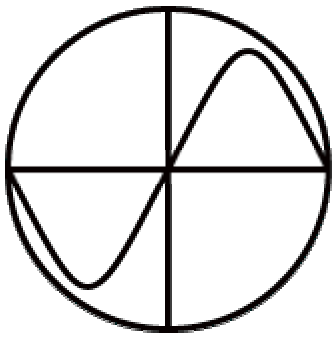

synthesis technology

MOTM-380 Quad LFO
Assembly Instructions & Owner's Manual

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April 7, 2002

MOTM-380 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 10 parts (***there is NO C1!)***

2ea 10mfd, 50V Electrolytic	C2, C3
4ea 100N (0.1uf) metal poly radial (marked 104)	C4, C5, C6, C7
4ea 0.1mfd (marked 104) ceramic axial	C8, C9, C10, C11

❒ **Resistor** bag, containing the following 31 parts (all are 5% tolerance):

6ea 39K (orange, white, orange)	R3, R7, R11, R15, R19, R23
6ea 1K (brown, black, red)	R10, R22, R24, R25, R26, R27
5ea 100K (brown, black, yellow)	R1, R5, R12, R13, R17
4ea 82 ohm (gray, red, black)	R2, R6, R14, R18
4ea 200K (red, black, yellow)	R4, R8, R16, R20
4ea 10K (brown, black, orange)	R28, R29, R30, R31
2ea 62K (blue, red, orange)	R9, R21

❒ **IC** bag, containing the following 4 parts:

3ea TL074AN quad op amp	U1, U3, U4
1ea NE5517 dual OTA	U2

❒ **Misc** #1 bag, containing the following 3 parts:

2ea Axial ferrite beads (plain, gray things)	L1, L2
1ea MTA-156 power connector	JP1

❒ **Knobs**, 4ea, ALCO PKES90B1/4

❒ **Jacks**, 4ea Switchcraft 112A

❒ **Pots**, 4ea containing the following:

4ea 100K log cond. plastic Spectrol 148	VR1-4

❒ **Front panel**

❒ **Mounting bracket**

❒ **Wire** bag, containing the following 5 wires:

2ea 3-wire set 22ga. (orange/white/gray) short
1ea 3-wire set 22ga. (orange/white/gray) long
1ea 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
6ea #6 KEPS nuts (2 for attaching bracket to front panel, 4 for pc board)
1ea small tie-wrap

❒ **Organic Solder**

❒ **No-clean Solder**

❒ **PC Board**, MOTM-380

GENERAL INFORMATION

Thank you for purchasing the MOTM-380 Quad 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 1 to 2 hours. 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-380:

* Soldering iron, 50W max power. Use 700F tip/temperature setting
* 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
* 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.

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.

You will start by soldering in ALL of the resistors.

❒ Find the **RESISTOR** bag.

❒ Find the MOTM-380 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 parts!

❒ Locate the 39K resistors (6) and solder into R3 (left of U1), R7 (left of U4), R11 (left of U3), R15 (right of U1), R19 (right of U4), and R23 (below R11).

❒ Locate the 1K resistors (6) and solder into R10 (left of U2), R22 (above VR3), R24 (right of U3), R25, R26 and R27 (above J4).

❒ Locate the 100K resistors (5) and solder into R1 (above C4), R5 (left of U4), R12 (below C5), R13 (right of U1) and R17 (right of U4).

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 about 15 minutes.

PART #3: Complete the Resistors

❒ Locate the 82 ohm resistors (4) and solder into R2 (by VR1), R6 (below VR2), R14 (below VR3), and R18 (beside R14).

❒ Locate the 200K resistors (4) and solder into R4 (left of U1), R8 (left of U4), R16 (below C6) and R20 (below C7).

❒ Locate the 10K resistors (4) and solder into R28-31 (right of U3).

❒ Locate the 62K resistors (2) and solder into R9 and R21 (either side of U2).

This completes the resistors.

PART #4 BOARD WASH #2

❒ 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 and blot dry. Take another break or set the kit aside for later. You are about one-third finished at this point: this is a good stopping-point.

PART #5 CAPACITORS

❒ Locate the **CAPACITOR** bag. Remember, there is no C1 on the board (I blame the computer).

❒ Locate the 100nf metal poly caps. (4). They are marked 104 and are reddish-brown in color. Solder into C4 –C7, beside U1 and U4.

❒ Locate the 0.1M caps (4). These are axial, yellowish-brown marked 104. Solder into C8-C11.

❒ 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 C2 and C3 with the stripe ***away*** from the + pad on the board.

PART #6: 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 TL074AN chips (3). Solder into U1, U3 and U4. Be sure the parts all point in the same direction: "up".

❒ Locate the NE5517 into U2. The orientation is the same as the TL074s.

❒ Apply 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.

PART #7: FINAL BOARD WASH & INSPECTION

❒ Verify all the parts are in the correct locations. Make sure all of the ICs are pointing the same direction and all pins are soldered.

❒ 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 #8: 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 (4). **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 pots into VR1, VR2, VR3, and VR4.

❒ Find the 3 sets of orange/gray/white wires. Very carefully, cut the ty-wrap off the bundle. These go into J1-J3. **NOTE**: the **longer** wire goes in **J3**. In all cases, solder the White wire into 3, the Gray wire into 2, and the Orange wire into 1.

❒ Find the 1 red/black twisted pair. It goes into J4. Solder the Red wire into the 2 hole and the Black wire in the 1 hole.

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

PART #9: 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 4 Switchcraft jacks. Notice that from the rear, there is a beveled corner. This corner is ALWAYS CONNECTED TO GROUND. 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 4 jacks/lockwashers, with the beveled corner in the ***upper right*** corner, into the 4 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 #10: ATTACH PC BOARD TO BRACKET/PANEL

❒ In the **HARDWARE** bag, locate 4 #6-32 x 3/8 screws, 6 #6 KEPS nuts, and 4 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. The #6 KEPS nut attaches on the bottom of the bracket. Note the bracket has 2 long mounting flanges with a hole in each. These attach to the 2 threaded studs sticking out of the rear of the panel. The 4 pots each stick in its panel hole when the bracket is screwed down on the 2 threaded posts.

Attach the pc board to the bracket. The flanges will point upwards when the pc board is sitting on the bracket. Note that the bracket holes for the pc board are actually oblong. This is to allow adjustment for the pc board to firmly press up against the back of the panel. As a start, set the 4 screws ALL THE WAY TO THE LEFT of the oblong holes. ***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!

Note that each of the 4 pots on the pc board have 2 hex nuts and a flat washer. Remove the first hex nut and the washer. Set aside.

What you will do now is adjust the remaining hex nuts so that when the bracket is all the way down on the panel's threaded studs, all the pot hex nuts touch the rear of the panel.

Screw (by hand) each hex nut on the pots so that it is all the way on (touching the face of the pot). Now, pick up the pc board/bracket assembly and carefully slide it over the 2 threaded studs, making sure the pots are aligned in the holes. Use 2 #6 KEPS nuts and tighten the bracket to the panel.

❒ Loosen the 4 KEPS nuts on the bottom of the bracket. Slide the pcb ALL THE WAY TO THE RIGHT AS FAR AS IT WILL GO, so that the 4 pot nuts are all pressing against the panel. By hand, put hex nuts on the outside threads of VR1 and VR4 to keep the pc board in place. Now, tighten the 4 KEPS nuts on the bracket. The pcb and bracket should be secure, with no gaps visible between the panel and the pot nuts. You may need to loosen the nuts on the pots, so that they are touching the back of the panel. Again, make sure each pot's nut is touching the back of the panel (no gaps!). There will be a gap from the edge of the *pc board* to the panel.

❒ Remove the hex nuts on VR1 & VR4. For all of the pots, first put on the flat washer, then the hex nut. Tighten with a ½" nut driver.

PART #11: 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. You may find, in some cases, easier to first remove a jack from the panel and solder the wires, then reattaching to the panel.

❒ The red/black wire in J4 goes to the TRI D jack. Solder the Black wire to the BEVELED lug and the Red wire to the LEFT lug. The TOP lug is not connected.

❒ Solder J2 wires to the TRI B jack. The White wire on the Left lug, the Gray wire to the Top lug, and the Orange wire to the Beveled lug.

❒ Solder J3 wires to the SINE C jack. The White wire on the Left lug, the Gray wire to the Top lug, and the Orange wire to the Beveled lug.

❒ Solder J1 wires to the Sine A jack. The White wire on the Left lug, the Gray wire to the Top lug, and the Orange wire to the Beveled lug. Ty-wrap the wires all together.

❒ Rotate all of the 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-380!

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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-380 Quad LFO uses 4 separate triangle/square oscillators. Two of the triangle outputs pass through a wave shaper to form sine waves.

Let's examine the "A" section of the module. This discussion applies to the others as well.

U1A and U1B form the basic oscillator. U1B is connected as an integrator by capacitor C4. This integrator is looking for a *current* into the – input to charge the cap. From Electronics 101, the current/voltage relationship for a capacitor is:

$$I = C\ (dV/dT)$$

Where I is current, C is the value of the cap, dV/dT is the rate change of Voltage over Time. And remember: 1/Time is frequency!

What this means is: if we add a current I to a capacitor C, it makes a Voltage that changes over time. Let's rewrite this equation as:

$$(1/dT) = (I)/(C)(dV)$$

This tells us that as C gets bigger, the frequency goes down (since 1/dT is *smaller*). It also says if we apply more current (I is larger) then the frequency goes up. So this is the mathematical basis for designing our LFO.

Let's discuss the dV term. What does that mean? It means that in *theory,* if you have a cap, and you apply a current, the voltage rises forever to infinite voltage. Well, that doesn't sound useful in this application. So, we want to have some limiting voltage the cap charges to. Let's pick +5V. So we need some sort of +5V detector that tells the integrator "Stop already!"

This is the op amp U1A and resistors R1 and R3. Assume for a moment R2 and VR1 are not in the circuit (the output of U1A goes directly to R4). The schematic is sort of 'drawn funny', but U1A is set up as a "trick". Look closely, the – input is grounded and we are applying positive-feedback to the + input. The resistors R1 and R3 apply what is called *hysteresis* to the comparator, which normally looks for the signal just to "cross zero" and then happily bangs the output to either supply voltage (minus 2 internal chip diode drops). But, the 39K and 100K set the hysteresis to approx. +-5V (the exact equation is a mess). This is how we get the amplitude of the Triangle Out to +-5V: by having this comparator.

Now here is the 'trick': we can make a triangle oscillator by "closing the loop". The output of the comparator (a square wave) drives the input of the integrator. The integrator cap C4 is charged/discharged by the comparator.

So, how do we alter the frequency?.....Well.....OK, you in the back asleep!

Since we fix the C value (it's 100nf), we fix the dV (to 5 volts), and we want to change (1/dT) all that's left is to vary I!

That is what VR1/R2/R4 do. R4 is set at 200K. So, the current into our cap C4 is:

$$I = Vadj/200K$$

All we need is a voltage divider on the comparator output to get an adjustable Vadj. This is formed by VR1/R2. R2 is in there so that we limit the smallest Vadj *not* to be zero. If is was, the oscillator would stop. R2 therefore sets the lowest LFO frequency.

Now we can calculate the frequency range of the LFO. We *can*, can't we??!?

The fastest the LFO can go is when the wiper of the pot VR1 is "all the way up" so that R4 sees the biggest voltage. Let's say it is 14V. The current I is (14/200K) or 70uA. Plugging this in:

$$(1/dT) = (70uA)/(5)(100nf)$$

$$= 140$$

but since we have to go through 2 "halves" of the triangle (going up and going down), and the waveform goes from –5V to +5V, the actual time is (140/4)or 35Hz! How many got it right?

Conversely, the lowest frequency is when the wiper of VR1 is on the 82ohm resistor. This divides the 14V out of the comparator to (82/100,082)th of the "big current" which makes the frequency about 0.03Hz (1 cycle in 33 seconds).

WAVESHAPER

The Sine shaper is the 'industry standard' overdriven OTA input stage. This circuit is used in several MOTM modules: '300 and the '410. It applies a critical voltage of 5/63,000 or 79uV to the differential pair of the OTA. The Triangle wave gets "distorted" by the transfer characteristic of the differential amplifier. This is an old trick from the 1960s. The result is a decent sine wave with about 1% THD. Certainly good enough for a LFO.

PASSIVE SUMMER

The MOTM-380 has a unique feature not found on any other LFO: the last output, TRI D, is connected to a common passive summing network. The internal switches on the output jacks are used to disconnect each of the previous 3 outputs (SINE A, TRI B and SINE C) when a patchcord is inserted. Signal TRI D is NOT switched. Resistors R28 to R31 form the passive summer. The summer has the feature that the resultant mixed output has constant output amplitude, no matter how many signals are connected.

PRELIMINARY CHECK-OUT & TROUBLESHOOTING

This is a simple design, so there is not much to go wrong. Checkout is easiest using an oscilloscope, with each RATE pot set to 10. One at a time, insert a patch cord into the outputs, looking with the probe on the other end of the patch cord. You should observe 10V

pk-pk triangle and sine waveforms, around 35Hz. If you don't have a 'scope, use the LFO output to modulate a VCO with RATE knobs about '4'. Listen to the rise/fall in frequency.

Check the passive summing network/front panel wiring by observing/listening to TRI D output, then inserting 3 patch cords, one at a time, into the other output jacks. Each time you insert a patch cord, the TRI D output should "remove" that LFO section from the summed output. When all 3 patch cords are inserted, then TRI D should be a simple triangle wave.

If you have problems:

a) check the front panel wiring to the jacks. Be sure the right color wire goes to the correct lug on the jack

b) be sure U2 is the NE5517, and the other ICs are TL074s.

c) all the ICs point the same direction: up towards VR1.

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-380 LFO

LFOs are used to modulate other signals. Vibrato and tremolo are two examples of LFO modulation.

The only thing to remember about the module is the built-in passive summer on the TRI D output. This output is the SUM of all the LFO sections that are NOT being used. If you insert 1 patch cord, just into the TRI D jack, that output is the SUM of ALL the LFO sections. This is useful for wild, bizarre FM of VCOs and VCFs.

So, if your patch needs 2 triangle LFO waves, then you MUST insert "dummy" patch cords into SINE A and SINE C jacks, to disconnect them from the summer.

The initial release panel artwork is somewhat misleading (OK I didn't want to scap it). The arrows should really all point to the TRI D jack, since each output goes there. Later panel artwork will correct this.

Just remember that only the TRI D output is unique. The others are just individual outputs.

The frequency range of the LFO is from about 0.03Hz to 35Hz. This will vary slightly section-to-section based on the component tolerances for the 200K cap and the 100nf integration capacitor.

SPECIFICATIONS
MOTM-380 Quad LFO

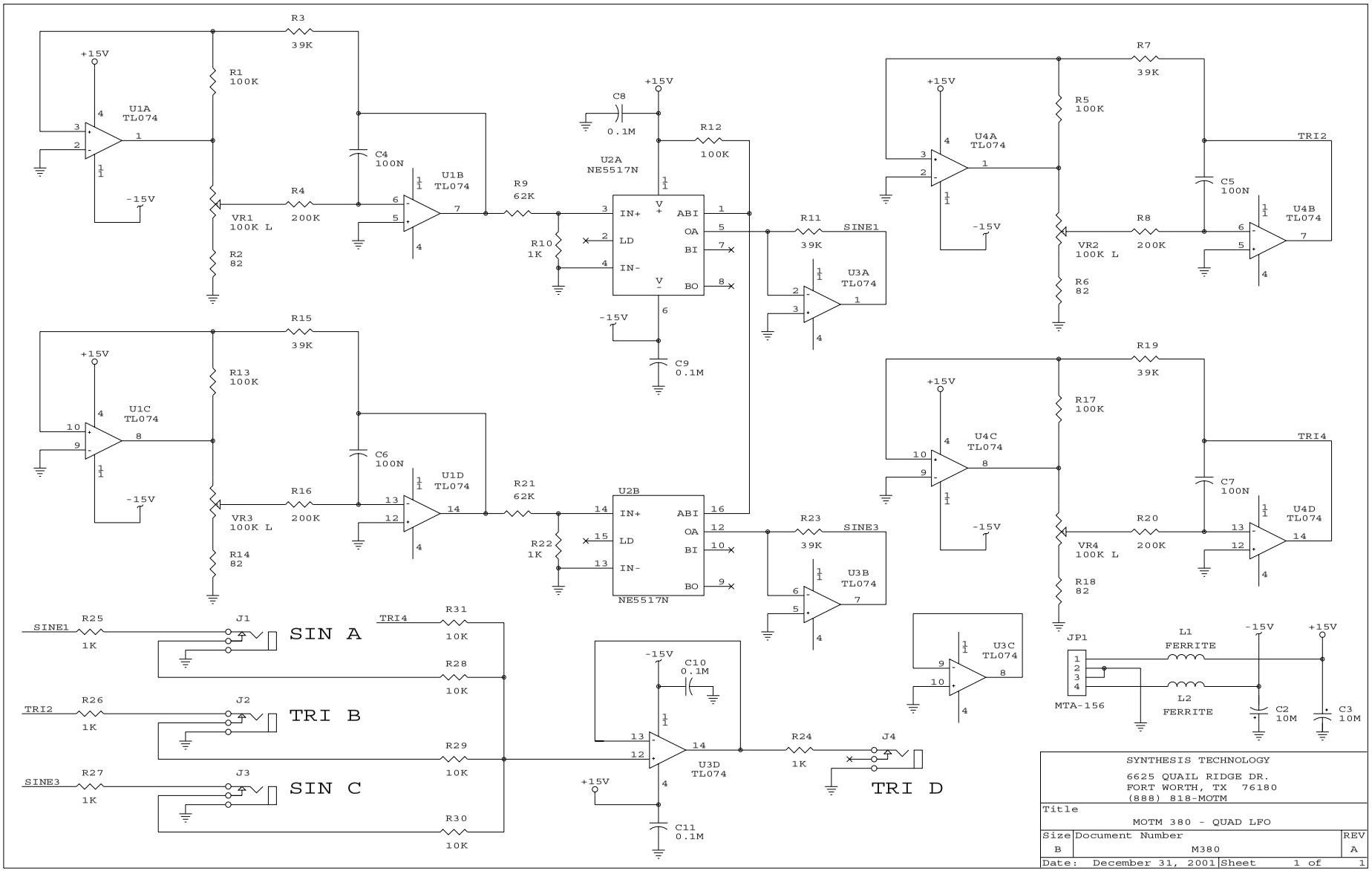
Waveform output level	10V pk-pk nom.
Output impedance	1000 ohms, nom.
Frequency Range	0.03Hz – 35Hz, nom.

CONTROLS

RATE A	sets LFO frequency for SINE A
RATE B	sets LFO frequency for TRI B
RATE C	sets LFO frequency for SINE C
RATE D	sets LFO frequency for TRI D

GENERAL

Power Supply	-15VDC @ 12ma +15VDC @ 12 ma
Size	1U x 5U 1.72" x 8.72" 44mm x 221.5mm
Depth behind panel	2.5 inches (63mm)



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Title
MOTM 380 - QUAD LFO

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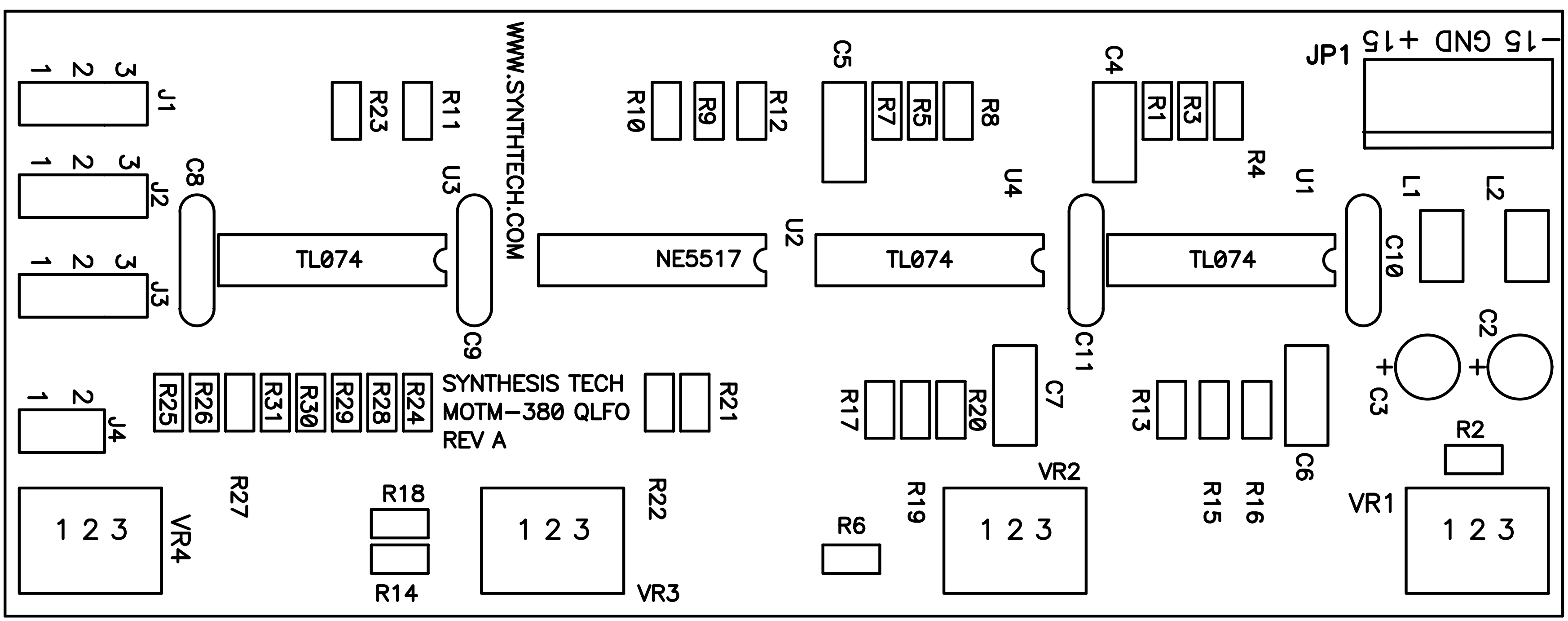
Date: December 31, 2001 Sheet 1 of 1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