synthesis
technology

MOTM-190 μVCA
Assembly Instructions & Owner's Manual

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MOTM-190 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 22 parts (there is *NO* C1-C8):

4ea 10mfd, 50V Electrolytic	C9, C10, C14, C17
2ea 3M3, 50V non-polar Electrolytic	C18, C23
4ea 1N (0.001uf) yellow box cap	C13, C27, C28, C29
10ea 0.1mfd (marked 104) ceramic axial	C11, C12, C15, C16, C19-21
	C24, C26, C30
2ea 22pf (marked 22P, 22J or 220) ceramic	C22, C25

☐ **Resistor** bag, containing the following 45 parts (all are 5% tolerance):

6ea 100K (brown, black, yellow)	R4, R26, R33, R34, R35, R37
4ea 10K (brown, black, orange)	R11, R21, R25, R45
4ea 20K (red, black, orange)	R18, R19, R22, R24
3ea 15K (brown, green, orange)	R16, R29, R43
3ea 180 ohm (brown, gray, brown)	R20, R27, R36
2ea 4K7 (yellow, violet, red)	R3, R42
2ea 12K (brown, red, orange)	R8, R31
2ea 220K (red, red, yellow)	R9, R10
2ea 1K (brown, black, red)	R12, R32
2ea 1M (brown, black, green)	R13, R28
2ea 27K (red, violet orange)	R17, R30
1ea 130K (brown, orange, yellow)	R1
1ea 47K (yellow, violet, orange)	R2
1ea 2K (red, black, red)	R5
1ea 150K (brown, green, yellow)	R6
1ea 100 ohm (brown, black, brown)	R7
1ea 68K (blue, gray, orange)　R14	
1ea 56K (green, blue, orange)	R15
1ea 5K1 (green, brown, red)	R23
1ea 7K5 (violet, green, red)	R38
1ea 3K3 (orange, orange, red)	R39
1ea 75K (violet, green, orange)	R40
1ea 43K (yellow, orange, orange)	R41
1ea 680 ohm (blue, gray, brown)	R44

☐ **IC** bag, containing the following 22 parts:

4ea TL072A dual op amp	U1, U3, U6, U8
1ea CA3280 dual OTA	U4
2ea OP275GP dual op amp	U5, U7
1ea LM78L05 voltage regulator	U2

7ea 1N4148 diodes	D1-D7
4ea BC560C PNP transistors	Q1-Q4
3ea BC550C NPN transistors	Q5-Q7

☐ **Misc** #1 bag, containing the following 8 parts:

2ea Axial ferrite beads (plain, gray things)	L1, L2
1ea MTA-156 power connector	JP1
1ea DPDT toggle switch	SW1
1ea SPDT toggle switch	SW2
1ea Bourns 3296 10K 25-turn trimmer	TP1
2ea Bourns 3386 100K trimmer	TP2, 3

☐ **Knobs**, 3ea, ALCO PKES90B1/4

☐ **Jacks**, 6ea Switchcraft 112A

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

3ea 100K cond. plastic Spectrol 148	VR1-3

☐ **Front panel**

☐ **Mounting bracket**

☐ **Wire** bag, containing the following 10 wires:

2ea 3-wire set 22ga. (orange/white/gray) short
4ea RG-174 coax, 5 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
5ea small tie-wrap

☐ **Organic Solder**

☐ **No-clean Solder**

☐ **PC Board**, MOTM-190

GENERAL INFORMATION

Thank you for purchasing the MOTM-190 MicroVCA. If you have any issues concerning the building or use of the kit, please contact us at (888) 818-MOTM [6686] or by email: synth1@airmail.net.

This kit should take the average builder between 2 to 3 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-190:

* 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-190 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 100K resistors (6) and solder into R4 (below U1), R26 (by VR3), R33-R35 (above J1) and R37 (also above J1).

☐ Locate the 10K resistors (4) and solder into R11 (above Q7), R21 (by TP3), R25 (right of U7) and R45 (below Q7).

☐ Locate the 20K resistors (4) and solder into R18 (above U4), R19 (by C23) and R22 and R24 (below TP3).

☐ Locate the 15K resistors (3) and solder into R16 (left of U4), R29 (below Q1) and R43 (above U8).

☐ Locate the 180 ohm resistors (3) and solder into R20 (by TP3), R27 (below U8) and R36 (above VR2).

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: More resistors!

☐ Locate the 4K7 resistors (2) and solder into R3 (below TP1) and R42 (below U6).

☐ Locate the 12K resistors (2) and solder into R8 (below Q2) and R31(above C28).

☐ Locate the 220K resistors (2) and solder into R9 (above U3) and R10 (above Q7).

☐ Locate the 1K resistors (2) and solder into R12 (below C30) and R32 (below C25).

☐ Locate the 1M resistors (2) and solder into R13 (by VR1) and R28 (by J3).

☐ Locate the 27K resistors (2) and solder into R17 (by SW1A) and R30 (by C24).

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, blot dry with an old towel (the leads will frazzle a good towel). Let dry about 15 minutes.

PART #5: Finish the resistors

☐ Locate the 130K resistor and solder into R1 (by TP1).

☐ Locate the 47K resistor and solder into R2 (below C18).

☐ Locate the 2K resistor and solder into R5 (above C19).

☐ Locate the 150K resistor and solder into R6 (right of R5).

☐ Locate the 100 ohm resistor and solder into R7 (above C18).

☐ Locate the 68K resistor and solder into R14 (by VR1).

☐ Locate the 56K resistor and solder into R15 (below U5).

☐ Locate the 5K1 resistor and solder into R23 (above VR2).

☐ Locate the 7K5 resistor and solder into R38 (below D5).

☐ Locate the 3K3 resistor and solder into R39 (above R38 you just soldered).

☐ Locate the 75K resistor and solder into R40 (above R39 you just soldered).

☐ Locate the 43K resistor and solder into R41 (below VR2).

☐ Locate the 680 ohm resistor and solder into R44 (above D7).

This completes the resistors.

PART #6 BOARD WASH #3

☐ 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.

PART #7 CAPACITORS

☐ Locate the **CAPACITOR** bag. Remember, there is **no** C1 to C8 on the board (I blame the computer).

☐ Locate the 1nf (0.001uf) yellow box caps. (4). They are marked 1n0. Solder into C13 and C27-29. They are not polarity sensitive.

☐ Locate the 22pf ceramic axial caps (2). Solder into C22 (by VR1) and C25 (by U7).

☐ Locate the 0.1uf axial caps (marked 104). There are 10 of these that you remove from the tape and solder into C11, C12, C15, C16, C19-21, C24, C26 and C30.

☐ Locate the 10µfd electrolytics (4). Note that there is a stripe on the NEGATIVE terminal. The pc board has a + on the POSITIVE terminal. Carefully stick the capacitors into C9, C10, C14 and C17 with the stripe *away* from the + pad on the board.

☐ Locate the 3M3 electrolytics (2). Note that these are non-polar, there is no stripe. These capacitors are not polarity sensitive. Solder into C18 and C23.

PART #8 BOARD WASH #4

☐ Verify all the capacitors are in the correct position.

☐ Verify all the axial capacitors are flat on the board. Correct if needed. Check solder joints. Check the orange caps to see all the black stripes are facing the same way: towards the top edge of the pc board (where TP1 is).

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

☐ Shake the board a couple of times and blot dry. You are about 80% finished at this point: this is a good stopping-point if you have to go do other boring stuff.

PART #9: 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 TL072 chips (4). Solder into U1, U3, U6 and U8. Be sure the parts all point in the same direction: "up". There is a small circular indention on the top of the IC by pin #1. Note that the solder pad for pin #1 is a square.

☐ Solder the CA3280 into U4. The orientation is the same for all the ICs!

☐ Locate the OP275 chips (2). Solder into U5 and U7. Be sure the parts all point in the same direction: "up". There is a small circular indention on the top of the IC by pin #1. Note that the solder pad for pin #1 is a square.

☐ Solder the LM78L05 into U2. It looks like a transistor, but it's really a voltage regulator! Match the flat side of the IC to the silkscreen pattern. Notice that it points to the "right" while all the transistors point "up".

☐ Locate the 1N4148 diodes (7). Notice the diodes have a black band around the part, towards one end. There is a matching stripe on the pc board's silkscreen (they point to the "left"). Solder the 7 diodes into D1-D7, making sure ALL of the diodes point the same way.

☐ Locate the 4ea BC560C transistors. Solder them into Q1-Q4, matching the flat side of the part to the silkscreen (pointing "up").

☐ Locate the 3ea BC550C transistors. Solder them into Q5-Q7, matching the flat side of the part to the silkscreen (pointing "up").

☐ 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. If you rub your finger over a soldered via hole, you shouldn't feel a 'bump'. An example of a via hole is in-between C20 and R13 (up in the top right corner by VR1).

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. Check the orientation of the diodes.

❐   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 2ea Bourns trimmers marked 3386 (the 'flat' ones). These solder into TP2 and TP3. Be sure they are flat on the board.

❐   Locate the Bourns multi-turn trimmer marked 3296. Solder into TP1, again making sure it is nice and sitting evenly on the pc board.

❐   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 pots into VR1, VR2 and VR3.

❐   Locate the 4 pieces of RG-174 black coax cable. Note that one end has longer wires stripped than the other. The short ends will go in the pc board in positions J2, J3, J5 and J6. 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 STRIPPED ENDS GOES INTO THE PC BOARD.

            There is a 'trick' to attaching the coax to the pc board. You pull gently on the braid with a pair of pliers from the underside until the coax is lying flat on the board. The inner conductor is at a 90 degree bend in the top hole. Then, solder the coax. 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. When properly done, the black outer jacket of the coax is all the way down, resting on the pc board.

Here is a photo of properly attached coax leads. This photo is also located at:

http://www.synthtech.com/pix/coax.html
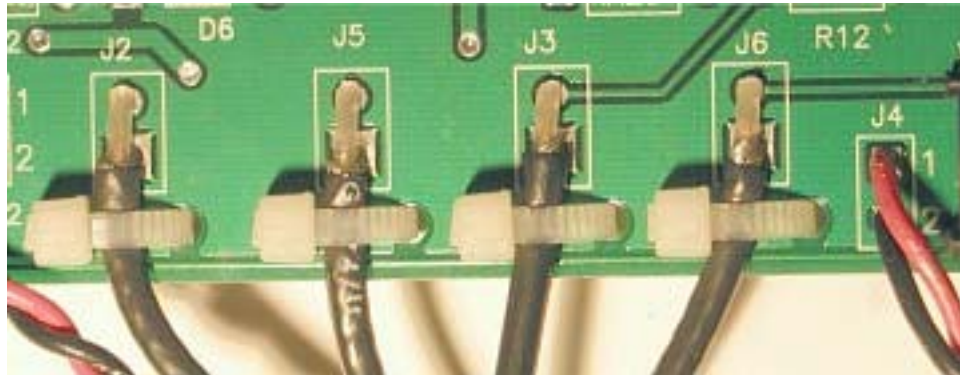
☐ Find the 3 red/black twisted pairs. They go into SW2, J1 and J4. Solder the Red wire into the top hole (#1) and the black wire into the bottom hole (#2). Be sure that the end with the shorter leads is soldered in the pc board.

☐ Find the 2 sets of orange/white/gray wires. They go into SW1A and SW1B positions. *Very carefully* clip off the ty-wrap. The 2 White wires go into the bottom (#1) pads, the 2 Gray wires into the middle pads (#2) and the 2 Orange wires go into the top pads (#3).

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 6 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 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 #10: ATTACH PC BOARD TO BRACKET/PANEL

☐ In the **HARDWARE** bag, locate 4 #6-32 x 3/8 screws, 4 #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. If the bracket has a protective plastic covering, remove it first. The #6 KEPS nuts attach 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*. Now, tighten the 4 KEPS nuts on the bracket. The pcb and bracket should be secure, with the pc board snugly against the flange.

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. The 2 notches in the flange will "go around" the 2 switch holes.

☐ Locate the DPDT toggle switch. It has 6 solder lugs, and goes into the top hole marked V/R. When viewed from the rear of the panel, the solder lugs are 2 "across" and 3 "down". The switch is not polarity sensitive, just as long as you don't put it in sideways. The lockwasher goes on the *back side* of the panel. Tighten the front hex nut, making sure the switch is "square" to the panel (not slightly rotated).

☐ Locate the SPDT switch and attach it to the lower hole marked L/E.

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 CV 2 jack. Solder the Black wire to the BEVELED lug and the Red wire to the LEFT lug. The TOP lug is not connected.

☐ Solder J5 coax to the IN 2 jack. The inner wire goes to the Left lug and the braided wire solder to the Beveled lug.

☐ Solder J6 coax to the OUT 2 jack. The inner wire on the Left lug and the braided wire to the Beveled lug.

☐ Solder J1 red/black wires to the CV 1 jack. Solder the Black wire to the Beveled lug and the Red wire to the Left lug. The TOP lug is not connected.

☐ Solder the coax in J2 to the IN 1 jack. The inner wire solders on the Left lug and the braided wire to the Beveled lug.

☐ Solder the coax in J3 to the OUT 1 jack. The inner wire solders on the Left lug and the braided wire to the Beveled lug. Attach the ty-wrap around the wires in a bundle about midway. Trim off the excess ty-wrap.

☐ Solder the red/black wires in SW2 to the SPDT switch. The Red wire solders to the Top switch lug, and the Black wire solders to the Middle switch lug. The Bottom switch lug is NOT USED.

☐ The 6 wires in SW1A/SW1B solder to the DPDT switch. Solder the wires in SW1B first! The set of lugs nearest the pc board solder to the 3 wires in SW1B. The Orange wire solder to the Top lug, the Gray wire solders to the Middle lug, and the White wire solders to the Bottom lug. The second group of wires in SW1A solder to the other set of lugs in the same manner: Orange, gray, then white, top to bottom.

☐ 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-190!

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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 'heart' of the MOTM0190 VCA/Ring mod circuits is the Intersil CA3280 dual OTA (operational transconductance amplifier). If you wish more detailed information on what these are and how they work, visit the Intersil website at www.intersil.com and download the datasheet and the 3 related application notes listed in the datasheet.

The MOTM-190 is in two different, separate sections. The "top" section is a combination VCA and Ring Modulator (RM). The "bottom" section is a linear/exponential response VCA.

TOP SECTION: VCA/RM

The basic VCA 'core' is ½ of CA3280 U4A. The OTA's output *current* is a linear function of the input voltage times a bias current. If the input voltage is audio, and we adjust the bias current, that is a basic VCA. The bias current is called Iabc and is fed into pin 3.

The audio input side is a simple follower U3B. Resistors R9-R11 and C18 AC couple the audio into R18. There is a DC offset trimming circuit (R19-R20 and TP2) and is later adjusted for reducing "thumps" in the output (caused by DC shifts in the output voltage).

First we will examine the VCA operation (switch SW1 is in the 'V' position). Since the output of the CA3280 is a current, not a voltage, we use a resistor to ground (R15) to convert the current into a voltage (good old Ohm's law at work). The output voltage is AC coupled through C23 into follower U5B (in this configuration, resistor R14 doesn't do anything. It's for the RM operation). The output stage U5 is a high-end audio op amp, the OP275GP.

VR1 is an interesting control: it acts as a "wet/dry" blend between the original audio signal and the VCA output. The other half of U5 is just a buffer to drive the output.

How does the CA3280 get a control current to act as a VCA? This is generated by U1A and Q1. This configuration is called a "constant current source". You will also see this configuration on U1B/Q2 (we'll get to that in a bit). So, what make this a "constant current" and why is that a good thing in this application?

Let's look at U1B and Q2. Ignore for now all the other parts. If you look closely, you will notice that PNP transistor Q2 has it's base-emitter junction "across" the op amp's feedback terminals (- and out). Recalling basic transistor theory, if Q2 is on, there is about a 0.6V drop across the base-emitter junction. You will also recall this voltage varies about 2mv/C, which is why VCOs drift and you can buy cheap digital thermometers. Diode D2 is used to compensate for the drift, and C29 is for stability (if you don't put it there, the small transistor capacitance makes a great 10Mhz oscillator).

In order to make a current, we add resistor R8. Since R8 is tied to the op amp's virtual ground point, the current out of the transistor is simply Vin/R8.

Turning our attention back to U1A: this circuit is what converts the control voltage into a control current for the CA3280. SW1A sends a small negative DC offset (-0.2V) into the summing node to guarantee that with no CV in, the VCA is off all the way (no audio

leakage). The control voltage is fed through 130K resistor R1, and the resulting current is fed out of Q1 into the Iabc pin of the CA3280.

So, what is the constant current source doing on pin 1, marked Id? Ahhh...you really need to read the data sheet and app notes to understand this. This is usually just a resistor to the positive supply, which biases the 2 internal Gilbert diodes (this reduces distortion by a factor of like 10). However, since this is MOTM we are not content with a resistor to the supply rail. Rather, we use a constant current source, fed by a stable +5V (using regulator U2). The stable, temperature-compensated current source assures that the 'operating point' of the Gilbert multiplier cell (the internal circuitry of the CA3280) stays fixed, and that any noise on the +15V supply rail is not present on the output (any noise on +15V would modulate the diode current, which then in turn modulates the output volume level, causing IM distortion).

The RM function is created by switching 2 circuit elements: the +5V 'reference' voltage is switched to the CV input summer, and the "ground side" of the 56K resistor R15 (you remember, the one that converts the OTA's current output into a voltage) is switched to the audio input.

How does this make a Ring Modulator? Well, first we switch the –0.2 bias used for the VCA to +5V to allow the "modulator" signal to swing a full -5V to +5V (in VCA mode, the CV is assumed to be over the range 0 to +5V). The second switch is complicated and tricky: the simple explanation is that the OTA's current output and a current generated by the input "carrier" (the switched side of R15) performs the RM multiplication function. A similar scheme is used in the older MOTM-110 RM circuit.

In RM mode, there has to be a balance between the 'carrier' and the 'modulator' voltages in the OTA. This allows the carrier to be "nulled out" of the output signal. Trimmer network R3/TP1 is a gain control adjustment. This trim sets both the VCA gain (it's about 0.85) and the RM nulling simultaneously. See the **CALIBRATION** section for details.

BOTTOM SECTION: LIN/EXP VCA

Page 2 of the schematics shows the bottom section: a straight VCA with switchable linear/exponential response. You will immediately see identical circuitry form the top section: the Id current generator, the input follower/trimmer network, and the output buffer (the output buffer does use resistor R41/U7B as the I/V converter/buffer all in one stage). Also, the Audio input is DC coupled so that the bottom VCA can modulate not just audio but control voltages as well.

The portion which is different is in the CV generation section. Current source U8B is still there, but is fed by the linear/expo generator U6A/U6B. The difference between linear and exponential responses is set by transistor Q5. For a linear response, Q5 is not in the circuit. When exponential response is needed, Q5 is switched in. Q5 is biased by R38/R40 to keep it on all the time. Diode D5 is again temperature compensation for changes in Vbe over temperature. The summed voltage from U6A modulated the base-emitter voltage, which is an exponential transfer function. In exponential mode, U6B and the components around it convert the exponential current from Q5/Q6 to a voltage. In VCA mode, they act as a follower.

CALIBRATION

There are three trim pots on the MOTM-190:

a) RM carrier null (also sets the VCA gain)
b) VCA #1 CV rejection
c) VCA #2 CV rejection

An oscilloscope is ideal for setting these trimmers to optimum setting. However, you can also set these by 'ear'.

USING AN OSCILLOSCOPE

1) Apply power. Set the upper switch to 'R' (RM mode).
2) Apply a +-5V pk-pk audio signal from a VCO at about 1Khz into the IN 1 jack. A sine wave is best, but any signal will work.
3) Set the top knob to "RM" setting (where the '10' would be).
4) With nothing plugged into the CV 1 jack, monitor the OUT 1 signal. As you turn TP1 (it's a 25-turn trimmer), you should see the signal getting smaller and smaller (if it gets larger and larger, turn the opposite direction). You will have to keep switching range scales on the scope to see the signal as it approached the 'null point'. The null point is NOT the point where the signal goes completely to zero! Rather, it is the point where the signal output reaches a *minimum amplitude*. Once you get past this point, the signal starts getting larger as you turn the trimmer. You want to set the trimmer at the null point.

To set the 2 CV Reject (also called CV Feedthrough) trimmers, you need a MOTM-800 EG or some other signal that you can use that is 0 to +5V (*feeding in a bipolar +-5V signal will not work)*. If you do not have a MOTM-800 EG (or other EG that puts out 0 to +5V), then set both trimmers to mid-rotation.

If you do have a MOTM-800, patch the + OUT from the '800 to the CV 1 IN of the '190. Set the scope on DC coupling, and set the '800 as Attack=Decay=Release=1, Sustain = 10. If you have a '300. '310. '320, or '390 then use a PULSE output into the GATE input of the '800, setting the PULSE rate to about 30Hz. This will send a constant stream of 0 to +5V fast envelopes to the '190. If you do not have a source to drive the EG, just use a GATE from a keyboard or MIDI-CV converter.

5) Set the upper switch to 'V' (VCA position). When you look at the OUT 1 signal while slowly adjusting the CV FEED A trimmer (TP2), what you should see is the envelope 'leaking' to the output. Just like the RM Null trimmer, you should reach a trim position where the overall amplitude of the output is at a minimum. This setting may not be at the point of 0V DC out, but at a point say +-5mv from 0V. This is OK, what we want is for the output not to "thump", and the "thump" is when the DC level rapidly jumps. The trimmer is somewhat sensitive, be slow and methodical when setting the null point.

6) Repeat for the other VCA. Set the lower switch to 'L' (Linear), and monitor OUT 2 while sending the EG stream to the CV 2 jack. Adjust the CV FEED B trimmer (TP3) for smallest output amplitude.

SETTING TRIMMERS BY EAR

The most important thing when setting the trimmers by ear is to **watch your audio levels!** Use a mixer to attenuate the '190 OUT signals BEFORE the amplifier. Don't complain to me that you blew up your tweeters or power amp. Bring the volume up SLOWLY.

1) Apply power. Set the upper switch to 'R' (RM mode).
2) Apply a +-5V pk-pk audio signal from a VCO at about 1Khz into the IN 1 jack. A sine wave is best, but any signal will work.
3) Set the top knob to "RM" setting (where the '10' would be).
4) With nothing plugged into the CV 1 jack, monitor the OUT 1 signal. As you turn TP1 (it's a 25-turn trimmer), the volume will get smaller and smaller as you turn the trimmer (if it gets louder and louder, turn it the other way). When the volume is at the quietest level, stop the adjustment.

To set the 2 CV Reject (also called CV Feedthrough) trimmers, you need a MOTM-800 EG or some other signal that you can use that is 0 to +5V (*feeding in a bipolar +-5V signal will not work).* If you do not have a MOTM-800 EG (or other EG that outputs 0 to +5V), then set both trimmers to mid-rotation.

If you do have a MOTM-800, patch the + OUT from the '800 to the CV 1 IN of the '190. Set the '800 as Attack=Decay=Release=1, Sustain = 10. If you have a '300. '310. '320, or '390 then use a PULSE output into the GATE input of the '800, setting the PULSE rate to about 30Hz. This will send a constant stream of 0 to +5V fast envelopes to the '190. If you do not have a source to drive the EG, just use a GATE from a keyboard or MIDI-CV converter.

5) Set the upper switch to 'V' (VCA position). When you look at the OUT 1 signal while slowly adjusting the CV FEED A trimmer (TP2), what you should hear are 'pops', 'thumps' or a 'clicking buzz' as you turn the CV FEED 1 trimmer. **START WITH THE TRIMMER IN THE MIDDLE OF ROTATION!** The trimmer is somewhat sensitive, be slow and methodical when setting the null point.

6) Repeat for the other VCA. Set the lower switch to 'L' (Linear), and monitor OUT 2 while sending the EG stream to the CV 2 jack. Adjust the CV FEED B trimmer (TP3) for smallest output amplitude.

7) If rotating the trimmers doesn't change the output volume, then you got a 'really good' CA3280 chip. Set the trimmers to mid-position.

USE OF THE MOTM-190 VCA/RM

The two sections of the MOTM-190 operate in different ways. Please read the following to familiarize yourself with the different operations of the switches and front panel controls.

The 'top' section consists of the switch marked 'V' and 'R", and the top panel control BLEND. These controls are associated with CV 1/IN 1/OUT 1 jacks. The switch sets VCA mode ('V') or Ring Modulation mode ('R').

When set to VCA mode, the top section is a standard linear-response VCA. The audio signal is fed into IN 1, and the control voltage is fed into CV 1. *In VCA mode, it is important to note that the CV input operates over the range 0V (VCA off) to +5V (VCA fully on).* Also, the gain from input-to-output when the CV is +5.0V is not unity: rather, it's about 0.85. This is a tradeoff in sharing the came current source for the Ring Mod. The 'null point' set by TP1 also sets the gain through the VCA. In theory, the gain should be close to 1, but in reality the gain will be closer to 0.80 – 0.90.

The user has one control: BLEND. Note that this VCA does not have a CV attenuator, so if you want to use this VCA as your "final output" stage, you may first want to use a MOTM-830 Mixer to attenuate the envelope driving CV 1. This will set the overall output volume.

The BLEND control is a 'wet-dry' fade between the original input signal (what you have plugged into IN 1) and the VCA output. In most cases, you will simply set BLEND to the RM position, which is for full VCA signal (you'll see why it's labeled RM in the next section). If you set BLEND counterclockwise, more and more of the original signal "bleeds through" until the VCA is no longer part of the output signal.

This VCA is AC coupled: you cannot use it to modulate DC control voltages. VCA #2 will do this, however.

When set to RM mode, the input IN 1 changes functions and signal level restrictions. The CV 1 input can now accept –5V to +5V signals, which is usually an audio sine wave called the "modulator" signal. The IN 1 jack is the "carrier", another audio signal. The circuit multiplies the two signals together, creating the sum and difference between the 2 signals (and their harmonics). The result is often a harsh, metallic sound. This is a good thing.

The BLEND control acts slightly differently. When fully counterclockwise (the IN position), the output is the input. At the '5' tick mark (knob is straight up), the output is a 100% AM modulated signal. This is the *same* output as in VCA mode, when BLEND is all the way to RM. As BLEND is turned to RM, the output is a 100% RM (also called a 4-quadrant multiplication) signal. If you are fortunate to have ever played a CS-80, this is the same operation as its RM 'lever' control. You will discover many interesting RM sounds by using the BLEND setting.

The lower VCA is a more 'traditional' VCA, similar to the operation of the previous MOTM-110 VCA. The switch selects 'L' (Linear) or 'E' (Exponential) response. In 99.5% of the cases, you will want to use 'L' mode. This is the usual 0V to +5V DC control signal, standard VCA. The exception is that this VCA is DC coupled: you can use it to modulate not just audio but CV as well. The 'E' response is for generating extremely 'tight' or 'percussive' outputs. In 'E'

mode, the VCA has very low gain (say less than 10%) when the CV 2 signal is between 0 and +3.5V. Over the last 1.5V range of the CV, the output rapidly goes from 10% to 100% (unity) gain.

The GAIN control sets the initial gain of the VCA. Normally, you want to set this to the '0' tick. As you increase the GAIN knob, you will hear the input signal at the output. So, one way to think about this control is that it is a DC offset (or bias) to the CV 2 input.

The CV MOD is a simple linear attenuator in series with the CV 2 input signal. This is handy if VCA #2 is the 'final output stage' of your patch. You can use CV MOD to set the overall volume of the audio output.

Thanks for purchasing and using the MOTM-190. Please email or call if you have any questions regarding its operation.

SPECIFICATIONS
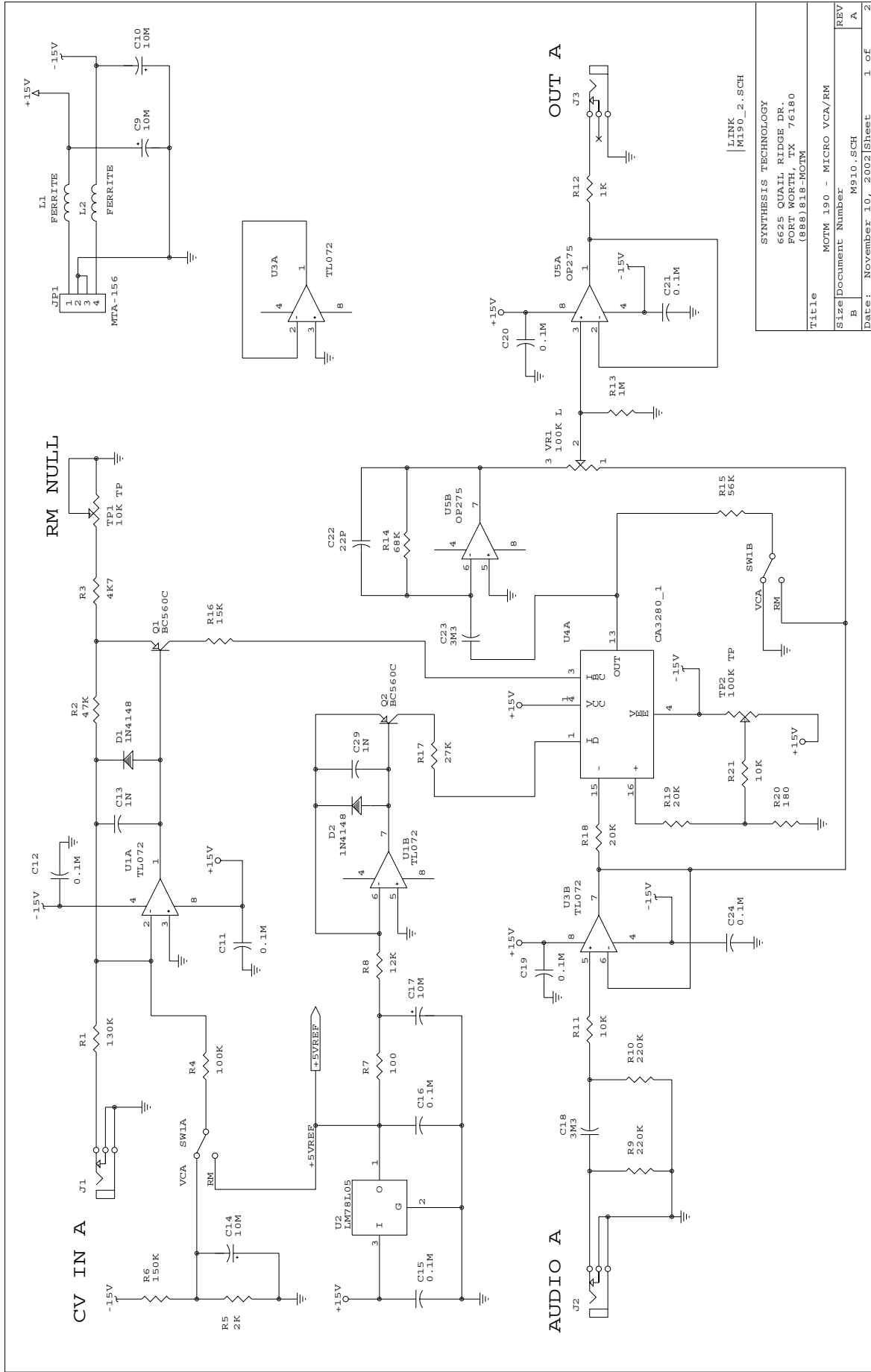# MOTM-190 VCA/RM

Audio Input Level (IN 1 and IN 2)   12V pk-pk maximum

Frequency Response   20Hz to 35Khz

Output impedance   100 ohms, nom.

THD + noise   0.025%, 1Khz at 0dBv reference

Dynamic range   >106dB

CONTROLS

BLEND   fades between the IN 1 and the VCA/RM

GAIN   sets the initial gain for VCA #2

CV MOD   attenuates the CV 2 input
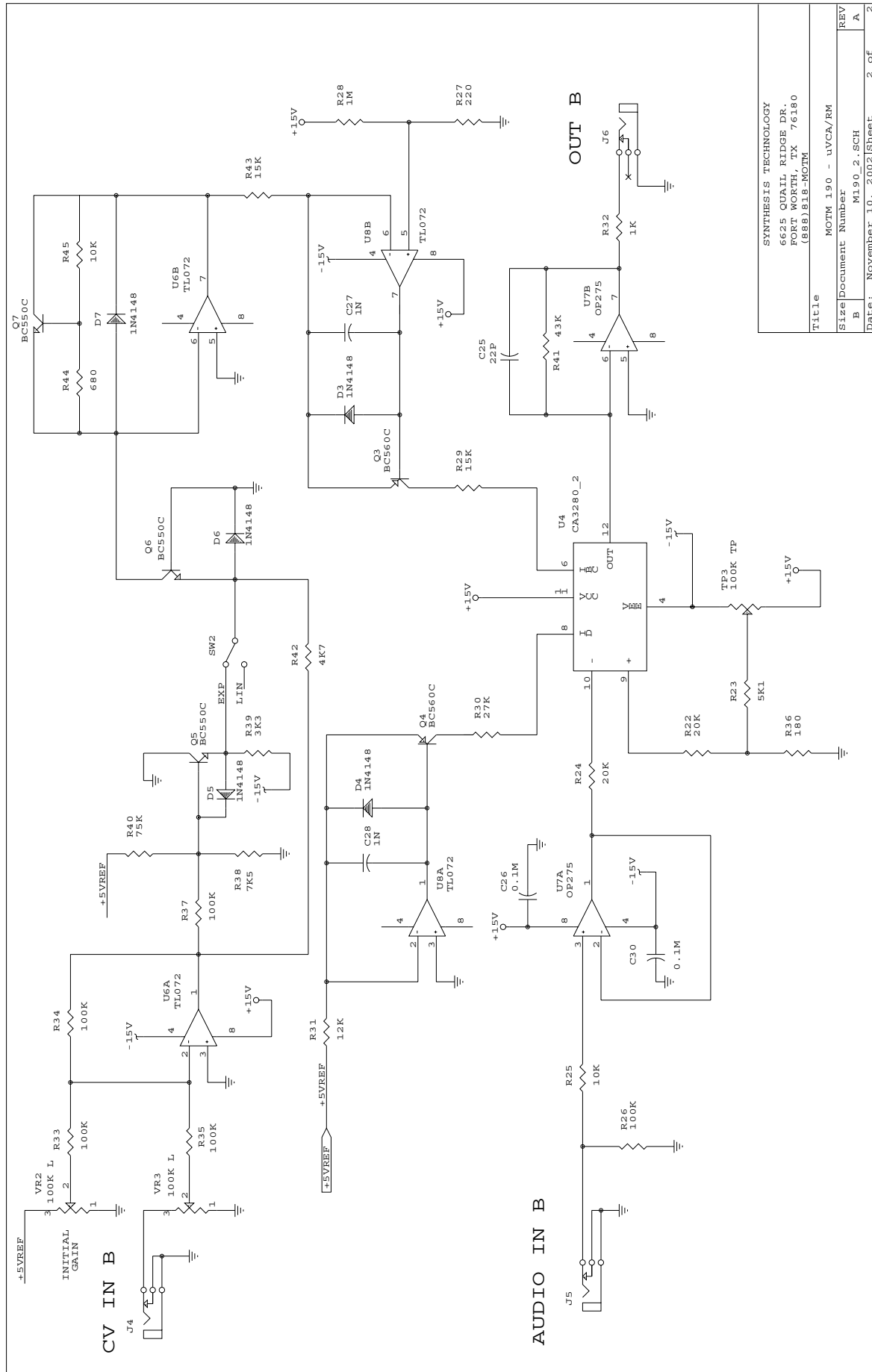
GENERAL

Power Supply   -15VDC @ 38ma
+15VDC @ 38 ma

Size   1U x 5U
1.72" x 8.72"
44mm x 221.5mm

Depth behind panel   4.5 inches (114.3mm)

CV IN A

RM NULL

OUT A

AUDIO A

SYNTHESIS TECHNOLOGY
6625 QUAIL RIDGE DR.
FORT WORTH, TX   76180
(888)818-MOTM

Title
MOTM 190 - MICRO VCA/RM

Size Document Number   REV
B   M910.SCH   A

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CV IN B

AUDIO IN B

OUT B

MOTM—190 uVCA REV A
WWW.SYNTHTECH.COM

RM MODE
ZERO TRIM

−15 GND +15

JP1

R33 R34 R35 R37 R38 R39 R40

D5

R3

TP1

D1

J1
1 2

R42
SW2
1 2

C12
U6
C11

R9
U3
L1
L2
C15
C17
U2
C13
C16
R1

R4

U1
C19
R5
C29

Q5
C10
C9

J2

Q6
D6
R44
R45
Q7

R11
R10
R2
C18
R7
C14

D7
Q4

D3
Q3
SW1A
3
2
3
2
1

D2
Q2
R8
R6

J5

C28
R31
R30
R29
R16
R17

D4
Q1
SW1B

J3

R28
R27
U8
R43
C24
U4
R18
R15
C21
U5
C20

J6

C30
U7
C26
R24
R22
TP3
CV FEED A
C22
R14
R13
VR1

R12
C27
VR2
1 2 3
CV FEED B
TP2
C23

J4
1 2

R26
R25
R32
C25
R41

1 2 3

VR3
1 2 3

R36
R23
R21
R20
R19