A-100 DIY page

Separate document: Timing capacitors of A-100 modules

Some very useful A-100 modifications are described on the website of Dr. Timothy E. Stinchcombe (thank you Tim for the permission to publish this link): www.timstinchcombe.co.uk

This document is intended for A-100 users who want to learn a little bit about the technical details of the A-100. We will start with some electronic basics and introduce at first the most important electronic parts used in the A-100 circuits. Then we will show how some basic circuits (like attenuators, amplifiers, mixers, inverters and so on) can be realized with these parts. The following paragraph will show some simple modifications of A-100 modules: e.g. changing the sensitivity of CV or audio inputs, increasing or decreasing output levels (e.g. VCAs or mixers with maximum amplification > 1), adding offset feature to mixers, changing between DC and AC coupled inputs/outputs, adding feedback inserts for VC resonance to all filters and many more.
This page starts September 2004. New items will be added little by little. If you have any suggestion for this page please send your ideas to hardware@doepfer.de. We will try to fulfil all wishes, providing they are possible and will not contain confidential information.

Additional information about technical details (e.g. CV/gate control principles, A-100 bus, A-100 power supply) and mechanical details (frontpanel measures, A-100 frame concept) is available in these documents:

- A-100 Technical details
- A-100 Mechanical details

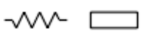
The A-100 service manual is available only for A-100 customers (see price list for current price). The words - mainly building, testing and adjustment notes for the manufacturer - are in German but the schematics, silk screen and bill of material are international.

Other pages of interest for DIY:

- Vactrol basics
- A-101-1 Technical Details

1. Electronic Parts

(For some parts different signs are shown. Normally the left one is used in USA or Japan, the right one in Germany or Europe)



Fixed resistors

A resistor is determinded by these parameters:

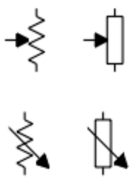
- value (... Ohm, ... kOhm, ... MOhm, usual abbreviations kOhm = k and MOhm =M, e.g. 2.2 kOhm = 2.2k or 2k2)
- power (.. mW, ...W)
- tolerance (%)
- max. voltage
- dimensions (e.g. length, diameter and especially the grid between the legs on the pc board)

In the A-100 normally only resistors with 1/4W (250mW) and 5%, 1% or 0.1% tolerance are used. For the value and tolerance of a resistor normally a color code is used (should we add the color code at this place ?).

Potentiometers

Potentiometers are available as rotary potentiometers or fader types. Normally, a potentiometer has 3 terminals: two end terminals and a slider terminal (upper picture). The slider touches a resistance surface that is located between the end terminals. Sometimes the second end terminal is not shown (lower picture) if only one end terminal is required, e.g. if the part works only as a variable resistor rather than a voltage divider.

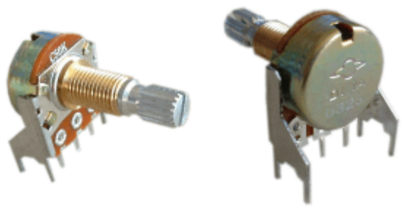
A potentiometer is determined by these parameters:



- value (... Ohm, ... kOhm, ... MOhm)
- power (.. mW, ...W)
- tolerance (%)
- characteristics (law)
- mechanical dimensions (e.g. diameter, type, length and material of the axis, distance and diameter of the holes required on the pc board, position of auxiliary terminals without electronic function and so on)

The characteristics - sometimes even called law - is a very important parameter of a potentiometer. This parameter describes the connection between the rotary angle (resp. fader position for fader potentiometers) and the resistance value between terminal 1 and slider terminal. Typical characteristics are linear, logarithmic and inverse logarithmic. Sometimes special characteristics are used (e.g. S-type law) but these are not very common. For audio attenuation normally logarithmic potentiometers are used as the human ear senses the loudness of an audio signal in a logarithmic way too. The same applies to potentiometers that are used to control time parameters (e.g. attack/decay/release time of an envelope generator). For attenuation of control signals normally linear potentiometers are used. For special functions inverse logarithmic potentiometers are used (e.g. resonance/emphasis control in filter circuits).
Another special type is a stereo potentiometer: two potentiometers with one common axis. The values for the two potentiometers vary in the same way. Used e.g. for manually controlled filters or stereo applications.
Other special types of potentiometers are not described here (e.g. dual potentiometers with 2 concentric axis, or potentiometers with additional terminals) as they are not used in the A-100.

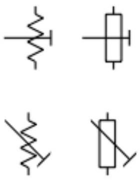
A very special circuit is a so-called **vactrol**. This is a combination of a light depending resistor (LDR) and LED both put into a small 100% light-proof case. For details please refer to the vactrol document.



front view rear view
Potentiometers used in the A-100

The above pictures shows the type of potentiometers used in the A-100 system. These potentiometers are equipped with a mounting bracket that increases the mechanical stability. For most of the A-100 modules the potentiometers (together with the sockets) are used to mount the pc boards to the front panels.
The A-100 potentiometers are available as spare parts with these values: 10K (A and B), 50K (A, B and C), 500k (B), 1M (A and B) with A = logarithmic (audio type), B = linear and C = inverse logarithmic (ususally for filter resonance controls used). For prices please look at the price list.

Trimming potentiometers



The electronic function of a "normal" potentiometer and a trimming potentiometer is the same. The only difference is the mechanical appearance: trimming potentiometers are normally much smaller and have a very short axis that is adjusted with a screw driver. Trimming potentiometers are used to adjust parameters that have to bet set once at the factory and that are normally not controlled by the user (e.g. offset frequency and scale of a VCO, maximum/minimum limitation of values, adjustment of click/pop feedthrough of sound processing devices like VCA, VCF, ring modulator, frequency shifters and so on). Sometimes users replace trimming potentiometers with normal ones to have access to such additional parameters.
Trimming potentiometers are available normally only linear. Apart from that they are defined by the same parameters as normal potentiometers.

Capacitors

A capacitor is determinded by these parameters:

- value (... pF/picofarad, ... nF/nanofarad, ... uF/microfarad, usual abbreviations pF =p, nF =n, uF =u, 2.2 nF = 2.2n or 2n2)
- type of dielectric (foil, ceramic, multilayer, electrolytic)
- tolerance (%)
- max. voltage
- polarized/non polarized (electrolytic capacitors are normally polarized)
- dimensions (e.g. length/width/height or length/diameter and especially the grid between the legs on the pc board)

In the A-100 all types of capacitors are used. Value, voltage and tolerance are normally written as normal characters on the component (e.g. 4n7 63V). But even color codes and number codes are used (e.g. 103 means 10x1000=10000). Sometimes it is difficult to find the value of a capacitor. E.g. "100" without additional pF/nF could mean 100pF or 100nF. Some experience is required to find out the correct value if the declaration on the component is not readable, or complete. To be certain of a capacitors value, one could use a capacitor measuring instrument such as a multimeter with capacitor measuring option.

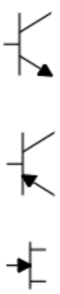
So-called electrolytic capacitors are used for values of 1uF and more as the other types of capacitors would be too large. Normally electrolytic capacitors are polarized (i.e. one has to pay attention to positive and negative terminal of the part). If there are "+" or "-" signs in a schematic this means that an electrolytic capacitor is used. The three examples on the left with "+" and "-" signs denote an electrolytic capacitor.

Other types of capacitors (e.g. variable capacitors) are not used in the A-100.

Diodes

Electronic part that works as one-way for electric current. The triangle terminal (left) of the symbol is the positive side (or anode), the single vertical line (right) is the negative terminal (or cathode). Used e.g. for clipping, rectifying or overvoltage protection. Even light emitting versions (LED) available in different colors (red, green, yellow, orange, blue, white). In this case the brightness is approximately proportional to the current.

A very special circuit is a so-called **vactrol**. This is a combination of a light depending resistor (LDR) and LED both put into a small 100% light-proof case. For details please refer to the vactrol document.

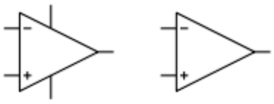


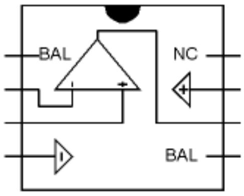
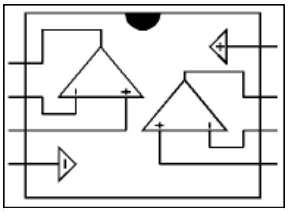
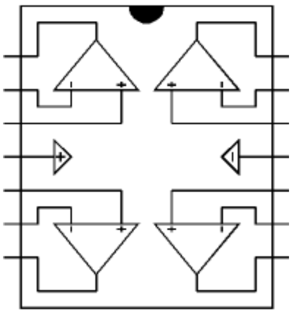
Transistors

Different types of transistors are available, e.g. bipolar npn or pnp, field effect (FET). A transistor can be used with the suitable circuit (i.e. with additional resistors and capacitors) e.g. as amplifier, switch or current source.

Operational Amplifiers

Operational amplifiers are special integrated circuits that make available a standard amplifier with 2 inputs (inverting and non-inverting input) and high amplification (typ. > 1000). Circuits with one, two or more opamps (abbreviation for operational amplifier) are available. The following table shows the pin-out of the most popular types of single, dual and quad opamps.



	Single type e.g. uA741, TL061, TL071, TL081, TLC271, NE5534, LF411, LF351, LF356
	Dual type e.g. uA747, LM1458, LM4558, TL062, TL072, TL082, TLC272, NE5532, LF412, LF353
	Quad type e.g. LM124, LM224, LM324, TL064, TL074, TL084, TLC274, LF444

The power supply pins (marked with the "+" and "-" triangles) of the integrated circuit in question have to be connected to +12V and -12V for A-100 applications. In schematics the power supply pins of opamps are often omitted. The left opamp symbol includes the power supply pins. The right symbol is without the power supply pins.
Unused OpAmps (if e.g. only 3 devices of a quad opamp are used) have to be terminated in this way: non-inverting input has to be connected to GND, inverting input and output have to be connected (directly or even via resistor in the 1k...100k range).

Switches

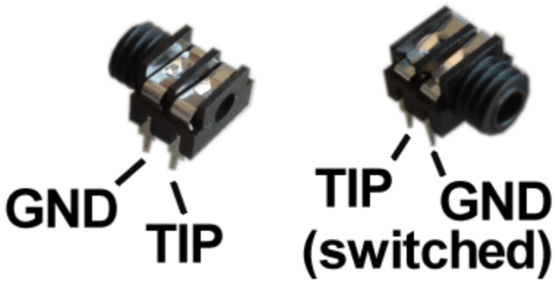
A lot of different switches are available. There exist different distinguishing marks, e.g.:

- type of operation: momentary or permanent
- number of terminals
- number of parallel switches
- number of positions

The pictures show from top to bottom the symbols for a simple on/off switch (SPDT with one ON contact only) , a change-over switch (SPDT with two ON contacts), a rotary switch with 3 positions, a change-over switch with middle position (SPDT with ON-OFF-ON) and a rotary switch witch 5 positions.

Jack sockets

Standard sockets used in the A-100 for all inputs and outputs. Provided that a plug is inserted into the socket the GND and tip terminals of the plug are connected to the corresponding terminals of the socket. The tip is normally the "hot" pin, i.e. the terminal leading the CV resp. audio signal. The sockets are equipped with switching contacts (the arrow in the symbol). Both the GND and tip terminal are switched but only the switching feature of the tip terminal is used in some A-100 modules. Provided that no plug is inserted into the socket the switched tip contact (arrow terminal in the left symbol) is connected to the "normal" tip contact (the terminal represented by the horizontal line in the left symbol). As soon as a plug is inserted this connection is interrupted and the signal at the tip of the plug is connected to the tip terminal of the socket. This feature can be used for default connections (i.e. connection within a module that is established provided that no plug is inserted into the corresponding socket). Example: internal default connections of the A-109 signal processor. This function is often called "normalling" or "normalizing".



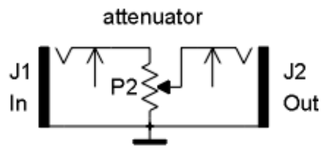
rear view front view
jack sockets used in the A-100

The above pictures show the type of jack sockets used in the A-100 system. For most of the A-100 modules the sockets (together with the potentiometers) are used to mount the pc boards to the front panels. The A-100 sockets are available as spare parts. For prices please look at the price list.

Power Supply

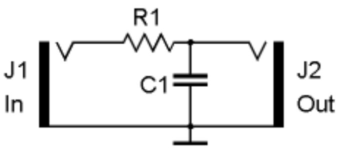
For each circuit, a power supply is required. The three symbols to the left side denote +12V, -12V and GND. Some circuits may require no power supply (e.g. multiples or the simple attenuator below) or only a positive supply. All circuits that use operational amplifiers require all three +12V, GND and -12V. Some modules even require +5V (mainly "digital" modules with digital circuits - like microprocessors, memories, or logic circuits - which often require a +5V power supply).

2. Basic circuits



Simple attenuator

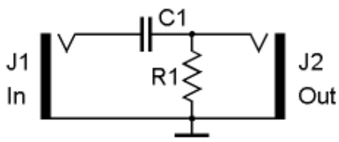
This is a simple passive attenuator (i.e. no power supply required). J1 is the input socket, J2 the output socket. A typical value for P2 is 10k...100k. A linear or logarithmic type can be used for P2 (logarithmic especially for audio applications as the loudness characteristics of the human ear is approx. logarithmic).



Simple lowpass

This is a simple passive lowpass with 6dB/octave slope. A non-inverting amplifier can be added at the output (and even at the input) to make the circuit independent of input/output impedance (i.e. the "loads" connected to J1 resp. J2). Replacing of R1 by a vactrol leads to simple voltage controlled lowpass filter. Replacing R1 by a potentiometer leads to a simple manually controlled lowpass filter

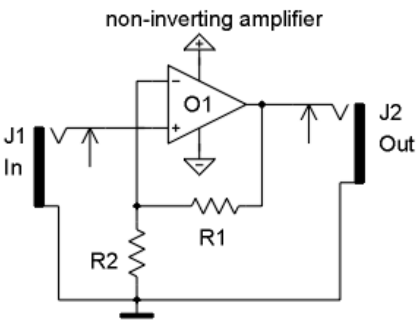
Frequency of the lowpass: f = 1/(2 * Pi * R1 * C1) with Pi = 3.14
Example: R1 = 47kOhm, C1 = 10nF -> f ~ 340 Hz



Simple highpass

This is a simple passive highpass with 6dB/octave slope. A non-inverting amplifier can be added at the output (and even at the input) to make the circuit independent of input/output impedance (i.e. the "loads" connected to J1 resp. J2). Replacing of R1 by a vactrol leads to simple voltage controlled highpass filter. Replacing R1 by a potentiometer leads to a simple manually controlled highpass filter

Frequency of the highpass: f = 1/(2 * Pi * R1 * C1) with Pi = 3.14
Example: R1 = 10k, C1 = 2,2n -> f ~ 7.2 kHz



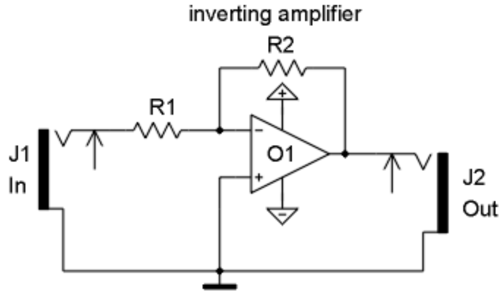
Non-inverting amplifier

This is a simple non-inverting amplifier: The term "non inverting" means that the polarity of input and output signal are the same. In other words: a positive input signal applied to J1 will cause a positive output signal at J2 and a negative input signal applied to J1 will cause a negative output signal at J2.

The amplification of this circuit is 1 + R1/R2.
Example 1: R1 = 0 Ohm (connection), R2 omitted -> A = 1
Example 2: R1 = 47k, R2 = 47k -> A = 2
Example 3: R1 = 100k, R2 = 10k -> A = 11

If R1 or R2 is replaced by a potentiometer the amplification can be adjusted. If e.g. R1 in the last example is replaced by a 100k potentiometer the amplification is adjustable in the range 1...11. This circuit can be used to built an simple amplifier if the desired audio or CV signal is too small for a certain application.

Attention ! The minimum amplification of this circuit is 1 (no real attenuation possible provided that no external attenuator is used).



Inverting amplifier

This is a simple inverting amplifier: The term "inverting" means that the polarity of input and output signal are opposite. In other words: a positive input signal applied to J1 will cause a negative output signal at J2 and a negative input signal applied to J1 will cause a positive output signal at J2.

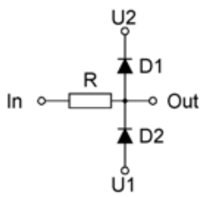
The amplification of this circuit is - R2/R1 (" - " indicates the opposite polarity of input and output)
Example 1: R1 = R2 = 47k -> A = - 1
Example 2: R1 = 10k, R2 = 100k -> A = - 10

If R2 is replaced by a potentiometer the amplification can be adjusted. If e.g. R2 in the last example is replaced by a 100k potentiometer the amplification is adjustable in the range 0...-10. This circuit can be used to built an simple (inverting !) amplifier if the desired audio or CV signal is too small for a certain application.

The minimum amplification of this circuit is zero (if R2 = 0). To obtain a non-inverted output another inverting amplifier with amplification - 1 has to be used.

The inverting amplifier can be extended by adding more input sockets (J1) and corresponding input resistors (R1). The right terminals of all input resistors are connected to the inverting input (-) of the operational amplifier O1. The relation between the corresponding input resistor R1 and R2 (the same for all inputs) defines the sensitivity of the input in question. If all resistors have the same value (e.g. 100 kOhm) the amplification is "1" for all inputs. Lowering R1 (e.g. 47k or 22k) increases the sensitivity of the input in question. Increasing R2 (e.g. 220k or 1M) increases the amplification resp. sensitivity for all inputs simultaneously.
The minus terminal of the operational amplifier is often called "virtual GND" in this circuit as the voltage measured at this point is very close to GND within a few millivolts - independent of the incoming voltages!

The first circuit example (chapter 3: "CV mixer with offset function") shows a typical application of inverting amplifiers with several inputs.



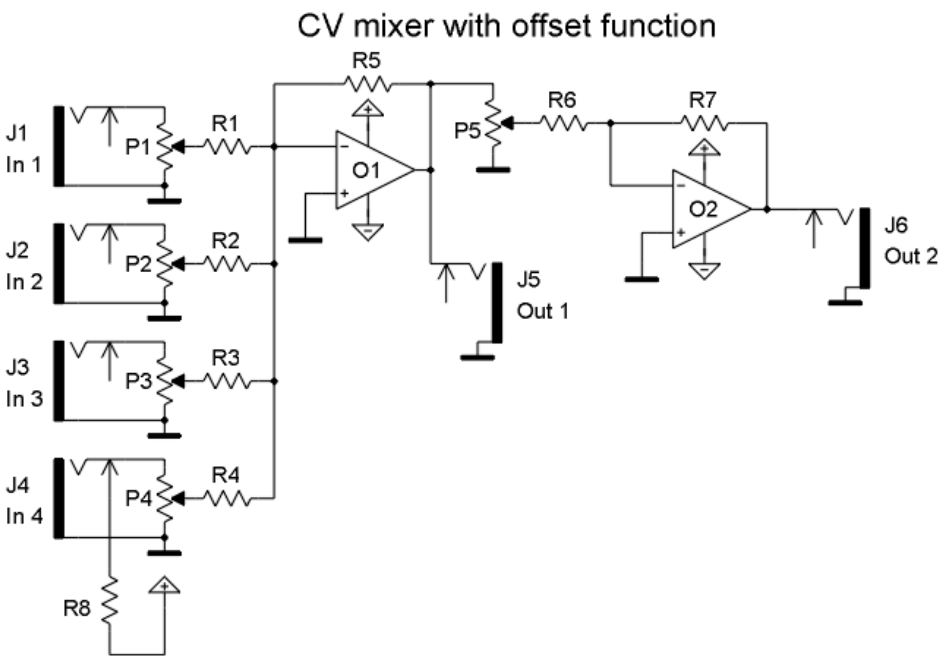
Voltage clamping / limiting / clipping

This is a circuit that limits an incoming voltage to the range U1-UD2 ... U2+UD1. The voltage U1 has to be less than U2. UD1 and UD2 are the forward voltages of the diodes D1 and D2. To keep these voltages as small as possible Schottky diodes (e.g. BAT42) ore germanium diodes are recommended because their forward voltages are in the 0.2...0.3V range. R works as a serial protection resistor. A typical value for R is 1k.

A typical application is the limitation of an analog voltage to 0...+5V (e.g. for the inputs of Pocket Electronic or USB64). In this case U1 is connected to GND and U2 to +5V.

Another application is sound distortion by voltage clipping. If U1 and U2 are variable voltages (e.g. outputs of operational amplifiers of one of the circuits in this document) the clipping levels can be voltage controlled too.

3. Circuit examples



Mixer with optional offset function and inverted/non-inverted outputs

Inputs J1 ... J3 are standard inputs.
Input J4 has offset function provided that no plug is inserted into J4 as the switching contact of J4 is connected to the positive supply voltage in this case (via the protection resistor R8).

At J5 the inverting sum of all inputs is available. J6 outputs the non-inverting sum. P5 allows an additional attenuation of the complete signal (affects only J6).

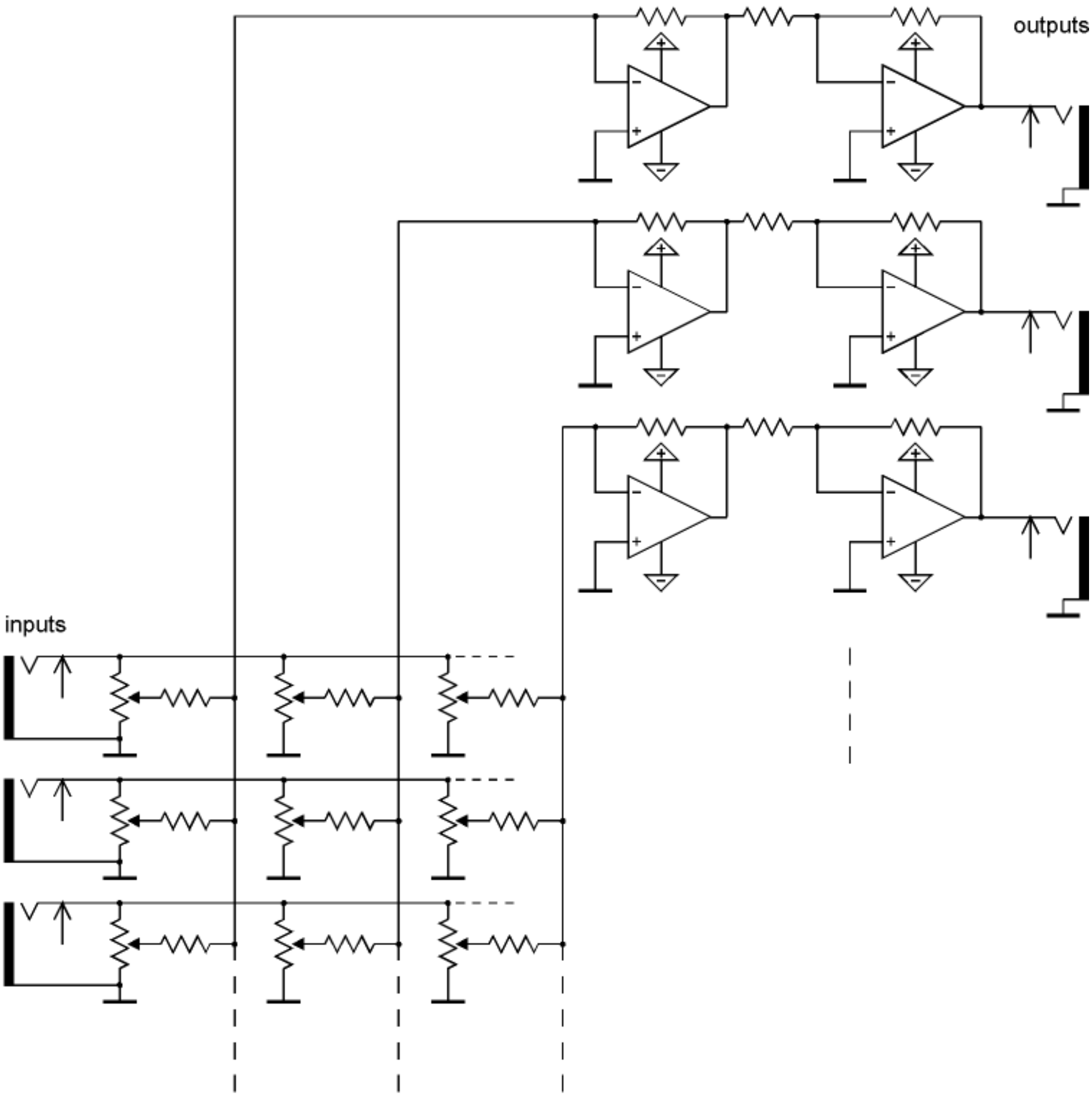
Typical values for the parts used:
O1, O2 = LM1458, TL082, NE5532
P1...P4 = 47k linear (CV) or log (audio)
R1...R7 = 100k (for overall amplification 1)
To obtain a higher overall amplification R5 has to be increased (e.g. to 220k for overall amplification ~ 2 or to 1M for overall amplification ~ 10).

The value of R8 defines the offset range (about 0...+6V for R8=33k, a lower value of R8 will increase the offset range and vice versa).

Matrix Mixer

Matrix Mixer

The CV mixer described above can be expanded to a so-called matrix



mixer. This circuit has several inputs available (three in the example circuit) that can be mixed to different outputs (three in the example circuit) with adjustable levels. At each point of the matrix a potentiometer is available that defines the level for the matrix junction in question.

The circuit can be used for CV or audio applications. The number of inputs and outputs can be increased to the desired value of columns and rows. For each of the outputs the two OpAmp circuit with the corresponding output socket is required. For each input another socket and the corresponding quantity of potentiometers and resistors is required.

Typical values for the parts used:
All operational amplifiers: LM1458, TL082, NE5532
All potentiometers: 47k linear (CV) or log (audio)
All resistors: 100k

To obtain a higher or smaller overall amplification the feedback resistor of the first (left) OpAmp of each output circuits has to be adjusted (as described above).

It is recommended to use a separate pcb for the output circuits. The input sockets and matrix potentiometers/ resistors can be wired by hand very easily.

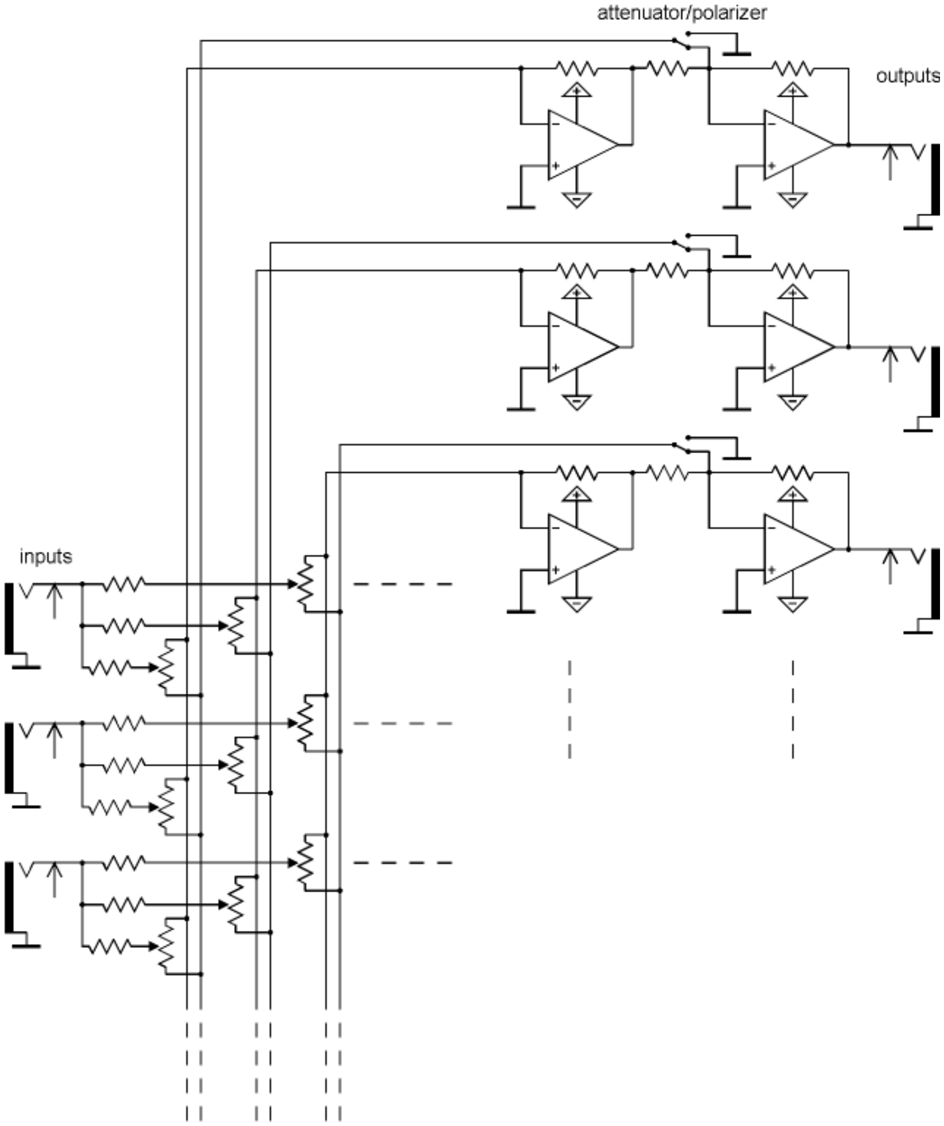
Matrix Mixer II

Matrix Mixer II

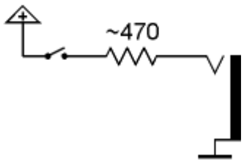
The matrix mixer circuit described above can be modified to obtain polarizer function for the controls. This means that zero level appears at the center position, positive levels appear clockwise from center (addition), negative levels counterclockwise from center (subtraction).

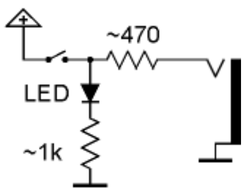
An (optional) switch is used for each column to select between normal mixer mode (same function as the matrix mixer above) or polarizer mode for this column. If a multiple switch is used the complete unit can be switched between normal or polarizer mode.

The typical values for the parts used are the same as for the matrix mixer above. But the potentiometers have to be linear types ! Otherwise the zero position is not the center position.



Manual Gate





Manual Gate

The left picture shows the basic circuit of a manual gate. The 470 Ohm resistor serves as a short circuit protector. Without this resistor the +12V supply would be shorted to GND if a patch cable is inserted to the socket while the button is pressed.

The right picture is expanded by a LED display that lights up while the button is pressed.

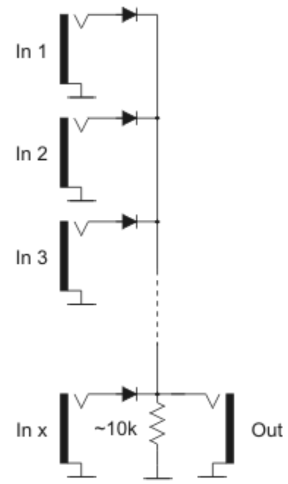
Or-wired sockets

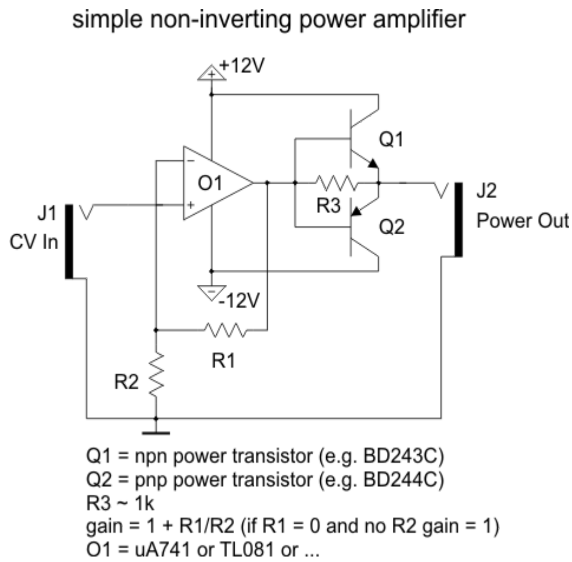
Or-wired sockets

The left picture shows the circuit of "or-wired" sockets. This circuit is useful to combine gate or trigger signals. The incoming signals are or-wired, i.e. if any of the inputs is "high" the output turns "high" too ("high" means a positive voltage in the range of typical +5...+12V). If none of the inputs is high the 10k pull-down resistor pulls the output to GND, i.e. "low". For most applications this resistor is not required as the input load of the following module acts as pull-down resistor. But it should be added to be on the safe side.

As a modification of this circuit even "and-wired" sockets can be realized. But this type of combination is not used very often: all inputs have to be "high" to turn the output to "high". For all other conditions the output remains "low". On this the diodes have to be flipped (i.e. the cathodes at connected to the input sockets) and the resistor has to be connected between the output and +12V (so-called pull-up resistor). In addition the switching contacts of the input sockets have to be connected to GND (normalled to GND). This measure is necessary in order that unused sockets read "low". Otherwise unused sockets would read "high" because of the pull-up resistor.

For example a multiple A-180 can be modified with 7 additional diodes and one resistor to obtain seven or-wired sockets and one output socket. For this the pcb tracks between the eight multiple sockets have to be interrupted (not the GND connections, only the "hot" connections) and re-wired with the diodes and the resistor.





Non-inverting power amplifier

This is a simple non-inverting power amplifier that can be used to drive loads like light bulbs, LED bars, fairy lights, motors, magnets, relays or other loads. Pay attention that the connected load is suitable for 12V supply voltage. Otherwise the supply voltages of the operational amplifier and the power transistors have to be adapted. If only positive output voltages are required Q2 can be omitted. If an operational amplifier is available in the preceding module (e.g. a mixer A-138) this operational amplifier can be used and only Q1, Q2 and R3 have to be added. The maximum output current depends upon the specifications of the power transistors. Pay attention that the power supply has to be able to deliver the additional load current ! For higher currents (~ beyond 100mA) the transistors have to be mounted on suitable heat sinks.

Attention: The output is not short circuit protected. If a standard A-100 jack socket is used the output connection has to be established before power is turned on ! During the insertion of a plug into the jack socket a short circuit is made for a short time. Therefore another type of socket is recommended for the output (not the jack socket shown in the picture).

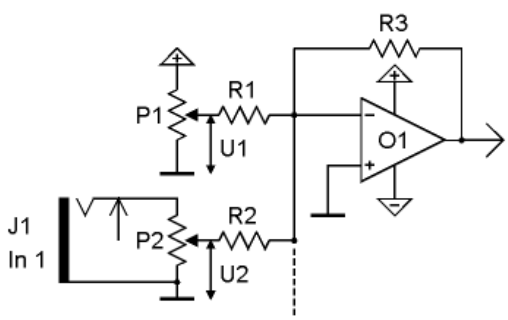
If only positive voltages referenced to GND are required (e.g. to drive lamps, LEDs, motors and so on) the circuit becomes very simple: In this case only Q1 is required and R3 can be omitted (i.e. the base of Q1 is connected to the output of the OpAmp, the collector of Q1 goes to +12V and the emitter is the new "power output" - this circuit is called "emitter follower"). This circuit can be used with all module outputs. In our A-100 demo system an A-183-2 Offset Generator/Attenuator/Polarizer, that has been modified in this way (i.e. only Q1 = BD243C), is used to drive a LED strip that is glued by means of a double sided self-adhesive tape to the upper front rail of the case. The brightness of the LEDs can be controlled manually and/or by a control voltage (e.g. an ADSR which is is sync with a running sequence). A picture of the A-183-2 with LED strip will follow soon.

4. Module modifications

4.1. General modifications (not for one module only)

4.1.1. Changing the sensitivity of manual controls, control voltage inputs and audio inputs

The following picture shows the control voltage input circuit for most of the A-100 modules:



P1 is the manual control of the corresponding parameter (e.g. tune for a VCO, frequency for a VCF, manual gain for a VCA, manual phase shift for a phaser and so on). P1 generates the voltage U1.
J1 is the (first) input socket for the external control voltage. P2 is the corresponding attenuator. The slider of P2 outputs the voltage U2. Additional CV inputs with our without attenuators may be available (e.g. two or more CV inputs for frequency control for a VCF). The dashed line in the picture is the common point in the circuit where all CV's are added.
The output voltage of the circuit (output of O1) is used to control the corresponding parameter (tune, filter frequency, gain ...) of the module in question. The output voltage is defined by:

R3/R1 * U1 + R3/R2 * U2

The relations R3/R1 resp. R3/R2 determine the sensitivity of the corresponding control (P1) resp. input (J1/P2). If for example all resistors are 47k (a common value in the A-100) the sensitivity is 1 for each input. Provided that R3 remains unchanged the resistors R1 and R2 determine the sensitivity of the corresponding control resp. input. Reducing the resistance of R1 resp. R2 increases the sensitivity of the manual control (P1) resp. input (J1/P2). Increasing the resistance of R1 resp. R2 reduces the sensitivity. To modify the sensitivity of a control knob (P1) or CV input (J1/P2) the corresponding resistor R1 resp. R2 simply has to be changed.
Changing the resistance of R3 has the opposite effect and affects the sensivity of both the manual control and CV input.

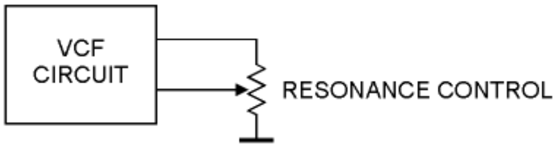
The audio input circuit for most A-100 modules is similar but the manual control P1 is absent (a DC offset would not make sense for an audio input, audio signals are AC signals). Normally only one audio input is available but there are exceptions (e.g. VCA A-130 and A-131, signal processor A-109). To change the sensitivity of an audio input simply the resistor R2 connected to the slider P2 of the audio input has to be replace. A smaller value will increase the sensitivity and consequently lead to clipping/distortion for higher input levels. Especially for the first A-100 VCFs and VCAs (A-120, A-121, A-122 and first versions of A-130, A-131) the audio inputs have been designed to avoid distortion with standard A-100 signals (e.g. VCO). Lowering the input resistors will allow distortion for these moduls too.

Even the input resistors of CV or audio mixers (e.g. A-138a/b) can be changed to allow "real" amplification (i.e. > 1). The factory values of the resistors in the mixer modules A-138a/b allow a maximum amplification of about 1 (which is not really amplification). Reducing the input resistors (R2 type) or increasing the feedback resistor (R3 type) will increase the amplification of the circuit.

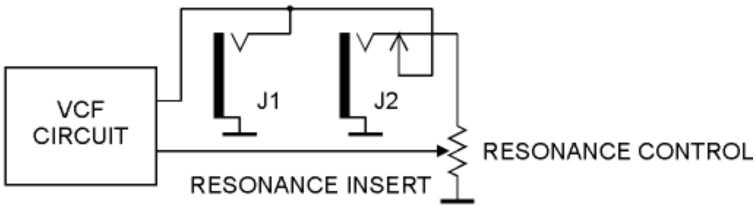
The factory values of the corresponding resistors (R1, R2, R3) for all modules can be found in the A-100 service manual. Normally they are in the 100k range (~ 47k...220k).

4.1.2. Insert sockets for external resonance control of filters, phasers and similar modules

To enable voltage control of resonance for filters insert sockets in the feedback loop can be used.

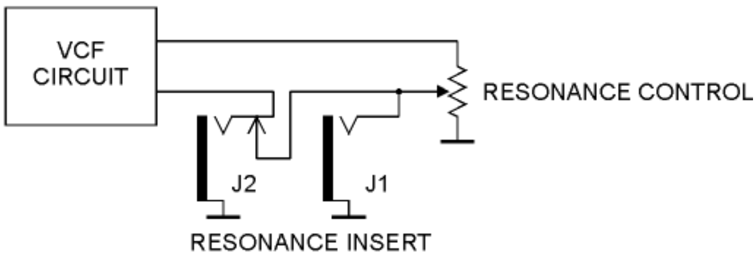


The left picture shows the resonance control in a filter or phaser circuit. Essentially it is an attenuator that controls the feedback of the circuit. To enable external control of the resonance external access to the feedback loop is recessary.
For resonance control normally C-law potentiometers are used (i.e. inverse logarithmic, e.g. 47kC).



This is the first solution how to install the insert sockets (pre resonance control). J1 is connected to the slider of the resonance control. Provided that no plug is inserted into J2 the function of the module is unchanged as the switching contact of J2 is active.

As soon as a plug is inserted into J2 the default connection is interrupted and the signal fed to J2 is used as feedback signal. Consequently J1 and J2 can be used to insert e.g. an external VCA to control the resonance. J1 has to be connected to the audio input of the VCA, J2 to the audio output of the VCA. The resonance control can be used to adjust the maximum resonance available with different gain settings of the external VCA. But not only a VCA but any audio processing module can be inserted into the feedback loop (e.g. phaser, spring reverb, waveshaper, limiter, wave multiplier, divider, ring modulator, frequency shifter, or even another filter).



This is another solution how to install the insert sockets (post resonance control).

The location of the resonance control at the pc board for all modules in question can be found in the A-100 service manual.

4.1.3. Changing between AC and DC coupling

There are two types of coupling between electronic circuits:

- AC coupling (alternate current)
- DC (direct current)

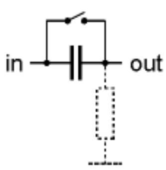
AC coupling means that only the AC parts of the signal will pass. For this normally a capacitor is used that connects the two circuits. The minimum value of the capacitor depends upon the lowest frequency (f) that has to be transmitted and the input/output impedance (R) of the two circuits. The approximate formula for the minimum capacity is C ~ 1/(R*f) with f = lowest frequency, R = in/output resistance

Example: minimum frequency = 50Hz, in/output resistance = 10kOhm -> C ~ 2 uF (u = micro = 1/1000000). A usual value would be 2.2uF in this example.

AC coupling is normally used for audio signals. For audio signals AC coupling has the advantage that unwanted DC shares in the signal are removed. For some AC processing circuits (e.g. amplifiers, filters) DC voltages are not allowed in the input signal. Therefore very often a capacitor can be found in the input stage of such circuits.

DC coupling means that both DC and AC parts of a signal are transmitted. For control voltages (normally) only DC coupling can be used as even fixed voltages (e.g. coming from a manual control) have to be transmitted.

In a module patch each A-100 module can be treated as an electronic circuit that is connected to another one. Consequently one has to take into consideration the type of coupling (AC or DC) between modules as the strict differentiation between AC and DC applications os softened for some A-100 modules. E.g. a VCA can be used to process audio signals (i.e. normally AC coupled signals) as well as slowly changing CV voltages (e.g. envelope or modulation amount). Therefore one needs to know if a VCA used is AC or DC coupled. Another example is a divider (e.g. A-115 or A-163) as even these module can be used to process audio or (slow) clock/gate signals.



Luckily it is not very complicated to switch between AC and DC coupling. All one has to do is to bride (i.e. short circuit) the capacitor in case of an AC coupled in/output. The left picture shows how the switch is connected in parallel to the AC coupling capacitor (the broken line resistor symbol represents the load to GND that is always available in each circuit as reference to GND). If AC coupling is required for a DC coupled in/output simply a capacitor has to be added.

From the schematics it can be seen if an in/output is AC or DC coupled. We will add this information also to the user's manual for modules that may be used for both types of coupling.

For some circuits resp. modules changing from AC to DC coupling is not possible. E.g. the "old" VCAs A-130 and A-131 (those with CEM3381 or CEM3382) are AC coupled as the special CEM circuits cannot be DC coupled because of the internal negative reference voltage. The "new" VCAs A-130 and A-131 (those with CA3080) are DC coupled and can be used to process CV signals too.

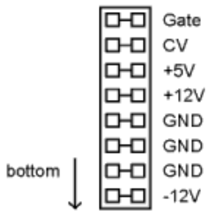
A list with the type of coupling for all modules in question will follow soon. For most of the modules the question about the type of coupling does not arise. E.g. all filters are AC coupled and all CV generating and processing modules (e.g. ADSR, LFO, slew limiter, Theremin, Ribbon controller, random voltage) are DC coupled. But for other modules the type of coupling is not obvious (e.g. VCA, divider, waveshaper).

4.1.4. Subsequent bus normalling of modules

Only a few modules (typically VCOs, envelope generators or Midi interfaces) feature access to the CV and Gate signal of the A-100 bus. For details please refer to the information about the module in question. General information about the CV and Gate signals of the bus are available in the A-100 FAQ section.
If another module has to be modified accordingly.

Examples:

- rectangle output of an LFO to "write" the LFO rectangle as gate signal to the bus gate
- gate input of the A-143-2 Quad ADSR from the bus gate
- CV input of a filter from the bus CV

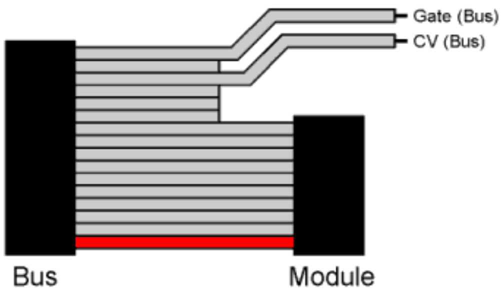


The left picture shows the pin out of the bus. The signals Gate and CV are available at the two upper pin pairs of the bus (left and right pins are always connected on the bus board and carry the same signal).

One has to distinguish between two types of modules (the bus connector is always 16 pin):

- modules with 16 pin male bus connectors
- modules with 10 pin male bus connectors

If the module in question is equipped with a 16 pin male connector both signals CV and gate are available at the upper two pin pairs of the modules bus connector. One simply has to wire the corresponding pin (one of the upper pair for Gate, one of the second pair for CV) of the 16 pin connector to signal in question (e.g. to the rectangle output of a LFO or to the gate input of an VCADSR or VC Decay).



If the module in question is equipped with a 10 pin male connector the signals CV and gate are not available at the modules bus connector. In this case a special bus cable has to be used. The left picture shows how this works. A 16 pin ribbon cable with a 16 pin female connector on one side and a 10 pin female connector on the second side is used. The 10 pin female connector is used to establish the connection between the module and the bus. It is put to the module's 10 pin male connector. The wire of the 16 pin ribbon cable that corresponds to Gate resp.CV of the bus is connected to the corresponding input (e.g. gate in, CV in) or output (e.g. rectangle out) of the module. The wires #15 or #16 are gate, the wires #13 or #14 are CV. The red marked wire is the bottom wire that leads -12V (same for all modules).

Pay attention that only one module is allowed to "write" to the same bus signal. If two or more modules write to the bus this leads to a short circuit of the corresponding outputs.

The bus board has available two jumpers (located in the middle of the bus board). If these are removed the gate and CV lines are divided and both the left and right part of the bus board are separate bus areas concerning CV and gate. The power supply lines (-12V, GND, +12V, +5V) are always connected and cannot be interrupted.

If more than three VCO CV inputs are connected to the same bus the Bus Access Module A-185 is recommended to write to the bus. Otherwise signal losses may occur and lead to scaling problems.

4.1.5. Subsequent socket normalling of modules

coming soon ....

(how to make use of unused switching contacts of sockets for module pre-patching)

4.2. Specific modifications for certain modules

Important note: Warranty is void if these modifications are carried out by the customer !

4.2.1. A-128 filter bank modification: single outputs

This document shows how to add single outputs to the filter bank A-128: A128_single_outputs.pdf

4.2.2. A-136 Modification: bypassing the internal pre-amplifier

Module A-136 contains an internal pre-amplifier that is used to amplify the input signal by about 3.5 before it is processed by the A-136. Especially for low level audio signals (e.g. output from a VCF) this is useful. But for all signals with a level beyond ~ 7V this causes clipping before the internal processing takes place. Especially for the processing of LFOs or unfiltered VCOs this may cause a problem. To bypass the internal pre-amplifier resistor R2 has to be removed (e.g. by pinching off). R2 is the resistor in the upper third of the pcb which is very close to the rear edge. When R2 is removed the amplification of the internal pre-amplifier becomes "1" (which means that it does no longer amplify).
In addition one has to pay attention that the knob positions may vary a bit from the front panel printing because of mechanical tolerances of the potentiometers and knobs (i.e. "0" is not always exactly the neutral position for "A", "+A" or "-A")

4.2.4. A-151 Modification: switch for limiting the number of steps (only for old versions of A-151)

A toggle switch 1-0-1 type is required (i.e. with center position). A hole for the additional switch can be drilled e.g. below the socket I/O4.
This is how the switch has to be wired:

- terminal 1 to CD4052 pin 11 (= LED control for I/O 2)
- center terminal to reset input via a standard diode (e.g. 1N4148), cathode (-) on reset, anode (+) on switch terminal
- terminal 2 to CD4052 pin 15 (= LED control for I/O 3)

The new version of the A-151 is already equipped with this switch. Thank's to Peter Grenader for this idea.

4.2.5. A-148 Modification (old version): T&H instead of S&H

The new version of the Dual S&H module A-148 has a jumper available for each sub-unit that is used to set the operation mode for the corresponding sub-unit to S&H or T&H. The old version of the A-148 was fixed to the S&H mode. To make available T&H for the old version of the A-148 one has to replace the capacitor C1 (10nF) by a resistor (about 1k). C1 is available twice on the pc board: one for the upper and one for the lower unit. It is also possible to add a switch that is used to switch between S&H (capacitor) and T&H (resistor).

4.2.6. A-152 Modification: S&H instead of T&H

Normally the eight S&H outputs of the module A-152 work not as S&H but as T&H outputs (details can be found in the A-152 user's manual). To obtain S&H function instead of the T&H function the module has to be modified in that way:
A connection has to be made between pin 6 of the microcontroller IC1 (on board A, PIC16F676) and pin 2 of IC6 (on board B, DG408). The 10k resistor R32 next to C5 on board B has to be removed. And that's how it works: the enable pin of the multiplexer DG408 is normally connected to +12V ("high") via resistor R32. Pin 6 of the microcontroller (RC4) outputs a short high pulse whenever the address changes. If the enable pin of the multiplexer (DG408) is connected to this pin (instead to +12V via R32) the T&H function changes to a S&H function as the multiplexer is enabled only for a short time at each address change. Even a toggle switch that selects the desired mode can be connected to the pins and the resistor.

4.2.7. A-155 modifications/undo modifications: gate reset, manual step debouncing

This document shows how to modify or undo the modifications of the sequencer module A-155: A155_Modifications_Undo.pdf

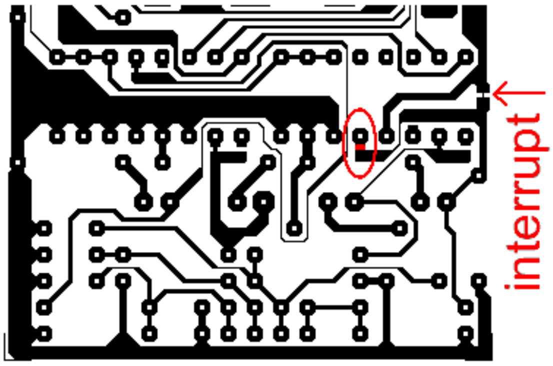
There are two possible modifications:

Modification #1 refers to the behaviour of the gate row. Without this modification the gate output remains "high" if the sequence stops at a position with the corresponding gate switch in the on position. If this modification is carried out the gate outputs turns "low" as soon as the sequence stops. It's an AND wiring of the gate outpout with the start/stop state of the A-155. If the A-155 is combined with the A-154 this modification has to be removed !

Modification #2 is a debounding circuit to avoid multiple triggering if the manual step button is used. This modification limits the maximal clock frequency to some hundred Hz (digital low pass). For normal sequencer applications this is no restriction but if the A-155 is used e.g. as a graphic VCO the modification has to be removed. It is not necessary to remove this modification if the A-155 is combined with the A-154.

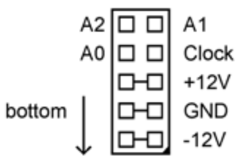
4.2.8. A-155 Modification: changing gate row into trigger row #4

The factory setting of the function of row #4 of the trigger board is ***Gate***. If one prefers another ***Trigger*** row the following modification has to be carried out:
The connection marked by the arrow in the picture has to be interrupted. Instead of this a connection between pin 5 of IC2 (CD4053) and the close-by pcb track has to be installed (solder jumper).



4.2.9. A-155 Modification: adding sockets for address outputs

This is the pinout of the internal 10 pin connector that leads from the small control board to the potentiometer and switch boards:



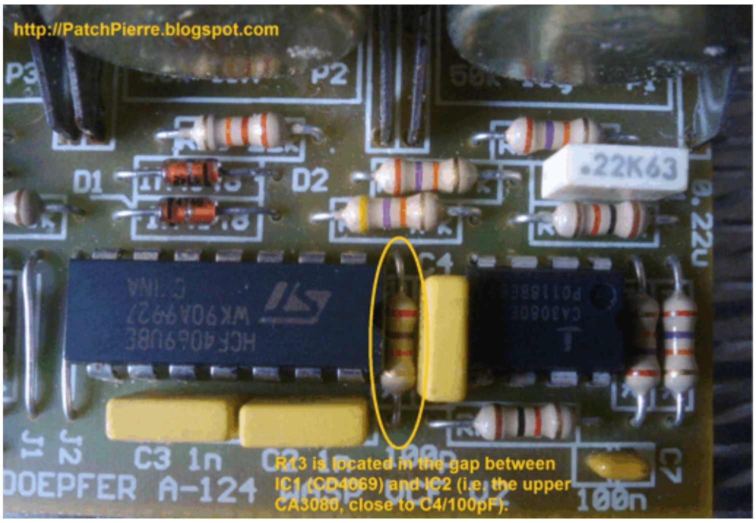
Besides the supply terminals (-12V, GND, +12V) these signals are available:

- Address signals A0, A1, A2
- Clock signal

The A-155 control board includes a simply binary counter (CD4024) that generates the address signals (A0, A1, A2). The advance of the binary counter to the next address is triggered by the clock signal. The control boards outputs the three address signals and the clock signal. The potentiometer and switch boards receive these signals. The signals have CMOS levels (~ 0/+12V) as the CMOS circuits of the control board are 12V powered. They are not TTL compatible ! A simple solution to have the address signals A0, A1 and A2 and the internal clock signal available for other modules the corresponding pins of the control board can be connected to sockets via protection resistors (typ. 1k). A better solution is to insert suitable buffers into the outputs. It's also possible to feed the potentiometer and switch boards with other address and clock signals than those coming from the A-155 control board. The signals have to be 12V CMOS compatible (i.e. low = 0V, high = +12V).
All modifications should be carried out by experts only as the modules contain charge sensitive devices. We have to point out that warranty is lost if such modifications are carried out.

4.2.10. Modifying the A-124 Wasp Filter for self-oscillation

Soldering a 10k resistor in parallel to R13 (27k) leads to self-oscillation of the filter at the max. resonance setting of the resonance control. R13 is located in the gap between IC1 (CD4069) and IC2 (i.e. the upper CA3080, close to C4/100pF).



(Thanks to Pierre Serné for the permission to publish this picture)

4.2.11. Modifying the A-163 voltage controlled frequency divider for DC coupling

Shortening the electrolytic capacitor C7 (2u2) changes the output from AC to DC coupling. C7 is located between the input and the output socket After this modification the A-163 can be used e.g. for frequency dividing of LFO signals too (only suitable for rectangles). Instead of the short circuit even a switch can be used that switches between AC and DC coupling. The only difference between AC and DC coupling is that in the DC coupled mode the output rectangle switches from GND to ~ +5V while in the AC coupled mode the signal is symmetrically around GND (~ -2.5/+2.5V). Usually even the DC coupled mode can be used for audio signals as most of the audio processing modules (e.g. filters) have an AC coupled audio input that removes the positive offset of the A-163 output in DC coupled mode.

4.2.12. Modifying the A-165 trigger inverter/modifier for S-Trig input

This document shows how to modify the trigger modifier/inverter for S-Trig input: A165_strig_modification.pdf. The modification is very simple. Just one 100k resistor has to be added between the input socket and +12V.

4.2.13. Shortening the output protection resistor of A-156, A-170 and other modules

Most of the A-100 modules are equipped with a 1k protection resistor at the output. This resistor protects the output of the module against shortening to GND or shortening to another output. In sensitive CV applications (typically driving the CV input of one or more VCOs) these protection resistors may cause a small voltage drop that leads to inaccuracy in the 1V/Oct scale. There are two solutions:

- Usage of a CV buffer between the output of the A-156/A-170 and the VCO input(s), e.g. A-185-1 or A-185-2)
- Shortening the output protection resistor

If the protection resistor is shortened the output is no longer protected against shortening to GND or another output but the voltage drop caused by the protection resistor is eliminated. For the A-170 the protection resistor is R2 (positioned below the imprint "A-100 MODULAR SYSTEM" on the pc board. For the A-156 the resistors are R17 and R20 (above and below the upper integrated circuit IC3/TLC274).

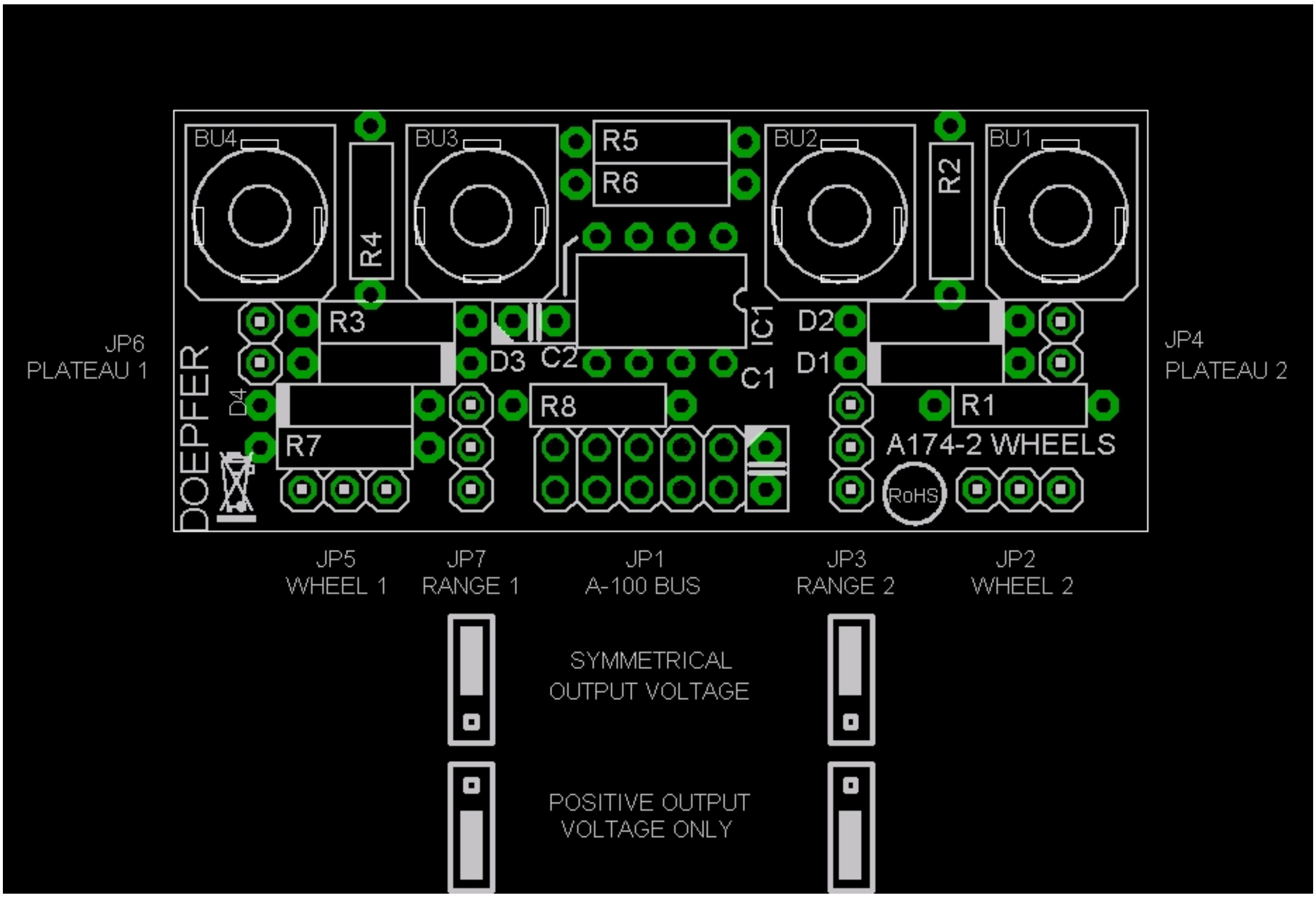
4.2.14. Removing the springs of the A-174 joystick module

Method #1: Bend very carefully the four metallic tongues of the corresponding potentiometer that hold the end plate of the potentiometer in question. E.g. a small screw driver could be used. Pay attention not to break off the tongues. Then the end plate and the spring can be removed. Re-install the end plate by bending back the four tongues. This can be done for both or only one of the two potentiometers of the joystick.

Method #2:Another possibilitly is to compress the two ends of the spring and cut with a suitable small cutting pliers without dismantling the potentiometer. In this case the remnant of the spring remains in the potentiometer.

Pay attention that warranty is lost if the joystick is modified !

4.2.15. Meaning of the pin headers of the A-174-2 wheel module



The jumpers JP4 and JP6 are used to install a small voltage plateau around 0V. The plateau appears if the corresponding jumper is removed (normally used for the spring loaded wheel only to obtain 0V output in the neutral position).
The jumpers JP3 and JP7 are used to select the output voltage range (i.e. symmetrical or positive voltage only). Pay attention that this corresponds to the mechanical adjustment of the wheels ! This means one has to re-adjust the wheels also if the jumper settings of JP3 or JP7 are changed. That's a bit tricky and only recommended for experienced users. Otherwise the voltage range of the outputs will be not correct (e.g. not starting with 0V or a large "dead range" for the wheel without spring, or not 0V in the center position of the spring loaded wheel).

Pay attention that a re-adjustment of the wheels liable to pay costs if the wheel adjustment has been changed by the customer !

4.2.16. Changing the BBD circuit in the A-188-1 BBD module / Adjustment of the A-188-1 BBD module

The following document describes the A-188-1 adjustment procedure: A1881_adjustment.pdf

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to be continued

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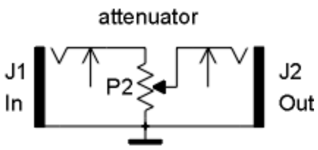
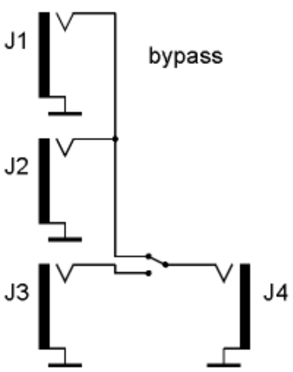
5. Simple DIY modules / frames

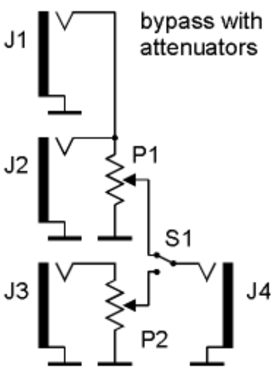
5.1. Attenuator



This is the simple attenuator circuit mentioned in chapter 2. The two sockets J1 and J2, and the potentiometer P2 can be mounted on a blind panel with 8 HP (4 HP will be a little to small for the potentiometer). To take advantage of the whole 8 HP panel a second attenuator or a small multiple (i.e. some connected sockets) can be mounted on the same panel. A value of 50k is recommended for P2 (linear for CV applications, log for audio applications).

5.2. Bypass / Bypass with attenuator

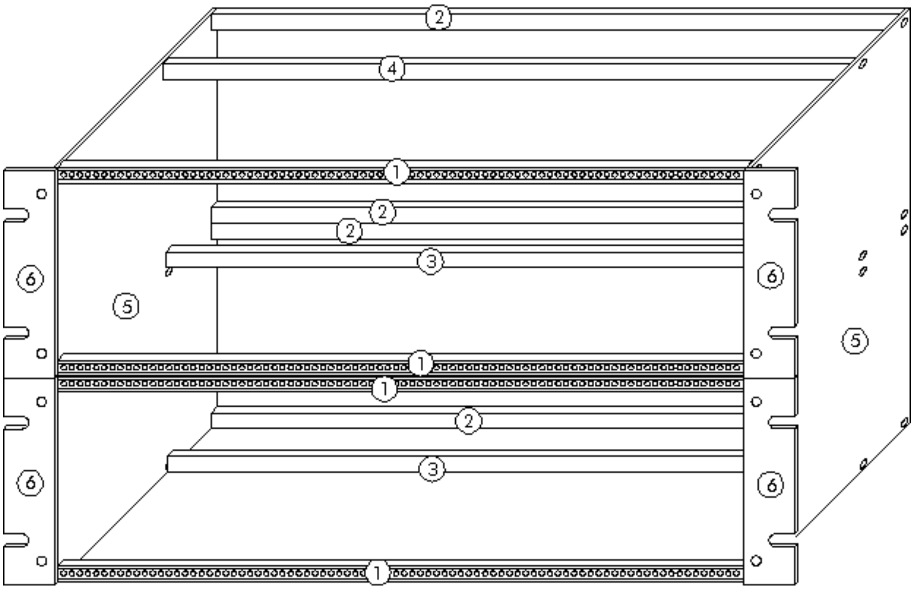




The left circuit is a simple bypass that can be used to decide if an audio processing module (e.g. a filter or a phaser) is active or not. J1 and J2 form a miniature multiple. J1 is connected to the audio source (e.g. a VCO output or a mixer output), J2 to the audio input of the audio processing module (e.g. filter). J3 is connected to the audio output of the processing module. The position of the switch determines if the audio processing module is active (lower position of the switch) or not (upper position of the switch). The four sockets and the switch can be mounted on a blind panel with 4 HP.

In the right circuit the bypass is expanded by two attenuators (P1, P2) that can be used to compensate possible audio level differences, i.e. no or little audio level changes appear when the switch is operated. One of the attenuators may be omitted if not both levels have to be adjusted. The four sockets, the two potentiometers and the switch can be mounted on a blind panel with 8 HP. 50k log is recommended for P1 and P2.

5.3. Self-construction of A-100 frames



The left picture shows the construction of the standard 6 HU A-100 frame (A-100G6). The construction is described in detail in this document:

- A-100 Mechanical details

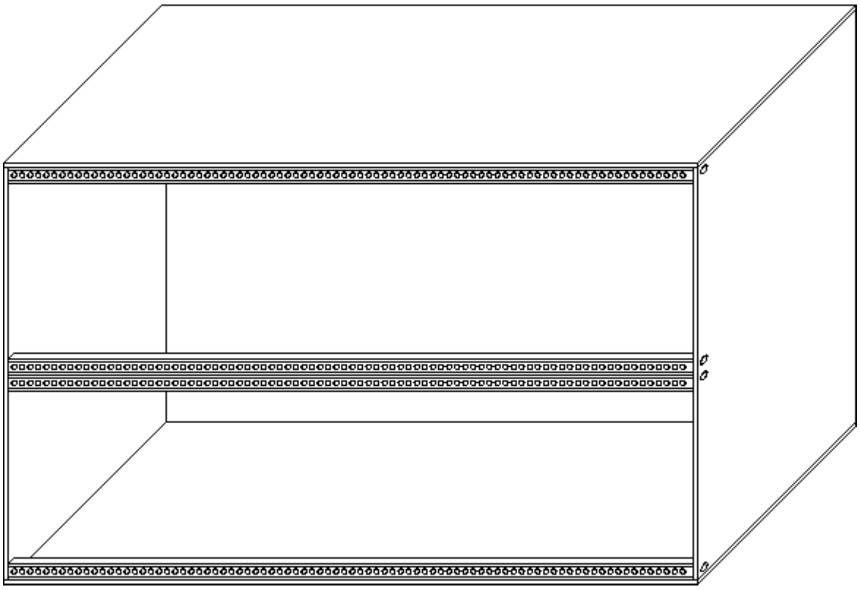
The standard 6 HU frame is made of the following components:

- (1) front rail version 1 (with lip), with threaded inserts (for module mounting)
- (2) front rail version 1 (with lip), with slide nuts (for rear covers mounting)
- (3) front rail version 2 (without lip), with slide nuts (for bus board mounting)
- (4) front rail version 2 (without lip), for increasing stability only
- (5) side plate
- (6) 19" mounting flange
- (x) top and bottom cover (not shown in the picture)

A detailed description of the A-100 frame construction is available as pdf document A100G6_e.pdf

The most expensive parts of the frame are the side plates, mounting flanges and top/bottom covers. If you do not care much for a 19" compatible housing a low cost version of an A-100 frame can be built according to the following instructions.

Pay attention that this is suitable for qualified personnel only who are able to ensure the electrical safety of the final construction. On no account beginners or laymans are allowed to assemble frames. Dangerous mains voltage 115V / 230V. Danger to life !



From the parts list above only the front rails version 1 with "lip" and threaded inserts (1) and the accessory screws are required (the screws that are used to mount the rails to the side plates in the standard version of the frame). Around these 4 rails a suitable case has to be constructed as outlined in the left picture. The rails and accessories are available from the German company ProMA (www.proma-technologie.de) but there are many other companies on the market too. Even rails longer than the 19" standard can be used to obtain bigger non-19" frames (from ProMA e.g. rails with 1m length are available).

At the rear of the case the A-100 power supply (A-100NT12 or A-100PSU2, with mains inlet, power switch and fuse holder) and the bus boards have to be mounted with distance sleeves or spacers.

The wiring of the power supply and the bus boards is described in this document:

- A100_MAINS_PS_BUS.PDF
- A100_NT5_VERDR.PDF (wiring an additional +5V power supply).

As these works affects parts, pc boards and cables that conduct mains voltage (230/115V) carrying out of these works is allowed only for experts or authorized personnel who are familiar with all valid safety rules. Laymen are not allowed to carry out these works ! Danger to Life.

6. Miscellaneous

6.1. A-100 Power Supply

The A-100 requires a bipolar/symmetrical power supply with -12V, GND and +12V. A high quality linear power supply is recommended. Switching power supplies are not recommended. We tried several switching power supplies for A-100. The main advantages of switching power supplies would be the wide range AC input (typ. 90-240V AC, i.e. no supply modification if you move e.g. from USA to Europe and vice versa), low price and small shape/weight. As some customers suggested switching supplies we ordered three types of switching supplies with different power (Meanwell, Sun Power, Condor/SL) and installed them into standard 6U/84HP cases and a 12U/168HP monster case. For all tested supplies the results are very poor. The main problem is the unsufficient load regulation that may lead to VCO tuning problems. We found up to 200 mV (=0.2 V) voltage change of the +/-12V supplies while the load changes. Such load changes are caused e.g. by different LED illuminations (normally a module will consume more current if a LEDs is bright compared to the dark state) or other effects (e.g. frequency changes of VCO/VCF). If the linear A-100PSU2 was used the +/-12V changed only by about 5mV under the same conditions. Consequently switching power supplies can be recommended only for "non-critical" DIY applications (e.g. if only CV sources/modifiers and audio modifiers are installed). For frames that include one or more VCOs we recommend the A-100PSU2 or another linear supply with good load regulation (10 mV or better).

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