

Volume

1

A-WIT TECHNOLOGIES INC.

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... a passion for execution ...

# C Stamp Syntax and Reference Guide Manual

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Version 1.8

A-WIT TECHNOLOGIES INC.

# C Stamp Syntax and Reference Manual

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Phone (800) 985-AWIT • Fax (800) 985-2948

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# Table of Contents

|  |    |                                       |    |
|--|----|---------------------------------------|----|
| Acknowledgements                           | 1  | Event Handling with Interrupts        | 38 |
| Registering Your C Stamp or C Stamp        |    | C Stamp Interrupts Infrastructure     | 39 |
| Related Product                            | 1  | Event Handling Examples               | 42 |
| Introduction to the C Stamp                | 1  | WC Program Structure                  | 48 |
| Notices                                    | 11 | Program Comments                      | 49 |
| Getting Support                            | 12 | Defining and Using Variables          | 49 |
| Installing the Microchip MPLAB and C       |    | Predefined Values                     | 50 |
| Compiler Software                          | 12 | Rules of Variable Names               | 51 |
| Installing the A-WIT C Stamp Quick         |    | Defining Arrays                       | 51 |
| Programmer                                 | 12 | Constants and Number Representations  | 52 |
| Installing the USB Software                | 12 | Taking Advantage of the Large C Stamp |    |
| Setting Up the C Stamp Software            |    | RAM                                   | 53 |
| Templates                                  | 13 | Taking Advantage of the Large C Stamp |    |
| Documentation                              | 13 | Program Memory                        | 54 |
| Creating your First C Stamp Program        | 14 | Functions                             | 55 |
| Assembling Your C Stamp Prototyping        |    | Prototypes                            | 56 |
| Circuit                                    | 17 | The Scope and Lifetime of Variables   | 56 |
| Downloading and Running Your Program       | 21 | Math and Operators                    | 56 |
| Bypassing the START/RESET Sequence         | 22 | Relational and Logical Operators      | 58 |
| Developing Your Own Programs and           |    | The Bitwise Operators                 | 59 |
| Projects                                   | 22 | Assignment Operator                   | 59 |
| Exploring the Data EEPROM in the MPLAB     |    | Operator Precedence Summary           | 59 |
| IDE  | 23 | break                                 | 60 |
| Breakpoints                                | 24 | case                                  | 61 |
| Timing – Stop Watch                        | 25 | continue                              | 61 |
| Logic Analyzer                             | 31 | default                               | 61 |
| Memory Usage Gauge                         | 34 | do                                    | 61 |
| Introduction to Event Handling             | 36 | else                                  | 62 |
| Event Handling with a Task Wheel           | 37 | for                                   | 62 |
| Event Handling with a Finite State Machine | 37 | if                                    | 62 |

|           |     |                    |     |
|-----------|-----|--------------------|-----|
| return    | 63  | PULSOUT            | 105 |
| switch    | 63  | PWM                | 105 |
| void      | 64  | rand               | 106 |
| while     | 64  | READ               | 107 |
| #include  | 65  | REV                | 108 |
| abs       | 65  | SATH               | 109 |
| ANALOGIN  | 66  | SATL               | 110 |
| ANALOGOUT | 70  | SERIN              | 111 |
| atoW      | 71  | SEROUT             | 114 |
| BUTTON    | 71  | SERIN2             | 117 |
| BYTEIN    | 73  | SEROUT2            | 119 |
| BYTEOUT   | 73  | SHIFTIN            | 121 |
| CLPINPU   | 74  | SHIFTOUT           | 123 |
| COMPARE   | 74  | SHIFTOUT2          | 124 |
| COUNT     | 76  | SLEEP              | 125 |
| COUNT2    | 77  | SPIIN              | 125 |
| DCD       | 77  | SPIOUT             | 126 |
| DTMFOUT   | 78  | sprintf            | 127 |
| END       | 80  | srand              | 129 |
| FLOOKDOWN | 81  | STOP               | 129 |
| FLOOKUP   | 83  | STPIND             | 130 |
| FREQOUT   | 84  | STPINPU            | 130 |
| GTPIND    | 86  | TOGGLE             | 130 |
| HYP       | 87  | WCatan2            | 131 |
| I2CIN     | 88  | WCcos              | 132 |
| I2COUT    | 89  | WCfabs             | 135 |
| INTSET    | 90  | WCftoa             | 135 |
| INTSOURCE | 91  | WCsin              | 135 |
| LOOKDOWN  | 91  | WCsqrt             | 137 |
| LOOKUP    | 93  | WRITE              | 138 |
| NAP       | 94  | Wtoa               | 139 |
| NCD       | 95  | LDCMD_CS410000     | 140 |
| PARINA    | 96  | LCDIN_CS410000     | 143 |
| PAROUTA   | 99  | LCDOUT_CS410000    | 143 |
| PAUSE     | 101 | COMPASSIN_CS420000 | 144 |
| PAUSEUS   | 102 | EXREAD_CS450000    | 145 |
| PULSIN    | 103 | EXWRITE_CS450000   | 145 |
| PULSIN2   | 104 | TEMPSIN_CS452000   | 145 |

---

|                      |     |
|----------------------|-----|
| TEMPSST_CS452000     | 146 |
| DPOTSET_CS458000     | 147 |
| RADIOCMD_CS470000    | 148 |
| RADIOIN_CS470000     | 151 |
| RADIOOUT_CS470000    | 152 |
| BLUECMD_CS47100X     | 153 |
| BLUEIN_CS47100X      | 161 |
| BLUEOUT_CS47100X     | 162 |
| HUMSIN_CS490000      | 163 |
| Terms and Conditions | 165 |

# Introduction to the C Stamp

Welcome to the world of the C Stamp™ microcontroller module. C Stamp modules are microcontrollers (self contained single chip computers) that are designed for use in a wide variety of applications. Projects that form an embedded system, meaning that they have some level of intelligence derived from hardware-software interaction, can use a C Stamp module as the controller.

## Acknowledgements

A-WIT Technologies would like to thank and recognize Mr. Keith Kitowski, “Tinkerer Extraordinaire”, for a very thorough review of this manual.

## Registering Your C Stamp or C Stamp Related Product

At A-WIT Technologies we respect your privacy; however, we do ask you to register your C Stamp or C Stamp related product, so you can receive free of charge product updates. The registration procedure is simple. Just send an e-mail to [tech\\_support@awit.com](mailto:tech_support@awit.com) with the word “REGISTRATION x” in the subject line, where “x” is the product number that you purchased. If you purchased more than one product, send an e-mail for each different product.

## Introduction to the C Stamp

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, and analog functions. The C stamp is complemented by a set of library function commands for math, pin operations, and much more. C Stamp modules are capable of running many thousands of 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. This manual includes an extensive section devoted to each of the available functions. The table below provides the specifications of the CS110000 C Stamp module.

| <i><b>Features/Attributes</b></i> |   |
|-----------------------------------|---|
| PACKAGE                           | 48-pin DIP                                  |
| PACKAGE SIZE (L x W x H)          | 2.4" x 1.1" x 0.4"                          |
| PINS ATTACHMENT METHODOLOGY       | Through Hole<br>Strong<br>Will not fall off |
| 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   | MPLAB IDE (v7.22 and up)                    |

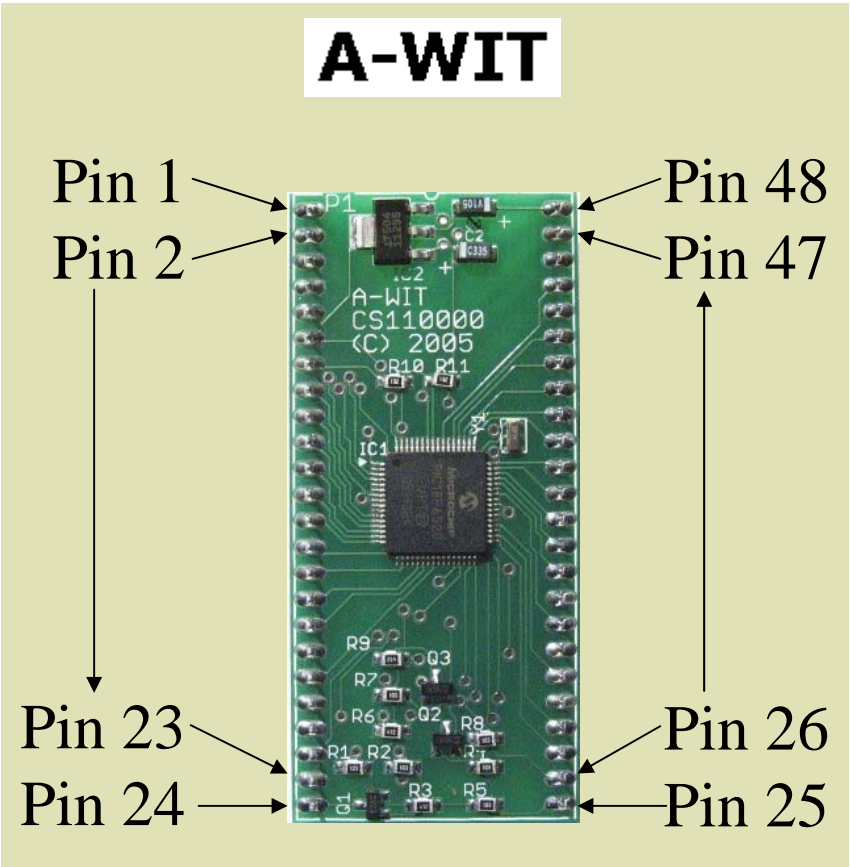
| <i>Features/Attributes</i>     |  |
|--------------------------------|--|
| ENVIRONMENT                    |  |
| EEPROM (DATA) SIZE             | 1K Byte  |
| INTERRUPTS                     | 8  |
| DIGITAL TO ANALOG CONVERTERS   | 2 channels (10 bits)<br>single ended           |
| OTHER COMMUNICATION INTERFACES | 3-wire SPI™, I <sup>2</sup> C Master and Slave |
| PARALLEL SLAVE PORT            | 8 bits   |
| ANALOG TO DIGITAL CONVERSION   | 12 channels (10 bits)<br>single ended          |
| ANALOG COMPARATORS             | 2  |

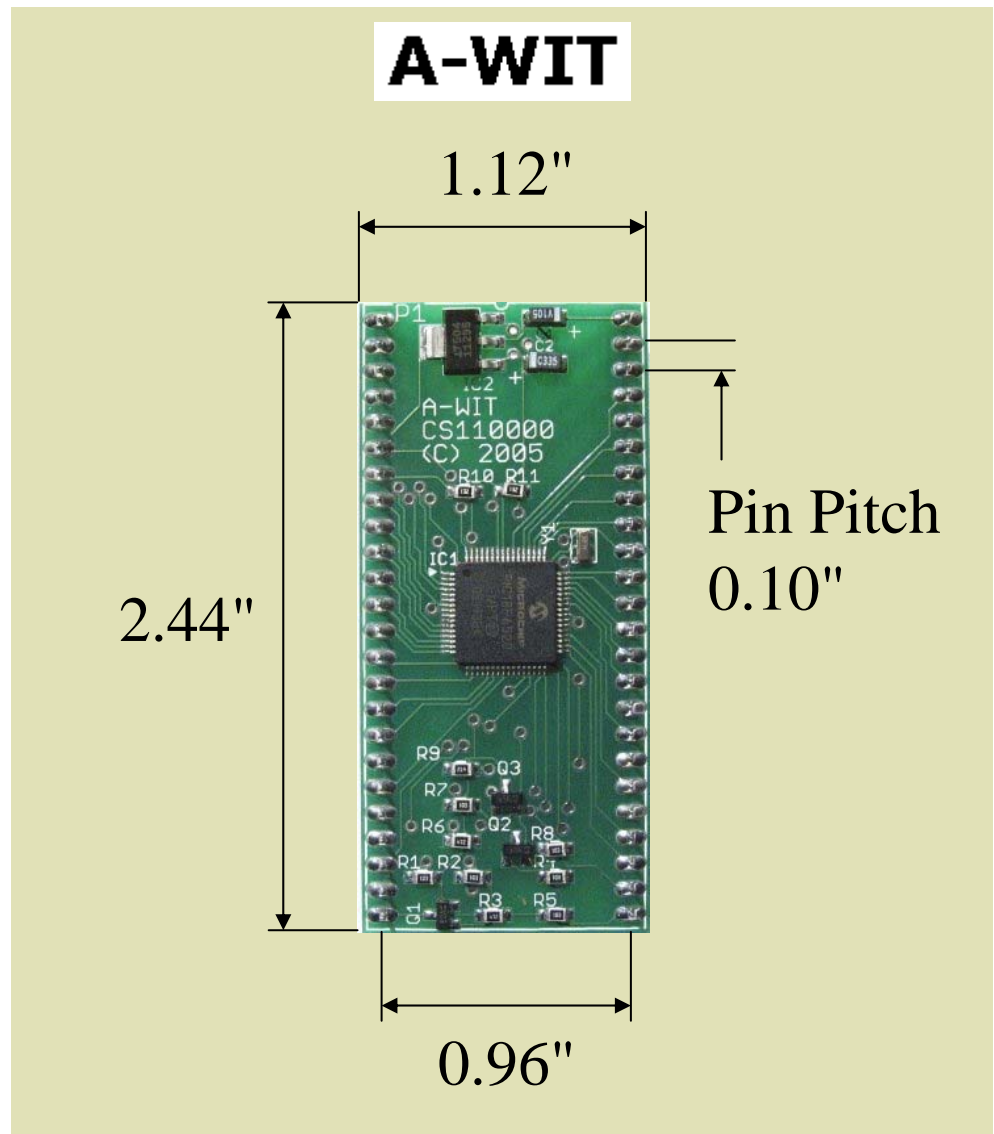
All C Stamp models come in Industrial-rated versions, with an environmental temperature tolerance range of -40°C to +85°C.

NOTE: UNDER NO CIRCUMSTANCES SHOULD THE TOTAL CURRENT SUPPLIED BY ALL THE PINS OF THE CS110000 C STAMP MODULE BE GREATER THAN 200 mA.



The figures below shows how the pins of the CS110000 C Stamp module are numbered and the dimensions associated with the C Stamp. The table after that provides the CS110000 C Stamp module Pin Descriptions.





| <i>Pin #</i> | <i>Name</i>                                   | <i>Type</i> | <i>Buffer</i> | <i>Description</i>                                 |
|--------------|---|-------------|---------------|--|
| 1            | RE1/WR <sub>n</sub><br>RE1<br>WR <sub>n</sub> | I/O<br>I    | ST<br>TTL     | Digital I/O Port E, bit 1<br>Write control for PSP |
| 2            | RE0/RD <sub>n</sub><br>RE0<br>RD <sub>n</sub> | I/O<br>I    | ST<br>TTL     | Digital I/O Port E, bit 0<br>Read control for PSP  |
| 3            | RG0/CCP3<br>RG0<br>CCP3                       | I/O<br>I/O  | ST<br>ST      | Digital I/O Port G, bit 0<br>Capture3 input /      |

| <i>Pin #</i> | <i>Name</i>                                     | <i>Type</i>        | <i>Buffer</i>                    | <i>Description</i>   |
|--------------|---|--------------------|----------------------------------|--|
|              |   |                    |                                  | Compare3 output / PWM3 output  |
| 4            | RG1   | I/O                | ST                               | Digital I/O Port G, bit 1  |
| 5            | MCLRn   | I                  | ST                               | Dedicated Master Clear (Reset) input   |
| 6            | VSS   | P                  |                                  | Ground reference   |
| 7            | VDD   | P                  |                                  | Positive supply  |
| 8            | RF7/SSn<br>RF7<br>SSn                           | I/O<br>I           | ST<br>TTL                        | Digital I/O Port F, bit 7<br>SPI slave select input  |
| 9            | RF6/AN11<br>RF6<br>AN11<br>C1INM                | I/O<br>I<br>I      | ST<br>Analog<br>Analog           | Digital I/O Port F, bit 6<br>Analog input 11<br>Comparator 1 input -                             |
| 10           | RF5/AN10/OVREF<br>RF5<br>AN10<br>C1INP<br>OVREF | I/O<br>I<br>I<br>O | ST<br>Analog<br>Analog<br>Analog | Digital I/O Port F, bit 5<br>Analog input 10<br>Comparator 1 input +<br>Voltage reference output |
| 11           | RF4/AN9<br>RF4<br>AN9<br>C2INM                  | I/O<br>I<br>I      | ST<br>Analog<br>Analog           | Digital I/O Port F, bit 4<br>Analog input 9<br>Comparator 2 input -                              |
| 12           | RF3/AN8<br>RF3<br>AN8<br>C2INP                  | I/O<br>I<br>I      | ST<br>Analog<br>Analog           | Digital I/O Port F, bit 3<br>Analog input 8<br>Comparator 2 input +                              |
| 13           | RF2/AN7/C1OUT<br>RF2<br>AN7<br>C1OUT            | I/O<br>I<br>O      | ST<br>Analog                     | Digital I/O Port F, bit 2<br>Analog input 7<br>Comparator 1 output                               |
| 14           | RF1/AN6/C2OUT<br>RF1<br>AN6<br>C2OUT            | I/O<br>I<br>O      | ST<br>Analog                     | Digital I/O Port F, bit 1<br>Analog input 6<br>Comparator 2 output                               |
| 15           | RF0/AN5<br>RF0<br>AN5                           | I/O<br>I           | ST<br>Analog                     | Digital I/O Port F, bit 0<br>Analog input 5  |
| 16           | RA3/AN3/VREFP<br>RA3<br>AN3<br>VREFP            | I/O<br>I<br>I      | TTL<br>Analog<br>Analog          | Digital I/O Port A, bit 3<br>Analog input 3<br>A/D reference voltage (High) input                |

| <i>Pin #</i> | <i>Name</i>                          | <i>Type</i>           | <i>Buffer</i>           | <i>Description</i>   |
|--------------|--------------------------------------|-----------------------|-------------------------|--|
| 17           | RA2/AN2/VREFM<br>RA2<br>AN2<br>VREFM | I/O<br>I<br>I         | TTL<br>Analog<br>Analog | Digital I/O Port A, bit 2<br>Analog input 2<br>A/D reference voltage<br>(Low) input  |
| 18           | RA1/AN1<br>RA1<br>AN1                | I/O<br>I              | TTL<br>Analog           | Digital I/O Port A, bit 1<br>Analog input 1  |
| 19           | RA0/AN0<br>RA0<br>AN0                | I/O<br>I              | TTL<br>Analog           | Digital I/O Port A, bit 0<br>Analog input 0  |
| 20           | RA5/AN4<br>RA5<br>AN4                | I/O<br>I              | TTL<br>Analog           | Digital I/O Port A, bit 5<br>Analog input 4  |
| 21           | RA4                                  | I/O                   | ST/OD                   | Digital I/O Port A, bit 4  |
| 22           | RC1                                  | I/O                   | ST                      | Digital I/O Port C, bit 1  |
| 23           | RC0                                  | I/O                   | ST                      | Digital I/O Port C, bit 0  |
| 24           | TX1                                  | O                     | ST                      | Dedicated USART<br>asynchronous transmit   |
| 25           | RX1                                  | I                     | ST                      | Dedicated USART<br>asynchronous receive  |
| 26           | ATN                                  | I                     |                         | Dedicated Serial (USART<br>asynchronous) DTR   |
| 27           | RC2/CCP1<br>RC2<br>CCP1              | I/O<br>I/O            | ST<br>ST                | Digital I/O Port C, bit 2<br>Capture1 input /<br>Compare1 output / PWM1<br>output  |
| 28           | RC3/SCK/SCL<br>RC3<br>SCK<br><br>SCL | I/O<br>I/O<br><br>I/O | ST<br>ST<br><br>ST      | Digital I/O Port C, bit 3<br>Synchronous serial clock<br>input/output for SPI mode<br>Synchronous serial clock<br>input/output for I <sup>2</sup> C mode |
| 29           | RC4/SDI/SDA<br>RC4<br>SDI<br>SDA     | I/O<br>I<br>I/O       | ST<br>ST<br>ST          | Digital I/O Port C, bit 4<br>SPI data in<br>I <sup>2</sup> C data I/O  |
| 30           | RC5/SDO<br>RC5<br>SDO                | I/O<br>O              | ST                      | Digital I/O Port C, bit 5<br>SPI data out  |
| 31           | RB7/KBI3<br>RB7                      | I/O                   | TTL                     | Digital I/O Port B, bit 7  |

| <i><b>Pin #</b></i> | <i><b>Name</b></i>      | <i><b>Type</b></i> | <i><b>Buffer</b></i> | <i><b>Description</b></i>  |
|---------------------|-------------------------|--------------------|----------------------|--|
|                     | KBI3                    | I                  | TTL                  | Interrupt-on-change pin 3<br>Built-in pull-up                              |
| 32                  | RB6/KBI2<br>RB6<br>KBI2 | I/O<br>I           | TTL<br>TTL           | Digital I/O Port B, bit 6<br>Interrupt-on-change pin 2<br>Built-in pull-up |
| 33                  | RB5/KBI1<br>RB5<br>KBI1 | I/O<br>I           | TTL<br>TTL           | Digital I/O Port B, bit 5<br>Interrupt-on-change pin 1<br>Built-in pull-up |
| 34                  | RB4/KBI0<br>RB4<br>KBI0 | I/O<br>I           | TTL<br>TTL           | Digital I/O Port B, bit 4<br>Interrupt-on-change pin 0<br>Built-in pull-up |
| 35                  | RB3/INT3<br>RB3<br>INT3 | I/O<br>I           | TTL<br>ST            | Digital I/O Port B, bit 3<br>External Interrupt 3<br>Built-in pull-up      |
| 36                  | RB2/INT2<br>RB2<br>INT2 | I/O<br>I           | TTL<br>ST            | Digital I/O Port B, bit 2<br>External Interrupt 2<br>Built-in pull-up      |
| 37                  | RB1/INT1<br>RB1<br>INT1 | I/O<br>I           | TTL<br>ST            | Digital I/O Port B, bit 1<br>External Interrupt 1<br>Built-in pull-up      |
| 38                  | RB0/INT0<br>RB0<br>INT0 | I/O<br>I           | TTL<br>ST            | Digital I/O Port B, bit 0<br>External Interrupt 0<br>Built-in pull-up      |
| 39                  | RD7/PSP7<br>RD7<br>PSP7 | I/O<br>I/O         | ST<br>TTL            | Digital I/O Port D, bit 7<br>Parallel Slave Port Data, bit 7               |
| 40                  | RD6/PSP6<br>RD6<br>PSP6 | I/O<br>I/O         | ST<br>TTL            | Digital I/O Port D, bit 6<br>Parallel Slave Port Data, bit 6               |
| 41                  | RD5/PSP5<br>RD5<br>PSP5 | I/O<br>I/O         | ST<br>TTL            | Digital I/O Port D, bit 5<br>Parallel Slave Port Data, bit 5               |
| 42                  | RD4/PSP4                |                    |                      |  |

| <i><b>Pin #</b></i> | <i><b>Name</b></i>      | <i><b>Type</b></i> | <i><b>Buffer</b></i> | <i><b>Description</b></i>                                    |
|---------------------|-------------------------|--------------------|----------------------|--|
|                     | RD4<br>PSP4             | I/O<br>I/O         | ST<br>TTL            | Digital I/O Port D, bit 4<br>Parallel Slave Port Data, bit 4 |
| 43                  | RD3/PSP3<br>RD3<br>PSP3 | I/O<br>I/O         | ST<br>TTL            | Digital I/O Port D, bit 3<br>Parallel Slave Port Data, bit 3 |
| 44                  | RD2/PSP2<br>RD2<br>PSP2 | I/O<br>I/O         | ST<br>TTL            | Digital I/O Port D, bit 2<br>Parallel Slave Port Data, bit 2 |
| 45                  | RD1/PSP1<br>RD1<br>PSP1 | I/O<br>I/O         | ST<br>TTL            | Digital I/O Port D, bit 1<br>Parallel Slave Port Data, bit 1 |
| 46                  | RD0/PSP0<br>RD0<br>PSP0 | I/O<br>I/O         | ST<br>TTL            | Digital I/O Port D, bit 0<br>Parallel Slave Port Data, bit 0 |
| 47                  | RE2/CSn<br>RE2<br>CSn   | I/O<br>I           | ST<br>TTL            | Digital I/O Port E, bit 2<br>Chip select control for PSP     |
| 48                  | VIN                     | P                  |                      | Input voltage into module                                    |

Legend: TTL = TTL compatible input

ST = Schmitt Trigger input with CMOS levels

Analog = Analog input

I = Input

O = Output

P = Power

OD = Open-Drain

For the Schmitt Trigger inputs, the hysteresis levels are 1 V and 4 V, except for pins 28 and 29. For these two pins, the hysteresis levels are 1.5 V and 3.5 V.

Pin 3 is CCP3 and Pin 27 is CCP1. There is no CCP2.

Pin 21 is an Open Drain output, so it needs an external pull-up resistor to VDD. A 10 K $\Omega$  will do.

Pin 26 (ATN) is not available to the user. It is there for future enhancements of the C Stamp programmer software.

## Getting Started

This chapter is a quick start guide to connecting the C Stamp to the PC and programming it. Without even knowing how the C Stamp functions, you should be able to complete the tutorial in this chapter and complete and run your first C Stamp program. The tutorial assumes you have a C Stamp and an appropriate connection kit or development board. You will also need a programming cable, power supply, PC running Windows® 2000/XP/Media with a quantity of RAM recommended for the OS, sufficient free hard disk drive space for the software installations, CD-ROM drive, Internet access (recommended only), and available port compatible with your programming cable.

### Notices

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DAMAGES OR OTHER LIABILITY ARISING OUT OF OR IN CONNECTION WITH THE SOFTWARE OR FIRMWARE OR THE USE OF OTHER DEALINGS IN THE SOFTWARE OR FIRMWARE.

## Getting Support

If possible, please check the C Stamp website [www.c-stamp.com](http://www.c-stamp.com) under SUPPORT for any updates to documentation, changes, or notices that may have become available since your Installation CD was produced. If you continue to have any issues for which a solution is not found in the aforementioned website, please e-mail [tech\\_support@a-wit.com](mailto:tech_support@a-wit.com) for help.

## Installing the Microchip MPLAB and C Compiler Software

The first step is to install the Microchip MPLAB software that you will use to develop your programs.

Insert your A-WIT provided Installation CD in your CD drive. Go to the MPLAB directory in the CD and double click on the “MPLAB vX.XX Install” file in that directory. Follow the installation steps, prompts, and directions provided by the installer software, accepting all the default options.

After the MPLAB installation is complete, switch to the C18 directory in the CD, and double click on the file in that directory. Follow the installation steps, prompts, and directions provided by the installer software, accepting all the default options. The only exception to accepting all the default options is that on the 6<sup>th</sup> window of the installation process for the C18 Compiler make sure to select everything. This will ensure that MPLAB is configured to use the C18 Compiler.

## Installing the A-WIT C Stamp Quick Programmer

To install the A-WIT C Stamp Quick Programmer, switch to the CSTAMPQP directory in the CD using Windows Explorer, and double click on the file in that directory. Follow the installation steps, prompts, and directions provided by the installer software, accepting all the default options.

## Installing the USB Software

If you purchased a product with a USB download cable, make sure that the A-WIT provided CD is in the CD drive of your PC and insert the USB cable in the USB port of your PC. Windows auto detects the new USB device. If Windows prompts you to

install drivers for the USB cable device, follow the installation steps, prompts, and directions provided by the installer software, accepting all the default options.

After the USB adapter has been installed, open a Windows Explorer window from the Accessories sub-menu in the Start menu, and right click on My Computer. Proceed to select Properties, and then select the Hardware tab. Click on the Device Manager button and expand the Ports (COM & LPT) branch. Make a note of the COM port that has been assigned to the USB-to-Serial adapter. This is the port that should be selected in the C Stamp programmer software.

## Setting Up the C Stamp Software Templates

To set up the C Stamp Software Templates, switch to the CSTAMP\_Template directory in the CD using Windows Explorer and double click on the file in that directory. Follow the installation steps, prompts, and directions provided by the installer software, accepting all the default options.

## Documentation

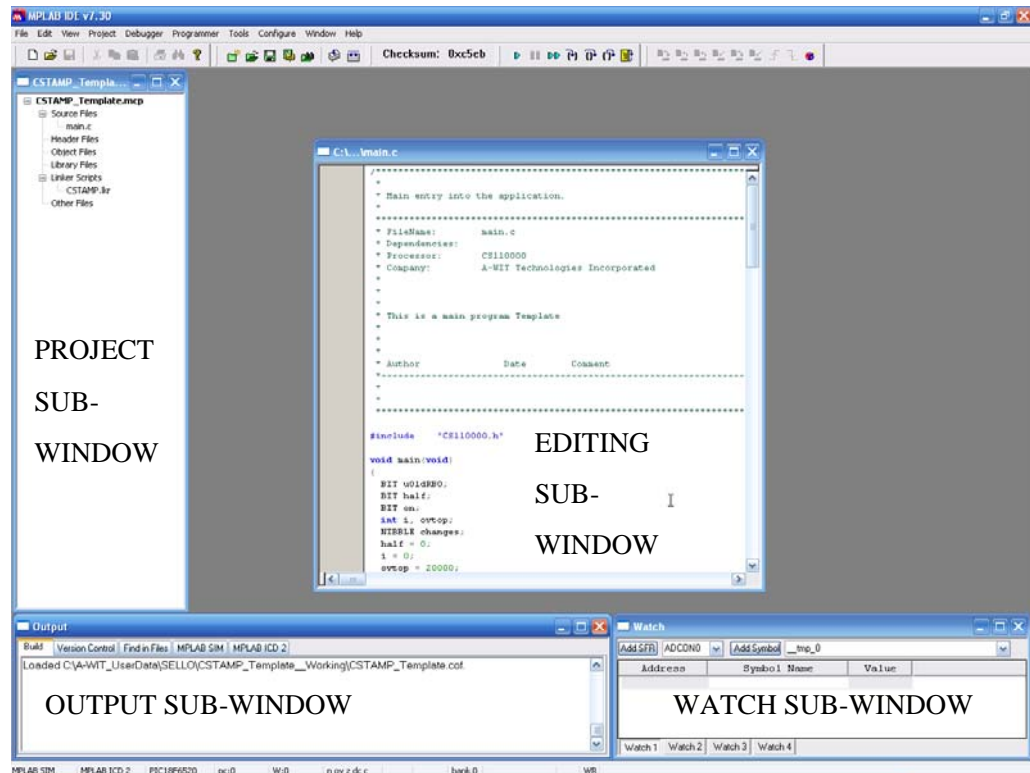
Copy the DOCS directory from the C Stamp Installation CD to your C:\A-WIT directory. This directory contains all the C Stamp related documentation in PDF format.

## Creating your First C Stamp Program

Create a directory where you want to have the files for your program; for example, FIRST\_LED\_APP. We recommend making this directory under your C:\A-WIT directory, so you can have all your CSTAMP related files in one place.

Copy all the files in your C Stamp Software Templates directory C:\A-WIT\CSTAMP\_Template to the directory you just made.

Open the Microchip MPLAB IDE application. As shown in the following figure, the IDE has several sub-windows. Depending on the resolution of your screen, your sub-windows may have a different layout. However; you can move and resize these into the position that you want to fit your screen, and your layout for that particular project will get saved upon answering yes to the prompt of saving the workspace when you exit the software development environment.



Go to the “File” menu to “Open Workspace...”. Then navigate to your program directory and open CSTAMP\_Template.mcw.

Right click on CSTAMP\_Template.mcp in the “Project” sub-window, and “Save as...” the name of your program project after you have navigated to your program

directory. For example, your program project could be named “FIRST\_LED\_APP”. Now when you open the Microchip MPLAB IDE (Integrated Development Environment) and go to your program directory to open the workspace for your program, you will see a .mws file with the name of your program preceding it. This is the file that you should open any time you want to work on your program.

Double click on the main.c source and type the following code fragment where it is indicated. You can omit the comments for brevity, as they are written here to offer clarifications of what the code does. Do pay attention, however to the indentation of the code blocks between curly brackets for loops, if statements, etc. Although indenting the code is not a requirement for the compiler to parse your code (i.e. any blank spaces are ignored by the compiler), it does help tremendously to make your code much more readable, and consequently, it makes finding any errors easier. Keywords and function names in the code fragment below are bolded.

After you START the C Stamp in user mode as explained in the “Downloading and Running Your Program” section (this will not be the RESET/BOOT/DOWNLOAD mode), the program will run. This programs starts by lighting all 8 LEDs in your KIT and waits for the utility button at pin 37 to be pushed and let go (cycled). When you do this, the program blinks 4 of the 8 LEDs in your KIT. Any time you cycle the utility button, it switches to blinking the other four LEDs alternating the blinking of the LEDs between each bank of 4 LEDs. The program executes indefinitely until you restart it by pushing and releasing the RESET button while holding the START button and then letting go of the latter.

```
// Declare some necessary variables
  BIT button_pushed;
  BIT half;

// Initialize variable
  half = 0;           // Denotes which half (4 LEDs) of the
                      // 8 LEDs blinks

// Light LED's connected to the following pins
  STPIND(46, HIGH); STPIND(45, HIGH);
  STPIND(44, HIGH); STPIND(43, HIGH);
  STPIND(42, HIGH); STPIND(41, HIGH);
  STPIND(40, HIGH); STPIND(39, HIGH);

// Wait for button connected to pin 37 to be pushed
  button_pushed = FALSE;
  while(!button_pushed){
    button_pushed = BUTTON(37, LOW, HIGH, 5);
  }
```

```

    button_pushed = FALSE;

    while(1){
    // Check if button is pushed every second
        button_pushed = BUTTON(37, LOW, HIGH, 5);
    // If button was pushed, reset the variable that keeps
    // track of that event, and switch the half of the LEDs
    // that is lit
        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);
        }
        PAUSE(250);
    }

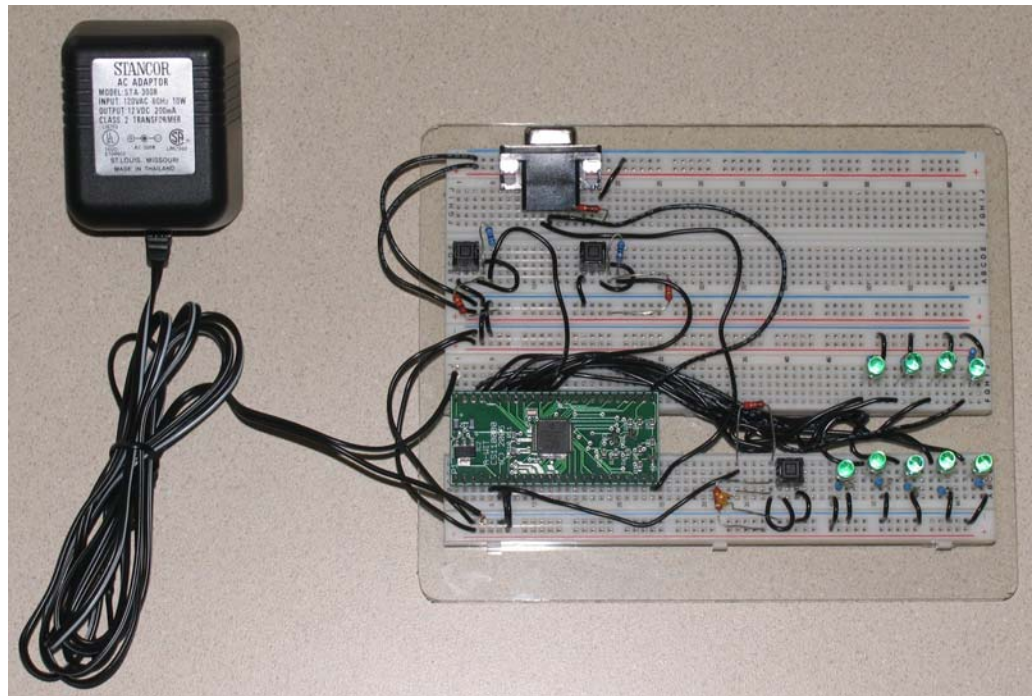
```

Save your program from the “File” menu or by clicking on the appropriate icon in the tool bar. Then “Build All” from the “Project” menu or from the tool bar.

If the code was typed correctly, you will have a file in your program directory with the name of your program project and a .HEX extension. An example is FIRST\_LED\_APP.HEX. This is the file that you will download to the C Stamp, as explained up ahead.

If you get an error message or an indication that your program did not build successfully in the “Output” sub-window of the IDE, you probably have one or more syntax errors. Double click on the line of the “Output” sub-window that mentions the error, and the program line that most likely contains the error will be indicated in the sub-window where you were editing your program. Correct as necessary and “Build All” again until you get a successful .HEX file output.





The overall goals of the prototyping kit is to allow you to download programs from the PC to the C Stamp, run demo programs, and serve as a starting platform for your own projects. The prototyping kit features a connector to the PC, power supply input, reset and start buttons, a utility button for generic inputs, and eight LED's for outputs.

In the schematic, JP1 represents the side of the C Stamp with pins 1-24, and JP2 represents the side of the C Stamp with pins 25-48. So JP2-pin1 is the C Stamp's pin 25 and JP2-pin 24 is the C Stamp's pin 48.

To build your prototyping kit, start with the special C Stamp solder-less breadboard. Notice that this breadboard has two panels; one with a separation in the middle to accommodate the C Stamp (BOTTOM), and another without it (TOP). Breadboards are simply a matrix of inserts that allow you to connect electrical circuits a simple manner with the supplied jumper wires without the need of solder. At the top and bottom of each panel there are rows of connections that are used for power. These are denoted with a solid red or blue line, and each row corresponding to a color has all its inserts connected together. The rest of the inserts are labeled in rows (A-J) and columns (1-63). For each column, each group of rows (A-E) or (F-J) are connected together inside the breadboard, and are used to connect different components by inserting terminals into the inserts of that group. If you run out of inserts in a group, then jump a connection to an unused group and keep connecting components.

These are the step-by step instructions and comments about building your prototyping kit. The first step is to connect all the blue rows together that are going to supply your ground (node GND), and all the red rows together which are going to supply your positive supply as it is output from the C Stamp pin 7 (node VDD).

Then insert your C Stamp all the way to left in the BOTTOM panel as shown in the figure. Connect pin 6 of the C Stamp to ground (blue), and pin 7 to the positive supply (red). The C Stamp is a very sophisticated piece of electronics, so try not to touch its pins, so they do not get bent or damaged.

Connect the first four output LEDs in the lower corner of the breadboard (LEDs 1-4 in the schematic). Each LED has a limiting resistor connected to ground on one side. This resistor sets the current flowing through the LED to provide enough illumination (about 15 mA). Connect the resistors vertically. If leads of components have to be trimmed, a wire cutter or a set of shears can be used. Also, as you connect components, you can push wires out of the way. Then the short lead of the LED connects to the ungrounded side of the resistor, and the other lead of the LED connects to a C Stamp pin. Connect the right most LED to pin 46 of the C Stamp, and so on, so that the left most LED is connected to pin 43 of the C Stamp. For example, to start these connections, you can connect a resistor from B-63 to B-62 in the very lower-right corner of the breadboard, then connect a wire from A-63 to the grounding terminal (the nearest blue row), then connect the short LED lead to C-62 in that region and the other LED lead in the next insert C-61, and then connect a wire from the LED to the C Stamp pin 46 by connecting a wire from E-61 in the lowest right most region to next to the C Stamp pin 46, which is insert G-3 in the breadboard (by pin 46 of the C Stamp).

Repeat the above step for LEDs 5-8 in the schematic, placing these LEDs above the previous four. Connect the right most LED to pin 42 of the C Stamp, and so on, so that the left most LED is connected to pin 39 of the C Stamp.

The next step is to connect the power indication LED. This is the fifth right most LED in the most bottom row of LEDs, and it signals that the C Stamp is generating power correctly on pin 7. Connect this LED like the others, but connect the long lead of the LED to the nearest red row or the positive supply out of the C Stamp.

Next, connect the reset push-button S1 as shown in the schematic. The provided switches have four legs, but two electrical contacts. As you look at the switch with the button up and one of the smooth sides toward you, the two legs on your right is one contact tied together inside the switch, and the other two are the other electrical contact tied together inside the switch. After assembled, the reset circuit connects to the master reset (MCLRn) input of the C Stamp at pin 5. When the button is pushed, the MCLRn is LOW, and the C Stamp is doing nothing in reset mode. When the button is depressed, the RC circuit attached to the button allows for a smooth LOW-



HIGH transition on the MCLRn pin, and the C Stamp exits reset mode, and enters active mode.

The next steps are to connect push-buttons S2 and S3, as indicated in the schematic. S2 is the START button, which will be explained later, and S3 is a utility switch that you can use for the demo program and your own projects.

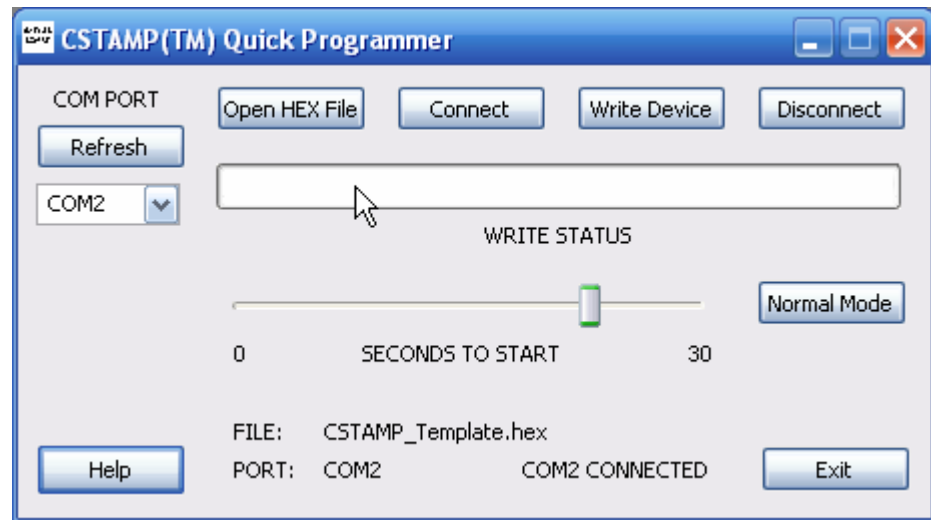
Next, connect the serial cable assembly that will connect to the breadboard, and provide a connector for the cable that will connect the breadboard to the PC. If you look at the connector in the assembly, you will see that the terminals (holes) are numbered. These are the same numbers that are used in the schematic. Our recommendation is to use the area of the breadboard above switches S2 and S3 to connect the serial assembly. Connect terminals 1-5 of the assembly to inserts H-10 through H-14, and then connect a wire from F-11 of that area to JP1-pin 24 (pin 24 of the C Stamp). Connect terminal 3 of the assembly to JP2-pin 1 (pin 25 of the C Stamp). These two pins of the C Stamp are the ones used for the serial connection to the PC. The third connection is for terminal 5 of the assembly to the ground (GND) plane through a 10 $\Omega$  resistor.

The last step in putting together the kit is to connect the power supply. The positive terminal of the power supply is the wire with the white stripe, and the negative terminal of the power supply is the one with the solid colored wire (i.e. the wire does NOT have a white stripe). Connect the positive terminal to JP-pin 24 (pin 48 of the C Stamp), and connect the negative terminal to any ground (GND) connection.

At this point your kit is ready to accept programs from the PC, and to run programs, which will be explained subsequently.

## Downloading and Running Your Program

Power up your kit, and connect the it to the PC with the provided cable. Upon power up, the C Stamp will be in RESET/BOOT/DOWNLOAD mode. To go back to this mode at any time, just push and let go of the RESET button. Then open the A-WIT C Stamp Quick Programmer application shown in the next figure.



The first step is to choose the serial port that you are using from the drop-down menu. Then click on “Refresh”, so that the program registers your selection. Your selection should show in the status area of the program next to “PORT:”. Then click on “Open HEX File” and load/select the HEX file that you had previously created during the development of your program. The status should indicate that the file has been loaded successfully. This is what will be downloaded to the C Stamp. Then click on “Connect”, and the PC will be connected to the kit, and the status area should indicate so. To download the HEX file to the C Stamp, just click on “Write Device”, and you should see the progress bar after a few seconds, as the HEX file is downloaded. At this point, you can click on “Disconnect” to disconnect the PC from the kit, disconnect the serial cable from both the PC and the kit, and start your program manually at the kit. To do this just push and let go of the RESET button while pushing the START button. Then you can let go of the START button. Alternatively, you can click on “Normal Mode” to start your program from the PC. This will also disconnect the program/PC from the kit. Then you can disconnect the serial cable from the PC and the kit. You can also instruct the CSTAMP™ Quick Programmer to wait several seconds before starting your program from the PC and disconnecting by adjusting the “SECONDS TO START” slide. This feature is useful in case you want to keep the PC connected with the serial cable, but need time to manually set up something in a circuit that you have built. If this is not the case it can just be left at the default of “0”, and your program will get started from the PC right away. After you click “Normal Mode”

and your program is started, the CSTAMP™ Quick Programmer will not be communicating with the C Stamp any longer, so if you want to reconnect, you must click on “Connect” again.

## Bypassing the START/RESET Sequence

If you want the C Stamp to bypass the START button sequence and start your program at power up or when the RESET button is pressed, the solution is simple. Tie pin 38 of the C Stamp permanently to ground through a low value resistor equal to or less than 287  $\Omega$ . Of course, this is after the C Stamp has been programmed. To program the C Stamp, pin 38 should be tied to a HIGH through the same type resistor (287  $\Omega$  or less). Although bypassing the RESET sequence costs a pin (i.e. you cannot use pin 38 for anything else in your project), the C Stamp has so many I/O pins that this should be an acceptable option.

## Developing Your Own Programs and Projects

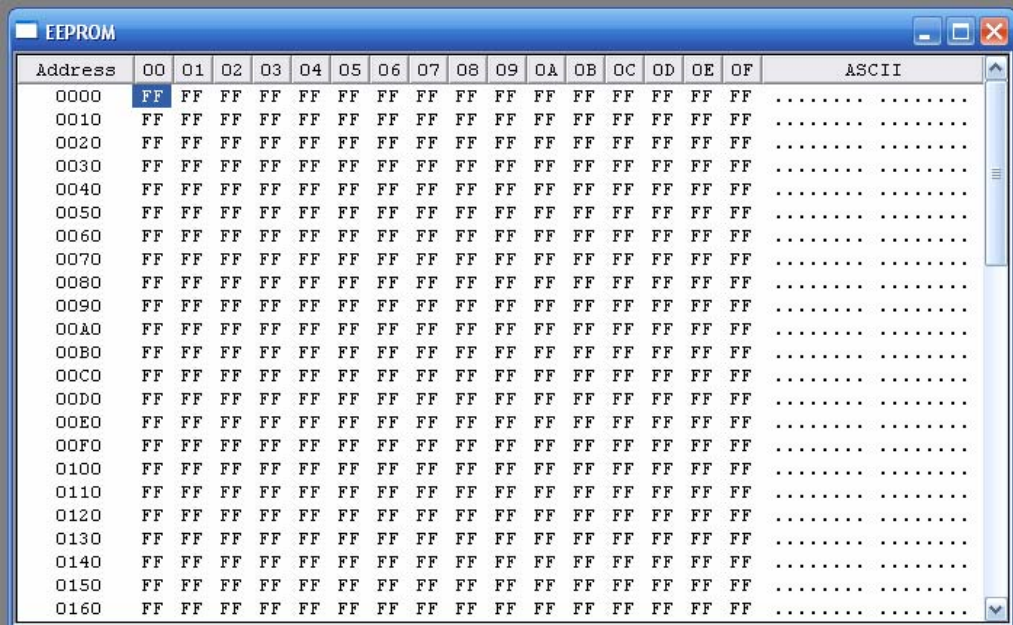
Now that you have successfully developed and run your program, it is easy to move on to more complex and elaborate projects and circuits of your own. To do this, your first step should be to thoroughly study Chapter 4 of this manual: C Stamp Language and Command Reference.

## Getting More from the Tools

This chapter addresses various techniques to get more information from the project development software tools, as well as advanced usage, and debugging with these tools. The software tools have many advanced features that will give you information about your C Stamp, and help you with the debugging of your programs. The more you get familiar with the tools, the easier project development will be. It is suggested that you explore all the menu items, and the Help facilities, and if you have any problems or questions you can always contact our support department by e-mailing at [tech\\_support@a-wit.com](mailto:tech_support@a-wit.com).

### Exploring the Data EEPROM in the MPLAB IDE

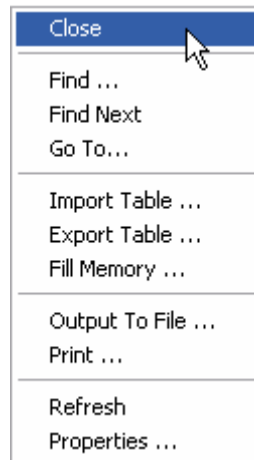
Go to the “View” menu, and click on EEPROM. This will bring up a sub-window with the contents of the EEPROM. Such window is shown below.



| Address | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 0A | 0B | 0C | 0D | 0E | 0F | ASCII |
|---------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-------|
| 0000    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0010    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0020    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0030    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0040    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0050    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0060    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0070    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0080    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0090    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 00A0    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 00B0    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 00C0    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 00D0    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 00E0    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 00F0    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0100    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0110    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0120    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0130    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0140    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0150    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |
| 0160    | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | ..... |

This sub-window presents the contents of the Data EEPROM in table format with 16 addresses in each row. The C Stamp has 1024 Data EEPROM locations of 1 BYTE each, so the Data EEPROM address locations run from 0 through 1024; or from 0000 through 03FF in hexadecimal (hex). The addresses in the “Address” column is the first address of a 16 BYTE block, but in hex format. The hex numbers in the header row of the next 16 columns (00 through 0F) are the added to the base block address in the “Address” column to form the actual address. This amounts to replacing the last digit of the base address, which is always 0, with the second digit (0 through F) of the hex numbers in the headers of the columns. This sub-window also presents each BYTE in the Data EEPROM as an ASCII character if the BYTE indeed converts to an ASCII equivalent character, which may not always be the case.

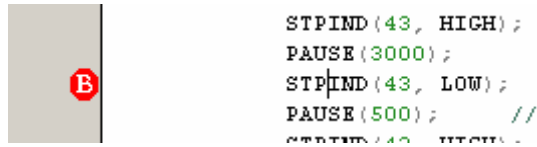
If you right-click on this sub-window, you will see a menu like the one shown below. The entries in this menu will allow you to Close the sub-window, find a specific value, go to a specific address, import and export the contents of the memory as a single column textual value format for any memory range, fill the memory with a specific value, output the complete table to as a text file or a portion of it by lines or addresses, print the table, refresh it, and change its properties. The properties that can be changed are the font and the font color for values that just changed, but this will apply to other sub-windows as well, so it recommended that these properties are NOT changed.



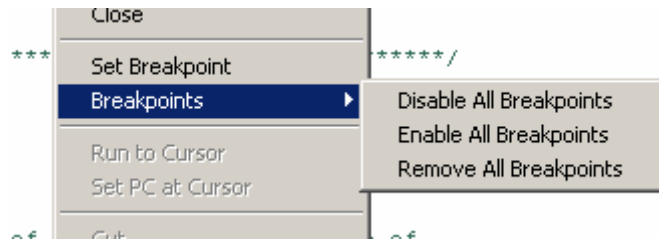
## Breakpoints

Sometimes while performing a simulation you may wish to pause the simulation at a specific line of code. To do this you must add a Breakpoint at that particular line of code. Setting a Breakpoint can be done one of several ways. One way is to simply double click on the line at which you wish to pause. When you set a Breakpoint somewhere, the simulation will pause just prior to executing this command. Once you

double click the line at which you wish to set a Breakpoint, and a red circle with a white letter “B” inside of it will appear to the left of the line of code as shown below.

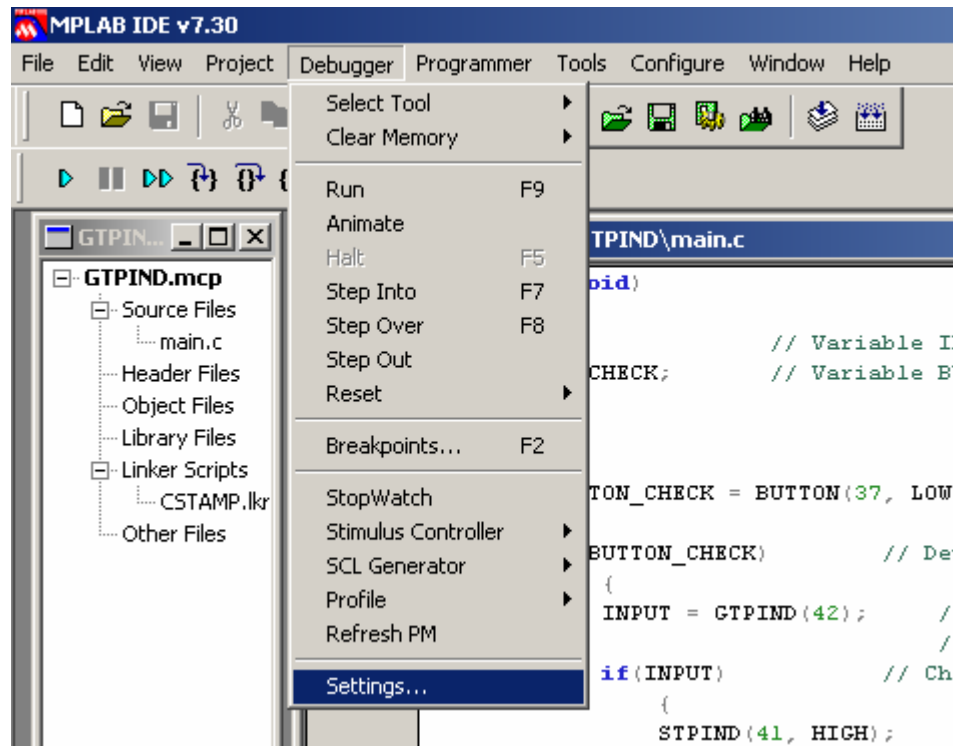


Another way to set a Breakpoint is to right click on the line of code and select the “Set Breakpoint” option in the menu that appears. The menu that appears also has a submenu titled “Breakpoints” in which you can remove all Breakpoints, temporarily disable all Breakpoints and restore all previously disabled Breakpoints. Part of this menu is shown below.

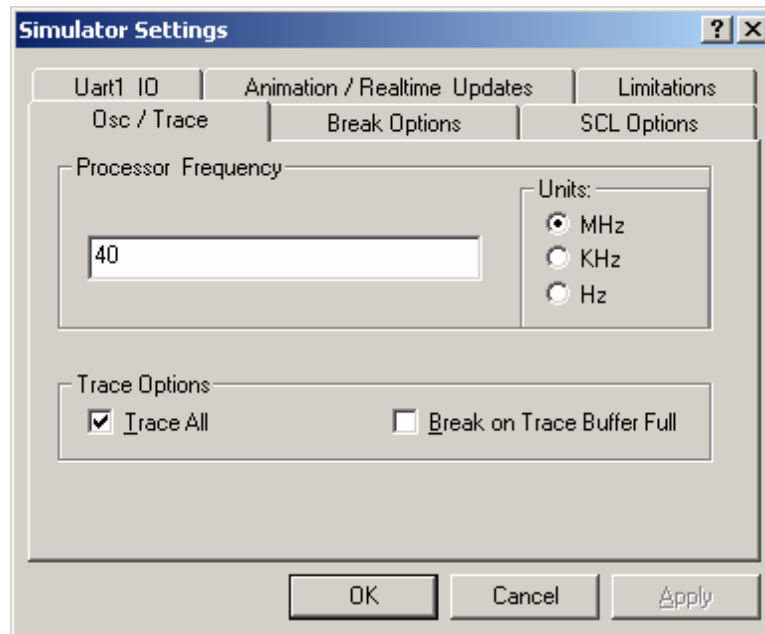


## Timing – Stop Watch

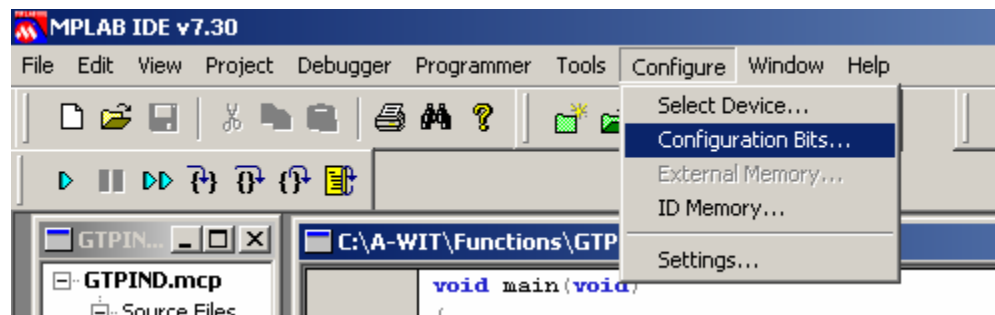
Included in the tools, there is one named the “Stop Watch”, which allows the user to determine the actual time spent executing a line or group of consecutive lines of code. The first step to utilize the Stop Watch tool is to ensure that the software development environment is properly configured to simulate the C Stamp. First select the “Debugger” menu, then under the Debugger menu select “Settings...”, as shown below.



Once you have selected Settings, a dialog window will open. Select the tab “Osc / Trace” if it is not already selected. Under “Processor Frequency”, enter the number “40”. Under “Units”, select the radial button next to “MHz”. The dialog window should look as depicted below.



After the dialog window looks as shown, press OK and continue by going to the “Configure” menu and selecting the “Configuration Bits...” option.



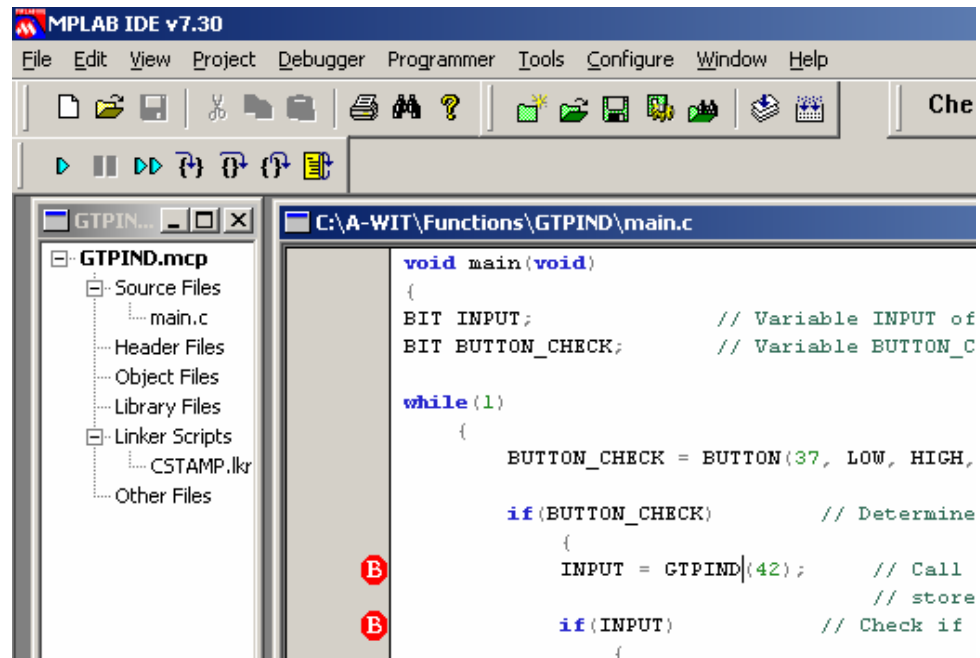
Once selected a window will appear which displays the options for the various configuration bits. To complete configuration to properly simulate the timing of the C Stamp the setting for the “Oscillator” must be “HS-PLL Enabled”. Once this selection is made as shown below, simply close the window by clicking on the “X” for the Configuration Bits window.



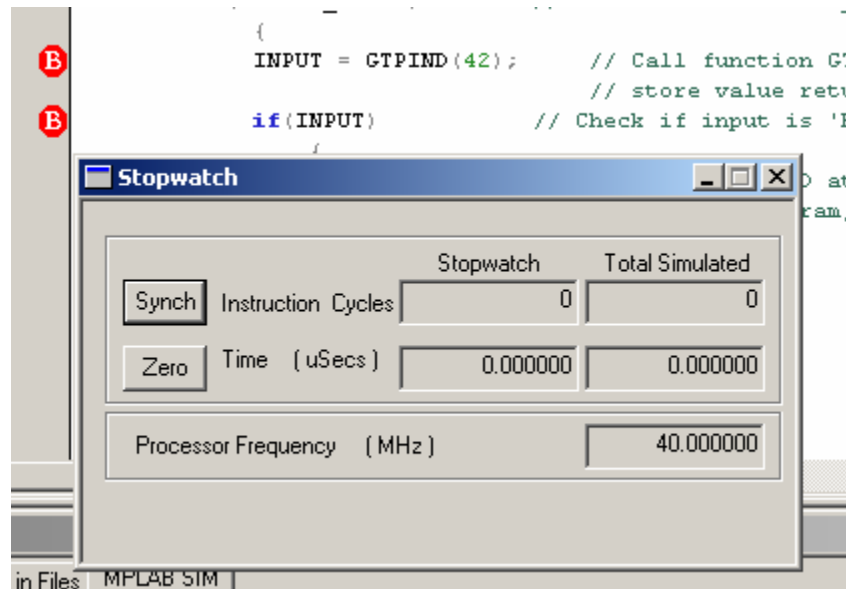
11(BUTTON CHECK) // DETERMINE IF BUTTON CHECK IS TRUE

| Address | Value | Category                 | Setting              |
|---------|-------|--------------------------|----------------------|
| 300001  | 26    | Oscillator               | HS-PLL Enabled       |
|         |       | Osc. Switch Enable       | RC-OSC2 as RA6       |
| 300002  | 0F    | Power Up Timer           | HS-PLL Enabled       |
|         |       | Brown Out Detect         | EC-OSC2 as RA6       |
|         |       | Brown Out Voltage        | EC-OSC2 as Clock Out |
| 300003  | 0F    | Watchdog Timer           | RC-OSC2 as Clock Out |
|         |       | Watchdog Postscaler      | HS                   |
| 300005  | 03    | CCP2 Mux                 | XT                   |
| 300006  | 85    | Stack Overflow Reset     | LP                   |
|         |       | Low Voltage Program      | Enabled              |
| 300008  | FF    | Code Protect 00800-01FFF | Disabled             |
|         |       | Code Protect 02000-03FFF | Disabled             |
|         |       | Code Protect 04000-05FFF | Disabled             |
|         |       | Code Protect 06000-07FFF | Disabled             |

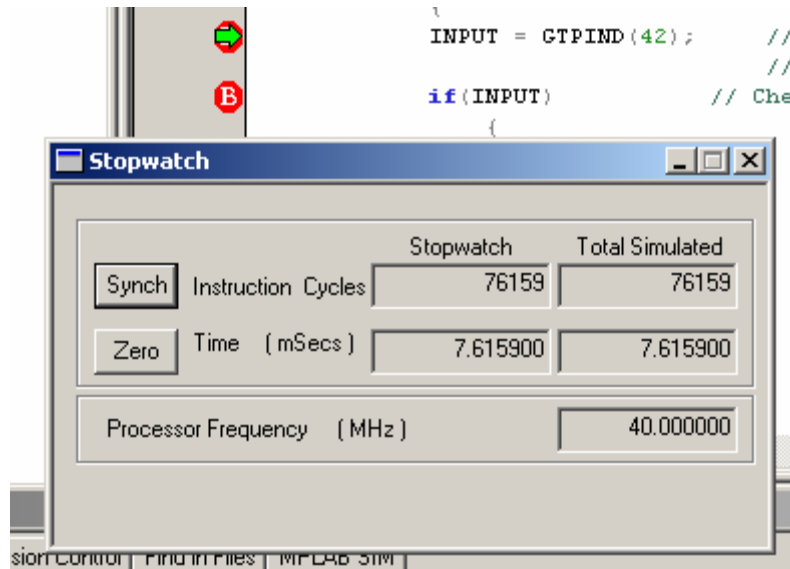
Now we are finished with the setup to simulate timing events on the C Stamp. To use the Stop Watch we must first let the tool know where to pause simulation. For our purpose we will want to pause simulation just before and just after the code we're interested in timing. In this example we want to know how long it would take for the C Stamp to read the digital value at a pin and then store that value in a variable. First, we begin by double clicking on the line of code where we call the command to read the value of the pin and store it in a variable. When we do this, to the left beyond where text can be entered, a red circle with a white "B" inscribed can be seen. Next, we will double click the line of code just below the command and another red circle with inscribed white "B" will appear to the left of that line. It is important to note that if the line immediately following the line of interest does not contain code then you cannot place a "Breakpoint" there. The simulation will not be affected by the empty line in between so in such a case simply place the Breakpoint on the next line of code.



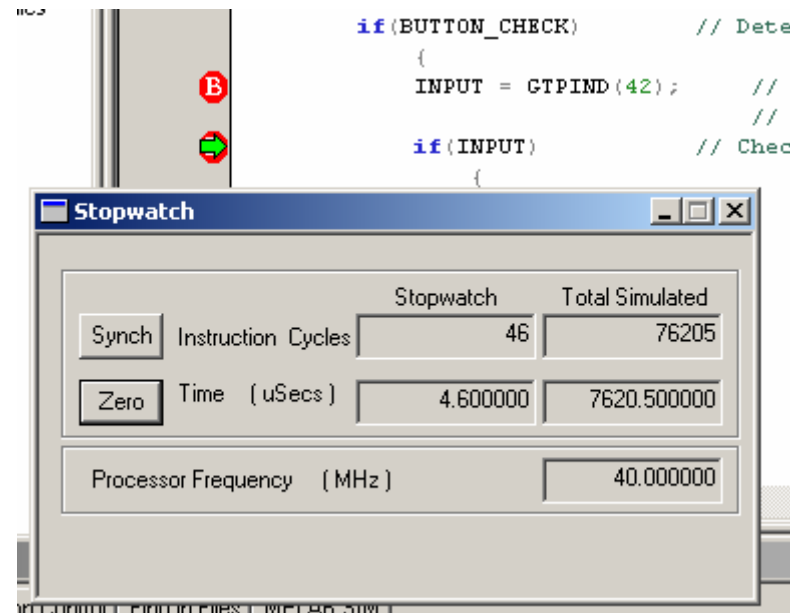
After selecting your Breakpoints select “Stop Watch” out of the Debugger menu and the Stop Watch tool window will appear. Once the window has been opened select the blue play button from the toolbar, or select the Run option in the Debugger menu, or press the F9 key.



Clicking the play button from the toolbar starts the simulation. Once the simulation reaches the first Breakpoint it will stop and a green arrow will appear over top of the Breakpoint symbol found on the left. The Stop Watch window will display the number of instruction cycles as well as real time that has passed since the beginning of the program to the first Breakpoint.



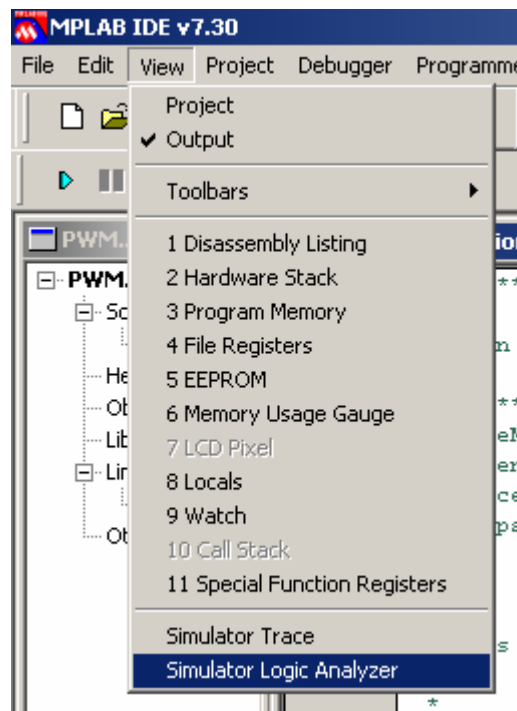
To determine how much time will pass in between the two Breakpoints click the “Zero” button on the Stop Watch tool window and hit the play button from the toolbar once more.



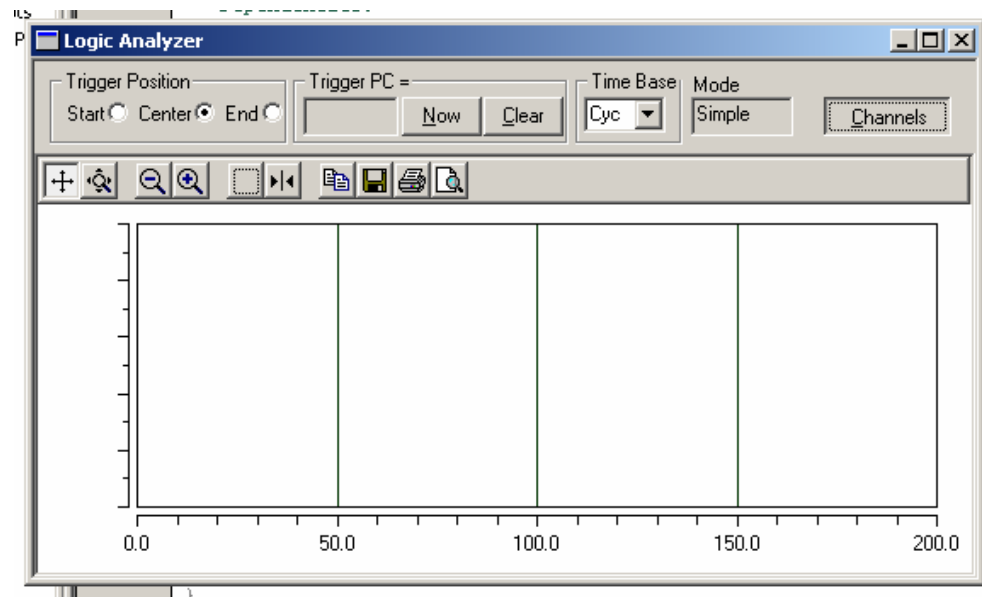
The Stop Watch tool will now show how many instruction cycles have been simulated since the last Breakpoint as well as the total amount simulated. This is also true of the real time which has passed in between Breakpoints and since the beginning of the program. In this case the Stop Watch tool shows that it would take the C Stamp 4.6  $\mu$ s to find the value of a pin and store it in a variable. While this is only a simulation and experimental data may differ, the Stop Watch tool allows for very accurate predictions of how long events will take to execute within the C Stamp.

## Logic Analyzer

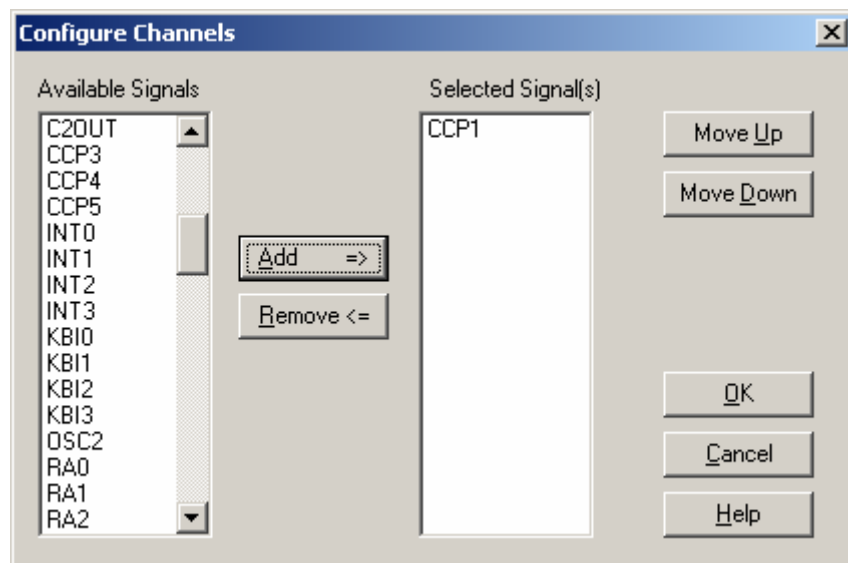
Included in the tools, there is one called the Simulator Logic Analyzer. This tool allows us to accurately simulate the waveform that will appear at a given pin over the execution of the program. To access this tool, select the “View” menu and select the option “Simulator Logic Analyzer” as shown in the picture below.



Once selected, the Simulator Logic Analyzer window will appear. To choose which pin you wish to analyze click the “Channels” button and a new dialog window will appear where you can make your selection.

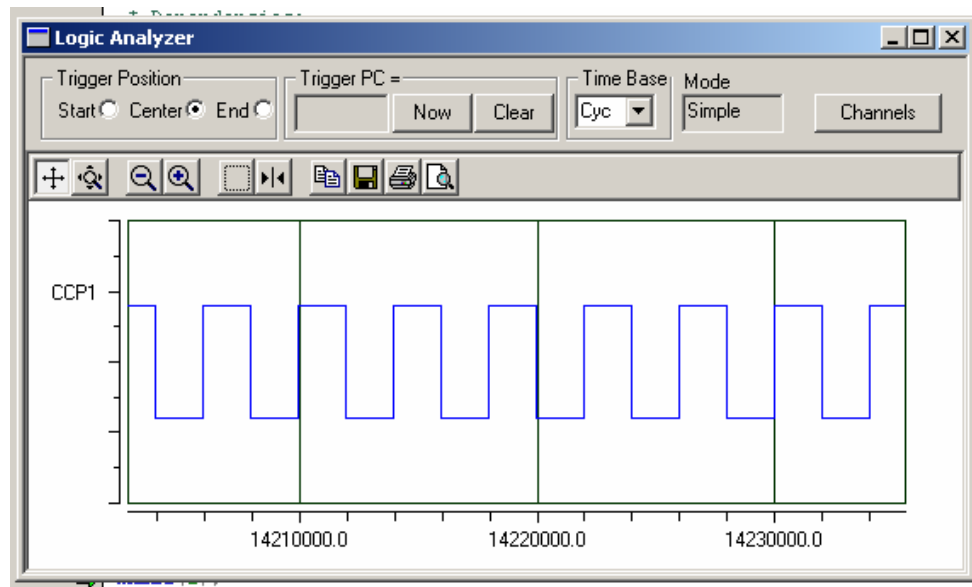


In the new dialog window select the channel you wish to view. You may have to reference the C Stamp pin out table in this manual to determine which “Available Signal” goes along with the pin you wish to analyze. In our case we will be looking at pin 27 which is CCP1.



After selecting the proper signal click OK and the Logic Analyzer will be ready to graphically display the waveform which will appear on this pin. Simply start the simulation by either pressing the blue play button in the toolbar, choosing “Run” from

the Debugger menu, or by pressing the F9 key. This starts the simulation, but in some cases, such as this one, if there is no termination written in the program we must end the simulation manually but pressing the blue pause button in the toolbar, choosing “Halt” from the Debugger menu or by pressing the F5 key. Once the simulation has been stopped the Simulation Logic Analyzer will display the desired waveform as seen below.



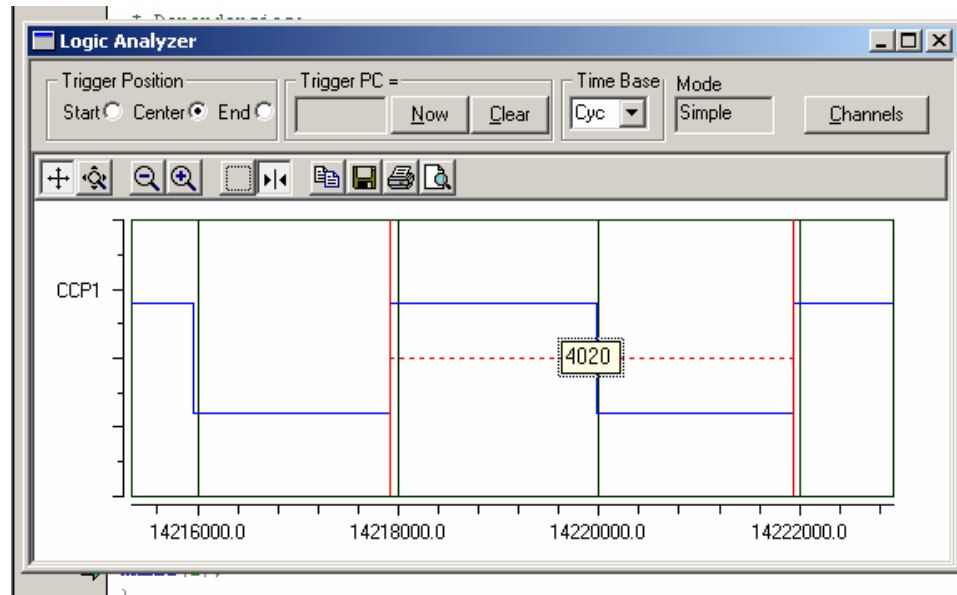
It is important to note that the time scale is in machine cycles and that one machine cycle is  $0.1 \mu\text{s}$ . To measure simply select the button that has two arrows point inward at a line as seen below.



This will allow two red bars to appear on the screen which displays the number of machine cycles that separates the two. You may also zoom a specific axis, most commonly the time axis, by selecting the icon on the toolbar with a magnifying glass and four arrows pointing away as seen below.

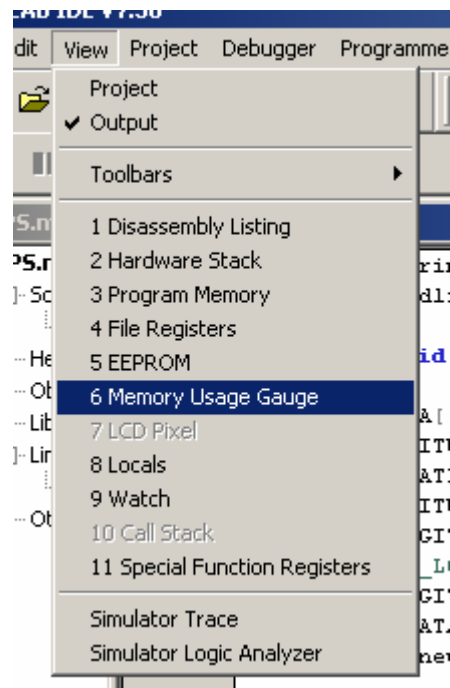


Once selected, simply click on the axis and drag left or right to zoom in or out until you find the appropriate magnification.

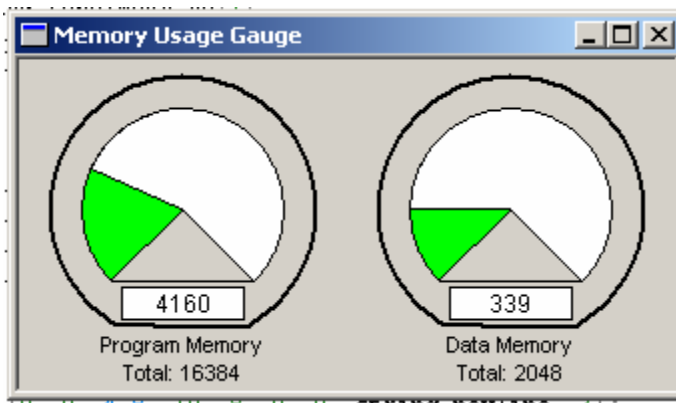


## Memory Usage Gauge

The MPLAB IDE software provides a tool called the Memory Usage Gauge. The Memory Usage Gauge allows us to find out how much memory we are using for our programs and variables. With this tool we can find out the number of bytes being used as well as the total available. To open the Memory Usage Gauge, select “6 Memory Usage Gauge” from the “View” menu.



Once it has been selected from the menu, the Memory Usage Gauge will appear as shown below. The numbers inside of white rectangles are the number of bytes currently being used by the program (Program Memory) and for data storage (Data Memory). The gauge graphically displays the memory used as a percentage of the total memory available. The total memory available can be seen listed at the bottom.





## Interrupts

This chapter covers the Interrupts infrastructure in the C Stamp system. One of the many features that set the C Stamp apart from all the other Stamp form-factor microcontrollers is the availability of Interrupt-drive event handling integrated seamlessly into the very user friendly software environment of the C Stamp. Thus, it was felt that a whole Chapter should be devoted to this topic. It is important to stress that it is **NOT** necessary to implement Interrupts into a project to be able to use the C Stamp. In fact, all projects supplied by A-WIT do not use Interrupts, and instead use the simpler technique of Polling-based event handling.

### Introduction to Event Handling

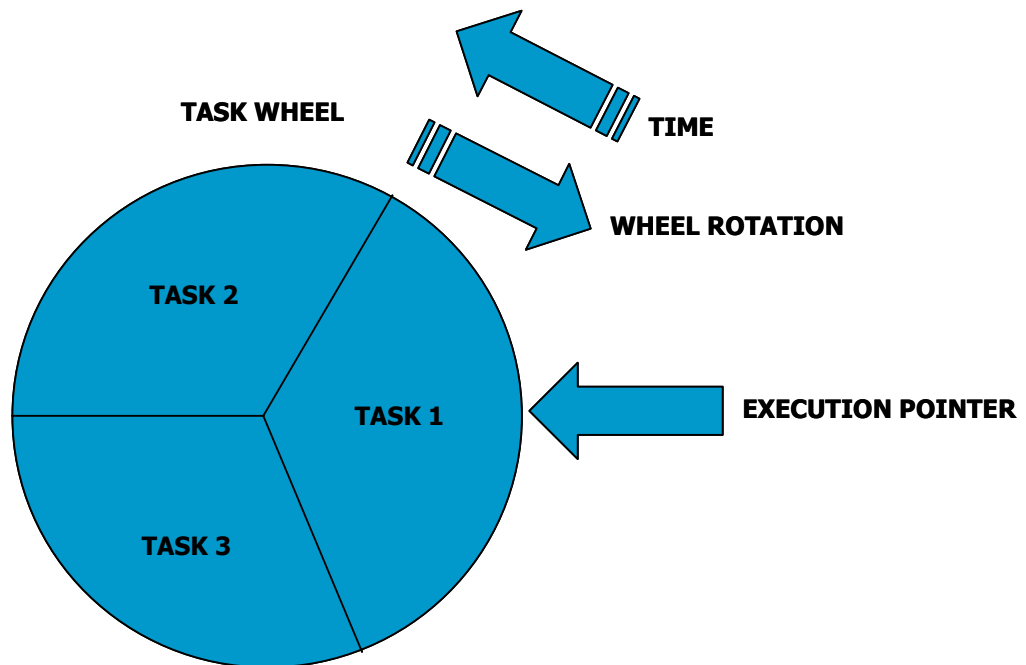
There are two general ways of handling events in Microcontroller-based systems. One is via polling the event sources, and the other is by servicing Interrupts originating from event sources. Since we encourage the handling of events via Polling, we also review both Polling and Interrupt techniques in this Chapter.

The dichotomy of event handling in Microcontroller-based systems can be seen in the table below.

| <i>Event Handling Approach</i> | <i>Controller Software Architecture</i> | <i>Experience Level Required</i> |
|--------------------------------|---|----------------------------------|
| POLLING                        | TASK WHEEL                              | LOW                              |
|                                | FINITE STATE MACHINE                    | MEDIUM                           |
| INTERRUPT                      | INTERRUPT SERVICE ROUTINE               | HIGH                             |

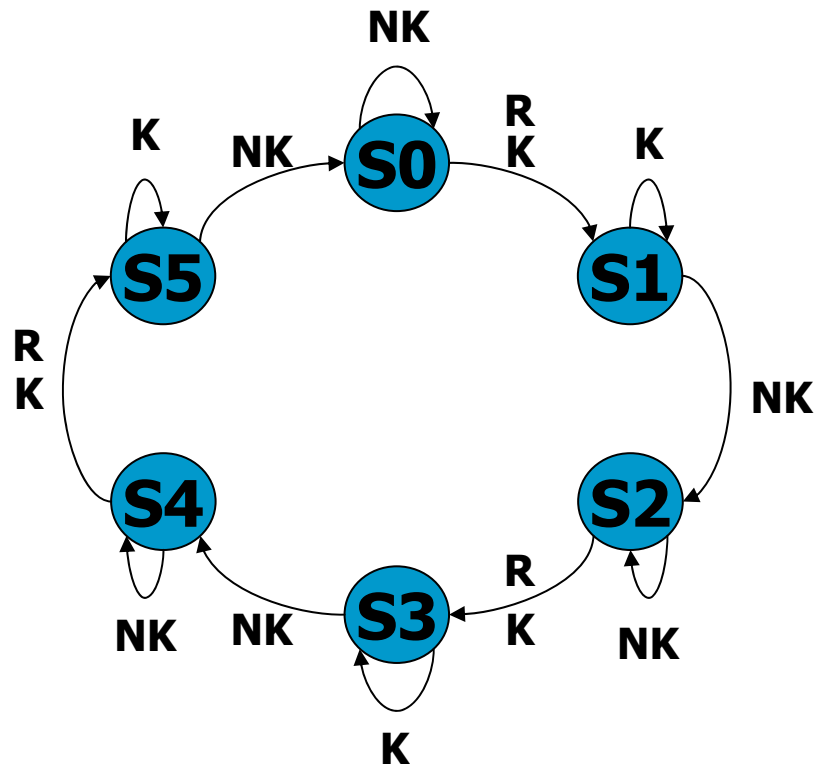
## Event Handling with a Task Wheel

When using a Task Wheel, we start our program by resetting and initializing the system. Then we start the main infinite loop of our program, which essentially forms the Task Wheel. This approach entails having one main, large, outer loop to do or check on all the tasks that our program needs to do by polling different components of our overall system. This wheel is defined by main non conditional processes, and conditional processes are said to be hidden within these non conditional tasks. Flags and counters are used for inter process communications. A visual depiction of a Task Wheel is shown in the figure below.



## Event Handling with a Finite State Machine

Although a Finite State Machine is usually associated with logic design, it can also be used in embedded systems software development. The software flow follows a State Diagram, where actions out of the system are taken depending on the Present State of the system, as given by a Present State Variable, and state transitions are taken based on the Present State and the inputs to the system that are polled during every execution cycle of the system. This execution cycle does not refer to the CPU execution cycle, but to the execution cycle of the main loop of the program. An example of a State Diagram is shown in the figure below with input actions results: NK, RK, and K; as a matter of example.

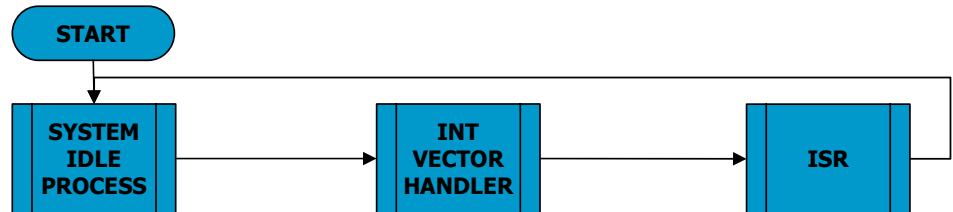


This state diagram has 6 states. We start at state S0, and as long as NK is TRUE, we remain in that state. Then if RK is TRUE, we transition state to S1, and we remain in that state until NK is TRUE. Then we transition to S2 so on until we get back to state S0 to start a new sequence.

## Event Handling with Interrupts

When handling events with Interrupts, the main program consists of a System Idle Process, which can usually be an infinite loop where the processors is waiting for events to occur, and thus be interrupted out of the Idle Process to service the event in an Interrupt Service Routine (ISR). When an Interrupt occurs, the processor automatically goes to a specific Interrupt Vector Handler function depending on the priority level of the Interrupt event source, and from there the user can direct the processor to the appropriate ISR depending on the source and priority level of the interrupt. Once the Interrupt has been “serviced”, the processor returns to the System Idle Process to wait for other events to occur and be serviced. Interrupt sources can usually be given an individual level of Priority (High or Low), and they can be individually enabled or disabled. Process intercommunication is handled via global variables, which can take the form of data structures, such as semaphores, message

queues, linked lists, buffers, etc. The flowchart in the following figure illustrates event handling via interrupts.



## C Stamp Interrupts Infrastructure

The C Stamp provides 8 external interrupt source events as summarized in the table below. The **KBIx** group is sensitive to both edges (HIGH to LOW **and** LOW to HIGH transitions), and the **INTx** group is sensitive to a single edge (HIGH to LOW **or** LOW to HIGH transitions), which can be programmed. All interrupt sources, except INT0, which is always HIGH priority, can be assigned a priority level (HIGH or LOW).

| <i>Interrupt Name</i> | <i>C Stamp Pin</i> | <i>Sensitivity</i>   | <i>Priority</i>             |
|-----------------------|--------------------|----------------------|-----------------------------|
| <b>KBI3</b>           | 31                 | CHANGE               | HIGH or LOW<br>programmable |
| <b>KBI2</b>           | 32                 | CHANGE               | HIGH or LOW<br>programmable |
| <b>KBI1</b>           | 33                 | CHANGE               | HIGH or LOW<br>programmable |
| <b>KBI0</b>           | 34                 | CHANGE               | HIGH or LOW<br>programmable |
| <b>INT3</b>           | 35                 | EDGE<br>programmable | HIGH or LOW<br>programmable |

| <i><b>Interrupt Name</b></i> | <i><b>C Stamp Pin</b></i> | <i><b>Sensitivity</b></i> | <i><b>Priority</b></i> |
|------------------------------|---------------------------|---------------------------|------------------------|
| <b>INT2</b>                  | 36                        | EDGE<br>programmable      | HIGH                   |
| <b>INT1</b>                  | 37                        | EDGE<br>programmable      | valueless              |
| <b>INT0</b>                  | 38                        | EDGE<br>programmable      |                        |

The interrupts subsystem in the C Stamp software support infrastructure consists of two Interrupt Vector Handler function templates in the C Stamp software template, and two functions to set up the interrupts and to find the sources of interrupts respectively. The **zInterruptsH.c** Interrupt Vector Handler function handles the HIGH priority interrupts, the **zInterruptsL.c** Interrupt Vector Handler function handles the LOW priority interrupts, the **INTSET** function sets up the interrupts, and the **INTSOURCE** queries the sources of interrupts.

When using interrupts with the C Stamp, a user **MUST** follow the following steps:

1. Set up the appropriate global variables outside the **main** function in the **main.c** file in the Project.
2. Set up the interrupts using the **INTSET** function inside the **main** function in the **main.c** file in the Project.
3. Set up the System Idle Process infinite loop inside the **main** function in the **main.c** file in the Project.
4. If there are low priority interrupts:
  - a. Query the interrupt sources using the **INTSOURCE** function inside the **InterruptHandlerLow** function in the **zInterruptsL.c** file in the Project.
  - b. Setup the servicing calls for the low priority interrupts in the **InterruptHandlerLow** function in the **zInterruptsL.c** file in the Project.

- c. Restore the interrupts settings using the **INTSET** function before exiting the **InterruptHandlerLow** function in the **zInterruptsL.c** file in the Project. This is necessary, because the **INTSOURCE** function that was called previously disables interrupts, so that there are no conflicts when interrupts are getting serviced.
5. If there are high priority interrupts:
- a. Query the interrupt sources using the **INTSOURCE** function inside the **InterruptHandlerHigh** function in the **zInterruptsH.c** file in the Project.
  - b. Setup the servicing calls for the high priority interrupts in the **InterruptHandlerHigh** function in the **zInterruptsH.c** file in the Project.
  - c. Restore the interrupts settings using the **INTSET** function before exiting the **InterruptHandlerHigh** function in the **zInterruptsH.c** file in the Project. This is necessary, because the **INTSOURCE** function that was called previously disables interrupts, so that there are no conflicts when interrupts are getting serviced.

The two functions provided to support interrupts are described below:

```
void INTSET(BYTE interrupts, BYTE edge,
            BYTE priorities);
```

The **INTSET** function enables or disables interrupts, and sets the priority for each one of them.

**interrupts** is a variable/constant/expression (0 – 255) indicating whether each interrupt is going to be enabled or disabled. Each bit of this argument corresponds to an interrupt as shown in the following table. If the bit is **ONE**, the interrupt is enabled; if it is **ZERO**, the interrupt is disabled.

**edge** is a variable/constant/expression (0 – 255) indicating the edge of a particular INTx interrupt. Each bit (7 – 4) of this argument corresponds to the edge of an interrupt as shown in the following table. If the bit is **ONE**, the interrupt edge is a rising edge; if it is **ZERO**, the interrupt edge is a falling edge.

**priorities** is a variable/constant/expression (0 – 255) indicating the priority level of a particular interrupt. Each bit of this argument corresponds to the priority level of an interrupt as shown in the following table. When enabled, if the bit is **ONE**, the interrupt priority level is HIGH; if it is **ZERO**, the priority level is LOW.

| <b>interrupts and priorities BYTE BITS mapping to Interrupts</b> |              |              |              |              |              |              |              |
|--|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>BIT 7</b>   | <b>BIT 6</b> | <b>BIT 5</b> | <b>BIT 4</b> | <b>BIT 3</b> | <b>BIT 2</b> | <b>BIT 1</b> | <b>BIT 0</b> |
| INT0   | INT1         | INT2         | INT3         | KBI0         | KBI1         | KBI2         | KBI3         |

When a particular interrupt BIT is disabled, its corresponding **edge** and **priorities** BITs are meaningless.

**BITs 3 - 0** of the **edge** BYTE can be anything, as the KBIx interrupts are sensitive to change, not edges.

**BIT 7** of the **priorities** BYTE can be anything, as the priority of INT0 cannot be set. It is always a high priority interrupt.

If any of the KBIx interrupts have a high priority, then all of the KBIx interrupts will be treated as high priority.

**BYTE INTSOURCE(void);**

The **INTSOURCE** function returns a BYTE that contains the sources of pending interrupts. When this information has been identified to be returned to the user, all interrupts will be disabled. Each bit of the returned BYTE corresponds to an interrupt as shown in the following table. If the bit is **ONE**, the interrupt is pending; if it is **ZERO**, the interrupt is not pending.

| <b>Pending interrupts returned BYTE BITS mapping to Interrupts</b> |              |              |              |              |              |              |              |
|--|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>BIT 7</b>   | <b>BIT 6</b> | <b>BIT 5</b> | <b>BIT 4</b> | <b>BIT 3</b> | <b>BIT 2</b> | <b>BIT 1</b> | <b>BIT 0</b> |
| INT0   | INT1         | INT2         | INT3         | KBI0         | KBI1         | KBI2         | KBI3         |

If any of the KBIx interrupts are pending, then all of them will be identified as pending.

## Event Handling Examples

In this Section, we will code the same program using the three event handling techniques described in this Chapter, so users can compare and contrast the differences between these approaches.

The problem to be coded is as follows. There are two LEDs properly biased and connected to pins 1 and 2 respectively. When the pins are HIGH, the LEDs are on, and when the pins are LOW, the LEDs are off. There is also a pushbutton properly biased and connected to Pin 38, such that when the Button is pushed, Pin 38 is LOW; otherwise, Pin 38 is HIGH. The functionality of the program needs to be such that the program starts by blinking the LED at Pin1 at a rate of 1 second (1 second on, 1 second off). Then, every time the Button is pushed, the LED that is blinking will get turned off and the other LED will start blinking at the same rate.

The following code implements this program using a Task Wheel technique. The comments in the code offer more clarifications.

```
#include  "CS110000.h"

void main(void)
{
// TYPE YOUR CODE HERE AFTER THIS LINE

    BYTE ON_PIN = 1;
    BYTE OFF_PIN = 2;
    BIT BUTTON_PUSHED;

// initialize LEDs
    STPIND(ON_PIN, HIGH);
    STPIND(OFF_PIN, LOW);

    while(TRUE){
// delay of 1 second built into BUTTON call
        BUTTON_PUSHED = BUTTON(38, LOW, LOW, 5);

// process button
        if(BUTTON_PUSHED){
            if(ON_PIN == 1){
                ON_PIN = 2;
                OFF_PIN = 1;
            }
            else{
                ON_PIN = 1;
                OFF_PIN = 2;
            }
        }

// set up LEDs
        STPIND(OFF_PIN, LOW);
        TOGGLE(ON_PIN);
    }
}
```

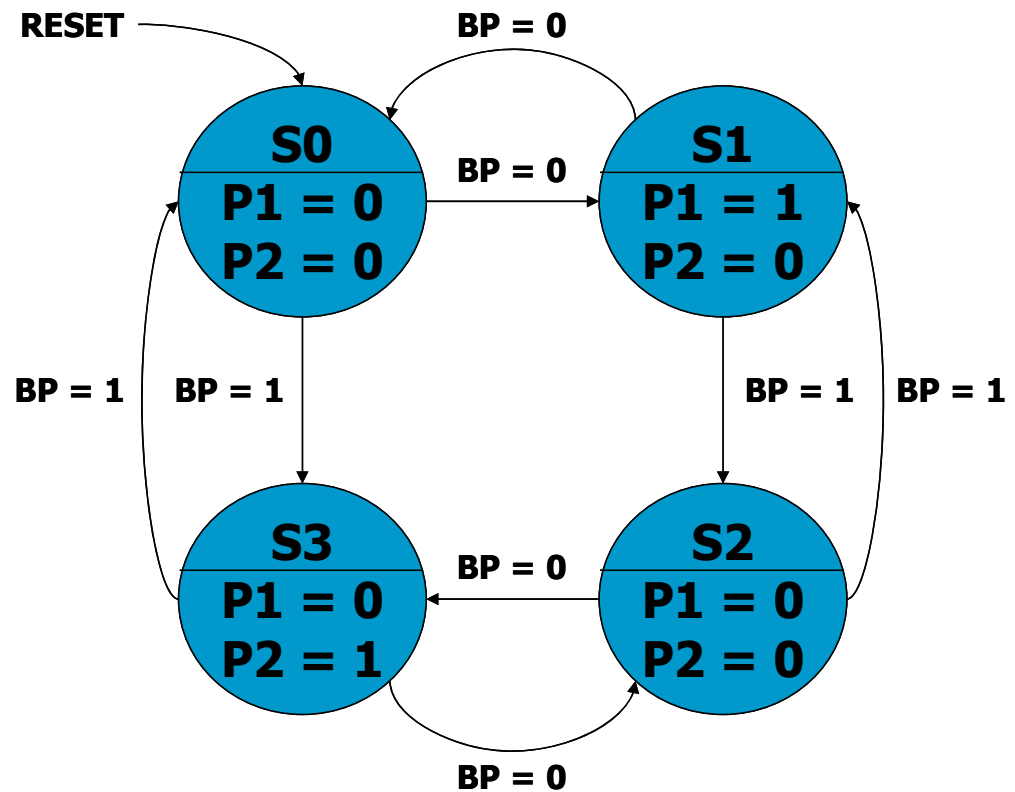


```

    }
}

```

To implement the program using a State machine technique, we can use the State Diagram in the figure below. The solution is comprised of 4 states: 0, 1, 2, and 3 denoted as S0, S1, S2, and S3 respectively below. After RESET, the machine starts in State 0, and at each state, pins 1 and 2 (P1 and P2 respectively) are set to the necessary value. The input to the state machine is the BP signal, which is 1 if the Button is pushed and 0 if it has not.



The following code implements this program using a State Machine technique. The comments in the code offer more clarifications.

```

#include "CS110000.h"

void main(void)
{
// TYPE YOUR CODE HERE AFTER THIS LINE

    NIBBLE PRESENT_STATE = 0;

```

```

NIBBLE PRESENT_STATE = 0;
BIT BP;

while(TRUE){
// delay of 0.2 second built into BUTTON call
    BP = BUTTON(38, LOW, LOW, 1);

// next state logic
    switch(PRESENT_STATE){
        case 0:
            if(BP) NEXT_STATE = 3;
            else NEXT_STATE = 1;
            break;
        case 1:
            if(BP) NEXT_STATE = 2;
            else NEXT_STATE = 0;
            break;
        case 2:
            if(BP) NEXT_STATE = 1;
            else NEXT_STATE = 3;
            break;
        case 3:
            if(BP) NEXT_STATE = 0;
            else NEXT_STATE = 2;
            break;
    }

// output logic
    switch(PRESENT_STATE){
        case 0:
            STPIND(1, LOW);
            STPIND(2, LOW);
            break;
        case 1:
            STPIND(1, HIGH);
            STPIND(2, LOW);
            break;
        case 2:
            STPIND(1, LOW);
            STPIND(2, LOW);
            break;
        case 3:
            STPIND(1, LOW);
            STPIND(2, HIGH);
            break;
    }

```

```

    }

    // state transition
    // this delay + 0.2 seconds from the BUTTON call make
    // up the total 1 second delay of each machine cycle
    PAUSE(800);
    PRESENT_STATE = NEXT_STATE;
  }
}

```

The last example of this Section implements the program using interrupts. The pin that is used for the Button is also INT0, which is programmable edge sensitive and always high priority. We need to make INT0 sensitive to a falling edge, because the Button is LOW when pushed. The comments in the code offer more clarifications.

```

#include "CS110000.h"

// global variables for inter-process communications
BYTE ON_PIN = 1;
BYTE OFF_PIN = 2;

void main(void)
{
  // TYPE YOUR CODE HERE AFTER THIS LINE

  // initialize LEDs
  STPIND(ON_PIN, HIGH);
  STPIND(OFF_PIN, LOW);

  // enable INT0 for falling edges
  INTSET(0x80, 0x00, 0x80);

  while(TRUE){
    // set up LEDs and wait
    STPIND(OFF_PIN, LOW);
    TOGGLE(ON_PIN);
    PAUSE(1000); // 1 second
  }
}

#pragma code
#pragma interrupt InterruptHandlerHigh
void InterruptHandlerHigh(void)
{
  // TYPE YOUR CODE HERE AFTER THIS LINE

```

```

// we use the following command, just to disable
// interrupts
// we do not need to find out explicitly the source of
// the interrupt in this case, because INT0 is the only
// one enabled
// if there were more than one interrupt enabled, we
// would receive the returned value from INTSOURCE into
// a local variable, and test the bits with and
// operations and masks
// then we would use those results in if constructs to
// execute the code that services each pending
// interrupt
    INTSOURCE();

// process button
// in a larger system, the interrupt may get serviced
// by a function call at this point in the code that
// does that
// since this is a small example, we do it right here
    if(ON_PIN == 1){
        ON_PIN = 2;
        OFF_PIN = 1;
    }
    else{
        ON_PIN = 1;
        OFF_PIN = 2;
    }

// restore interrupts settings
// enable INT0 for falling edges
    INTSET(0x80, 0x00, 0x80);
}

```

## C Stamp Language and Command Reference

This chapter describes the elements of WC. WC is the combination of the minimum subset of ANSI C necessary to program the C Stamp, and the functionality and commands provided by A-WIT Technologies, Inc. that make the C Stamp so versatile and easy to use. To generate a C Stamp program, you type your program in the Compiler Environment, and build it. Most lines in a WC program end with a semicolon “;”. You can also put the equivalent of multiple lines of code in a single line of program text by separating them with a semicolon. You can use spaces and extra lines freely, as the compiler simply ignores all spaces and new-line markers when parsing the code. While this manual is generally written in a variable size font, code and its comments are written with a “fixed font”. Additionally, keywords, functions, and commands of the language are in “**bold**”. Generic syntax is in a “***bold and italics fixed font***”.

### WC Program Structure

The structure template of a WC program file is as follows. Although any comments are optional, beginning comments are encouraged, and comments can be anywhere in the program, as well as extra lines for clarity and readability of your program. The sections are: the beginning comments of the program, included files and other directives, function prototypes, global variable declarations, and the **main** function followed by any number of other functions. It is possible that **main** is the only function.

Beginning comments for program

Included files and other pre-processor directives

Function prototypes (except main)

Global variable declarations

Main function

Beginning comments for main function

```

    Local variables for main function
    Code for main function

```

```

Other functions

```

```

Function 1
    Beginning comments for function 1
    Local variables for function 1
    Code for function 1

```

```

Function 2
    Beginning comments for function 2
    Local variables for function 2
    Code for function 2

```

```

.
.
.

```

```

Function N
    Beginning comments for function N
    Local variables for function N
    Code for function N

```

The file **CS110000.h** **MUST** always be included in the **Included files and other pre-processor directives** section of the program.

## Program Comments

You should be generous with your programs comments, and strive toward self-documenting code. There are two types of comments. These are single line comments and multi line comments. The single line comments are denoted by a double slash “//”. This instructs the compiler to ignore any text after the double slash to the end of the line, so it can be used to comment single lines in their entirety or the rest of a line after some valid code. The multi line comments starts with a slash and an asterisk “/\*” and ends with an asterisk and a slash “\*/”. This instructs the compiler to ignore any text between these two pairs of characters, so it can be used to put comments in the middle of a line and to comment any number of lines, including a single line.

## Defining and Using Variables

Before you can use a variable in a WC program you must declare it. “Declare” means letting the compiler know that you plan to use a variable, what you want to call it, and how big it is. Here is the syntax for a variable declaration:

```

BYTE VariableName;

```

-- Or --

```
int VariableName;
```

where `VariableName` is the name by which you will refer to the variable, and the preceding keywords denote the data type.

A variable can be initialized by following its name with an equal sign and an initial value. For example, this declaration assigns `count` an initial value of 100:

```
int count = 100;
```

| <i>Data Types</i> | <i>Size in Bits</i> | <i>Numerical Range</i> |
|-------------------|---------------------|------------------------|
| <b>BIT</b>        | 1                   | 0 to 1                 |
| <b>NIBBLE</b>     | 4                   | 0 to 15                |
| <b>BYTE</b>       | 8                   | 0 to 255               |
| <b>WORD</b>       | 16                  | 0 to 65535             |
| <b>int</b>        | 16                  | -32768 to 32767        |
| <b>float</b>      | 32                  | 6 digits of precision  |
| <b>void</b>       |                     | valueless              |

A variable should be assigned the smallest sized data type that will hold the largest value that the variable will ever hold. If you need a variable to hold the on/off status (1 or 0) of a switch, use a **BIT**. If you need a counter for a loop that will count from 1 to 100, use a **BYTE**; and so on. If you assign a value to a variable that exceeds its size, the excess bits will be lost. For example, suppose you use the **BYTE** variable `dog`, and write `dog = 260` (100000100 binary). What will `dog` contain? It will hold only the lowest 8 bits of 260 (00000100 binary = 4 decimal). In the same way, if you assign a variable type of a given size to another of a smaller size, the excess bits will be lost. However, you can always assign a variable type or value of a smaller size to a variable type of a larger size without loss of data.

## Predefined Values

WC has the following predefined values that can be used in logical expressions, to set pin values, and for the purpose of making easier mathematical calculations:

| <i>Value Name</i> | <i>Value Type</i> | <i>Value</i> |
|-------------------|-------------------|--------------|
| <b>TRUE</b>       | <b>BIT</b>        | 1            |
| <b>FALSE</b>      | <b>BIT</b>        | 0            |
| <b>ONE</b>        | <b>BIT</b>        | 1            |
| <b>ZERO</b>       | <b>BIT</b>        | 0            |
| <b>HIGH</b>       | <b>BIT</b>        | 1            |
| <b>LOW</b>        | <b>BIT</b>        | 0            |
| <b>PI</b>         | <b>float</b>      | 3.1416       |
| <b>TWOPI</b>      | <b>float</b>      | 6.2832       |

## Rules of Variable Names

Variable names are strings of letter or digits from one to several characters in length. A digit cannot begin a name. Variable names can be a maximum of 31 characters. The underscore may also be used as part of the variable name for clarity, as in `first_time`. WC is case sensitive for its keywords, commands, function names, and variable names. That means that uppercase and lowercase are different. For example `test` and `TEST` are two different variable names. Some programmers define all **float** type variables in lowercase and all others in uppercase.

Variable names cannot be reserved words that the language uses for data types, predefined values, keywords, commands, or function names.

## Defining Arrays

You can also define multipart variables called arrays. An array is a group of variables of the same size, and sharing a single name, but broken up into numbered cells, called elements. You may declare arrays of any data type. This is the general form of a singly dimensioned array:

```
type var-name[size];
```

where **size** specifies the number of elements in the array. For example, to declare an integer array `x` of 100 elements, you would write:

```
int x[100];
```



This will create an array of integers that is 100 elements long, with the first element being 0 and the last one being 99. Numbering always starts at 0 and ends at **size-1**.

```
x[3] = 57;
```

will set the fourth element of the **x** array to 57. The real power of arrays is that the index value can be a variable itself. For example:

```
BYTE myBytes[10]; // Define 10-byte array
NIBBLE idx; // Define 4-bit var
// Repeat with idx = 0, 1, 2...9
for (idx = 0; idx < 10; idx = idx + 1){
    // Write idx * 13 to each cell
    myBytes[idx] = idx * 13;
}
```

A word of caution about arrays: WC provides no array bounds-checking. Such safety checks are your responsibility. Bounds are the lower and upper limits of the index or subscript variable of the array. For instance, in the example above, **myBytes** is a 10-cell array. Allowable index numbers are 0 through 9. If your program exceeds this range, the compiler will not respond with an error message. Instead, it will access the next memory location past the end of the array. If you are not careful about this, it can cause all sorts of bugs. It's up to the programmer (you!) to prevent bugs.

## Constants and Number Representations

Variables of type **const** may not be changed by your program during execution. For example,

```
const int a;
```

will create an integer called **a** that may not be modified by your program. It can however be used in other types of expressions. A **const** variable will receive its value either from an explicit initialization or by some hardware-dependent means.

WC constants can be of any of the data types. The way each constant is represented depends upon its type.

In your programs, you may express a number in various ways, depending on how the number will be used and what makes sense to you. By default, the compiler recognizes numbers like 0, 99 or 62145 as being in our everyday decimal (base-10) system. However, you may also use hexadecimal (base-16; also called hex) or octal (base-8). Since the symbols used in decimal, hex and octal numbers overlap (e.g., 0 through 7 are used by all; 0 through 9 apply to both decimal and hex) the compiler needs prefixes to tell the numbering systems apart, as shown below:

```
99 // Decimal (no prefix)
```

```
0x1A6 // Hex (prefix '0x' required)
```

```
012 // Octal (prefix '0' required)
```

The compiler also automatically converts quoted text into ASCII codes. For example:

```
BYTE LetterA = 'A'; // ASCII code for A (65)
```

```
BYTE Cheers = 3;
```

```
BYTE Hex128 = 0x80;
```

```
BYTE OctalNumber = 0101;
```

```
-- or --
```

```
const BYTE LetterA = 'A'; // ASCII code for A (65)
```

```
const BYTE Cheers = 3;
```

```
const BYTE Hex128 = 0x80;
```

```
const BYTE OctalNumber = 0101;
```

## Taking Advantage of the Large C Stamp RAM

By default, the compiler for the C Stamp tries to fit all the program data into a space of 120 bytes, and if you have a lot of variables, or large arrays like strings of characters in your program you may get a “stack frame too large” error during compilation. This is easily solved by forcing the compiler to use the very large RAM space present in the C Stamp. To do this, the optional **RAM** data type modifier is used when declaring variables or arrays. For example:

```
RAM int a;
```

will force the compiler to put variable **a** anywhere in the 2K RAM present in the C Stamp, instead of trying to fit it in the preferred 120 bytes space.

The WC **RAM** modifier can be applied to any of the data types.

For example, if you do not have many variables in your program, you may declare the following variables like shown below, or you can use the **RAM** modifier and force the compiler to put them in RAM when the program is run.

```

BYTE LetterA = 'A'; // ASCII code for A (65)

BYTE Cheers = 3;

BYTE Hex128 = 0x80;

BYTE OctalNumber = 0101;

-- or --

RAM BYTE LetterA = 'A'; // ASCII code for A (65)

RAM BYTE Cheers = 3;

RAM BYTE Hex128 = 0x80;

RAM BYTE OctalNumber = 0101;

```

## Taking Advantage of the Large C Stamp Program Memory

Although the aggregate of all functions can use up to the whole memory amount, any single function can use up to 256 BYTES, because the RAM is divided in banks of 256 BYTES. When you need to store more than this, for example, when working with large arrays of constant data strings, then **ROM** is better. In this case, the data is stored in program memory, and you can take advantage of the large program memory (up to 32K BYTES including your code and your large constant data). To do this, the optional **ROM** data type modifier is used when declaring variables or arrays. For example,

```

ROM BYTE LetterA = 'A'; // ASCII code for A (65)

```

will force the compiler to put variable LetterA anywhere in the 32K Program Memory along with your code.

WC **ROM** modifier can be applied to any of the data types.

For example, if you do not have many constants in your program, you may declare the following variables like shown below, or you can use the **ROM** modifier and force the compiler to put them in Program Memory.

```

BYTE Cheers = 3;

BYTE Hex128 = 0x80;

BYTE OctalNumber = 0101;

```

-- Or --

**ROM BYTE** Cheers = 3;

**ROM BYTE** Hex128 = 0x80;

**ROM BYTE** OctalNumber = 0101;

## Functions

A WC program is a collection of one or more user-defined functions. One of the functions must be called **main** because it is at this function where execution will begin. Traditionally, **main()** is the first function in a program; however, it could go anywhere in the program. This is the general form of a WC function:

```
return_type function_name(parameter list)
{
    body of function
}
```

The parameter list is a comma-separated list of local variables (local to the function itself) that will receive any arguments passed to the function. If the function has no parameters, then no parameter declaration is needed. For example, this function has two integer parameters called **i** and **j**, and a float parameter called **count**:

```
void fn1(int i, int j, float count)
{ ...
```

Notice that you must declare each parameter separately.

Functions terminate and return automatically to the calling procedure when the last brace is encountered. You may force a return prior to that by using the **return** statement.

All functions (except those declared as **void**) return a value. The type of the return value must match the type declaration of the function. The **void** type is used to explicitly declare functions that return no value. It is also used to explicitly denote that a function takes no arguments. For example the code fragment “**void main(void)**” means that the function **main** returns no value, and it also takes no arguments.

## Prototypes

It is necessary to declare functions (other than `main`) prior to using it. This is done in the global definition area of the program, which is before any functions are coded. A general form of a prototype is shown here:

**`type name(parameter list);`**

In essence, a prototype is simply the return type, name, and parameter list of a function definition, followed by a semicolon.

The example here shown how the function **`fn( )`** is prototyped.

```
float fn(float x); /* prototype */
```

```
void main(void)
{
    .
    .
    .
    y = fn(0.23);
    .
    .
    .
}

float fn(float x)
{
    return x * 3.1416;
}
```

In addition to telling the compiler about the return type of a function, a function prototype also tells the compiler the number and type of function parameters.

## The Scope and Lifetime of Variables

WC has two general classes of variables: *global* and *local*. A global variable is available for use by all functions in the program, while a local variable is known and used only by the function in which it is declared.

## Math and Operators

For non-floating numbers, the C Stamp performs all math operations by the rules of positive integer math. That is, it handles only whole numbers, and drops any fractional

portions from the results of computations. The C Stamp handles negative numbers using two's complement rules.

WC has the following arithmetic operators:

| <i>Operator</i> | <i>Action</i>            |
|-----------------|--------------------------|
| -               | Subtraction, unary minus |
| +               | Addition                 |
| *               | Multiplication           |
| /               | Division                 |
| %               | Modulus division         |

The -, +, \*, and / operators behave in the expected fashion. The % operator returns the remainder of an integer division.

These operators have the following order of precedence:

| <i>Precedence</i> | <i>Operators</i> |
|-------------------|------------------|
| Highest           | - (unary minus)  |
|                   | * / %            |
| Lowest            | - +              |

Operators on the same precedence level are evaluated left to right, so WC follows the rules of conventional algebra.

Operators that take two arguments are called “binary” operators, and those that take only one argument are called “unary” operators. Please note that the term “binary operator” has nothing to do with binary numbers; it’s just an inconvenient coincidence that the same word, meaning ‘involving two things’ is used in both cases. The minus sign (-) is a bit of a hybrid. It can be used as a binary operator, as in  $8-2 = 6$ , or it can be used as a unary operator to represent negative numbers, such as -4.

## Relational and Logical Operators

The relational and logical operators are used to produce true/false results, and are often used together. In WC, *any* non-zero value is considered as true. The only value that is considered as false is 0. The relational and logical operators are listed in the following tables.

Relational Operators:

| <i>Operator</i> | <i>Meaning</i>           |
|-----------------|--------------------------|
| >               | Greater than             |
| >=              | Greater than or equal to |
| <               | Less than                |
| <=              | Less than or equal to    |
| ==              | Equal                    |
| !=              | Not Equal                |

Logical Operators:

| <i>Operator</i> | <i>Meaning</i> |
|-----------------|----------------|
| &&              | AND            |
|                 | OR             |
| !               | NOT            |

The relational operators are used to compare two values. The logical operators are used to connect two values or, in the case of NOT, to reverse a value. The precedence of these operators is as follows:

| <i>Precedence</i> | <i>Operators</i> |
|-------------------|------------------|
| Highest           | !                |

| <i>Precedence</i> | <i>Operators</i> |
|-------------------|------------------|
|                   | > >= < <=        |
|                   | == !=            |
|                   | &&               |
| Lowest            |                  |

## The Bitwise Operators

WC provides operators that manipulate the actual bits inside a variable. The bitwise operators cannot be used in floating point variables. They are listed here:

| <i>Operator</i> | <i>Meaning</i>                  |
|-----------------|---------------------------------|
| &               | AND                             |
|                 | OR                              |
| ^               | XOR                             |
| ~               | Complement                      |
| >>              | Right shift by specified amount |
| <<              | Left shift by specified amount  |

## Assignment Operator

In WC, the assignment operator is the single equal sign.

## Operator Precedence Summary

The table below lists the precedence of all WC operators. Please note that all operators, except the unary operators, associate from left to right. The unary operators associate from right to left.

| <i>Precedence</i> | <i>Operators</i> |
|-------------------|------------------|
|-------------------|------------------|



| <i>Precedence</i> | <i>Operators</i> |
|-------------------|------------------|
| Highest           | () []            |
|                   | ! ~ -            |
|                   | * / %            |
|                   | + -              |
|                   | << >>            |
|                   | > >= < <=        |
|                   | == !=            |
|                   | &                |
|                   | ^                |
|                   |                  |
|                   | &&               |
|                   |                  |
| Lowest            | =                |

## break

**break** is used to exit from a **do**, **for**, or **while** loop, bypassing the normal loop condition. It is also used to exit from a **switch** statement.

An example of a **break** in a loop is shown here:

```
while (x < 100){
    x = x + 1;
    if (x > 50) break; /* will not let x reach 52,
                       terminate when x is 51 */
    process (x);
}
```

Here, if **x** is 51, the loop is terminated. The if statement will not let **x** reach 52.

A **break** always terminates the innermost **for**, **do**, **while**, or **switch** statement, regardless of the way these might be nested. In a **switch** statement, **break** effectively keeps program execution from falling through to the next **case**. (See “**switch**” for details.)

## case

See “**switch**”.

## continue

**continue** is used to bypass the portions of code in a loop that follows it and force the conditional test to be performed. For example, the following **while** loop will simply **process** the values of **x** that are less than 51; however, **x** will reach a value of 100.

```
while (x < 100){
    x = x + 1;
    if (x > 50) continue; /* will only process values of
                           x that are less than 51 */
    process (x);
}
```

The call to **process()** will only occur when **x** is less than 51.

## default

**default** is used in the **switch** statement to signal a default block of code to be executed if no **case** matches are found in the **switch**. (See “**switch**”.)

## do

The **do** loop is one of the three loop constructs available in WC. This is the general form of the **do** loop:

```
do {
    statement block
} while (condition);
```

If only one statement is repeated, the braces are not necessary, but they do add clarity to the statement.

The **do** loop is the only loop in WC that will always have at least one iteration, because the condition is tested at the bottom of the loop. The fragment shown here will store **ch** until **fp** is zero, but it will always store the first **ch** regardless of the value of **fp**.

```
do {
    ch = fp;
    store (ch);
} while (!fp);
```

else

See “**if**”.

for

The **for** loop allows automatic initialization and update of a counter variable. This is the general form:

```
for (initialization; condition; update) {
    statement block
}
```

If the ***statement block*** is only one statement, the braces are not necessary.

It is important to understand that if the ***condition*** is false to begin with, the body of the **for** will not execute even once.

The following code will store the squared values of 0 to 9 in an array.

```
for (t = 0; t < 10; t = t + 1) {
    x[t] = t * t;
}
```

if

This is the general form of the **if** statement:

```
if (condition) {
    statement block 1
}
else {
    statement block 2
}
```

If single statements are used, the braces are not needed. The **else** is optional.

The ***condition*** may be any expression. If that expression evaluates to any value other than 0, then ***statement block 1*** will be executed; otherwise, if it exists, ***statement block 2*** will be executed.

The following fragment checks for the letter **q**, which terminates the function.

```
if (ch == 'q') {
    return;
}
else {
    proceed ();
}
```

## return

The **return** statement forces a return from a function and can be used to transfer a value back to the calling routine.

For example, the following function returns the product of its two integer arguments.

```
mul (int a, int b)
{
    return (a * b);
}
```

Keep in mind that as soon as **return** is encountered, the function will return, skipping any other code that may be in the function after it.

Remember also that a function can contain more than one **return** statement.

## switch

The **switch** statement is WC's multi-way branch statement. It is used to route execution one of several different ways. This is the general form of the **switch** statement:

```
switch (control_var) {
    case constant 1:
        statement sequence 1
        break;
    case constant 2:
        statement sequence 2
        break;
    .
    .
    .
    case constant n:
        statement sequence n
        break;
```

```

    default:
        default statements
}

```

Each statement sequence may be from one to several statements long. The **default** portion is optional.

**switch** works by checking the **control\_var** against the constants. If a match is found, that sequence of statements is executed. If the statement sequence associated with the **case** that matches the value of **control\_var** does not contain a **break**, execution will continue on into the next **case**. Put differently, from the point of the match, execution will continue until either a **break** statement is found or the **switch** ends. If no match is found and a **default** case exists, its statement sequence is executed. Otherwise, no action takes place. The following example processes a command selection.

```
ch = getcommand();
```

```

switch (ch) {
    case 'e':
        erase();
        break;
    case 'r':
        read();
        break;
    case 'w':
        write();
        break;
    default:
        return;
}

```

## void

The **void** type is used to explicitly declare functions that return no value. It is also used to explicitly denote that a function takes no arguments.

## while

The **while** loop has the following general form:

```

while (condition) {
    statement block
}

```

If a single statement is the object of the **while**, then the braces may be omitted.

**while** tests its **condition** at the top of the loop. Therefore, if the **condition** is false to begin with, the loop will not execute even once. The **condition** may be any expression.

An example of a **while** loop is shown below. It will transfer 100 characters from an array to another array.

```
BYTE y[256];
```

```
t = 0;
```

```
while (t < 100) {
    y[t] = x[t];
    t = t + 1;
}
```

## #include

The **#include** preprocessor directive instructs the compiler to read and compile another source file. It takes these general forms:

```
#include "filename"
```

```
#include <filename>
```

The source file to be read in must be enclosed in double quotes or angle brackets. If the **filename** is enclosed by angle brackets, the file is searched for in a manner defined by the creator of the compiler. This means searching some special directory set aside for include files. If the **filename** is enclosed in quotes, the file is looked for in the current working directory. If the file is not found, the search is repeated as if the **filename** had been enclosed in angle brackets.

**#include**'s may be nested within other included files.

For example,

```
#include "CS110000.h"
```

will instruct the compiler to read and compile the header for the C Stamp CS110000.

## abs

```
int abs(int num);
```

The **abs** function returns the absolute value of the integer **num**.

#### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    // Declare two variables, one to evaluate in the abs
    // function and one to compare with the result of the
    // abs function
    int EVALUATE;
    int COMPARE;

    // Set the variable EVALUATE to a negative integer
    // ex: -1
    EVALUATE = -1;
    // Set the variable COMPARE to the abs value of the
    // integer previously used
    COMPARE = 1;

    while(1){ // Continuous loop
        if(BUTTON(38, LOW, HIGH, 5)){ // Check state of
            // utility button
        // Find the absolute value of EVALUATE and then
        // store the value in the variable EVALUATE
            EVALUATE = abs(EVALUATE);
        // Test to see if COMPARE is equal to the absolute
        // value of EVALUATE
            if(COMPARE == EVALUATE)
                STPIND(46, HIGH); // If COMPARE and the
        // absolute value of EVALUATE are the same then light
        // the LED attached to pin 46
            else
                STPIND(42, HIGH); // If COMPARE and the
        // absolute value of EVALUATE are not the same, light
        // the LED attached to pin 42
            break; // This breaks from the while loop
        }
    }
}
```

#### ANALOGIN

```
float ANALOGIN(BYTE pin, NIBBLE tpins, NIBBLE refmode,
```

**float VREFM, float VREFP);**

The **ANALOGIN** function samples the indicated analog input **pin** (pins 9 through 20) and returns a floating point digital value corresponding to the value of the analog voltage at the analog input **pin**. The BANDWIDTH of the sampled signal **MUST** be less than or equal to 14 KHz, bounded by **VREFM** and **VREFP**. If unsuccessful, the function returns -1.

**pin** is a variable/constant/expression that specifies the analog input pin to be sampled.

**tpins** is a variable/constant/expression that specifies the total number of analog input pins being used in the project. These pins will be set to input mode. Depending on the number of analog inputs required by your project, analog input pins (pins 9 through 20) **MUST** be used according to the table below (D = digital I/O. A = analog input). This also includes the case where one or two external voltage references are used.

| <i>Number<br/>of<br/>Analog<br/>Inputs<br/>Required</i><br><b>tpins</b> | <i>C Stamp Pins Usage</i> |    |    |    |    |    |    |    |    |    |    |    |
|---|---------------------------|----|----|----|----|----|----|----|----|----|----|----|
|   | 9                         | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 0   | D                         | D  | D  | D  | D  | D  | D  | D  | D  | D  | D  | D  |
| 1   | D                         | D  | D  | D  | D  | D  | D  | D  | D  | D  | A  | D  |
| 2   | D                         | D  | D  | D  | D  | D  | D  | D  | D  | A  | A  | D  |
| 3   | D                         | D  | D  | D  | D  | D  | D  | D  | A  | A  | A  | D  |
| 4   | D                         | D  | D  | D  | D  | D  | D  | A  | A  | A  | A  | D  |
| 5   | D                         | D  | D  | D  | D  | D  | D  | A  | A  | A  | A  | A  |
| 6   | D                         | D  | D  | D  | D  | D  | A  | A  | A  | A  | A  | A  |
| 7   | D                         | D  | D  | D  | D  | A  | A  | A  | A  | A  | A  | A  |
| 8   | D                         | D  | D  | D  | A  | A  | A  | A  | A  | A  | A  | A  |
| 9   | D                         | D  | D  | A  | A  | A  | A  | A  | A  | A  | A  | A  |



| <i>Number<br/>of<br/>Analog<br/>Inputs<br/>Required<br/><br/>tpins</i> | <i>C Stamp Pins Usage</i> |    |    |    |    |    |    |    |    |    |    |    |
|--|---------------------------|----|----|----|----|----|----|----|----|----|----|----|
|  | 9                         | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 10   | D                         | D  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  |
| 11   | D                         | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  |
| 12   | A                         | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  |

**refmode** is a variable/constant/expression that specifies the configuration of the voltage references for the analog-to-digital conversion according to the table below.

| <b>refmode</b><br><i>Value</i> | <b>A/D VREFM</b>                                   | <b>A/D VREFP</b>                                  |
|--------------------------------|--|---|
| 0                              | Internal<br><br>VREFM = 0 V                        | Internal<br><br>VREFP = 5.0 V                     |
| 1                              | Internal<br><br>VREFM = 0 V                        | External<br><br>VREFP = 3 V to 5.3 V              |
| 2                              | External<br><br>VREFM = -0.3 V to 2 V              | Internal<br><br>VREFP = 5.0 V                     |
| 3                              | External<br><br>VREFM =<br>-0.3 V to (VREFP – 3 V) | External<br><br>VREFP =<br>(VREFM + 3 V) to 5.3 V |

**VREFM** is a variable/constant/expression that specifies the VREFM value if a low external voltage reference is used. If **refmode** is 0 or 1, this argument is ignored, but some argument still needs to be given to the function.

**VREFP** is a variable/constant/expression that specifies the VREFP value if a high external voltage reference is used. If **refmode** is 0 or 2, this argument is ignored, but some argument still needs to be given to the function.

#### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    float value_pin_19; // Declare variable value_pin_19
                        // of type float to store value
                        // returned by ANALOGIN function
    float value_pin_18; // Declare variable value_pin_18
                        // of type float to store value
                        // returned by ANALOGIN function

    // Call ANALOGIN function, store value returned in
    // value_pin_19
    value_pin_19 = ANALOGIN(19, 2, 0, 0, 5);

    // Call ANALOGIN function, store value returned in
    // value_pin_18
    value_pin_18 = ANALOGIN(18, 2, 0, 0, 5);

    // Check if value_pin_19 is 3.75 volts +/- .05 volts
    if((value_pin_19 <= 3.8) && (value_pin_19 >= 3.7)){
        STPIND(45, HIGH); // Light LED attached to pin 45
        PAUSE(2000);      // Pause for 2 seconds
        STPIND(45, LOW);  // Turn off LED attached to pin 45
        PAUSE(2000);      // Pause for 2 seconds
    }

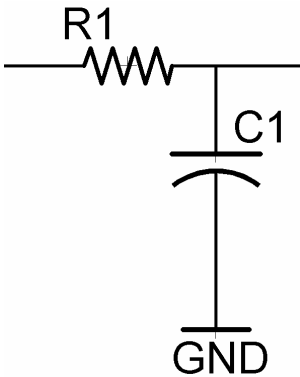
    // Check if value_pin_18 is 1.25 volts +/- .05 volts
    if((value_pin_18 <= 1.3) && (value_pin_18 >= 1.2)){
        STPIND(45, HIGH); // Light LED attached to pin 45
        PAUSE(2000);      // Pause for 2 seconds
        STPIND(45, LOW);  // Turn off LED attached to pin 45
        PAUSE(2000);      // Pause for 2 seconds
    }

    END(); // Stop program, CStamp enters low power mode
}
```

# ANALOGOUT

**BIT ANALOGOUT**(**BYTE pin**, **float V**);

The **ANALOGOUT** function converts a floating point digital value to analog output via pulse-width modulation on one the PWM outputs (pin 3 or 27). The maximum real-time BANDWIDTH of the digital signal being converted to analog is 19 KHz. To actually do the Digital to Analog conversion, the PWM output pin being used needs to drive a Low-Pass-Filter (LPF). This LPF is shown in the following figure. The C Stamp PWM pin will be connected to the left of R1, and the analog voltage will be available to the right of R1 (i.e. at C1). To drive DC motors; however, it is not necessary to use an LPF, because the inertial dynamics that are inherent to DC motors act as a built-in LPF in the motor. The values for the LPF components are shown in the table below. If the values for the components of the LPF are not available, some other RC combination can be used, as long as the product of the component values  $R \times C = 1.0 \times 10^{-6}$ .



| <i>Low Pass Filter Components Values</i> |                                    |
|--|------------------------------------|
| R  | 1 KΩ (or as close as possible)     |
| C  | 0.001 μF (or as close as possible) |

**pin** is a variable/constant/expression that specifies the I/O pin to use. This pin will be set to output mode.

**V** is a variable/constant/expression (0 – 5 V) that specifies the analog output level (0+ to **HIGH** level).

If **V** is 0, then the PWM output is disabled, if it had been previously enabled, meaning that the PWM output will be 0 V.

If successful, the function returns **TRUE**; otherwise it returns **FALSE**.

#### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    BIT SUCCESS; // Declare variable SUCCESS of type BIT

    // Call function ANALOGOUT, store value returned in
    // SUCCESS
    SUCCESS = ANALOGOUT(3, 2);

    // Check if ANALOGOUT executed successfully
    if(SUCCESS){
        STPIND(45, HIGH); // Light LED attached to pin 45
    }

    END(); // Stop program, C Stamp enters low power mode
}
```

## atoW

**WORD** **atoW**(**BYTE** **a**[], **BYTE** **radix**);

The **atoW** function converts the null terminated **BYTE** array **a** into its numeric equivalent, and returns the result. The base of the input string is given by **radix**, which may be 2, 10, or 16.

Be sure to call **atoW** with an array **a** that represents a number no larger than what can be held in a **WORD**: [0 to 65535].

## BUTTON

**BIT** **BUTTON**(**BYTE** **pin**, **BIT** **downstate**, **BIT** **targetstate**,  
**WORD** **delay**);

The **BUTTON** function monitors and returns **TRUE** if the processing of a pushbutton input is successful resulting from the button being pushed and reaching the **targetstate**; otherwise it returns **FALSE**. Button circuits may be active-low or active-high.

**pin** is a variable/constant/expression that specifies the I/O pin to use. This pin will be set to input mode.

**downstate** is a variable/constant/expression (0 or 1) that specifies which logical state occurs when the button is pressed.

**targetstate** is a variable/constant/expression (0 or 1) that specifies which state the button should be in for the function to return **TRUE**. (0=not pressed, 1=pressed)

**delay** is a variable/constant/expression (1 – 65535) that specifies for how long the button will be monitored. The unit of time for **delay** is 0.2 second.

If the button is not pressed, then the function returns **FALSE**.

#### EXAMPLE PROGRAM:

```
#include    "CS110000.h"

void main(void)
{
    BIT CHECK_BUTTON; // Declare variable CHECK_BUTTON to
                      // store the utility button's state

    STPIND(43, HIGH); // Light LED attached to pin 43 to
                      // show program is running.

    // Use the BUTTON function to check if the utility
    // button has been pushed the value of the BUTTON
    // function is the stored in the variable CHECK_BUTTON
    // If after 10 seconds the utility button has not been
    // pushed CHECK_BUTTON will have a value of FALSE (0)
    CHECK_BUTTON = BUTTON(37, LOW, LOW, 50);

    if(CHECK_BUTTON){ // Tests to see if CHECK_BUTTON is
// TRUE or FALSE (1 or 0 respectively)
        STPIND(46, HIGH); // If CHECK_BUTTON is TRUE light
                          // the LED attached to pin 46
    }
    else{
        STPIND(45, HIGH); // If CHECK_BUTTON is FALSE light
                          // the LED attached to pin 45
    }
    END(); // The END function stops the program from
          // continuously looping
}
```

## BYTEIN

**BYTE BYTEIN(BYTE pins[]);**

The **BYTEIN** function sets the pins in the array **pins** to digital input mode and returns the BYTE value at those pins. **pin[0]** is the least significant bit (LSB) of the desired BYTE and **pin[7]** is the most significant bit (MSB). User **MUST** ensure that the **pins** array has at least 8 elements.

### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    BYTE pins[8];    // Declare array pins of type BYTE
    BYTE BYTE_READ;  // Declare variable BYTE_READ of type
                    // BYTE

    /* Set array pins to the appropriate pins on which data
    is placed, where 12 is the LSB and 19 is the MSB */
    pins[0] = 12; pins[1] = 13;
    pins[2] = 14; pins[3] = 15;
    pins[4] = 16; pins[5] = 17;
    pins[6] = 18; pins[7] = 19;

    // Call function BYTEIN and store value in BYTE_READ
    BYTE_READ = BYTEIN(pins);

    // Check if value returned by BYTEIN function is
    // hexadecimal AA or binary 10101010
    if(BYTE_READ == 0xAA){
        STPIN(45, HIGH); // Light LED attached to pin 45
    }

    // Stop program, CStamp enters low power mode
    END();
}
```

## BYTEOUT

**BIT BYTEOUT(BYTE value, BYTE pins[]);**

The **BYTEOUT** function sets the pins in the array **pins** to digital output mode and to **value**. **pin[0]** corresponds to the LSB of **value** and **pin[7]** to the MSB. User

**MUST** ensure that the **pins** array has at least 8 elements. If the operation is successful, it returns a value of **TRUE**; otherwise, it returns a value of **FALSE**.

#### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    BYTE pins[8]; // Declare array pins of type BYTE with
                  // 8 elements
    BIT SUCCESS; // Declare variable SUCCESS of type BIT
                 // to store value returned by BYTEOUT
                 // function

    /* The array pins is defined element by element so that
    pin 8 is the LSB and pin 15 is the MSB */
    pins[0] = 8; pins[1] = 9;
    pins[2] = 10; pins[3] = 11;
    pins[4] = 12; pins[5] = 13;
    pins[6] = 14; pins[7] = 15;

    // Call function BYTEOUT, store value returned in
    // SUCCESS
    SUCCESS = BYTEOUT(0xAA, pins);

    // Check if function BYTEOUT executed successfully
    if(SUCCESS){
        STPIND(45, HIGH); // Light LED attached to pin 45
    }

    // Stop program, CStamp enters low power mode
    END();
}
```

## CLPINPU

**void CLPINPU(void);**

The **CLPINPU** function clears (disables) the built-in pull-up resistors available in the module (Pins 31 – 38).

## COMPARE

**BIT COMPARE(NIBBLE comparator, NIBBLE mode);**

The **COMPARE** function enables or disables a comparator, compares voltages on its pins, and returns the comparison result.

**comparator** is a variable/constant/expression (1 or 2) that denotes on which comparator the function operates.

**mode** is a variable/constant/expression (0 – 2) that enables or disables the comparator and determines if the optional comparator output pin is enabled or not.

The table below shows an explanation of the mode values.

| <b>mode Values</b> | <b>Function Behavior</b>   |
|--------------------|--|
| 0                  | Disables the comparator  |
| 1                  | Enables the comparator with comparator output as result output<br><br>If the voltage at the comparator (+) input is greater than the voltage at its (-) input, returns <b>TRUE</b> and outputs a <b>HIGH</b> at the comparator output pin; otherwise it returns <b>FALSE</b> and outputs a <b>LOW</b> at the comparator output pin |
| 2                  | Enables the comparator without comparator output as result output<br><br>If the voltage at the comparator (+) input is greater than the voltage at its (-) input, returns <b>TRUE</b> ; otherwise it returns <b>FALSE</b>  |

If Comparator 1 is disabled, then Comparator 2 gets disabled too. If Comparator 2 is enabled, then Comparator 1 gets enabled too, although it does not have to be used. This means that if you need only one comparator, you should use Comparator 1 first and then use Comparator 2 if a second is necessary. If you need only one comparator, then you can use Comparator 1 and disable Comparator 2. The comparators operate independently of the execution speed of the module and will continue to run and update their outputs if **mode = 1**, even during sleep mode. To avoid additional current draw during sleep mode, disable the comparators before entering sleep mode.

#### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
```



```

    BIT RESULT; // Variable RESULT of type BIT to store
                // value returned by function COMPARE

    STPIND(42, LOW); // Set LED attached to pin 42 LOW
    STPIND(46, LOW); // Set LED attached to pin 46 LOW

    RESULT = COMPARE(1, 1); // Call function COMPARE,
    // activate comparator 1 on mode 1, store the logical
    // value returned in the variable RESULT
    if(RESULT){ // Check to see if + or - pin is higher
    // (TRUE or '1' for + pin FALSE or '0' for - pin)
        STPIND(42, HIGH); // If + pin higher, Light LED
                        // attached to pin 42
    }
    else{
        STPIND(46, HIGH); // If - pin higher, Light LED
                        // attached to pin 46
    }
    PAUSE(10); // Pause program for 10 milliseconds
                // before looping.
}

```

## COUNT

**WORD COUNT(BYTE pin, WORD duration);**

The **COUNT** function counts the number of cycles (0-1-0 or 1-0-1) on the specified Capture **pin** during the **duration** time frame and returns that number.

**pin** is a variable/constant/expression that specifies the I/O pin to use. This pin will be set to input mode.

**duration** is a variable/constant/expression (1 – 65535) specifying the time during which to count. The unit of time for **duration** is 1 millisecond.

If an error occurs or no pulse is detected, the function returns **FALSE**.

### EXAMPLE PROGRAM:

```

#include  "CS110000.h"

void main(void)
{
    WORD i; // Counter variable used in for loop

```

```

    WORD NUMBER_OF_CYCLES = 0; // Declare variable to
    // store the number of cycles detected

    STPIND(40, HIGH); // Light LED attached to pin 40 to
                        // show program is running.

    NUMBER_OF_CYCLES = COUNT(3, 65000); // Call function
    // COUNT on pin 3 for 65 seconds and store value
    // returned in variable NUMBER_OF_CYCLES

    // for loop which will blink the LED attached to pin 42
    // once for each cycle
    for(i = 0; i < NUMBER_OF_CYCLES; i = i + 1){
        STPIND(42, HIGH); // Turn on LED connected to pin
                           // 42
        PAUSE(2000); // PAUSE command stops program for
                     // 2000 milliseconds (2 seconds)
        STPIND(42, LOW); // Turn off LED connected to pin
                          // 42
        PAUSE(2000); // PAUSE command stops program for
                     // 2000 milliseconds (2 seconds)
    }
    STPIND(40, LOW); //Turn off LED attached to pin 40
    END(); //END function ends program and stops program
          // from looping
}

```

## COUNT2

**WORD COUNT2(BYTE pin, WORD duration);**

The **COUNT2** function counts the number of cycles (0-1-0 or 1-0-1) on the specified **pin** during the **duration** time frame and returns that number.

**pin** is a variable/constant/expression that specifies the I/O pin to use. This pin will be set to input mode.

**duration** is a variable/constant/expression (1 – 65535) specifying the time during which to count. The unit of time for **duration** is 1 millisecond.

If an error occurs or no pulse is detected, the function returns **FALSE**.

## DCD

**WORD DCD(NIBBLE num);**

The **DCD** function is a 2<sup>n</sup>-power decoder of a four-bit value. **DCD** accepts a value from 0 to 15, and returns a 16-bit number with the bit described by the value **num** set to 1, and all others to 0.

#### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    WORD RESULT;

    RESULT = DCD(1); // Call function DCD to decode '1'
    // store value returned in variable RESULT
    if(RESULT == 0x2){ // Check if RESULT is equal to
                        // hexadecimal '2' or binary '10'
        STPIND(42, HIGH); // Light LED attached to pin 42
        PAUSE(1000); // Pause for 1 second
        STPIND(42, LOW); // Turn off LED attached to pin 42
        PAUSE(1000); // Pause for 1 second
    }
    else{
        STPIND(46, HIGH); // Light LED attached to pin 46
        PAUSE(1000); // Pause for 1 second
        STPIND(46, LOW); // Turn off LED attached to pin 46
        PAUSE(1000); // Pause for 1 second
    }
    END(); // Stops the program from further execution,
           // C Stamp enters low power mode
}
```

## DTMFOUT

```
BIT DTMFOUT(BYTE pin, WORD ontime, WORD offtime,  
             BYTE tone);
```

The **DTMFOUT** function generates dual-tone, multi-frequency tones (DTMF, i.e. telephone “touch” tones) on one of the PWM outputs (Pin 3 or 27).

If the operation is successful, the function returns **TRUE**; otherwise it returns **FALSE**.

**pin** is a variable/constant/expression that specifies the I/O pin to use. This pin will be set to output mode.

**ontime** is a variable/constant/expression (0 – 65535) specifying a duration of the tone. The unit of time is 1 millisecond.

**offtime** is a variable/constant/expression (0 – 65535) specifying the length of silent pause after a tone for when consecutive DTMF commands are issued. The unit of time is 1 millisecond.

**tone** is a variable/constant/expression (0 – 19) specifying the DTMF tone to generate. Tones 0 through 11 correspond to the standard layout of the telephone keypad, 12 through 15 are the fourth column tones used by phone test equipment and in ham-radio applications, and 16 through 18 correspond to events. This is summarized in the following table:

| <b>tone value</b> | <b><i>Meaning</i></b> | <b><i>Low frequency</i></b> | <b><i>High frequency</i></b> |
|-------------------|-----------------------|-----------------------------|------------------------------|
| 0                 | 1                     | 697 Hz                      | 1209 Hz                      |
| 1                 | 2                     | 697 Hz                      | 1336 Hz                      |
| 2                 | 3                     | 697 Hz                      | 1477 Hz                      |
| 3                 | 4                     | 770 Hz                      | 1209 Hz                      |
| 4                 | 5                     | 770 Hz                      | 1336 Hz                      |
| 5                 | 6                     | 770 Hz                      | 1477 Hz                      |
| 6                 | 7                     | 882 Hz                      | 1209 Hz                      |
| 7                 | 8                     | 882 Hz                      | 1336 Hz                      |
| 8                 | 9                     | 882 Hz                      | 1477 Hz                      |
| 9                 | *                     | 941 Hz                      | 1209 Hz                      |
| 10                | 0                     | 941 Hz                      | 1336 Hz                      |
| 11                | #                     | 941 Hz                      | 1477 Hz                      |
| 12                | A                     | 697 Hz                      | 1633 Hz                      |
| 13                | B                     | 770 Hz                      | 1633 Hz                      |
| 14                | C                     | 882 Hz                      | 1633 Hz                      |

| <b>tone value</b> | <b><i>Meaning</i></b> | <b><i>Low frequency</i></b> | <b><i>High frequency</i></b> |
|-------------------|-----------------------|-----------------------------|------------------------------|
| 15                | D                     | 941 Hz                      | 1633 Hz                      |
| 16                | busy signal           | 480 Hz                      | 620 Hz                       |
| 17                | dial tone             | 350 Hz                      | 440 Hz                       |
| 18                | ring-back (US)        | 440 Hz                      | 480 Hz                       |

**EXAMPLE PROGRAM:**

```
#include "CS110000.h"

void main(void)
{
    STPIND(46, HIGH); // Light LED attached to pin 46

    while(1){ // Continuous loop
        DTMFOUT(3, 10000, 100, 2); // DTMFOUT function
        // called to output DTMF signal for the number '3' on
        // pin 3
        // On duration of 10 seconds - off of 100 milliseconds.
    }
}
```

END

```
void END(void);
```

The **END** function ends the program, placing the C Stamp into low-power mode indefinitely. This is required to have a program that does not loop continuously. If no **END** statement is present, program execution restarts at the beginning of the **main()** function once all the statement in it have been executed.

**END** puts the C Stamp into its inactive, low-power mode. In this mode the Stamp's current draw (excluding loads driven by the I/O pins) is minimized. **END** keeps the C Stamp inactive until the reset line is activated or the power is cycled off and back on.

Pins will retain their input or output settings after the C Stamp is deactivated by **END**.

**EXAMPLE PROGRAM:**

```
#include "CS110000.h"
```

```

void main(void)
{
    BIT STARTBUTTON; // Declare variable STARTBUTTON of
                      // type BIT

    STARTBUTTON = BUTTON(37, LOW, HIGH, 5); // Use
// function BUTTON to see if the utility button at pin
// 37 has been pressed and store value returned in
// STARTBUTTON

    while(STARTBUTTON){ // Loop that begins when
                        // STARTBUTTON is TRUE (1)
        STPIND(42, HIGH); // Turns on the LED attached to
                        // pin 42

/* The END function stops the program from executing
any further and places the CSTAMP in a low power mode.
Nothing placed after an END statement will be executed
since the CSTAMP stops the program once it encounters
the END function.
When the CSTAMP is in the low power mode the output to
the pins do not change so the LED attached to
pin 42 remains lit */

        END(); // END function is executed, program stops,
              // CSTAMP enters low power mode
        STPIND(46, HIGH); // This statement will never get
                        // executed
        STPIND(42, LOW); // This statement will never get
                        // executed
    }
}

```

## FLOOKDOWN

```

int FLOOKDOWN(float target, NIBBLE comparison_op,
              float array[], int array_size);

```

The **FLOOKDOWN** function compares the value of the **float target** to a list of values in an **array** of **float**, and returns the index number of the first value that matches the **comparison\_op** condition. If no value in the list matches or an error is encountered, the function returns -1.

**target** is a variable/constant/expression (floating point) to be compared to the values in the list.

**comparison\_op** is a comparison operator, as described in the table below, to be used as the criteria when comparing values.

| <b>comparison_op code</b> | <b>value</b> | <b><i>Meaning</i></b>   |
|---------------------------|--------------|---|
| EQ                        | 1            | =<br>Find the first value equal to <b>target</b> .                  |
| NE                        | 2            | !=<br>Find the first value not equal to <b>target</b> .             |
| GT                        | 3            | ><br>Find the first value greater than <b>target</b> .              |
| LT                        | 4            | <<br>Find the first value less than <b>target</b> .                 |
| GE                        | 5            | >=<br>Find the first value greater than or equal to <b>target</b> . |
| LE                        | 6            | <=<br>Find the first value less than or equal to <b>target</b> .    |

**array** is an array of floating point values to be compared to **target**.

**array\_size** is the number of elements in **array** (1 to 32767).

The function returns the index value (0 for the first element to 32766 for the 32767<sup>th</sup> element).

#### EXAMPLE PROGRAM:

```
#include "CS110000.h"
```

```

void main(void)
{
    int index_result; // Variable index_result of type
// int to store the result from FLOOKDOWN function
    float test_array[6]; // Array test_array of type
// float to store values and compare against the
// target
    float target; // Variable target of type float to
// store the target value

// Explicitly defining the array
test_array[0] = 15.1; // Defining index 0
test_array[1] = 9.24; // Defining index 1
test_array[2] = 0.0; // Defining index 2
test_array[3] = 3.9; // Defining index 3
test_array[4] = 21.451; // Defining index 4
test_array[5] = 3.1; // Defining index 5

target = 3.1; // Set target equal to 3.1

/*Example: Comparison_op = 1, find the index of the
first value equal to target (index 5)*/

    index_result = FLOOKDOWN(target, 1, test_array, 6);
// Call the function FLOOKDOWN to find the array index
// and store the result in the variable
// index_result

    END(); // Stop program execution, C Stamp enters low
// power mode
}

```

## FLOOKUP

```

float FLOOKUP(int index, float array[],
              int array_size);

```

The **FLOOKUP** function returns the value at location **index** in an **array** of **float**. If **index** is not in the proper range (0 to **array\_size** - 1), zero is returned.

**index** is a variable/constant/expression (0 for the first element to 32766 for the 32767<sup>th</sup> element) indicating the list item to retrieve.



**array** is an array of floating point numbers.

**array\_size** is the number of elements in **array** (1 to 32767).

#### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    float lookup; // Variable lookup of type float to
                  // store the value returned by FLOOKUP
    float array[6]; // Array of type float

    //Defining the array one element at a time
    array[0] = 3.1;
    array[1] = 9.24;
    array[2] = 0.0;
    array[3] = 3.9;
    array[4] = 21.451;
    array[5] = 15.1;

    lookup = FLOOKUP(3, array, 6); // Call the function
    // FLOOKUP to find the value of the element in array at
    // index 3 (4th element) and store it in lookup
    if(lookup == 3.9) // Check to see if the value
                     // returned was 3.9
        STPIND(42, HIGH); // Light LED attached to pin 42
    else
        STPIND(46, HIGH); // Light LED attached to pin 46
}
```

## FREQOUT

```
BIT FREQOUT(BYTE pin, WORD duration, float freq1,
            float freq2);
```

The **FREQOUT** function generates one or two sine-wave tones for a specified **duration** on one of the PWM outputs.

**pin** is a variable/constant/expression that specifies the I/O pin to use. This pin will be set to output mode.

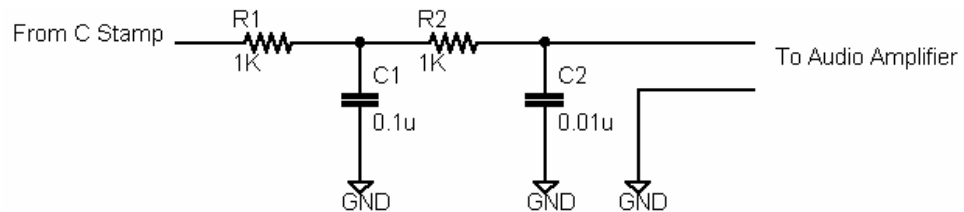
**duration** is a variable/constant/expression (0 - 65535) specifying the amount of time to generate the tone(s). The unit of time for **duration** is 1 millisecond.

**freq1** is a variable/constant/expression ( $0^+ - 2000$ ) specifying the frequency of the first tone. The unit of **freq1** is 1 Hz. If **freq1** is zero, the function will PAUSE for the **duration**.

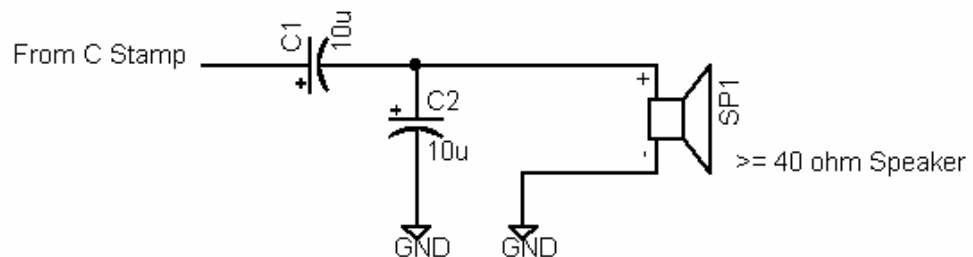
**freq2** is an argument exactly like **freq1**. When **freq1** and **freq2** are non-zero, two frequencies will be mixed together on the specified I/O pin.

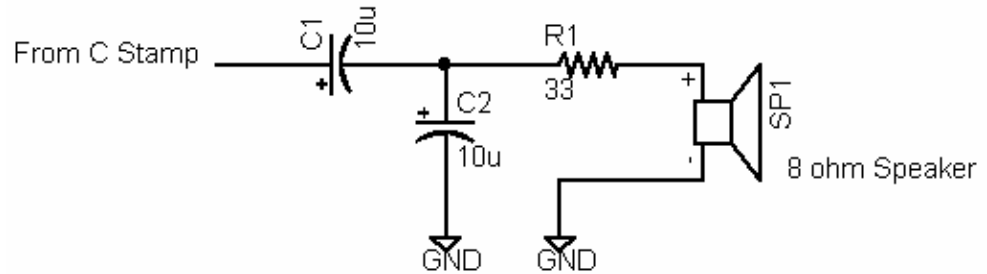
If successful, the function returns **TRUE**; otherwise it returns **FALSE**.

To drive an audio amplifier, a filter like the one shown in the figure below should be used.



To drive a speaker directly, a filter like the one shown in the figure below should be used depending on the speaker being driven. A piezo speaker would fall in the category of a  $\geq 40 \Omega$  speaker. Even though the speakers below are shown with polarity, many speakers do not have polarity (+ or -), so those speakers can be connected either way.



**EXAMPLE PROGRAM:**

```
#include "CS110000.h"

void main(void)
{
    while(1){ // Continuous loop
        FREQOUT(3, 65000, 1000, 0); // Call function
        // FREQOUT to generate a 1000 Hz signal via PWM on
        // pin 3
    }
}
```

**GTPIND**

**BIT GTPIND(BYTE pin);**

The **GTPIND** function sets **pin** to digital input mode and returns the value of **pin**.

**EXAMPLE PROGRAM:**

```
#include "CS110000.h"

void main(void)
{
    BIT INPUT; // Variable INPUT of type BIT to store the
    // value returned by function GTPIND
    BIT BUTTON_CHECK; // Variable BUTTON_CHECK of type
    // BIT to store the value returned by BUTTON function

    while(1){
        BUTTON_CHECK = BUTTON(37, LOW, HIGH, 5); // Check
        // if utility button at pin 37 has been pressed and
```

```

// store value in variable BUTTON_CHECK
    if(BUTTON_CHECK){ // Determine if BUTTON_CHECK is
                        // true
        INPUT = GTPIND(42); // Call function GTPIND to
// find the digital value of pin 42
// store value returned in variable INPUT
        if(INPUT){ // Check if input is 'HIGH'
            STPIND(41, HIGH); // Light LED attached to pin
                                // 41
            END(); // End program, C Stamp enters low power
                    // mode.
        }
    }
}

```

## HYP

**float HYP(float x, float y);**

The **HYP** function returns the hypotenuse of the (x, y) vector.

### EXAMPLE PROGRAM:

```

#include "CS110000.h"

void main(void)
{
    float hypotenuse; // Variable hypotenuse of type
// float to store value returned by HYP function
    float x; // Variable x of type float to store one
              // input for the HYP function
    float y; // Variable y of type float to store one
              // input for the HYP function
    float ans; // Variable ans of type float to store the
               // pre-calculated answer

//Example
    x = 5.1; // Set variable x to 5.1
    y = 6.8; // Set variable y to 6.8
    ans = 8.5; // Set variable ans to 8.5
    hypotenuse = HYP(x, y); // HYP functino returns the
// hypotenuse of <x, y> (or <5.1, 6.8>) and stores it
// in the variable hypotenuse
    if(hypotenuse == ans){ // Check if hypotenuse is

```

```

// equal to ans
STPIND(41, HIGH); // If so, Turn on LED connected
// to pin 41
}

END( );
}

```

## I2CIN

```

BIT I2CIN(BYTE slaveID, NIBBLE addressmode,
          BYTE address, BYTE lowaddress,
          BYTE inputdata[], BYTE n);

```

The **I2CIN** function receives data in master mode from a device using the I<sup>2</sup>C protocol on the C Stamp I<sup>2</sup>C pins (Pin 28 for the I<sup>2</sup>C Clock and Pin 29 for the I<sup>2</sup>C Data). The I<sup>2</sup>C protocol is a form of synchronous serial communication developed by Phillips Semiconductors. It only requires two I/O pins and both pins can be shared between multiple I<sup>2</sup>C devices. Both I/O pins will be toggled between input and output modes during the **I2CIN** command and both will be set to input mode by the end of the **I2CIN** command. If the function is successful, it returns **TRUE**; otherwise, it returns **FALSE**. This could mean that there was an error in the arguments of the function or some other problem.

**slaveID** is a variable/constant/expression (0 – 255) indicating the unique ID of the I<sup>2</sup>C device sending data.

**addressmode** variable/constant/expression (0 – 2) that indicates the number of bytes used for the address within the I<sup>2</sup>C device sending data. If **addressmode** is 0, this indicates that the I<sup>2</sup>C device sending data does not require an address, and both **address** and **lowaddress** are ignored. If **addressmode** is 1, **address** is the byte address in the sender and **lowaddress** is ignored. If **addressmode** is 2, **address** is the high byte of the word address at the sender and **lowaddress** is the low byte. When **address** and/or **lowaddress** are ignored, they can be any value. However, a value for each of these arguments always has to be provided.

**address** is a variable/constant/expression (0 – 255) indicating the desired address within the I<sup>2</sup>C device from which data is received. The **address** argument may be used with the **lowaddress** argument to indicate a word-sized address value when **addressmode** is 2.

**lowaddress** is a variable/constant/expression (0 – 255) indicating the low-byte of the word-sized address within the I<sup>2</sup>C device from which data is received when **addressmode** is 2.

**inputdata** is a **BYTE** array to put the received data. The array fills up from the low address 0 to the high address **n-1**.

**n** is a variable/constant/expression (1 – 255) indicating the capacity of **inputdata** in bytes.

## I2COUT

```
BIT I2COUT(BYTE slaveID, NIBBLE addressmode,
           BYTE address, BYTE lowaddress,
           BYTE outputdata[], BYTE n);
```

The **I2COUT** function sends data in master mode to a device using the I<sup>2</sup>C protocol on the C Stamp I<sup>2</sup>C pins (Pin 28 for the I<sup>2</sup>C Clock and Pin 29 for the I<sup>2</sup>C Data). The I<sup>2</sup>C protocol is a form of synchronous serial communication developed by Phillips Semiconductors. It only requires two I/O pins and both pins can be shared between multiple I<sup>2</sup>C devices. Both I/O pins will be toggled between input and output modes during the **I2COUT** command and both will be set to input mode by the end of the **I2COUT** command. If the function is successful, it returns **TRUE**; otherwise, it returns **FALSE**. This could mean that there was an error in the arguments of the function or some other problem.

**slaveID** is a variable/constant/expression (0 – 255) indicating the unique ID of the I<sup>2</sup>C device receiving data.

**addressmode** variable/constant/expression (0 – 2) that indicates the number of bytes used for the address within the I<sup>2</sup>C device receiving data. If **addressmode** is 0, this indicates that the I<sup>2</sup>C device receiving data does not require an address, and both **address** and **lowaddress** are ignored. If **addressmode** is 1, **address** is the byte address in the receiver and **lowaddress** is ignored. If **addressmode** is 2, **address** is the high byte of the word address at the receiver and **lowaddress** is the low byte. When **address** and/or **lowaddress** are ignored, they can be any value. However, a value for each of these arguments always has to be provided.

**address** is a variable/constant/expression (0 – 255) indicating the desired address within the I<sup>2</sup>C device to which data is sent. The **address** argument may be used with the **lowaddress** argument to indicate a word-sized address value when **addressmode** is 2.

**lowaddress** is a variable/constant/expression (0 – 255) indicating the low-byte of the word-sized address within the I<sup>2</sup>C device to which data is sent when **addressmode** is 2.

**outputdata** is a **BYTE** array with the data to be sent. The array gets sent from the low address 0 to the high address **n-1**.

**n** is a variable/constant/expression (1 – 255) indicating the capacity of **outputdata** in bytes.

## INTSET

```
void INTSET(BYTE interrupts, BYTE edge,  
            BYTE priorities);
```

The **INTSET** function enables or disables interrupts, and sets the priority for each one of them.

**interrupts** is a variable/constant/expression (0 – 255) indicating whether each interrupt is going to be enabled or disabled. Each bit of this argument corresponds to an interrupt as shown in the following table. If the bit is **ONE**, the interrupt is enabled; if it is **ZERO**, the interrupt is disabled.

**edge** is a variable/constant/expression (0 – 255) indicating the edge of a particular INTx interrupt. Each bit (7 – 4) of this argument corresponds to the edge of an interrupt as shown in the following table. If the bit is **ONE**, the interrupt edge is a rising edge; if it is **ZERO**, the interrupt edge is a falling edge.

**priorities** is a variable/constant/expression (0 – 255) indicating the priority level of a particular interrupt. Each bit of this argument corresponds to the priority level of an interrupt as shown in the following table. When enabled, if the bit is **ONE**, the interrupt priority level is HIGH; if it is **ZERO**, the priority level is LOW.

| <b>interrupts and priorities BYTE BITS mapping to Interrupts</b> |              |              |              |              |              |              |              |
|--|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>BIT 7</b>   | <b>BIT 6</b> | <b>BIT 5</b> | <b>BIT 4</b> | <b>BIT 3</b> | <b>BIT 2</b> | <b>BIT 1</b> | <b>BIT 0</b> |
| INT0   | INT1         | INT2         | INT3         | KBI0         | KBI1         | KBI2         | KBI3         |

When a particular interrupt BIT is disabled, its corresponding **edge** and **priorities** BITs are meaningless.

**BITs 3 - 0** of the **edge** BYTE can be anything, as the KBIx interrupts are sensitive to change, not edges.

**BIT 7** of the **priorities** BYTE can be anything, as the priority of INT0 cannot be set. It is always a high priority interrupt.

If any of the KBIx interrupts have a high priority, then all of the KBIx interrupts will be treated as high priority.

## INTSOURCE

**BYTE INTSOURCE(void);**

The **INTSOURCE** function returns a **BYTE** that contains the sources of pending interrupts. When this information has been identified to be returned to the user, all interrupts will be disabled. Each bit of the returned **BYTE** corresponds to an interrupt as shown in the following table. If the bit is **ONE**, the interrupt is pending; if it is **ZERO**, the interrupt is not pending.

| <i>Pending interrupts returned BYTE BITS mapping to Interrupts</i> |              |              |              |              |              |              |              |
|--|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>BIT 7</b>   | <b>BIT 6</b> | <b>BIT 5</b> | <b>BIT 4</b> | <b>BIT 3</b> | <b>BIT 2</b> | <b>BIT 1</b> | <b>BIT 0</b> |
| INT0   | INT1         | INT2         | INT3         | KBI0         | KBI1         | KBI2         | KBI3         |

If any of the **KBIx** interrupts are pending, then all of them will be identified as pending.

## LOOKDOWN

**int LOOKDOWN(int target, NIBBLE comparison\_op,  
int array[], int array\_size);**

The **LOOKDOWN** function compares the value of the **int target** to a list of values in an **array** of **int**, and returns the index number of the first value that matches the **comparison\_op** condition. If no value in the list matches or an error is encountered, the function returns -1.

**target** is a variable/constant/expression (-32768 to 32767) to be compared to the values in the list.

**comparison\_op** is a comparison operator, as described in the table below, to be used as the criteria when comparing values.

| <b>comparison_op code</b> | <b>value</b> | <b>Meaning</b>   |
|---------------------------|--------------|--|
| EQ                        | 1            | =<br><br>Find the first value equal to <b>target</b> . |
| NE                        | 2            | !=   |



| <b>comparison_op code</b> | <b>value</b> | <b><i>Meaning</i></b>   |
|---------------------------|--------------|---|
|                           |              | Find the first value not equal to <b>target</b> .                   |
| GT                        | 3            | ><br>Find the first value greater than <b>target</b> .              |
| LT                        | 4            | <<br>Find the first value less than <b>target</b> .                 |
| GE                        | 5            | >=<br>Find the first value greater than or equal to <b>target</b> . |
| LE                        | 6            | <=<br>Find the first value lees than or equal to <b>target</b> .    |

**array** is an array of integers with values (-32768 to 32767) to be compared to **target**.

**array\_size** is the number of elements in **array** (1 to 32767).

The function returns the index value (0 for the first element to 32766 for the 32767<sup>th</sup> element).

#### **EXAMPLE PROGRAM:**

```
#include    "CS110000.h"

void main(void)
{
    int index; // Variable index of type int, used to
// store the value returned by the LOOKDOWN function
    NIBBLE i; // Variable i of type NIBBLE, used as
// counter in the for loop which generates test_array
    int test_array[6]; // Array test_array of type int,
// used to store the values to be processed by the
// LOOKDOWN function
```

```

    for(i = 0; i < 6; i = i + 1){ // for loop to generate
                                   // values in test_array
        test_array[i] = i * 2; // Each index of test_array
// has a value of twice the index, i.e. index 4 has a
// value of 8.
    }

    index = LOOKDOWN(8, 1, test_array, 6); // Call
// function LOOKDOWN to find which index has a value
// equal to 8 (index 4)
// store the value returned in variable index

    END(); // Stop program from looping, C Stamp enters
           // low power mode
}

```

## LOOKUP

```
int LOOKUP(int index, int array[], int array_size);
```

The **LOOKUP** function returns the value at location **index** in an **array** of **int**. If **index** is not in the proper range (0 to **array\_size** - 1), zero is returned.

**index** is a variable/constant/expression (0 for the first element to 32766 for the 32767<sup>th</sup> element) indicating the list item to retrieve.

**array** is an array of integers with values (-32768 to 32767).

**array\_size** is the number of elements in **array** (1 to 32767).

### EXAMPLE PROGRAM:

```

#include  "CS110000.h"

void main(void)
{
    int VALUE; // Variable VALUE of type int to store the
               // value returned by the function LOOKUP
    NIBBLE i; // Variable i of type NIBBLE, used as
              // counter in for loop
    int test_array[10]; // Array test_array to store even
                       // numbers 0-20

    for(i = 0; i < 10; i = i + 1){ // for loop to
                                   // generate array

```

```

        test_array[i] = i * 2; // Sets each element as
                                // twice it's index value
    }

    VALUE = LOOKUP(4, test_array, 10); // Call function
    // LOOKUP to determine value of test_array at element 4
    // the value returned is then stored in VALUE

    if(VALUE == 8){ // Check to see if VALUE is 8
        STPIND(42, HIGH); // Turn LED attached to pin 42 on
    }
    else{
        STPIND(46, HIGH); // Turn LED attached to pin 46 on
    }
}

```

## NAP

**BIT NAP(NIBBLE value);**

The **NAP** function enters sleep mode for a short period of time. Power consumption is reduced.

**value** is a variable/constant/expression (0 – 7) that specifies the duration of the reduced-power nap. The duration is ( $2^{\text{value}}$ ) x 18 mS.

If successful, the function returns **TRUE**; otherwise it returns **FALSE**.

### EXAMPLE PROGRAM:

```

#include "CS110000.h"

void main(void)
{
    while(1){ // Continuous loop
        STPIND(42, HIGH); // Light LED attached to pin 42
        NAP(5); // Call NAP function for a duration of
            // 576 mS
        STPIND(42, LOW); // Turn off LED attached to pin 42
        NAP(5); // Call NAP function for a duration of
            // 576 mS
    }
}

```

## NCD

**BYTE NCD(WORD num);**

The Encoder function **NCD** is a "priority" encoder of a 16-bit value **num**. **NCD** takes a 16-bit value, finds the highest bit containing a 1 and returns the bit position plus one (1 through 16). If the input value is 0, **NCD** returns 0.

### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    BYTE ENCODED; // Declare variable ENCODED of type
    // BYTE to store value returned by function NCD

    ENCODED = NCD(0x1000); // Call function NCD to encode
    // hexadecimal 1000 or binary 1 0000 0000 0000 store
    // value returned in variable ENCODED

    if(ENCODED == 13){ // Check if ENCODED is 13
        STPIND(42, HIGH); // Light LED attached to pin 42
    }
    else{
        STPIND(46, HIGH); // Light LED attached to pin 46
    }

    /*
    The inputs for DCD range from 0 to 15. The values
    returned by DCD range from 1 to 8000 in hexadecimal.
    The inputs for the function NCD range from 0 to 8000.
    The outputs, however, range from 1 to 16 instead of 0
    to 15. This means that if you were to call DCD(5) which
    should return 10 hexadecimal and then NCD(0x10) you
    would not get the value 5 returned. 10 hexadecimal is
    10000 in binary, NCD finds the position of the bit
    which is set to 1, in this case the 5th bit and then
    adds one and so returns 6. To directly compare the two
    you must take the value of one less than the value
    returned by NCD.
    */

    ENCODED = NCD(DCD(5)); // Call function DCD to decode
    // 5, the value returned is then encoded by the
```

```
// function NCD, the result is stored in ENCODED

if((ENCODED - 1) == 5){ // Check if ENCODED - 1 is 5
    STPIND(41, HIGH); // Light LED attached to pin 41
}
else{
    STPIND(45, HIGH); // Light LED attached to pin 45
}
}
```

## PARINA

```
NIBBLE PARINA(WORD timeout, BYTE buffer[],
               BYTE Lbuffer);
```

The **PARINA** function receives asynchronous parallel data via the built-in asynchronous 8-bit parallel slave port in the C Stamp. The connections of this port, from the C Stamp's perspective are shown in the following table.

| <i>Pin Name</i>    | <i>Pin Number</i> | <i>Pin Function</i> | <i>Pin Direction</i> |
|--------------------|-------------------|---------------------|----------------------|
| <b>CSn</b>         | 47                | Chip select control | input                |
| <b>WRn</b>         | 1                 | Write Control       | input                |
| <b>RDn</b>         | 2                 | Read control        | input                |
| <b>PSP7 – PSP0</b> | 39 - 46           | Data Bus            | input                |

This built-in parallel port functions in the following manner in receive mode:

1. The external entity sending data to the C Stamp (sender) puts the data on the Data Bus.
2. The sender pulls the CSn line LOW.
3. The sender pulls the WRn line LOW for at least 50 nS.
4. The sender pulls the WRn line HIGH.
5. The sender waits for at least 25 nS.
6. The sender removes the data from the Data Bus if necessary. This is optional.

7. The sender waits for at least 25 nS.
8. The sender pulls the CSn line HIGH.

**timeout** is a variable/constant/expression (0 – 65535) that tells **PARINA** how long to wait in mS for incoming data. If data does not arrive in time or if the buffer gets full before the timeout condition occurs, the function will return with the appropriate return code. The value of 0 is special; it indicates that the function will wait until it receives enough data to fill the buffer before it returns. The usage of timeouts applies to each data unit being received.

**buffer** is the name of the array of **BYTES** that the function will use as storage to return the received data to the calling function. This can be an array of length equal to 1 byte. The maximum length of the buffer is 255 bytes.

**Lbuffer** is the maximum number of bytes that can be placed in **buffer**. If fewer bytes are received than what can be placed in the buffer, the buffer gets filled from the low to high direction of its index address space (i.e. from 0 to **Lbuffer-1**).

On exit, the function returns one of the following exit codes.

| <i>return code</i>    | <i>value</i> | <i>Meaning</i>  |
|-----------------------|--------------|---|
| <b>PARINA_ARGERR</b>  | 0            | There was at least one error in the arguments of the function.<br><br>Function did not execute.   |
| <b>PARINA_BUFULL</b>  | 1            | Function returned with the buffer full of data.   |
| <b>PARINA_TIMEOUT</b> | 2            | The function exited after a timeout condition occurred.<br><br>The highest index of buffer ( <b>Lbuffer-1</b> ) contains the index of the last byte that was received successfully before the timeout occurred. If this location contains the value 0xFF, this indicates that no data was received. |
| <b>PARINA_OVRERR</b>  | 4            | An overrun error occurred.<br><br>The highest index of buffer ( <b>Lbuffer-1</b> ) contains the index of the last byte that was received successfully before the error occurred. If this location contains the value 0xFF, this indicates that  |

| <i>return code</i> | <i>value</i> | <i>Meaning</i>        |
|--------------------|--------------|-----------------------|
|                    |              | no data was received. |

**EXAMPLE PROGRAM:**

```

#include "CS110000.h"

void main(void)
{
    NIBBLE RETURNED; // Declare variable RETURNED of type
                    // NIBBLE to store value returned by
                    // PARINA function
    BYTE DATA[1];   // Declare array DATA of type BYTE
                    // with 1 element to store data that
                    // will be received by PARINA
                    // function

    // Light LED attached to pin 20 to show program is
    // running
    STPIND(20, HIGH);

    // Call function PARINA, store value returned in
    // RETURNED and the data read in the array DATA
    RETURNED = PARINA(0, DATA, 1);

    // Turn off LED attach to pin 20 to show data has been
    // read
    STPIND(20, LOW);

    // Check if PARINA function returned with a full buffer
    // of data
    if(RETURNED == 1){
        STPIND(23, HIGH); // Light LED attached to pin 23
        PAUSE(1000);      // Pause for one second
        STPIND(23, LOW);  // Turn off LED attached to pin 23
        PAUSE(1000);      // Pause for one second
    }

    // Check if data read was hexadecimal AA or binary
    // 10101010
    if(DATA[0] == 0xAA){
        STPIND(23, HIGH); // Light LED attached to pin 23
    }
}

```

```

        PAUSE(1000);        // Pause for one second
        STPIND(23, LOW);    // Turn off LED attached to pin 23
        PAUSE(1000);        // Pause for one second
    }
    else{
        STPIND(20, HIGH);   // Light LED attached to pin 20
        PAUSE(1000);        // Pause for one second
        STPIND(20, LOW);    // Turn off LED attached to pin 20
    }

// End program and stop C Stamp from looping
END();
}

```

## PAROUTA

**NIBBLE PAROUTA(WORD timeout, BYTE buffer[],  
BYTE Lbuffer);**

The **PAROUTA** function sends asynchronous parallel data via the built-in asynchronous 8-bit parallel slave port in the C Stamp. The connections of this port, from the C Stamp's perspective, are shown in the following table.

| <i>Pin Name</i>    | <i>Pin Number</i> | <i>Pin Function</i> | <i>Pin Direction</i> |
|--------------------|-------------------|---------------------|----------------------|
| <b>CSn</b>         | 47                | Chip select control | input                |
| <b>WRn</b>         | 1                 | Write Control       | input                |
| <b>RDn</b>         | 2                 | Read control        | input                |
| <b>PSP7 – PSP0</b> | 39 - 46           | Data Bus            | output               |

This built-in parallel port functions in the following manner in send mode:

1. The external entity receiving data from the C Stamp (receiver) pulls the CSn line LOW.
2. The receiver pulls the RDn LOW for at least 50 nS.
3. The C Stamp puts the data on the Data Bus.
4. The receiver reads the data.



5. The receiver pulls the RDn line HIGH.
6. The receiver waits for at least 125 nS.
7. The receiver pulls the CSn line HIGH.

**timeout** is a variable/constant/expression (0 – 65535) that tells **PAROUTA** how long to wait in mS for the receiver to read more data. If data is not read before the timeout condition occurs, the function will return with the appropriate return code. The value of 0 is special; it indicates that the function will wait indefinitely until the data is read. The usage of timeouts applies to each data unit being sent.

**buffer** is the name of the array of **BYTES** that the function will send. This can be an array of length equal to 1 byte. The maximum length of the buffer is 255 bytes.

**Lbuffer** is the maximum number of storage bytes to be sent in the buffer. The buffer gets processed for transmission from the low to high direction of its index address space (i.e. from 0 to **Lbuffer**-1).

On exit, the function returns one of the following exit codes.

| <i>return code</i>     | <i>value</i> | <i>Meaning</i>  |
|------------------------|--------------|---|
| <b>PAROUTA_ARGERR</b>  | 0            | There was at least one error in the arguments of the function.<br><br>Function did not execute. |
| <b>PAROUTA_BUFEMP</b>  | 1            | Function returned after transmitting all data in the buffer.                                    |
| <b>PAROUTA_TIMEOUT</b> | 2            | The function exited after a timeout condition occurred. Some or all of the data was not sent.   |

#### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    NIBBLE RETURNED; // Declare variable RETURNED of type
                     // NIBBLE to store value returned by
                     // PAROUTA function
    BYTE DATA[1];   // Declare array DATA of type BYTE
```

```

// with one element, used to store
// the data which will be placed on
// pins 39-46 by PAROUTA function

// Set first element of DATA to hexadecimal AA or
// binary 10101010
DATA[0] = 0xAA;

// Light LED attached to pin 23 to show program is
// running
STPIND(23, HIGH);

// Call function PAROUTA with no timeout to display the
// data in array DATA
RETURNED = PAROUTA(0, DATA, 1);

// Turn off LED attached to pin 23
STPIND(23, LOW);
PAUSE(1000); // Pause for 1 second

// Check if PAROUTA function returned code for all data
// in buffer being transmitted
if(RETURNED == 1){
    STPIND(23, HIGH); // Light LED attached to pin 23
    PAUSE(1000);      // Pause for 1 second
    STPIND(23, LOW);  // Turn off LED attached to
}                    // pin 23

// Stop program from further execution, C Stamp enters
// low power mode
END();
}

```

## PAUSE

**void PAUSE(WORD duration);**

The **PAUSE** function pauses the program (does nothing) for the specified **duration**. **duration** is a variable/constant/expression (0 – 65535) that specifies the duration of the pause. The unit of time for **duration** is 1 millisecond.

## EXAMPLE PROGRAM:

```
#include "CS110000.h"
```

```

void main(void)
{
    BIT ON; // Declare variable ON of size BIT to store
            // value of BUTTON function

    ON = BUTTON(37, LOW, LOW, 50); // Use BUTTON function
    // to determine if the utility button connected to pin
    // 37 has been pushed.

    if(ON){ // Check to see if the utility button was
           // pushed
        while(1){ // Continuous loop
            STPIND(43, HIGH); // Turn LED connected to pin 43
                             // on
            PAUSE(3000); // Wait 3000 milliseconds
                         // (3 seconds)
            STPIND(43, LOW); // Turn LED connected to pin 43
                             // off
            PAUSE(500); // Wait 500 milliseconds
                       // (0.5 seconds or half of a second)
            STPIND(43, HIGH); // Turn LED connected to pin 43
                              // on
            PAUSE(5000); // Wait 5000 milliseconds
                        // (5 seconds)
            STPIND(43, LOW); // Turn LED connected to pin 43
                              // off
            PAUSE(1000); // Wait 1000 milliseconds (1 second)
        }
    }
}

```

## PAUSEUS

**void PAUSEUS(WORD duration);**

The **PAUSEUS** function pauses the program (does nothing) for the specified **duration**. **duration** is a variable/constant/expression (0 – 65535) that specifies the duration of the pause. The unit of time for **duration** is 2.2 microseconds.

### EXAMPLE PROGRAM:

```

#include "CS110000.h"

void main(void)
{

```

```

    BIT ON; // Declare variable ON of size BIT to store
           // value of BUTTON function

    ON = BUTTON(37, LOW, LOW, 50); // Use BUTTON function
    // to determine if the utility button connected to pin
    // 37 has been pushed.

    if(ON){ // Check to see if the utility button was
           // pushed
        STPIND(39, HIGH); // Set pin 39 HIGH
    /* The following loop's speed is too quick to be
    visible via LED. */
        while(1){ // Continuous loop
            PAUSEUS(100); // Pause for 220 microseconds
            TOGGLE(39); // Toggle pin 39
        }
    }
}

```

## PULSIN

**WORD PULSIN(BYTE pin, BIT state, WORD delay);**

The **PULSIN** function measures the width of a pulse on a Capture **pin** described by **state** and returns the result.

**pin** is a variable/constant/expression that specifies the I/O pin to use. This pin will be set to input mode.

**state** is a variable/constant/expression (0 – 1) that specifies whether the pulse to be measured is low (0) or high (1). A low pulse begins with a 1-to-0 transition and a high pulse begins with a 0-to-1 transition.

If an error occurs or no pulse is detected, the function returns **FALSE**; otherwise the width of the pulse is returned in units of 0.8  $\mu$ S.

**delay** is a variable/constant/expression (1 – 65535) that specifies for how long the pin will be monitored. The unit of time for **delay** is 1 millisecond.

### EXAMPLE PROGRAM:

```

#include    "CS110000.h"

void main(void)
{

```

```

    BIT ON; // Declare variable ON of type BIT, used to
           // store value returned by BUTTON function
    WORD WIDTH; // Declare variable WIDTH of type WORD,
               // used to store value returned by PULSIN function

    while(1){ // Continuous loop
        ON = BUTTON(37, LOW, HIGH, 5); // Check if utility
        // button at pin 37 has been pressed and store value in
        // variable ON
        if(ON){ // If ON is TRUE (1)
            WIDTH = PULSIN(3, 1, 65000); // Call function
            // PULSIN to determine the width of the pulse on pin 3
            // the value returned is then stored in the variable
            // WIDTH
            if((WIDTH<=6500) && (WIDTH >=5500)){ // Check if
            // WIDTH is in the correct range
                STPIND(46, LOW); // Turn off LED attached to
                               // pin 46
                STPIND(42, HIGH); // Light LED attached to
                               // pin 42
                END(); // Stop program from looping, C Stamp
                     // enters low power mode
            }
            else
                STPIND(46, HIGH); // Light LED attached to
                               // pin 46
        }
    }
}

```

## PULSIN2

**WORD PULSIN2(BYTE pin, BIT state, WORD delay);**

The **PULSIN2** function measures the width of a pulse on a **pin** described by **state** and returns the result.

**pin** is a variable/constant/expression that specifies the I/O pin to use. This pin will be set to input mode.

**state** is a variable/constant/expression (0 – 1) that specifies whether the pulse to be measured is low (0) or high (1). A low pulse begins with a 1-to-0 transition and a high pulse begins with a 0-to-1 transition.

If an error occurs or no pulse is detected, the function returns **FALSE**; otherwise the width of the pulse is returned in units of  $2.2\ \mu\text{S}$ .

**delay** is a variable/constant/expression (1 – 65535) that specifies for how long the pin will be monitored. The unit of time for **delay** is 1 millisecond.

## PULSOUT

```
BIT PULSOUT(BYTE pin, WORD duration, BIT mode,
            BIT polarity);
```

The **PULSOUT** function generates a pulse on **pin** with a width of **duration** and a given **polarity**.

**pin** is a variable/constant/expression that specifies the I/O pin to use. This pin will be set to output mode.

**duration** is a variable/constant/expression (0 – 65535) that specifies the duration of the pulse. The unit of time for **duration** is  $7.5\ \mu\text{S}$  if **mode** is a variable/constant/expression that evaluates to 0. If **mode** evaluates to 1, then the unit of time for **duration** is  $2.5\ \mu\text{S}$ .

**polarity** is a variable/constant/expression (0 – 1) that specifies the polarity of the generated pulse. If **polarity** is 0, then a negative pulse is generated (1 – 0 – 1). If **polarity** is 1, then a positive pulse is generated (0 – 1 – 0).

The function returns **TRUE** if successful; **FALSE** otherwise.

### EXAMPLE PROGRAM:

```
#include  "CS110000.h"

void main(void)
{
    while(1){ // Continuous loop
        PULSOUT(3, 100, 0, 1); // Call function PULSOUT to
        // generate a positive pulse for 750 microseconds on
        // pin 3
        PAUSEUS(10); // Pause for 22 microseconds
    }
}
```

## PWM

```
BIT PWM(BYTE pin, WORD duty, BYTE period);
```

The **PWM** function converts a digital value to analog output via pulse-width modulation on one the PWM outputs (Pin 3 and 27).

**pin** is a variable/constant/expression that specifies the I/O pin to use. This pin will be set to output mode.

**duty** is a variable/constant/expression (0 - 1023) that specifies the analog output level (0+ to **HIGH** level).

If **duty** is 0, then the PWM output is disabled, if it had been previously enabled.

**period** is one less the integer part of the multiple of 1.6  $\mu$ S time units that the real time period is desired to be. For example, if we wanted to synthesize an analog signal with a low-pass bandwidth of 40 KHz, the sampling rate would be at least 80 KHz. Then the real time period is the reciprocal of the sampling rate, which is  $\frac{1}{80 \text{ KHz}} = 12.5 \mu\text{S}$ . We take this value and divided by 1.6  $\mu$ S, which yields 7.8. We take the integer part and subtract 1. This is the **period** argument for the **PWM** command; 6 in this case.

If successful, the function returns **TRUE**; otherwise it returns **FALSE**.

#### EXAMPLE PROGRAM:

```
#include    "CS110000.h"

void main(void)
{
    /* PWM differs from functions like PULSOUT in that you
    do not have to continue calling it.
    Once the PWM function has been called, C Stamp
    will continue to produce the pulse even after the PWM
    function is not longer being called. */

    PWM(3, 512, 250); // Set PWM on pin 3 to a 50% duty
    // cycle for a duration of about 400 microseconds
    while(1); // Continuous loop, holds program looping
    // at the while statement so that PWM is not
    // interrupted by the PWM function being called again.
}

rand

WORD rand(void);
```

The **rand** function generates a sequence of random numbers. Each time it is called, a different random **WORD** value is returned.

#### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    WORD RANDOM_WORD = 0; // Variable RANDOM_WORD of type
    // WORD to store value returned by rand function
    // initialize RANDOM_WORD to 0

    srand(0x5); // srand function sets starting point for
    // random word generation at hexadecimal 5

    while(1){ // Continuous loop
        RANDOM_WORD = rand(); // Call rand function and
        // store the value returned in RANDOM_WORD

        if(RANDOM_WORD == 0){ // Check that rand returned a
            // new value
            STPIND(46, HIGH); // Light LED attached to pin 46
        }
        else{
            STPIND(42, HIGH); // Light LED attached to pin 42
        }

        PAUSE(100); // Pause program for 100 milliseconds
        // before looping
    }
}
```

## READ

**BYTE READ(WORD location);**

The **READ** function reads the value at **location** in data EEPROM and returns the result.

**location** is a variable/constant/expression that specifies the data EEPROM address from which to read.

The user must ensure that the **location** value is within the bounds of the existing data EEPROM address space.



**EXAMPLE PROGRAM:**

```
#include "CS110000.h"

void main(void)
{
  /* This program should be used after first downloading
  and running the WRITE program so that a value will
  first be stored in the EEPROM. The EEPROM will not lose
  the information stored there if the CSTAMP was turned
  off before this program has been executed.*/

  BYTE EEPROM_VALUE; // Variable EEPROM_VALUE of type
  // BYTE to store value returned from READ function

  EEPROM_VALUE = READ(0000); // Call READ function to
  // retrieve value stored in EEPROM at location '0000'
  // this value is then stored in the variable
  // EEPROM_VALUE

  if(EEPROM_VALUE == 0x64){ // Check to see if value
  // stored in EEPROM_VALUE is the hexadecimal value '64'
    STPIND(41, HIGH); // Turn on LED attached to pin 41
  }
  END();
}
```

**REV**

**WORD REV(WORD value, BYTE num);**

The **REV** function returns a reversed (mirrored) copy of a specified number of bits **num** of **value**, starting with the right-most bit (least significant bit or “LSB”).

**EXAMPLE PROGRAM:**

```
#include "CS110000.h"

void main(void)
{
  BYTE FORWARD; // Variable FORWARD of type BYTE, used
  // to store the bits in their forward direction
  BYTE REVERSED; // Variable REVERSED of type BYTE,
  // used to store the bits in their reversed direction
  FORWARD = 0xA2; // Set FORWARD to 'A2' in
```

```
// hexadecimal, A2 in hex is equal to 10100010 in
// binary
REVERSED = REV(FORWARD, 8); // Call function REV to
// reverse the bits in the variable FORWARD and
// store them in the variable REVERSED

/* 10100010 reversed becomes 01000101, the zero can be
ignored and this becomes 1000101 in binary which is
equal to 45 in hexadecimal. */

    if(REVERSED == 0x45){ // Check to see if REVERSED is
                        // equal to hexadecimal 45
        STPIND(42, HIGH); // Turn on LED attached to pin 42
    }
    else{
        STPIND(46, HIGH); // Turn on LED attached to pin 46
    }
}
```

## SATH

**float SATH(float num, float limit);**

The **SATH** function saturates high or limits the value of **num** to specified high **limit**. It returns **num** if **num** is less than **limit**, or it returns **limit** if **num** is greater than or equal to **limit**.

### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    float LIMIT; // Variable LIMIT of type float to store
                // the upper saturation limit
    float NUMBER; // Variable NUMBER of type float to
// store the value to be compared with LIMIT
    float SATURATION; // Variable SATURATION of type
// float to store the value returned by SATH function

//Example
    LIMIT = 14.671; // Set LIMIT to 14.671
    NUMBER = PI * 10; // Set NUMBER to PI * 10 or 31.416
                    // (PI is defined as 3.1416)
```

```

SATURATION = SATH(NUMBER, LIMIT); // Function SATH
// returns NUMBER or LIMIT which ever is least which is
// then stored in the variable SATURATION

    if (SATURATION == NUMBER){ // Check to see if
// SATURATION is equal to NUMBER
        STPIND(41, HIGH); // If so, light LED attached to
                        // pin 41
    }

    if (SATURATION == LIMIT){ // Check to see if
// SATURATION is equal to LIMIT
        STPIND(45, HIGH); // If so, light LED attached to
                        // pin 45
    }

    END(); //END function stops program and puts CSTAMP
        // into low power mode.
}

```

## SATL

```
float SATL(float num, float limit);
```

The **SATL** function saturates low or limits the value of **num** to specified low **limit**. It returns **num** if **num** is greater than **limit**, or it returns **limit** if **num** is less than or equal to **limit**.

### EXAMPLE PROGRAM:

```

#include "CS110000.h"

void main(void)
{
    float LIMIT; // Variable LIMIT of type float to store
                // the upper saturation limit
    float NUMBER; // Variable NUMBER of type float to
// store the value to be compared with LIMIT
    float SATURATION; // Variable SATURATION of type
// float to store the value returned by SATL function

//Example
    LIMIT = 5.1799; // Set LIMIT to 5.1799
    NUMBER = PI * 1.5; // Set NUMBER to PI * 1.5 or
                        // 4.7124

```

```

// (PI is defined as 3.1416)

SATURATION = SATL(NUMBER, LIMIT); // Function SATH
// returns NUMBER or LIMIT which ever is greatest which
// is then stored in the variable SATURATION

    if (SATURATION == NUMBER){ // Check to see if
// SATURATION is equal to NUMBER
        STPIND(41, HIGH); // If so, light LED attached to
                        // pin 41
    }

    if (SATURATION == LIMIT){ // Check to see if
// SATURATION is equal to LIMIT
        STPIND(45, HIGH); // If so, light LED attached to
                        // pin 45
    }

    END(); //END function stops program and puts the
        // CSTAMP into low power mode.
}

```

## SERIN

```

NIBBLE SERIN(BYTE fpin, BIT polarity, float baudrate,
            NIBBLE databits, NIBBLE parity,
            WORD timeout, BYTE buffer[],
            BYTE Lbuffer);

```

The **SERIN** function receives asynchronous serial data (e.g., RS-232 data) via the built-in asynchronous serial receiver in the C Stamp (Pin 25). This is the same connection used to download programs to the C Stamp.

**fpin** is a variable/constant/expression that specifies the I/O pin on which to indicate flow control status. This pin will be set to output mode. If **fpin** is 0, no flow control will be used.

**polarity** is an argument that specifies how the **fpin** will be used in the cases that the user chooses to utilize flow control. The allowed values are **TRUE** and **FALSE**. If polarity is **TRUE**, a ONE or HIGH will be used as the value of **fpin** that will signal the sender to send more data, and a ZERO or LOW will be used as the value of **fpin** that will signal the sender not to send more data and wait for the value of **fpin** to be ONE or HIGH again. If polarity is **FALSE**, a ZERO or LOW will be used as the value of **fpin** that will signal the sender to send more data, and a ONE or HIGH will

be used as the value of **fpin** that will signal the sender not to send more data and wait for the value of **fpin** to be ZERO or LOW again.

**baudrate** is a variable/constant/expression (4.8, 9.6, 19.2, 38.4, 57.6, 76.8, 96, 115.2, 300, 500, 625, 1250, or 2500) that specifies serial timing in 1000's of bits per second (Kbps).

**databits** is a variable/constant/expression (7 or 8) that specifies the length of each data unit ("byte") to be received.

**parity** is an argument that specifies which type of parity to check for each received byte. If parity is used, the parity bit is expected to be the Most Significant Bit (MSB) of the data unit. The allowed values for **parity** are in the table below.

| <b>parity code</b> | <b>value</b> | <b>Meaning</b> |
|--------------------|--------------|----------------|
| <b>NOPAR</b>       | 0            | No parity      |
| <b>EVENPAR</b>     | 1            | Even parity    |
| <b>ODDPAR</b>      | 2            | Odd parity     |

**timeout** is a variable/constant/expression (0 – 65535) that tells **SERIN** how long to wait in mS for incoming data. If data does not arrive in time or if the buffer gets full before the timeout condition occurs, the function will return with the appropriate return code. The value of 0 is special; it indicates that the function will wait until it receives enough data to fill the buffer before it returns. The usage of timeouts applies to each data unit being received.

**buffer** is the name of the array of **BYTES** that the function will use as storage to return the received data to the calling function. This can be an array of length equal to 1 byte. The maximum length of the buffer is 255 bytes.

**Lbuffer** is the maximum number of bytes that can be placed in **buffer**. If fewer bytes are received than what can be placed in the buffer, the buffer gets filled from the low to high direction of its index address space (i.e. from 0 to **Lbuffer**-1).

On exit, the function returns one of the following exit codes.

| <b>return code</b>  | <b>value</b> | <b>Meaning</b>   |
|---------------------|--------------|--|
| <b>SERIN_ARGERR</b> | 0            | There was at least one error in the arguments of the function. |

| <i>return code</i>   | <i>value</i> | <i>Meaning</i>   |
|----------------------|--------------|--|
|                      |              | Function did not execute.  |
| <b>SERIN_BUFULL</b>  | 1            | Function returned with the buffer full of data.  |
| <b>SERIN_PARERR</b>  | 2            | A parity error occurred.<br><br>The highest index of buffer (Lbuffer-1) contains the index of the last byte that was received successfully before the error occurred. If this location contains the value 0xFF, it indicates that no data was received.                                  |
| <b>SERIN_TIMEOUT</b> | 3            | The function exited after a timeout condition occurred.<br><br>The highest index of buffer (Lbuffer-1) contains the index of the last byte that was received successfully before the timeout occurred. If this location contains the value 0xFF, it indicates that no data was received. |
| <b>SERIN_OVRERR</b>  | 4            | An overrun error occurred.<br><br>The highest index of buffer ( <b>Lbuffer</b> -1) contains the index of the last byte that was received successfully before the error occurred. If this location contains the value 0xFF, it indicates that no data was received.                       |

**EXAMPLE PROGRAM:**

```

#include "CS110000.h"

void main(void)
{
    NIBBLE RETURNED; // Declare variable RETURNED of type
                     // NIBBLE to store value returned by
                     // SERIN function
    BYTE buffer[10]; // Declare array buffer of type BYTE
                     // to store input from terminal
    // Declare array string1 of type BYTE to store the new
    // line character (\n) followed by the carriage return

```

```

// (\r) character and the string "Hello "
  BYTE string1[] = "\n\rHello ";
// Declare array string2 of type BYTE to store the new
// line character followed by the carriage return
// character and then the string "Enter your name
// (using ten characters total)"
  BYTE string2[] =
    "\n\rEnter your name (using ten characters total): ";

// Call function SEROUT
  SEROUT(0, 0, 9.6, 0, 8, 0, 0, string2, 48);
  PAUSE(100); // Pause for 100 milliseconds
// Call function SERIN to get data from terminal, store
// value returned in RETURNED
  RETURNED = SERIN(0, 0, 9.6, 8, 0, 0, buffer, 10);

// Check if SERIN function executed successfully
  if(RETURNED == 1){
    STPIND(42, HIGH); // Light LED attached to pin 42
  }
  PAUSE(100); // Pause for 100 milliseconds
// Call function SEROUT
  SEROUT(0, 0, 9.6, 0, 8, 0, 0, string1, 9);
  PAUSE(100); // Pause for 100 milliseconds
// Call function SEROUT
  SEROUT(0, 0, 9.6, 0, 8, 0, 0, buffer, 10);
  PAUSE(100); // Pause for 100 milliseconds

// Stop program, C Stamp enters low power mode
  END();
}

```

## SEROUT

```

NIBBLE SEROUT(BYTE fpin, BIT polarity, float baudrate,
               WORD pace, NIBBLE databits,
               NIBBLE parity, WORD timeout,
               BYTE buffer[], BYTE Lbuffer);

```

The **SEROUT** function transmits asynchronous serial data (e.g., RS-232 data) via the built-in asynchronous serial transmitter in the C Stamp (Pin 24). This is the same connection used to download programs to the C Stamp.

**fpin** is a variable/constant/expression that specifies the I/O pin on which to indicate flow control status. This pin will be set to input mode. If **fpin** is 0, no flow control will be used.

**polarity** is an argument that specifies how the **fpin** will be used in the cases that the user chooses to utilize flow control. The allowed values are **TRUE** and **FALSE**. If polarity is **TRUE**, a ONE or HIGH from the receiver will be interpreted as a request to send more data, and a ZERO or LOW will be interpreted as not to send more data and wait for the value of **fpin** to be ONE or HIGH again. If polarity is **FALSE**, a ZERO or LOW from the receiver will be interpreted as a request to send more data, and a ONE or HIGH will be interpreted as not to send more data and wait for the value of **fpin** to be ZERO or LOW again.

**baudrate** is a variable/constant/expression (4.8, 9.6, 19.2, 38.4, 57.6, 76.8, 96, 115.2, 300, 500, 625, 1250, or 2500) that specifies serial timing in 1000's of bits per second (Kbps).

**pace** is a variable/constant/expression (0 – 65535) that determines the length of the pause between transmitted data units (“bytes”) in mS. If **pace** is 0, there is no pause between sending data units. NOTE: **pace** cannot be used simultaneously with **timeout** and **fpin**.

**databits** is a variable/constant/expression (7 or 8) that specifies the length of each data unit (“byte”) to be sent. If 7 data bits are selected for transmission with no parity, a full byte will be sent with the MSB set to ZERO.

**parity** is an argument that specifies which type of parity to use for each sent byte. If parity is used, the parity bit is the MSB of the data unit. The allowed values for **parity** are in the table below.

| <b>parity code</b> | <b>value</b> | <b>Meaning</b> |
|--------------------|--------------|----------------|
| <b>NOPAR</b>       | 0            | No parity      |
| <b>EVENPAR</b>     | 1            | Even parity    |
| <b>ODDPAR</b>      | 2            | Odd parity     |

**timeout** is a variable/constant/expression (0 – 65535) that tells **SEROUT** how long to wait in mS for the receiver to request more data via **fpin** if flow control is used. If data is not requested before the timeout condition occurs, the function will return with the appropriate return code. The value of 0 is special; it indicates that the function will



wait indefinitely until it receives a data request from the receiver. The usage of timeouts applies to each data unit being sent.

**buffer** is the name of the array of **BYTES** that the function will send. This can be an array of length equal to 1 byte. The maximum length of the buffer is 255 bytes.

**Lbuffer** is the maximum number of storage bytes to be sent in the buffer. The buffer gets processed for transmission from the low to high direction of its index address space (i.e. from 0 to **Lbuffer**-1).

On exit, the function returns one of the following exit codes.

| <i>return code</i>    | <i>value</i> | <i>Meaning</i>  |
|-----------------------|--------------|---|
| <b>SEROUT_ARGERR</b>  | 0            | There was at least one error in the arguments of the function.<br><br>Function did not execute. |
| <b>SEROUT_BUFEMP</b>  | 1            | Function returned after transmitting all data in the buffer.                                    |
| <b>SEROUT_TIMEOUT</b> | 2            | The function exited after a timeout condition occurred. Not all data was sent.                  |

#### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    // Array string1 of type BYTE to store the string "ABC"
    // with a new line and carriage return character
    // following
    BYTE string1[] = "ABC\n\r";
    // Array string2 of type byte to store the string "DEF"
    // with a new line and carriage return character
    // following
    BYTE string2[] = "DEF\n\r";
    // Variable RESULT of type NIBBLE to store value
    // returned by SEROUT
    NIBBLE RESULT;

    // Call function SEROUT and store value returned in
```

```

// variable RESULT
    RESULT = SEROUT(0, 0, 9.6, 0, 8, 0, 0, string1, 5);

// Check that SEROUT function executed successfully
    if(RESULT == 1){
        STPIND(42, HIGH); // Light LED attached to pin 42
    }

// Call function SEROUT and store value returned in
// variable RESULT
    RESULT = SEROUT(0, 0, 9.6, 0, 8, 0, 0, string2, 5);

// Check that SEROUT function executed successfully
    if(RESULT == 1){
        STPIND(46, HIGH); // Light LED attached to pin 46
    }

    END(); // End program, C Stamp enters low power mode
}

```

## SERIN2

```

NIBBLE SERIN2(BYTE fpin, BIT polarity, float baudrate,
              NIBBLE databits, NIBBLE parity,
              WORD timeout, BYTE buffer[],
              BYTE Lbuffer, BYTE RXpin);

```

The **SERIN2** function receives asynchronous serial data via any I/O pin, except the built-in asynchronous serial transmitter (Pin 24) and receiver (Pin 25).

**fpin** is a variable/constant/expression that specifies the I/O pin on which to indicate flow control status. This pin will be set to output mode. If **fpin** is 0, no flow control will be used.

**polarity** is an argument that specifies how the **fpin** will be used in the cases that the user chooses to utilize flow control. The allowed values are **TRUE** and **FALSE**. If polarity is **TRUE**, a ONE or HIGH will be used as the value of **fpin** that will signal the sender to send more data, and a ZERO or LOW will be used as the value of **fpin** that will signal the sender not to send more data and wait for the value of **fpin** to be ONE or HIGH again. If polarity is **FALSE**, a ZERO or LOW will be used as the value of **fpin** that will signal the sender to send more data, and a ONE or HIGH will be used as the value of **fpin** that will signal the sender not to send more data and wait for the value of **fpin** to be ZERO or LOW again.

**baudrate** is a variable/constant/expression (4.8, 9.6, 19.2, 38.4, 57.6, 76.8, 96, or 115.2) that specifies serial timing in 1000's of bits per second (Kbps).

**databits** is a variable/constant/expression (7 or 8) that specifies the length of each data unit ("byte") to be received.

**parity** is an argument that specifies which type of parity to check for each received byte. If parity is used, the parity bit is expected to be the Most Significant Bit (MSB) of the data unit. The allowed values for **parity** are in the table below.

| <b>parity code</b> | <b>value</b> | <b>Meaning</b> |
|--------------------|--------------|----------------|
| <b>NOPAR</b>       | 0            | No parity      |
| <b>EVENPAR</b>     | 1            | Even parity    |
| <b>ODDPAR</b>      | 2            | Odd parity     |

**timeout** is a variable/constant/expression (0 – 65535) that tells **SERIN2** how long to wait in mS for incoming data. If data does not arrive in time or if the buffer gets full before the timeout condition occurs, the function will return with the appropriate return code. The value of 0 is special; it indicates that the function will wait until it receives enough data to fill the buffer before it returns. The usage of timeouts applies to each data unit being received.

**buffer** is the name of the array of **BYTES** that the function will use as storage to return the received data to the calling function. This can be an array of length equal to 1 byte. The maximum length of the buffer is 255 bytes.

**Lbuffer** is the maximum number of bytes that can be placed in **buffer**. If fewer bytes are received than what can be placed in the buffer, the buffer gets filled from the low to high direction of its index address space (i.e. from 0 to **Lbuffer**-1).

**RXpin** is a variable/constant/expression that specifies the I/O pin to be used as a receiver. This pin will be set to input mode. **RXpin** cannot be equal to **fpin**.

On exit, the function returns one of the following exit codes.

| <b>return code</b>  | <b>value</b> | <b>Meaning</b>   |
|---------------------|--------------|--|
| <b>SERIN_ARGERR</b> | 0            | There was at least one error in the arguments of the function. |

| <i>return code</i>   | <i>value</i> | <i>Meaning</i>   |
|----------------------|--------------|--|
|                      |              | Function did not execute.  |
| <b>SERIN_BUFULL</b>  | 1            | Function returned with the buffer full of data.  |
| <b>SERIN_PARERR</b>  | 2            | A parity error occurred.<br><br>The highest index of buffer (Lbuffer-1) contains the index of the last byte that was received successfully before the error occurred. If this location contains the value 0xFF, this indicates that no data was received.                                  |
| <b>SERIN_TIMEOUT</b> | 3            | The function exited after a timeout condition occurred.<br><br>The highest index of buffer (Lbuffer-1) contains the index of the last byte that was received successfully before the timeout occurred. If this location contains the value 0xFF, this indicates that no data was received. |
| <b>SERIN_OVRERR</b>  | 4            | An overrun error occurred.<br><br>The highest index of buffer ( <b>Lbuffer</b> -1) contains the index of the last byte that was received successfully before the error occurred. If this location contains the value 0xFF, this indicates that no data was received.                       |

## SEROUT2

```

NIBBLE SEROUT2(BYTE fpin, BIT polarity, float baudrate,
               WORD pace, NIBBLE databits,
               NIBBLE parity, WORD timeout,
               BYTE buffer[], BYTE Lbuffer,
               BYTE TXpin);

```

The **SEROUT2** function transmits asynchronous serial data via any I/O pin, except the built-in asynchronous serial transmitter (Pin 24) and receiver (Pin 25).

**fpin** is a variable/constant/expression that specifies the I/O pin on which to indicate flow control status. This pin will be set to input mode. If **fpin** is 0, no flow control will be used.

**polarity** is an argument that specifies how the **fpin** will be used in the cases that the user chooses to utilize flow control. The allowed values are **TRUE** and **FALSE**. If polarity is **TRUE**, a ONE or HIGH from the receiver will be interpreted as a request to send more data, and a ZERO or LOW will be interpreted as not to send more data and wait for the value of **fpin** to be ONE or HIGH again. If polarity is **FALSE**, a ZERO or LOW from the receiver will be interpreted as a request to send more data, and a ONE or HIGH will be interpreted as not to send more data and wait for the value of **fpin** to be ZERO or LOW again.

**baudrate** is a variable/constant/expression (4.8, 9.6, 19.2, 38.4, 57.6, 76.8, 96, or 115.2) that specifies serial timing in 1000's of bits per second (Kbps).

**pace** is a variable/constant/expression (0 – 65535) that determines the length of the pause between transmitted data units (“bytes”) in mS. If **pace** is 0, there is no pause between sending data units. NOTE: **pace** cannot be used simultaneously with **timeout** and **fpin**.

**databits** is a variable/constant/expression (7 or 8) that specifies the length of each data unit (“byte”) to be sent. If 7 data bits are selected for transmission with no parity, a full byte will be sent with the MSB set to ZERO.

**parity** is an argument that specifies which type of parity to use for each sent byte. If parity is used, the parity bit is the MSB of the data unit. The allowed values for **parity** are in the table below.

| <b>parity code</b> | <b>value</b> | <i>Meaning</i> |
|--------------------|--------------|----------------|
| <b>NOPAR</b>       | 0            | No parity      |
| <b>EVENPAR</b>     | 1            | Even parity    |
| <b>ODDPAR</b>      | 2            | Odd parity     |

**timeout** is a variable/constant/expression (0 – 65535) that tells **SEROUT2** how long to wait in mS for the receiver to request more data via **fpin** if flow control is used. If data is not requested before the timeout condition occurs, the function will return with the appropriate return code. The value of 0 is special; it indicates that the function will wait indefinitely until it receives a data request from the receiver. The usage of timeouts applies to each data unit being sent.

**buffer** is the name of the array of **BYTES** that the function will send. This can be an array of length equals to 1 byte. The maximum length of the buffer is 255 bytes.

**Lbuffer** is the maximum number of storage bytes to be sent in the buffer. The buffer gets processed for transmission from the low to high direction of its index address space (i.e. from 0 to **Lbuffer**-1).

**TXpin** is a variable/constant/expression that specifies the I/O pin to be used as a transmitter. This pin will be set to output mode. **TXpin** cannot be equal to **fpin**.

On exit, the function returns one of the following exit codes.

| <i>return code</i>    | <i>value</i> | <i>Meaning</i>  |
|-----------------------|--------------|---|
| <b>SEROUT_ARGERR</b>  | 0            | There was at least one error in the arguments of the function.<br><br>Function did not execute. |
| <b>SEROUT_BUFEMP</b>  | 1            | Function returned after transmitting all data in the buffer.                                    |
| <b>SEROUT_TIMEOUT</b> | 2            | The function exited after a timeout condition occurred. Not all data was sent.                  |

## SHIFTIN

```
WORD SHIFTIN(BYTE dpin, BYTE cpin, NIBBLE mode,  
               BYTE bits);
```

The **SHIFTIN** function shifts data in from a synchronous serial device and returns the received data.

The transfer data rate is about 65 Kbits/S.

**dpin** is a variable/constant/expression that specifies the I/O pin that will be connected to the synchronous serial device's data output. This pin will be set to input mode.

**cpin** is a variable/constant/expression that specifies the I/O pin that will be connected to the synchronous serial device's clock input. This pin will be set to output mode.

**mode** is a variable/constant/expression (0 – 3), or one of four predefined symbols, that tells **SHIFTIN** the order in which data bits are to be arranged and the relationship of clock pulses to valid data. The table below shows these relationships.

**bits** is a variable/constant/expression (1 – 16) specifying how many bits are to be input by **SHIFTIN**.

If the function is not successful, it returns **FALSE**.

| <i>Symbol</i>  | <i>Value</i> | <i>Meaning</i>                                    |
|----------------|--------------|---|
| <b>MSBPRE</b>  | 0            | Data is MSB-first; sample bits before clock pulse |
| <b>LSBPRE</b>  | 1            | Data is LSB-first; sample bits before clock pulse |
| <b>MSBPOST</b> | 2            | Data is MSB-first; sample bits after clock pulse  |
| <b>LSBPOST</b> | 3            | Data is LSB-first; sample bits after clock pulse  |

#### EXAMPLE PROGRAM:

```
#include    "CS110000.h"

void main(void)
{
    WORD GET_WORD = 0; // Variable GET_WORD of type WORD,
    // used to store value returned by SHIFTIN function
    // from a DM74165N 8-Bit Parallel In/Serial Output
    // Shift Register chip

    STPIND(12, HIGH); // Set pin 12 high to enable clock
                      // inhibit
    STPIND(13, HIGH); // Set Load/Shift to Shift
    PAUSE(5);         // Wait 5 milliseconds
    STPIND(13, LOW);  // Set Load/Shift to Load
    PAUSE(1);         // Wait 1 millisecond
    STPIND(13, HIGH); // Set Load/Shift to Shift
    PAUSE(1);         // Wait 1 millisecond
    STPIND(12, LOW);  // Turn off clock inhibit
    PAUSE(1);

    GET_WORD = SHIFTIN(10, 11, 0, 8); // Call function
    // SHIFTIN where the data is going to be received on
```

```
// pin 10, the clock is on pin 11 of eight bits long.
// Store the value in the variable GET_WORD

    if(GET_WORD == 0xAA){ // Check if GET_WORD is
// hexadecimal AA or binary 10101010
        STPIND(45, HIGH); // Turn on LED attached to pin 45
    }

    END(); // Stop program from looping, C Stamp enters
           // low power mode
}
```

## SHIFTOUT

**BIT SHIFTOUT**(**BYTE** *dpin*, **BYTE** *cpin*, **BIT** *mode*,  
**WORD** *outputdata*, **BYTE** *bits*);

The **SHIFTOUT** function shifts data out to a synchronous serial device.

The transfer data rate is about 65 Kbits/S.

**dpin** is a variable/constant/expression that specifies the I/O pin that will be connected to the synchronous serial device's data input. This pin will be set to output mode.

**cpin** is a variable/constant/expression that specifies the I/O pin that will be connected to the synchronous serial device's clock input. This pin will be set to output mode.

**mode** is a variable/constant/expression (0 – 1), or one of two predefined symbols, that tells **SHIFTOUT** the order in which data bits are to be arranged. The table below shows the values and symbols definitions.

**outputdata** is a variable/constant/expression containing the data to be sent.

**bits** is a variable/constant/expression (1 – 16) specifying how many bits are to be output by **SHIFTOUT**.

If the function is successful, it returns **TRUE**; otherwise it returns **FALSE**.

| <i>Symbol</i>   | <i>Value</i> | <i>Meaning</i>                |
|-----------------|--------------|-------------------------------|
| <b>LSBFIRST</b> | 0            | Data is shifted out LSB-first |
| <b>MSBFIRST</b> | 1            | Data is shifted out MSB-first |



**EXAMPLE PROGRAM:**

```
#include "CS110000.h"

void main(void)
{
    while(1) { // Continuous loop
        SHIFTOUT (10, 11, 1, 0xABCD, 16); // Call SHIFTOUT
        // function where pin 10 will be used as the data pin,
        // pin 11 used as the clock pin, the data will be
        // shifted 'Most Significant Bit' first, the data being
        // hexadecimal ABCD or binary 1010101111001101, and the
        // total number of bits being 16
    }
}
```

**SHIFTOUT2**

```
BIT SHIFTOUT2(BYTE dpin, BYTE cpin, BIT mode,
               WORD outputdata, BYTE bits);
```

The **SHIFTOUT2** function shifts data out to a synchronous serial device using a high impedance as a **HIGH** level in the data line.

The transfer data rate is about 65 Kbits/S.

**dpin** is a variable/constant/expression that specifies the I/O pin that will be connected to the synchronous serial device's data input. This pin is restricted to pins from the following list: 28, 29, 31 – 38.

**cpin** is a variable/constant/expression that specifies the I/O pin that will be connected to the synchronous serial device's clock input. This pin will be set to output mode.

**mode** is a variable/constant/expression (0 – 1), or one of two predefined symbols, that tells **SHIFTOUT2** the order in which data bits are to be arranged. The table below shows the values and symbols definitions.

**outputdata** is a variable/constant/expression containing the data to be sent.

**bits** is a variable/constant/expression (1 – 16) specifying how many bits are to be output by **SHIFTOUT2**.

If the function is successful, it returns **TRUE**; otherwise it returns **FALSE**.

| <i>Symbol</i>   | <i>Value</i> | <i>Meaning</i>                |
|-----------------|--------------|-------------------------------|
| <b>LSBFIRST</b> | 0            | Data is shifted out LSB-first |
| <b>MSBFIRST</b> | 1            | Data is shifted out MSB-first |

## SLEEP

**BIT SLEEP(WORD duration);**

The **SLEEP** function puts the C Stamp into low-power mode for a specified time, and then resumes program execution.

**duration** is a variable/constant/expression (1 – 65535) that specifies the duration of sleep. The unit of time for **duration** is 1 second.

If successful, the function returns **TRUE**; otherwise it returns **FALSE**.

### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    STPIND(42, HIGH); // Light LED attached to pin 42
    PAUSE(10000);     // Pause for 10 seconds
    STPIND(42, LOW);  // Turn off LED attached to pin 42
    SLEEP(1);         // Call function SLEEP to enter CSTAMP
                     // into sleep mode for 1 second
    TOGGLE(43);       // Toggle pin 43
}
```

## SPIIN

**BIT SPIIN(NIBBLE speed, BYTE inputdata[], BYTE n);**

The **SPIIN** function receives data in master mode from a device using the SPI™ protocol on the C Stamp SPI pins (Pin 28 for the SPI Clock, Pin 29 for the SPI Data In, and Pin 30 for the SPI Data Out). The SPI protocol is a form of high speed synchronous serial communication developed by Motorola Corporation. The I/O pins can be shared between multiple SPI devices. The Data In pin will be set to input mode, and the Clock and Data Out pins will be set to output mode. If the function is

successful, it returns **TRUE**; otherwise, it returns **FALSE**. This could mean that there was an error in the arguments of the function or some other problem.

Clock Polarity is such that idle state for the clock is a low level, transmit occurs on the transition from idle to active clock state, and input data is sampled at the end of the data output time.

**speed** is a variable/constant/expression (3 – 1) indicating the reception speed according to the table below.

| <i>Symbol</i> | <i>Value</i> | <i>Meaning</i>                         |
|---------------|--------------|--|
| <b>SPISH</b>  | 3            | Data is received at 10.0 Mbits/second  |
| <b>SPISM</b>  | 2            | Data is received at 2.5 Mbits/second   |
| <b>SPISL</b>  | 1            | Data is received at 625.0 Kbits/second |

**inputdata** is a **BYTE** array to put the received data. The array fills up from the low address 0 to the high address **n-1**.

**n** is a variable/constant/expression (1 – 255) indicating the capacity of **inputdata** in bytes.

## SPIOUT

**BIT SPIOUT(NIBBLE speed, BYTE outputdata[], BYTE n);**

The **SPIOUT** function sends data in master mode from a device using the SPI™ protocol on the C Stamp SPI pins (Pin 28 for the SPI Clock, Pin 29 for the SPI Data In, and Pin 30 for the SPI Data Out). The SPI protocol is a form of high speed synchronous serial communication developed by Motorola Corporation. The I/O pins can be shared between multiple SPI devices. The Data In pin will be set to input mode, and the Clock and Data Out pins will be set to output mode. If the function is successful, it returns **TRUE**; otherwise, it returns **FALSE**. This could mean that there was an error in the arguments of the function or some other problem.

Clock Polarity is such that idle state for the clock is a low level, transmit occurs on the transition from idle to active clock state, and input data is sampled at the end of the data output time.

**speed** is a variable/constant/expression (3 – 1) indicating the reception speed according to the table below.

| <i>Symbol</i> | <i>Value</i> | <i>Meaning</i>                     |
|---------------|--------------|------------------------------------|
| <b>SPISH</b>  | 3            | Data is sent at 10.0 Mbits/second  |
| <b>SPISM</b>  | 2            | Data is sent at 2.5 Mbits/second   |
| <b>SPISL</b>  | 1            | Data is sent at 625.0 Kbits/second |

**outputdata** is a **BYTE** array with the data to be sent. The array gets sent from the low address 0 to the high address **n-1**.

**n** is a variable/constant/expression (1 – 255) indicating the capacity of **outputdata** in bytes.

## sprintf

```
int sprintf(BYTE buf[], const BYTE format[], ...);
```

The **printf** function writes to **buf** the arguments that comprise the argument list as specified by the string **format**. The string **format** consists of two types of items. The first type is made up of characters that will be written to **buf**. The second type contains format commands that define the way the arguments are written. A format command begins with a percent sign and is followed by the format code. There must be exactly the same number of arguments as there are format commands, and the format commands and the arguments are matched in order. For example, this **sprintf** command

```
sprintf(mybuf, "Hi %c %d %s", 'U', 10, "there!");
```

writes "Hi U 10 there!" to **mybuf**.

If there are insufficient arguments with which to match the **format** commands, the contents of **buf** is undefined. If there are more arguments than format commands, then the remaining arguments are discarded. The format commands are shown here.

| <i>Code</i> | <i>Format Meaning</i>  |
|-------------|------------------------|
| <b>%c</b>   | Character              |
| <b>%d</b>   | Signed decimal integer |
| <b>%o</b>   | Unsigned octal         |

| <i>Code</i> | <i>Format Meaning</i>                    |
|-------------|--|
| <b>%s</b>   | String of characters                     |
| <b>%u</b>   | Unsigned decimal integers                |
| <b>%x</b>   | Unsigned hexadecimal (lowercase letters) |
| <b>%X</b>   | Unsigned hexadecimal (uppercase letters) |
| <b>%%</b>   | Writes a % sign                          |

The **sprintf** function returns the number of characters actually written. A negative return value indicates that an error has taken place.

The **format** commands may have modifiers that specify the field width, the number of decimal places, and a left justification flag. An integer placed between the % sign and the format command acts as a minimum field width specification. This pads the output with blanks or zeros to ensure that it is at least a certain minimum length. If the string or number is greater than the minimum, it will be written in full even if it outruns the minimum. The default padding is done with spaces. If you wish to pad with zeros place a 0 before the field width specification. For example, **%05d** will pad a number of less than 5 digits with zeros so its total length is five.

You can also place a decimal point followed by the number after the field width specification. For example **%5.7s** will write a string that will be at least five characters long and will not exceed seven characters. If the string is longer than the maximum field width, the excess characters will be truncated off of the end.

By default, all output is right-justified. If the field width is larger than all the data printed on the right edge of the field, the data will be placed on the right edge of the field. You can force the information to be left-justified by placing a minus sign directly after the %. For example, **%-10d** will left-justify an integer number in a ten character field.

If you precede the x format code with a #, the hexadecimal number will be written with a 0x prefix. If you precede the o format code with a #, the octal value will be written with a 0 prefix. The # cannot be applied to any other format specification.

The minimum field width and precision specifications may be provided by arguments to **sprintf** instead of by constants. To accomplish this, use an asterisk (\*) as a placeholder. When the format string is scanned, **sprintf** will match the \*s to the arguments in the order in which they occur.

## srand

**void srand(WORD seed);**

The **srand** function is used to set a starting point for the random sequence generated by **rand**.

## STOP

**void STOP(void);**

The **STOP** function stops program execution.

**STOP** prevents the C Stamp from executing any further instructions until it is reset. The following actions will reset the C Stamp: Reset line is activated or the power is cycled off and back on.

**STOP** does not put the C Stamp into low-power mode. The C Stamp draws just as much current as if it were actively running program instructions.

### EXAMPLE PROGRAM:

```
#include  "CS110000.h"

void main(void)
{
    BIT STARTBUTTON; // Declare variable STARTBUTTON of
                     // type BIT

    STARTBUTTON = BUTTON(37, LOW, HIGH, 5); // Use
// function BUTTON to see if the utility button at pin
// 37 has been pressed and store value returned in
// STARTBUTTON

    while(STARTBUTTON){ // Loop that begins when
                        // STARTBUTTON is TRUE (1)
        STPIND(42, HIGH); // Turns on the LED attached to
                        // pin 42

/* The STOP function stops the program from executing
any further but the CSTAMP will draw just as much power
as if a program was running. Nothing placed after a
STOP statement will be executed since the CSTAMP stops
the program once it encounters the STOP function. */
```

```

    STOP(); // STOP function is executed, program
           // stops.
    STPIND(46, HIGH); // This statement will never get
                     // executed
    STPIND(42, LOW);  // This statement will never get
                     // executed
}
}

```

## STPIND

**BIT STPIND(BYTE pin, BIT value);**

The **STPIND** function sets **pin** to digital output mode and to **value**. If the operation is successful, it returns a value of **TRUE**; otherwise, it returns a value of **FALSE**.

## STPINPU

**void STPINPU(void);**

The **STPINPU** function sets (enables) the built-in pull-up resistors available in the module (Pins 31 – 38).

## TOGGLE

**BIT TOGGLE(BYTE pin);**

The **TOGGLE** function inverts the state of an output pin.

**pin** is a variable/constant/expression that specifies on which I/O pin to switch logic state. This pin will be placed into output mode.

**TOGGLE** sets a pin to output mode and inverts the output state of the pin, changing 0 (**LOW**) to 1 (**HIGH**) and 1 (**HIGH**) to 0 (**LOW**).

If the function is successful, it returns **TRUE**; otherwise it returns **FALSE**.

### EXAMPLE PROGRAM:

```

#include  "CS110000.h"

void main(void)
{
    BIT ON; // Variable ON of type BIT to store value

```

```
// from utility button to determine if LED should be on
// or off.
```

```
    STPIN(43, HIGH); // Start with LED attached to pin
                      // 43 on
    while(1){
        ON = BUTTON(37, LOW, HIGH, 5); // Check if utility
        // button at pin 37 has been pressed and store value in
        // variable ON
        if(ON){ // If ON is TRUE (1)
            TOGGLE(43); // TOGGLE function toggles the value
            // of pin 43 (HIGH becomes LOW, LOW becomes HIGH)
        }
    }
}
```

## WCatan2

```
float WCatan2(float y, float x);
```

The **WCatan2** function returns the arc tangent of **y/x**. It uses the signs of its arguments to compute the quadrant of the return value.

### EXAMPLE PROGRAM:

```
#include "CS110000.h"

void main(void)
{
    float y; // Declare variable y of type float for use
              // in WCatan2 function
    float x; // Declare variable x of type float for use
              // in WCatan2 function
    float arctangent; // Declare variable arctangent of
    // type float to store value returned by the function
    // WCatan2
    float ans; // Variable ans used to store hand
               // calculated answer for example
    float ans_high; // Variable used to store the upper
                   // range for the answer
    float ans_low; // Variable used to store the lower
                  // range for the answer

    //Example
    y = -5.5;
```



```

    x = 2.75;
    arctangent = WCatan2(y, x); // function WCatan2 is
    // used to evaluate the arctangent of -5.5/2.75. The
    // value is then stored in the variable arctangent.

    ans = -1.10714; // An approximation of the answer
    // computed by hand is stored in the variable ans3.
    // Float variables can only hold six digits of
    // precision
    // this means that some approximations must be made

    /* Since our answer computed by hand is an
    approximation we will compare the value returned by the
    function WCatan2 as being greater than 99.9% of our
    hand calculated value and less than 100.1%. */

    ans_high = ans * 1.001; // ans_high stores 100.1% of
    // our estimate of the arctangent
    ans_low = ans * 0.999; // ans_low stores 99.9% of
    // our estimate of the arctangent

    /* Note: we want the value returned to be less than
    ans_low because we know the arctangent will be
    negative. Had it been positive we would have wanted the
    answer to be greater than ans_low.
    Similarly, arctangent should be greater than ans_high
    since arctangent is negative */

    if(arctangent < ans_low){ // Value returned by
    // WCatan2 less than 99.9% of believed
        if(arctangent > ans_high){ // Value returned by
        // WCatan2 greater than 100.1% of believed
            STPIND(41, HIGH); // If both are true turn on LED
                                // connected to pin 41
        }
    }

    END; // CSTAMP enters inactive, low power mode
        // Stops program from looping
}

WCCos

float WCCos(float num);

```

The **WCcos** function returns the cosine of the floating point number **num**. The value of **num** must be given in radians.

#### EXAMPLE PROGRAM:

```
#include    "CS110000.h"

void main(void)
{
    float ANGLE; // Variable NUMBER of type float to
// store the angle who's cosine will be determined
    float COSINE; // Variable COSINE of type float to
// store the value returned by the WCcos function
    float ANS; // Variable ANS of type float to store the
// hand calculated value of the cosine of ANGLE
    float ANS_HIGH; // Variable ANS_HIGH of type float to
// store the high limit for comparison
    float ANS_LOW; // Variable ANS_LOW of type float to
// store the low limit for comparison

//Example
    ANGLE = 27.384;
    ANS = -0.629152;
    COSINE = WCcos(ANGLE); // WCcos function returns the
// cosine of ANGLE which is stored in the variable
// COSINE
    ANS_HIGH = ANS * 1.01; // 101% of the value stored in
                           // ANS is stored in ANS_HIGH
    ANS_LOW = ANS * 0.99; // 99% of the value stored in
                           // ANS is stored in ANS_LOW

/* Since COSINE is not restricted to positive numbers
only the outer-most if-else pair is to determine if
COSINE is positive or negative. If it is positive it
goes through two more if-else pairs which test to make
sure that the expression ANS_LOW < COSINE < ANS_HIGH is
true. If COSINE is negative however, the two following
if-else pairs are used to determine if the expression
ANS_HIGH < COSINE < ANS_LOW is true. This is because a
number which is negative and with a larger magnitude
than another is considered to be the smaller number. */

    if(COSINE == WCFabs(COSINE)){ // If statement to test
// if COSINE is positive or negative COSINE is positive
        if(COSINE > ANS_LOW){ // If statement to test if
```

```

// the positive COSINE is greater than ANS_LOW
// ANS_LOW < COSINE
    if(COSINE < ANS_HIGH){ // If statement to test if
// the positive COSINE is less than ANS_HIGH
// COSINE in range (ANS_LOW < COSINE < ANS_HIGH)
        STPIND(39, HIGH); // Light LED attached to
                           // pin 39
    }
    else{
// COSINE out of range (ANS_HIGH < COSINE)
        STPIND(43, HIGH); // Light LED attached to
                           // pin 43
    }
}
else{
// COSINE out of range (COSINE < ANS_LOW)
    STPIND(43, HIGH); // Light LED attached to pin 43
}
}
else{
// COSINE is negative
    if(COSINE < ANS_LOW){ // If statement to test if
// the negative COSINE is less than ANS_LOW
// COSINE < ANS_LOW
        if(COSINE > ANS_HIGH){ // If statement to test if
// the negative COSINE is greather than ANS_HIGH
// COSINE in range (ANS_HIGH < COSINE < ANS_LOW)
            STPIND(39, HIGH); // Light LED attached to
                               // pin 39
        }
        else{
// COSINE out of range (COSINE < ANS_HIGH)
            STPIND(43, HIGH); // Light LED attached to
                               // pin 43
        }
    }
    else{
// COSINE out of range (COSINE > ANS_LOW)
        STPIND(43, HIGH); // Light LED attached to pin 43
    }
}
}

END(); // END function stops the program and puts the
      // CSTAMP into low power mode.
}

```

## WCfabs

```
float WCFabs(float num);
```

The **WCfab**s function returns the absolute value of the of the floating point number **num**.

## WCftoa

```
BYTE WCftoa(float num, BYTE buffer[]);
```

The **WCftoa** function converts the floating point number **num** into its ASCII string equivalent, and places the result in the **buffer**. The result is terminated with a null character '\0' (**BYTE** value 0).

The user must ensure that **buffer** has sufficient space or capacity in number of characters/**BYTES** to hold the converted result and the terminating null character.

The return value is equal to the number of characters actually placed into the buffer array excluding the null terminator.

## WCsin

```
float WCsine(float num);
```

The **WCsin** function returns the sine of the floating point number **num**. The value of **num** must be given in radians.

### EXAMPLE PROGRAM:

```
#include  "CS110000.h"

void main(void)
{
    float ANGLE; // Variable NUMBER of type float to
    // store the angle which sine will be determined
    float SINE; // Variable SINE of type float to store
    // the value returned by the WCsine function
    float ANS; // Variable ANS of type float to store the
    // hand calculated value of the sine of ANGLE
    float ANS_HIGH; // Variable ANS_HIGH of type float to
    // store the high limit for comparison
    float ANS_LOW; // Variable ANS_LOW of type float to
    // store the low limit for comparison
```

```

//Example
ANGLE = 27.384;
ANS = 0.777281;
SINE = WCsine(ANGLE); // WCsine function returns the
// sine of ANGLE which is stored in the variable SINE
ANS_HIGH = ANS * 1.0001; // 100.01% of the value
// stored in ANS is stored in ANS_HIGH
ANS_LOW = ANS * 0.9999; // 99.99% of the value stored
// in ANS is stored in ANS_LOW

/* Since SINE is not restricted to positive numbers
only the outer-most if-else pair is to determine if
SINE is positive or negative. If it is positive it goes
through two more if-else pairs which test to make sure
that the expression ANS_LOW < SINE < ANS_HIGH is true.
If SINE is negative however, the two following if-else
pairs are used to determine if the expression
ANS_HIGH < SINE < ANS_LOW is true. This is because a
number which is negative and with a larger magnitude
than another is considered to be the smaller number. */

    if(SINE == WCsine(SINE)){ // If statement to test if
// SINE is positive or negative
// SINE is positive
        if(SINE > ANS_LOW){ // If statement to test if the
// positive SINE is greater than ANS_LOW
// ANS_LOW < SINE
            if(SINE < ANS_HIGH){ // If statement to test if
// the positive SINE is less than ANS_HIGH
// SINE in range (ANS_LOW < SINE < ANS_HIGH)
                STPIND(39, HIGH); // Light LED attached to
                                // pin 39
            }
        }
    }
    else{
// SINE out of range (ANS_HIGH < SINE)
        STPIND(43, HIGH); // Light LED attached to
                        // pin 43
    }
}
else{
// SINE out of range (SINE < ANS_LOW)
    STPIND(43, HIGH); // Light LED attached to pin 43
}
}
else{

```

```

// SINE is negative
    if(SINE < ANS_LOW){ // If statement to test if the
// negative SINE is less than ANS_LOW
// SINE < ANS_LOW
        if(SINE > ANS_HIGH){ // If statement to test if
// the negative SINE is greather than ANS_HIGH
// SINE in range (ANS_HIGH < SINE < ANS_LOW)
            STPIND(39, HIGH); // Light LED attached to
                                // pin 39
        }
    }
    else{
// SINE out of range (SINE < ANS_HIGH)
        STPIND(43, HIGH); // Light LED attached to
                            // pin 43
    }
}
else{
// SINE out of range (SINE > ANS_LOW)
    STPIND(43, HIGH); // Light LED attached to pin 43
}
}

END(); // END function stops the program and puts the
        // CSTAMP into low power mode.
}

```

## WCsqrt

**float WCsqrt(float num);**

The **WCsqrt** function returns the square root of the floating point number **num**. The value of **num** must not be negative.

### EXAMPLE PROGRAM:

```

#include  "CS110000.h"

void main(void)
{
    float NUMBER; // Variable NUMBER of type float, used
// to store the number to be square rooted
    float SQRT; // Variable SQRT of type float, used to
// store the value returned by the WCsqrt function
    float ANS; // Variable ANS of type float,
                // Pre-calculated answer

```

```

float ANS_HIGH; // Variable ANS_HIGH of type float,
                // high limit of range
float ANS_LOW;  // Variable ANS_LOW of type float,
                // low limit of range

NUMBER = 3 * PI / 4; // Set NUMBER to 3 * PI / 4
                    // where PI is defined as 3.1416
ANS = 1.53499;
SQRT = WCsqrt(NUMBER);
ANS_HIGH = ANS * 1.000001; // ANS_HIGH is set to
                          // 100.0001% of ANS
ANS_LOW = ANS * 0.999999; // ANS_LOW is set to
                          // 99.9999% of ANS
if(SQRT < ANS_HIGH){ // Check if SQRT is less than
                    // ANS_HIGH
    if(SQRT > ANS_LOW){ // Check if SQRT is greater
                      // than ANS_LOW
        STPIND(40, HIGH); // Turn on LED connected to
                          //pin 40
    }
    else{
        STPIND(44, HIGH); // Turn on LED connected to
                          // pin 44
    }
}
else{
    STPIND(44, HIGH); // Turn on LED connected to
                      // pin 44
}
}
END(); // Stops the program from looping, CSTAMP
      // enters low power mode
}

```

## WRITE

**BIT WRITE(WORD location, BYTE value);**

The **WRITE** function writes **value** into **location** in data EEPROM.

The user must ensure that the **location** value is within the bounds of the existing data EEPROM address space (0 – 1023). If successful, the function returns **TRUE**; otherwise it returns **FALSE**.

### EXAMPLE PROGRAM:

```

#include "CS110000.h"

void main(void)
{
    BIT SUCCESSFUL; // Declare variable SUCCESSFUL of
                    // type bit

    SUCCESSFUL = WRITE(0000, 0x64); // Call function
    // WRITE to store the hexadecimal value 64 in the
    // EEPROM at location '0000'. WRITE returns TRUE if it
    // is successful and FALSE if it fails, this is then
    // stored in the variable SUCCESSFUL
    if(SUCCESSFUL){ // Check to see if the WRITE was
                    // successful
        STPIND(42, HIGH); // Light LED attached to pin 42
    }

    END(); // End program execution, C Stamp enters low
          // power mode
}

```

## Wtoa

```
void Wtoa(WORD W, BYTE a[], BYTE radix);
```

The **Wtoa** function converts the **WORD W** into its string equivalent with leading zeros and capital letters, and places the result in the **BYTE** array **a**. The base of the output string is determined by **radix**, which may be 2, 10, or 16.

Be sure to call **Wtoa** with an array **a** of sufficient length to hold the converted result.



## Accessory Specific Functions and Commands Reference

This chapter describes the functions and commands that are specific to the software support of different types of accessories that are available from A-WIT Technologies to complement the function and projects developed with the C Stamp. The user should consult the manual for a specific accessory for full information on connectivity and usage.

### LCD\_CMD\_CS410000

```
BIT LCD_CMD_CS410000(BYTE command, BYTE B0, BYTE B1,
                      BYTE B2, BYTE B3, BYTE B4,
                      BYTE B5, BYTE B6, BYTE B7);
```

The **LCD\_CMD** function sends a command to the CS410000 LCD display according to the table below. If the function is successful, it returns **TRUE**; otherwise, it returns **FALSE**. This could mean that there was an error in the arguments of the function or some other problem.

**command** is a variable/constant/expression (1 – 17) indicating the LCD command to send.

**B0 – B7** are bytes variables/constants/expressions that are used by different commands. Not all bytes are used by all commands. If a byte is not used by a command, any value can be passed to the function (e.g. **ZERO**), and it will be ignored. However, something must be passed in all the arguments. If the usage of a byte is not specified in the table below, it means that byte is not used and is ignored by the function.

| <i>Symbol</i> | <i>Value</i> | <i>Command</i> | <i>Description</i> |
|---------------|--------------|----------------|--------------------|
|---------------|--------------|----------------|--------------------|

| <i>Symbol</i>      | <i>Value</i> | <i>Command</i>              | <i>Description</i>   |
|--------------------|--------------|-----------------------------|--|
| <b>LCD_HOME</b>    | 1            | Cursor Home                 | Sets the cursor to the home position (top left).   |
| <b>LCD_SETC</b>    | 2            | Set Cursor (1 – 80)         | Set cursor to a position specified by <b>B0</b> , where 1 is the top left and 80 is the bottom right.        |
| <b>LCD_SETCLC</b>  | 3            | Set Cursor (line, column)   | Sets cursor using two bytes, where <b>B0</b> is the line and <b>B1</b> is the column.                        |
| <b>LCD_HIDECLC</b> | 4            | Hide Cursor                 | Stops the position cursor from appearing on the display.   |
| <b>LCD_UNDLCLC</b> | 5            | Show Underline Cursor       | Changes the cursor to the underline type.  |
| <b>LCD_BLNKCLC</b> | 6            | Show Blinking Cursor        | Changes the cursor to the blinking type.   |
| <b>LCD_BACKS</b>   | 7            | Backspace                   | Deletes the preceding character from the current position on the display.                                    |
| <b>LCD_HTAB</b>    | 8            | Horizontal Tab (by Tab Set) | Moves the current position across by the tab space set by command <b>LCD_SETTA</b> (default tab space is 4). |
| <b>LCD_SLF</b>     | 9            | Smart Line Feed             | Moves the cursor down one line to the position beneath it in the same column.                                |
| <b>LCD_VTAB</b>    | 10           | Vertical Tab                | Moves the cursor up one line to the position above it in the same column.                                    |
| <b>LCD_CLRS</b>    | 11           | Clear Screen                | Clears the screen and sets the cursor to the home position.  |
| <b>LCD_CR</b>      | 12           | Carriage Return             | Moves the cursor to the start of the next line.  |
| <b>LCD_CLRC</b>    | 13           | Clear Column                | Clears the contents of the current column and moves the cursor right by one column.                          |

| <i>Symbol</i>     | <i>Value</i> | <i>Command</i>           | <i>Description</i>  |
|-------------------|--------------|--------------------------|---|
| <b>LCD_SETTA</b>  | 14           | Tab Set                  | Sets the tab size to <b>B0</b> . <b>B0</b> can be a size between 1 and 10.  |
| <b>LCD_BLON</b>   | 15           | Backlight On             | Turns the backlight of the LCD on.  |
| <b>LCD_BLOFF</b>  | 16           | Backlight Off (default)  | Turns the backlight of the LCD off.   |
| <b>LCD_CCHAR</b>  | 17           | Custom Character         | Sends one of 8 possible custom characters to the LCD to be used later. <b>B0 – B7</b> define the custom character. See below.                                 |
| <b>LCD_DCCHAR</b> | 18           | Display Custom Character | Displays a custom character at the current cursor position. <b>B0</b> has a value 0 – 7 that specifies which one of the custom characters is to be displayed. |

Up to 8 custom characters can be stored in the LCD for subsequent usage by sending an 8 byte map in bytes **B0 – B7** with the LCD command **LCD\_CCHAR**. The example below shows how to define a byte map for a custom character.

| Byte | Char # | Bits of B0 – B7  |   |   |          |   |   |   |   | Byte in Binary | Byte in Hex |
|------|--------|------------------|---|---|----------|---|---|---|---|----------------|-------------|
|      |        | Char # in Binary |   |   | Char Map |   |   |   |   |                |             |
| B0   | 2      | 0                | 1 | 0 | 0        | 0 | 0 | 0 | 0 | 0100 0000      | 0x40        |
| B1   | 2      | 0                | 1 | 0 | 0        | 0 | 1 | 0 | 0 | 0100 0100      | 0x44        |
| B2   | 2      | 0                | 1 | 0 | 0        | 1 | 1 | 1 | 0 | 0100 1110      | 0x4E        |
| B3   | 2      | 0                | 1 | 0 | 1        | 0 | 1 | 0 | 1 | 0101 0101      | 0x55        |
| B4   | 2      | 0                | 1 | 0 | 0        | 0 | 1 | 0 | 0 | 0100 0100      | 0x44        |
| B5   | 2      | 0                | 1 | 0 | 0        | 0 | 1 | 0 | 0 | 0100 0100      | 0x44        |
| B6   | 2      | 0                | 1 | 0 | 0        | 0 | 1 | 0 | 0 | 0100 0100      | 0x44        |

| Byte | Char # | Bits of B0 - B7  |   |   |          |   |   |   |   | Byte in Binary | Byte in Hex |
|------|--------|------------------|---|---|----------|---|---|---|---|----------------|-------------|
|      |        | Char # in Binary |   |   | Char Map |   |   |   |   |                |             |
| B7   | 2      | 0                | 1 | 0 | 0        | 0 | 0 | 0 | 0 | 0100 0000      | 0x40        |

The bytes **B0 - B7** defined above would store an up-arrow as custom character # 2. To store this character in the LCD, we would call **LCDCMD** as:

```
result = LCDCMD_CS410000(LCD_CCHAR, 0x40, 0x44, 0x4E,
                          0x55, 0x44, 0x44, 0x44,
                          0x40);
```

Checking the result of calling the function is optional, although it is a good programming practice. Also, decimal values could be sent for **B0 - B7**, instead of hexadecimal; so an alternative way of calling **LCDCMD** is:

```
LCDCMD_CS410000(LCD_CCHAR, 64, 68, 78, 85, 68, 68, 68,
                 64);
```

Then to display this character at the current cursor position, we would call:

```
result = LCDCMD_CS410000(LCD_DCCHAR, 2, 0, 0, 0, 0, 0,
                          0, 0);
```

or

```
LCDCMD_CS410000(LCD_DCCHAR, 2, 0, 0, 0, 0, 0, 0, 0);
```

## LCDIN\_CS410000

```
NIBBLE LCDIN_CS410000(void);
```

The **LCDIN** function receives data from the CS410000 LCD display. This command supports the feature of the CS410000 LCD to host a standard 3 x 4 Matrix keypad, like the CS410001. **LCDIN** returns the number corresponding to the key that is being pressed in the keypad (0 – 9, 10 for the \* key, and 11 for the # key). If there is an error, the function returns 12.

## LCDOUT\_CS410000

```
BIT LCDOUT_CS410000(BYTE string[], BYTE n);
```

The **LCDOUT** sends ASCII bytes to the CS410000 LCD for displaying. Displaying of these characters will start at the current cursor position. If the function is successful, it returns **TRUE**; otherwise, it returns **FALSE**.

**string** is an array of the ASCII bytes to be displayed.

**n** is a variable/constant/expression that specifies how many bytes are in **string**.

## COMPASSIN\_CS420000

```
NIBBLE COMPASSIN_CS420000(BYTE Npin, BYTE Epin,  
                           BYTE Spin, BYTE Wpin);
```

The **COMPASSIN** function returns a direction by querying a CS420000 Digital Compass Sensor that is connected to the C Stamp.

**Npin** is a variable/constant/expression that specifies the I/O pin that is connected to the North Signal of the compass. This pin will set to input mode.

**Epin** is a variable/constant/expression that specifies the I/O pin that is connected to the East Signal of the compass. This pin will set to input mode.

**Spin** is a variable/constant/expression that specifies the I/O pin that is connected to the South Signal of the compass. This pin will set to input mode.

**Wpin** is a variable/constant/expression that specifies the I/O pin that is connected to the West Signal of the compass. This pin will set to input mode.

On exit, the function returns one of the following exit codes.

| <i>return code</i>     | <i>value</i> | <i>Meaning</i>   |
|------------------------|--------------|--|
| <b>COMPASSIN_ERROR</b> | 0            | There was at least one error while executing the function. |
| <b>COMPASSIN_N</b>     | 1            | Direction is North.  |
| <b>COMPASSIN_NE</b>    | 2            | Direction is Northeast.                                    |
| <b>COMPASSIN_E</b>     | 3            | Direction is East.   |
| <b>COMPASSIN_SE</b>    | 4            | Direction is Southeast.                                    |
| <b>COMPASSIN_S</b>     | 5            | Direction is South.  |

| <i>return code</i>  | <i>value</i> | <i>Meaning</i>          |
|---------------------|--------------|-------------------------|
| <b>COMPASSIN_SW</b> | 6            | Direction is Southwest. |
| <b>COMPASSIN_W</b>  | 7            | Direction is West.      |
| <b>COMPASSIN_NW</b> | 8            | Direction is Northwest. |

## EXREAD\_CS450000

**BYTE EXREAD\_CS450000(WORD location);**

The **EXREAD** function reads the value at **location** in the CS450000 EEPROM and returns the result.

**location** is a variable/constant/expression that specifies the CS450000 EEPROM address to read from.

The user must ensure that the **location** value is within the bounds of the CS450000 EEPROM address space and that the chip is selected.

## EXWRITE\_CS450000

**BIT EXWRITE\_CS450000(WORD location, BYTE value);**

The **EXWRITE** function writes **value** into **location** in the CS450000 EEPROM.

The user must ensure that the **location** value is within the bounds of the CS450000 EEPROM address space, and that the chip is selected and not write protected. If successful, the function returns **TRUE**; otherwise it returns **FALSE**.

## TEMPSIN\_CS452000

**float TEMPSIN\_CS452000(NIBBLE A, NIBBLE scale);**

The **TEMPSIN** function returns the temperature read by the Temp Sensor. If the function is not successful, it returns the value of 500, which is outside the range of measurable temperature by the sensor in any of the available formats. This could mean that there was an error in the arguments of the function or some other problem.

**A** is a variable/constant/expression (0 – 7) indicating the binary address assigned to the Temp Sensor by connecting its  $A_2 - A_0$  address inputs to appropriate logic levels.

**scale** is a variable/constant/expression that indicates the scale for the returned temperature value according to the table below.

| <i>Symbol</i>  | <i>Value</i> | <i>Temperature Scale</i> |
|----------------|--------------|--------------------------|
| <b>TEMPS_C</b> | 1            | Degrees Celsius          |
| <b>TEMPS_F</b> | 2            | Degrees Fahrenheit       |
| <b>TEMPS_K</b> | 3            | Degrees Kelvin           |

## TEMPSST\_CS452000

```
BIT TEMPSST_CS452000(NIBBLE A, float TH, float TL,
                      NIBBLE scale, BIT active_level,
                      BIT LP);
```

The **TEMPSST** sets up the thermostat alarm function of the Temp Sensor, or to set it to inactive low power mode. If the function is successful, it returns **TRUE**; otherwise, it returns **FALSE**.

**A** is a variable/constant/expression (0 – 7) indicating the binary address assigned to the Temp Sensor by connecting its  $A_2 - A_0$  address inputs to appropriate logic levels.

**TH** is a variable/constant/expression that specifies the High Temperature value of the thermostat function.

**TL** is a variable/constant/expression that specifies the Low Temperature value of the thermostat function.

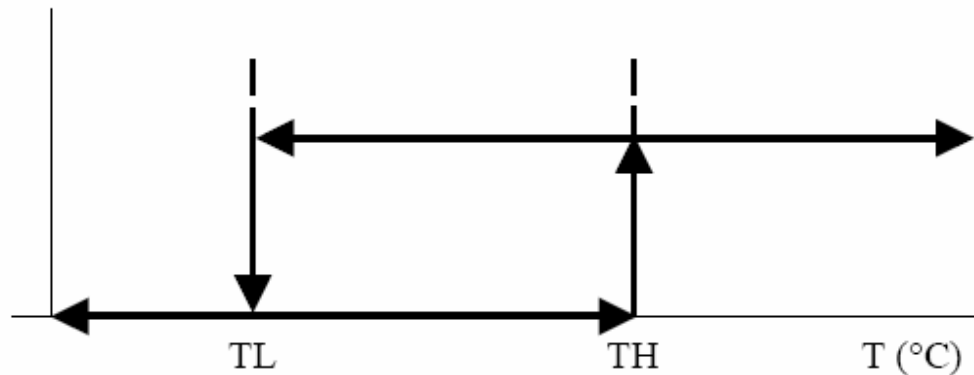
**scale** is a variable/constant/expression that indicates the temperature scale for both **TH** and **TL** according to the table below.

| <i>Symbol</i>  | <i>Value</i> | <i>Temperature Scale</i> |
|----------------|--------------|--------------------------|
| <b>TEMPS_C</b> | 1            | Degrees Celsius          |
| <b>TEMPS_F</b> | 2            | Degrees Fahrenheit       |
| <b>TEMPS_K</b> | 3            | Degrees Kelvin           |

**active\_level** is a variable/constant/expression that specifies the active state for the output  $T_{OUT}$ . An active state may either be a logic "1" (VDD) or a logic "0" (0V). Typically, **active\_level** is set **HIGH** for activating a cooling device at **TH** degrees and **LOW** for activating a heating device at **TL** degrees.

**LP** is a variable/constant/expression that sets the Temp Sensor in inactive low power mode. If **LP** is **TRUE**, all other arguments are ignored, and the Temp Sensor is set to inactive low power mode. If **LP** is **FALSE**, then the thermostat function is set using the rest of the arguments. The function always needs to receive a value for each argument, so if it is being used to set the Temp Sensor in inactive low power mode, **ZERO**'s or any other values should be passed for the non **LP** arguments.

Even though **TH** and **TL** can be specified in any of the three available temperature scales, these values are rounded internally to the nearest  $\frac{1}{2}$  °C. When the Temp Sensor's temperature meets or exceeds the **TH** value, the  $T_{OUT}$  output pin of the Temp Sensor becomes active and will stay active until the temperature falls below the temperature **TL**. In this way, any amount of hysteresis may be obtained. This is shown in the figure below for the case where both **TH** and **TL** are specified in °C's, and the active level of  $T_{OUT}$  is specified as **HIGH**.



## DPOTSET\_CS458000

```
void DPOTSET_CS458000(float value);
```

The **DPOTSET** function sets the resistance of the CS458000 Digital POT from terminal W to terminal B to **value**, or to the closest one supported by the device. The resistance from the W terminal to A, will then be: (total resistance of the POT – **value**).

**value** is a variable/constant/expression that specifies the resistance value.



If **value** is a negative number, the Digital POT will be put into a power-saving mode. In this mode, the A terminal is open-circuited and the B and W terminals are shorted together. Once the potentiometer has entered the shutdown mode, it will remain in this mode until a new valid **value** is written to the potentiometer.

The user must ensure that the chip is selected.

## RADIOCMD\_CS470000

```
BYTE RADIOCMD_CS470000(NIBBLE command,
                        WORD Wparameter, BYTE RXpin,
                        BYTE TXpin);
```

The **RADIOCMD** function sends a command to the CS470000 RF Module according to the table below. If the function is successful, it returns a non zero number depending on the command; otherwise, it returns zero. This could mean that there was an error in the arguments of the function or some other problem.

**command** is a variable/constant/expression (1 – 3) indicating the RADIO command to send.

**Wparameter** is a word variable/constant/expression that is used by different commands. This parameter is not used by all the commands. If the parameter is not used by a command, any value can be passed to the function (e.g. **ZERO**), and it will be ignored. However; something always must be passed in all the arguments. If the usage of the parameter is not specified in the table below, then it is not used and ignored by the function.

**RXpin** is a variable/constant/expression that specifies the I/O pin to be used as a receiver. This pin will be set to input mode.

**TXpin** is a variable/constant/expression that specifies the I/O pin to be used as a transmitter. This pin will be set to output mode.

| <b>command</b><br><i>Symbol</i> | <i>Value</i> | <i>Command</i>                | <i>Description</i>   |
|---------------------------------|--------------|-------------------------------|--|
| <b>RF_DB</b>                    | 1            | Receive<br>Signal<br>Strength | Returns the signal strength (in decibels) of the last received packet.<br><br>Range: 37 - 106                        |
| <b>RF_DT</b>                    | 2            | Destination<br>Address        | Sets the address that identifies the module's address and the destination of the RF packet. The address is specified |

| <b>command<br/>Symbol</b> | <b>Value</b> | <b>Command</b> | <b>Description</b>  |
|---------------------------|--------------|----------------|---|
|                           |              |                | by <b>Wparameter</b> , and it can be any value from 0x0 to 0xFFFF in hexadecimal, or from 0 to 65535 in decimal. The factory default for the RF Module address is 0x0 in hex. Only radio modems having matching addresses can communicate with each other. If successful, this command returns 200.                             |
| <b>RF_MK</b>              | 3            | Address Mask   | Sets the address mask to configure local and global address space. The address mask is specified by <b>Wparameter</b> , and it can be any value from 0x0 to 0xFFFF in hexadecimal, or from 0 to 65535 in decimal. The factory default for the RF Module address mask is 0xFFFF in hex. If successful, this command returns 200. |

Destination Addresses and Masks provide the means to set up global or local addresses for establishing module groups, subnets, etc. The Destination Address network layer provides for more granular isolation of radio modems. The Destination Addresses and Masks can be used to:

- Set up point-to-point and point-to-multipoint network configurations
- Provide greater flexibility in establishing module groups, subnets, etc.

Each radio modem in a network can be configured with a 16-bit Destination Address to establish selective communications within a network. This address is set to one of 65535 values using the **RF\_DT** (Destination Address) Command. The default Destination Address is 0.

All radio modems with the same Destination Address can transmit and receive data among themselves. Radio modems having different Destination Addresses still detect and listen to the data (in order to maintain network synchronization); however, the data is discarded rather than passing on through the DO pin.

CS470000 Radio Modems are packet based. This means that all data shifted into one module is packetized and sent out the antenna port. Because these RF modules use a peer-to-peer architecture, all modules will receive the packet and decide whether to pass it to the host or to throw it away. Each transmitted packet contains information about the transmitting module.

Any module that receives a packet will check the address values and decide what to do with the packet. The options are as follows:

- Receive the packet as a global packet
- Receive the packet as a local packet
- Discard the packet

The mask parameter can be used to allow a base module to receive data from a range of addresses. It may also be used to configure "subnets" of modules that communicate in a group together.

The RF Module uses the bit-wise "AND" operation to qualify the Destination Addresses and Address Masks. This operation is performed bit by bit on each of the 16 bits in the Destination Address and Address Mask parameters. The table below shows the Bit-Wise AND Truth Table.

| <i>Bit-Wise AND Operation</i> |                      |                 |
|-------------------------------|----------------------|-----------------|
| <b>Operand 1</b>              | <b>AND Operand 2</b> | <b>= Result</b> |
| 0                             | 0                    | 0               |
| 0                             | 1                    | 0               |
| 1                             | 0                    | 0               |
| 1                             | 1                    | 1               |

The Address Mask can be used as an additional method of facilitating communications between modules. The Address Mask can be set to one of 65535 possible values using **RF\_MK** (Address Mask) Command. The default value of the **RF\_MK** Parameter is 0xFFFF.

All transmitted data packets contain the Destination Address of the transmitting module. When a transmitted packet is received by a module, the Destination Address of the transmitter (contained in the packet) is logically "ANDed" (bitwise) with the

Address Mask of the Receiver. If the resulting value matches the Destination Address of the Receiver, or if it matches the Receiver Address Mask, the packet is accepted. Otherwise, the packet is discarded.

Note: When performing this comparison, any “0” values in the Receiver Address Mask are treated as irrelevant and are ignored.

For example, suppose that two RF modules are setup as follows. RF Module 1 has a Destination Address of 0x1 and an Address Mask of 0xFFFF, and RF Module 2 has a Destination Address of 0x1 and an Address Mask of 0x000F. In this case RF Module 1 will always transmit to RF module 2, but it will receive from any module with any Destination Address. RF Module 2; however, will also transmit to RF Module 1, but it will only receive from modules with Destination Addresses from 0 through 15 (0x0 through 0xF in hex). This range, of course, includes RF Module 1.

## RADIOIN\_CS470000

```
NIBBLE RADIOIN_CS470000(WORD timeout, BYTE buffer[],  
                           BYTE Lbuffer, BYTE RXpin);
```

The **RADIOIN** function receives asynchronous serial data from the CS470000 RF Module via any I/O pin, except the built-in asynchronous serial transmitter (Pin 24) and receiver (Pin 25), and the ATN pin (Pin 26).

**timeout** is a variable/constant/expression (0 – 65535) that tells **RADIOIN** how long to wait in mS for incoming data. If data does not arrive in time or if the buffer gets full before the timeout condition occurs, the function will return with the appropriate return code. The value of 0 is special; it indicates that the function will wait until it receives enough data to fill the buffer before it returns. The usage of timeouts applies to each data byte being received.

**buffer** is the name of the array of **BYTES** that the function will use as storage to return the received data to the calling function. This can be an array of length equals to 1 byte, and the maximum length of the buffer is 255 bytes.

**Lbuffer** is the maximum number of bytes that can be placed in **buffer**. If fewer bytes are received than what can be placed in the buffer, the buffer gets filled from the low to high direction of its index address space (i.e. from 0 to **Lbuffer**-1).

**RXpin** is a variable/constant/expression that specifies the I/O pin to be used as a receiver. This pin will be set to input mode.

On exit, the function returns one of the following exit codes.

| <i>return code</i> | <i>value</i> | <i>Meaning</i> |
|--------------------|--------------|----------------|
|--------------------|--------------|----------------|

| <i>return code</i>  | <i>value</i> | <i>Meaning</i>  |
|---------------------|--------------|---|
| <b>RFIN_ARGERR</b>  | 0            | There was at least one error in the arguments of the function.<br><br>Function did not execute.   |
| <b>RFIN_BUFULL</b>  | 1            | Function returned with the buffer full of data.   |
| <b>RFIN_TIMEOUT</b> | 2            | The function exited after a timeout condition occurred.<br><br>The highest index of buffer ( <b>Lbuffer-1</b> ) contains the index of the last byte that was received successfully before the timeout occurred. If this location contains the value 0xFF, this indicates that no data was received. |
| <b>RFIN_OVRERR</b>  | 3            | An overrun error occurred.<br><br>The highest index of buffer ( <b>Lbuffer-1</b> ) contains the index of the last byte that was received successfully before the error occurred. If this location contains the value 0xFF, this indicates that no data was received.                                |

## RADIOOUT\_CS470000

```
BIT RADIOOUT_CS470000(BYTE buffer[], BYTE Lbuffer,  
                        BYTE TXpin);
```

The **RADIOOUT** function transmits asynchronous serial data to the CS470000 RF Module via any I/O pin, except the built-in asynchronous serial transmitter (Pin 24) and receiver (Pin 25), and the ATN pin (Pin 26).

**buffer** is the name of the array of **BYTES** that the function will send. This can be an array of length equals to 1 byte, and the maximum length of the buffer is 255 bytes.

**Lbuffer** is the maximum number of storage bytes to be sent in the buffer. The buffer gets processed for transmission from the low to high direction of its index address space (i.e. from 0 to **Lbuffer-1**).

**TXpin** is a variable/constant/expression that specifies the I/O pin to be used as a transmitter. This pin will be set to output mode.

On exit, the function returns one of the following exit codes.

| <i>return code</i>  | <i>value</i> | <i>Meaning</i>  |
|---------------------|--------------|---|
| <b>RFOUT_ARGERR</b> | 0            | There was at least one error in the arguments of the function.<br><br>Function did not execute. |
| <b>RFOUT_BUFEMP</b> | 1            | Function returned after transmitting all data in the buffer.                                    |

## BLUECMD\_CS47100X

```
BIT BLUECMD_CS47100X(BYTE command, WORD Wparameters[],
                     BYTE RXpin, BYTE TXpin,
                     WORD Wresponses[],
                     BYTE Sparameter[]);
```

The **BLUECMD** function sends a command to the CS47100X Bluetooth Module according to the tables below. If the function is successful, it returns **TRUE**; otherwise, it returns **ZERO**. This could mean that there was an error in the arguments of the function or some other problem.

**command** is a variable/constant/expression (1 – 17) indicating the BLUETOOTH command to send.

**Wparameters** is a 4 WORD array that is used by different commands. This parameter is not used by all the commands. If the parameter is not used by a command, any value can be passed to the function (e.g. **ZERO**), and it will be ignored. However; something always must be passed in all the arguments. If the usage of the parameter is not specified in the tables below, then it is not used and ignored by the function.

**RXpin** is a variable/constant/expression that specifies the I/O pin to be used as a receiver. This pin will be set to input mode.

**TXpin** is a variable/constant/expression that specifies the I/O pin to be used as a transmitter. This pin will be set to output mode.

**Wresponses** is a 3 WORD array that is used by different commands. This array is not used by all the commands. If the array is not used by a command, any value can be passed to the function (e.g. **ZERO**), and it will be ignored. However; something always

must be passed in all the arguments. If the usage of the array is not specified in the tables below, then it is not used and ignored by the function.

**Sparameter** is a string array of 16 alpha-numeric characters that is used by different commands. This parameter is not used by all the commands. If the parameter is not used by a command, any value can be passed to the function (e.g. **ZERO**), and it will be ignored. However; something always must be passed in all the arguments. If the usage of the parameter is not specified in the tables below, then it is not used and ignored by the function.

| <i>Command Categories</i> |             |              |                       |
|---------------------------|-------------|--------------|-----------------------|
| <i>Command Category</i>   |             | <i>Value</i> | <i>command Symbol</i> |
| RESET                     |             | 1            | <b>BT_SWRST</b>       |
|                           |             | 2            | <b>BT_HWRST</b>       |
| BLUETOOTH                 | Mode        | 3            | <b>BT_MODE</b>        |
|                           | Status      | 4            | <b>BT_CANCEL</b>      |
|                           |             | 5            | <b>BT_SCAN</b>        |
|                           |             | 6            | <b>BT_SCANT</b>       |
|                           |             | 7            | <b>BT_SCANA</b>       |
|                           | Connection  | 8            | <b>BT_CLAST</b>       |
|                           |             | 9            | <b>BT_CA</b>          |
|                           |             | 10           | <b>BT_REL</b>         |
|                           | Information | 11           | <b>BT_ALAST</b>       |
|                           |             | 12           | <b>BT_SIGSTR</b>      |
|                           | Security    | 13           | <b>BT_KEY</b>         |
|                           |             | 14           | <b>BT_STKEY</b>       |
|                           |             | 15           | <b>BT_STAUTH</b>      |

| <i>Command Categories</i> |               |              |                       |
|---------------------------|---------------|--------------|-----------------------|
| <i>Command Category</i>   |               | <i>Value</i> | <i>command Symbol</i> |
|                           | Miscellaneous | 16           | <b>BT_STLP</b>        |
|                           |               | 17           | <b>BT_NAME</b>        |

| <i>command Symbol</i> | <i>Value</i> | <i>Command</i>     | <i>Description</i>   |
|-----------------------|--------------|--------------------|--|
| <b>BT_SWRST</b>       | 1            | Software Reset     | <p>This has the same effects as power cycling the unit.</p> <p>This command disconnects any connected Bluetooth devices, and stops ongoing tasks.</p> <p>After rebooting, the status will be decided by the preset operation mode.</p>                                 |
| <b>BT_HWRST</b>       | 2            | Hardware Reset     | All parameters are initialized to factory defaults.  |
| <b>BT_MODE</b>        | 3            | Set Operating Mode | <p>Operating Mode is set to the one given by <b>Wparameters[0]</b>.</p> <p><b>Wparameters[0] = 0:</b><br/>MODE 0, (Default)</p> <p><b>Wparameters[0] = 1:</b><br/>MODE 1</p> <p><b>Wparameters[0] = 2:</b><br/>MODE 2</p> <p><b>Wparameters[0] = 3:</b><br/>MODE 3</p> |



| <b>command<br/>Symbol</b> | <b>Value</b> | <b>Command</b>  | <b>Description</b>  |
|---------------------------|--------------|---|---|
| <b>BT_CANCEL</b>          | 4            | Terminate the Current Task  | This terminates the current task being executed, such as Inquiry scan and Page scan.  |
| <b>BT_SCAN</b>            | 5            | Wait for Inquiry and Connection From Other Bluetooth Devices                      | <p>This allows Inquiry and Connection from the other Bluetooth devices.</p> <p>When connection is made the BD address of the connected device is returned in the <b>Wresponses</b> array as follows:</p> <p><b>Wresponses[0] =</b><br/>Left most 4 digits of the BD Address</p> <p><b>Wresponses[1] =</b><br/>Middle 4 digits of the BD Address</p> <p><b>Wresponses[2] =</b><br/>Right most 4 digits of the BD Address</p> |
| <b>BT_SCANT</b>           | 6            | Wait for Inquiry and Connection From Other Bluetooth Devices for a Given Duration | <p>The module waits for <b>Wparameters[1]</b> seconds for Inquiry and Connection from other Bluetooth devices. If the <b>Wparameters[1]</b> is 0, the module waits forever.</p> <p><b>Wparameters[0] = 1:</b><br/>Allows Inquiry Scan</p> <p><b>Wparameters[0] = 2:</b><br/>Allows Page Scan</p> <p><b>Wparameters[0] = 3:</b><br/>Allows both Inquiry and Page Scan</p>  |

| <b>command<br/>Symbol</b> | <b>Value</b> | <b>Command</b>   | <b>Description</b>   |
|---------------------------|--------------|--|--|
|                           |              |  | <p>When connection is made the BD address of the connected device is returned in the <b>Wresponses</b> array as follows:</p> <p><b>Wresponses[0] =</b><br/>Left most 4 digits of the BD Address</p> <p><b>Wresponses[1] =</b><br/>Middle 4 digits of the BD Address</p> <p><b>Wresponses[2] =</b><br/>Right most 4 digits of the BD Address</p>  |
| <b>BT_SCANA</b>           | 7            | Wait for Connection by the Bluetooth Device with the Given Bluetooth Device (BD) Address | <p>The module waits for <b>Wparameters[3]</b> seconds to be connected to by the Bluetooth device with the given BD address. If <b>Wparameters[3]</b> is 0, the module waits forever.</p> <p><b>Wparameters[0] =</b><br/>Left most 4 digits of the BD Address</p> <p><b>Wparameters[1] =</b><br/>Middle 4 digits of the BD Address</p> <p><b>Wparameters[2] =</b><br/>Right most 4 digits of the BD Address</p> |
| <b>BT_CLAST</b>           | 8            | Connect to the Last Connected Bluetooth Device   | <p>The CS47100X devices save the BD Address of the Bluetooth device that was last connected to it.</p> <p>When connection is made the BD address of the connected device is returned in the <b>Wresponses</b> array as</p>   |

| <b>command<br/>Symbol</b> | <b>Value</b> | <b>Command</b>   | <b>Description</b>  |
|---------------------------|--------------|--|---|
|                           |              |  | <p>follows:</p> <p><b>Wresponses[0] =</b><br/>Left most 4 digits of the BD Address</p> <p><b>Wresponses[1] =</b><br/>Middle 4 digits of the BD Address</p> <p><b>Wresponses[2] =</b><br/>Right most 4 digits of the BD Address</p>  |
| <b>BT_CA</b>              | 9            | Connect to a Specific Bluetooth Device with a Given BD Address | <p>The CS47100X attempts to connect to the Bluetooth device with the given BD address. To make a successful connection, the Bluetooth device must be in Page scan mode. This attempt continues for 5 minutes.</p> <p><b>Wparameters[0] =</b><br/>Left most 4 digits of the BD Address</p> <p><b>Wparameters[1] =</b><br/>Middle 4 digits of the BD Address</p> <p><b>Wparameters[2] =</b><br/>Right most 4 digits of the BD Address</p> |
| <b>BT_REL</b>             | 10           | Release the Current Connection                                 | The current Bluetooth connection is disconnected. It takes about 30 seconds to detect an abnormal disconnection such as power off or moving out of service range.   |
| <b>BT_ALAST</b>           | 11           | Returns the BD Address of the Last Connected Device            | The CS47100X devices return the BD Address of the Bluetooth device that was last connected to it. This is   |

| <b>command<br/>Symbol</b> | <b>Value</b> | <b>Command</b>       | <b>Description</b>   |
|---------------------------|--------------|----------------------|--|
|                           |              |                      | <p>returned in the <b>Wresponses</b> array.</p> <p><b>Wresponses[0]</b> =<br/>Left most 4 digits of the BD Address</p> <p><b>Wresponses[1]</b> =<br/>Middle 4 digits of the BD Address</p> <p><b>Wresponses[2]</b> =<br/>Right most 4 digits of the BD Address</p>   |
| <b>BT_SIGSTR</b>          | 12           | Test Signal Strength | <p>When a Bluetooth connection is established, you can use this command to query the module for the signal strength. This is returned in the <b>Wresponses</b> array.</p> <p><b>Wresponses[0]</b> =<br/>LinkQuality with range [0, 255]. Higher is better.</p> <p><b>Wresponses[1]</b> =<br/>RSSI (interference) with range [0, 255]. Lower is better.</p> <p>If the LinkQuality is close to 255, and the RSSI is close to 0, it implies that the signal strength is good.</p> |
| <b>BT_KEY</b>             | 13           | Change Pin Code      | <p>Pin code is a string in the <b>Sparameter</b> array, which allows up to 16 alpha-numeric characters. Based on this pin code, the CS47100X generates a link key which is used in the actual authentication process.</p> <p>The default code is “1234”.</p>   |

| <b>command<br/>Symbol</b> | <b>Value</b> | <b>Command</b>   | <b>Description</b>  |
|---------------------------|--------------|--|---|
| <b>BT_STKEY</b>           | 14           | Set Generation of Link Key Every Time a Connection Is Made | <p>If <b>Wparameters[0]</b> is set to 1, the CS47100X asks for the pin code every time a connection is made. This can be used to increase security.</p> <p>If <b>Wparameters[0]</b> is set to 0, this feature is deactivated.</p>   |
| <b>BT_STAUTH</b>          | 15           | Set Authentication and Data Encryption                     | <p>Authentication is set with <b>Wparameters[0]</b>.</p> <p><b>Wparameters[0] = 0:</b><br/>Inactive (Default)</p> <p><b>Wparameters[0] = 1:</b><br/>Active</p> <p>Encryption is set with <b>Wparameters[1]</b>.</p> <p><b>Wparameters[1] = 0:</b><br/>Inactive (Default)</p> <p><b>Wparameters[1] = 1:</b><br/>Active</p>                           |
| <b>BT_STLP</b>            | 16           | Set Low Power Mode   | <p>If <b>Wparameters[0]</b> is set to 1, Low Power Mode is enabled.</p> <p>If <b>Wparameters[0]</b> is set to 0, this feature is deactivated.</p> <p>When activated, and while data is not being transmitted or received, the CS47100X goes into low power mode to save power. It takes a few seconds to wake the CS47100X from low power mode.</p> |

| <b>command<br/>Symbol</b> | <b>Value</b> | <b>Command</b>     | <b>Description</b>  |
|---------------------------|--------------|--------------------|---|
| <b>BT_NAME</b>            | 17           | Change Device Name | The CS47100X can have a user friendly name for easy identification. The name is allowed to be up to 30 alpha-numeric characters, and is passed in the <b>Sparameter</b> character array.<br><br>The default is "PSDv3b-445566". |

## BLUEIN\_CS47100X

```
NIBBLE BLUEIN_CS47100X(WORD timeout, BYTE buffer[],  
                        BYTE Lbuffer, BYTE RXpin);
```

The **BLUEIN** function receives asynchronous serial data from the CS47100X Bluetooth Module via any I/O pin, except the built-in asynchronous serial transmitter (Pin 24) and receiver (Pin 25), and the ATN pin (Pin 26).

**timeout** is a variable/constant/expression (0 – 65535) that tells **BLUEIN** how long to wait in mS for incoming data. If data does not arrive in time or if the buffer gets full before the timeout condition occurs, the function will return with the appropriate return code. The value of 0 is special; it indicates that the function will wait until it receives enough data to fill the buffer before it returns. The usage of timeouts applies to each data byte being received.

**buffer** is the name of the array of **BYTES** that the function will use as storage to return the received data to the calling function. This can be an array of length equals to 1 byte, and the maximum length of the buffer is 255 bytes.

**Lbuffer** is the maximum number of bytes that can be placed in **buffer**. If fewer bytes are received than what can be placed in the buffer, the buffer gets filled from the low to high direction of its index address space (i.e. from 0 to **Lbuffer-1**).

**RXpin** is a variable/constant/expression that specifies the I/O pin to be used as a receiver. This pin will be set to input mode.

On exit, the function returns one of the following exit codes.

| <b>return code</b> | <b>value</b> | <b>Meaning</b>                                       |
|--------------------|--------------|--|
| <b>BTIN_ARGERR</b> | 0            | There was at least one error in the arguments of the |

| <i>return code</i>  | <i>value</i> | <i>Meaning</i>  |
|---------------------|--------------|---|
|                     |              | function.<br>Function did not execute.  |
| <b>BTIN_BUFULL</b>  | 1            | Function returned with the buffer full of data.   |
| <b>BTIN_TIMEOUT</b> | 2            | The function exited after a timeout condition occurred.<br><br>The highest index of buffer ( <b>Lbuffer</b> -1) contains the index of the last byte that was received successfully before the timeout occurred. If this location contains the value 0xFF, this indicates that no data was received. |
| <b>BTIN_OVRERR</b>  | 3            | An overrun error occurred.<br><br>The highest index of buffer ( <b>Lbuffer</b> -1) contains the index of the last byte that was received successfully before the error occurred. If this location contains the value 0xFF, this indicates that no data was received.                                |

## BLUEOUT\_CS47100X

```
BIT BLUEOUT_CS47100X(BYTE buffer[], BYTE Lbuffer,  
BYTE TXpin);
```

The **BLUEOUT** function transmits asynchronous serial data to the CS47100X Bluetooth Module via any I/O pin, except the built-in asynchronous serial transmitter (Pin 24) and receiver (Pin 25), and the ATN pin (Pin 26).

**buffer** is the name of the array of **BYTES** that the function will send. This can be an array of length equals to 1 byte, and the maximum length of the buffer is 255 bytes.

**Lbuffer** is the maximum number of storage bytes to be sent in the buffer. The buffer gets processed for transmission from the low to high direction of its index address space (i.e. from 0 to **Lbuffer**-1).

**TXpin** is a variable/constant/expression that specifies the I/O pin to be used as a transmitter. This pin will be set to output mode.

On exit, the function returns one of the following exit codes.

| <i>return code</i> | <i>value</i> | <i>Meaning</i>  |
|--------------------|--------------|---|
| <b>BT_ARGERR</b>   | 0            | There was at least one error in the arguments of the function.<br><br>Function did not execute. |
| <b>BT_BUFEMP</b>   | 1            | Function returned after transmitting all data in the buffer.                                    |

## HUMSIN\_CS490000

```
float HUMSIN_CS490000(BYTE Dpin, BYTE Cpin,
                      NIBBLE command, NIBBLE format);
```

The **HUMSIN** function returns a measurement of Relative Humidity, Temperature, Dew Point. If the function is not successful, it returns the value of 500, which is outside the range of any measurement by the sensor in any of the available formats. This could mean that there was an error in the arguments of the function or some other problem.

**Dpin** is a variable/constant/expression that specifies the I/O pin to be used as the DATA pin.

**Cpin** is a variable/constant/expression that specifies the I/O pin to be used as the SCK pin. This pin will be set to output mode.

**command** is a variable/constant/expression (1 – 3) indicating the measurement to get from the sensor.

| <i>Command Symbol</i> | <i>Value</i> | <i>Description</i>   |
|-----------------------|--------------|--|
| <b>HUMS_REH</b>       | 1            | Returns the Relative Humidity.<br><br>Range: 0% – 100%   |
| <b>HUMS_TMP</b>       | 2            | Returns the Temperature in the scale given by <b>format</b> .<br><br>Range: -40 – 123.8 °C, or |



| <i><b>Command<br/>Symbol</b></i> | <i><b>Value</b></i> | <i><b>Description</b></i>  |
|----------------------------------|---------------------|--|
|                                  |                     | Range: -40 – 254.9 °F, or<br>Range: 233.15 – 396.95 °K   |
| <b>HUMS_DPT</b>                  | 3                   | Returns the Dew Point Temperature in the scale given by <b>format</b> .<br><br>Range: -40 – 123.8 °C, or<br><br>Range: -40 – 254.9 °F, or<br><br>Range: 233.15 – 396.95 °K |

**format** is a variable/constant/expression that indicates the format for the returned Temperature or Dew Point value according to the table below. This argument is not used if the measurement requested is Relative Humidity. In this case, any value can be passed to the function (e.g. **ZERO**), and it will be ignored. However; something always must be passed in all the arguments.

| <i><b>Symbol</b></i> | <i><b>Value</b></i> | <i><b>Temperature Scale</b></i> |
|----------------------|---------------------|---------------------------------|
| <b>TEMPS_C</b>       | 1                   | Degrees Celsius                 |
| <b>TEMPS_F</b>       | 2                   | Degrees Fahrenheit              |
| <b>TEMPS_K</b>       | 3                   | Degrees Kelvin                  |

## Terms and Conditions

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### **90-Day Limited Warranty**

A-WIT Technologies, Inc warrants its products against defects in materials and workmanship for a period of 90 days. If you discover a defect, A-WIT Technologies, Inc. will, at its option, repair, replace, or refund the purchase price. After 90 days, products can still be sent in for repair or replacement, but there will be a \$10.00USD minimum inspection/labor/repair fee (not including return shipping and handling charges).

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Please contact our Sales Department at [sales@a-wit.com](mailto:sales@a-wit.com) if you have any questions regarding our warranty policy or if you are requesting an RMA number.

