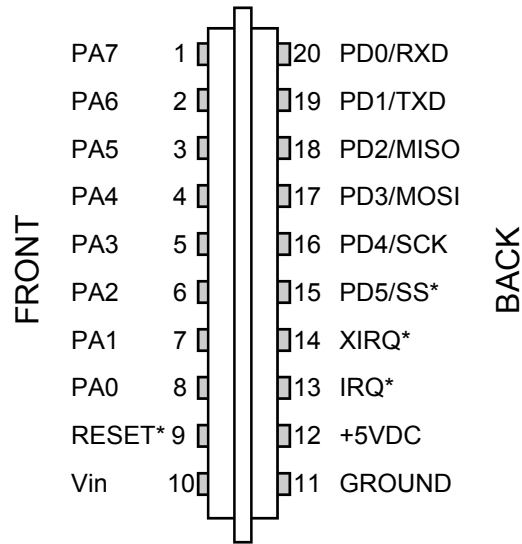


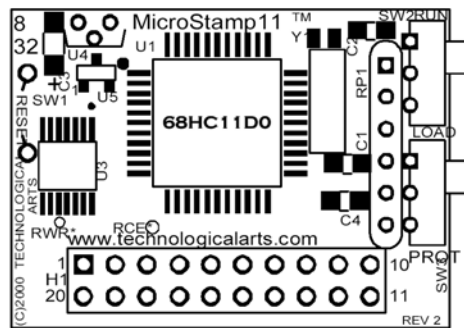
APPENDIX B

Pinouts for SB Connector Option



"BIRD'S-EYE" VIEW

Note: * indicates 'active low'



FRONT VIEW

1 INTRODUCTION

1.1 Thank you...

Congratulations on purchasing **MicroStamp11**, the world's smallest 68HC11 microcontroller module! From model rocketry to microrobotics, the applications are endless! We'd love to have you tell us about your application. Consider joining our Support Forum for networking with other customers using our 68HC11-based products. Visit www.microstamp11.com for more information. Your questions and comments are always welcome. We provide friendly, knowledgeable technical support via email and the Support Forum to all our customers. As well, we have a comprehensive Resource page on our website, offering product information, software, code examples, application notes, and links to useful sites on the Internet. Visit www.microstamp11.com.

1.2 What is MicroStamp11™?

MicroStamp11 is a complete working stamp-sized computer based on Motorola's popular MC68HC11 microcontroller. It is a fully functional, standalone implementation of an expanded-mode 68HC11 configuration, and can be plugged, just like a chip, into your solderless breadboard. Then you simply wire up the desired application circuits write your program, and download it into **MicroStamp11**'s memory from your PC serial port, using the **MicroStamp11 Docking Module**. Even with the power off, your program stays in **MicroStamp11**'s memory. If you make some changes to your program, just download the new file— the old one is automatically overwritten.

1.3 Product Description

MicroStamp11 comes with on-board EEPROM program memory (8K or 32K, depending on the version you purchased). Using the RS232 interface provided by the Docking Module (or a ComStamp232), **MicroStamp11**'s memory is directly loadable via your PC serial port (i.e. ComPort) for quick and easy programming. For newer PCs which have only USB ports, you'll need a USB-to-Comport adapter, such as our USB2COM product, available from most computer stores.

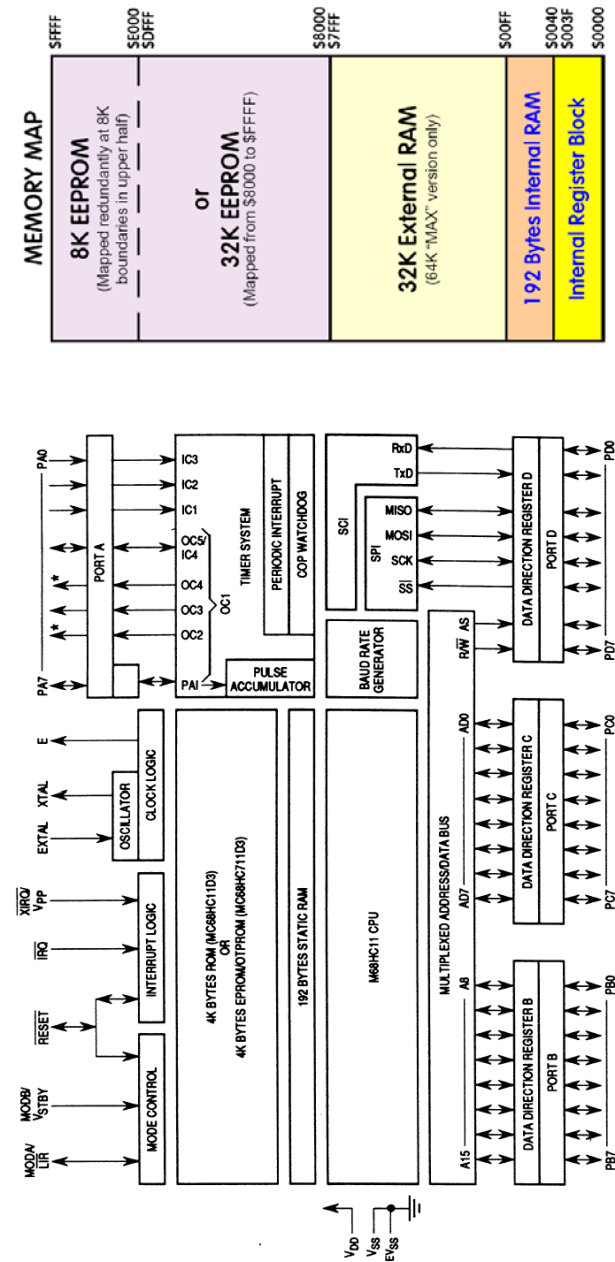
1.4 Description of Product Configurations

MicroStamp11 is based on the 68HC11D0 MCU, with 192 bytes of RAM on-chip. This MCU has no internal program memory, and therefore operates in expanded-chip mode, with 16 of its pins acting as a multiplexed address/data bus to interface to external memory, along with a couple more pins for control. An industry-standard 32K EEPROM is mapped to the upper half of the 64K memory map. In configurations which have only 8K EEPROM, the 8K block appears redundantly, at each 8K boundary in the upper half of the memory map. A “64K” version with an additional 32K RAM “piggy-backed” on top of the 32K EEPROM chip is also available. The RAM is mapped in the lower half of the 68HC11’s memory map, with “holes” in the memory map for the internal RAM and register block. Each of the above configurations is also offered in a “Turbo” version, operating with a 9.8304 MHz crystal. Among its advantages are: a 23% speed increase, up to 38.4Kbaud serial communications rate, and a speedier bootloading process.

MicroStamp11 satisfies the needs of users who want lots of memory, but only require a modest number of I/O lines, and no analog-to-digital converter (analog-to-digital converters and extra I/O lines are very easy to add via SPI, however). With the 68HC11’s hardware timer subsystem, implementing motor control, tone generation, pulse-width modulation, pulse-width measurement, and communication are just a few examples of what is easily achievable. Because of the 68HC11’s powerful hardware interrupt system, all of the above functions can be easily multi-tasked, and achieved in real-time. This is a very important advantage over popular PIC-based modules, which are basically “one-trick ponies” (albeit, fast ones)! There is a lot more software overhead and complexity involved in getting a PIC to do multiple simultaneous tasks, and respond to multiple asynchronous events. In fact, PIC-based modules in the same price range as MicroStamp11 are simply not able to match the real-time control and multi-tasking capability of **MicroStamp11**.

1.5 Serial Ports

An RS-232-compatible 3-wire serial interface port (RX, TX, and Ground) is built into the MicroStamp11 Docking Module, allowing communication with a PC, or any other device which has an RS-232 serial port. The logic-level RXD and TXD signals from the MCU are



MEMORY MAP

68HC11D0 INTERNAL BLOCK DIAGRAM

	Bit 7	6	5	4	3	2	1	Bit 0	
\$0000	PA7	PA6	PA5	PA4	PA3	PA2	PA1	PA0	PORTA
\$0001									Reserved
\$0002			CWOM						PIOC
\$0003	PC7	PC6	PC5	PC4	PC3	PC2	PC1	PC0	PORTC
\$0004	PB7	PB6	PB5	PB4	PB3	PB2	PB1	PB0	PORTB
\$0005									Reserved
\$0006	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	DDRB
\$0007	DDC7	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0	DDRC
\$0008	PD7	PD6	PD5	PD4	PD3	PD2	PD1	PD0	PORTD
\$0009	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	DDRD
\$000A									Reserved
\$000B	FOC1	FOC2	FOC3	FOC4	FOC5	0	0	0	CFORC
\$000C	OC1M7	OC1M6	OC1M5	OC1M4	OC1M3	0	0	0	OC1M
\$000D	OC1D7	OC1D6	OC1D5	OC1D4	OC1D3	0	0	0	OC1D
\$000E	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	TCNT
\$000F	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
\$0010	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	TIC1
\$0011	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
\$0012	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	TIC2
\$0013	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
\$0014	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	TIC3
\$0015	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
\$0016	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	TOC1
\$0017	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
\$0018	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	TOC2
\$0019	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
\$001A	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	TOC3
\$001B	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
\$001C	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	TOC4
\$001D	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
\$001E	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	TI405
\$001F	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
\$0020	FPMP	OLP	OLM	OLN	OLP	OLM	OLN	OL5	TCTL1

\$0021	EDG4B	EDG4A	EDG1B	EDG1A	EDG2B	EDG2A	EDG3B	EDG3A	TCTL2
\$0022	OC11	OC21	OC31	OC41	MO51	IC11	IC21	IC31	TMSK1
\$0023	OC1F	OC2F	OC3F	OC4F	MO5F	IC1F	IC2F	IC3F	TFLG1
\$0024	TO1	RT11	PAOV1	PA11	0	0	PR1	PR0	TMSK2
\$0025	TOF	RTF	PAMOVF	PA1F	0	0	0	0	TFLG2
\$0026	DDRA7	PAEN	PAMOD	PEUGE	DDRA3	I4/05	RTR1	RTR0	PACTL
\$0027	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	PACNT
\$0028	SPIE	SPE	DWOM	MSTR	CPOL	CPHA	SPR1	SPR0	SPCR
\$0029	SPIF	WCOL	0	MODF	0	0	0	0	SPSR
\$002A	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	SPDR
\$002B	TCLR	0	SCP1	SCP0	RCKB	SCR2	SCR1	SCR0	BAUD
\$002C	R8	T8	0	M	WAKE	0	0	0	SCCR1
\$002D	TIE	TCIE	RIE	ILIE	TE	RE	RWU	SBK	SCCR2
\$002E	TDRE	TC	RDRF	IDLE	OR	NF	FE	0	SCSR
\$002F	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	SCDR
\$0030									Reserved
\$0038									Reserved
\$0039	0	0	IRQE	DLY	CME	0	CR1	CR0	OPTION
\$003A	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	COPRST
\$003B	MBE	0	ELAT	EXCOL	EXROW	0	0	PGM	PPROG*
\$003C	RBOOT	SMOD	MDA	IRVNE	PSEL3	PSEL2	PSEL1	PSEL0	HPRIO
\$003D	RAM3	RAM2	RAM1	RAM0	REG3	REG2	REG1	REG0	INIT
\$003E	TILOP	EPTST	OCCR	CBYP	DISR	FCM	FCDP	0	TEST1
\$003F	0	0	0	0	0	NOCCP	EPON**	0	CONFIG

* — Not present in ROM-based MC68HC11D3
 ** — ROMON in MC68HC11D3

68HC11D0 REGISTER BIT SUMMARY

available on **MicroStamp11's** connector, for applications such as RS-485 or MIDI. Of course, if your application doesn't need communication, these two pins can be configured as general purpose I/O lines. For applications where the Docking Module is too big to be practical, a miniature RS232 interface board called COMStamp232 is available. Check www.microstamp11.com for details.

The 68HC11's industry-standard Serial Peripheral Interface (SPI) provides an excellent means of expanding the capabilities of MicroStamp11 to suit more demanding applications. There are many SPI-compatible chips available, including analog-to-digital converters, serial EEPROMs, UARTs, display drivers, and shift registers, to name just a few. Examples for interfacing these devices can be found on the Resources page of www.microstamp11.com.

1.6 The Big Picture

With **MicroStamp11**, all of the 68HC11's available I/O lines and control signals are brought out to a standard 20-pin interface connector. With several different connector options available, you can use the module in whatever way best suits your needs.

A female right-angle connector (option -FRA) is supplied as the default option for the MicroStamp11 supplied in the Starter Package. With the adapter supplied (ADIDC20-M), you can use the module like a big chip, plugging it right into your breadboard. A ribbon cable is supplied so that you can keep MicroStamp11 in the Docking Module during development, and plug its I/O pins into the breadboard via the ribbon cable/adaptor combination. Forget soldering or wire-wrapping—get started developing your application right away. Your prototyping space is virtually unlimited, using solderless breadboards! Once you have your design working and you're ready to move to something more permanent, you can incorporate one of the supplied mating connectors into your design, and just plug MicroStamp11 into it. MicroStamp11 becomes a sort of modular "brain" that you can plug into many different projects you develop.

2 USING MICROSTAMP11 WITH SOLDERLESS BREADBOARDS

As mentioned previously, the standard connector style on your **MicroStamp11** is “FRA”, which stands for “female right-angle”. Plug it into the supplied adapter, and it can straddle the center channel of a solderless breadboard, providing several tie-points associated with each pin. This allows you to plug in wires and other components such as resistors and LEDs, to build your application. If your board has a different connector option, you can still use it with a solderless breadboard, by way of the appropriate 20-pin solderless breadboard adapter. See the **MicroStamp11 Accessories** page on our website, www.microstamp11.com.

Refer to Appendix B and the enclosed schematic for pinout information for **MicroStamp11** and its Docking Module.

CAUTION!

Never insert your module into or remove it from a “live” breadboard. Make sure the power is OFF!

1) Any breadboard will do; however, you will find that the kind made with a softer, more pliable plastic (such as nylon) will be easier to use and more durable. It is recommended that you dedicate a section of your breadboard to the **MicroStamp11** adapter, since its square pins may cause the breadboard spring contacts to spread eventually, so that they will no longer hold small-diameter wires.

2) First plug **MicroStamp11** into the vertical 20-pin connector on the Docking Module, lining up the white pin 1 dots.

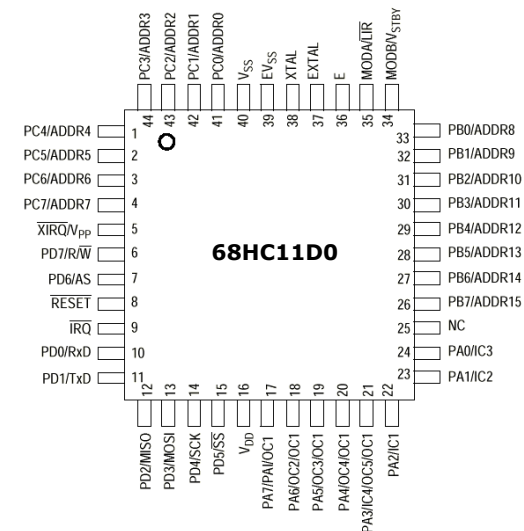
3) Attach the supplied ribbon cable by plugging the strain relief end into P2 of the Docking Module, lining up the ribbon cable pin 1 indicator to P2’s pin 1 dot.

4) Plug the adapter into your breadboard.

- Microcontrollers: Architecture, Implementation, & Programming
 - Kenneth Hintz and Daniel Tabak - ISBN 0-07-028977-8
 - 1992, McGraw-Hill Inc.
- Mobile Robots: Inspiration to Implementation
 - Joseph L. Jones and Anita M. Flynn - Very hands-on book.
 - Detailed design & construction of “Rug Warrior”
- Programming Microcontrollers in C
 - Ted Van Sickle - ISBN 1-878707-14-0
 - 1994, HighText Publications - 394 pages
 - thorough tutorial on C programming, covers aspects of C programming specific to embedded systems
- MC68HC11: An Introduction
 - Han-Way Huang - West Publishing
 - ISBN 0-314-06735-3
- The M68HC11 Microcontroller: Applications in Control, Instrumentation and Communication
 - Michael Kheir
 - Prentice Hall

APPENDIX A - REFERENCE DATA

Pinouts for Surface Mount Package of 68HC11D0



5.0 SOURCES

Internet Resources

•Technological Arts: www.microstamp11.com

• Freescale: www.freescale.com

Freescale Publications

•M68HC11 Reference Manual (M68HC11RM/AD)

•M68HC11 E-series Technical Data book (MC68HC11E/D)

•Single- and Multiple-Chip Microcomputer Interfacing

(Prentice-Hall or Motorola TB316; Lib. of Cong. Cat. # 87-60656)

Other Books

•The 68HC11 Microcontroller

- Joseph D. Greenfield (at R.I.T.) - ISBN 0-03-051588-2
- 1992, Saunders College Publishing, (Harcourt Brace Jovanovich)

•Data Acquisition & Process Control w/ the M68HC11 Microcontroller

- Frederick Driscoll, Robert Coughlin, Robert Villanucci of
Wentworth

Institute of Technology.

- 1994, Macmillan Publishing Company

- ISBN 0-02-33055-X

- example applications of interfaces to various sensors.

•Design with Microcontrollers

- John B. Peatman (professor at Georgia Tech)

- ISBN 0-07-049238-7

- This book is on a more advanced level. Uses both the 68hc11
and Intel 8096 as example systems.

•Embedded Systems Programming in C and Assembler

- John Forrest Brown

- ISBN 0-442-01817-7

- Van Nostrand Reinhold, 1994 - 304 pages, \$49.95

- covers Motorola and Intel processors

•Microcomputer Engineering

- Gene H. Miller

- ISBN 0-13-584475-4

- 1993, Prentice Hall, Englewood Cliffs, NJ 07632

- Explains basics. Many clear, concise examples.

•Microcontroller Technology, The 68HC11

- Peter Spasov

- ISBN 0-13-583568-2 - Prentice Hall

5) Plug the other end of the ribbon cable into the adapter, with the pin 1 indicators lined up. For convenience, you may want to place additional breadboard sections in parallel on each side for easier wiring of your circuits

6) Choose a convention for wiring your power distribution buses. A logical approach is to make the inside bus logic 5V, and the outside buses GROUND.

There are two ways to power **MicroStamp11** Supply regulated 5V power to the +5V pin (pin 12), or supply an unregulated DC voltage in the range of 7 to 12V to the Vin pin (pin 10). The DockingModule provides a convenient connector for this purpose. A DC adapter or 9V battery will work fine.

Note that if you supply a voltage to Vin, the +5V pin becomes an output, supplying regulated 5V from the on-board regulator, which has some excess capacity to power your circuits in addition to **MicroStamp11**'s. No matter which approach you use, always connect your circuit GROUND to **MicroStamp11** GROUND.

7) If you are using voltages other than 5V in your application, make sure to keep these well away from **MicroStamp11** pins and tie-strips, to avoid accidental shorts which may damage the module.

3 TUTORIAL

Note that this manual is not meant to provide an exhaustive study of the 68HC11, but rather to help you get started using **MicroStamp11** as a learning and application development tool for 68HC11, whether you're a beginner or an expert. If you are a beginner, you will benefit from additional material listed in the Reference section of this manual, and links provided on the Applications, Tech Support, and Resources pages of our website (see back cover for URL).

3.1 Getting Started

Important! Be sure to browse the README.TXT file on your Starter Package disk for information on what's on the disk and how to use it. Use any text editor or browser you like, such as Notepad or DOS edit, and follow the instructions for copying the disk contents onto your hard drive.

If you have a Windows computer, you should also install the MicroLoad application, included with your package. Check the RESOURCES page on our website to make sure you have the latest version. MicroLoad is the recommended utility for loading your program into **MicroStamp11**'s memory.

MicroStamp11 has a demo program already programmed into the EEPROM when you receive it. This is a useful program for testing your communications setup and monitoring and controlling the various I/O lines of the MCU.

Plug **MicroStamp11** into the Docking Module, and supply power via the external power connector. Just connect a DC voltage of 5V or higher (up to 12V) to the external power connector (J1) on the Docking Module. Red is positive, and black is negative (ground). *CAUTION! Make sure you have the polarity correct!*

To use the demo program, connect the supplied serial cable between the Docking Module and a serial port on your PC. (With some PCs, you will need a 9-pin to 25-pin adapter.) Run a terminal program (such as TeraTermPro, or the Windows HyperTerminal program) on your PC. In your terminal program, set the baud rate to 9600 (38400 for "Turbo" versions), parity to NONE, #DATA BITS = 8, and #STOP BITS = 1, and "no handshaking". With SW2 set to RUN, press the Docking Module RESET button. LED D2 will blink twice, indicating the demo programming is running. Hit <ENTER> on your keyboard. A menu of commands will appear on your terminal window's screen, followed by a command prompt "?" symbol. Each command is activated by a single keystroke. A sample screen showing results of each command is shown in Figure 3.1. Typing a command not listed will cause the menu to be re-displayed.

The A and D commands in the demo program allow you to examine the states of PORTA and PORTD. Try putting switches on some of these input port lines. Use a 10K or higher pullup resistor on one side and connect the other side of the switch to ground. Note that PA0-PA2 are inputs, PA3 and PA7 are programmable as input or output, and default to inputs. PA4-PA6 are outputs only. In the demo program, PA6 is used as a tone output for a speaker. It is also connected to LED D2, when plugged into the Docking Module, to provide a visual output. You can drive a small piezo speaker directly by hooking one end to PA6 through a 330-Ohm resistor, and the other end to ground. When you press RESET, or type "S" when the demo program is running,

To compile and download **hello.c**, select **Compile to Executable** in the pulldown menu. ICC11 will compile, assemble, and link, creating an s-record file called **hello.s19**. This is the file you will download to your board. ICC11 does not support downloading to the D-series 68HC11, so you'll need to use MicroLoad (or one of the DOS batchfiles included with your starter package).

Plug **MicroStamp11** into the Docking Module, and use MicroLoad to download the s-record you just created (or use **pms1** or **pms2** from DOS). Press the RESET button and slide the Write Protect switch (SW3) to WRITE. Then press any key. When finished, slide SW3 back to PROT, SW2 to RUN, and press RESET to run your program.

4.5 Handy Reference Information

Baudrate Settings for Standard MicroStamp11

Value	Speed
\$30	9600
\$31	4800
\$32	2400
\$33	1200

Baudrate Settings for Turbo MicroStamp11

Value	Speed
\$20	38400
\$21	19200
\$22	9600
\$23	4800
\$24	2400
\$25	1200

Port A

PA0	Input
PA1	Input
PA2	Input
PA3	I/O Set by bit 3 of PACTL (Default: Input)
PA4	Output
PA5	Output
PA6	Output
PA7	I/O* Set by bit 7 of PACTL (Default: Input)

*Note- there is a typo regarding this bit in the HC11D3 Programming Reference Guide

The LINKER is the part of a compiler package that marries the software with the particular hardware configuration being used. Therefore, you need to setup the LINKER before using ICC11. Find the Linker setup tab by pulling down the OPTIONS menu to COMPILER. In the Linker, “text” refers to code, and should be the starting address of EEPROM (or wherever you plan to put the code); “data” is for variables, and should be the start of RAM; “stack” should be the end of RAM, since it builds “downward”. For **MicroStamp11**, you would set “text” to 0xE000 (for 8K EEPROM) or 0x8000 (for 32K EEPROM). Set “data” to beginning of RAM (0x40), and “stack” to end of RAM (0xFF). For ICC11 Version 6 or later, selections already exist for MicroStamp11 variants in the list of targets, so you can just select the variant you are using.

Since the register block in D-series 68HC11chips starts at 0x00 instead of 0x1000, as in E-series chips, you’ll need to add a line of code to initialize the register map to 0x1000. You should also clear the CONFIG register (i.e. write 0x04 to CONFIG), disabling the COP. So here is what you need to add at the beginning of your program:

```
void _HC11Setup() {
    *(unsigned char volatile *) (0x3D) = 0x01;
    CONFIG = 0x04;
}
```

Also, every C program that you write requires the file **vectors.c** to be included (either explicitly at the end of the program, or as the last file in the Project, if you are using the ProjectBuilder feature of ICC11)..

To get you started with ICC11, examine, modify, and compile the program **hello.c**, in the Examples directory of ICC11. This program has the essentials set up for you. Modify it to look like this:

```
#include<hc11.h>
void _HC11Setup() {
    *(unsigned char volatile *) (0x3D) = 0x01;
    CONFIG = 0x04;
}
main()
{
    setbaud(0x30);
    puts("Hello World\n");
    while(1)
    }
#include "vectors.c"
```

MICROSTAMP11 DEMO PROGRAM COMMAND MENU

```
A => SHOW PORT A STATUS
C => CLEAR PORT A OUTPUTS
D => SHOW PORT D STATUS
S => BEEP SPEAKER (CONNECT TO PA6)
?
<A>
PORTA=000
<D>
PORTD=001
<S>
>>> BEEP! <<<
```

Figure 3.1 MicroStamp11 Demo Software Screen

you will hear two beeps from the speaker (or the LED will flash twice).

Typing a digit between **4** and **6** causes the output state of the corresponding PORTA line to be toggled (eg. typing **5** causes PA5 to flip to a high if it was low previously, or a low if it was high previously). This allows you to activate LEDs (when driving LEDs directly from an output port, limit the current to a maximum of 10mA with 330-Ohm current limiting resistors on each LED); or drive relays, solenoids, or motors (with appropriate driver circuits).

3.2 Writing Your First Program

If you are already experienced with the 68HC11 family of microcontrollers, you can skip this section. However, you may find the suggestions here useful to familiarize yourself with the essentials of getting a program to work the first time.

As mentioned in the previous section, a demo program resides in **MicroStamp11**’s EEPROM when you receive it. This demo program is written in Motorola’s Freeware AS11 cross-assembler syntax, and is intended to provide you with an easy way to verify your hardware setup (ie. power supply, serial connection, PC software, etc.). It also provides you with an excellent starting point for developing your own program. Rather than starting from scratch, you can make a copy of

the demo source file and remove and add features, to transform it into what you need.

Many people approach programming by spending hours or even days writing a program from scratch, then assembling it and downloading it. Then they cross their fingers and reset the board, praying everything will work. About 99% of the time, their hopes are dashed, as the board does something completely different than they expected, or worse— it appears to do nothing! At that point, they either give up, or purchase expensive diagnostic equipment, such as logic analyzers and in-circuit emulators to begin the long hard road of diagnosing and correcting their software and/or hardware mistakes.

A much more sensible— and rewarding— approach is to start with something that works, and then add new features incrementally. The modular design of MicroStamp11 gives you that starting point— hardware that works, and software that works. Now, if you build on that incrementally, each diagnostic step is small and manageable. And it will probably end up taking a lot less time, and costing a lot less money.

A powerful asset for program development is the serial communications interface (SCI). The SCI gives you a window on what's going on inside the microcontroller. Simple diagnostic messages, placed at strategic points in your evolving program, will be invaluable in debugging your software and hardware.

If you look at the demo source code (**ms11demo.asm**), you will see that it consists of an initialization section, one main loop, and several subroutines and interrupt routines. The main subroutine is called *ProcessCommand*. Its primary function is to interpret a single-character command that is received via the serial port, and perform the appropriate action for that command. You can easily extend the list of commands within the *ProcessCommand* subroutine by adding code to recognize and process other single-character commands you define. Then it is simply a matter of writing those subroutines to perform the functions you wish to implement. This software structure gives you a way to independently test each new function one at a time.

Forexample, let's suppose you are implementing an autonomous vehicle, using a miniature toy car. You will need to read position and collision sensors, and control the speed and direction of one or more motors. First write a basic motor-speed control routine, and assign

lines of code into the special **start11.lib** file that SBASIC uses for every program you compile. Doing this will ensure that the HC11 register block will always appear in the memory map at \$1000, regardless of which flavor of HC11 chip is being used. The point of all this is to ensure that the SBASIC library routines will function on **MicroStamp11** without modification. You may also want to write \$04 to the CONFIG register in **start11.lib** to disable the COP watchdog if you're not using it (for more on the COP, refer to the HC11 Reference Manual). The code to add at the beginning of start11.lib is shown below:

```
ldaa #1
staa $3d ;move register block to $1000
ldaa #4
staa $103f ;disable COP
```

Below are some example configurations and the appropriate */c* and */v* compiler options used to specify the starting addresses for code (EEPROM) and variables (RAM), where **infile** is your SBASIC program filename, and **outfile** is the name you want the target assembly language file to be called.

MicroStamp11 with 8K EEPROM:

sbasic infile /ce000 /v0040 /s00ff >outfile.asc

MicroStamp11 with 32K EEPROM:

sbasic infile /c8000 /v0040 /s00ff >outfile.asc

The resulting file **outfile.asc** is in assembler source code, and can be viewed and edited if you wish. When ready, assemble the file with ASMHC11 (included in the SBASIC distribution file) to produce an s-record file suitable for downloading to your board. Use it as follows:

asmhc11 outfile

and it will produce the file **outfile.s19**.

Now you can use MicroLoad (or the **pms** DOS batchfile mentioned earlier) to load it into MicroStamp's memory.

4.4 Using ImageCraft's ICC11 Windows C Compiler.

ImageCraft offers a good low-cost ANSI C compiler, which is quite popular in the 68HC11 community. The following section provides some basic hints and guidelines for setting up ICC11 and using it with the **MicroStamp11**.

Down arrow keys to make the changes, or enter new values via the keyboard. When you're done, press the ESC key to return to the PCBUG11 prompt. Now enter:

term

to open the terminal window. If you have the Demo program loaded in your board, you can use the terminal window to interact with it. Switch your board to RUN, and press RESET. Pressing ENTER will cause the menu of the demo program to be displayed. Select the menu commands, as you desire. When you have finished using the demo program, you can return to PCBUG11 by hitting ESC. To re-establish communication between PCBUG11 and the 'HC11, reset your board in BOOT mode, and enter:

restart

4.26 Exploring Further with PCBUG11. For information about PCBUG11 commands and their syntax, enter:

help

at the PCBUG11 prompt. For complete details on PCBUG11, refer to the PCBUG11 Manual (found on the Resources page at www.microstamp11.com).

4.3 Using SBASIC

SBASIC is a DOS-based compiler. It takes a BASIC text file as input and produces a 68HC11 assembler file as output. You assemble the resulting file to produce an s-record file (with extension **.s19**), which you can load into MicroStamp11 as described earlier. If you haven't used SBASIC before, make sure you read through the excellent documentation included in the distribution file, to familiarize yourself with what it's all about and how to use it.

To use SBASIC with MicroStamp11, you will first need to deal with the unique default register block address of the D-series 68HC11. As mentioned previously, it defaults to 0. By contrast, all E-series chips default the register block address to \$1000, and SBASIC assumes you're using an E-series chip. One way to deal with this is to change IOREGS to 0 in the first line of the file HC11REGS.LIB. But a better alternative would be to re-locate the register block to \$1000 immediately after reset. This can be done by adding two lines of code at the beginning of each program you write. An even easier way is to put those two

some commands to test it. You could assign "F" for faster (increase the motor speed), and "S" for slower (to decrease motor speed). Then implement a pulse-width modulation scheme in your motor speed routine, decreasing the pulse-width by some increment every time the "S" key is pressed, and incrementing pulse-width by the same amount every time the "F" key is pressed. Of course you will want to put tests for minimum and maximum pulse-widths before you decrement or increment, so that the motor doesn't suddenly jump from stopped to full speed when the pulse-width value "wraps" around.

Note: If you plan to incorporate all or part of the demo program in your own code, and you're using a different cross-assembler than AS11, you may have to revise the syntax.

3.21 A Very Simple Program If you are a beginner, the size of the demo program may look overwhelming, and you may wonder what is really required just to do something very simple. In reality, you can throw away almost everything, ending up with about a half dozen lines of code, to produce a very simple program.

Rule #1: Every program requires a Reset Vector (located at \$ffe and \$fff), since the contents of these locations is loaded into the Program Counter immediately after reset. Therefore, the Reset Vector should point to the beginning of your code.

Below is an example of a very simple program, which just turns on the LED on PORTA (PA6), and then waits in an infinite loop. (It was written for an 8K EEPROM space, so if your board has 32K, you can change the org to \$8000, but it's not necessary). *Note: the MCU has a watchdog timer (COP) which is enabled by default. Unless you plan to use this feature, you need to disable it (NOCOP bit in CONFIG register) at the beginning of your code.*

```
org    $e000 ;start at top 8K EEPROM

begin:  ldaa  #$04 ;disable COP in CONFIG register
        staa $3f
        ldaa  #$40 ;write logic high to PA6
        staa  $0  ; (and logic low to all other portA
bits)
        bra  *    ;branch forever (until reset occurs)
```

```

org   $fffe ;define the reset vector to point to
fdb   begin ; the beginning of your code

```

3.22 Adding a Little Complexity. Now let's take it one more step: blink the LED on and off. To make the blinking slow enough to perceive with the human eye, we will write a subroutine to create about a half-second delay.

Rule #2: If you are using interrupts, or incorporating any subroutines in your program, you must initialize the stack pointer at the beginning of your program.

```

org   $e000 ;start of top 8K EEPROM

begin:   ldaa  #$04 ;disable COP in CONFIG register
        staa  $3f
        lds   #$ff ;initialize the stack pointer
loop:    ldaa  #$40 ;write logic high to PA6
        staa  0 ; (and logic low to all other portA
bits)
        bsr   Delay ;do a time delay
        clr   $0 ;make all portA bits logic low
        bsr   Delay
        bra   loop ;do it all again

Delay:
        ldy   #$ffff
D1:      dey   ;pad delay loop with extra cycles
        iny   ; for total of 15 cycles
        dey   ;this gives approx. 1/2 second at
8MHz
        bne   D1
        rts

org   $fffe ;define the reset vector to point to
fdb   begin ; the beginning of your code

```

4.22 Verifying an S-record File in EEPROM. Suppose you have loaded a file called myprog.s19, use the following command to verify it is in EEPROM:

verf myprog

If it is in a different directory, (eg. c:\myfiles) you should specify the directory path. For example:

verf \myfiles\myprog

restart

To run your program, reset MicroStamp11 in RUN mode. To use PCBUG11 again, reset your board in BOOT mode, and type:

restart

Again, switch on access to external memory with:

ms 3c e5

4.23 Manipulating Memory. To change the value stored in a RAM or register location (eg. clear RAM location \$f0), simply use the Memory Set command, as follows:

ms f0 00

To alter an EEPROM location, you need to slide switch SW3 to WRITE. You can then modify it with Memory Set (as above), or with the Memory Modify command, as follows:

mm e000

In this example, PCBUG11 will display the current value of location \$e000. If you wish to change it, type the new value, and press ENTER. If not, just press ENTER. The next memory location will be displayed. To end the Memory Modify mode, press ESC on your keyboard.

4.24 Using PCBUG11's Terminal Window. PCBUG11 has a basic communications terminal which is useful for testing and debugging your software. To use it, set up the necessary communications parameters such as baud rate, parity, etc. by entering:

control

A list of parameters is displayed. Use the Page Down and Page Up keys to move to the parameter that needs changing. Use the Up and

pms2 myprog

4.2 Using PCBUG11 with MicroStamp11

Motorola's PCBUG11 is a flexible, powerful, and easy-to-use program that runs on a PC under DOS. It allows you to examine and modify register contents, RAM and EEPROM, debug, trace, disassemble blocks of code, assemble line-by-line, and even includes a basic terminal program. What's more, it works with all varieties of HC11 micros, and is fully compatible with **MicroStamp11**. PCBUG11 is included on your Starter Package disk, and is also available on the Resources page of our website. It is a self-extracting archive, so just copy it to the directory on your harddrive where you want it to reside, and type **pcbbug342** at the DOS prompt to extract all the files.

4.21 Running PCBUG11. Always RESET your module in BOOT mode before starting PCBUG11. It is important to make sure there are no background tasks running on your PC, such as faxmodem drivers, networks, etc. PCBUG11 needs to access the serial port chip of the PC directly, and does not co-exist very happily with other programs. Whenever possible, start PCBUG11 directly from DOS (not a DOS shell). If you can't get it to work at all, visit the Support Library on our website for tips on troubleshooting PCBUG11.

To run PCBUG11, type the following command at the DOS prompt (after resetting MicroStamp11 in BOOT mode):

```
pcbbug11 -d port=2
```

(if you're using COM1, omit the **port=2** parameter; if you have a "Turbo" MicroStamp11, add the parameter **baud=9600**).

If you prefer to use hexadecimal numbers in your PCBUG11 session (instead of the default decimal notation), enter the following command at the PCBUG11 prompt:

```
control base hex
```

Enable access to external memory by changing mode via the HPRIO register, and disabling internal ROM via the CONFIG register:

```
ms 3c e5
```

```
ms 3f 04
```

CAUTION! Avoid powering up MicroStamp11 with the WRITE PROT switch in the WRITE position. If you do so, one or more external EEPROM locations may get inadvertently corrupted. If this happens, your code may not work as intended, and you'll have to repeat the download procedure again. In rare cases, it's also possible to enable the Software Data Protection feature of the memory chip, making it impossible to load a new program.

3.3 Downloading Your Code

If you are using a Windows computer, we recommend you install and use our **MicroLoad** application to download your files. It is included with your Starter Package and also available on the RESOURCES page of our website. If you prefer to use DOS instead, read on. Otherwise skip to the next section.

Once you have assembled your code with no errors, you can download the resulting s-record file (*filename.s19*) to your board using the appropriate DOS batch file provided. Connect the supplied serial cable between connector J2 on your Docking Module and COM1 or COM2 of your PC. (You can use a different COM port, but you will need to edit the batchfile to reflect the COM port number you use).

Use **pms1.bat** (for COM1) or **pms2.bat** (for COM2). For "Turbo" versions of MicroStamp11, use **pms91.bat** or **pms92.bat**, respectively. If required, use a text editor to modify these batch files to suit your needs. On a Windows95/98 system, you may have to add **\dev** to every reference to the com port path (eg. **copy %1.s19 \dev\com1**).

You may find using the batchfile more convenient if you put it into your working directory, along with the assembler or compiler you are using, and the source code you are writing. Make sure to put the associated boot file in the directory as well (for example, **msload.bin** is required by **pms1.bat** and **pms2.bat**).

Always reset the board in BOOT mode and slide the WRITE PROT switch (SW3) to WRITE just before you download. During downloading, the red LED comes on and pulses while s-records are being loaded. When all the s-records have loaded, the LED goes off. Switch SW3 back to PROT, and switch SW2 to RUN mode. Press RESET to start your code running.

3.4 MicroStamp11 Memory Map

Appendix A shows a diagram of the **MicroStamp11** memory map. For more details of the MCU's internal memory, register definitions and their locations, refer to the 68HC11D3 Programming Reference Guide. Note that the internal MCU memory blocks such as RAM and registers take priority over any external devices mapped into their address space. In some situations, you may wish to move the internal RAM and/or Register Block to a different 4K address boundary. The Register Block defaults to the range \$00 to \$40, placing it within the first 256 bytes of the memory map. This allows use of the direct addressing mode of the 68HC11, making assembly-language coding simpler and more efficient. Internal RAM in the 68HC11D0 defaults to the range \$040 to \$ff. If you have a 64K version of MicroStamp11, external RAM will be accessible from \$100 to \$7fff.

3.5 About the On-board Voltage Regulator

MicroStamp11 uses a low-dropout LM2931Z-5 regulator in a TO-92 package, capable of dissipating about 500 mW at room temperature. It has some nice features, such as a very low quiescent current, and will work with an input voltage down to 5 Volts (or below), making it quite well-suited to battery operation. It is also designed to withstand reverse polarity and, if unused, does not present a load to an external regulated 5-Volt supply applied via the 20-pin header H1. One drawback, however, is that it can become unstable and start to oscillate at low temperatures, especially if the input voltage source is connected via long wires. In the former circumstance, the on-board 10uF tantalum capacitor can be replaced with a higher value (47uF or 100uF). To compensate for long lead-in wires, add capacitance of 100uF or so at, or close to, the Vin and GROUND pins on the H1 connector.

4 REFERENCE

4.1 How EEPROM is Programmed

MicroStamp11 uses parallel EEPROM for program storage, and requires only an RS232 interface and power to program, using the MCU in Special Bootstrap mode to erase and load code via any serial port. This means you can re-program your code easily, without the need for special programming boards or erasers. This approach results in a low-cost, easy-to-use configuration suitable for education and new product development.

Special Bootstrap Mode. All 68HC11 MCUs contain an internal bootstrap loader program in ROM. This program runs whenever the chip is powered up or reset with the mode select pins configured for Special Bootstrap mode (see Motorola 68HC11 Reference Manual for details). This configuration can be selected on **MicroStamp11** by placing the BOOT/RUN switch in the BOOT position. When the RESET button is pressed (or when a power-on event occurs), the MCU executes the internal bootstrap program (a bootloader ROM source code listing for the 68HC11D0 can be found on the Starter Package disk). It first initializes the serial port (SCI), and waits in a loop checking its receive buffer until it gets a value of \$FF (BREAK control character). It uses that character to determine the incoming baudrate, and adjusts its BAUD register accordingly. It then places each byte it receives in RAM, storing them sequentially, starting at address \$40 and continuing to address \$ff (a total of 192 bytes) or until a timeout delay has elapsed with no characters arriving at the serial port. At this point, the internal bootstrap program loads the Program Counter with \$40, causing the CPU to begin executing the program just loaded into RAM. Thus, the program that you have just downloaded begins executing. This feature of the 68HC11 allows an EEPROM erase/write routine to be placed in RAM and executed automatically. A bootloader ROM listing is provided so that the user can take advantage of some of the special features provided by this program. Routines for programming external EEPROM/RAM (in expanded mode) from an s-record file are included on your MicroStamp11 Starter Package disk. The source code file is called **msload.asm**.

To program the EEPROM from a DOS prompt, use **pms1.bat** (for COM1) or **pms2.bat** (for COM2). For example, to download your S-record file called **myprog.s19** to MicroStamp11, via COM2, at the DOS prompt, you would enter: