ASSEMBLY MANUAL
MRSX01 MEKATRONIX
SENSOR EXTENSION BOARD

By
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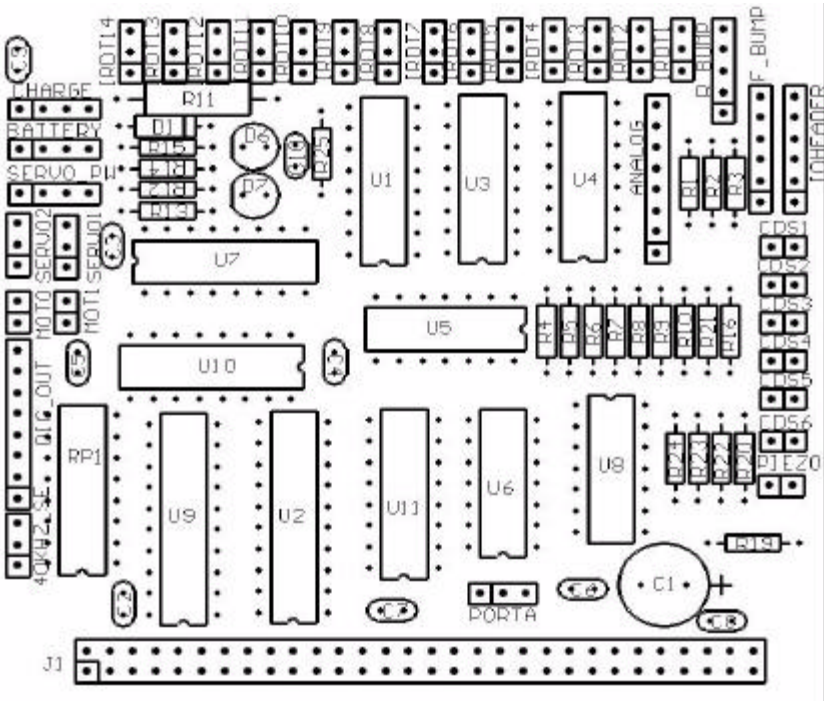

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- Low cost,
- Wide availability,
- Open architecture,
- An open, enthusiastic, dynamic community of users sharing information.

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1 ABSTRACT

The MRSX01 sensor expansion board mates with the MRC11 microcontroller board to form an extensive, sophisticated, general, microcontroller data acquisition and control system useful in a wide variety of embeded computer control and measurement applications such as instrumentation, robotics, hobby projects, etc. This manual provides instructions for the assembly of the MRSX01. Consult the MRC11 Assembly manual for the assembly of the microcontroller companion board. To test this board you will need the MRC11 or equivalent and a program to run diagnostics.

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 section)* 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. Pins on headers and connectors occasionally get bent. To restore the pin to proper function, careful straightening them with needle nose pliers should do the trick, but bending a pin certainly does not improve the pin's performance and can lead to failure.

2.4 Questions and Further Information on the MRSX01

For technical support email all questions to mek_tech@orlandonet.magicnet.net **.**
For technical information and further description of the MRSX01 refer to the free manual at http://www.mekatronix.com.

2.5 Equipment Needed to Construct the MRSX01

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 MRSX01

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

1. Multimeter

2. A Motorola MC68HC11 based controller such as the MRC11an MSCC11.
3. A MEKATRONIX™ MB2325 communications board with a MEKATRONIX™ C2325 6-wire serial cable.
4. 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.
5. Motorola PCBUG11 (freeware) or Interactive C (freeware for versions less than 3.1) or ICC11 (purchase from a MEKATRONIX™ distributor).
6. Power supply or 8 pack of AA rechargeable batteries to supply about 7-10 volts (We recommend Energizer rechargeable AA NiCd Batteries).
7. Cables, connectors, jumpers and/or switches

3 The MRSX01 Sensor Expansion Board

The MRSX01 serves as a general purpose sensor data acquisition and digital InputOutput control board for robotics and other applications requiring extensive sensor capability. The MRSX01 mates with the MRC11 controller to form the complete control and sensing capability of the TALRIK^{II}™ robot. Future MEKATRONIX™ kits will be based on these and other designs. In Figure 6 the fourteen, 3-pin male headers for the IR detectors along the top edge. The 60-pin male header J1, along the bottom edge of the board, attaches to the computer bus. The 2-pin male headers for the six CDS cells line up along the right side of the board. The charge circuit connector, the battery and servo power connectors, are in the upper left. Along the left side, just below the power connectors, are the motor and servo connectors. Below them you find the digital output enables and the 40 KHz jumper.

3.1 Features of the Sensor Expansion Board

The MRSX01 mates with the MRC11 to provide extensive sensor and control capabilities. The two-board stack, MRSX01 and MRC11, furnishes the circuitry that supports all the sensory, motor and cognitive functions for the TALRIK^{II} autonomous mobile robot and can be used for a wide variety of mechatronic applications that require extensive data acquisition and computer control. In particular, the MRSX01 features:

1. Twenty Analog Inputs,
2. Two Digital Inputs,
3. Eight Memory Mapped Digital Outputs
4. Four Memory Addressable Input Device Selects,
5. Three Memory Addressable Output Device Selects,
6. High Memory Select(Address >= b"1111 1111 1011 1xxx"),
7. Two Pulse Width Modulated Outputs for Motor Control,
8. Two Pulse Width Modulated Outputs for Servo Control,
9. One Pulse Width Modulated Output assigned to an optional piezo speaker,
10. A Battery charge circuit (100ma at 12 volts-DC),
11. Battery Voltage Sensor (Analog Input),
12. Charge Current Sensor (Analog Input),
13. Front Bumper Sensor (Analog Input),
14. Rear Bumper Sensor (Analog Input),
15. Forty KHz square wave generator,
16. Processor Data Bus and Ports brought out to a 60 pin Header
17. Battery-Power-In and Battery-Power-Out Headers

Fourteen analog inputs lead out to 3-pin male headers: (pin-1, pin-2, pin-3) = (Signal, 5 Volts, Ground). TALRIK^{II}™ uses these 14 analog inputs to sense IR detector signals. Six other analog inputs terminate on 2-pin male headers:(Signal, 5Volts). TALRIK^{II}™ employs these 6 analog inputs for light detection with photoresistors.

3.2 The MRSX01 Kit

The parts in your MRSX01 kit are listed in Figure 1. The female and male headers come in lengths of 36 pins. These will have to be cut to make the headers for the board. Instructions on how to do that are given in Section 4.3.

Quantity	Item
1	60-pin Double Row, Right Angle Male Header
3	14-pin Socket
6	16-pin Socket
2	20-pin Socket
1	470uF Electrolytic Capacitor
9	0.1uF Bypass Capacitor
1	1N4001 Diode
2.5	Single Row Female Header (36 pins)
3.5	Single Row Male Header (36 pins)

Qty	Integrated Circuits
1	74HC04
2	74HC11
1	74HC138
1	74HC390
2	74HC574
3	74HC4051
1	SN754410
	PCB
1	Printed Circuit Board

Qty	Resistors/Values
3	1KΩ
8	10KΩ
2	22KΩ
1	33KΩ
2	47KΩ
2	100KΩ
1	150KΩ

Qty	Resistors/Values
2	47Ω
1	100Ω
1	330Ω
9	470Ω

Figure 1 Tables listing the MRSX01 kit parts and quantities.

4 ASSEMBLING THE MRSX01

Error! Reference source not found. lists the MRSX01 bill of materials and Table 2 itemizes each part in alphabetic order. The part DESIGNATOR column in **Error! Reference source not found.** corresponds to the part labels in the circuit diagram in Figure 5 and the board layout in Figure 6. The table and figures together illustrate how to place the components for soldering.

***Note**: If the board has a silk-screen then*

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.*

Otherwise, look for an etched word to indicate which side of the board is **TOP** or **BOTTOM**.

Table 1 Bill of Materials for the MRSXO1

Qty	Designator	Value	Description
1	C1	470µf	POLARIZED ELECTROLYTIC CAPACITOR[1]
9	C2 C3 C4 C5 C6 C7C8 C9 C10	0.1µf	BYPASS CAP

1	R 1	150KΩ	RESISTOR, ¼ WATT
2	R 2 R6	100KΩ	RESISTOR, ¼ WATT
2	R 3 R7	47KΩ	RESISTOR, ¼ WATT
2	R 4 R8	22KΩ	RESISTOR, ¼ WATT
8	R 5 R 9 R10 R13 R16 R22 R23 R24	10KΩ	RESISTOR, ¼ WATT
1	R11	25Ω	RESISTOR, ½ WATT
1	R12	33KΩ	RESISTOR, ¼ WATT
1	R14	300Ω	RESISTOR, ¼ WATT
1	R15	100Ω	RESISTOR, ¼ WATT
3	R19 R20 R21	1KΩ	RESISTOR, ¼ WATT
1	R25	470Ω	RESISTOR, ¼ WATT
8	RP1	470Ω	IR CURRENT LIMITING RESISTORS, ¼ WATT
6	CDS1 CDS2 CDS3 CDS4 CDS5 CDS6	CON2	2-PIN MALE HEADER CdS PHOTORESISTORS
2	MOTOR_0 & 1	CON2	MOTOR 1 AND MOTOR2 HEADERS
1	PIEZO	CON2	PIEZO SPEAKER HEADER
1	40KHZ_SEL	CON3	3-PIN MALE JUMPER HEADERS
14	IRDT1 TO IRDT14	CON3	IR DETECTOR HEADERS
1	PORTA	CON3	HEADERS FOR PA0, PA1, PA2 OF PORTA
2	SERVO1 SERVO2	CON3	3-PIN MALE SERVO1 & SERVO2 HEADERS
3	BATTERY	CON4	4-PIN MALE BATTERY CONNECTOR
1	CHARGE	CON4	CHARGER CONNECTOR
1	SERVO_PWR	CON4	SERVO POWER CONNECTOR
1	R_BUMP	CON5	5-PIN MALE HEADERS RIGHT BUMPER CONNECTOR
1	F_BUMP	CON6	6-PIN MALE HEADERS FRONT BUMPER CONNECTOR
1	IOHEADER	CON6	BYTE INPUT-OUTPUT HEADER
1	ANALOG	CON8	8-PIN MALE HEADERS, ANALOG INPUTS
1	DIG_OUT	CON8	IR LED OUPUT
1	D1	DIODE	POWER DIODE
1	J1	IDC60	60 PIN IDC HEADER
2	D6 D7	LED	CHARGE LED
3	U 1 U3 U4	MC74HC4051	ANALOG 8:1 MUX
2	U 2 U9	MC74HC574	OCTAL D-FF SENSOR LATCH
1	U 5	MC74HC04	HEX INVERTER
2	U 6 U8	MC74HC11	TRIPLE INPUT AND
1	U 7	MC74HC138A	3:8 DECODER
1	U10	74410NE	QUAD HALF-H MOTOR DRIVER
1	U11	MC74HC390	DIVIDE BY 2 & 5 COUNTER

Table 2 Individual Parts List for the MRSXO1, Robot Sensor Expansion Board, Ordered by Designator.

Designator	**Part Type**	**Description**
40KHZ_SEL	CON3	3 CONNECTOR, IR DETECTOR
ANALOG	CON8	IR LED OUPUT HEADER

BATTERY	CON4	BATTERY CONNECTOR
C1	470µf	POLARIZED ELECTROLYTIC CAPACITOR[1]
C2	0.1µf	BYPASS CAPACITOR
C3	0.1µf	BYPASS CAPACITOR
C4	0.1µf	BYPASS CAPACITOR
C5	0.1µf	BYPASS CAPACITOR
C6	0.1µf	BYPASS CAPACITOR
C7	0.1µf	BYPASS CAPACITOR
C8	0.1µf	BYPASS CAPACITOR
C9	0.1µf	BYPASS CAPACITOR
C10	0.1µf	BYPASS CAPACITOR
CDS1 CDS2 CDS3 CDS4 CDS5 CDS6	CON2	2 CONNECTOR CdS PHOTORESISTORS
CHARGE	CON4	CHARGER CONNECTOR
D1	DIODE	POWER DIODE
D6	LED	CHARGE-ON LED
D7	LED	POWER-ON LED
DIG_OUT	CON8	IR LED OUPUT
F_BUMP	CON6	FRONT BUMPER CONNECTOR
IOHEADER	CON6	BYTE INPUT-OUTPUT HEADER
IRDT1 TO IRDT14	CON3	3-PIN MALE HEADERS FOR THE IR DETECTORS
J1	IDC60	60 PIN IDC HEADER
MOTOR_0 & 1	CON2	2 CONNECTOR, MOTORS 1&2
PIEZO	CON2	2 CONNECTOR, PIEZO SPEAKER
PORTA	CON3	HEADERS FOR PA0, PA1, PA2 OF PORTA
R_BUMP	CON5	RIGHT BUMPER CONNECTOR
R1	150K	RESISTOR, ¼ WATT
R2	100K	RESISTOR, ¼ WATT
R3	47K	RESISTOR, ¼ WATT
R4	22K	RESISTOR, ¼ WATT
R5	10K	RESISTOR, ¼ WATT
R6	100K	RESISTOR, ¼ WATT
R7	47K	RESISTOR, ¼ WATT
R8	22K	RESISTOR, ¼ WATT
R9	10K	RESISTOR, ¼ WATT
R 10	10K	RESISTOR, ¼ WATT
R 11	25	RESISTOR, ½ WATT
R 12	33K	RESISTOR, ¼ WATT
R 13	10K	RESISTOR, ¼ WATT
R 14	300	RESISTOR, ¼ WATT
R 15	100	RESISTOR, ¼ WATT

Table 2(Continued)

Designator	**Part Type**	**Description**
R 16	10K	RESISTOR, ¼ WATT
R 19	1K	RESISTOR, ¼ WATT
R 20	1K	RESISTOR, ¼ WATT

R 21	1K	RESISTOR, ¼ WATT
R 22	10K	RESISTOR, ¼ WATT
R 23	10K	RESISTOR, ¼ WATT
R 24	10K	RESISTOR, ¼ WATT
R 25	470	RESISTOR, ¼ WATT
RP1	EIGHT, 470 OHM RESISTORS	IR EMITTER CURRENT LIMITING RESISTORS MOUNT IN IC CARRIER
SERVO_PWR	CON4	SEPARATE POWER CONNECTOR FOR SERVOS
SERVO1 SERVO2	CON3	3-PIN MALE SERVO1 & SERVO2 HEADERS
U 1	MC74HC4051	ANALOG 8:1 MUX
U 2	MC74HC574	OCTAL D-FF SENSOR LATCH
U 3	MC74HC4051	ANALOG 8:1 MUX
U 4	MC74HC4051	ANALOG 8:1 MUX
U 5	MC74HC04	HEX INVERTER
U 6	MC74HC11	TRIPLE INPUT AND
U 7	MC74HC138A	3:8 DECODER
U 8	MC74HC11	TRIPLE INPUT AND
U 9	MC74HC574	OCTAL D-FF SENSOR LATCH
U10	74410NE	QUAD HALF-H MOTOR DRIVER
U11	MC74HC390	DIVIDE BY 2,5 COUNTER

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

4.1 Mounting, Cutting and Soldering Discrete Components

1. Solder single row, cut-to-length, female headers into the via pads for the CdS pull-down resistors R19, R20, R21, R22, R23, R24. The resistors provided are for nominal usage. Typically, users will need to determine CdS pull-up resistor values appropriate to their application. The female headers permit the resistors to be socketed for easy changing. Clip the resistor leads to link and insert them into the pins.
2. Insert resistors R1 through R16 and R25, bend their leads toward each other, solder and clip the leads.
3. Insert the nine bypass capacitors {C2 C3 C4 C5 C6 C7 C8 C9 C10}, bend their leads toward each other, solder and clip the leads.
4. Insert the polarized capacitor C1. Be sure the positive pole is in the via designated by the + sign next to it. Bend the leads toward each other, solder and clip the leads.

Caution: *Make sure you understand the markings on the capacitor before soldering it on the board. Improperly soldered electrolytic or tantalum capacitors can rupture with applied voltage.*

Caution*: The polarity signs may not be on the silk-screen of the PCB, so refer to Figure 6.*

5. Insert power diode D1, LEDs D6 and D7 (You may want to mount the power-on LED (D7) externally) with the correct polarity. See markings in Figure 6. Bend the leads toward each other, solder and clip.

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.*

6. Securely tape IC sockets RP1 and U1 through U11 to the top of the board with masking tape. Make sure the notches on the sockets line up with the notches in the outline on the top of the board.

***Caution**: Inserting the IC socket 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 of the socket first in order to clamp the socket securely to the board. Solder the rest of the socket pins after you have made certain that the socket notch matches up with the printed notch.

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 2). 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.

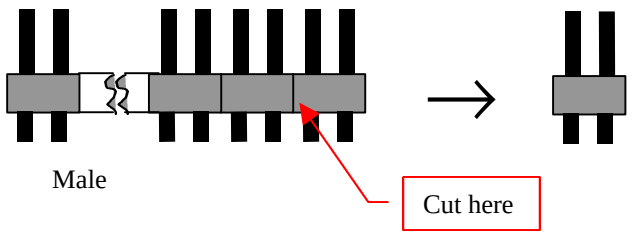

Figure 2 Cutting a CON2 male header. Insert the short leads of the male header into the PCB and solder on underneath side of the board.

***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.*

7. Cut the following male headers: nine CON2, eighteen CON3, three CON4, one CON5, two CON6 and two CON8.

8. For each male header, insert the short leads of the male header into the board. The long side of the male header faces outward from the top of the board and the plastic support rests on the top surface of the board. Tape the top side of the male header to hold it firmly in place. Solder the underneath side. Don't forget to remove the tape after you finish!

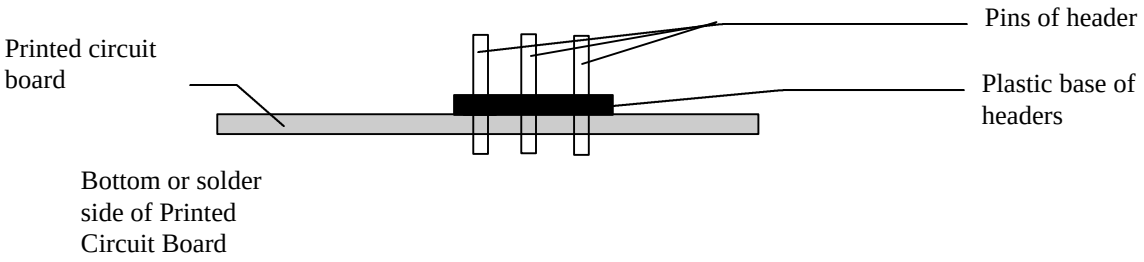

Figure 3 Proper placement of headers.

***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.*

9. Special care should be taken in inserting and aligning the 60 pin (2 rows of 30 pins) IDC (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 4), 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.

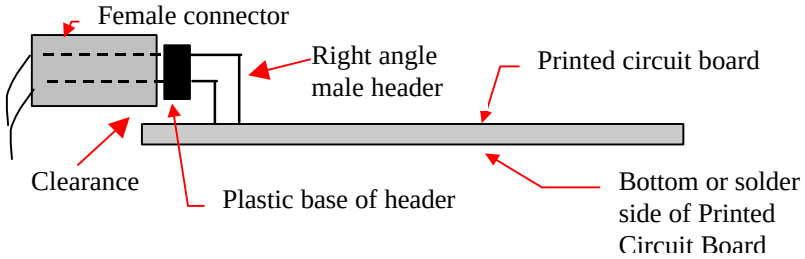

Figure 4 Placement of a right angle male header. Be sure there is plenty of clearance between the board and the male header to permit easy insertion and disconnection of a female connector.

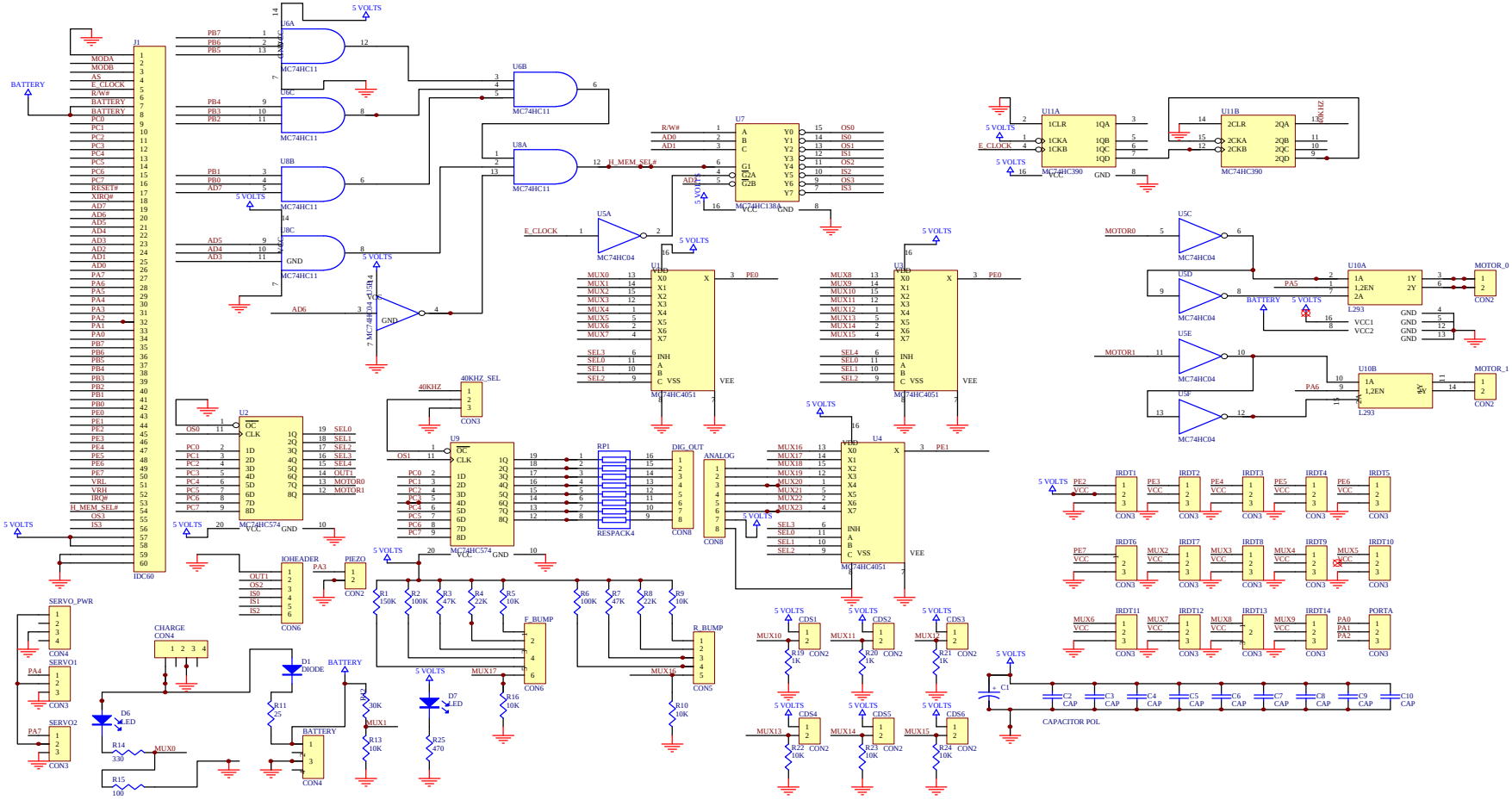

Figure 5 MRSX01 circuit diagram. Elements indicated by CON*j* are connectors with *j* pins.

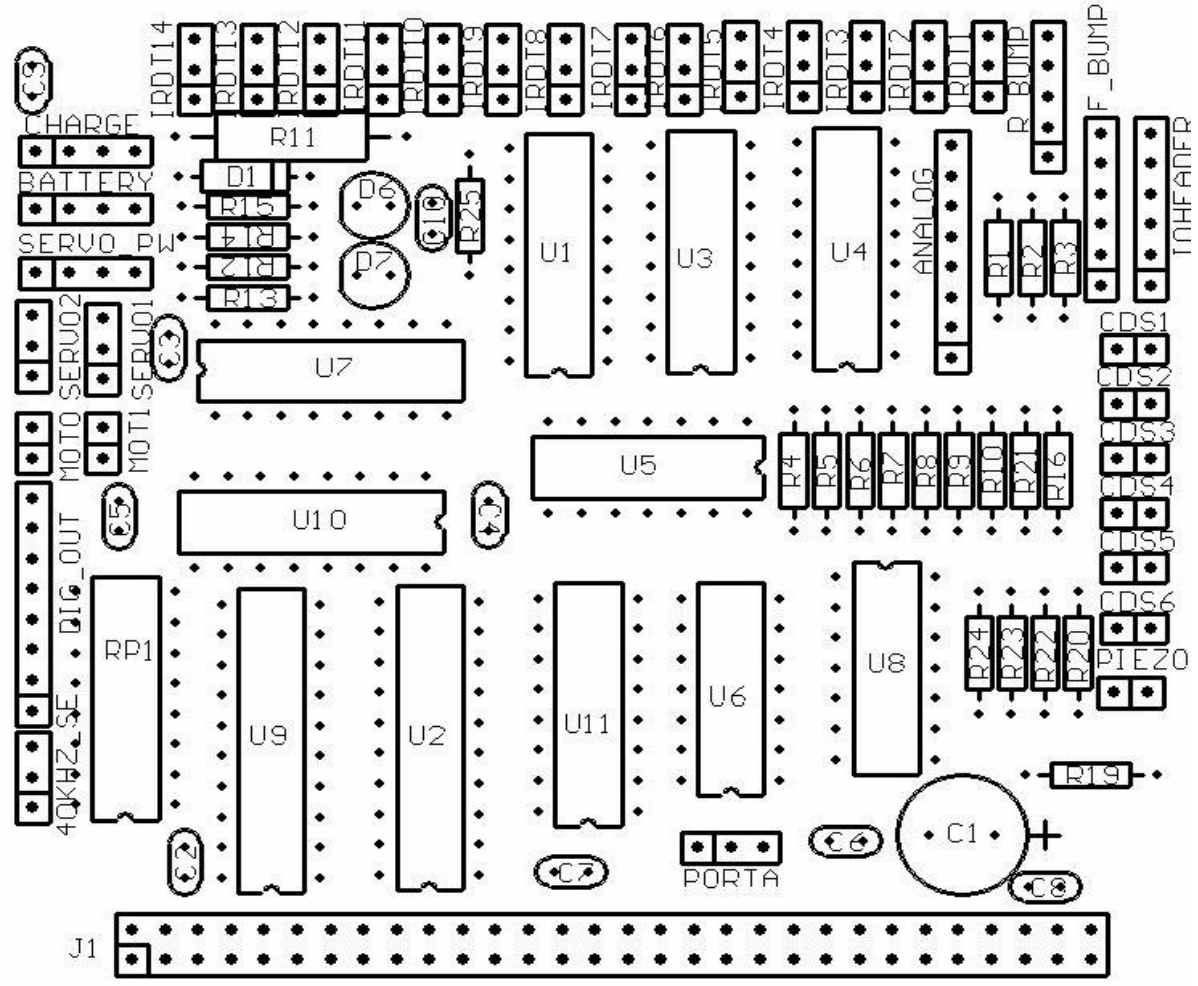

Figure 6 This layout of the MRSX01 locates all the sensor connectors. Pin one of the connectors is designated by a box around the pad. Two pin connectors on this board serve non-polarized devices, so pin number one is irrelevent here.

4.4 Making Connectors and Jumpers

The MRSX01 kit does not include female connectors. The TALRIK™ robot kit, which uses the MRSX01, 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 7). 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. For each CON2 male header, such as used with the CdS cells, you cut two pins. For a CON3 male header, such as used with the IR detectors, cut three pins, etc. 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.

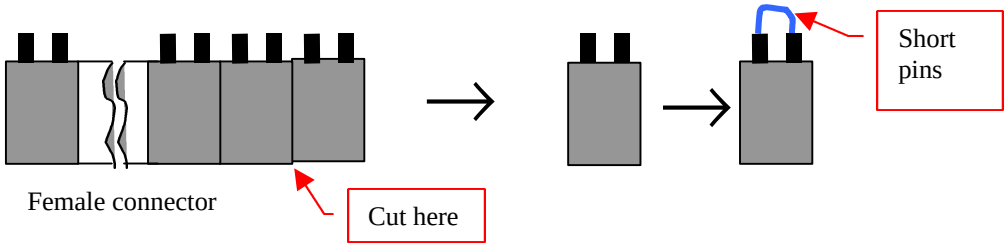

Figure 7 Constructing a two pin jumper from a female connector. Carefully cut away a group of two pins and short them together.

5 TEST BOARD

To test the MRSX01 board requires an external microcontroller. Sophisticate users may have their own setups and can use them to test the MRSX01. We can not anticipate all possible configurations, so we outline a procedure to test the MRSX01 board with the Mekatronix MRC11 microcontroller. If you purchase both the MRSX01 and MRC11 boards together, Mekatronix will supply a TALRIK^{II} test program that allows you to interactively test the various sensory connectors.

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 IDC (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 5 volts to J1 pins 59-60 and ground to IDC (J1) pins 57-58. Be sure you have the correct polarity. Connect an 8-AA battery pack to the BATTERY header: Positive terminal at BATTERY pin 1 and Ground at BATTERY pin 3. Be sure you have the correct polarity. ***DO NOT connect the battery directly to the 5volt supply!*** Check ground and 5 volts on the IDC (J1). 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.	Battery Volts Pin No.
U1	7, 8	16	-
U2	1	20	-
U3	7, 8	16	-
U4	7, 8	16	-
U5	7	14	-
U6	7	14	-
U7	8	16	-
U8	7	14	-
U9	1	20	-
U10	4, 5, 12, 13	16	8
U11	2, 8, 14	1, 16	-

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 2*, disconnect power. Insert one of the socketed ICs. Line up the notch of the IC with the notch on the silk screen. This should be the same as the notch on your socket, if you installed the socket as directed. In any case, it is imperative that the IC notches match the silk screen notches.

4. 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.

5. To functionally test the MRSX01, the user will need to connect it to an MRC11or equivalent with 60 wire ribbon cable and ribbon cable connectors. Other methods of testing functionality depend upon the user application and the user hardware.

NOTE: *The following procedure assumes you have assembled a two board stack, i.e., the MRSX01 on top of the MRC11; applied power; loaded our ICC11 program* tstsys.s19 *file into the MRC11 processor. This program will output all sensor readings to a terminal program. Further details can be found in the TALRIK^{II} ™ USERS MANUAL. The user, of course, can write thei own test programs in ICC11. IC programs can also be used to test this board.*

6. With all the ICs installed and voltages checked, stack the MRSX01 onto an MRC11and cable them together with a 60 wire ribbon cable from IDC (J1) on the MRSX01 to IDC (J1) on the MRC11. 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 (or equivalent) and test whether the MRSX01 functions properly. Power up the two boards with an 8-AA NiCd battery pack connected to the battery connections. ***DO NOT connect the battery directly to the 5volt supply!***

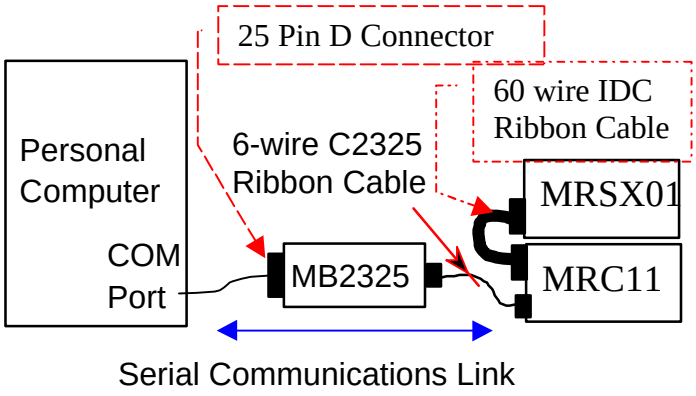

Figure 8 Configure your PC, the MB2325 communications board, and the MRC11 as shown. The MB2325 requires a 25-pin D-connector on the PC side. If the COM port on your PC has a 9-pin D-connector, you will have to get a 9-pin to 25-pin D-connector converter plug.

7. We suggest building a potentiometer with a three wire female connector to plug into the IRDTs. The wipper should be the signal connection, always one of the outside pins. ***Never the middle pin***. Under program control the user can then test all the IRDTs by adjusting the potentiometer setting to obtain different "IR" readings.

8. Plug CDS cells across the CDS connections and test the response to complete darkness and ambient light under program control. You will probably need to experiment with different values of the six CDS resistors R19-R24 to get the responses you want for your application.

9. Use MS455 servos or equivalent to test the SERVO1 and SERVO2 connections. Write servo control programs to drive the servos.

10. Your board works! You now have constructed a general-purpose sensory capability useful for a number of projects, including the sensualization of a mobile robot.