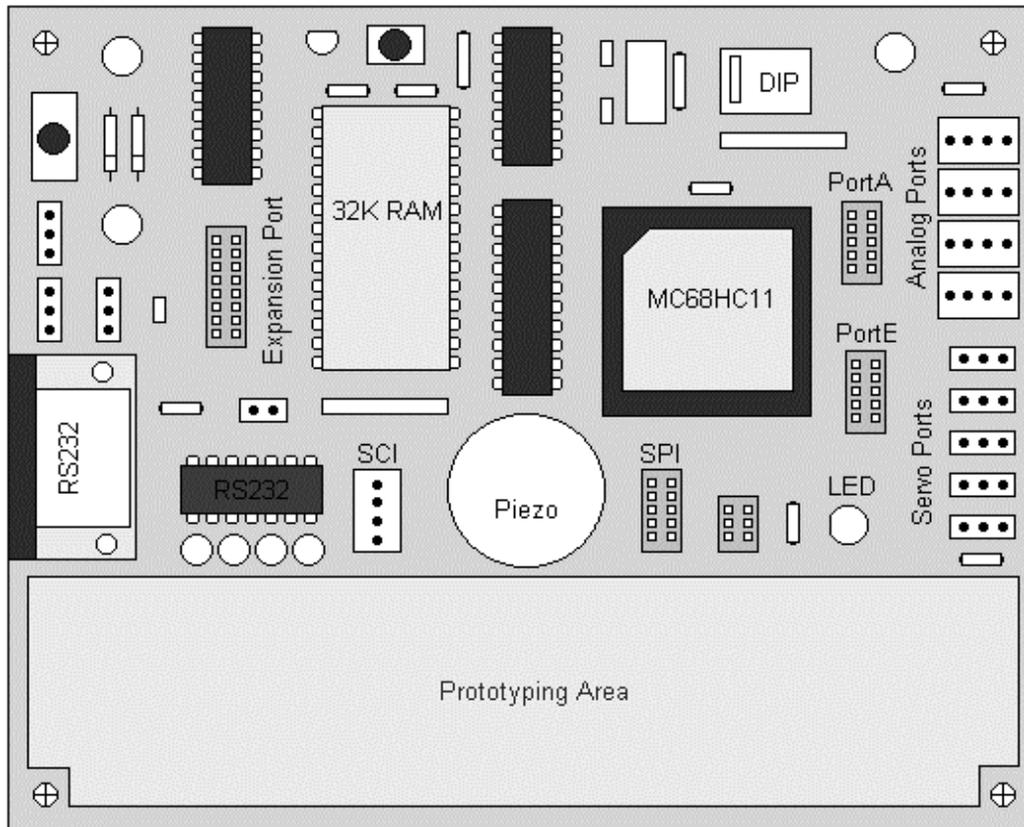


# The BOTBoard 2



Created by Marvin Green  
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<http://www.rdrop.com/~marvin>

## Quick Introduction.

Thank you for purchasing the BOTBoard 2. I think you will find the BOTBoard 2 a powerful tool for designing and building small microcontroller projects. The BOTBoard 2 was engineered to help you get your projects up and running quickly, easily and cheaply with a maximum amount of flexibility.

Please take note that this is not a programming guide for 68HC11, or a tutorial on microcontrollers, or electronics. This manual is an **introduction** to the BOTBoard 2. You should have some basic knowledge of electronics, microcontrollers and soldering before you tackle this project. Please contact Motorola for technical manuals on the 68HC11 and the support software like PCBUG11 and ASM11 development software.

BOTBoard 2 is a 4" X 5", printed circuit board designed to use 68HC11 family of microcontrollers. The BOTBoard 2, can use the 68HC11 in expanded mode and execute code from external battery backup RAM. Several I/O ports are provided on board, along with SCI and SPI ports for communication and networking. The BOTBoard 2 contains four Futaba servo ports and four analog to digital ports, the BOTBoard 2 has a flexible expansion port and prototyping area.

This board was designed with amateur robotics in mind, with a construction cost under \$50. The BOTBoard 2 is the next logical predecessor to the popular BOTBoard. The BOTBoard 2 layout is very generic and may be used for general experimentation and project development.

Please have fun with the BOTBoard 2.

Marvin Green 11-6-95

I created the BOTBoard 2 to encourage the building of small robots. It is a tool that I would like to have to help develop robot projects. Thanks goes to Karl Lunt, for all his help and suggestions, and a great deal for thanks goes to my wife Coreen for inspiration and enthusiasm.

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## Features of the BOTBoard 2 Board Design:

- 4' x 5' Inch Board Size
  - Large Prototyping Area
  - 4 Futaba Servo Ports
  - 4 Four pin Analog Ports
  - 10 pin IDC for PortE (analog) with 8 analog inputs.
  - 10 pin IDC for PortA
  - Full SPI Port
  - RS232 Serial Port
  - Via access to chip signals
  - BOTBoard Serial Port
  - 32k SRAM with Battery Backup
  - Easy to use Expansion Port with up to 64 pins I/O. (Just add latch.)
  - Piezo Speaker for sound.
  - LED indicator on I/O port.
  - Memory Protect Jumper.
  - DIP for MOD A/B and Other Functions
  - Low Voltage Reset with DS1233
  - Uses Motorola MC68HC11 family
  - Low current design
  - Double Sided, Silk Screened Board.
-

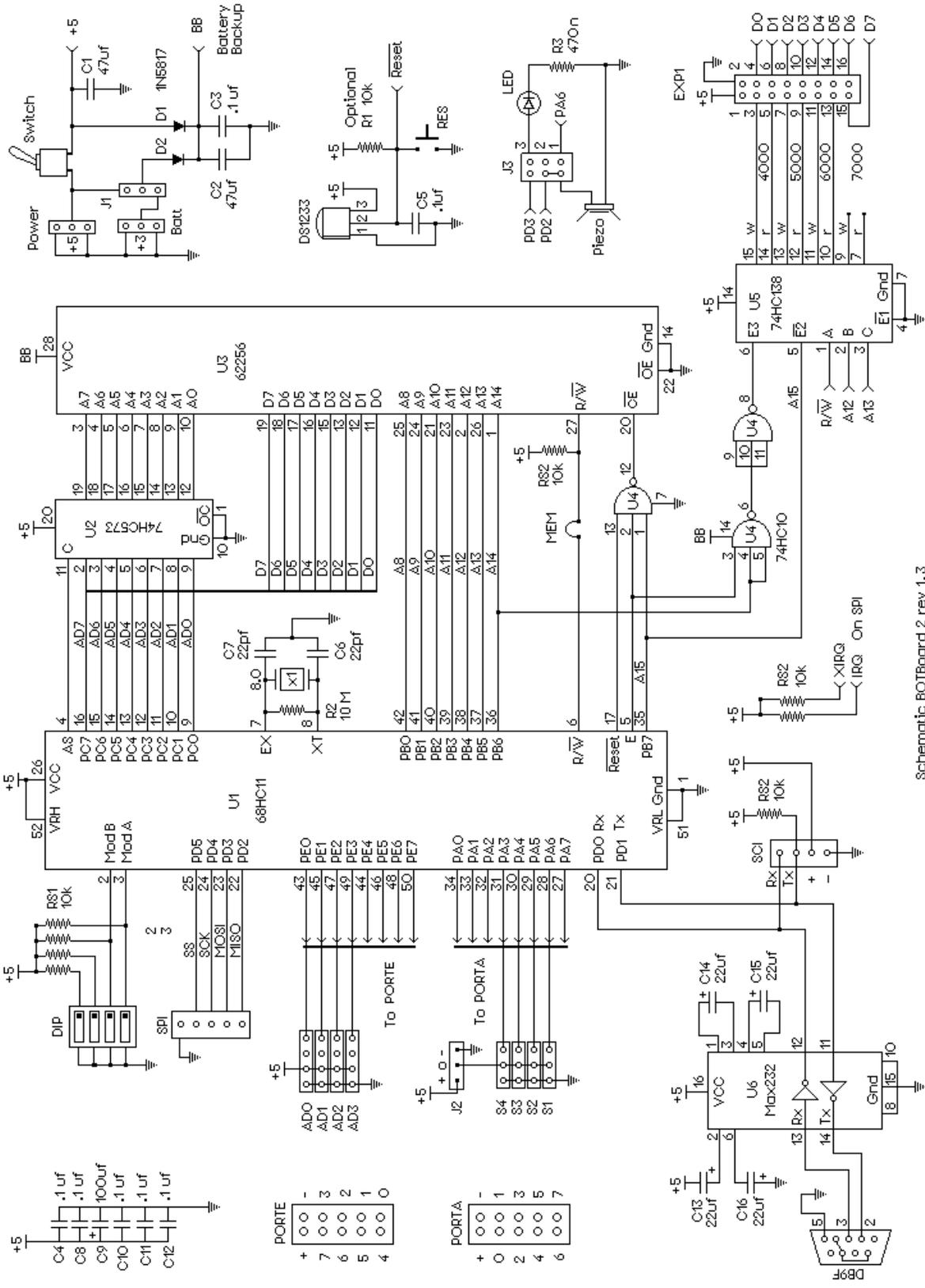
# Big Parts List:

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| Part                          | Description           | Digi Key #     | Cost    | Vendors            |
|-------------------------------|-----------------------|----------------|---------|--------------------|
| C1, C2                        | 47uf                  | 47R16          | .09     | JDR                |
| C3, C4, C5, C8, C10, C11, C12 | .1uf                  | .1UF-MONO      | .16     | JDR                |
| C6, C7                        | 22pf                  | 22PF           | .05     | JDR                |
| C9                            | 100uf                 | 100R16         | .14     | JDR                |
| C13, C14, C15, C16            | 22uf                  | P228-ND        | .23     | DK                 |
| R1                            | 10k                   | 10K            | .25 / 5 | DK                 |
| R2                            | 10meg                 | 10M            | .25 / 5 | DK                 |
| R3                            | 470 ohm               | 470            | .25 / 5 | DK                 |
| RS1, RS2                      | 10k - 5 res. SIP.     | Q5103-ND       | .23     | DK                 |
| D1, D2                        | Schottky              | 1N5817GICT-ND  | .56     | DK                 |
| LED                           | Low Current           | HLMP-4700QT-ND | .39     | DK                 |
| DS1233                        | Low Voltage Reset     | DS1233         | 1.95    | JDR                |
| X1                            | 8.00 mhz Crystal      | X021-ND        | 1.43    | DK                 |
| PZ                            | Piezo Speaker         | G6051          | .69     | EG                 |
| 52 Pin PLCC Socket            | Socket for 68HC11     | 72442          | 1.35    | JC                 |
| U1                            | MC68HC11A1FN          |                | 3.00    | BG, Beal and Glean |
| U2                            | 74HC573               | 74HC573        | .79     | JDR                |
| U3                            | 62256 - 32k memory    | 4325612L       | 4.96    | JC                 |
| U4                            | 74HC10                | 74HC10         | .29     | JDR                |
| U5                            | 74HC138               | 74HC138        | .45     | JDR                |
| U6                            | MAX232                | MAX232CPE      | 1.99    | JDR                |
| SWITCH                        | Power switch - toggle | 275-645        | 1.99    | RS                 |
| RES                           | Push Button           | P80375-ND      | .21     | DK                 |
| DIP                           | 4 pin DIP switch      | 4 POSITION     | .79     | JDR                |
| Power, Batt                   | 3 pin connectors      | 109575         | .22     | JC                 |
| AD0, AD1, AD2, AD3, SCI       | 4 pin connectors      | 117559         | .12     | JC                 |
| S1,S2,S3,S4, J1, J2           | 3 pin connectors      | 109575         | .22     | JC                 |
| PortE, PortA, SPI             | 10 pin IDC            | 67820          | .35     | JC                 |
| EXP1 Expansion Port           | 16 pin IDC            | 109567         | .49     | JC                 |
| MEM, J3 (1,2,3)               | 2 pin jumpers         | 115035         | .25     | JC                 |
| DB9F                          | Female 9 pin Serial   | DE9S318        | .59     | JC                 |

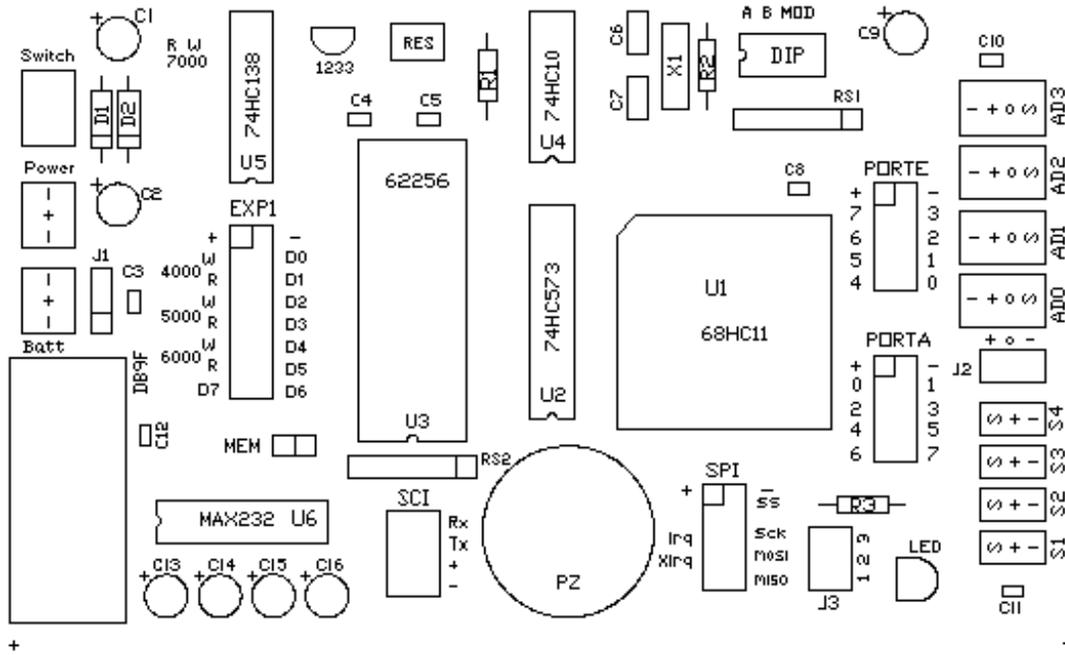
|             |     |                            |                |
|-------------|-----|----------------------------|----------------|
| Vendor Key: | JDR | JDR Microdevices           | 1 800 538-5000 |
|             | DK  | Digi-Key                   | 1 800 344-4539 |
|             | EG  | Electronic Goldmine        | (602) 451-9495 |
|             | JC  | Jameco                     | 1 800 831-4242 |
|             | BG  | B.G. Micro, Inc            | 1 800 276-2206 |
|             | RS  | Radio Shack                | ( local area ) |
|             |     | Beal and Glenn Enterprises | 1 800 874-4797 |
|             |     | Active Electronics         | 1 800 677 8899 |

**NOTE:** I have had very good luck with each of these vendors. The price list and part numbers listed above are a good starting reference point, but not the last word. I suggest that you get the catalogs from each vendor above, and shop around. You will find that each part above is carried by a multitude of vendors, and that several vendors have 90% of what you need. Good luck!

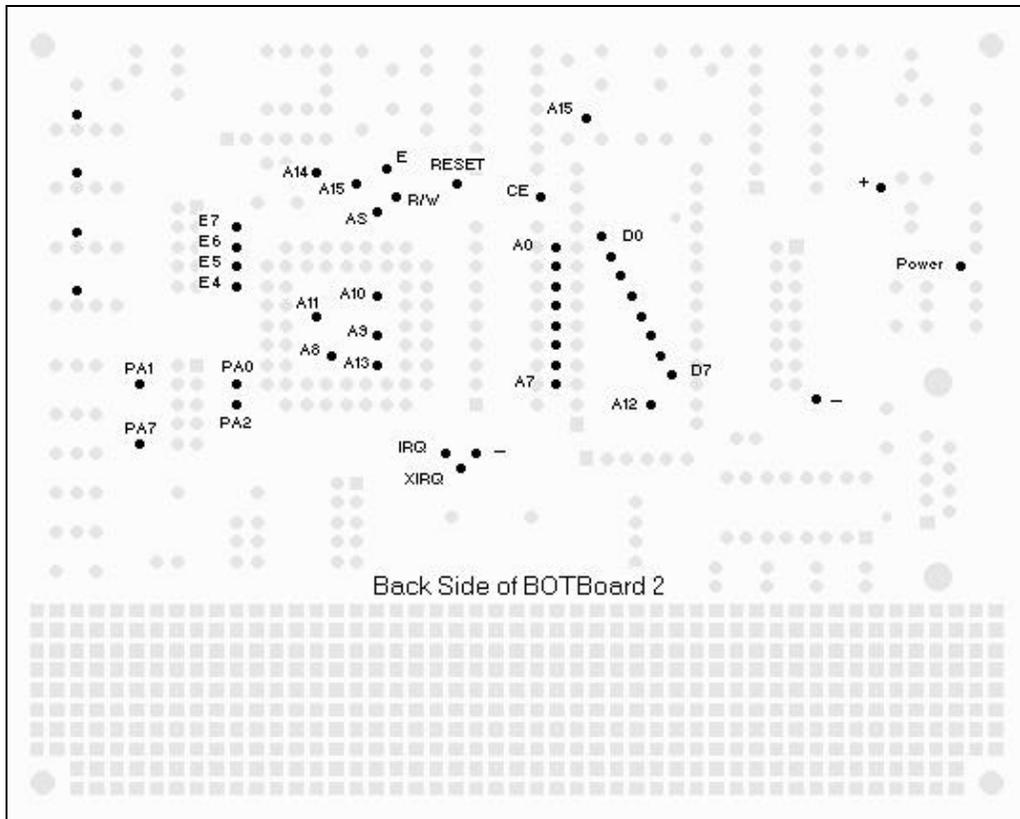


Schematic BOTBoard 2 rev 1.3

# Parts Layout of BOTBoard 2



# Via Layout



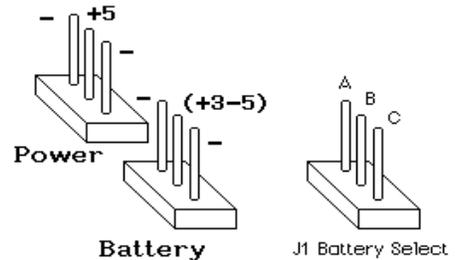
# Looking at the BOTBoard 2

## The Power Connections

The Power connector on the BOTBoard 2 [ - + - ] is the main supply for the board. The input is unregulated, and needs a regulated 5 volt source as input. The **Power** connector connects directly to the **Switch** to turn power on and off to the board. I have found that the BOTBoard 2 works fine using 6 volts such as 4 alkaline batteries. The BOTBoard 2 draws only about 18ma of current.

## Battery Backup

The **Battery** connector [ - + - ] can supply voltage to the static RAM and protects the memory contents during power down. The battery supply also connects to the 74HC10 IC to maintain a stable chip select for the battery backed RAM. On Jumper J1, connect pins B+C together to have the backup voltage come from the **Battery** connector. If you want the main **Power** connector to provide the backup voltage for the RAM, then connect pins A+B together on connector J1. Default is A+B.



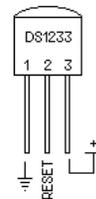
## The Microprocessor

The Microprocessor for the BOTBoard 2 is the MC68HC11 in a 52 pin PLCC package. This family of microprocessors from Motorola have a host of features that make it ideal for robotics. Some of the features include: Low current draw. 36 I/O pins. Built in EEPROM memory. RAM memory. Eight 8-bit A/D converters. RS232 and SPI serial ports. Real time interrupts and COP circuit. Auto start code in EEPROM. Timer subsystem with three input captures. Five output compares and input accumulator. Best of all, this little chip is easy to program.

Contact Motorola for technical documentation through a local dealer or at P.O. Box 20912 Santa Clara, CA 94039. Motorola's BBS is at (512) 891-3733, and you can contact their Design Team at (800) 512-6274. Please get Motorola's free development software, PCBUG11 and ASM11. Look for Motorola's WEB page on the internet at <http://motserv.indirect.com/>. See section internet resources..

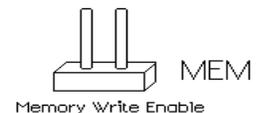
## Low Voltage Reset

The 68HC11 needs a clean reset during power up and down. A Low Voltage Reset chip is important when using battery backed RAM. The DALLAS DS1233 chip holds the reset line low for 350 ms after power up. This prevents the 68HC11 from operating in a low voltage state. This also helps protect the battery back RAM from becoming corrupted.. The MC34064 is a good substitute for DS1233, but pin orientation is different.



## Static RAM Memory

The low power 32k x 8 static RAM memory on the BOTBoard 2 occupies the upper address space from \$8000 to \$FFFF. This memory can hold its memory contents down to voltages of 2.2 volts with extremely low current draw. A small 3 volt lithium watch battery can hold the RAM contents well over 5 years. To protect the contents of RAM from being over written you can pull off the **MEM** jumper. This pulls the Read/Write line of the memory chip high and prevents a write enable to RAM.



## Memory Map

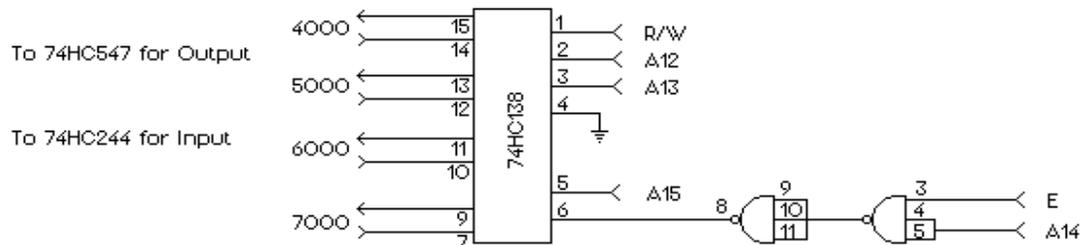
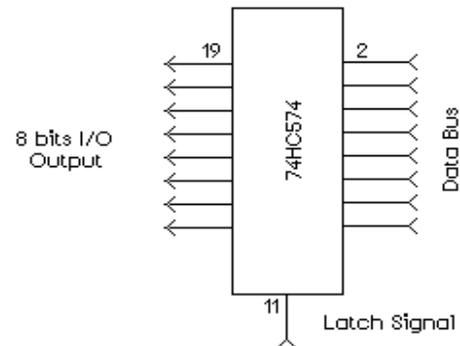
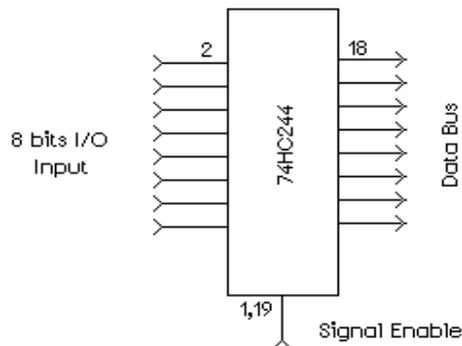
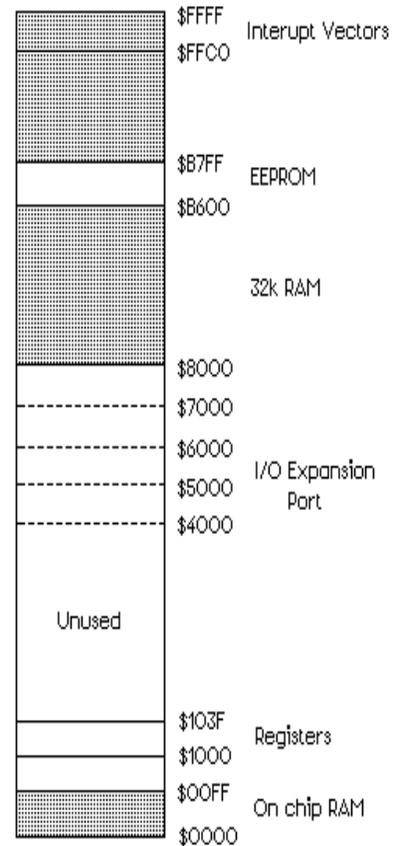
The memory map of the BOTBoard 2 shows that the 32k static RAM occupies from \$8000 to \$FFFF. Notice that internal EEPROM occupies address space within that RAM address space. All internal addresses take precedence over external memory. If needed you can disable EEPROM with the CONFIG register. The BOTBoard 2 expansion port **EXP1** occupies address space from \$4000 to \$7FFF.

## EXP1 Expansion Port

The expansion port on the BOTBoard 2 is very easy to use, and can support up to 64 I/O lines, 32 input and 32 output. It is designed to allow a simple latch or buffer to directly read and write data to the data bus. There are four address ranges used in the expansion port: \$4000 to \$4FFF, \$5000 to \$5FFF, \$6000 to \$6FFF, and \$7000 to \$7FFF.

On the expansion port each address range has two pins, a **Read select** pin and a **Write select** pin. The read pin enables a buffer and allows data to be read onto the data bus. The write pin enables a latch to output data from the data bus.

A 74HC138 is used to generate the correct chip select lines. Notice that address range \$7000 is not located directly on the expansion port, but is located on the board for use with the prototyping area.

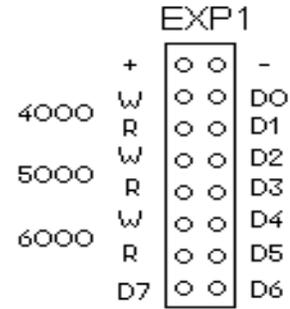


All Data lines are available on the BOTBoard 2 through via pads for uses with the prototyping area. Check out the Via Map for specific locations.

For example, if you connect up pin 11 *latch enable* of a 74HC574 to pin 9 of the 74HC138 and then a program write of \$FF to address \$7000, will make all output pins on 74HC574 high. A write of \$00 to address \$7000 will make all output pins would go low.

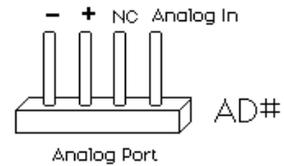
### Prototyping Area

A prototyping area is provided on the BOTBoard 2 that can handle a variety of IC chips, headers and connectors. Take care when placing components because of the bus structure of the prototyping area. A positive bus runs along the left edge and a negative bus runs along the right edge. With a little bit of planning, the buses will help provide ease of wiring up components and connectors. See PC board layout pages.



### Analog Ports

The BOTBoard 2 provides four 4 pin analog ports. Each port provides power and ground to power external sensors. The four pins connects pins 0, 1, 2, 3 of PortE. **AD0** is PortE pin 0, **AD1** is PortE pin 1 and so on. The inside most pin is ground, and then a power pin. The next pin has no connection, and a pad is provided to use this pin. The outside pin is the analog input pin. The analog input voltage is hard wired at VRH and VRL to ground to +5 volts.



### PortE

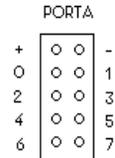
All eight of the analog inputs, of the 68HC11, are located on header. The header also includes positive and ground. documentation on setting up the analog digital converter in



**PortE**, a 10 pin IDC Consult Motorola software.

### PortA

All eight pins of **PortA** is proved on the 10 pin IDC header directly below **PortE**. **PortA** pins can be used as general purpose input output pins, or with the specialized timer subsystem pins. Pins PA0, PA1, and PA2 act as input capture. Pins PA3, PA4, PA5, PA6 act as output compares and can produce a pulse width signal. PA7 can act an input capture. Please refer to Motorola documentaion on using the timer system.

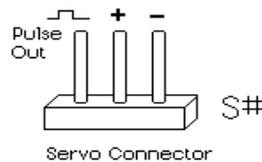


### Servo Ports and Jumper J2

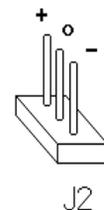
The servo ports on the BOTBoard 2 are designed to use Futaba compatible servo's. With the timer subsystem on the 68HC11 you can create a pulse width on the PA# output pins. This is all accomplished in hardware with almost no software overhead.

The servo connectors are as follows: Note pin orientation. Futaba uses a white wire for signal in.

- S4 - on pin PA3 using TOC5
- S3 - on pin PA4 using TOC4
- S2 - on pin PA5 using TOC3
- S1 - on pin PA6 using TOC2



Jumper **J2** allows you to select the source of power for the servos ports. If you jumper pins [ +, O ] then the BOTBoard 2 power supply will provide the voltage for the servo ports. You can also use **J2** to connect to an external power supply for the servo ports. Simply connect [ - ] to ground, and [O] to external power.



The original BOTBoard was designed to use Airtronic servos, not Futaba. The pin out is different between the Futaba and Airtronics servos, the positive and ground pins are reversed. You can use Airtronics servos if you rewire these pins.

Servo port S4 can be used as an output to a servo or to drive the piezo speaker you can select this option with J3-1. See the section on using J3 to enable the LED and Piezo speaker.

Example Code to Move Servos on S1 and S2.

```

LDD      #$0000          STOP SERVO'S
STD      $1018          TOC2 SET TO 0
STD      $101A          TOC3 SET TO 0

LDAA     #$60           BITS FOR OC2 AND OC3
STAA     $100C          OC1 WILL CONTROL OC2 AND OC3.
LDAA     #$00           WHEN OC1 TIMES OUT IT WILL
STAA     $100D          CLEAR OC2 AND OC3.
LDAA     #$F0           WHEN OC2 AND OC3 TIME OUT,
STAA     $1020          THEY WILL OUTPUT HIGH.
LDD      #$0000          GET TIMEOUT VALUE FOR OC1
STD      $1016          AND SAVE IN TIMER REG

LDD      #$F800          SERVO VALUE FOR CLOCK WISE
STD      $1018          SET TOC2, PA6 - J2.

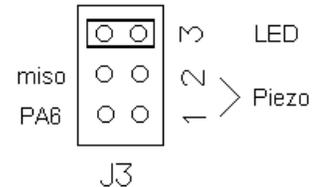
LDD      #$F200          SERVO VALUE FOR CCW
STD      $1018          SET TOC2, PA6 - J2.

```

Jumper J3 to Enable LED and the Piezo speaker.

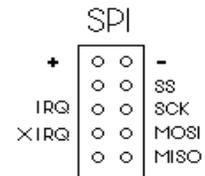
The jumper at **J3-3** enables the LED option. This connects the LED to pin 23 PD3, miso of the 68HC11.

Place a jumper on either **J3-1** or **J3-2** to enable the piezo speaker. Do not jumper both **J3-1** and **J3-2**. Using **J3-1** connects the piezo speaker up to PA6. This way the timer subsystem can operate the piezo speaker. Using **J3-2** lets you use the piezo speaker through pin 22, PD2, miso. While not as versatile as PA6, this option opens PA6 to use **S4** for a servo.



SPI Port and IRQs

The **SPI** port is a 10 pin header that contains all four SPI pins as well as the interrupt pins **IRQ** and **XIRQ**. The **SPI** port can be used to communicate with other SPI devices, external EEPROM, I/O devices, and real time clocks. The ground pin and SPI pins are in line so that you can connect a 5 pin SIP connector. This pin out is not the same as the original BOTBoard.

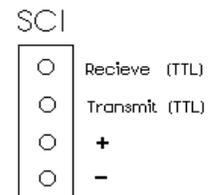


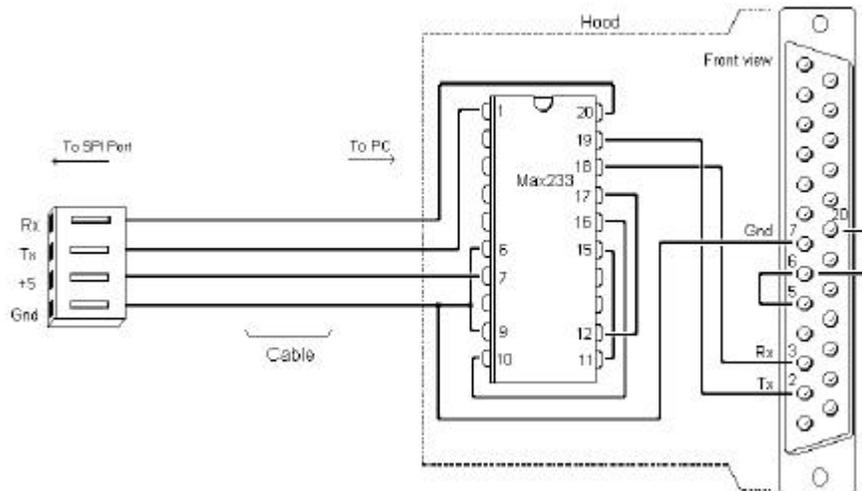
SCI Serial Port Compatible BOTBoard

This SCI port is provided so that you don't have to build the RS232 level converter on the BOTBoard 2. On the original BOTBoard, the RS232 level converter was housed in an external DB hood. The following is taken directly from the original BOTBoard manual if you wish to go this route:

*You will need to connect the BOTBoard to the serial port of a PC to download programs. To do this you must convert the TTL level signals of the 68HC11 to true RS232 levels. Once you build one converter, it may be used to program any number of BOTBoards, just by plugging it into the serial port.*

*Maxims **MAX233**, is a 20 pin IC that has the advantage of needing **no external capacitors**. One IC does it all. You can fit the **MAX233** in the case of the DB25 connector hood. The female connector is a MTA style plug, or equivalent, for the SCI.*





The 9 pin serial connector on the BOTBoard 2 is a DB9F and is designed to connect to a PC serial port with 9 pin straight through extension cable. The output of the DB9F is true RS232 levels because of the MAX232 level converter. If you need TTL level serial signals, use the SCI port.

#### The DIP Switch and MOD A B Selection

On the DIP switch two of the four switches are labeled A and B. These switches allow the 68HC11 to switch between different operating modes. The four different operating modes are single chip, expanded multiplexed, special bootstrap and special test mode. Please refer to Motorola documentation on these operating modes. The two extra switches on the DIP are for whatever you like. You can connect to them with the two pads between the DIP and C8. These two pads have a 10k pull-up resistor from RS1.

#### Putting the Board Together

When building the BOTBoard 2, it is a good idea to place the smallest components on the printed circuit board first. Place and solder the diodes, resistor, and capacitors, next the sockets and IC's. Place the tall components last, such as connectors and switches. When placing components on prototyping area, note layout of the bus structure. Use the PC board layout page as a guide.

#### Have Fun Building the BOTBoard 2

The BOTBoard 2 is a very flexible powerful board for building robots and other microcontroller projects. I hope you have as much fun using the BOTBoard 2 as I have. Please experiment with your board, hack it, cut traces, use the prototyping area and make the most of this board. If you have any questions or comments about this board, feel free to contact me at [marvin@agora.rdrop.com](mailto:marvin@agora.rdrop.com).

Marvin Green  
 190 SE Hacienda Ct.  
 Gresham Or, 97080  
 (503) 666-5907

If you would like to order a BOTBoard 2 at a cost of \$18 each, or 3 for \$45, please send check or money order with \$3 shipping and handling to the above address.

## Different Resources: Internet

Here are several internet resources that are of interest to robot builders, there are some Motorola sites as well. The nice thing about internet is that one interesting site can lead to another.

<ftp://cher.media.mit.edu/pub>  
<http://www.hhhh.org/srs/>  
<http://198.6.201.224/robotg/robo.html>

<http://nyquist.ee.ualberta.ca/html/motorola.html>  
<http://www.robix.com/>  
<http://www.usc.edu/dept/raiders/>

[http://www.yahoo.com/Science/Engineering/Mechanical\\_Engineering/Robotics/](http://www.yahoo.com/Science/Engineering/Mechanical_Engineering/Robotics/)  
<http://www.cs.cmu.edu/Web/Groups/AI/html/faqs/ai/robotics/top.html>  
<http://www.eg.bucknell.edu/~robotics/rirc.html>  
<http://www.sm.luth.se/csee/ra/sm-roa/RoboticsJump.html>

New Groups include: comp.robotics.misc, comp.robotics.research, sci.electronics

## Other Mail Order Places of Interest:

Marlin P. Jones & Assoc.  
P.O. Box 12685  
Lake Park, FL 33403-0685  
(407) 848-8236  
Motors, Electronic Surplus,  
Lots of neat stuff.

HosFelt Electronics, INC.  
2700 Sunset Blvd.  
(800) 524-6464  
More Electronic surplus gages,

Kelvin Electronics  
7 Fairchild Ave.  
Plainview, NY 11803  
(516)349-7620  
Plenty of robot kits, educational  
kits, from rockets to wire.

Winfred M. Berg, Inc.  
499 Ocean Ave.  
East Rockaway, NY 11518  
(516) 599-5010  
Gears, belts, couplings.

Edmund Scientific  
101 East Gloucester Pike  
Barrington, NJ 08007-1380  
(609) 547-8880  
Scientific kits, projects, lasers,  
microscopes, and more.

SIG  
401 South Front St.  
Montezuma, Iowa 50171  
(515) 623-5154  
R/C Airplane parts store.  
Great for robotic parts!

New Micros Inc.  
1601 Chalk Rd.  
Dallas, Texas 75212  
(214) 339-2204  
Best small computer board for the  
money. Powerful 68HC11, with FORTH.  
Good docs and good support.

Electronic Goldmine  
P.O. Box 5408  
Scottsdale, AZ 85261  
(602) 451-7454  
Lots of weird electronic stuff,  
super prices, but the stock comes  
and goes wildly.

Herbach and Rademan  
Bristol, PA 19007-0122  
(800) 848-8001 (orders only)  
(215) 788-5583 (office)  
DC motors, power supplies, batteries.

Suncoast Technologies  
P.O. Box 5835  
Spring Hill, Florida 34606  
(904) 596-7599  
8051 SBCs, kits, and software.

American Science and Surplus  
601 Linden Place  
Evanston, Illinois 60202  
(708) 475-8440  
Just about everything

Digi-Key  
P.O. Box 677  
Thief River Falls, MN 56701-0677  
Distributor for many lines of ICs,  
batteries, sockets, tools, and other  
electronic parts.

JDR Microdevices  
2233 Samaritan Drive  
San Jose, CA 95124  
(800) 538-5000 (orders)  
(800) 538-5005 (fax)  
(800) 538-5002 (tech support)

Lots of PC gear, EPROM programmers,  
sockets, ICs, batteries, tools,  
and other electronic parts

Mouser Electronics  
1-800-992-9943 (free catalog)  
Distributor for many lines of  
ICs and other electronic parts

