synthCube

AM4023
Voltage-Controlled 12dB Low Pass Filter
'ez-build' kit method

module documents v1.0

1/13/2012

Available Formats and Widths

MOTM format- 1 wide	AM4023-M1
MOTM format- 2 wide	AM4023-M2
Dotcom format- 1 wide	AM4023-D1
Dotcom format- 2 wide	AM4023-D2
Frac format- 1 wide	AM4023-F1
Frac format- 2 wide	AM4023-F2
Frac banana format- 1 wide	AM4023-F1B
Frac banana format- 2 wide	AM4023-F2B
Buchla-esque format	AM4023-U

Errata:

1) The pin notations for the 'RESO' header on the PCB are reversed. You must account for this when connecting the 'RESO' header to the 'RES (Q)' pot

Circuit Description

The AM4023 is a clone of the ARP 4023 2-pole 12dB low pass filter in the ARP Odyssey. This filter has a smooth behavior and unlike many 4-pole filters, does not attenuate the low end with increased resonance settings. Also, with a shallower cutoff slope, it could be argued that the Odyssey had a brighter sound overall. The filter is good for bass and bright lead sounds, and with modern components it is not noisy. It will self-oscillate at high Q settings and it can shred speakers – so beware! With so many 4-pole filters around, it's nice to have a 2-pole version for some contrast.

The control inputs are calibrated to 1V/octave, and there are up to two CV inputs which have front panel attenuators. There is also an un-attenuated CV in for direct connection to a keyboard or 1V/Octave input.

The filter frequency has two front panel controls; FREQ for coarse adjustment and FINE for fine adjustment, there is also an on-board trimmer to set the initial cut-off frequency. The filter has a frequency range of 1 Hz to over 20kHz.

The filter has a Q control (RESONANCE) to adjust the resonance of the filter. Higher settings of Q will take the filter into sine wave oscillation. The filter will oscillate from 16Hz to 20 kHz.

Original Circuit

The original ARP design dates back to 1972 and the creation of the Odyssey monophonic analog synthesizer. It's a 12dB voltage controlled low pass filter, and it was used in the original "white faced" ARP Odyssey as well as some of the "black faced" models up until 1975.

It is a 2-pole OTA design based around transistors, the CA3080 (OTA) and the LM301 Op Amp. The exponential converters use matched and thermally coupled PNP/NPN pairs. The filter will self-oscillate at higher Q settings and it is temperature compensated with a 1K87 3500ppm Tempco resistor.

The design is a departure from the previous "Moog like" ARP 4006 and 4012 transistor ladder filters, probably as a response to patent infringements.

synthCube AM4023 Circuit

The circuit is an exact replica, as all parts are still available, although the CA3080 is no longer manufactured; stock still exists at many suppliers.

The CA3080 OTA's are retained, modern 2N3904 and 2N3906 transistors are used instead of the original TZ581 and 2N5172's. The CV summer is a modern and stable OP177GP Op Amp.

The audio path Op Amps are the improved modern and cleaner OPA134's.

The tempco resistor can be omitted, and a standard metal film resistor used, if you are not concerned about the filter oscillation tracking properly.

The REV01 board is the production board, with no errors or corrections, and is suitable for +/- 15V power connections.

General Assembly Preparation

1) Check that the kit contains all of the parts noted in the BOM; notify us of any discrepancy using info@synthcube.com
2) Gather additional materials and tools necessary for your build:
    a. Tools (soldering iron, pliers, wire cutters/stripper, etc.)
    b. Solder of your choice
    c. Silicon grease or thermal compound
    d. Digital camera to document your progress
3) Prepare the pots for assembly:
    a. Break off the metal tab
    b. Slide the metal tab into the slot in the shaft- this adds some strength to the shaft for mounting knobs
    c. Carefully bend the pins to 90 degrees, facing away from the front face of the pot. This makes it easier to install the single-pin header wire connectors during assembly.

'ez build' Kit Method

This kit is configured with features to simplify construction and testing. For example, singlet and doublet resistors have been identified and labeled for you. (It is good practice to doublecheck the values before soldering .) Heat shrink tubing has been provided for jack and switch solder joints; it is good practice to use it, but it's a matter of personal preference.

The 'ez-kit build' method is designed to require minimum soldering. In this method, IDC headers and breakaway pin headers are used on the PCB. Connections to the pots are made using ribbon wires with crimped connections- the plastic headers snap onto the pot pins. Connections to switches and jacks use crimped IDC header sockets on the PCB end, and are soldered to the panel component. In this method, panel component soldering is limited to the panel-side of the jacks and switches.

If you so choose, you can modify the assembly to use more solder connections:

- You can form the pot pins into j-hooks and snip off the crimped ends of the ribbon wires if you prefer soldered pots.
- You can eliminate any or all of the IDC and breakaway pin headers on the PCB, and solder wires directly to the PCB in place of the headers.

This is a matter of personal preference, as some assemblers prefer soldered joints over the pin connectors.

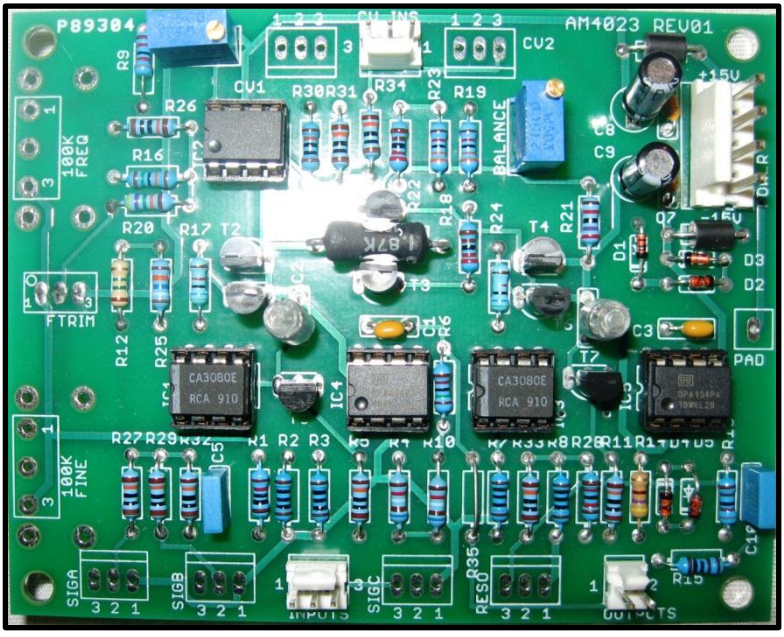
AM4023 Base PCB Parts List				
Description	Qty	Inc	Part Notes	Ref Designator
Aluminum Electrolytic Capacitors - 22UF	2			C8,C9
Ceramic Disc Capacitors 50V 100pF	2			C1,C3
Film Capacitors STYRENE 50V.001uF	2			C2,C4
Film Capacitors 50V0.22uF	2			C5,C10
Multilayer Ceramic Capacitors Axial 0.1uF	2			C6,C7
Metal Film Resistors - 100Kohms 1% 50PPM	10			R5,R11,R26,R27,R29,R30,R31,R32,R33,R34
Metal Film Resistors - 15Kohms 1% 50PPM	1			R6
Metal Film Resistors - 56Kohms 1% 50PPM	2			R17,R24
Metal Film Resistors - 150Kohms 1% 50PPM	1			R16
Metal Film Resistors - 10Kohms 1% 50PPM	1			R1
Metal Film Resistors - 1Kohms 1% 50PPM	1			R15
Metal Film Resistors - 100ohms 1% 50PPM	4			R2,R3,R7,R8
Metal Film Resistors -61.9Kohms 1% 50PPM	2			R4,R10
Metal Film Resistors - 82Kohms 1% 50PPM	1			R9
Metal Film Resistors - 1.5Mohms 1% 50PPM	1			R12
Metal Film Resistors -8.2Kohms 1% 50PPM	1			R13
Metal Film Resistors - 470ohms 1% 50PPM	1			R14
Metal Film Resistors - 2.2Kohms 1% 50PPM	2			R18,R22
Metal Film Resistors - 33Kohms 1% 50PPM	2			R19,R23
Metal Film Resistors - 475Kohms 1% 50PPM	1			R20
Metal Film Resistors - 27Kohms 1% 50PPM	1			R21
Metal Film Resistors - 196Kohms 1% 50PPM	1			R25
Metal Film Resistors - 12Kohms 1% 50PPM	1			R28
OPA177GP	1			IC2
OPA134PA	2			IC4,IC5
CA3080E	2			IC1,IC3
IC Sockets 8 pin	5			IC1-IC5
Transistors 2N3906	2			T1,T6
Transistors 2N3904	4			T2,T3,T4,T5
Transistors 2N3459_D75Z_JFET	2			T7,T8
EMI Filter Beads	2			L1,L2
Diodes 1N4148	5			D1-D5
Trimmer Resistors -100Kohms Vertical Adjust	1			FC_TRIM
Trimmer Resistors - 50Kohms Vertical Adjust	2			BAL.V/OCT
4P Square post header (power)	1			Power
FRICTION LCK HDR 3P Straight Post tin header	2			INPUTS.CV_INS
3P Red Header Socket	2			INPUTS.CV_INS
FRICTION LCK HDR 2P Straight Post tin header	1			OUTPUTS
2P Red Header Socket	1			OUTPUTS
Jumper	1			Scrap solid wire in place of R35
1.87K Tempco Resistor	1			PTC1

PCB Assembly Instructions

The base PCB assembly is the same regardless of the format you have chosen.

1. Solder the resistors to the PCB. Orient the resistors to 'read' in the same direction for easier identification and troubleshooting.
2. Solder the diodes and filter beads to the PCB. Be certain of the diode orientation.
3. Solder the IC sockets to the PCB, Be certain they sit flat against the PCB for the best solder connection.
4. Solder the capacitors to the PCB. Be certain to orient the electrolytic capacitors the right way- they are marked with a 'negative' side which should face away from the "+" on the PCB
5. Solder the transistors to the PCB. Be certain to orient them properly, using the flat part of the printed outline as a guide.
6. Solder the tempco resistor to the PCB between the transistors. Apply a small dab of silicon grease to each transistor and physically push the transistors to touch the tempco to ensure a good temperature exchange.
7. Solder the trimmer resistors to the PCB. Be certain to orient them properly. Note: the 'FC Trim' trimmer is soldered to the back side of the PCB ONLY if you are building the 1U Frac version. All other versions have the FC Trim trimmer soldered to the front of the PCB.

8. Solder the 4-pin power header, 3-pin 'Inputs' and 'CV Ins' headers, and the 2-pin 'Outputs' header to the PCB. Be certain to orient the header latch the proper direction
9. Install a short jumper wire in the space labeled 'R35'. R35 is optional, and if installed, is connected to the output of the first OAT/gain cell, and gives a 1 pole output.
10. If you have used water-washable solder, wash the back of your PCB thoroughly.
11. Install the ICs into the IC sockets. Be certain that all of the IC pins fit properly into the socket.
12. This completes the base PCB assembly. You are ready to move on to format-specific assembly.



Testing, Calibration and Operation

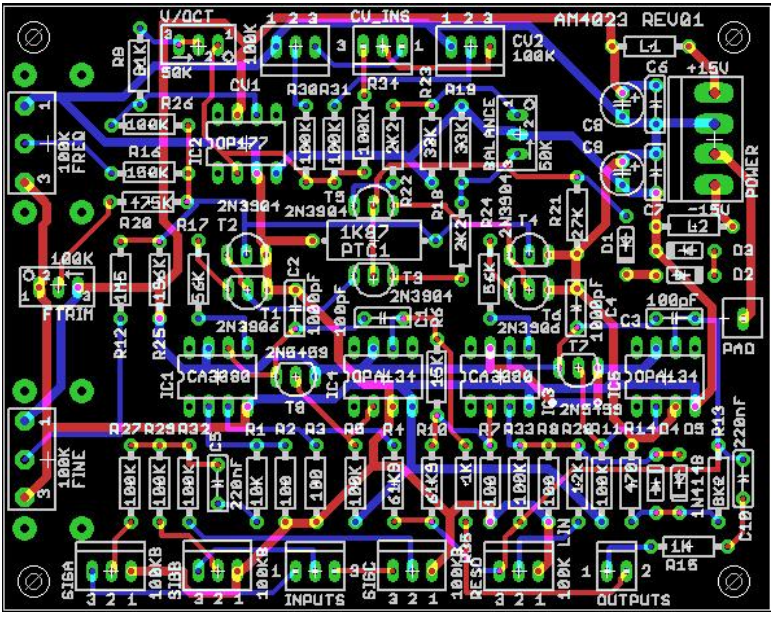
This module has three trimmers which need to be adjusted for accurate operation of the filter.

FC_TRIM This trimmer adjusts the initial cut-off frequency of the filter. Set the FREQ and FINE pots to minimum and turn RESO (Q) up so that the filter begins to oscillate. Monitor the filter output with an oscilloscope or frequency counter and adjust FC_TRIM for a 62.5msec. period or 16Hz.

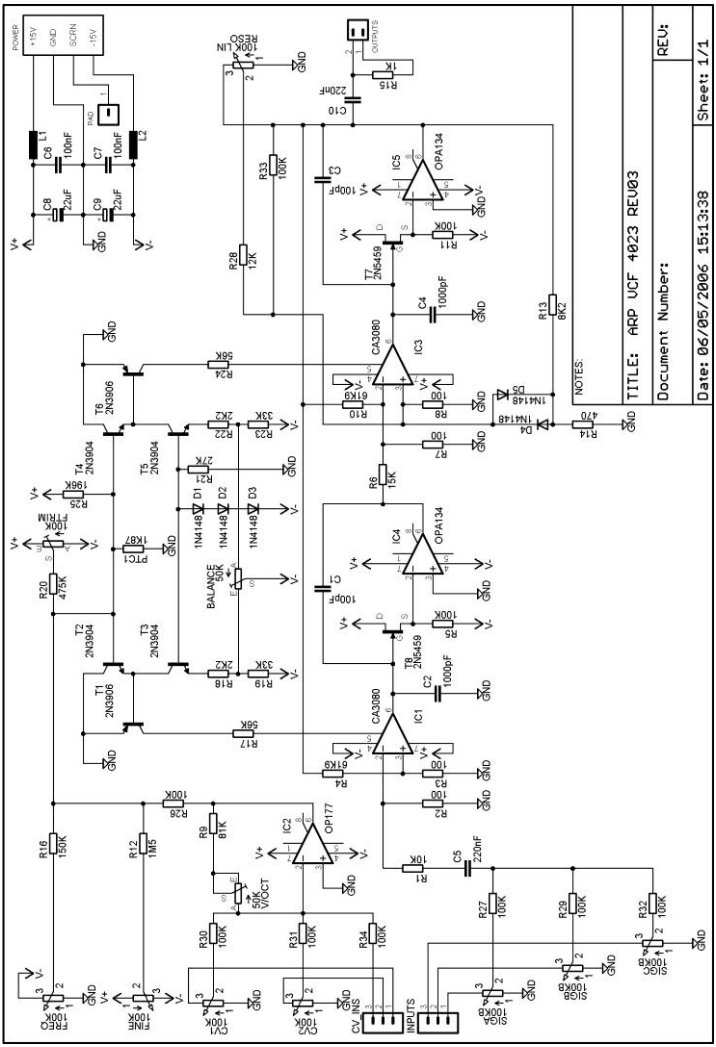
BALANCE This trimmer adjusts the two poles of the filters so that they have the same output levels. Set the FREQ and FINE pots to minimum and turn RESO (Q) up so that the filter begins to oscillate. Monitor the filter output and Pin 6 of IC4 with an oscilloscope. Adjust the FREQ and FINE pots to give a 1 kHz sine wave on the audio output of the filter. Adjust BALANCE to give the same level on both monitored outputs

V/OCT This trimmer adjusts the CV input response, so that the filter accurately tracks the keyboard and oscillators. Turn RESO (Q) so that the filter begins to oscillate. Patch the keyboard CV into the FM1 socket on the PCB. Press C4 on the keyboard and adjust the FREQ control so that turning V/OCT trimmer has minimal effect. Tune a reference oscillator so that it zero-beats with the note appearing at the Band Pass output. Be sure the reference oscillator is not controlled by the keyboard. Now, press C5 on the keyboard and trim V/OCT so the note from the filter zero-beats with the reference oscillator. Repeat as necessary.

PCB Layout


AM4023 REV01
V/OCT
CV_INS
CV1
CV2
IC1
IC2
IC3
IC4
FTRIM
FREQ
FINE
PAN
POWER
+15V
INPUTS
OUTPUTS
SIGA
SIGB
SIGC
RESO
LIN
BALANCE
PTC1
1K87

Schematic


TITLE: ARP UCF 4023 REV03
Document Number:
REV:
Date: 06/05/2006 15:13:38
Sheet: 1/1
NOTES:
IC1 CA3080
IC2 OP177
IC3 CA3080
IC4 OPA134
IC5 OPA134
T1 2N3906
T2 2N3904
T3 2N3904
T4 2N3904
T5 2N3904
T6 2N3906
T7 2N5459
T8 2N5459
D1 1N4148
D2 1N4148
D3 1N4148
D4 1N4148
D5 1N4148
50K V/OCT
BALANCE 50K
PTC1
PTRIM 100K
RESO 10K LIN
FREQ 100K
FINE 100K
CV1 100K
CV2 100K
CV INS
INPUTS
SIGA 100KB
SIGB 100KB
SIGC 100KB
OUTPUTS
POWER
+15V
GND
SCRN
-15V
PAD