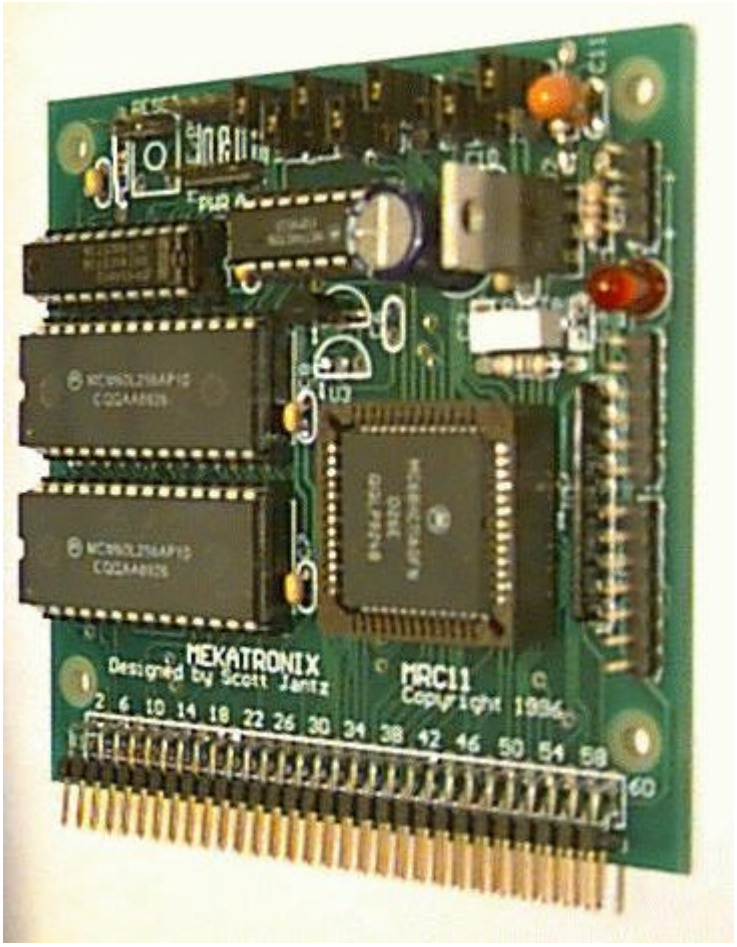
ASSEMBLY MANUAL
MEKATRONIX MRC11 CONTROLLER WITH 64KBYTES OF MEMORY

By Keith L. Doty



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- Low cost,
- Wide availability,
- Open architecture,
- An open, enthusiastic, dynamic community of users sharing information.

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Disclaimer

While MEKATRONIX™ has placed considerable effort into making these instructions accurate, MEKATRONIX™ does not warrant the results and the user assumes the risks to equipment and person that are involved.

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1. ABSTRACT

The MRC11 board, featuring the MC68HC11 microcontroller with up to 64Kbytes of RAM/ROM, provides a versatile package for embeded data acquisition and control systems useful in a wide variety of computer control and measurement applications such as instrumentation, robotics, control, hobby projects, etc. This manual provides instructions for the assembly of the MRC11.

2. ASSEMBLING MEKATRONIX PRINTED CIRCUIT BOARDS

2.1 Skill Level

Assembling this board requires the ability to solder and modest manual dexterity. If you are inexperienced in soldering or would like a quick review of soldering techniques, refer to *Soldering Note (http://www.mekatronix.com in the manuals sections)* for soldering tips. If you feel uncomfortable with assembling a printed circuit board you might want to consider purchasing one assembled and tested from the factory .

2.2 Personal Safety

Practice safe assembly techniques. When assembling printed circuit boards, be sure to work in a well ventilated area and wear eye protection. If you have not been instructed in PCB assembly techniques, you should seek assistance from an experienced technician.

2.3 Component Protection

Integrated circuits (IC) and other semiconductor devices are static sensitive. One can easily destroy an IC with static discharge. To protect against static discharge from destroying semiconductor devices, you might want to wear a wrist grounding strap while assembling your board. Axial and radial leaded components, such as resistors and capacitors, while rugged, can be damaged by careless handling. A common failure results when the leads are bent too much and their connection to the component is weakened or broken.

2.4 Questions

For technical support email all questions to mek_tech@orlandonet.magicnet.net **.**

2.5 Equipment Needed to Construct the MRC11

The following tools are needed to complete this board. Make sure you have them handy before you start work.

1. Soldering iron
2. 60/40 rosin core 0.032 diameter electronics solder (do not use an acid core solder or acid flux on the board)
3. Small diagonal cutters for cutting wire and headers
4. Needle nose pliers
5. Wire stripers
6. Hot glue gun and hot glue for mechanically securing wires to connectors.
7. Masking tape

2.6 Equipment Needed for Testing the MRC11

You will need the functionality or equivalent to the following equipment.

1. Multimeter
2. A MEKATRONIX™ MB2325 communications board with a MEKATRONIX™ C2325 6-wire serial cable.
3. A Personal Computer running DOS or Windows with a 25 pin serial cable connector capability for COM1 or COM2 to connect with the MB2325 board.
4. Motorola PCBUG11 (freeware) or Interactive C (freeware for versions less than 3.1) or ICC11 (purchase from a MEKATRONIX™ distributor).
5. Power supply or 8 pack of AA rechargeable batteries to supply about 7-10 volts.
6. Jumpers and/or switches

3. MRC11 ROBOT CONTROLLER

Note:

- *top of board* refers to the side with the white part outlines and text on it.
- *bottom of board* refers to the non-text side of the board.

Table 1lists the MRC11 parts. The part Designator corresponds to the part labels in the circuit diagram Figure 1. The location of these parts on the printed circuit board can be determined from
Figure 2. Together these diagrams illustrate how to place the components for soldering.

3.1 Brief Description of the MRC11 Robot Controller

The MEKATRONIX™ Robot Controller, MRC11, enables execution of machine intelligence programs on TALRIK and other MEKATRONIX™ products as well as your own special projects. The MRC11 provides you with a versatile microcontroller system useful in embedded applications. Engineers, technicians, students, and hobbyests have used the MRC11 in a wide range of applications other than robotics.

The MRC11's principle features are a

1. Motorola MC68HC11 processor,
2. Two 32KB Memory sockets for either RAM or ROM, 64KB total,
3. 5 Volt regulator,
4. Low voltage inhibit reset circuit,
5. Power on LED,
6. IO Map feature in the upper 32Kbyte Memory using H_MEM_SEL# . External address decode logic can be used to enable or disable H_MEM_SEL# for IO ports assigned in high storage.
7. 60-Pin Male Header serving as a Processor / IO bus.

3.2 Wiring Switches to the MRC11

The MRC11, neither the kit nor the assembled board, includes switches, but the board provides convenient footpads for the necessary switch connections. A Reset Footpad lies in the upper left of the PCB, next to the footpad for the power-on and mode control inputs MOD_A and MOD_B. In stand-alone configurations, a reset push button switch can be soldered to the board and a 4-pin DIP switch to the power and mode pins. These connections can also be taken out to a switch panel as is done with the TALRIK™ where reset is wired to a RESET push button switch and the power-on connection to a SPST toggle switch. MOD_A and MOD_B connect to the Download/Run SPST toggle switch which switches them simultaneously from 11 to 00.

3.3 Communicating with the MRC11

In TALRIK™ applications the right angle header on the 60-pin jumper J1 connects, via a ribbon cable, to the corresponding right angle male header on the MRSX01. This processor bus brings out the MC68HC11 pins relevent to interfacing with other systems. The Serial Peripheral Interface (SPI) connector on the right edge of the MRC11 board provides access to the high-speed, synchronous, serial facility on the MC68HC11. The Serial Communications (SCI) brings logic-level (5v-Ground) asynchronous serial communication signals to the MEKATRONIX™™ MB2325 serial communications interface board through a MEKATRONIX™™ 6-wire cable. The MB2325 connects to a PC COM port, either with a 25 pin RS232C cable or directly plugs into the PC COM connector. Configured in this way the MRC11 board can communicate with your PC using PCBUG11, Interactive C (IC) or ICC11.

Table 1 Bill-of-Materials for the MRC11 Robot Controller

Qty	Designator	Value	Description
0	(C2 C3)	(22pf)	(CRYSTAL LOAD CAPACITORS: Not included. Not required by the ceramic resonator which replaces the crystal circuit.)
0	(MODE/PWR/SW)	(SW DIP-4 / 2X CON4)	(MODE AND POWER SAVE DIP SWITCH FOOTPAD Switches not included)
0	(S1)	(SW-PB / CON3)	(RESET PUSH BUTTON FOOTPAD Switch not included)
1	BATT	CON4	4-PIN MALE BATTERY HEADER
6	C1 C4 C7 C8 C9 C10	0.1µf	BYPASS CAP
1	C5	470uf	POLARIZED FILTER CAPACITOR[1]
2	C6 C11	10µf	POLARIZED TANTALUM CAPACITOR[1]
1	D1	LED	VISIBLE LED
5	HMS ROMH ROML VRH VRL	3-PIN MALE HEADER =CON3	JUMPERS TO SELECT RAM OR ROM IN LOW MEMORY
1	J1	IDC60	60 PIN IDC HEADER
1	R1	10MΩ	CRYSTAL LOAD RESISTOR
1	R2	470Ω	RESISTOR, ¼ WATT
1	R4	10KΩ	RESISTOR, ¼ WATT
1	R5	1KΩ	RESISTOR, ¼ WATT
3	RAMH RAML SS	2-PIN MALE HEADER =CON2	JUMPER TO SELECT RAM OR ROM IN HIGH MEMORY, SLAVE SELECT JUMPER
1	SCI	6-PIN MALE HEADER =CON6	5 VOLT RS232 CONNECTOR
1	SIP	9 X 10K SIP	9 RESISTORS COMMON PIN 10K
1	SPI	7-PIN MALE HEADER =CON7	SYNCHRONOUS SERIAL PERIPHERAL INTERFACE HEADER
1	U1	68HC11	MC68HC11 MICROCONTROLLER
1	U2	LM2931T-5.0	5 VOLT REGULATOR
1	U3	MC34164	POWER ON RESET
1	U4	MC34064	LOW VOLTAGE INHIBIT
2	U5 U6	62256	MEMORY 32K SRAM OR ROM
1	U7	MC74HC573	74HC573 ADDRESS LATCH
1	U8	MC74HC10	74HC10 TRIPLE INPUT NAND
1	X1	8 MHZ	CERAMIC RESONATOR

[1]**IMPORTANT:** *If a part is polarized, then the insertion orientation is important. Incorrect insertion may cause the part to fail catastrophically when power is applied.*

Table 2 Parts List for the MRC11 Robot Controller,

Designator	Value	Description
BATT	CON4	4-PIN MALE BATTERY HEADER
C 1	0.1µf	BYPASS CAP
(C2 C3)	(22pf)	(CRYSTAL LOAD CAPACITORS: Not included. Not required by the ceramic resonator which replaces the crystal circuit.)
C 4	0.1µf	BYPASS CAP
C 5	470uf	POLARIZED ELECTROLYTIC FILTER CAPACITOR[1]
C 6	10µf	POLARIZED TANTALUM CAPACITOR[1]
C 7	0.1µf	BYPASS CAP
C 8	0.1µf	BYPASS CAP
C 9	0.1µf	BYPASS CAP
C10	0.1µf	BYPASS CAP
C11	10 µf	POLARIZED TANTALUM CAP
D1	LED	VISIBLE LED
HMS	CON3	3-PIN MALE JUMPER HEADER FOR HIGH MEMORY SELECT
J1	IDC60	60 PIN IDC HEADER
(MODE/PWR/SW)	(SW DIP-4 /2X CON4)	MODE AND POWER SAVE DIP SWITCH FOOT PAD (No switch included)
R1	10MΩ	CERAMIC LOAD RESISTOR
R2	470Ω	RESISTOR, ¼ WATT
R4	10KΩ	RESISTOR, ¼ WATT
R5	1KΩ	RESISTOR, ¼ WATT
RAMH	CON2	2-PIN MALE JUMPER HEADER FOR SELECTING HIGH RAM
RAML	CON2	2-PIN MALE JUMPER HEADER FOR SELECTING LOW RAM
ROMH	CON3	3-PIN MALE JUMPER HEADER FOR SELECTING HIGH ROM
ROML	3CON3	3-PIN MALE JUMPER HEADER FOR SELECTING LOW ROM
(S1)	(SW-PB / CON3)	(RESET PUSH BUTTON FOOTPAD ONLY Switch not included)
SCI	CON6	6-PIN MALE SERIAL HEADER: 5 VOLT RS232 CONNECTOR
SIP	9 X 10K SIP	9 RESISTORS COMMON PIN 10K
SPI	CON7	7-PIN MALE SYNCHRONOUS SERIAL PERIPHERAL INTERFACE HEADER
SS	2-PIN MALE HEADER =CON2	JUMPER HEADER FOR SPI SLAVE SELECT
U1	68HC11	MC68HC11 MICROCONTROLLER
U2	LM2931T-5.0	5 VOLT REGULATOR
U3	MC34164	POWER ON RESET
U4	MC34064	LOW VOLTAGE INHIBIT
U5	62256	MEMORY 32K SRAM OR ROM
U6	62256	MEMORY 32K SRAM OR ROM
U7	MC74HC573	74HC573 ADDRESS LATCH
U8	MC74HC10	74HC10 TRIPLE INPUT NAND
VRH	CON3	JUMPER HEADER FOR HIGH ANALOG REF. VOLT
VRL	CON3	JUMPER HEADER FOR LOW ANALOG REF. VOLT
X1	8 MHZ	CERAMIC RESONATOR

[1]**IMPORTANT:** *If a part is polarized, then the insertion orientation is important. Incorrect insertion may cause the part to fail catastrophically when power is applied.*

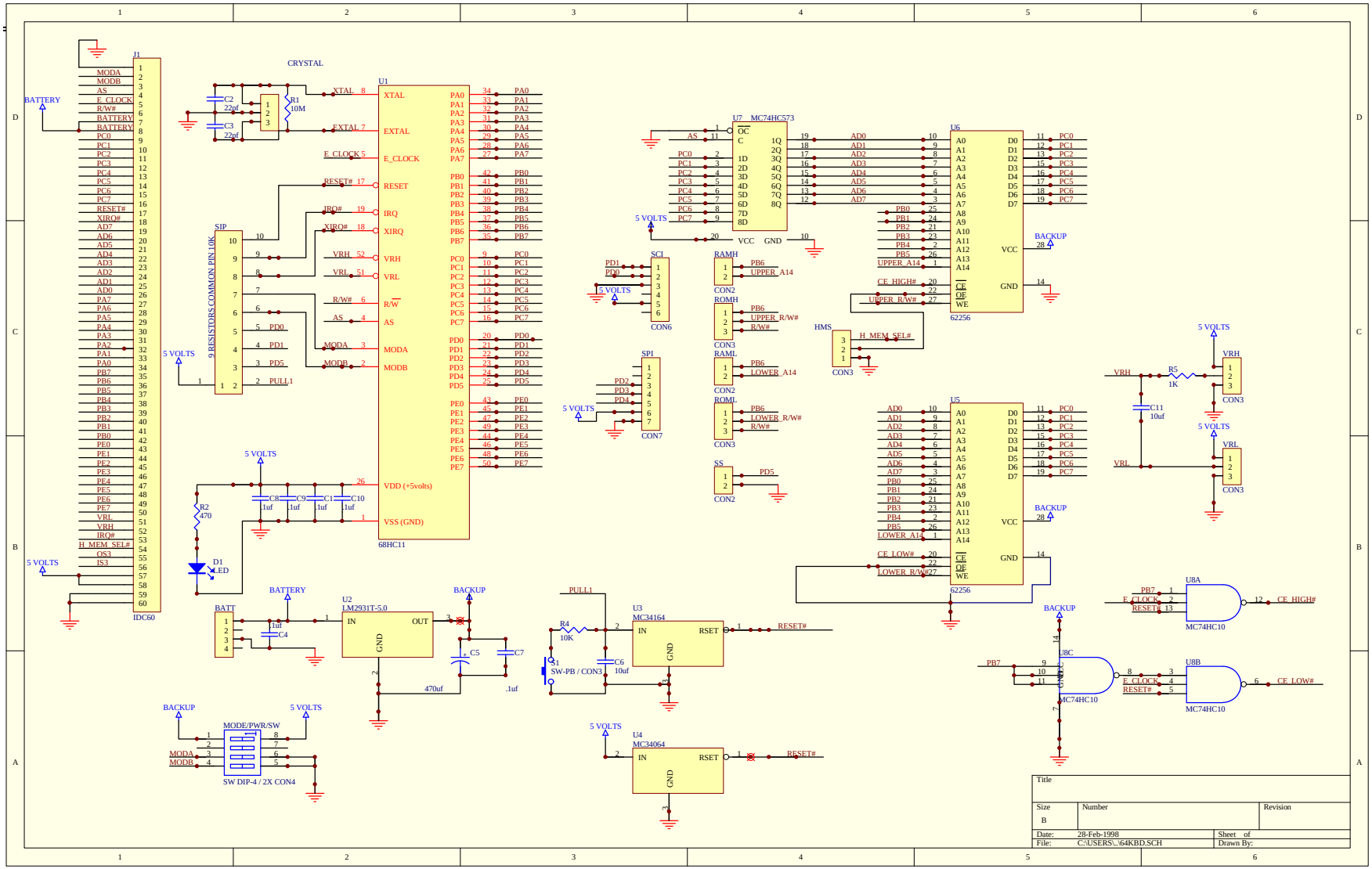


Figure 1 MRC11 circuit board. The dip-switch is not used in TALRIK. The dip-switch connections connect to TALRIK's Bridge switches..

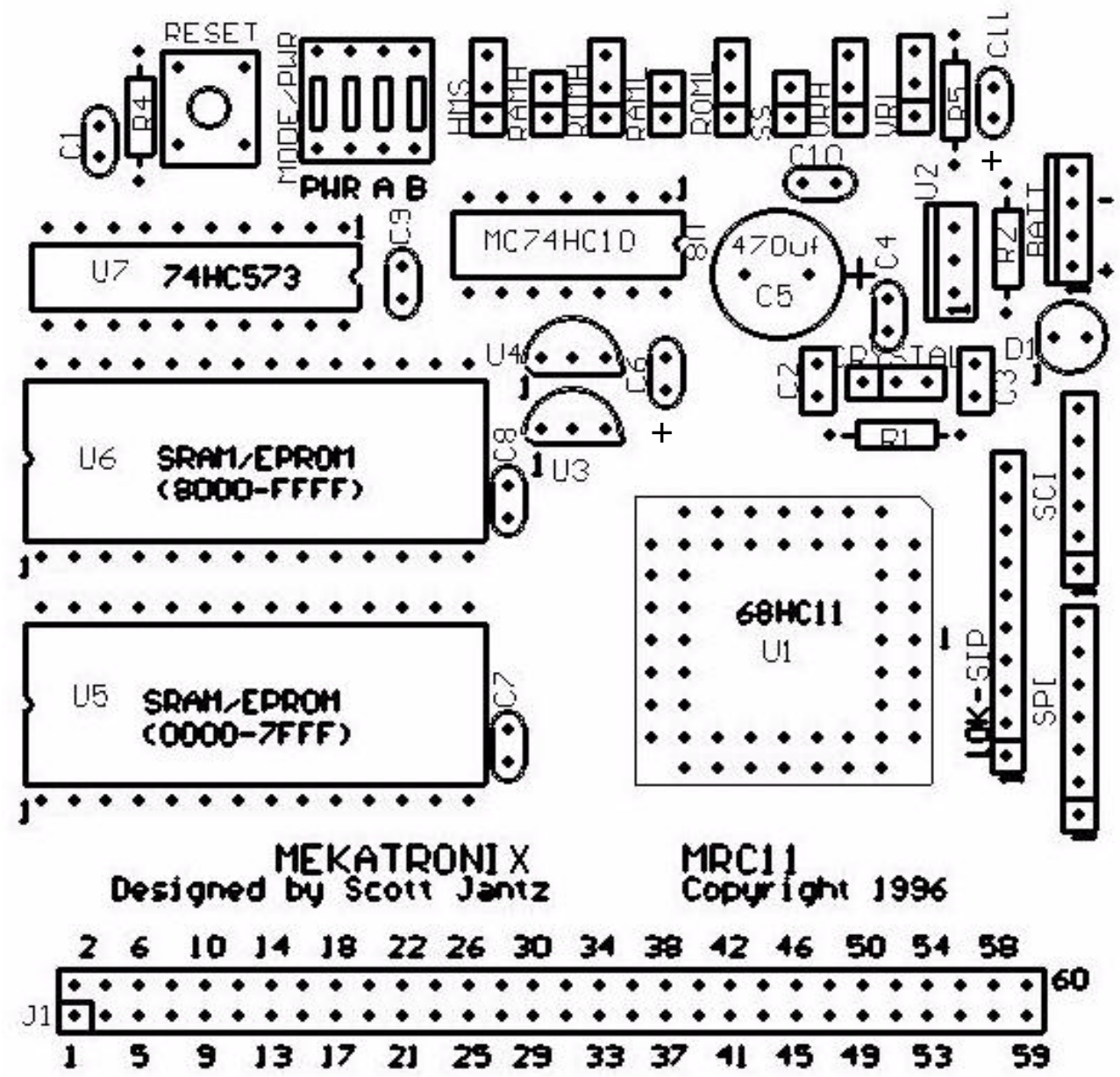


Figure 2 Parts placement on the MRC11 printed circuit board. The MRC11 offers an MC68HC11 processor with 64KBytes of RAM/ROM expansion. The 60 pin header brings out all the processor signals relevant to other systems.

4. MOUNTING COMPONENTS ON THE MRC11 PCB

Caution> Be sure to wear eye protection when clipping leads. Clipped leads can fly in any direction.

4.1 Mounting and Soldering Discrete Components

1. Place the 0.1uf capacitor leads through the pins labeled C1, C4, C7, C8, C9 and C10 on top of board. Bend the leads toward each other to clamp the component to the board. Solder the capacitor leads to the board on the bottom of the board. Clip excess leads off with the diagonal cutters (dikes).

Caution: *In the next two steps, make sure you understand the markings on the polarized capacitors before soldering it on the board. Improperly soldered electrolytic or tantalum capacitors can rupture with applied voltage.*

2. Insert the polarized tantalum capacitors C6 and C11 with the polarity as marked in

3. Figure 2. Bend, solder and clip the leads as in *Step 1*.

Caution*: These polarity signs may not be on the silk-screen of the PCB. Refer to* Figure 2.

4. Insert the leads of resistors R1, R2, R4, and R5, bend the leads, solder underneath the board, and clip. *Note: No resistor is labeled R3.*

5. If you desire to have a power on light on the board insert the LED D1. The LED must be inserted so that the beveled side is furthest from the board. Bend, solder and clip leads. LED D1 can also be mounted externally. For TALRIK™ the LED D1 is mounted at the switch panel on the right bridge support.

6. Insert the resistor SIP into the board. Be sure pin one of the SIP is in the via (pin hole) marked with a square. While holding the SIP firmly to the board (for example, with masking tapes or your hand), solder pin one and the last pin on the underneath side of the board. Release pressure on the SIP and solder the remaining pins.

7. Insert U2, the 5 volt regulator, again be careful and note pin one (labeled in Figure 2). The bar at the top of the rectangle indicates which side the flat, metal back of the regulator faces, namely, towards the interior of the PCB. Solder the leads underneath and clip the leads.

8. Correctly insert the large, electrolytic filter capacitor C5, noting the polarity as marked on the PCB. Bend leads, solder underneath and clip.

Caution*: Do this right or the capacitor may explode when powered up!*

9. Properly insert the three pin integrated circuits U3 and U4. Pin one is labeled on the silk-screen for each device. Solder and clip leads.

4.2 Mounting and Soldering IC Sockets

Comment on Sockets: *Be careful not to heat the IC socket pins too much as it might melt the socket plastic and cause the socket pins to short or open. On rare occasions sockets may already have shorts between a pair of pins or a pin may be open circuited. These manufacturing defects can cause serious hardware debugging problems. Most users do not bother checking sockets, because defective ones are so rare. But, the user should be informed of such possibilities.*

Note*: Occasionally one bends a pin. Use the needle nose pliers to straighten them.*
Caution*: Pins cannot withstand too much bending without damage and loss of function.*

10. When all headers are properly soldered, insert the PLCC socket U1 into the board with the rounded corner nearest the ceramic resonator X1 (

11. Figure 2). Use masking tape to tightly secure the socket to the top of the PCB.

***Caution**: Inserting the PLCC socket correctly is extremely important. Improper installation may cause the destruction of the microprocessor when power is applied.*

Be sure the socket is seated securely on the PC board before soldering a corner pin on the bottom of the PCB. Now, keeping the socket firmly placed against the board, solder the diagonally opposite corner. The PLCC is now firmly in place. Examine your work carefully to insure correct installation. Verify the rounded corner of the socket is located properly. Now, solder the remaining pins of the socket.

12. Tape in IC sockets U5, U6, U7 and U8 with masking tape with the notch on the socket lining up with the notch in the silkscreen outline on the top of the board.

***Caution**: Inserting IC sockets correctly is extremely important. Improper installation may cause the destruction of a socketed IC when power is applied.*

Flip the board and solder the socket leads, taking care to ensure that the sockets lie snug and flat against the top surface of the board. Solder opposite diagonal pins first in order to clamp the socket securely to the board. Solder the rest of the socket pins.

***Caution**: Do not insert ICs into Sockets until the Board has been checked.*

4.3 Cutting, Mounting and Soldering Headers

Use small, thin blade dikes (diagonal cutters) to cut male headers from a male header strip (Figure 3). For example, cut two pins for a CON2, three pins for a CON3 header, etc.

Caution: When cutting, hold both parts being separated by the cut, otherwise, the one not being held will fly across the room. Wear eye protection as a precaution.

When cutting headers be careful not to cut away too much plastic and expose the pins where the cut is made.

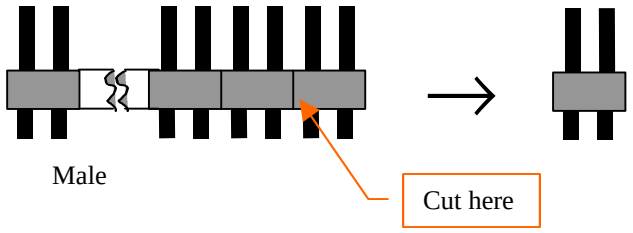


Figure 3 Cutting a CON2 male header. Insert the short leads of the male header into the PCB and solder on underneath side of the board.

***Note**: Occasionally one bends a pin. Use the needle nose pliers to straighten them.*
***Caution**: Pins cannot withstand too much bending without damage and loss of function.*

13. Cut the male headers HMS (3 pin), RAMH (2 pin), ROMH (3 pin) RAML (2 pin), ROML (3 pin), SS (2 pin), VRH (3 pin), VRL (3 pin), BATT (4 pin), SPI (7 pin), SCI (6 pin). Before soldering ensure that they are straight, aligned, and placed firmly against the board. If necessary align them with a piece of 100 mil perforated board. The three pin headers should look like Figure 4 when completed.

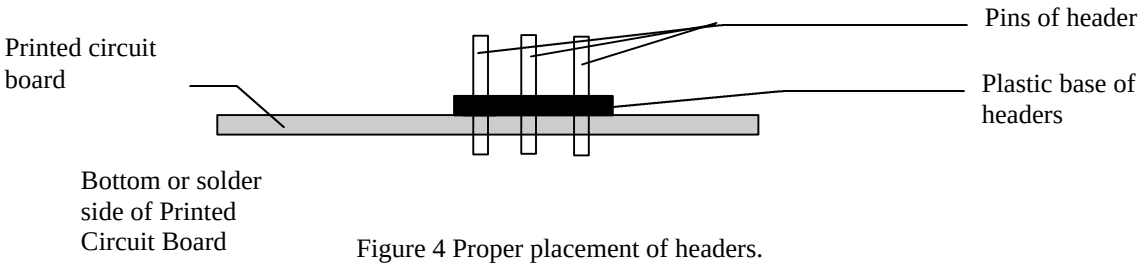


Figure 4 Proper placement of headers.

14. Special care should be taken in inserting and aligning the 60 pin (2 rows of 30 pins) J1. In some kits the header may have more than 30 pins in a row. In such cases, cut the 31st pin on top and bottom rows before cutting the plastic between the 30th and 31st pin. Exercise care here. The extra thickness of the header makes it easier to damage or expose pin 30 when making the cut. Bias your cut towards the 31st pin or even sacrifice the 31st pin (recommended). When inserting the connector, be sure it is vertical (straight male header) and firmly seated. With the male header firmly held against the MRSX01 PC board, solder one pin at the left end. Keeping the header firmly against the board solder the diagonally opposite pin. Next, solder all the other pins. If a right angle male header is used (Figure 5), first insert the male header into the female connector to be used. Second, insert the male header into the PCB with the female connector still attached. This forces you to leave adequate clearance for easy insertion and disconnecting of the female header. Solder the connector as described earlier.

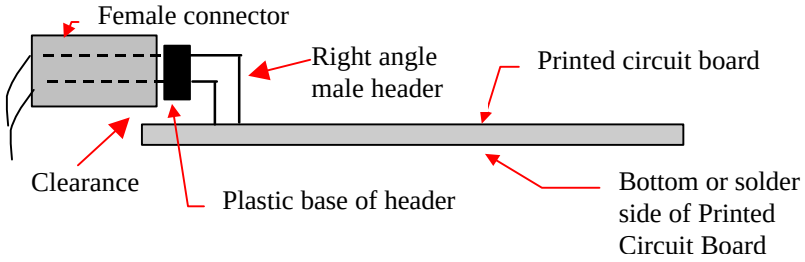


Figure 5 Placement of a right angle male header. Be sure there is plenty of clearance between the board and the male header to permit easy insertion and disconnection of a female connector.

4.4 Making Connectors and Jumpers

The MRC11 kit does not include female connectors. The TALRIK™ robot kit, which uses the MRC11, does provide female connectors. Make jumpers and connectors from female headers by cutting sections from a large, single-row female strips with the dikes (Figure 6). For a two pin jumper, short the pins together with a lead clipped from a resistor or capacitor. Solder the pins and the lead together. Cut between the sockets. Use the same cutting technique used with the male headers. When cutting connectors be careful not to cut away too much plastic and expose the pins where the cut is made.

Caution: When cutting, hold both parts being separated by the cut, otherwise, the one not being held will fly across the room. Wear eye protection as a precaution.

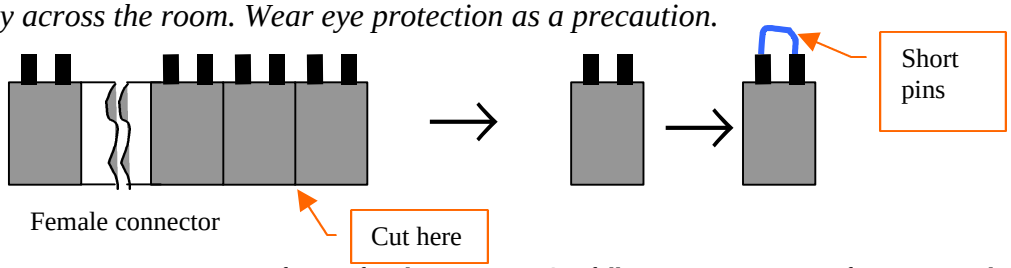
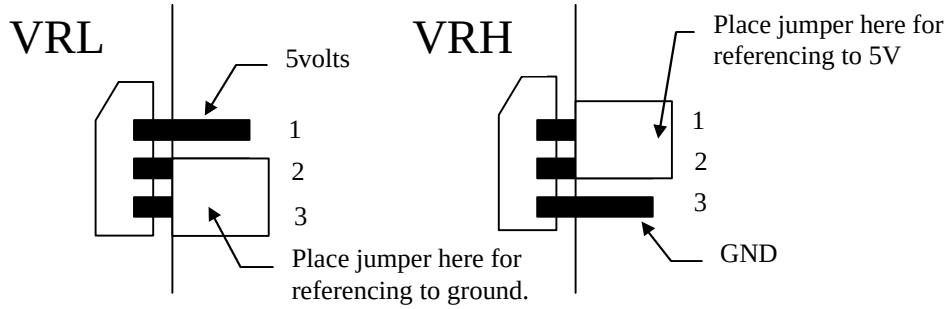


Figure 6 Constructing a two pin jumper from a female connector. Carefully cut away a group of two pins and short them together.

4.5 Jumper Placement

Refer to Figure 7 when installing the jumpers for the MRC11. The configuration show is for RAM chips. To install a ROM chip in either socket, remove the RAM jumper and move the ROM jumper to its alternate position.

1. Jumper for VRL and VRH are normally placed as follows.



2. The HMS jumper connects pin 2 to pin 1 for normal operation. This connection satisfies the active low logic signal OE# of U6, the upper 32K bytes of Memory. This memory can also be enabled to be selected externally by the active low logic signal H_MEM_SEL# when the jumper connects pins 2 and 3. This is the mode used when the MRXS01 is used with the MRC11.
3. If RAM is installed in upper memory U6, jumper RAMH and ROMH as shown. If RAM is installed in lower memory jumper RAML and ROML as shown.
4. If ROM is installed in upper memory U6, jumper ROMH and remove jumper RAMH. If ROM is installed in lower memory jumper ROML and remove jumper for RAML.
5. For serial synchronous communication the controller can be fixed as a slave processor by jumpering pin 1 to pin 2 on the SS jumper. Without the jumper you can specify the slave status by controlling pin 1of the SS jumper.

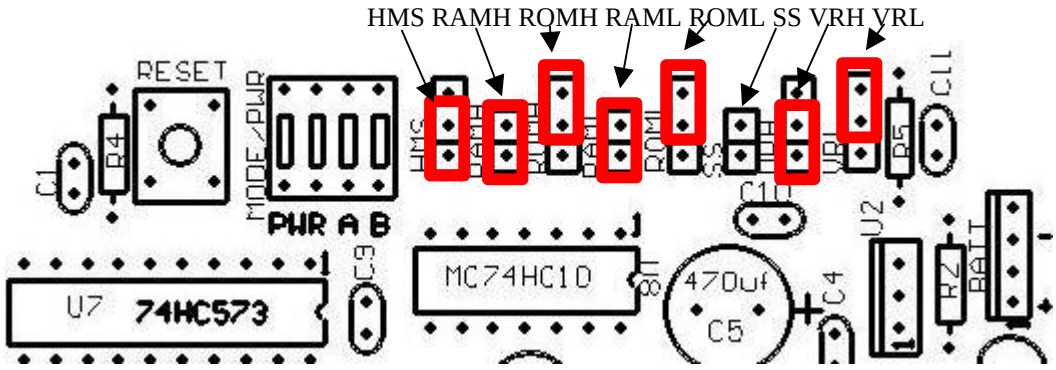


Figure 7 Placement of MRC11 Jumpers when installing RAM ICs into both memory sockets.

5. TESTING THE MRC11

1. No ICs in the sockets. Use a multimeter to test for shorts between the positive and negative terminals of BATT (pins one and three) and 5 volts and ground between pins 58 and 59 on J1. Some multimeters have a short circuit indicator that will beep if a short is detected. If there is a short circuit between power and ground, check for solder bridges or improper component placement. **Do not continue until all shorts are eliminated**. The multimeter should read a few hundred ohms if the LED was installed (or a large resistance otherwise) on a correctly assembled board.

2. No ICs in the sockets and all shorts have been cleared. Apply 6-10volts across the battery connector. ***DO NOT connect the battery directly to the 5volt supply!*** You can use the TALRIK^{II} ™ 8-AA NiCd Battery pack for the power supply. Be sure you have the correct polarity. Flip the power on switch, however you configured it. Check the output voltage of the regulator U2 to verify it is 5 volts. Check ground and 5 volts on the IDC (J1). If the voltage regulator U2 (LM2931T) gets hot, quickly unplug the battery pack and test for shorts again. If the voltage regulator (LM2931T) remains cool, use a multimeter to test for 5 volts and ground at the IC pins indicated in the following table:

IC	Ground at Pin No.	+5VDC at Pin No.
U1	1	26
U2	2	3
U3	3	2
U4	3	2
U5	14	28
U6	14	28
U7	10	20
U8	7	14

If your readings do not match the above table make sure you are reading the correct pins (Note: testing from the bottom of the board mirrors the pin positions and makes the measurement process error prone). To be on the safe side, verify that none of the other pins on the sockets have either 5volts or ground on them.

3. After completing *Step 15*, disconnect power. Insert one of the five socketed ICs. Power up the board and check the voltages again. If everything checks, power down the board and insert the next IC. Continue until all the ICs are installed and the voltages check.

4. With all the ICs installed and voltages checked, power up the board once again. Connect the MRC11 to a PC via the C2325 cable connecting the SCI jumper on the MRC11 and J2 on the MB2325 communications board (refer to Figure 8). You can now communicate with your MRC11 board and test whether the processor runs and whether the memory functions properly. Power up the boards with an 8-AA NiCd battery pack connected to the battery connections. ***DO NOT connect the battery directly to the 5volt supply!***

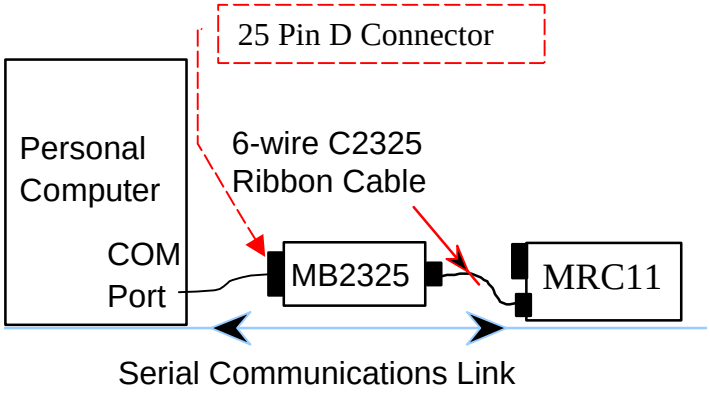


Figure 8 Configure your PC, the MB2325 communications board, and the MRC11 as shown. The MB2325 requires a 25-pin D-connector on the PC side. If the COM port on your PC has a 9-pin D-connector, you will have to get a 9-pin to 25-pin D-connector converter plug.

Successful execution of the following tests gives strong indication that the MRC11 is working properly.

- Execute PCBUG11 to verify communications with the processor.
- Use PCBUG11 to read processor registers and a few of the processor memory locations.
- Write a short program to write data to memory, read it back, and check the read data against the written data while stepping through all RAM addresses.

5. Your board works! You now have constructed a general purpose microcontroller with 64KRAM that is useful for a number of projects, including the control of a mobile robot.