F5m Redux Build Guide

Found an issue or need help? Post on the diyAudio thread, or contact me directly at reduxkits@gmail.com

Tools required:
Soldering iron, solder, tweezers, flush cutters, pliers, 2mm hex / allen key

Recommended:
63/37 leaded solder is significantly easier to work with compared to lead free solders. I prefer to use a “no clean” flux core that does not need to be washed off before the PCB can be used. Of course, cleaning the PCB gives a nicer appearance and can be done with isopropyl alcohol before mounting it to the heatsink

Inventory
Check that you have everything on the included parts list

Surface mount parts
All of the surface mount components are part of the power supply filtering. No particular order is required, but it’s helpful to consider the size and location of parts so that they don’t block access to other parts that will be soldered later in the process.

Start with C9, C10, and C11 as a warm up. These capacitors are for the auxiliary power supply that generates 9 volts for the fan and LED. Start by tinning only one of the two pads for each capacitor. Tinning just means we melt a small amount of solder on to the pad to cover its surface. Too much solder at this step will make it difficult to place the parts, so be sparing. Take a capacitor out of its “tape” packaging. These are not polarized so can be placed either direction. Grab the capacitor firmly using the tweezers with one hand and use the soldering iron in the other hand to melt the existing solder on the tinned pad while applying gentle downward pressure on the capacitor until it sits flat against the PCB. Remove the iron and hold the capacitor in place until the solder solidifies. Let go with the tweezers and inspect the alignment of the part. If its crooked or not flat, don’t worry, you get multiple tries with this method. Just grab the part with the tweezers again, melt the solder and adjust its location. Once you’re happy with how the part is placed on the board, solder the other end of the capacitor to the un-tinned pad, the first solder joint will hold it in place so no need for tweezers again. The first joint can now be touched up if it looks dull or has too little solder.

C1–C4 are the trickiest components in the kit. They are feedthrough capacitors which help remove high frequency switching noise from the power supplies. Each has four pads. Use the same method, tinning one of the larger pads, adjusting placement, then soldering the others. After each one is installed, check for shorts between its end connections and ground (all of the mounting holes are grounded).

R10–R13, FB1 and FB2 can be installed in the same way.

Inductors L1–L4 are large enough to be held by hand rather than tweezers just take care not to touch the soldering iron!

Q5 and Q6 are the last surface mount parts on this side of the board. The small pad on the right (gate pin) is the easiest to start with when tinning and aligning.

R14, R15, R16, R17 are on the back of the board and now is a fine time to solder those along with D1 and D2. **IMPORTANT: The D1 and D2 diodes shipped with the first batch of Rev 3 kits (batch 1024 on the included parts list) are directional but the boards are not marked for polarity. The line on each diode should be soldered to the pad on the right hand side when the text is the right way up.** Future kits will ship with bi-directional diodes and can be installed either way around.

Quality control

With all the surface mount parts taken care of, now is a good time to test the board. Using a multimeter set to ohms, check for shorts between either pad of L2 to ground and L4 to ground. Both should be high resistance, over 500k ohms.

Solder J1 and J2 to the PCB. Plug two power supplies into the wall, then into J1 and J2. Set the multimeter to volts and check that the voltage from L2 to ground is +24V and that L4 to ground is -24V. Unplug everything before continuing.

Through hole parts

Only though hole parts left! The zener diode, Z1, is directional. Align the black stripe on the part with the white stripe on the board.

Solder in the small resistors, R0, R1, R2, R8 and R9, followed by the larger resistors, R3, R4, R5, R6, Rx6, R7, and Rx7. R6 and Rx6 are in parallel with each other as are R7 and Rx7. This was done to reduce their temperature (heat gets split between them) because this is an “open air” design and they could be touched by curious fingers.

Next, solder in P1 and P2. Before moving on, we will set each to the right value for start up to ensure zero bias current at first power on. Measure the resistance between the labeled points on the back of the board and turn the screw on the potentiometer until it reads about zero ohms (anything less than 50 is fine). With the supplied part, this should be fully counter clockwise. Multi-turn potentiometer manufacturers have not standardized footprint and rotation direction, so measuring is best practice to reduce errors.

Solder in PS1, C5, C6, C7 and C8. Pay close attention to the direction of these capacitors. The longer wire is positive (+) and the negative side of the can is marked with a white stripe.

Add the JFETs, Q1 and Q2. At a glance, these look the same but they are not. Q1 is an N-channel 2SK170, marked “K170” and Q2 is a P-channel 2SJ74, marked “J74”. These should sit above the PCB at around the same height as the potentiometers.

Connectors and switches

J3 and J4 are the output connectors. Thread a 5 way binding post all the way into each right angle screw terminal and remove the knurled caps with the red or black marking. Align the hole in the binding post with the legs of the screw terminal (the goal is to have the binding post holes vertical on the final amp). The included gold split washers can optionally be used between the binding post and screw terminal if the holes do not align well without them. Heat and apply solder to the threads. This takes a bit of patience with a soldering iron. Both pieces need to get up to temp for a secure bond. A good indicator is when solder wicks into the threads between the pieces. These stay hot for a bit, so take a small break, then install them into the PCB with solder.

The RCA input connector, J5, is secured with solder to the board, so the nut and toothed washer are not needed.

Install SW1. Once the amp is fully assembled, this switch is turned on by pressing the top half of the rocker and turned off by pushing the bottom half.

The fan connector, J6 goes on the back side of the board as does the LED, D0. The LED is directional. The longer leg is positive and the negative side has a small flat spot in the plastic near the base. Feel free to substitute whatever color LED you like. The LED points upward through a hole in the heatsink. Placing it against the board will make it somewhat visible between the PCB and heatsink from the front, and raising it a few millimeters off the board will will make it less visible from the front, pick your preference. Both will cast the same amount of light upwards. R0 sets the LED brightness and it can also be swapped for a different value to your liking. Increasing the resistance reduces brightness and vice versa. Going lower than 400 ohms for R0 risks burning out most typical 5mm LEDs and will be obscenely bright.

Optional cleaning
Wash the PCB with isopropyl alcohol. Higher alcohol concentrations work more quickly and have less water in them so try to source 90% or greater. Letting the board soak, fully submerged in a plastic container, will soften and dissolve the flux left over from soldering. An old toothbrush works great for scrubbing off any stubborn bits of flux. Air drying is recommended since most cloths will leave bits of fiber behind.

Heatsink mounted parts
Thread four brass standoffs into the outermost holes of the heatsink.

To prepare the output MOSFETs, Q3, Q4, and the thermal switch, SW2, hold the body of the part firmly and bend the leads upward to a right angle. The leads will naturally bend where they widen near the body. Perform a dry fit by loosely mounting the FETs and switch to the heatsink so they are still free to rotate ten place the PCB over them, making sure the leads are aligned with their respective holes in the PCB. The PCB should slide down until it touches the brass standoffs with little to no force. Remove the PCB, FETs and thermal switch after the dry fit.

Apply a thin layer of thermal paste to both sides of each alumina thermal pad and place them on the heatsink where Q3 and Q4 will sit. Place each FET on top of its thermal pad and use the longer M3 x 10mm screw with a Belleville spring washer and flat washer to hold it in place but do not tighten. Apply a small amount of thermal paste directly to the back of SW2 and hold it in place using a shorter M3 x 5mm screw and Belleville washer. Like the dry fit, lower the PCB down over the leads, aligning each with the through holes on the board, until it sits flat against the brass standoffs. Secure the board to the standoffs using M3 x 5mm screws and tighten. Now tighten each screw for Q3, Q4, and SW2. Finally, solder the leads to the PCB pads.

The fan
The kit has three different lengths of black plastic standoff, 20mm, 45mm, and 50mm. Create 95mm standoffs by pairing each 45 with a 50mm. Place these through the outermost holes on the PCB and thread into the 20mm standoffs. Slide the tubing over each standoff until it touches the PCB.

Remove the four rubber mounts from the corners of the fan. Slide the fan corners over the tops of the standoffs and secure using the M4 thumbscrews.

The fan cables are longer than required. They can be shortened or be left full length and get tidied up with a ziptie, heatshrink, or string. To shorten, peel back the sicker on the bottom side of the fan where the wires enter. Note the orientation of the wires and de-solder them from the fan PCB. Cut the wires to length (not too short!), then strip the ends and re-solder to the board in the same orientation. A hot soldering iron will melt the plastic if it touches, and it's a bit tight inside the fan, so watch the angle of your iron. Alternatively, a section can be cut from the middle of the cable and then be spliced back together using solder and heatshrink tubing, or butt connectors.

First power on and biasing

With the switch in the off position (down), plug two power supplies into the wall and into the amplifier. Switch the amp on and watch for smoke and listen for any unexpected sounds. The fan should start turning and the LED should light. If all is well, the amp can now be biased. This is easiest with two multimeters but can be done with just one in a pinch. Set both meters to DC volts, place the amp on its side, and connect one meter to the output terminals to measure the DC offset and the other across either R6 or R7 to measure the bias current indirectly (as voltage). Both should read 0V at this point. Using a small flat blade screwdriver, turn each potentiometer up, one turn at a time, alternating between them. You will typically see the DC offset change before the bias voltage. Each half of this push-pull circuit contributes to the total bias, but the bias needs to be equal on both sides to get 0V on the output when there is no signal at the input. Turning one of the potentiometers up will make the reading more positive and turning the other up will make it more negative. In a way, this measures the difference in setting between the two potentiometers. For the rest of the biasing process, use this reading to decide when to alternate between potentiometers. I like to keep it within +/- 100 mV to start and then shrink that range toward zero as the bias current approaches its target.

The other meter is measuring the voltage across one of the pairs degeneration resistors. The bias current flows through both degeneration resistors and both MOSFETs. The current can calculated using I = V/R. In this case, the resistance is 0.5 ohms, so the current will be equal to twice the measured voltage. A reasonable bias target for this circuit is 1.4 A, so the pots will be adjusted until 700 mV is across R6 or R7 and there is close to zero DC offset voltage at the output.

Note that the bias and offset change with temperature. This is the minimal version, so the temperature compensation components have been left out. After the initial setting, leave the amp running for 20 – 30 minutes to ensure the temperature has stabilized, then check the values again and readjust as needed. Similarly, if the temperature of your listening room changes dramatically (for example, with the seasons), it might be a good idea to check the bias and offset again.

Final test

Turn the power switch off, then connect a source to the RCA input and a not-so-precious speaker to the binding posts. Power on and play some music. If there is no obvious distortion or unexpected noises, the amp should be safe to connect to your primary speakers. Always turn the amp off when connecting or disconnecting cables.

Build complete

Congratulations on your new F5m!