Analog Metropolis

AM8109
Roland Jupiter 8
Low Pass Filter

Project Notes
V1.01

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1 Module Description

The AM8109 is a clone of the beautiful Low Pass Filter from the legendary Roland Jupiter 8 analog polyphonic synthesizer that was launched in autumn 1981. The Jupiter 8 uses a special Roland filter chip, the IR3109. This is a single chip 2 and 4 pole OTA filter block that Roland first used in the Jupiter 4 in 1980, replacing a discrete version of the filter that uses many more components and takes up valuable PCB space.

The IR3109 chip featured in the next series of Roland polyphonic synthesizer to succeed the Jupiter 4 (due to the small space needed for each analog voice channel), including the Jupiter 6 and 8, as well as the Juno 6/60. It was also used in the Roland SH101 monosynth, various Boss Phasers and Roland guitar synthesizers. The 16 pin DIL chip was eventually replaced in 1984 with the 80017A chip which contains the VCF (as a SMD IR3109 chip) and a VCA. This chip was implemented in the Roland Juno 106 and MKS30.

Here is what Roland had to say:
The IR3109 chip contains four variable transconductance amplifiers designed for VCF application in electronic musical instruments. The device is equipped with for high impedance buffers and anti-log circuitry which controls conductances of four amplifiers.

The circuit is similar in concept to the SSM2040 and CEM3320 filter chips which are of the same time period.

I have kept the design of the AM8109 to just the LPF rather than replicating the HPF from the Jupiter 8 as well, that's simply because I don't have enough space on the PCB. The AM8109 is an excellent sounding OTA style filter, with the characteristic warmth and powerful resonance of the Jupiter 8.

The filter frequency is adjusted by the FREQ front panel control and there are two external CV inputs for frequency modulation. The filter mode can be switched from 2 to 4-pole using a locking push button. The filter has a Q control (RESONANCE) to adjust the resonance of the filter. Higher settings of the Q control will take the filter into sine wave oscillation.

INPUTS: SIGNALA, SIGNALB, SIGNALC
CV1, CV2

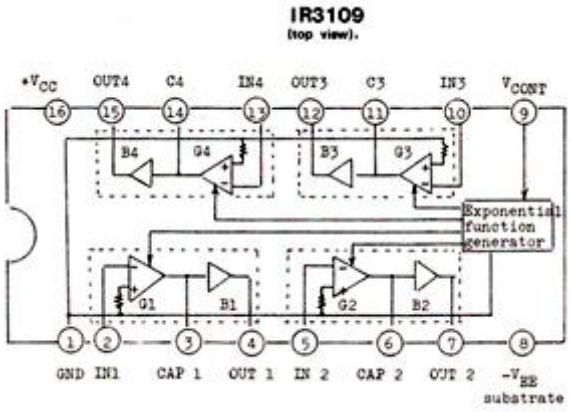
OUTPUTS: AUDIO SIGNAL

POTS: SIGNAL A, SIGNAL B, SIGNAL C
FREQUENCY, RESONANCE, CV1, CV2

SWITCH: FILTER MODE (2 or 4 POLE)

2 The Original Circuit

The original design is a classic 4 stage OTA filter block built into the 16-pin DIL IR3109 chip, along with an internal exponential CV generator to control the frequency cut off. 4 external capacitors are needed to form the four OTA filter stages.



The Jupiter 8 circuit uses additional components to enable voltage control of Frequency and Resonance.

3 The AM8109 Circuit

The cloned circuit is similar to the original with the core of the filter based on a single voice of the original Jupiter 8, and a resonance control circuit using a BA6110 as the VCA. The frequency control circuit is from the SH101 with temperature compensation via a 10K NTC. In the prototype I used high quality 240pF 1% axial polystyrene capacitors for the filter stages mounted horizontally. The production PCB is set up for either radial 220pF 5% polypropylene (5mm spacing) or vertically mounted 240pF axial 1% polystyrene capacitors. I have moved to using polypropylene capacitors for my filters, as they are cheaper and sound very (just as) good. I manually match them to 1%.

There are Op Amp buffers before and after the core to translate the signal levels to and from the higher levels used in a modular synthesizers. You can use high quality Op Amps like the OPA134 (audio) and OP177 (CV), or just plan old TL071/72. I do recommend using high quality audio grade Panasonic capacitors in the signal path for improved sound quality.

The prototype used a simple flip-flop circuit to switch between the 2 and 4 pole modes, and a 4013 CMOS chip driving a M5201 switching Op Amp. This is different to the Jupiter 8 design which uses FET's to switch between the poles. I stole the idea, along with some M5201 chips, from a Korg DSS-1 Sampler. Production PCB's use a simple C&K locking push button switch which is cheaper and gives up some space for the V/OCT trimmer and reduces the number of vias.

Trimmers have been added to enable the Frequency cutoff to be set, as well as the onset of oscillation as the Resonance pot is turned up. This is a

very smooth sounding filter which breaks into full sine wave oscillation at high resonance settings. The difference between 2 and 4 pole modes is not dramatic - with the 2 pole mode providing a more gradual cutoff slope, but nevertheless worthwhile.

The REV07 board is the production board, with no errors or corrections.

4 Front Panel Format

The AM8109 is designed to be used with a standard 3" FracRac panel, although other shapes and sizes can be used, for example Doepfer. I built my module with 6 jack sockets on the left hand side, the PCB mounted in the middle with the on board pots and then the off board pots for the signal levels and resonance on the right.

5 PCB, Pots and Power

The PCB is high quality, double sided with solder mask, 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 three pot brackets (available from Omeg). These brackets are centred at 1.0 inch apart. These brackets can be omitted if you wish; the pots will still hold the PCB in place. The PCB is designed to take 16mm Alpha PCB mounted pots, either round or splined shaft. Other makes of the same pin spacing and size will work.

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 (PAD).

6 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?
RESO	Pin 1	Resonance Pot	RESONANCE Pot Pin 1
	Pin 2	Resonance Pot	RESONANCE Pot Pin 2
	Pin 3	Resonance Pot	RESONANCE Pot Pin 3
CV_INS	Pin 1	CV1 In	Jack socket CV1 IN
	Pin 2	CV2 In	Jack socket CV2 IN
OUTS	Pin 1	Signal Output	Jack socket OUT
	Pin 2	Signal Output	Not Used
PAD	Pin 1	Panel Earth	Jack socket earth bus

The AM8109 has a MTA connector for 3 signal inputs (INS) but there are no individual connectors for each signal level pot (as per many other AM modules). This has been done to save PCB space and achieve a 100x80mm PCB size. The individual pots for each signal levels need to be manually wired up as shown below:

SIGNALA	Pin 1	Signal A Pot	Wire to GND (INS Pin 4)
	Pin 2	Signal A Pot	Wire to INS Pin 1
	Pin 3	Signal A Pot	Wire to SIGNALA Jack Socket
SIGNALB	Pin 1	Signal B Pot	Wire to GND (INS Pin 4)
	Pin 2	Signal B Pot	Wire to INS Pin 2
	Pin 3	Signal B Pot	Wire to SIGNALB Jack Socket
SIGNALC	Pin 1	Signal C Pot	Wire to GND (INS Pin 4)
	Pin 2	Signal C Pot	Wire to INS Pin 3
	Pin 3	Signal C Pot	Wire to SIGNALC Jack Socket

7 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. This is highly recommended given we are using a rare IR3109.

Power up and try out the filter. Then proceed to trimming. Job done!

8 Trimming

This module has three trimmers which need to be adjusted for accurate operation of the filter.

FTRIM This trimmer adjusts the initial cut-off frequency of the filter. Set the FREQ to minimum and connect a VCO output of around 80Hz to a filter input with the AIGNAL pot at maximum. Monitor the filter audio output and adjust FTRIM so that the FREQ pot cuts off the signal at low values, or to taste.

QTRIM This trimmer adjusts the resonance of the filter. Configure the filter as above and adjust the RESONANCE pot to a setting of 8. Adjust the trimmer to provide self oscillation at this setting, or to taste. You may need to adjust the FREQ pot and/or the VCO frequency.

V/OCT This trimmer adjusts the CV input response, so that the filter accurately tracks the keyboard and oscillators. Turn RESO so that the filter begins to oscillate. Patch the keyboard CV into the CV1 socket on the PCB. Press C4 on the keyboard and then C3, adjust the V/OCT trimmer to give an octave range and if possible zero beat with a VCO set at C3. You may need to adjust FTRIM as a result. Repeat as necessary.

9 Special Components

The AM8109 makes use of a small number of specialist components:

IR3109

This chip can be occasionally found on eBay or you can buy a second hand Boss PH-2 Super Phaser and carefully retrieve two IR3109 chips. You will need to cut them out with a fretsaw as they are soldered to the PCB.

BA6110

This single VCA chip can be found on eBay or you can buy one from me at: www.amsynths.co.uk.

Tempco Resistor

The 10k NTC Tempco resistor can be obtained from Farnell, the part number is 1672384.

Push Switch

The module uses a PCB mounted Omron B3F-3155 Momentary Push button switch and a round red button.

6X6MM 6.15MM 260GF SQ TACT SWITCH R/A RC

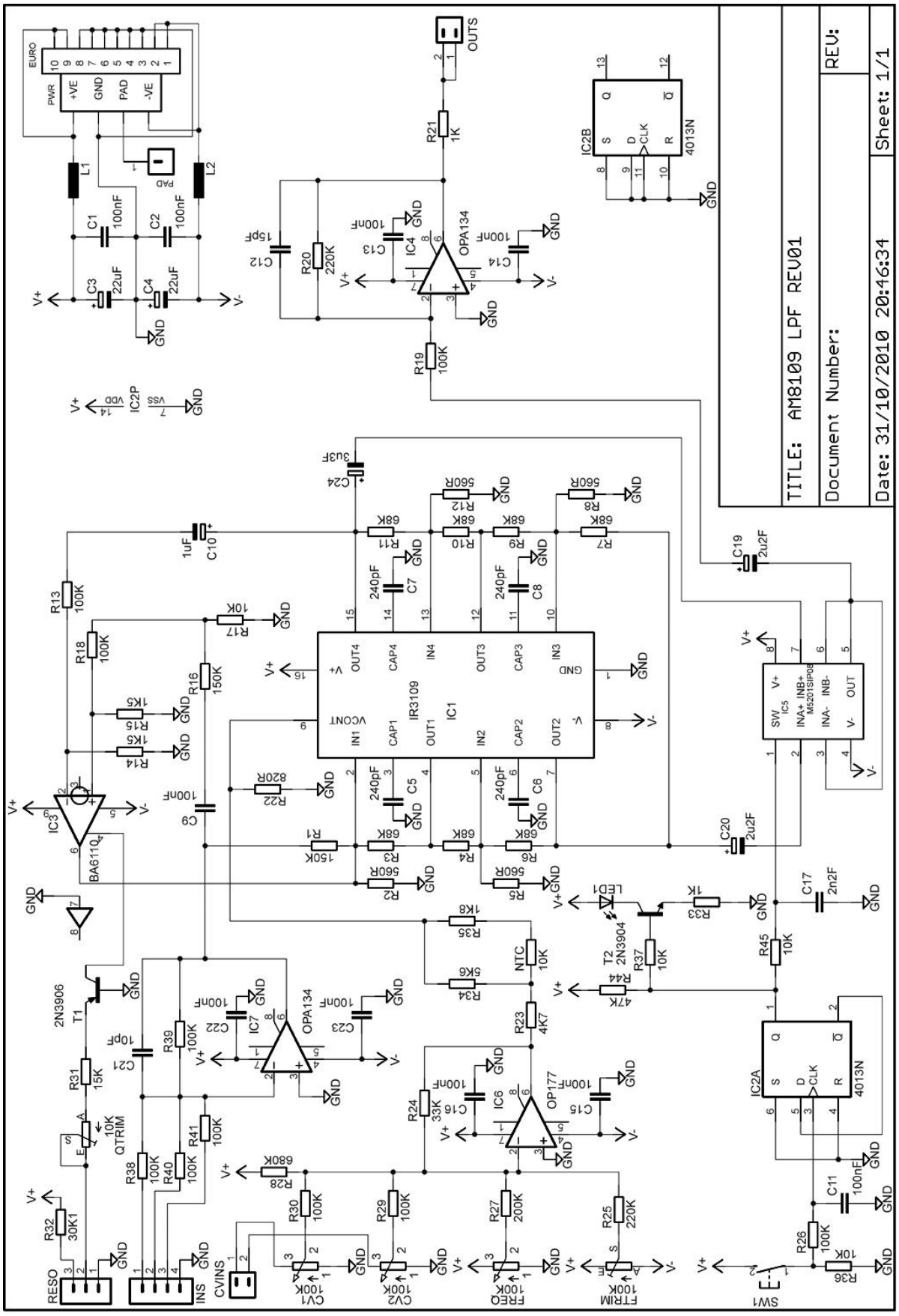
Pot Bracket

ECO pot brackets can be obtained from Omeg in the UK.
http://www.omeg.co.uk/

10 Parts Listing

Part Number	Value	Quantity	Comments
Capacitors			All 5mm spacing
C1, C2, C13, C14, C15, C16, C22, C23	100nF	8	Axial Ceramic
C3, C4	22uF 25V	2	Radial Electrolytic
C5, C6, C7, C8	240pF	4	240pF 1% Polystyrene or 220pF Polypropylene
C9, C11	100nF	1	High quality Polyester
C10	1uF 25V	1	Radial Electrolytic
C12	15pF	1	Low-K Ceramic
C17	2n2F	1	High quality Polyester
C19, C20	2u2F 25V	2	Radial Electrolytic
C21	10pF	1	Low-K Ceramic
C24	3u3F	1	Radial Electrolytic
Resistors			All 1% Metal Film
R1, R16	150K	2	
R2, R5, R8, R12	560R	4	
R3, R4, R6, R7, R9, R10, R11	68K	7	
R13, R18, R19, R26, R29, R30, R38, R39, R40, R41	100K	9	
R14, R15	1K5	2	
R17, R36, R37, R45	10K	1	
R20	220K	1	
R21, R33	1K	1	
R22	820R	1	
R23	4K7	1	
R24	33K	1	
R25	220K	1	
R27	200K	1	
R28	680K	1	
R31	15K	1	
R32	30K1	1	Or 30K
R34	5K6	1	
R35	1K8	1	
R44	47K	1	
NTC	10K	1	NTC Tempco
Potentiometers			
CV1, CV2, FREQ, RESO	100K LIN	4	Alpha 16mm
SIGNALA, SIGNALB, SIGNALC	100K LOG	3	Alpha 16mm
FTRIM	100K	1	25 turn cermet trimmer
QTRIM, V/OCT	10K	2	25 turn cermet trimmer
Semiconductors			
T1	2N3906	1	Transistor

Part Number	Value	Quantity	Comments
T2	2N3904	1	Transistor
IC1	IR3109	1	VCF chip
IC3	BA6110	1	Single VCA
IC2	HEF4013	1	Flip Flop
IC4, IC6, IC7	TL071	3	Single Op Amp
IC5	M5201	1	Switching Op Amp 8 pin SIP
Passives			
L1, L2		2	Inductor (1uH)
Hardware			
SW1		1	Omron B3F Push Switch
LED		1	3mm Red LED
CVINS, OUTS		1	MTA 0.1” 2-pin header
RESO		1	MTA 0.1” 3-pin header
INS		1	MTA 0.1” 4-pin header
POWER		1	MTA 0.156” 4-pin header or 10-pin 0.1” DIL header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IR3109
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IC4
IC6
IC7
OP177
BA6110
IC3
4013N
IC2A
IC2B
M52015SP08
IC5
2N3906
T1
2N3904
T2
LED1
OUTS
CVINS
RESO
INS
SW1
CV1 100K
CV2 100K
FREQ 100K
FTRIM 100K
QTRIM 10K
NTC 10K
PAD
EURO
PWR
+VE
GND
PAD
-VE