Kit Assembly Instructions

Parts List

The first step is to check that your kit has the following parts.

Part #	Value	Description	Polarized
Resistors			
O R1	10 M	1/4 W carbon film 5%	
O R2-6	4.7 K	1/4 W carbon film 5%	
O R7	220 Ohm	1/4 W carbon film 5%	
Capacitors			
O C1-2	22 pF	monolithic ceramic disc	
O C3,5	0.1 uF	monolithic ceramic disc	
O C4	22 uF	tantalum	polarized
Integrated Circuits			
O U1	68HC11E1/2	Integrated Microcontroller	polarized
O U2	MAX233	Single-supply Integrated RS-232 Interface Chip	polarized
O U3	7805	+5V Voltage Regulator	polarized
Sockets			
O U1	52 pin PLCC	Socket (PLCC to DIP)	polarized
O U2	20 pin DIP	Socket	
O optional: Wire wrap adapter for U1 socket (SIPP wire-wrap pins)			
Jumpers			
O J1	RJ11 female	6P4 serial port connector	polarized
O J2	Female barrel connector	+9V “Wall Wart” power supply connector	polarized
Miscellaneous			
O D1		Green LED (Light Emitting Diode)	polarized
O SW1		4 position DIP switch	
O SW2		Low profile momentary normally open SPST switch	
O X1		Quartz Crystal, 8.000 MHz	
O		4 3/4” 6-32 thread hexagonal aluminum standoffs	
O		4 6-32 thread 1/4” flathead screws for standoffs	
O		2 Male RJ-11 6P4 (6 position, 4 conductor) modular plugs	
O		3 feet of standard four-conductor flat phone wire	
O		1 DB-9 Female to RJ-11 adapter kit	
O PC Board		Double-sided through hole plated printed circuit board (PCB)	

Soldering

In this workshop, you will assemble the REC Basic HC11 Board (hereafter referred to as the Board) by soldering it together. Soldering (pronounced “sodder-ing”) involves bonding two pieces of metal with a third metal, heated to a liquid, which laters cools and solidifies to form a solid, conductive joint. The two pieces of metal, in this case, are called the **lead** (pronounced "leed") and the **pad**, and the bonding metal is called **solder**. The pad surrounds a **via**, or a plated-through hole. Solder is usually a 60% lead 40% tin alloy that is designed to melt at a relatively low temperature, typically around a few hundred farenheight. Most varieties of solder also have a **flux** embedded in them. This flux is an organic acid which liquifies upon heating. The liquid organic acid flows about the joint and cleans it so that the metals can bond better. This cleaning process is referred to as wetting. After soldering, the organic acid crystalizes and forms a light yellowish crust around the joint. This crust can be removed by using a strong organic solvent by a process known as cleaning or washing.

The tool used to heat the joint and the solder is called a **soldering iron**. Soldering irons should be treated with great care, as they get to be very hot. One should always assume that the soldering iron is hot, even if it is not currently plugged in (soldering irons will remain burning hot for some time after power is removed).

Figure 1: Soldering a joint

The basic soldering procedure is simple: first, the pad and lead are simultaneously warmed up by the soldering iron for a second or so; then, still holding the iron on the joint, the solder is melted onto the joint by pushing the solder into the iron where the iron touches the joint. Enough solder should be melted into the joint to just fill the gap between the lead and the pad. Finally, the iron is gently pulled away and the joint is allowed to cool for a few seconds.

Despite its simplicity, there are a number of things that can go wrong with soldering. If too much solder is added, it will flow out of the joint and bond to neighboring joints or traces, causing a **solder bridge**. If too little solder is used, then the hole will not be filled and the lead could fall out, or make poor electrical contact. Also, a dirty joint and/or a connection that was not thoroughly heated can cause a **cold solder** joint, which looks very similar to a correct joint except for the pad or the lead was not properly wetted, and the although the solder may have flowed over the joint, it did not make electrical contact.

Assembly Procedure

Be sure to insert all components on the correct side of the board. The component side has all the lettering and parts outlines, while the solder side has all the conducting traces.

Most devices with long or flexible leads can be held in place on the board prior to soldering by bending one or two of the leads out at an angle. If the device leads are not bent to hold the device in, then when the board is inverted for soldering, the device may fall out. Devices without bendable leads will have to be held in place with a finger or some other object.

You may wish to loosley attach your standoffs to the component side of the board before assembly if you find that it makes soldering easier.

Place a check mark next to each step its completion.

O 1. Insert J2 (female barrel connector for DC power input) in board. Make sure that the connector's mouth is facing outward. Solder the connector in place. This connector can be a bit tricky because the holes are very large. Be sure to use copious quantities of solder in order to make sure that the holes are filled.

O 2. Insert and solder U3. Estimate where the leads for U3 need to be bent by holding U3 against the outline of the part on the board. Bend the leads with a pair of pliers before soldering the device in place. The flat side of the device shold be against the board, while the side with the lettering should be facing up.

O 3. Insert and solder C4. Note that this capacitor is polarized (ie, it matters which way you put it in). C4 will have a "+" mark closer to one of the leads; that is the positive lead. Be sure to insert the "+" lead into the hole with the "+" sign next to it. After soldering the device in place, clip off excess lead length with a pair of flush-cutters.

O 4. Insert and solder SW1. Although SW1 is non-polarized, it is common practice to orient the lettering on the switch with the lettering on the board.

O 5. Insert and solder R7. R7 is 220 ohms, or Red-Red-Brown. Form R7's leads prior to inertion by bending one of the leads by nearly 180 degrees.

O 6. Insert and solder D1. Note that D1 is polarized. The longer lead is "+"; make sure that lead goes into the hole with the "+" next to it.

O 7. Enough of the board has been assembled to test the power supply circuitry. As a safety measure, take an ohmmeter and measure the resistance between +5 and GND and +9 and GND. The resistance should either be infinite or very large (on the order of kiloohms). If the resistance is very small, chances are you have a solder bridge and you should check your board. If your board passes this test, plug in the +9V AC Adapter ("wall wart" power supply). Touch U3 gently to insure that it is not overheating. If you smell smoke or if U3 gets very hot, immediately disconnect the AC adapter. The switch nearest the board's edge on SW1 is a power switch. By flipping this switch you should be able to get D1 to turn on and off. Get a REC member to assist you if you are not sure what you are doing.

O 8. **Disconnect power from the board before proceeding**.

O 9. Insert and solder C1 and C2. These are the small brown disk capacitors with "220" or "22" marked on them.

O 10. Insert and solder X1. X1 looks like a metal can with 8.000 Mhz printed on it.

O 11. Insert and solder C3 and C4. These are the squarish yellow capacitors with "104" printed on them.

O 12. Insert and solder R2, R3, R4, and R6. These are all 4.7 K (yellow violet red) resistors.

O 13. Insert and solder R1. R1 is a 10 M (brown black blue) resistor. Form R1's leads by bending both leads at right angles flush to the resistor's body.

O 14. Insert and solder R5. This is a 4.7K resistor.

O 15. Insert and solder SW2, the RESET switch. This switch may be a bit tough to insert; apply a gentle force so as to get as much of the pins through the vias as possible.

O 16. Insert and solder J1, the RJ-11 serial jack. RJ-11 jacks looks like those on a regular telephone. The RJ-11 jack has two mounting nubs which should fit snugly in the provided holes.

O 17. Insert and solder the 20 pin socket for U2. This socket is polarized; one end has a small indentation near the top which should correspond to the indentation on the component outline on the board. Before soldering all the pins, tack the socket on the board by holding it to the board with your finger and soldering pins 1 and 11 to the board. With pins 1 and 11 soldered, you can remove your finger and soldering is much easier and safer. You may wish to reheat the solder on pins 1 and 11 after you are finished soldering all the other pins.

O 18. If you prefer to have your 68HC11 mounted on a wire-wrap socket, find a REC member to help you assemble the socket before proceeding to step 19. Wire wrap, for those not familiar with the technique, is a rapid prototyping method for simple circuits. It consists of using a special tool to wrap very fine wire around square wire-wrap posts to form gas-tight seals. Mounting the 68HC11 in a wire-wrap socket has the advantage of making simple prototypes a bit easier to fabricate, but has the disadvantage of increasing the thickness of the board by about an inch.

O 19. Insert and solder socket assembly for U2. Note that U2 is polarized. U2's socket should be oriented so the flattened corner of the socket aligns with the flattened corner of the socket's outline on the component side of the board. One can also check for correct polarization by making sure that the small arrow which indicates pin 1, printed inside the socket, is pointing toward you if you are holding the board in a way so that the text is right side up. If the socket assembly includes a wire wrap adapter, note that soldering can be slightly tricky, and you may have to end up bending some of the wire wrap pins slightly in order to accomodate the soldering iron's tip.

O 20. Attach the standoffs to the solder side of the board. The standoffs insure that the board does not short out on any conductive objects which may be laying underneath the board.

O 21. You are now ready to test your board. Before applying power, test the board for any critical short circuits that may have been inadvertently created during assembly. Do this by using a ohmmeter to measure the resistance between the middle pin of U3 and **both** of the outer pins. If you are not sure how to use an ohmmeter, call a REC member. If the measured resistance is below 1 K, you may have a short on your board. Inspect the board carefully for shorts; if you do not find any shorts, call a REC member and he or she will help you.

O 22. Plug in the AC adapter. Gently touch U3 to verify that it is not getting very hot. If you smell smoke or if U3 gets burning hot to touch, immediately disconnect the power. Turn the power switch on. The LED should light. Use a voltmeter to verify the voltage between the +5V rail and GND. The test points for +5 and GND can be found in the lower left hand corner of the board to the left of SW1. If the voltage of the +5 rail is not +5 volts (within 10%), you can damage the ICs which you will insert in the next step. Call a REC member if the voltage is not +5 volts.

O 23. **Turn the power off**, and disconnect the AC adapter.

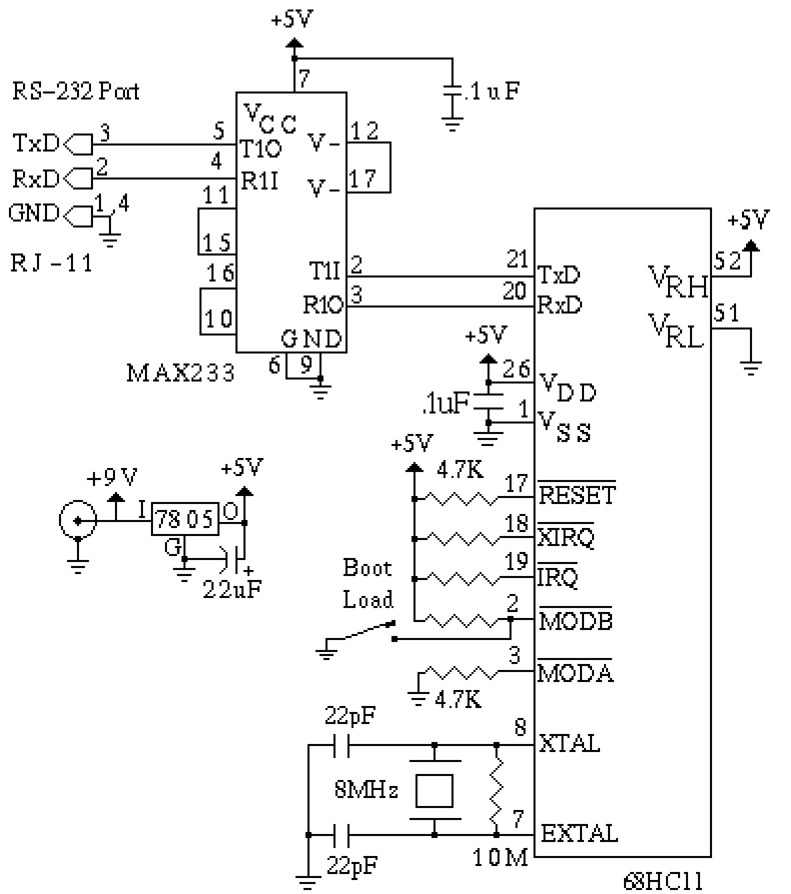
O 24. Insert U2. Note that U2 is polarized. U2 has a notch on one end which should line up with the notch in the outline of the IC on the board. The notch should be facing away from you if the board is oriented so that the text on the board is right side up. Be sure not to bend any of the pins on U2; some care will be needed when inserting U2 since the pins stick out slightly farther than the sockets spacing. The manufacturer makes the pins flare outwards slightly in order to make sure the IC does not fall out of its mounting.

O 25. Insert U1. Note that U1 is polarized. U1 will not fit in its socket if it is not oriented properly. The side of U1 with the small dot and the bevelled edge should face you if you are holding the board in an orientation such that the text is right side up. The text on the face of the IC should appear to be upside down. U1 may require a bit of force to insert even if properly aligned. Make sure that you do not permanently damage your board by flexing it too much while inserting U1. When properly inserted, U1 will make a satisfying tactile snap as it falls into the socket. U1 is an expensive chip, and the REC does not have many spares.

O 26. Plug in the AC adapter. Turn the power switch on, and gently touch U1, U2, and U3 for a second or so to insure that none of them are burning hot to touch. If you smell smoke, or feel one of the chips heating up, immediately disconnect the power and get a REC member to assist you. The LED should light up. You are now ready to bring the board to room 4-409 for a functional verification and EEPROM download.

A schematic of the circuit is included for reference.

COMPUTER INTERFACE WORKSHOP BOARD (Rev. 2)



Assembling the Serial Adapter

You need to assemble a serial adapter now that your board is finished. The serial adapter will convert the RJ-11 phone-style plug into a connector that will fit your computer's serial port. The serial connectors that the REC supports are DB-9 female (most IBM PCs), DB-25 male (Sun Sparc 5's), and DB-9 male (Sun Sparc Classics). A DB-9 female adapter is included in your kit. All other adapters for Athena-type machines are generally not distributed but available for use.

Assembly of the serial connector is simple, and is the same for all varieties with the exception of what pin you map your wires to.

First, cut the pin or socket connected to the red wire.

Second, insert the black, green, and yellow wires in the following holes for their respective connectors. The pins go all the way into the connector shell--you should not see any of the gold portion of the pin protruding beyond the connector shell. You may have to use your fingernails or a small screwdriver to assist you. You know when you have inserted the pins fully when you feel a very slight tactile snap.

DB-9 Female (IBM PC)

Hole #	Wire Color
5	Green

2	Black
3	Yellow

DB-25 Male (Sun Sparc 5)

Hole #	Wire Color
	Green
	Black
	Yellow

DB-9 Male (Sun Sparc Classic)

Hole #	Wire Color
	Green
	Black
	Yellow

Finally, take the entire wires and connector and place it in one half of the plastic housing. There are preformed grooves in which each portion should fit. It is important to fit the components properly so that the assembly does not fall apart with use. Now place the metal screw-pins in the holes on the side, and snap on the other half of the housing. The housing should appear to be seamless. If wires hang out, or if there is a large gap between the halves, chances are that you have not properly aligned the components in their respective grooves.

Now, find a REC member to assist you in making an RJ-11 male to RJ-11 male cable. The process is a bit tricky for first-timers and involves using a special crimping tool.

If you wish to test your cable and adapter assembly before proceeding, find a REC member and we will provide the proper test equipment.

Software Tools

Insert Randy Sargent's EZ-Mon/EZ-IO forms here

Application Notes

Relays by Ara Knaian <ara@mit.edu>

What is a relay?

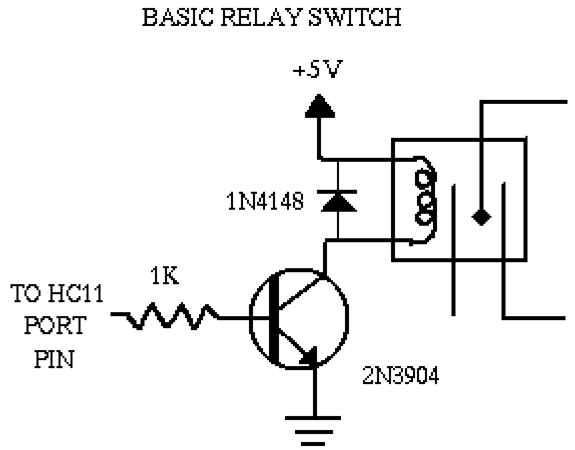
A relay is an electrically operated switch. When you turn it on, it switches one way. When it is off, it switches the other way.You can use a relay to switch on and off a high current device, like a coffemaker.

How does a relay work?

A relay has an electromagnet, called a coil, and a lightweight switch inside it. When you energize the coil, a piece of the switch is attracted by the coil's magnetic field, which switches the switch on or off.

How do I attach a relay to the board?

The following schematic shows the basic circuit.



Attach the circuit to one of the HC11's port pins. Use the switch terminals of the relay to switch the device on and off.

WARNING: Never touch a circuit that is plugged into the wall! Make sure any wires attached to the AC line are well insulated and all connections involving the AC line are covered with tape. Line power has killed before and will kill again!

The transistor allows the HC11 to control the relay's medium-sized coil current. The diode prevents inductive backlash by providing a return path for the energy stored in the coil's magnetic field, extending the driving circuit's and the relay's life.

How do I identify the relay's pins?

Get an ohmmeter, and measure the resistance between all the relay's pins. The pair of pins with a low but not zero resistance (300 ohms or so) are the coil pins. Then, use the ohmmeter as a continuity checker, and see which pins connect to which other pins both when the relay is energized and not energized. This procedure will allow you to determine the relay's switching configuration.

Some relays have more complicated switching configurations than the one in the picture, for example, some have several switches in parallel. Other relays, called latching relays, have two or more coils and a mechanical latching mechanism inside. A momentary pulse on one of the coils switches the switch. The switch stays switched until you put a momentary pulse on the other coil.

Troubleshooting

If the relay dosen't seem to do anything, it may have the wrong coil voltage. Most relays have a 12 volt coil, but some have a five volt coil. Five volt coil relays are easier to use, since you don't need a high voltage power supply. If you have a twelve volt relay and want to put it on your board, you might try putting nine volts (which is avaliable on the board) on the coil instead of five volts, as shown in the schematic.

http://web.mit.edu/afs/athena/user/a/r/ara/www/home.html -- Ara Knaian

Photoresistors by Ara Knaian and Pushpinder Singh

What is a photoresistor?

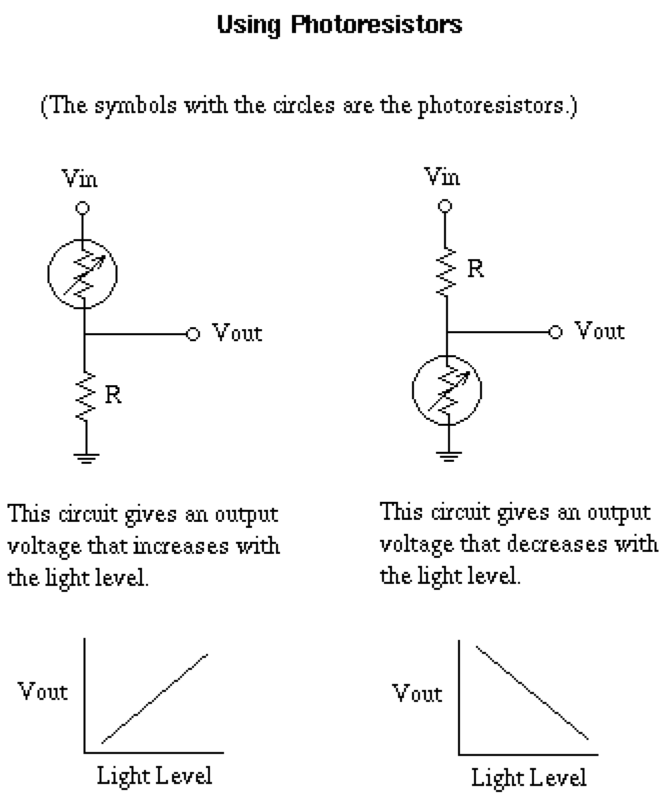
Photoresistors are light sensitive resistors whose resistance decreases with the amount of light falling on them. You can vary a voltage using them by a simple voltage divider circuit.

How do photoresistors work?

It's a quantum thing. Take 8.04.

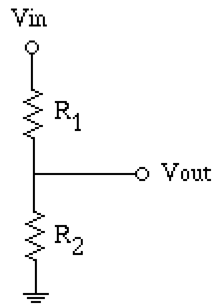
How do I attach a photoresistor to the board?

The following schematic shows the basic circuit.



If you pick the resistors correctly, you can make the output of this circuit vary between a little over zero and a little under five volts for your range of light intensity. To pick the resistor, you need to realize that this circuit is just a generalization of the basic building block of analog electronics, the voltage divider.

Voltage Divider



$$V_{out} = \frac{R_2}{R_1 + R_2} V_{in}$$

Use an ohmmeter to measure the resistance range of your photoresistor for your range of light intensities. Using the above equation, make the output of the voltage divider vary between zero and five volts. Then, you can attach the circuit to the HC11's A/D converter to get a digital representation of the light intensity on the photoresistor.

Pushpinder Singh
http://web.mit.edu/afs/athena/user/a/r/ara/www/home.html -- Ara Knaian

Piezo Buzzers and Speakers

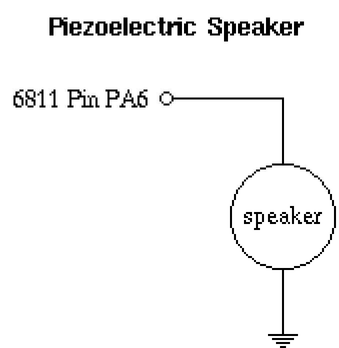
by Ara Knaian and Pushpinder Singh

What are Piezo Buzzers and Speakers?

Piezobuzzers are piezo-electric devices that buzz when you place a voltage across them. Piezospeakers are different -- they are more like regular speakers in that oscillating the voltage across them at a frequency produces a tone at that frequency. They are different from regular speakers in that they require much less current to drive.

How do I attach Piezo Buzzers and Speakers to my Board?

Here is a sample circuit:



If you connect one pin of the piezospeaker to pin PA6 of the 6811 and the other to ground, then you can us the ez-mon (`http://www.ai.mit.edu/people/rsargent/ezmon.html`) command 'o' to create tones of desired frequencies and durations. For instance, the following sequence plays the alien greeting from Close Encounters of the Third Kind:

```
ez-mon> o 0 1000 500
ez-mon> o 0 900 500
ez-mon> o 0 1100 500
ez-mon> o 0 ? ?
ez-mon> o 0 ? ?
```

Pushpinder Singh
http://web.mit.edu/afs/athena/user/a/r/ara/www/home.html -- Ara Knaian

Board Specs

Board Size: in. x   in. x in.
Voltage Input: +9V Nom., 7V-17V max
Quiescent Current: mA

Host Interface: RS-232 Compatible Serial Interface, 9600 baud default, 8-N-1. RJ-11 6P4 modular jack.

Microcontroller: MC68HC11E1/2

- 8 MHz crystal
- 8 multiplexed 8-bit Analog Inputs
- # digital IOs
- 512 bytes program RAM
- 2K EEPROM (E2) / 512 Bytes EEPROM (E1)
- Serial Interface
- Built in timers
- etc...

Insert 6811 pinouts and PLCC-PGA pin map diagrams here