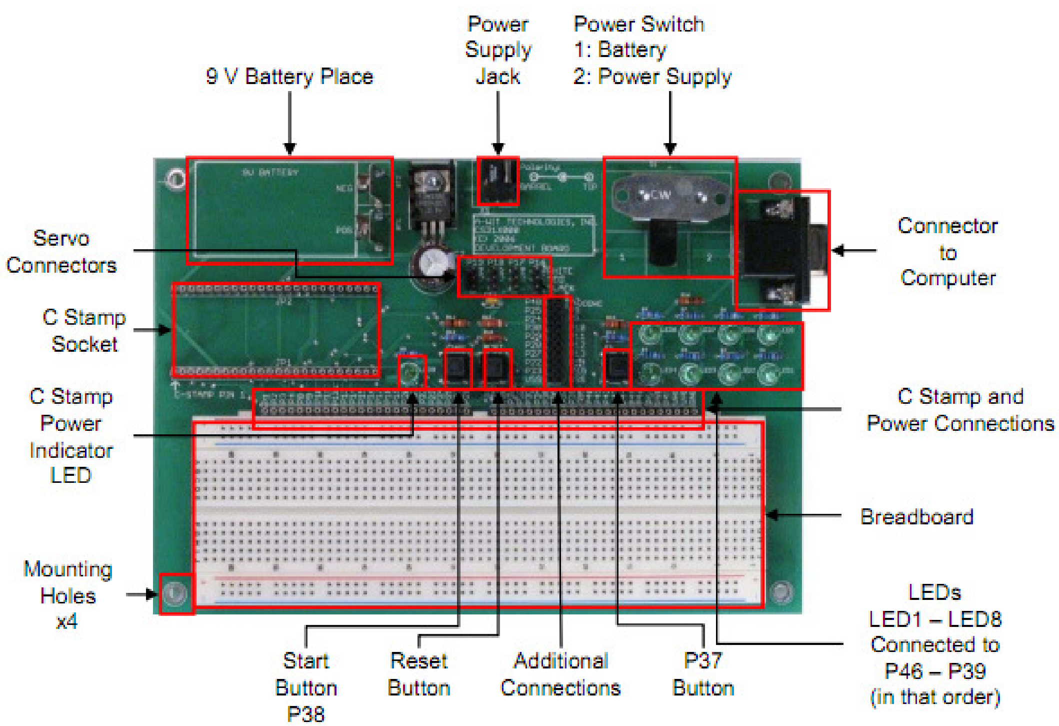

Figure 2 CS310X00 BOL with all features highlighted

As you can see, the students can use BOL to integrate their hardware designs with provided breadboard. In the following sessions, two senior design projects using C Stamp will be explained.

Smart Parking Lot:

This system will guide vehicles to the most convenient parking spot available through the use of an LCD/LED display located at the lot entrance. A priority system will be implemented to allow the best possible parking slot chosen. Infrared sensors will be used to detect vehicles entering the lot, and also vehicles in parking spots. A mechanical arm implemented by a servo will control the flow of traffic into the lot. Once the lot is full, a display alongside the road will notify the drivers, and the gate/arm will not be activated until a parking spot is available. Since the library provided by the C Stamp has the function to control the servo as well as the LCD display, the implementation of the design is very simple.

Figure 3 shows a layout of a small scale parking lot. Figure 4 shows the workings of this system.

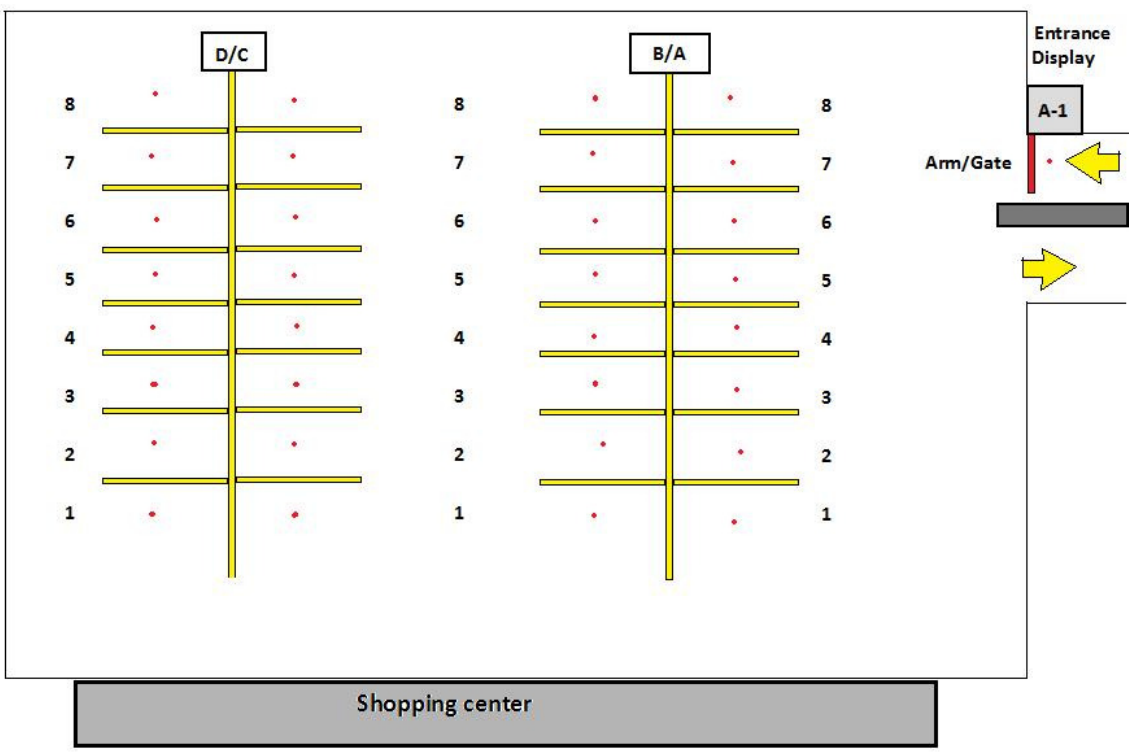

Figure 3 Layout of the simulated parking lot

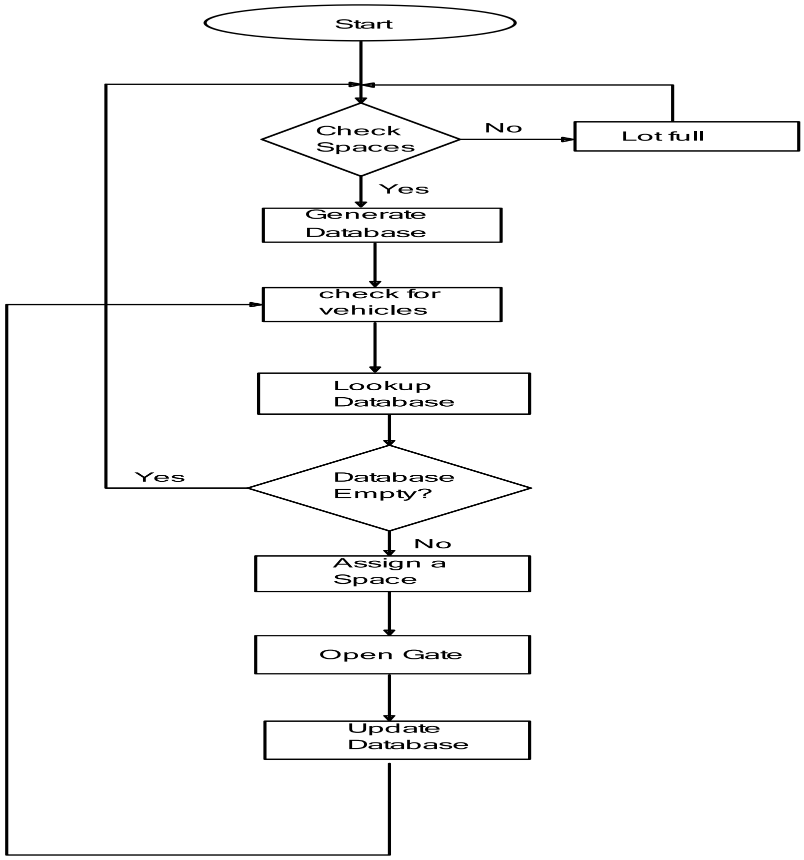

Figure 4 Flowchart of the system

Figure 5 and Figure 6 show the “end product” of this project.

Figure 5 Parking Lot Entrance

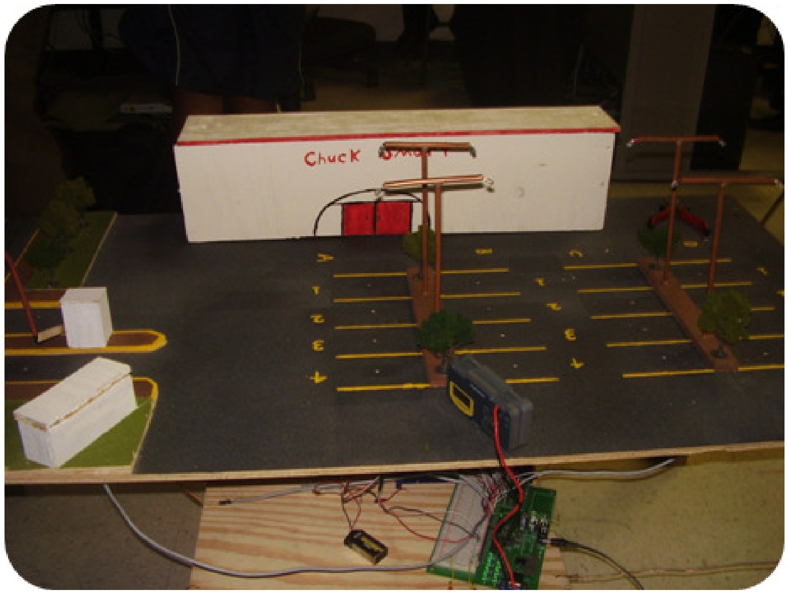

Figure 6 Parking Lot

Arcade Basket Ball Game

This project is an electronic scoreboard. The scoreboard can connect to one or two basketball rims and has two playing modes: 1-player mode and 2-player mode. In the 1-player mode, the player has 30 seconds to score as many baskets as possible. The score is then recorded and the highest score achieved is displayed at end of each game. In the 2-player mode, each player has 30 seconds to score as many baskets as possible. The winner is displayed after the time has expired. The following figure is a design block diagram. In the center there's C-STAMP microcontroller. It will interface with outside world using key pad and LCD& LED display.

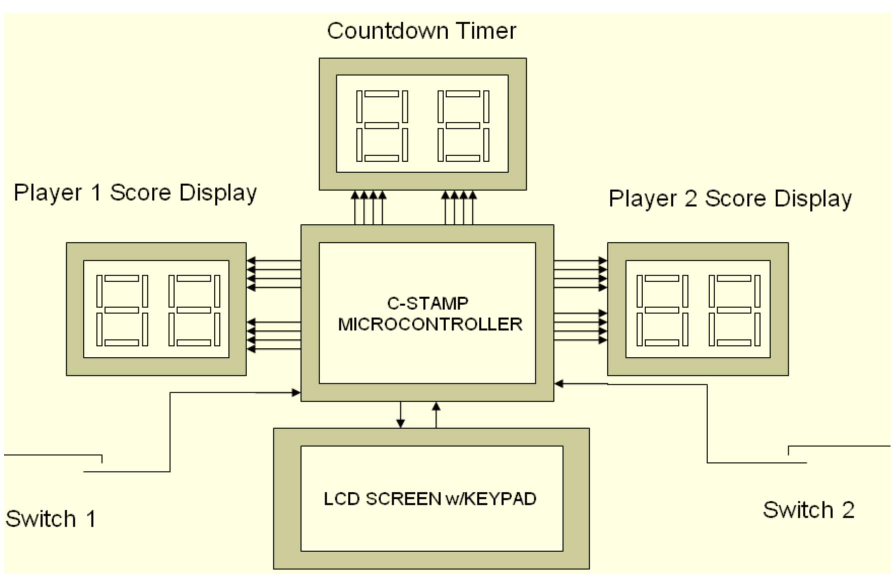

Figure 7 Design Block Diagram

This project contains the hardware and the software design. The key components of each design are listed below.

Software Design:

- Basket Selection Prompt: Prompts user to enter the number of baskets to be used by the scoreboard (1 or 2).
- Basket Mode: Keeps track of made baskets and creates a record of the highest score.
- Basket Mode: Keeps track of made baskets and indicates which basket had the most made shots.
- Continue/Exit Prompt: Prompts user to start another session or exit.

Hardware Design:

- Beam Break Detection: Each basket has an attached IR LED that provides a beam across the basketball rim.
- Microcontroller: Performs specific functions for each basket mode.
- Score Displays: Provides the current number of made baskets.

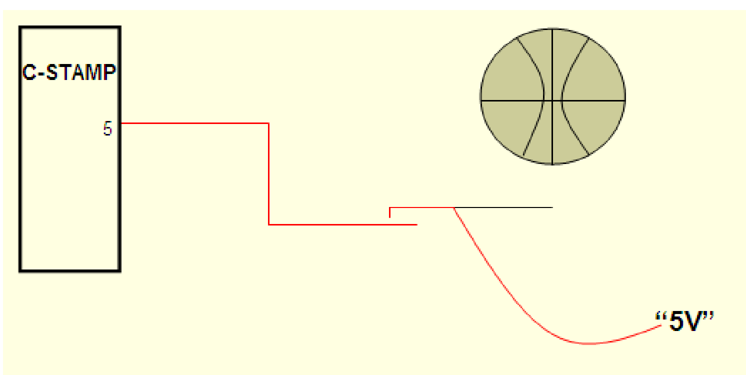

Figure 8 Illustration of detection of scoring

Figure 8 shows the principle behind the "Beam Break Detection".   5 volt power supply is applied to the switch and the switch makes contact with the metal plate. The metal plate is connected to C-Stamp. When the basketball falls through the hoop, the level will be lifted and the 5V won't be connected to I/O port of the PIC microcontroller.

The keyboard and LCD display are used to interface with the people who play it. The following picture shows a final end project.

Figure 9 End product of “Arcade Scoring System”

In both projects, the students had good experiences in the design of the system using C Stamp microcontroller. With the library and interfaces provided by the C Stamp, the students had little difficulty in programming and designing the software. This integrated design experience will be very valuable when they go to work in the industry.

Bibliography

[1] Muhammad Mzidi, Rolin McKinlay and Danny Causey, “PIC Microcontroller and Embedded Systems, Using Assembly and C for PIC18”, Pearson Prentice Hall Publishing Company, 2008.

[2] http://www.microchip.com

[3] http://www.microdigitaled.com

[4] http://www.a-wit.com

[5] Orlando Hernande, “Microcomputer Based Electronics: Using the C Stamp in the Pre-Engineering, Technology, and Engineering Programs”, Proceedings of the 2006 Mid-Atlantic Section Conference of the American Society for Engineering Education