MOTM GENERAL ASSEMBLY GUIDE

PLEASE READ ME FIRST!

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INTRODUCTION

This tutorial covers the general skills needed to assemble your MOTM kit. If you have assembled other kits, or have electronics experience, we suggest that you at least read this over once.

TOOLS YOU WILL NEED

The most important factor in successful kit-building is having the proper tools. This does not mean the most expensive tools, but the *correct* tools. Having moderately priced tools will greatly speed the building process, and treated nicely will last many years. The following is a list, in order of importance, of the tools you will need.

- Soldering Iron. The proper wattage is 35-50W. We recommend the Weller WTCPT, which is 42W.
- A good pair of diagonal cutters. These cost about $18.
- A good pair of chain nose, serrated-jaws pliers. Also about $18.
- A lead-bending tool. Used to bend resistor, capacitor, and diode leads to the proper size. About $2.

A pc board holder is not required, but a great time-saver. The PanaVise Model 396 (about $42) is a good choice and is built to last (I've had mine 14 years).

See the MOTM FAQ at www.synthtech.com for a full discussion of proper tools.

IDENTIFYING PARTS

This section will help in determining exactly the type of parts in the kit, and how they go into the pc board.

RESISTORS

The majority of parts in every MOTM kit are almost always resistors. They have 2 leads, and are marked with different color stripes. The color and order of the bands is a code: it tells you what the value of the resistor is.

A fair question is: what do you mean by 'value'?

A resistor is like a water valve: it restricts the flow of current in the circuit. The value is in a unit of measure called an Ohm (after some old dead guy). In the circuits in MOTM, an ohm is very small, so most of the resistors are in units of 1000 ohms, called a K. So, a 1K resistor is shorthand for a 1000 ohm. In a few cases, you will see a M, which is a Million (which another old dead guy started calling a Meg, after his girlfriend). So a resistor that is 1M is a 1,000,000 ohms, or a Megohm.

Resistors can be something like 1200 ohms, which in the US is written as 1.2K. However, a much more clever system is used in Europe, where the K or M is used in place of the itty bitty decimal point that sometimes gets overlooked. The resistor is then written as 1K2. This is the convention used in the MOTM kits. For example, a 2.2M ohm resistor is shown as 2M2.

Resistors (and capacitors) have a *tolerance*, which is how close to the correct value the resistor really is. In all but a very few cases, the MOTM resistors are 5% tolerance. This means a 1K resistor can be in the range of 950 – 1050 ohms. In some modules, we will need more accurate parts, and these will be 1% tolerance.

Resistors are not polarity sensitive: it does not matter which lead goes into which hole on the board. It will help in debugging (and the finished board will look much nicer) if all the resistors are oriented the same way, by the stripes.

COLOR CODES

The value of the resistor is contained in the order of color stripes. For the 5% resistors, the FIRST TWO color stripes are the 'base value', and the third stripe is the 'multiplier'. Here is the chart, and we will then go over some examples.

COLOR BAND	VALUE	MULTIPLIER
BLACK	0	1
BROWN	1	10
RED	2	100
ORANGE	3	1 000
YELLOW	4	10 000
GREEN	5	100 000
BLUE	6	1 000 000
VIOLET	7	none
GRAY	8	none
WHITE	9	none

The 5% resistors will also have a gold stripe on one end of the part, while the 1% resistors will have a brown stripe.

HOW TO READ A 5% RESISTOR

Look at the stripes, starting with the one on the opposite end from the gold stripe. The first two bands are the value, and the third band multiplies. Here are some 'popular' resistors and their stripes.

1K (1000 ohms) – brown, black, red. This is 1 0 x 100 = 1000.
10K – brown, black, orange. This is 1 0 x 1000 = 10 000.
100K – brown, black, yellow.
1Meg – brown, black, green.

A 47K resistor is yellow, violet, orange. And so on.

After looking at these examples, a quick hint is to look at the third band to see the decade of the value, and then the first 2 bands for the value.

THIRD BAND COLOR	RESISTOR RANGE
BLACK	1-99 ohms
BROWN	100 – 999 ohms
RED	1K – 9K9
ORANGE	10K – 99K
YELLOW	100K – 999K
GREEN	1MEG – 9M9

After reading 100's of these resistors, you will automatically look for the decade band first.

HOW TO READ A 1% RESISTOR

The astute reader will notice that all 5% resistors have only 2 significant digits in their values. This is because it does not make sense to have a 104 ohm, 5% resistor that will vary 5 ohms. However, all of the 1% resistors use 3 digits of accuracy. So, this means a 1% resistor has an *extra color band*.

What is confusing about reading 1% resistors is that the decade band is now the fourth band, and it is one color 'off' from a 5% resistor. For example, a 100K, 1% resistor is coded as:

Brown black black orange which is 1 0 0 x 1000 = 100 000.

Thankfully, there are not many 1% resistors in MOTM, and when there is we will pay special attention to them in the assembly directions.

CAPACITORS

Unlike resistors, capacitors come in all shapes and sizes. The reasons for this are:

- Capacitors have a *voltage rating*, that if exceeded, causes bad things to happen
- Capacitors have a value, measured in farads. Now, a farad is HUGE, so most capacitors are in *millionths* of a farad (microfarad). More on this later.
- Capacitors can be made from many different materials, and these materials dictate the size and shape as well.
- Some types of capacitors, called *electrolytics*, are polarity sensitive. Putting these in backwards is ***very bad.***

The following is a list of the capacitors found in MOTM, and how they are identified.

Since a farad is so big in the capacitor world, capacitors used in MOTM are measured in picofarads (a pico is 1E-12 of a farad) or microfarads (a micro is 1E-6 farads).

FILM AND AXIAL CAPACITORS

Film caps are usually the little yellow box style with leads sticking out of the bottom. They are made with a plastic film rolled up inside the box. They are NOT polarity sensitive.

These capacitors range in value from 1000 picofarads to 0.47 microfarad. The ever astute reader will instantly see that a 1000 picofarad cap is the same as a 0.001 microfarad cap. The capacitor values are abbreviated pf and mfd in MOTM documentation.

If you look closely on the tops of these little yellow caps, you will see a 3-digit code number (none of those pesky color stripes!). The code is read like the color bands: the first 2 digits are the value, the third digit is the multiplier. Here are some examples.

CODE	**VALUE**
104	0.1mfd
103	0.01mfd
102	0.001 mfd OR 1000pf
101	100pf
100	10pf

So a cap marked 223 would be a 0.022mfd capacitor and an axial with 180 stamped on it would be 18pf. In some cases, the caps will have the value in *nanofarads* (1E-9) stamped on them. A 1N marking is the same as a 102 marking (do the math!).

The axial ceramic capacitors are the tiny, yellowish-orange capacitors with long leads (like a resistor). Their value code is printed on them as well, and you need good eyes (or a magnifying glass) to see them!

The MOTM directions will refer to ‘yellow box cap’ or ‘axial ceramic cap’ for these types of capacitors.

ELECTROLYTICS

Capacitors over 0.47 mfd are usually of the type called *electrolytics*. These capacitors are little aluminum cans, with a plastic label, and 2 leads sticking out of the bottom. In most cases, these capacitors are polarity sensitive: like a battery, they have a + and a – terminal. **IT IS VERY IMPORTANT THAT THESE CAPS ARE NOT INSTALLED BACKWARDS IN THE CIRCUIT, OR DAMAGE TO THE BOARD MAY RESULT.**

If you look closely at these caps, the MINUS terminal is clearly marked on the case with a white stripe. On the MOTM pc boards, the PLUS terminal is clearly marked 2 ways: there will be a ‘+’ sign on the board, and the + pad is square.

Electrolytic caps also have the value and voltage rating printed directly on them without any secret code!

Most of the time, the only electrolytic caps in MOTM kits will be the 2 blue-ish purple caps near the power supply connector.

NON-POLAR ELECTROLYTIC CAPS (also called bipolar caps)

There is a *special case* of electrolytic cap which is NOT polarity sensitive. These are use in the MOTM-100 Noise/S&H kits, and possibly more in the future. They are small cans, but without the polarity stripe. They have the letters ‘NP’ or ‘BP’ on them instead. The ‘+’ sign will NOT be on the pc board.

SIGNAL DIODES

A diode is a one-way gate for current flow. The diode schematic symbol is a brilliant example of actually showing what happens: current flows in the direction of the arrow. The ‘arrow’ end is called the anode, and the ‘bar’ end is the cathode (old terms left over from vacuum tube rectifiers).

Diodes are polarity sensitive, and they are marked with a single band on the ***cathode*** end. The pc board has this band symbol clearly marked: just stick the part in with the band on the correct end.

LEDs

A LED is also a diode, and must be installed with the correct polarity. The MOTM front panel LEDs have one lead which is *longer* than the other: this lead is the anode. Please carefully read the directions when installing the LEDs.

FRONT PANEL SWITCHES

Many MOTM modules use a toggle switch for switching. In most cases, these are SPDT (single pole, double throw) switches that select between 2 things. What is confusing about them is the wiring terminals. As viewed from the back, when the switch handle is UP, the 2 terminals that are connected are the center and bottom. This always confuses me, so I thought I’d mention it. The directions will clearly describe how to wire them up (using color-coded wire).

MOUNTING HARDWARE

Every MOTM kit has screws, nuts, and washers. The hardware is 'US' or 'Imperial', not metric. That's because the kits are based on the US EIA 19" rack standard.

The hardware has sizes that are based on a numbering system. Where this system came from is anybody's guess! The sizes are designated #2, #4, #6, …. A number 2 (#2) is smaller than a #6. The most common hardware around your house (well, in the US) is #6.

MOTM kits use #4, #6, #8, and #10 hardware. The thing to remember: the bigger the number, the larger the size (fatter, thicker, etc).

The pots, jacks, and switches all use their own special hardware..

You will see in the MOTM parts a description like '#6-32 x ½". The –32 means 32 threads per inch. So a '#4-40' screw has 40 threads per inch. The ' x ½' means the screw is ½ inches long.

MOTM uses special nuts, called a KEPS nut. These nuts have a built-in lockwasher to prevent the nut from getting loose. In some cases we will need to use a separate lockwasher, which can have little 'teeth' to grip the nut or something called a 'split-ring', which is a washer that at first looks defective: it has a cut (split) in the washer. This is used as a compression spring: as you tighten the nut down on the split-ring washer, it pushes back and makes a secure fit.

It is HIGHLY RECOMMENDED that you buy a set of hollow-shaft nut drivers (about $5 each) to tighten the nuts in the MOTM. Using pliers is not a good idea. It could mar the surface of panels, round the corners of nuts, or crush the threads of a screw (when the pliers inevitably slip).

On the MOTM-900 power supply and power distribution board, special connectors are used. These are called FASTONs. They come in two sizes: 0.187 wide and 0.250 wide. These are used with mating 'female' connectors that push on without solder. The key here is to be sure the female end is pushed all the way down on the male connector. The fit is quite snug (on purpose) so be sure the connectors are fully mated.

WIRING TO THE JACKS

The ¼" phone jacks used in MOTM are wired using 'braided shield' cable. This cable is supplied pre-cut and pre-stripped, with solder coated ends. All you have to do is solder the ends!

On the pc board end, there are special locations the cable solders to. These locations are clearly labeled on the pc board and in the assembly notes. The braid, which is the grounded side, goes into the large hole. The conductor(s) solder in the smaller holes. The cable is secured to the pc boards by a small nylon wire tie, which is threaded in 2 small holes next to where the wires solder in.

The cables are either black (1 conductor) or gray (2 conductor). The 2-conductor cables use a smaller 'drain' wire that touches a thin foil shield which is wrapped around the wires. The drain wire is used to solder to ground as the braided shield is in the coax.

WIRING TO OTHER FRONT PANEL STUFF

Most modules have switches, LEDs, or a pot that needs wiring to the pc boards. We provide 'twisted pair' wires for this. They are just wires of different colors twisted together. One end solders into the pc board, and the other end connects like a jack cable: you ***first*** slip the heat-shrink tubing over the wire, solder, and then slip the tubing over the connection and shrink.

On wiring to the switches, the tubing is not needed. Switches have nice big solder terminals for mechanical support.

THE JOY OF SOLDERING

Soldering is what kit-building is all about. It can be relaxing, like needlepoint, or very messy and frustrating. The difference is having the correct soldering iron, and practice. It is also a good idea to take a 5 minute break every 20 minutes or so.

Soldering is a high temperature adventure: the common soldering irons use 700F tips. Molten solder does cool extremely quickly, except when you get some on your skin.

The first rule of soldering is: use only enough to get the job done. Most soldering problems arise by using *too much solder*. It is easy to get carried away and glob a huge blob of solder on the connection.

The second rule is: heat the connection for about half a second before you apply solder. This pre-heating is used to prevent the molten solder from hitting cold metal and cooling too fast. This results in what's called a 'cold joint', which is loose connection where the solder did not adhere to the metal. The technique (which becomes automatic after a while) is to put the tip on the board first, and then apply the solder. Once the solder is on the joint, you hold the iron there for another half second, and pull the iron away. If the solder doesn't flow easily, perhaps you haven't allowed your iron to warm up.

When you insert a part into the pc board (on the side of the board with the white lettering), the leads will need to be bent outwards before soldering. This is called a 'cinch'. Also, it is important that the parts be all the way down on the pc board. ICs will be slightly off the board, to allow the flux to be washed off (see next section).

Remember, it's easy to *add* solder, but difficult to *remove*.

TYPES OF SOLDER IN MOTM

Each MOTM kit has 2 types of solder.

In order for solder to 'stick' to the joints, a chemical called 'flux' is inside the solder. The two different solders used in MOTM have 2 different types of fluxes.

The thinner diameter solder is used for the pc board. It is called 'organic flux' because all you need to remove flux residue is warm water. After you solder about 20 parts on the pc board, you wash the board in a sink under warm water. Use a soft scrub brush, and scrub the solder joints thoroughly. The water will not harm the parts on the pc board. Turn the board over and wash/scrub the top side as well. DO NOT USE ANY SOAP OR OTHER CLEANSER!!

IMPORTANT: THE FLUX RESIDUE CANNOT BE LEFT ON THE PC BOARD! YOU MUST WASH IT OFF WITHIN 2 HOURS AFTER SOLDERING.

The flux residue left on the board will cause high impedance paths between connections. This will make the board act funny. Also, organic flux, over a long period of time (say, 6 months) may start to corrode the connections. We certainly don't want that!!!

Again, this flux comes off easily with water. It is OSHA approved for flushing down the sink. I use an old-fashioned fingernail brush (about 1 x 3 inches. It has a curved handle that slips over your hand. I paid $1 for it at the drugstore) to scrub the flux off.

After washing, blot it dry with a paper towel and let it air-dry for about 20 minutes. Then you can solder more parts. This is spelled out in the instructions: please follow this procedure.

You may be asking: why in the world is he going through all this trouble over solder?? The answer is simple: no type of solder will give a high quality joint quite like organic solder will. When the board is washed and dried, the joints are near mirror finish. The older rosin-based fluxes leave this nasty brown reside which is very sticky and over the long run attracts moisture. The organic solder used in MOTM washes away 100% clean.

NO-CLEAN SOLDER

The fatter, or thicker, solder in the kit is called 'no-clean' solder. The name tells it all: with this solder you can just leave it alone. No washing or cleaning is needed. The solder is specifically for soldering the wires to the front panel jacks, switches, LED, etc. which you don't want to put in the sink and wash!

You CAN use no-clean on the pc board, but you must be a very careful not to use too much.

The reason is that no-clean solder behaves very differently than other solder. It does not 'flow' nearly as easily as other solder. Even when molten, no-clean solder is the consistency of toothpaste. It is too easy to apply too much solder on pc boards.

We want to use no-clean on the wiring to the front panel and on the pots, because it's difficult to wash them after soldering. Also, you can be a little "sloppy" on soldering the wires, much more so than on the pc board.

THE BIG MOMENT

The Big Moment is of course when you have finished your MOTM kit, and are ready to turn it on for the first time.

BUT BEFORE YOU DO …

- Carefully inspect the component side of the board. Are all the diodes pointing the same direction? Are all the polar electrolytic caps pointing the same direction?
- Check to see that all of the ICs are pointing the same direction.
- Check for missing parts (this may seem silly, but it does happen)
- Inspect the solder side (before installing the bracket). Any solder shorts? Any missing solder joints?

It has been my experience that 99.9% of all 'it doesn't work' problems arise from the wrong parts, or bad solder joints. VERY RARELY is an IC really bad.

Thanks for building our MOTM kits. Many hours of work went into the design and component selection process. These kits will give many years of reliable service.

If you have any questions, please contact us:

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