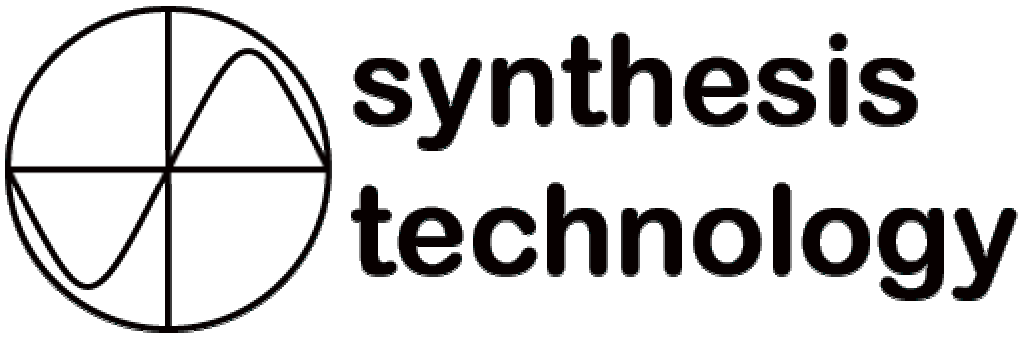

MOTM-390 μLFO
Assembly Instructions & Owner's Manual

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Fort Worth, TX 76180
(817) 281-7776
www.synthtech.com

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MOTM-390 PARTS LIST

Please carefully check that all parts are in your kit. If you have a suspected shortage, please call or email. If you get free extra stuff, keep it for next time.

❒ **Capacitor** bag, containing the following 9 parts:

2ea 10mf, 50V Electrolytic	C1, C2
1ea 220nf film (reddish-brown, marked 224) cap	C7
1ea 100nf film (reddish-brown, marked 104) cap	C8
5ea 0.1mfd (marked 104) ceramic axial	C3 – C6. C9

❒ **Resistor** bag, containing the following 37 parts (5%, 1/4W):

6ea 1K (brown, black, red)	R15, R23, R29, R32, R34, R35
5ea 220K (red, red, yellow)	R1, R5, R12, R21, R28
5ea 100K (brown, black, yellow)	R7, R10, R20, R27, R33
4ea 20K (red, black, orange)	R3, R22, R31, R37
3ea 39K (orange, white, orange)	R8, R13, R14
2ea 2K7 (red, violet, red)	R17, R24
2ea 56K (green, blue, orange)	R18, R25
2ea 330Ω (orange, orange, brown)	R19, R26
2ea 10K (brown, black, orange)	R30, R36
1ea 6K8 (blue, gray, orange)	R2
1ea 3K9 (orange, white, red)	R4
1ea 8K2 (gray, red, red)	R6
1ea 4K7 (yellow, violet, red)	R9
1ea 82Ω (gray, red, black	R11
1ea 62K (blue, red, orange)	R16

❒ **IC** bag, containing the following 10 parts:

2ea TL074ACN quad op amp	U1, U2
1ea NE5517 dual OTA	U3
1ea 78L05ACZ +5V regulator	U4
2ea BC550C NPN transistor	Q3, Q5
4ea BC560C PNP transistor	Q1, Q2, Q4, Q6

❒ **Misc** #1 bag, containing the following 5 parts:

2ea Axial ferrite beads (plain, gray things)	L1, L2
1ea MTA-156 power connector	JP1
2ea Red LED, panel mount	D1, D2

❒ **Knobs**, 3ea, ALCO PKES90B1/4

❒ **Jacks**, 6ea Switchcraft 112A

❒ **Pots**, 3ea containing the following:

1ea 100K log cond. plastic Spectrol 148	VR1
2ea 100K cermet Spectrol 149	VR2, VR3

❒ **Front panel**

❒ **Mounting bracket**

❒ **Wire** bag, containing the following 9 wires:

4ea RG-174 coax, 4 ½ inches
1ea RG-174 coax, 7 inches
3ea 2-wire set, 22ga, 3 ½ inches (red/black)
1ea Power Cable, 20”

❒ **Hardware** bag, containing:

4ea #8-32 x 3/8 black screws (for mounting module to rack)
4ea #6-32 x 1/2 zinc screws (for attaching pc board to bracket)
4ea 1/4 inch aluminum spacers
4ea #6 KEPS nuts
4ea small heat-shrink tubing
6ea small tie-wraps

❒ **Organic Solder**

❒ **No-clean Solder**

❒ **PC Board**, MOTM-390

GENERAL INFORMATION

Thank you for purchasing the MOTM-390 Micro Low-Frequency Oscillator (LFO). If you have any issues concerning the building or use of the kit, please contact us at (817) 281-7776 or by email: synth1@airmail.net.

This kit should take the average builder between 3 to 4 hours. The LFO kit contains many different resistors and special parts that require very accurate soldering skills. However, please remember this is NOT a speed contest; it is an accuracy contest. There is no rule that you have to complete the entire kit in one day (as long as you wash the flux off!).

Successful kit building relies on having the proper tools. Here is a list of what you will need to build your MOTM-390:

* Soldering iron, 50W max power
* Needle-nose or chain-nose pliers
* Diagonal cutters
* Allen key set for securing the knobs (1/16" or 1.58mm)
* Magnifying glass: to read the capacitor codes and to inspect solder joints
* Lead bending tool (optional, but makes the job go much faster)
* DVM (Digital Volt Meter) or oscilloscope (to check the output)
* #1 Philips screwdriver
* Small, flat screwdriver for adjusting the trimmers
* Fingernail brush for washing off the organic flux
* Old towel for blotting dry pc board

For more information of tools used and suggestions, see the MOTM FAQ and Tutorial pages at http://www.synthtech.com.

HOW TO FOLLOW THE DIRECTIONS

Please read the entire instruction before proceeding. There may be valuable information at the end of the instruction. Each instruction has a check box ❒ next to it. After you complete the instruction, check the box. This way you can keep track of where you are in the process.

VERY IMPORTANT – PLEASE READ!

It is critical that you follow the steps exactly in order for proper operation. Please read ALL of an instruction before proceeding.

VERIFY THE PARTS LIST

❒ Verify that all of the parts are in the kit as shown on the parts list.

A WORD ON SOLDERING

There are 2 very different types of solder used in the kit. Most of the soldering uses 'Organic Flux' solder. ***This is strictly for use on the pc board, and is NOT to be used on the front panel wiring!***

In order for solder to 'stick' to the copper, a chemical called 'flux' is embedded in the solder. The flux leaves a residue on the pc board that should be cleaned with warm water. DO NOT USE SOAP OR OTHER CLEANSERS. Most of the parts in the kits are 'waterproof' and can be washed in the sink. The flux is OSHA approved for flushing down the drain, so don't worry about that! A soft brush is used to gently scrub the board. We recommend a 'fingernail brush', which is about 1" x 2" and can be found for about $1.

The other type of solder is called 'No Clean Flux'; because as the name implies it does, not require washing. This solder is used for wiring the pots, switches, jacks, etc. This solder is harder to use on the pc board; because even when melted, it is not very fluid (about the consistency of toothpaste). We will use it VERY SPARINGLY on the pc board.

OK, let's get started on the board!

PART #1: SOLDERING THE RESISTORS

Since there are more resistors than anything else, we will start here. If you do not know the resistor color code, refer to the parts list. Resistors are not polarity sensitive, but the board will be easier to debug (and look nicer) if you point the first color band in the same direction for all the parts. The color code is also in the README FIRST document that every customer receives with his or her first order.

If you are unsure of a resistor's value, use your trusty DVM to measure it! Inserting the wrong resistor in the LFO kit will cause interesting behavior! And, it's very hard to find the error.

You will start by soldering in ALL of the resistors.

❒ Find the **RESISTOR** bag.

❒ Find the MOTM-390 blank pc board. There is a copy (larger than actual size) of the silkscreen which shows where the parts go at the end of this document. It will be useful if you locate the part on the print first, put the part in the board, then 'check off' the silkscreen. All parts are inserted from the side of the board with the white silkscreen (the "top" side).

❒ We will stuff the resistors by value to make things easier. The resistors (and other long-leaded parts) are inserted on a 0.4 inch spacing. The important thing is to be sure that the part is sitting all the way down on the board. Push the leads in the holes, push the part on the board, and then bend the leads on the bottom outwards to a 45 degree angle (roughly!). This is called 'cinching the leads' and keeps the part from falling out! From the bottom of the board, solder (using the organic flux),

applying heat to the pad for about a half second first, then applying just enough solder to make a small puddle that looks like a tiny pyramid. Enough solder should flow in the hole such that on the top (component) side, a small amount is on the top pad as well. A ***SMALL AMOUNT***, not a blob!

The rule of soldering: don't use too much, you can always add more! Cut the leads flush with the top of the solder joint with your diagonal cutters.

This pc board has parts ***very close together***. It may not be clear where a certain resistor or capacitor is. We will try to give you a "hint" for the hard-to-find parts!

❒ Locate the 1K resistors (6) and solder into R15 (right of U3), R23 (by J5), R29 (above J1), R32, R34 and R35 (by the jack wiring holes).

❒ Locate the 220K resistors (5) and solder into R1 and R5 (by VR2), R12 (left of U2), R21 (by Q3) and R28 (by Q5).

❒ Locate the 100K resistors (5) and solder into R7 (left of U1), R10 (left of U2), R20 (beside Q4), R27 (by Q6), and R33 (right of C4).

❒ Locate the 20K resistors (4) and solder into R3 (by VR2), R22 (below C2), R31 (below R22) and R37 (right of U1).

❒ Locate the 39K resistors (3) and solder into R8 (by left of U3), R13 (left of U2) and R14 (left of U1).

PART #2: BOARD WASH #1

❒ Verify all the resistors are in the correct position.

❒ Verify all the resistors are flat on the board. Correct if needed. Check solder joints.

❒ Wash the board in warm water, gently scrubbing *both* sides.

❒ Shake the board a couple of times, blot dry with an old towel (the leads will frazzle a good towel). Let dry at least 15 minutes.

PART #3: Complete the Resistors

- ❒ Locate the 2K7 resistors (2) and solder into R17 (by Q4) and R24 (by Q6).
- ❒ Locate the 56K resistors (2) and solder into R18 (by Q3) and R25 (by Q5).
- ❒ Locate the 330 ohm resistors (2) and solder into R19 (by D1) and R26 (by D2).
- ❒ Locate the 10K resistors (2) and solder into R30 (by R31) and R36 (by R37).
- ❒ Locate the 6K8 resistor and solder into R2 (below Q1).
- ❒ Locate the 3K9 resistor and solder into R4 (below R1).
- ❒ Locate the 8K2 resistor and solder into R6 (above Q2).
- ❒ Locate the 4K7 resistor and solder into R9 (by R8).
- ❒ Locate the 82 ohm resistor and solder into R11 (above VR1).
- ❒ Locate the 62K resistor and solder into R16 (right of U3).
- ❒ This completes the resistors. Check your solder joints and wash the board again. Let dry 15 minutes. Take a little break!

PART #4: CAPACITORS

- ❒ Locate the **CAPACITOR** bag.
- ❒ Locate the 0.1mf axial ceramic caps (attached to the 2 pieces of removable tape) and solder into C3, C4, C5, C6 and C9.
- ❒ Locate the 100nf stacked-metal film cap marked 104. Solder into C8.
- ❒ Locate the 220nf stacked-metal film cap marked 224. Solder into C7.
- ❒ Locate the 10µfd electrolytics (2). Note that there is a stripe on the NEGATIVE terminal. The pc board has a + on the POSITIVE terminal. Carefully stick the capacitors into C1 and C2 with the stripe ***away*** from the + pad on the board. Check to be sure both electrolytic caps have their stripes facing the SAME WAY.
- ❒ Wash the board again, gently scrubbing both sides. Use ONLY warm water!

PART #5: MISC and IC STUFF

Almost done with the parts on the pc board! This will finish up the soldering with the organic flux.

❒ Locate the **MISC #1** bag and the **IC** bag.

❒ Locate the ferrite beads (2). They are axial parts, gray colored with no markings. These are non-polar, and are soldered into L1 and L2.

❒ Locate the MTA-156 power connector. Solder into JP1. Note that the connector has a 'locking tab' on one side. This side is the "inside" facing relative to the pc board. Note the silkscreen symbol for JP1 has a line on one side, indicating this is the side where the locking tab goes.

❒ Locate the 2ea TL074s. Solder into U1 and U2. Carefully orient the part such that the 'notch' in the top of the package matches the silkscreen (pointing towards the power connector).

❒ Locate the NE5517 OTA. Solder into U3, noticing that it points in the same direction as U1 and U2. If you are not sure, please CALL OR EMAIL FIRST.

❒ Locate the 78L05ACP voltage regulator. It looks like a transistor! Solder into U4 (up there by L2). Match the flat side of the part to the flat indication on the silkscreen.

❒ Locate the 4ea BC560C transistors. Solder into Q1, Q2, Q4 and Q6. Match the flat side of the transistors to the flat indication on the silkscreen.

❒ Locate the 2ea BC550C transistors. They solder into Q3 and Q5.

❒ Being careful NOT to solder the remaining component holes, solder a small bit of solder to the via holes. These are the small pads (no components go in them) that allow traces to "change sides" of the pc board. DO NOT SOLDER PADS FOR THE REMAINING COMPONENTS!! The via holes need a **VERY SMALL AMOUNT** of solder. An example of a via hole is to the lower left of JP1, above C3.

PART #6: FINAL BOARD WASH & INSPECTION

❒ Verify all the parts are in the correct locations. Make sure all of the ICs are pointing the same direction as well as all of the transistors.

❒ Inspect the solder joints. Any solder shorts? Too much solder? Missing joints?

❒ Wash the board under warm water. Scrub gently. Dry.

THIS IS A GOOD STOPPING PLACE TO REST OR PUT THE KIT AWAY UNTIL LATER.

You are now finished with the Organic flux solder. All soldering past this point is using the No-Clean solder. You do not have to wash the board anymore.

PART #7: FINISHING THE PCB

You will now solder in the remaining parts on the pcb in preparation for wiring to the front panel. ***USE THE NO-CLEAN SOLDER. BE CAREFUL!***

❒ Locate the Spectrol pots (3). **IMPORTANT**: in order for the pc board to properly align with the front panel, each pot must be ***absolutely flat*** on the pc board, with the shafts pointing away from the pc board. Solder the ***log pot*** into VR1 (marked 148-9609-104) and the 2 linear pots into VR2 and VR3.

❒ Locate the 5 pieces of RG-174 black coax cable. Again, note that one end has longer wires stripped than the other. Look at the pc board. Notice that in the coax positions, there is a large hole pad (lower pad) and a smaller pad (top hole). The braided wire is soldered into the larger hole. The smaller, inner conductor goes in the top hole. BE SURE THE SHORTER BRAIDED END GOES INTO THE PC BOARD.

The longer piece of coax solders into J3. The shorter coax solder into J1, J4, J5 and J6.

Solder each coax cable into the holes. Attach a tie-wrap to secure the coax cable flush to the board. The tie-wrap goes down, into the left hole and up through the right hole. Secure and trim off any excess.

❒ Find the 3 red/black twisted pairs. They go into D1 and D2 (in the holes RED and BLK) and J2 (black into TOP (#1) hole and the red wire into the BOTTOM (#2) hole).

YOU ARE NOW FINISHED WITH THE PC BOARD WORK! BREAK TIME.

PART #8: FRONT PANEL PREPARATION

You will now attach components to the front panel. It is HIGHLY recommended that you use a set of hollow shaft nut drivers, NOT PLIERS, to tighten the nuts. This prevents scratching. NOTE: all references to part orientation is from the REAR of the panel.

❒ Locate the 6 Switchcraft jacks. Notice that from the rear, there is a beveled corner. This corner is ALWAYS CONNECTED TO GROUND, USUALLY WITH THE BRAIDED CONDUCTOR. Each jack has a flat washer, a lockwasher, and a ½" hex nut. Remove the nuts and washers from each jack. Place aside. Keep the lockwasher on the jacks.

❒ Insert the 6 jacks/lockwashers, with the beveled corner in the ***upper right*** corner, into the 6 holes. Place the flat washer on the jack, then the hex nut. Hold the jack with one hand on the backside, keeping it 'square'. Tighten the hex nut with a nut driver. NOTE: when tight, not much of the exposed threads of the jack are exposed.

You are now ready to attach the pc board to the bracket and then wire up to the panel.

PART #9: ATTACH PC BOARD TO BRACKET

❒ In the **HARDWARE** bag, locate 4ea #6-32 x 3/8 screws, 4ea #6 KEPS nuts, and 4ea spacers.

❒ Locate the mounting bracket. The pc board attaches to the bracket, with the 4 screws threading from the top of the board, through the spacers, through the bracket, and then out the bottom of the bracket. If the bracket has a protective plastic covering, remove it first. The #6 KEPS nut attaches on the **bottom** of the bracket. Note the bracket has 3 large holes on the "flange", where the 3 pots "stick out". The first step is to attach a hex nut (without the washer and outer hex nut) to each pot. Tighten each nut by hand, all the way until it touches the face of the pot. ***Then, loosen the nut one-fourth of a turn.***

Attach the pc board to the bracket. You will have to angle the pc board slightly as you insert the 3 pots through the 3 large holes on the flange. Place the 4 spacers over the 4 holes, and thread the screws in from the TOP side. ***Loosely*** tighten the 4 KEPS nuts on the bottom.

❒ THIS IS A VERY IMPORTANT STEP, SO PAY ATTENTION AND READ ALL OF IT BEFORE PROCEEDING!

❒ Slide the pcb ALL THE WAY TO THE RIGHT AS FAR AS IT WILL GO, so that the 3 pot nuts are all *pressing against the flange*. By hand, put hex nuts on the outside threads of VR1 and VR3 to keep the pc board in place. Now, tighten the 4 KEPS nuts on the bracket. The pcb and bracket should be secure, with the pc board snugly against the flange.

Remove the hex nuts on VR1 & VR3. Insert the pcb/bracket assembly through the 3 pots holes on the rear of the front panel. As you press the assembly in place, place a washer and hex nut over each pot from the front. Using a hollow-shaft nut driver, tighten each outer hex nut as far as it will go, up against the washer.

PART #10: FINISH WIRING TO THE PANEL

Please read the following instructions carefully. In order to neatly attach the many wires to the front panel components, the wires are soldered in a specific order.

❒ Insert the 2 red LEDs through the front of the panel, with the longer lead "up" (towards the VR1). From the back, facing the rear of the panel, this would be to the "left". After you verify that indeed, the longer of the LED leads is to the "left", cut the 4 LED leads about halfway off. Using a pair of needle-nose pliers, bend a 'J' shape (like a fish hook) in the ends of each lead. LED D1 is the topmost LED (in between VR1 and VR2). Untwist the red/black lead wire in D1 on the board about 2 times, slip a piece of heat-shrink tubing over each wire, and form a 'J' hook at the end. Attach the RED wire in D1 to the "left" lead of the LED. Gently squeeze the two "J" hooks together and solder. In the same manner, attach the BLACK wire in D1 to the 'right' lead of the LED. *Slip the heat-shrink tubing as far as it will go* towards the back end of the LED and shrink in place.

In a similar manner, attach the wires in D2 to the other LED. Red wire to the "left" lead and the black wire to the "right" lead.

❒ Solder coax in J6 to the SQR jack (it's a stretch, but will reach). The inner wire goes to the LEFT lug and the braid goes to the BEVELED lug. The TOP lug is not connected.

❒ Solder the Red/Black wire in J2 to the FM IN jack. Red wire to Left, Black wire to Beveled.

❒ Solder the coax in J3 to the TRI (not TRI-A!) out jack.

❒ Solder the coax in J5 to the SINE jack.

❒ Solder the coax in J4 to the SQR-A jack.

❒ Solder the coax in J1 to the TRI-A jack.

❒ Use the remaining ty-wrap to gather up the coax wires in J1-J5 and bundle together.

❒ Rotate all front panel pots fully counter-clockwise. Locate the **KNOBS**.

Notice each knob has a white line on it. Place the knob on the pot shaft, align the white line to the '0' tick mark, and tighten the hex screw. The silver part of the knob has a protective clear plastic overlay that can be removed if desired. Gently rub with your fingernail across it and it will peel off.

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CONGRATULATIONS! YOU HAVE FINISHED BUILDING THE MOTM-390!

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All that's left to do is test it! But before we do, please read the following Theory of Operation.

THEORY OF OPERATION

The MOTM-390 has 2 independent sections: a "fixed" frequency LFO and a voltage-controlled LFO.

The fixed section is a simple triangle/square oscillator based on integration capacitor C8 (for an extremely detailed explanation, see the MOTM-380 User Guide). VR1 and R11 form a resistor divider that applies a current through R12. The smaller the current, the lower the frequency. Resistors R10 and R13 set the output to +-5V pk-pk. The output of the comparator U2A is "rail-to-rail" (not quite, but close) so resistors R30 and R31 divide down this to a +-5V swing.

The LED drivers are driven from the 2 LFO triangle wave outputs. Looking at the fixed LED circuit: resistors R17 and R21 bias 'up' Q4 (since the collector is grounded) to offset the triangle above ground. R20 and R17 form an input divider that regulated the current into Q3 (Q3 is just a buffer). R19 sets the maximum brightness level of the LED. As the triangle wave rises and falls, the current "sucked" by Q3 gradually turns on and off D1.

The second section of the LFO is similar to the LFOs in the MOTM-410. The circuit of the basic oscillator is nearly identical, except we have replaced the pot divider and resistor R20 with an OTA stage, U3A. An OTA outputs a current, which we require to directly drive integration capacitor C7. Resistors R8 and R9 divide the "rail-to-rail" square wave down, but not that much: the OTA still saturates. This is done on purpose, so that the LFO speed is set by the bias current into the OTA (pin 1).

The OTA current comes from simple exponential pair Q1 and Q2. Resistors R1 and R4 set the FM voltage, and R5 and R4 set the initial voltage. The base of Q1 is a 'summing node', and the emitter current is controlled in this manner. Since the relationship between Vbe and Ic is exponential (and assuming hfe is large so Ic = Ie), we have an exponential current. Q2 is a 'current mirror', since the 2 emitters are tied together through the same resistor (R2).

This LFO has one additional stage: sine shaper U3B. This circuit is also used on the MOTM-300 VCO. In this case, R15 and R16 are *carefully selected* to provide the exact voltage needed to operate the OTA's input differential pair in a certain 'knee' of operation.

The triangle wave is 'warped' into an approximation of a sine. R22 sets the final output level.

PRELIMINARY CHECK-OUT & CALIBRATION

There are no trimmers on the MOTM-390. Apply power and turn both RATE knobs to tick '6'. The LEDS should be "flashing", but at different speeds. Applying a positive voltage to FM IN should increase the rate of the second LFO. Adjust the FM pot to verify.

TROUBLESHOOTING

If your MOTM-390 does not work, please verify ALL of the following before contacting us. The following reference directions assume that you are looking at the pc board with the panel to the right and the power connector to the left.

- ❒ All of the ICs are pointing the same way and all notches are pointing to the 'left', which is away from the front panel. The NE5517 is the IC closest to the panel.

- ❒ Check EVERY transistor for proper location, and BE SURE that U4 really is a 78L05!

- ❒ The 2 red/black wires are correctly soldered into D1 and D2. If the TRI outputs are correct, and the LED(s) are not working, chances are you swapped the LED leads. Probably the easiest fix is to swap the wires in D1/D2 (OK so they won't match the silkscreen anymore).

- ❒ The braided wire on the coax goes to the beveled side of the jacks.

- ❒ The board has all the right parts in all the right places.

If you still can not get the module to perform correctly, please contact us by phone at (888)818-MOTM or by email to synth1@airmail.net

USE OF THE MOTM-390 LFO

The MOTM-390 is used to add time-varying modulation to VCOs, VCFs, VCAs, and just about any module with a CV in jack. All 5 outputs can be used at the same time. The SQUARE output of the lower section is useful for triggering MOTM-800 EGs (it likes square waves best).

Since the exponential converter is not temperature compensated (and the transistors are not thermally matched) the LFO speed will 'drift' over temperature. The drift is on the order of say 5% over a 30F change. Chances are, you will never see such a change in cabinet temperature. The circuit is not intended to be a VCO substitute, although some will try.

The voltage-controlled section has a much wider frequency span than the fixed LFO.

You can change the maximum frequency simply by changing capacitors C7 and C8. The smaller the value, the faster the frequency. Of course, this also changes the lowest frequency as well. The capacitors need to be metallized film types, or polystyrene. Don't exceed say 0.47uf on the slow side or use a value lower than 10nf for the 'fast' mod. Waveform distortion and/or start-up problems will occur.

SPECIFICATIONS
MOTM-390 Voltage-Controlled LFO

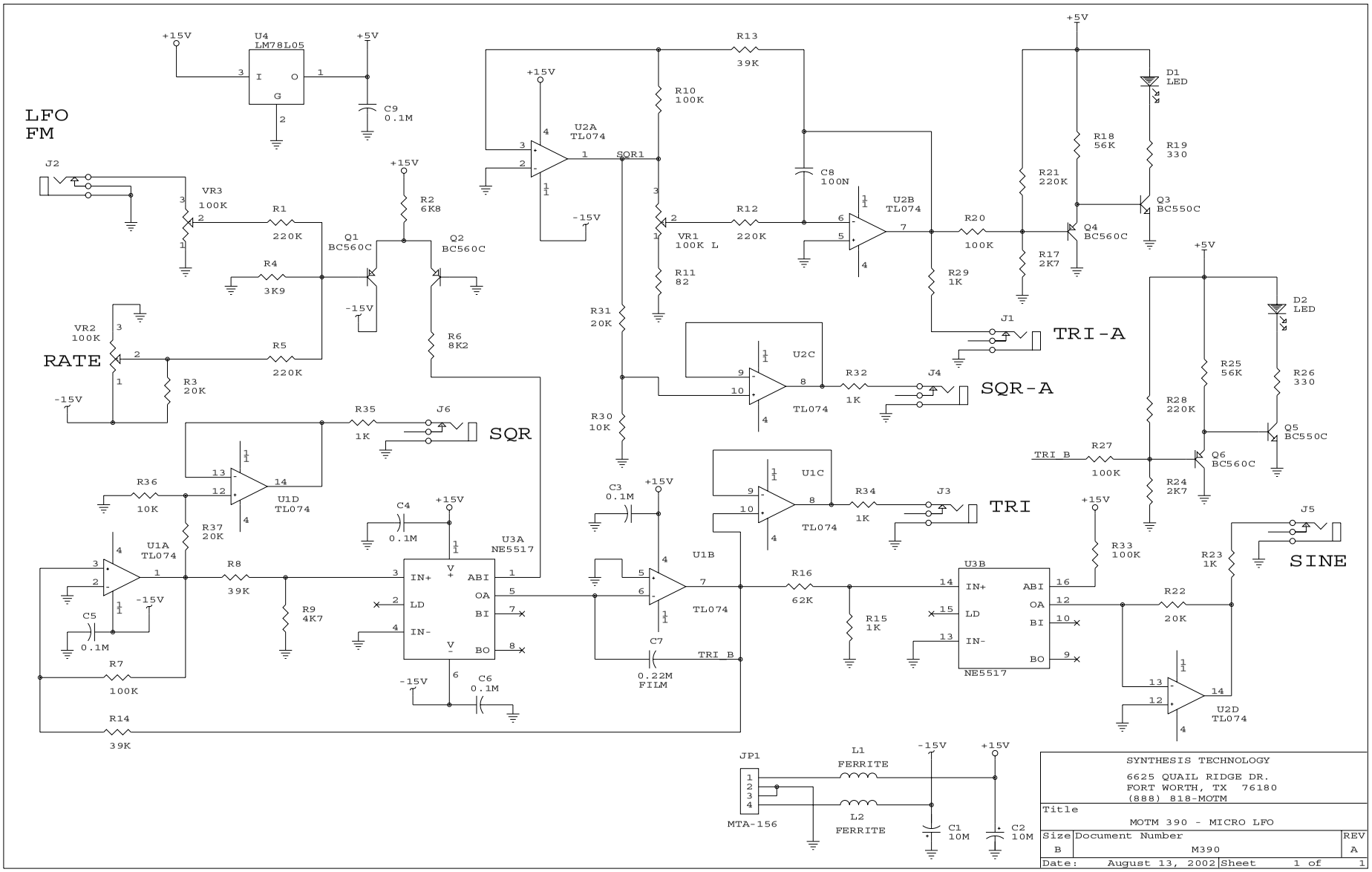
Waveform output level	10V pk-pk nom.
Output impedance	1000 ohms, nom.
Frequency Range	Fixed: 0.03Hz to 33Hz VC'd: 0.01Hz to 120Hz
FM voltage range	-7V to +7V

CONTROLS

RATE-A	sets fixed LFO 'A' output rate
RATE	sets LFO 'B' output rate
FM	attenuates the CV applied to FM jack

GENERAL

Power Supply	-15VDC @ 10 ma +15VDC @ 10 ma
Size	1U x 5U 1.72" x 8.72" 44mm x 221.5mm
Depth behind panel	3.5 inches (89mm)



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Title	MOTM 390 - MICRO LFO
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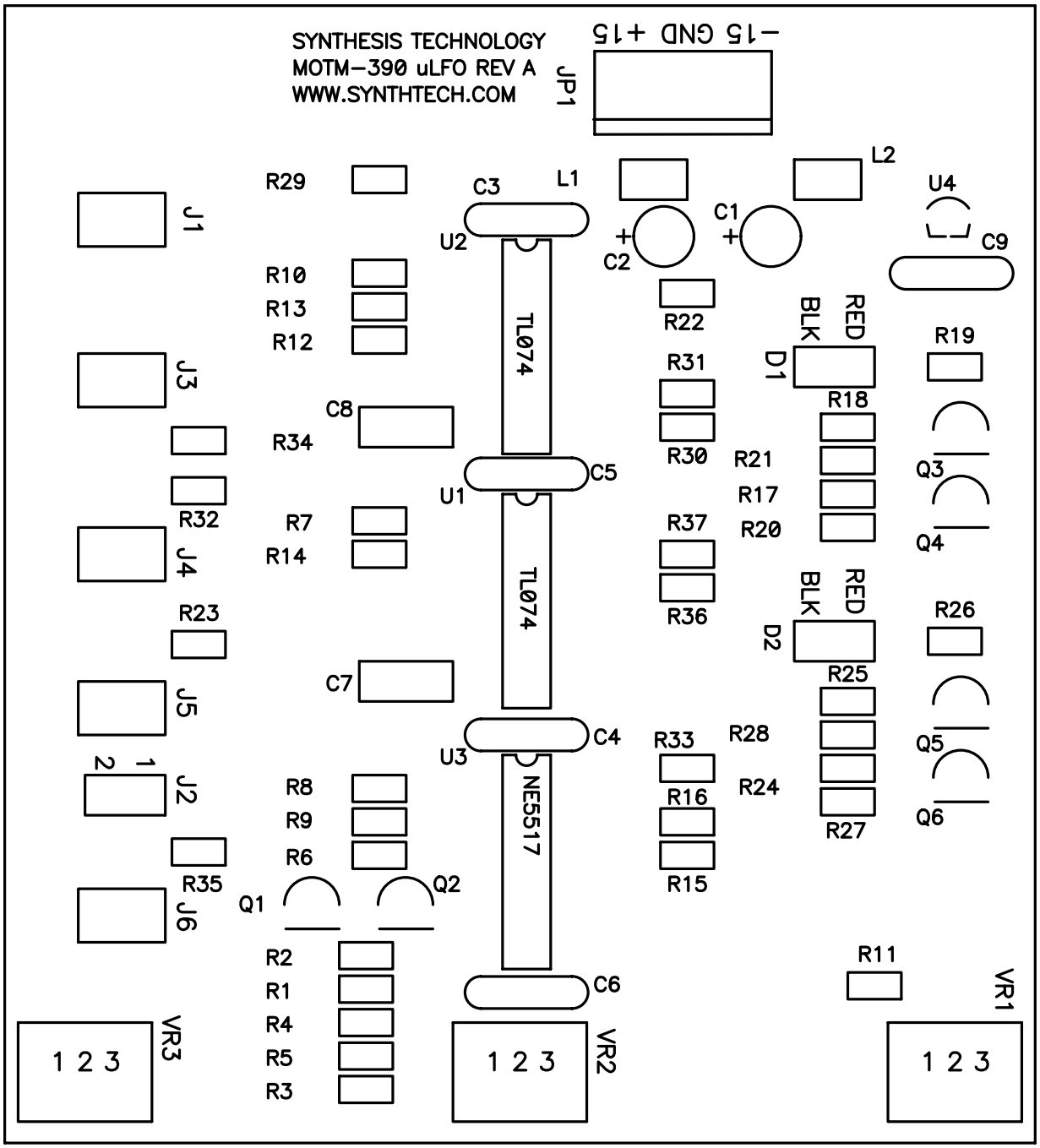
Date: August 13, 2002	Sheet 1 of 1


SYNTHESIS TECHNOLOGY
MOTM-390 uLFO REV A
WWW.SYNTHTECH.COM
JP1
-15 GND +15
L1
L2
C1
C2
C3
U2
TL074
U1
TL074
C5
U3
NE5517
C4
C6
U4
C9
R22
R29
R10
R13
R12
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