Microcomputer Based Electronics: Using the C Stamp™ in Pre-Engineering, Technology, and Engineering Programs

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ABSTRACT

This paper describes the usage of a microcomputer platform that can serve both recruitment and retention purposes. This platform can be deployed in both secondary and higher education, including technology programs, to address the chasm that exists in educational tools usage in those two educational environments. The paper concentrates in describing how to conduct and develop electronics projects with the C Stamp™ microcomputer module.

Keywords: C Language, Engineering Education, Microcomputers, Microcontrollers, Pre-Engineering Education

1. INTRODUCTION

In recent years, the issue of retention in Engineering Education programs has taken a forefront position relative to the issue of recruitment. Many efforts are under way to try to improve engineering education retention through programming as a form of collaborative learning. This paper describes the usage of a microcomputer platform that can serve both recruitment and retention purposes. This platform can be deployed in both secondary and higher education, including technology programs, to address the chasm that exists in educational tools usage in those two educational environments. The paper concentrates in describing how to conduct and develop electronics projects with the C Stamp™ microcomputer module. C Stamp modules are very affordable and capable microcomputers (self contained single chip computers) that are designed for use in a wide variety of projects. The paper presents hardware aspects of the C Stamp, as well as programming, various input/output techniques, and functional commands available to make project development and student experience most rewarding; all with professional tools, and with a focus on Digital Control, Signal Processing, and Mechatronic applications.

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 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.

The Electrical Engineering Program at the Milwaukee School of Engineering (MSOE) has implemented a new introductory electrical engineering (EE) course in the first quarter of the freshman year. Student retention is the primary motivation, and the special manner in which the course is team-taught helps to ensure the desired student satisfaction. Initial feedback has shown that the students are excited to experience the breadth and flexibility of EE by understanding how familiar, everyday electronic items work. A pass/fail type grading system lessens student first-term stress, while encouraging participation and no-risk experimentation.

Examination of the "cone of learning" shows an increase in retention when students are actively engaged in the learning process. Mechatronics is loosely defined as the application of mechanical engineering, electrical

engineering, and computer intelligence to the design of products or systems. The mechatronics course at Bucknell consists of mechanical and electrical engineering students at the senior and graduate levels. The students engage in a variety of activities in teams comprised of members from each of these groups. In addition to team laboratory exercises and homework assignments, the students work in interdisciplinary groups to process their efforts. That is, they engage in meaningful discussion among themselves concerning their activities and the implications of the various results. The students also act as teachers by preparing lectures and exercises on topics from their discipline to the students in the cross discipline. Specifically, the electrical engineers teach the mechanical engineers microcontrollers, and the mechanical engineers teach the electrical engineers mechanisms.

2. THE C STAMP

The table below, Table 1, provides the specifications of the CS110000 C Stamp module.

Table 1: C Stamp Module Specifications

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™, I2C Master and Slave
PARALLEL SLAVE PORT	8 bits
ANALOG TO DIGITAL CONVERSION	12 channels (10 bits) single ended
ANALOG COMPARATORS	2

All C Stamp models come in Industrial-rated versions, with an environmental temperature tolerance range of -40°C to +85°C.

The figure below, Figure 1, shows how the pins of the CS110000 C Stamp module are numbered.

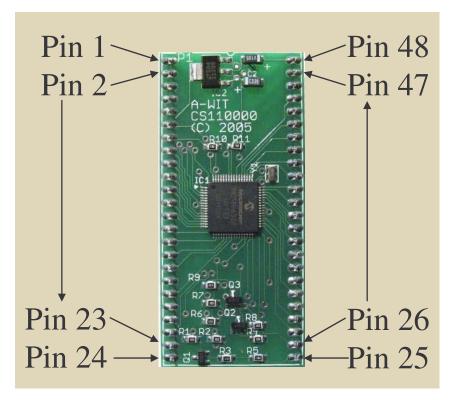**Figure 1: C Stamp Microcontroller**

3. BOARD OF LEARNING

The C Stamp is complemented by the CS310X00 (µC 101) Microcontroller Fundamentals Board of Learning (BOL). 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. The list below provides the specifications of the CS310X00 BOL.

- 2.0 mm center-positive plug that accepts different outer diameters for 5 to 24 V DC power supplies and 9 V battery connections; electronically interlocked to prevent dual connections, while both the power supply and battery can be present on the board at the same time. With the BOL having the breadboard toward you, if the switch is to the left, then the battery will be supplying the power. If the switch is to the right, then the external power supply will be supplying power.

- Independent 1 A high current power (VHC) generated on board for servos or other components that require more current than what the C Stamp can provide in large projects.

- No jumpers required for configuration.

- Serial (DB-9) connector for C Stamp IC programming and serial communication during runtime.

- C Stamp I/O pins, VIN, VHC, and GND connections brought adjacent to spacious full size 6.50" x 2.14" breadboard area.

- Female 10-pin dual row connector for additional connections.

- Four servo connectors pre-connected to VHC, GND, and C Stamp I/O pins for control.

- RESET button with high tactile feedback.

- START button with high tactile feedback. START button can be used as a utility button during run time.

- Additional utility button with high tactile feedback.

- Eight utility green, high intensity, general purpose Light Emitting Diodes (LEDs).

- C Stamp power indicator LED.

- Mechanical Dimensions:

  o PCB: 7.50" x 5.28"

  o MOUNTING HOLES: 7.00" x 4.78"

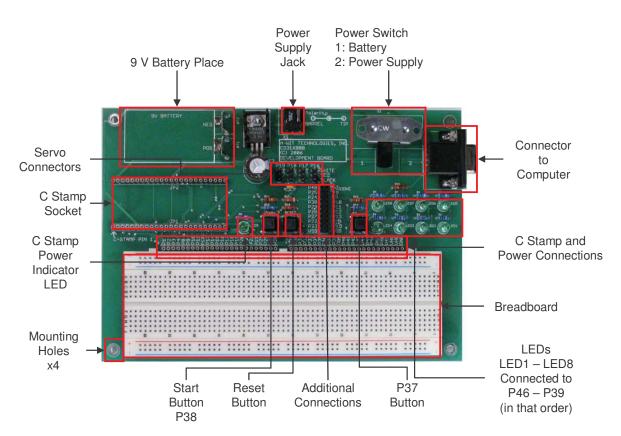The figure below, Figure 2, shows the CS310X00 BOL with all features highlighted.

Figure 2: Microcontroller Fundamentals Board of Learning

4. PROJECTS

Developing programs and projects with the C Stamp is easy. Simply input the WC program into the professional Integrated Development Environment (IDE), and compile into a HEX file. Then use the programming software to download the program to the C Stamp. The program can then be executed in the C Stamp anywhere. Figure 3 below shows the program development flow with the C Stamp.
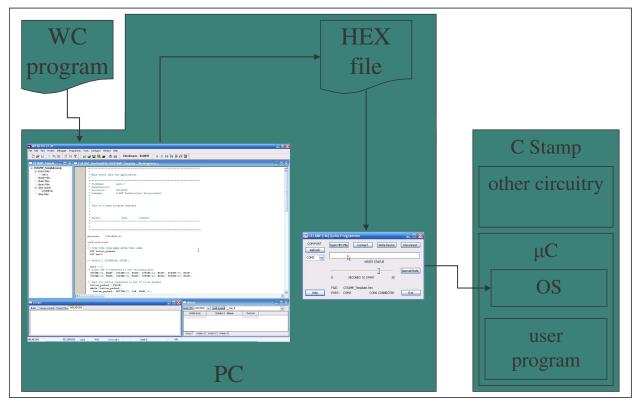

Figure 3: Program Development Flow

The following is an example of how programs written for the C Stamp look. It can be seen that students gain experience in C via WC program, while working with a software infrastructure that is very user friendly. This program starts by lighting all 8 LEDs in the BOL, and waits for the utility button at pin 37 to be pushed and let go (cycled). When this is done, then the program blinks 4 of the 8 LEDs in the BOL. Any time the utility button is cycled, the program switches to blinking the other four LEDs alternating the blinking of the LEDs between each bank of 4 LEDs. The program executes indefinitely until it is restarted it by pushing the RESET button while holding the START button and then letting go of the latter. In the code below, the keywords of the language have been bolded.

```
void main (void){
  BIT button_pushed, half; // Declare some necessary variables
  half = 0; // Denotes which half (4 LEDs) of the 8 LEDs blinks
// Light LED's connected to the following pins
  STPIND(46, 1); STPIND(45, 1); STPIND(44, 1); STPIND(43, 1);
  STPIND(42, 1); STPIND(41, 1); STPIND(40, 1); STPIND(39, 1);
// Wait for button connected to pin 38 to be pushed
  button_pushed = FALSE;
  while(!button_pushed){
    button_pushed = BUTTON(38, LOW, HIGH, 1);
  }
```

```
      button_pushed = FALSE;
      while(1){ // Check if button is pushed every second
        button_pushed = BUTTON(38, LOW, HIGH, 1);
        if (button_pushed){
          button_pushed = FALSE;
          if (half == 0) half = 1;
          else half = 0;
        }
// Set one half of the LEDs to LOW, and toggle the other
        if (half == 0){
          STPIND(42, 0); STPIND(41, 0); STPIND(40, 0); STPIND(39, 0);
          TOGGLE(46); TOGGLE(45); TOGGLE(44); TOGGLE(43);
        }else{
// Set the other half of the LEDs to LOW, and toggle the other
          STPIND(46, 0); STPIND(45, 0); STPIND(44, 0); STPIND(43, 0);
          TOGGLE(42); TOGGLE(41); TOGGLE(40); TOGGLE(39);
        }
      }
    }
```

5. CONCLUSION

This paper describes a comprehensive C based platform used in the Freshman Engineering Design Experience at TCNJ. With this platform, students receive a solid foundation in micro-controller based design. The goal is to provide student with powerful learning experiences that they can easily transfer to a future workplace.

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