Analog Metropolis

AM2010
Dual Voltage
Controlled Amplifier

Project Notes
V1.0

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1 Module Description

This module is a clone of half of the Quad VCA in the Eμ Systems Modular.

The Dual VCA consists of two independent linear two-quadrant multipliers. Each of the identical VCA sections are voltage controlled, with a front panel switch for + or – control, a GAIN control setting the overall volume, and a LAG control introduces a delay to the triggering of the module from a few milliseconds to 0.1 seconds. This ensures that when controlled by digital control signals, the sharp attack does not create pops in the audio signal output from the VCA.

This dual VCA module does not

INPUTS	AUDIO INPUT1, AUDIO INPUT2 CVIN1, CVIN2
OUTPUTS	AUDIO OUT1, AUDIO OUT2
POTS	GAIN1, GAIN2 LAG1, LAG2
SWITCHES	SWITCH1 = VCA1 CV POLARITY SWITCH2 = VCA2 CV POLARITY

The front panel controls for each VCA consists of GAIN and LAG potentiometers, a switch that selects + or – control polarity. The front panels jacks are SIGNAL IN and OUT plus a CONTROL CV.

2 The Original Circuit

The original module dates back to January 1973 and was probably based around the CA3080 OTA chip, which was also used in the 2000 single VCA. Both these VCA modules were updated to harness the new SSM chips that Dave Rossum co-designed with Ron Dow in the late 1970's. The single VCA took the SSM2010, and the Quad VCA used the SSM2020.

The SSM2010 VCA chip was a major improvement on the existing OTA based VCA designs of 1977 and it would be attractive to use today, however it is unobtainable. The SSM2020 is not quite as agile as the SSM2010, but it has an improved noise level over a CA3080 based VCA (x5 better), but it doesn't offer any improvements in control rejection or signal attenuation.

A modern VCA chip like the THAT2180 will provide a significant improvement in noise (x10 better) and a 15dB increase in dynamic range. The SSM2010 is unobtainable and therefore not capable of cloning, so for a quality Eμ Systems VCA design that can be replicated, the SSM2020 based VCA is the one to go for. The Prophet 5 REV 1 and 2 uses the same SSM2020 chip, as does a lot of the Audity.

3 The AM Circuit

The AM circuit is a straight copy of the original Eμ Systems VCA circuit. The SSM2020 is a dual VCA, so the circuit is mirrored. The + and – control voltages are brought into the VCA using a dual Op Amp (originally a LM1458) and a lag processor based around a 1M Log potentiometer. The audio input is buffered before and after the VCA by a dual (TL082) Op Amp.

The front panel controls consist of GAIN and LAG, a switch selects + or – control polarity and the front panels jacks are AUDIO IN and AUDIO OUT plus a CONTROL CV.

The Op Amps can be upgraded, an OPA2134 replaces the TL082 with improved offset and faster slew rate, and a LT1013 replaces the 1458 with improved offset.

The REV04 board is the production board. There are no errors.

4 PCB

The PCB is double sided with solder mask and silkscreen on the upper surface. The component names are shown in the silk screen but not the component values. The size of the PCB is 80mmx100mm.

The PCB is held to the front panel at 90 degrees by the use of two pot brackets manufactured by Omeg (www.omeg.oc.uk). These brackets (and pots) are centred at 40mm apart. The GAIN1 and DELAY1 pots hold the PCB to the front panel.

5 PCB Connections

The PCB has a number of connections designed for MTA 0.1” headers, so that the panel components can be connected to the PCB. I use headers and sockets to enable the board to be easily replaced, however you can solder wires straight to the PCB.

PCB Header Name	Pin #	What is it?	Where does it go?
INS	Pin 1	Audio Input	Jack Socket VCA2 Audio Input
	Pin 2	Audio Input	Jack Socket VCA1 Audio Input
CV-INS1	Pin 1	CV Input VCA1	SWITCH1 Top Pin (CV-)
	Pin 2	CV Input VCA1	SWITCH1 Bottom Pin (CV+)
CV_INS2	Pin 1	CV Input VCA2	SWITCH2 Top Pin (CV-)
	Pin 2	CV Input VCA2	SWITCH2 Bottom Pin (CV+)
GAIN2	Pin 1	Gain Pot VCA2	Gain Pot VCA2 Pin 1
	Pin 2	Gain Pot VCA2	Gain Pot VCA2 Pin 2
	Pin 3	Gain Pot VCA2	Gain Pot VCA2 Pin 3
LAG2	Pin 1	Lag Pot VCA2	LAG Pot VCA2 Pin 1
	Pin 2	Lag Pot VCA2	LAG Pot VCA2 Pin 2
	Pin 3	Lag Pot VCA2	LAG Pot VCA2 Pin 3
OUTS	Pin 1	Audio Output	Jack Socket VCA2 Audio Output
	Pin 2	Audio Output	Jack Socket VCA1 Audio Output
PAD	Pin 1	Panel Earth	Jack socket earth bus

6 Pots

The PCB is designed to be used with Spectrol 248J conductive plastic pots; they are a reasonable price and very high quality. The PCB will work with either 3.18mm or 6.35mm spindle diameter models. The PCB can be used with other pots such as sliders provided they are all mounted off the PCB.

7 Switches

Switch Name	Pin #	What is it?	Where does it go?
SWITCH1	Top	CV Input -	PCB VCA1 CV- Input
	Centre	CV Input	Jack Socket VCA1 CV Input via 100K resistor R25
	Bottom	CV Input +	PCB VCA1 CV+ Input
SWITCH2	Top	CV Input -	PCB VCA2 CV- Input
	Centre	CV Input	Jack Socket VCA2 CV Input via 100K resistor R26
	Bottom	CV Input +	PCB VCA2 CV+ Input

8 Power

The module should be powered from a well regulated +15V and -15V power supply, current consumption is around 25mA. The power connector is the standard two ground MOTM/Oakley 4-pin Molex connector. One ground is for the circuit, the other is for the panel ground (PAD).

9 Front Panel

The AM2010 is a standard AM format module which can be built into a number of panel formats. You can use your own format or choose from the following:

AM High Density
This panel format enables a higher density of controls on each panel, and panels are usually 90mm wide. All the pots have a small spindle diameter of 3.18mm which enables the control knobs to be located closer together. Both 19mm and 13mm control knobs can be used. The "look and feel" is similar to the ARP 2500.

Panels are 4U high and 90mm wide. Panels are fitted to horizontal 12mm angled aluminium strip using 4mm diameter machine screws in each corner of the panel. The strip is mounted into a standard 19" rack unit with small wooden end strips.

AM Low Density
This panel format has a lower density of controls on each panel, and panels sometimes have to be 135mm wide to accommodate all the controls. All the pots have a spindle diameter of 6.35mm which means 19mm control knobs can be used, such as those used in the Eμ Systems Modular. The "look and feel" is similar to the Eμ Systems Modular.

Panels are 4U high and 90mm or 135mm wide. Panels are fitted to horizontal 12mm angled aluminium strip using 4mm diameter machine screws in each corner of the panel. The strip is mounted into a standard 19" rack unit with small wooden end strips.

MOTM Panels
This established panel format has pot spacing very close in dimensions to the AM PCB's, MOTM is 41.275mm compared with 40mm of the AM format. This means you can design MOTM style front panels but with 40mm spacing and this won't look significantly different. Alternatively you maybe be able to mount the AM PCB on 41.275mm hole centres by slightly bend the pot brackets to fit.

10 Building the Module

This module is simple to build. The recommended build order is:

- Resistors
- Inductors
- IC Sockets
- Capacitors
- Trimmers
- Connectors
- Transistors
- Pot Brackets and Potentiometers

Check all the electrolytic capacitors and transistors are fitted the right way round. Before fitting the IC's its worth connecting up the module to a power supply and checking that the power rail voltages are as expected at each IC socket, then power down, and fit the IC's ensuring correct orientation.

Remember: Two 100K resistors (R25 and R26) are mounted off board.

Power up and try out each VCA. Then proceed to trimming.

10 Trimming

This module is simple to set-up.

REJECT1, REJECT2 These trimmers adjust the VCA chip for maximum dynamic range. Apply a 10V peak to peak audio signal into the VCA and trim for minimum signal output. Keep the LAG control at minimum.

11 Special Components

The AM2010 makes use of a small number of specialist components:

SSM2020

The SSM2020 chip is hard to locate, but it be found especially on eBay.

ECO/Omeg Pot Brackets

These can be obtained from Omeg in the UK. http://www.omeg.co.uk/. Oakley have them again, and I have stock them too.

12 Parts Listing

Part Number	Value	Quantity	Comments
Capacitors			
C1, C2, C6, C12	100nF 100V	4	Multi-layer Polyester
C3, C4	22uF 25V	2	Radial Electrolytic
C5, C10	5pF	2	Low K Ceramic
C7, C13	100pF	2	Low K Ceramic
C8, C11	10nF	2	Multi-layer Polyester
C9, C14	22pF	2	Low K Ceramic
Resistors			
R1, R3, R6, R7, R8, R14, R16, R19, R20, R23	100K	10	1/4W 1% metal film
R2, R15	1M	2	1/4W 1% metal film
R4, R10, R17, R22	1K	4	1/4W 1% metal film
R5, R18	270K	2	1/4W 1% metal film
R9, R21	10K	2	1/4W 1% metal film
R13, R24	22K	2	1/4W 1% metal film
R25, R26[1]	100K	2	1/4W 1% metal film
Trimmers			
REJECT1, REJECT2	1M	2	25 turn cermet trimmer
Potentiometers			
GAIN1, GAIN2	100K LIN	2	Spectrol 248
LAG1, LAG2	1M LOG	2	Spectrol 248
Passives			
L1, L2		2	Inductor
Semiconductors			
IC1, IC4	LT1013	2	Dual Op Amp, low offset
IC2, IC5	TL082P or OPA2134	2	Dual FET Op Amp, audio quality
IC3	SSM2020	1	VCA chip
T1, T2	2N4250	2	Transistor
D1, D2, D3, D4	1N914	4	Signal Diode
Hardware			
VCA1CVIN, VCA2CVIN INPUTS, OUTPUTS		4	0.1” MTA 2-Pin Header
POWER		1	0.156” MTA 4-Pin Header
SWITCH1, SWITCH2		2	DPDT Toggle Switch Centre Off

[1] R25 and R26 are mounted on the switches and not on the PCB.