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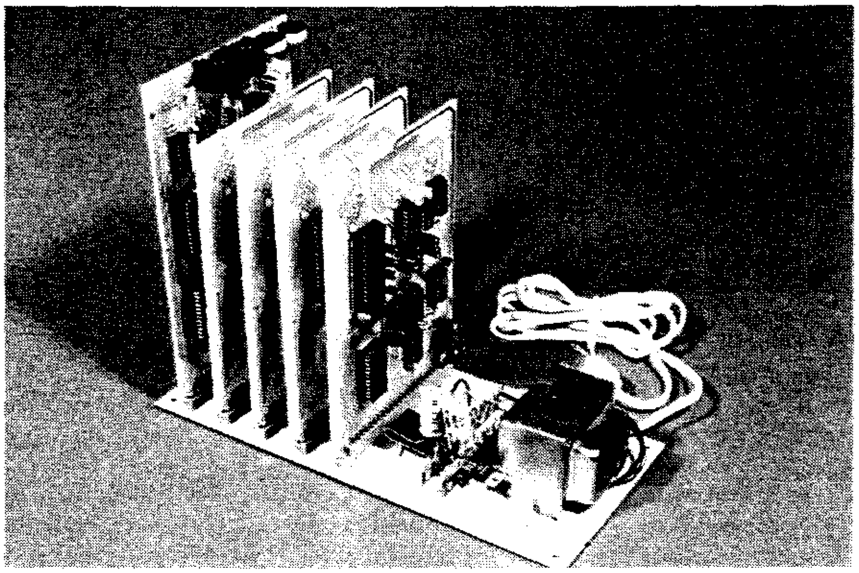
MCVI/MUX EXPANDER SYSTEM
OPERATION MANUAL



The combination of MCVI and MUX cards provide an extraordinarily powerful system for MIDI control of a wide variety of equipment including pre-MIDI synths and other voltage controlled audio processing devices, stage lighting control and automation, recording or PA mixing console control and automation and a host of others.

The cost of this power and versatility is very low in financial terms, but may be high in terms of investment of your time in understanding the configuration of modules required to suit your needs. You cannot cut corners here. If you do not fully understand your application, its requirements and how the MCVI/MUX cards will solve those problems you will not have a rewarding experience. You don't want that. We don't want that.

If you are not familiar with terms like "Control Change data" or "Multi-timbral MIDI mode 4", you have some homework to do. In this case, there is no better place to start than Craig Anderton's book "MIDI for Musicians" (available from PAIA).

HARDWARE DETAILS

At the heart of every system will be the PAIA MIDI to Control Voltage Interface (MCVI). It is this card that provides the computing horsepower needed to convert a stream of MIDI data into a control voltage and vice-versa. If there is an application where only one Control Voltage input and one CV output is needed, the MCVI will handle the job alone.

Most useful applications require more than a single input or output and this is where the PAIA Multiplexer/De-multiplexer card (MUX) comes in. MUX cards are essentially switches and Sample/Hold circuits which are controlled by the MCVI, allowing it to sequentially sample a number of inputs and refresh a number of outputs while also reading or generating a MIDI data stream. These things happen so quickly that they appear to all be going on at the same time.

While the MCVI can work with no MUXs attached, MUXs alone can do nothing, so most real-world systems will consist of an MCVI and one or more MUX cards. While the most common applications will require 1-4 MUXs, Up to 16 MUX cards can be used with the MCVI. The first MUX card in any configuration must be a MASTER card as this card contains RAM memory and other support required by the MUXs. All cards other than the first will be lower cost Expander cards.

An MCVI talks to its MUXs over a 44 pin buss much like those found in PCs. Systems can be wired together directly to the edge connector fingers on the card (not recommended) or to 44 pin euro-card connectors available from Radio Shack and others (this works OK) or using the PAIA MCVI Buss Board (the best idea). The Buss Boards are similar to PCs in that they provide "slots" into which MUX cards can be plugged. Hardware configuration of a system using the Buss Board consists of plugging an MCVI into one slot and from 1 to 4 MUXs into the remaining slots.

A power supply for a system consisting of an MCVI and up to 4 MUX cards is available from PAIA and these components can be mounted on the Buss Board if desired.

MODIFYING THE MCVI FOR MUX FIRMWARE

The firmware required to drive the MUX's is provided in the 2732 EPROM supplied with the MUX Master Card kit, but this part is installed on the MCVI/CPU board. Before installing the new EPROM, the MCVI card must be modified to access the entire program space of this new memory. The modification will consist of using the length of 30 gauge insulated wire provided with the MUX-M to make a connection between U9 (the 6511 MCU) and U8 (the EPROM). The modification allows the

MCU's I/O line PA5 to select the EPROMs address line A11. Address line A11 of the EPROM is presently tied to +5v. with a jumper from U8 pin 21 to pin 24.

If you have purchased assembled MCVI and MUX cards together, this modification should already have been made, check to make sure.

() Carefully remove the EPROM (U8) from the MCVI circuit board and place it in the block of conductive foam provided

() On the bottom (non-component) side of the MCVI circuit board, de-solder and remove the jumper wire presently connecting pins 21 and 24 of the socket for EPROM U8.

() Remove approximately 1/4" (5mm) of insulation from each end of the 4" length of 30 gauge insulated wire provided.

() Refer to the MCVI parts placement diagram, figure 2 and figure 1 below. Locate the solder pad for PA5 at the lower right corner of the MCU chip U9. Insert one end of the jumper wire in this hole from the component side of the board and solder in place.

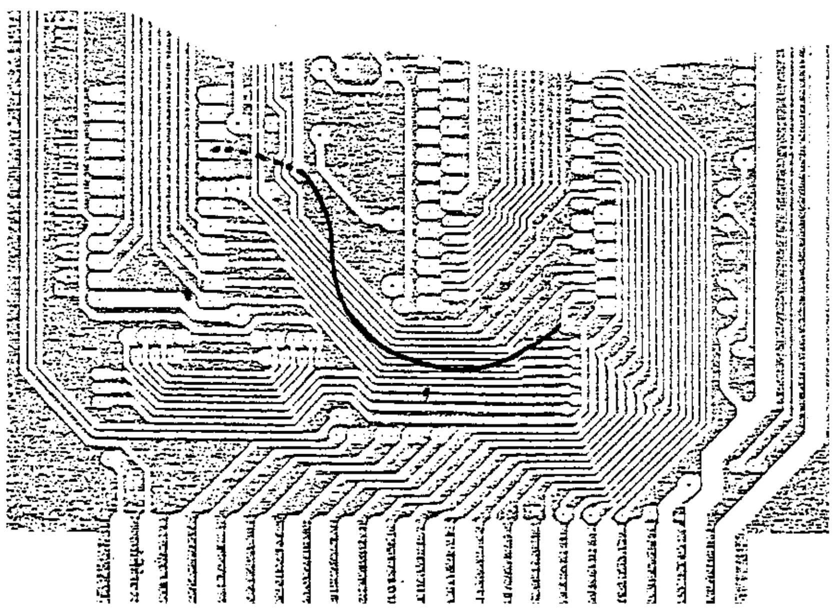


Figure 1
PA5 - U8/pin 21 MCVI CIRCUIT MODIFICATION FOR MUX-M/E USE

() Route this wire through the large hole in the ground trace between U8 and U9.

() From the bottom (non-component) side of the board, solder the other end of the wire routed above to the solder pad of pin 21 of the socket for EPROM U8.

() install the new EPROM supplied with MUX-M kit in the MCVI U8 socket. Note the orientation of the EPROM which is keyed with a notch in one end which when properly installed will correspond to the notch in one end of the socket.

This completes the EPROM modification to the MCVI card. Proceed to selection of MCVI operating modes and MUX card number selection.

MCVI MODE SELECTION / MUX CARD ADDRESS SELECT

Both the MCVI and MUX circuit cards have programming areas which must be properly configured for the operating MODE, MIDI channel and MUX card addresses (card select) required by a specific application.

MCVI MODE AND MIDI CHANNEL SELECTION

The desired MODE and MIDI channel number are selected on the MCVI card by placing jumpers at the locations labeled PB 0-7 on this card. For applications in which the system is dedicated to performing a specific function, the MODE and MIDI channel can be selected by wiring jumpers in the appropriate locations. For greater flexibility in MODE and MIDI channel selection, this programming area is in the configuration of a 16 pin IC, so a DIP switch can be installed instead of the jumpers. Turning a switch "on" is equivalent to placing a jumper in the corresponding position.

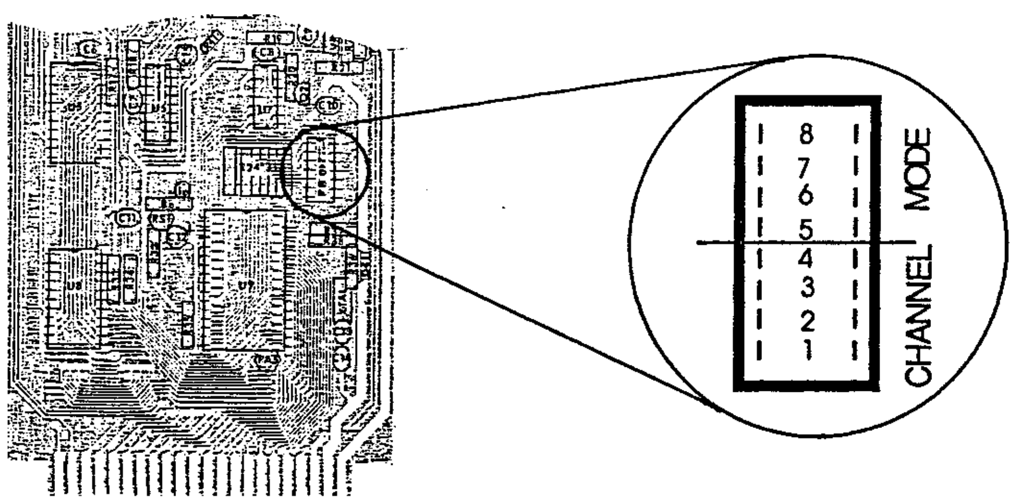


Figure 2a
MCVI MODE SELECT CIRCUIT BOARD LOCATION

Some of the modes covered below allow for "on-the-fly" switching between input and output modes. In the interest of ease of operation in these applications a panel mounted switch can be wired into the location indicated in the detailed operating mode descriptions beginning on page 10. If extending a switch from the MCVI board to a front switch, keep the wires from the switch to the board as short as possible and in any case no longer than 18".

Note in particular that MODE is selected using the top 4 jumper positions and MIDI Basic channel (both send and receive) is selected by the lower 4 jumper positions.

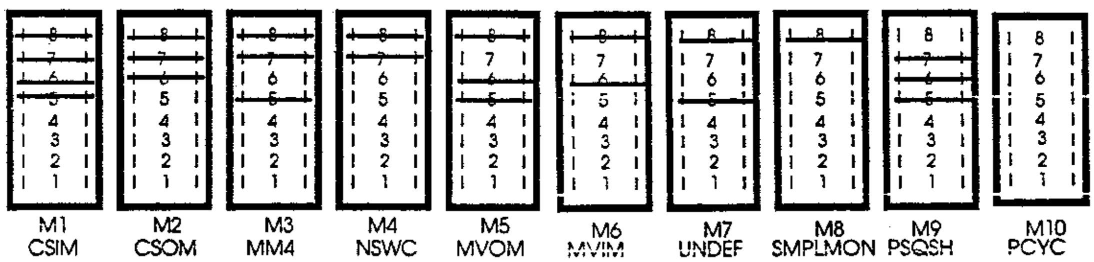


Figure 2b
MODE SELECT JUMPER LOCATIONS
(refer to modes descriptions to select mode of operation)

MUX CARD SELECT

In general, the card select addresses of the MUX card will remain fixed for any given mode of operation. The Master Card being Card 1, the next card 2 and so on. Specific cases which can violate this rule are covered in the operating mode details.

Card address selection is accomplished by properly placing 4 diodes in the Card select circuit board location on the MUX card. (NOTE: Factory assembled MUX MASTER CARDS are pre-wired as CARD 1. A 16 pin DIP header is supplied for the purpose of constructing the card select header. Assemble the header to correspond with the diagram in figure 4 of the card number you have assigned to this card. When installing the card select diodes, notice in particular the orientation of the colored band of the diode. This band must be on the left end of the part when installed.

Diodes are heat sensitive components and it is best to grasp the lead being soldered with a pair of needle-nosed pliers to provide a heat sink.

Plug the header into the socket labeled as CARD SELECT being careful to orient the header as shown in figure 4.

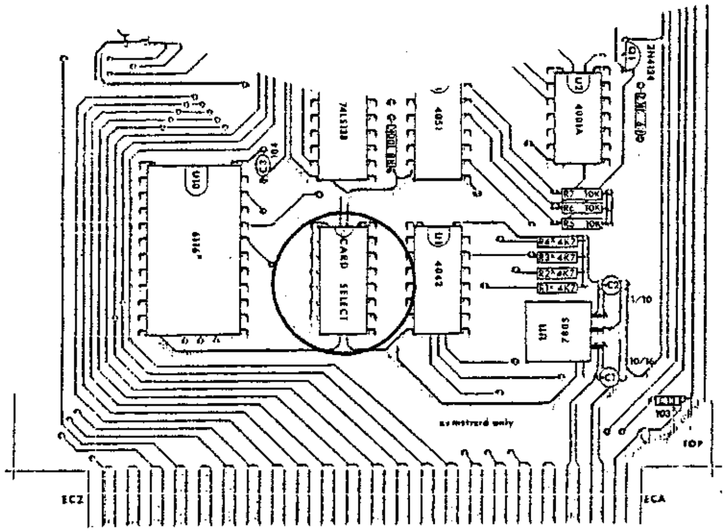


Figure 3
CARD SELECT POSITION ON MUX CIRCUIT BOARD

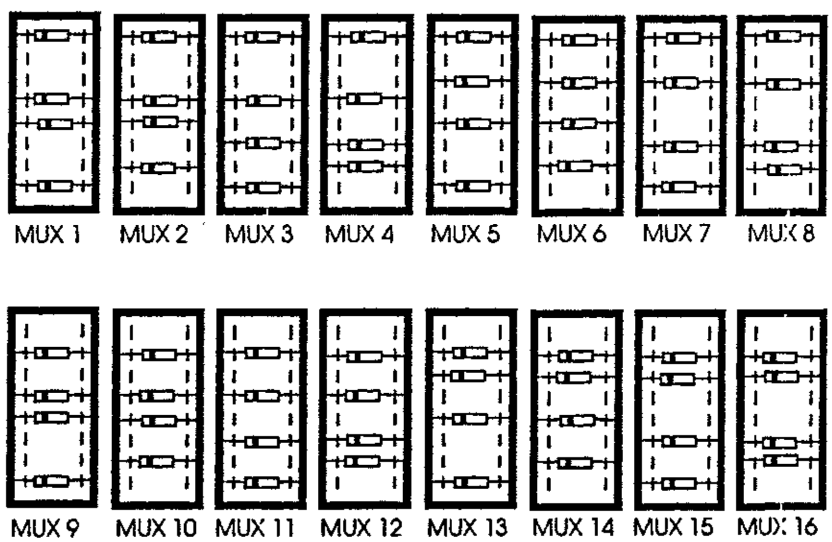


Figure 4
POSITIONING DIODES ON CARD SELECT HEADER

CONTROL VOLTAGE AND GATE INPUTS AND OUTPUTS

Each MUX card's Control Voltage and Gate inputs and outputs terminate at solder pads on the end of the board opposite the edge connector fingers as shown below. Note in particular that there are two ground pins in the group and that pin 18 should be used as the common ground for all Control Voltages while pin 17 should be the reserved for use with the Gates.

Specific correspondence between CVs and Gates and MIDI data will change depending on the MODE selected and these specifics are covered in the operating mode details which follow.

While in some applications these pads may be hard-wired to sources or destination of the signals, note that they are configured in a dual row on .100" centers. You may elect to use a 34 pin IDC header on the pc board and a mating IDC socket on a piece of ribbon cable to make these connections.

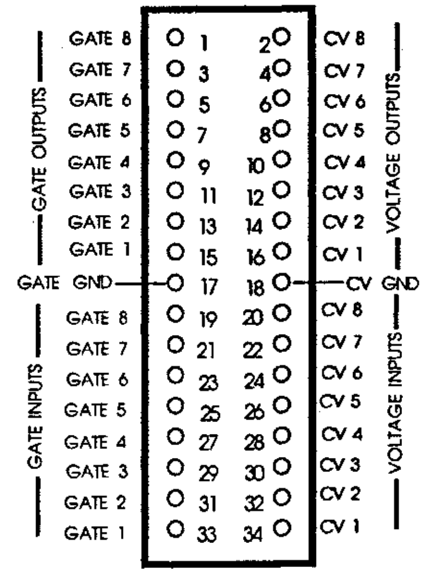


Figure 5
I/O TERMINATION DIAGRAM

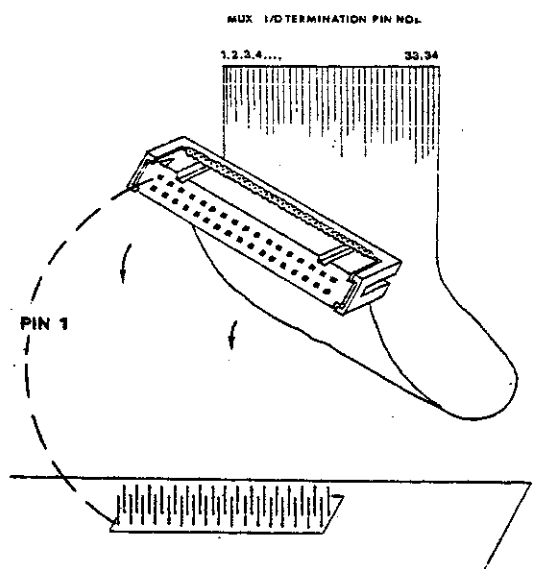


Figure 6
IDC CONNECTOR DIAGRAM

Similarly, there are a variety of options available for terminating the I/O lines. They may be hard-wired to control points in the equipment being MIDIfied where appropriate, or may terminate in 1/4" phone jacks. Since you will probably be dealing with a large number of inputs or outputs, the most appropriate means of terminating these lines is by wiring them to RCA Phono jacks which are mounted on a panel. These connectors provide the most compact means of providing the flexibility of pluggable connections.

In some cases, Control Voltage inputs and/or outputs may need to be properly conditioned before being used with the MCVI/MUX. Details and example circuits are provided beginning on page 22 of this manual.

Gate inputs and outputs can also be thought of as corresponding to Trigger signals (when they are produced in response to MIDI note On/Off messages) or switches. To avoid confusion, we universally refer to them as Gates. A Gate signal is "active" when it changes from 0v (ground) to +5v levels. Some modes provide complementary (not)Gate outputs which, when active, switch from +5v to ground. In illustrations, a (not)Gate signal will be designated with an overbar such as --. Details and examples of using Gates with switches are provided beginning on page 25.

BUSS EXPANSION USING THE BUSS BOARD

An MCVI and up to 4 MUX cards may be plugged into the PAIA BUSS BOARD. Since a MUX card's address is selected by the placement of diodes in the card select area of the circuit board, "slot number" is not important and any card can be plugged into any empty edge connector. Proper orientation of the card in the edge connector is important and the component side of the card must face toward the area of the buss board which provides mounting space for the power supply.

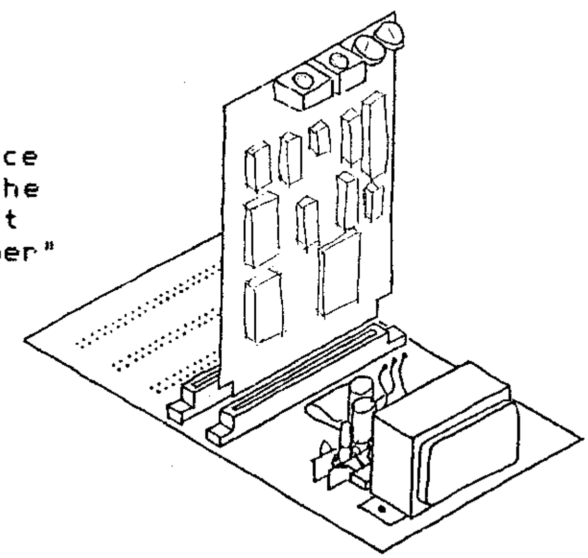


Figure 7
ORIENTATION OF CARDS ON THE BUSS-BOARD

Details of wiring the expansion buss in applications which do not use the buss-board are included beginning on page 20.

MCVI/MUX SYSTEM OPERATING MODES

M1) CSIM - Controller/Switch Input Mode
M2) CSOM - Controller/Switch Output Mode

These two modes will find their greatest application in retro-fitting equipment such as signal processors and mixing consoles to MIDI compatibility. They access and convert the Control Change data provided for in MIDI. Requires 1-4 MUX cards.

In the input mode (M1), Control Voltages and Gates applied to MUX Card are multiplexed and converted to MIDI Control Change messages. In the output mode, MIDI Control Change messages received by the MCVI are converted and de-multiplexed to MUXs as Control Voltages and Gates.

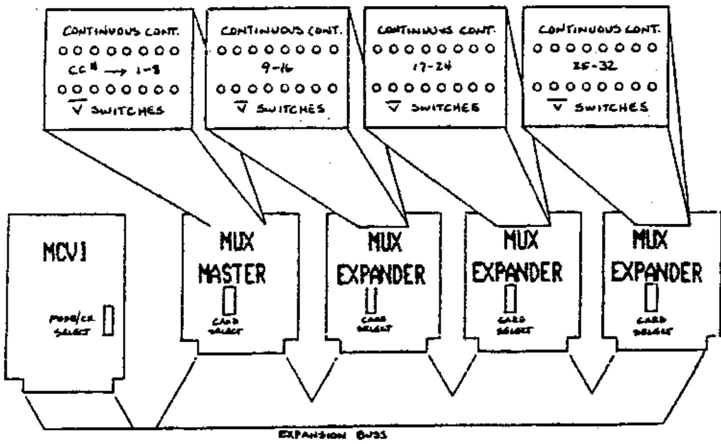
Each MUX Card handles eight Control Voltages and Gates. Up to four MUX Cards can be used to provide access to all thirty-two CVs and Gates corresponding to the various Control Changes on the MIDI Basic Channel selected on the MCVI's MODE header. The first MUX Card corresponds to CC Numbers 0-7 (CVs) and 64-71 (SWs); the second card to CC Numbers 8-15 (CVs) and 72-79 (SWs); the third to CC Numbers 16-23 (CVs) and 80-87 (SWs); and the fourth, CC Numbers 24-31 (CVs) and 88-95 (SWs).

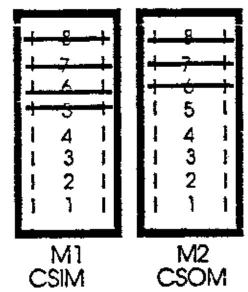
It is not necessary to use all four MUX cards serviced by this mode and if a specific group of CC Numbers is desired, the MUX Card Select ID should be selected to correspond.

While these two modes will not run simultaneously, you can switch back and forth between them on-the-fly without having to do a power-up or system reset. To make this more convenient, the jumper on the MCVI MODE Select header which selects between the two modes (position 5) can be replaced with a switch for easy front panel selection of input or output. Closing the switch selects M1 (input) while opening it selects M2 (output).

There will be applications where it is desirable to have the CV and Gate outputs track (or echo) changes in the Inputs as they occur; for example, when an existing control voltage path in a piece of equipment must be interrupted and its source tied to MUX CV inputs and its destination connected to MUX CV outputs. The input mode (M1) can be set to provide this feature by grounding control line PA0 on the MCVI card edge connector. Jumpering pins 4 and A together with a short piece of wire will implement this change or a switch can be used in place of the jumper to provide front panel control of echo (switch closed) and non-echo (switch open) operation.

On reset or power-up, the system will behave in different ways depending on whether input (M1) or output (M2) is selected. A system reset in output mode will leave all CV outputs at 0v and all Gate outputs high. When the system is reset in input mode, the status of all Control Voltage and Gate inputs are read and that status echoed to the outputs. Simultaneously, control and Gate status is sent out on MIDI.





MCVI MODE SELECT
JUMPER SETTING

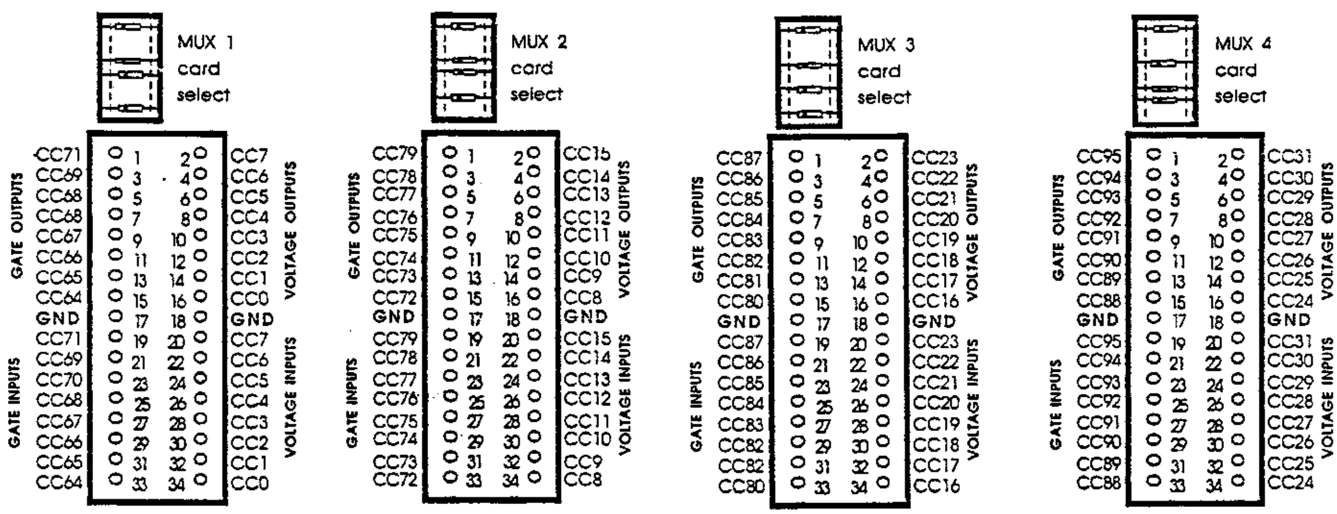


Figure 8
MODE/CARD SELECTS/I-0 HEADERS

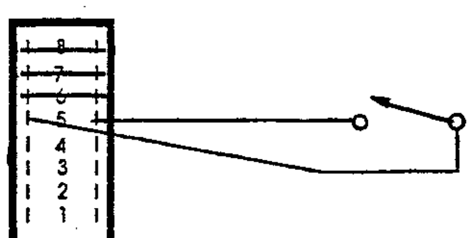


Figure 9
SWITCH ON MODE HEADER - SWITCH ON BACKPLANE

M3) MVOM - Mono Voice Output Mode / MIDI Mode Four

This mode is intended for control of up to 8 synths. Requires 1-3 MUX cards.

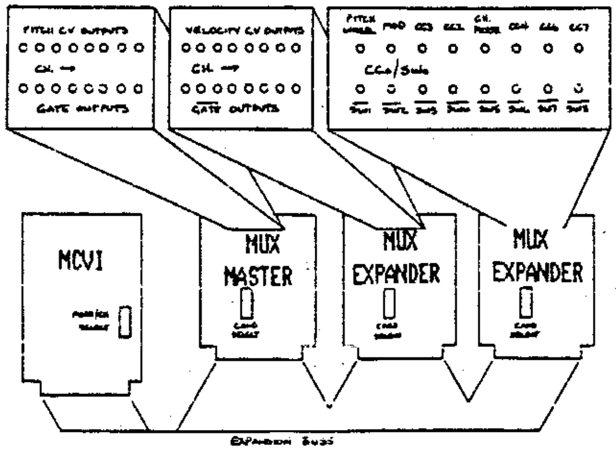
Up to eight channels of multi-timbral MIDI Mode 4 messages are output as CVs and Gates to multiple MUX Cards. Pitch CVs are de-multiplexed to the first MUX Card, Velocity CVs to the second card, and a selection of voice parameters to the third.

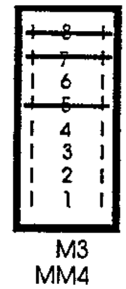
It isn't necessary to add all three MUX cards. If only Pitch CVs are desired, only one is required. If you want Pitch and Velocity outputs, two MUXs are needed.

Similarly, the third MUX is optional but if added provides Voice parameter CVs corresponding to Pitch Wheel, Channel Pressure, CC1 (Modulation), CC2 (Breath), CC3 (pressure), CC4 (Foot Pedal), CC6 (Data Slider), and CC7 (Volume). Data received on any of the channels within the range of channels that the system is listening to will appear at these outputs.

Complementary Trigger (not)Trigger outputs appear at the first and second MUX cards respectively in correspondence to the Pitch and Velocity CVs. Control Change Switch Status messages for the first eight switches, CC64 - 71, appear as active low Gates at the third card's Gate Outputs.

On power-up or reset, the system defaults to receiving 8 channels starting with the Basic Channel selected by the MODE header on the MCVI. Basic Channel can only be selected from this header, but the number of channels to be received may be reduced by sending the appropriate MIDI Mode 4 Channel Mode message with the number of channels to be received set as desired. When the number of channels is set to be less than 8, the higher order CV and GATE outputs are disabled.





MCVI MODE SELECT
JUMPER SETTING

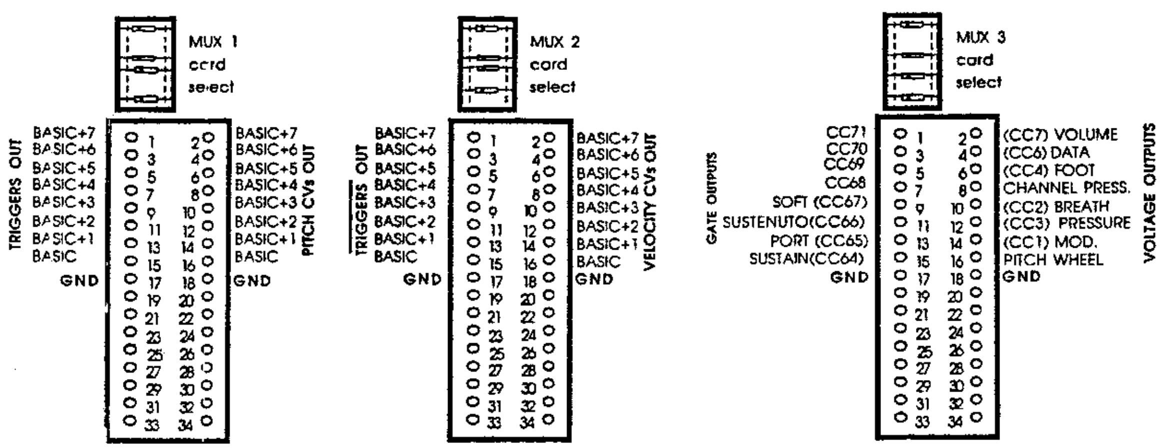


Figure 10
MODE/CARD SELECT/I-O HEADER

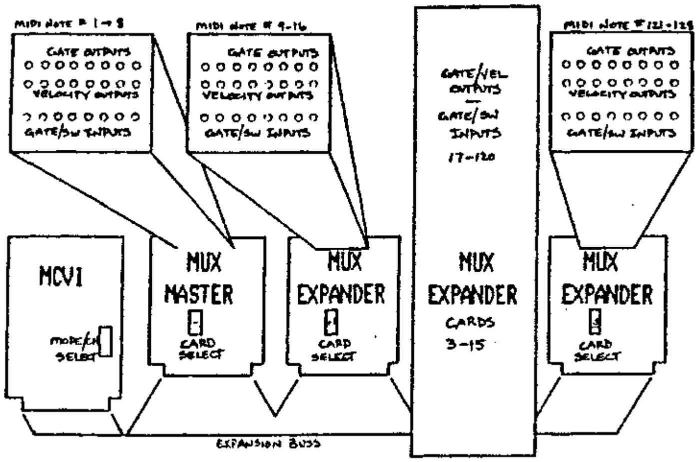
M4) NSWC - Note Switch Conversion Mode

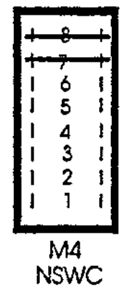
This mode is intended for applications which require a very large number of Gates and Control Voltages, such as complex stage lighting. Since Note On/Off messages are converted to Gates in this mode, it is also suitable for MIDIfying keyboard instruments in which individual notes are keyed on. Requires up to 16 MUX cards.

Provides up to 128 Control Voltage and Gate outputs or up to 128 Gate inputs. CV to MIDI conversion is not supported in this mode. Each MUX Card added to the MCVI provides Gate Inputs/Outputs corresponding to blocks of eight consecutive MIDI Note Numbers, beginning with note numbers 1-8 (first MUX Card) and ending with 121-128 (sixteenth Card). The velocity data accompanying each note is converted and de-multiplexed to the CV outputs on each MUX Card.

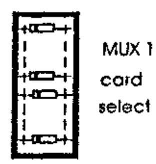
An active high Gate applied to a MUX Card input causes a MIDI Note On message (corresponding to MUX Card position and input number) to be transmitted over the Basic Channel. De-activation of the applied Gate causes transmission of a corresponding MIDI Note Off message. Conversely, MIDI Note On/Note Off messages received appear as individual Gate and Velocity CV outputs.

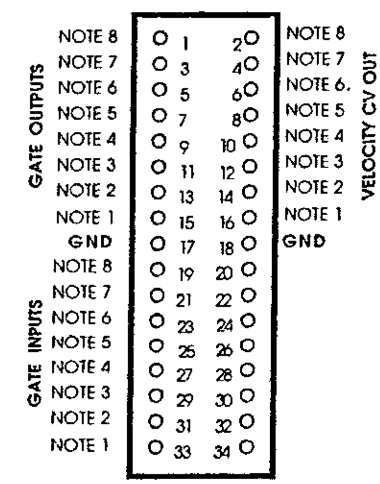
Conversion direction is automatically set to the first input received after power-up or reset. If the first activity is a Gate, direction is Gate to MIDI. If MIDI is received first, direction is MIDI to Gate. MIDI Note On/Note Off messages are recognized and transmitted on the Basic Channel selected on the MCVI MODE header.





MCVI MODE SELECT
JUMPER SETTING





MUX CARD #1 SHOWN. WIRE CARD SELECT FOR NOTE # RANGE DESIRED

IDC PIN NUMBER

GATE IN	GATE OUT	VELOCITY	MUX CARD SELECT # 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
19	1	2	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128
21	3	4	7	15	23	31	39	47	55	63	71	79	87	95	103	111	119	127
23	5	6	6	14	22	30	38	46	54	62	70	78	86	94	102	110	118	126
25	7	8	5	13	21	29	37	45	53	61	69	77	85	93	101	109	117	125
27	9	10	4	12	20	28	36	44	52	60	68	76	84	92	100	108	116	124
29	11	12	3	11	19	27	35	43	51	59	67	75	83	91	99	107	115	123
31	13	14	2	10	18	26	34	42	50	58	66	74	82	90	98	106	114	122
33	15	16	1	9	17	25	33	41	49	57	65	73	81	89	97	105	113	121

Figure 11
MODE AND CARD SELECT WIRING

M5) MVOM - Mono Voice Output Mode
M6) MVIM - Mono Voice Input Mode

These two modes are primarily intended for complete control of single monophonic synths and provide 8 control voltage and 8 Gates which correspond to the most common usages of MIDI data in these applications. Requires 1 MUX card.

In the output mode (M5) MIDI Voice Messages received by the MCVI are converted and de-multiplexed to the MUX card's outputs as Control Voltages and Gates.

Note On and Note Off messages appear as Pitch and Velocity CV Outputs. The last note data received is the value that appears at these outputs. Pitch Wheel, Control Change 1 (Modulation), CC3 (Channel pressure), CC4 (Foot Pedal), CC6 (Data Slider), and CC7 (Volume) messages are also converted to Control Voltage outputs.

Note On/Note Off messages activate or de-activate the Trigger and (not)Trigger outputs. Control Change Switch Status messages for Numbers CC64 (Sustain switch), CC65 (Portamento switch), CC66 (Sustenuto switch), CC67 (Soft switch), CC68, and CC69 are recognized and appear as active low signals at the remaining Gate Outputs (switch on = 0V, switch off = 5V).

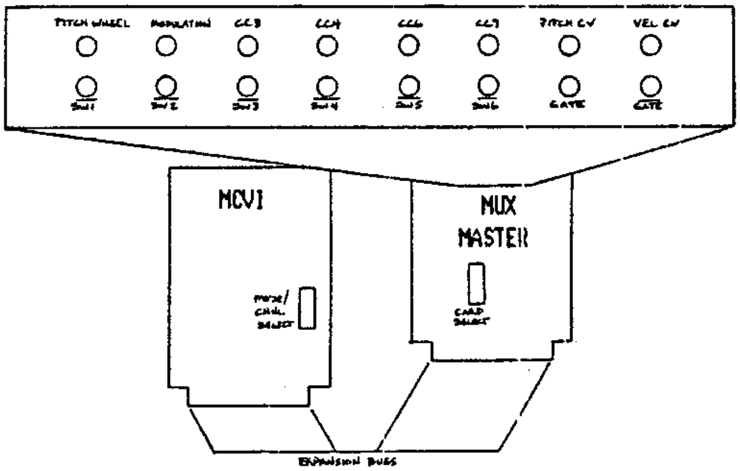
In the input mode (M6) Control Voltages and Gates presented to the MUX inputs are multiplexed to the MCVI for conversion to MIDI Voice Messages.

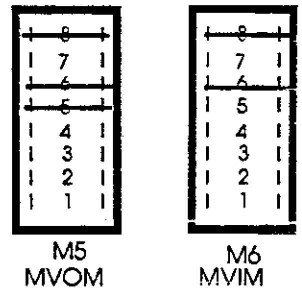
Control Voltage inputs provided are: Pitch, Velocity, Pitch Wheel, Control Change 1 (Modulation Wheel), CC3 (channel pressure on older DX7's), CC4 (Foot Pedal), CC6 (Data Slider), and CC7 (Volume).

The Gate input status is converted to MIDI Note On or Note Off messages with Note number and Velocity corresponding to the value of these Control Voltage Inputs when the Trigger occurred. The remaining CV inputs are converted to MIDI anytime a change in value is sensed. For user convenience a complementary (not)Trigger input is also provided.

The remaining six (not)Gate inputs are treated as sources of Control Change Switch Status messages corresponding to CC64 (sustain switch), CC65 (Portamento switch), CC66 (Sustenuto switch). CC67 (Soft switch), CC68 and CC69.

These two complementary modes are arranged so that the single jumper at location 5 of the MCVI MODE select header selects between them. If front panel switching between these two modes is desired, a switch can be used in place of the jumper. Closing the switch selects the output mode M5 while opening it selects input mode M6. The system must be reset after switching between modes.





MVCI MODE SELECT
JUMPER SETTING

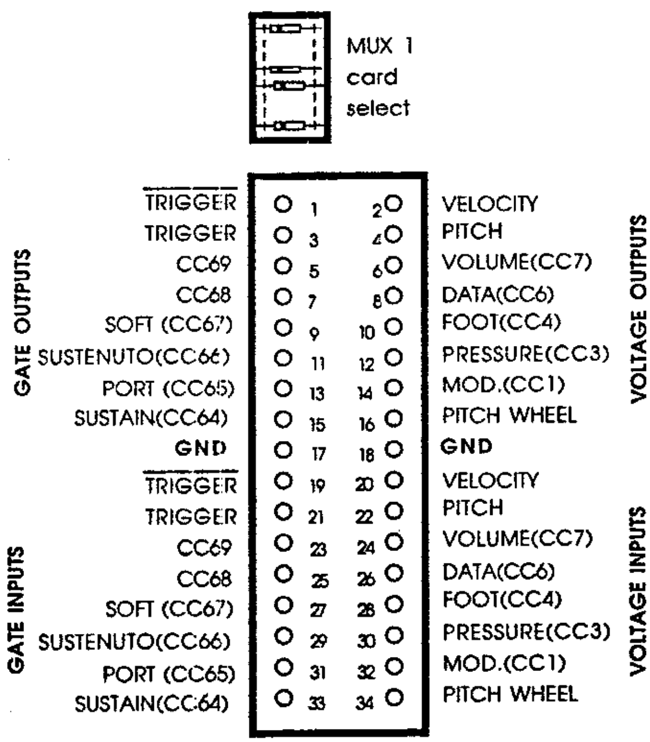
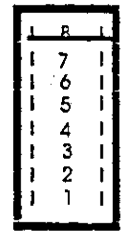


Figure 12
MODE SELECT M5, M6 / CARD SELECT / I-O HEADER

M7) Undefined

This mode is reserved for future expansion.



M8
SMPLMON

Figure 13
MODE ONLY

M8) SMPLmon - Machine Code Monitor

Refer to the MCVI Operation Manual for details on this mode (same SMPLmon Monitor supplied with the MCVI/CPU firmware.)

M9) PSQSH - Poly Squash Mode

M9 and M10 allow control of up to 8 synths in MIDI Poly Mode. Requires 1 MUX card.

MIDI Poly Mode Note On/Note Off messages are converted and de-multiplexed as CV and Gate Outputs. Only one MUX Card is supported in this mode for a total of 8 CV and Gate outputs. MIDI Channel is selected on the MCVI.

Note On messages are assigned to the lowest number available outputs as they are received. An output becomes available when the note assigned to it is released. From an "all Keys released" starting point, the first note played and sustained will always be assigned to output number one, the next note played to output 2 and so on. This allows the player control of which notes are assigned to which outputs and the outputs will typically be connected to different timbers.

M10) PCYC - Poly Cycle Mode

This mode is the same as M9 above except that notes are assigned to outputs on a rotational basis and a note remains assigned to an output even when released. When a total of 8 notes have been played, the next note is assigned to output 1.

Typically, the CV and Gate Outputs would be applied to analog voices all having the same timbre. If less than 8 synths are available, the wrap-around point can be reduced to an appropriate number by variations of the MODE Select settings for this Mode.

Notice that PSQSH is PCYC with only one channel selected, if only one channel is desired in the first place, M4 or M5 is a better choice of operating mode.

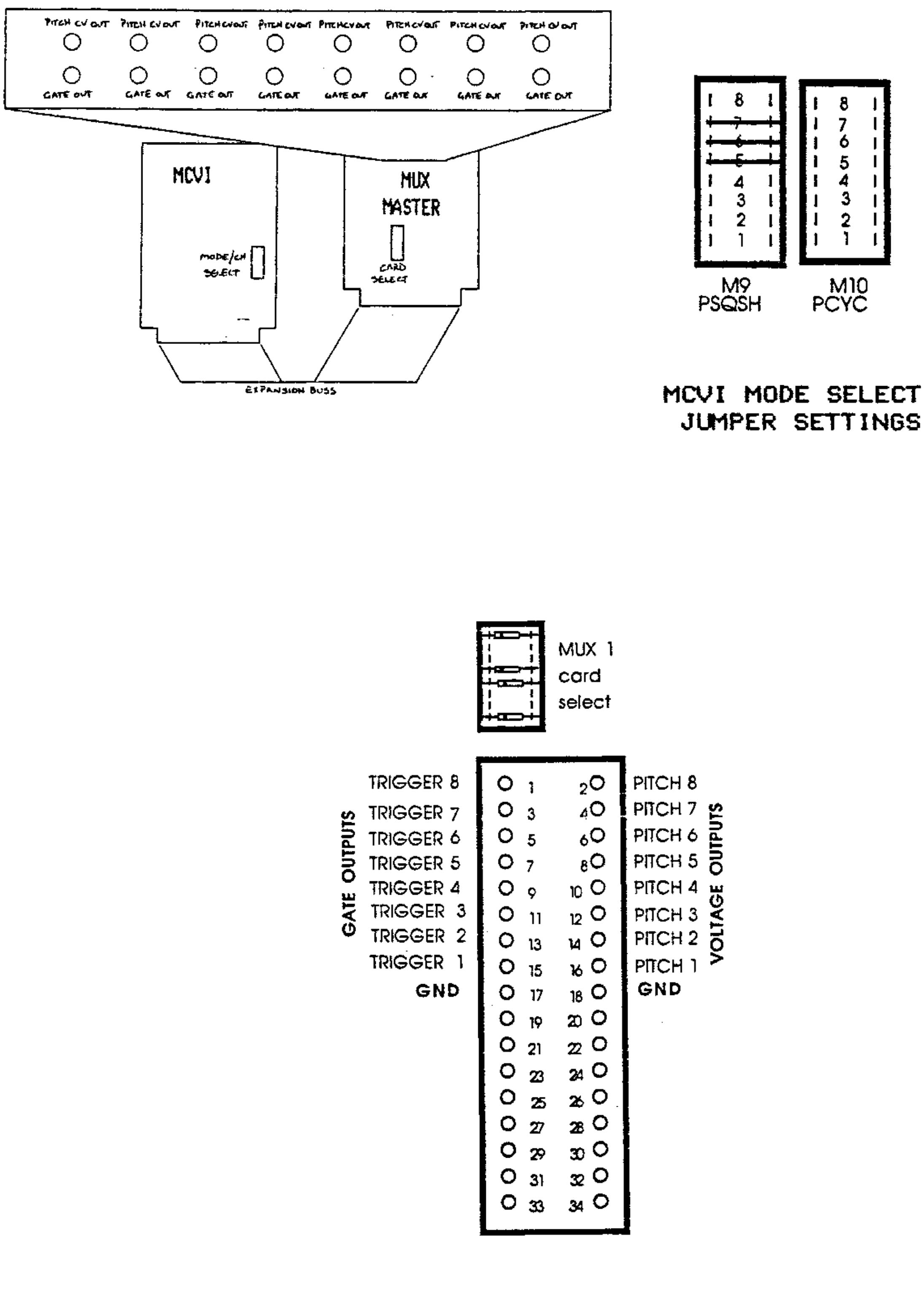


Figure 14
MODE, SELECT, I/O

EXPANSION BUSS WIRING GUIDE

EXPANSION

In some special applications, perhaps when retro-fitting existing equipment with MIDI capabilities, it may be more desirable to wire individual card edge connectors together than to use the PAIA Buss-Board. The following information will be helpful in hand wiring a buss.

The MCVI's Expansion Buss is available at the 44 pin card edge. The required number of 44 pin 0.156" spacing card edge connectors (sometimes called euro-card format) are wired in a simple parallel configuration to form the buss.

Refer to the Expansion Buss Diagram to visualize how the card edge connectors relate to one another. The edge connector terminals are wired to like terminals on successive connectors across the buss. The buss wiring should be as compact as possible to minimize the effects of reactive loading and radiation that excessive buss wire lengths can cause. It is recommended that the total buss length be kept under 18 inches.

Because of the noise sensitivity of the Control Voltage lines in the buss (pins 1 and 2 of the edge connectors), these connections should be made using shielded co-axial cable. RG-174 or some similarly small diameter co-ax will do nicely. The good news is that the shield braid of this cable can be used for the AGND and DGND power ground buss (pins A & B respectively).

+15v and -15v power supply buss wiring (pins C & 3) should be made with 18-22 gauge insulated stranded hook-up wire with the same size or larger wire used to make the connections from the power supply to the first connector of the buss. The two ground wires, AGND and DGND, should be kept separate until they terminate at the power supply ground terminal. The length of the wires used between the supply and buss wiring should also be kept as short as possible. Two to three feet is the longest recommended run.

The remainder of the buss wiring connections should be made using solid or stranded 22-30 gauge insulated wire.

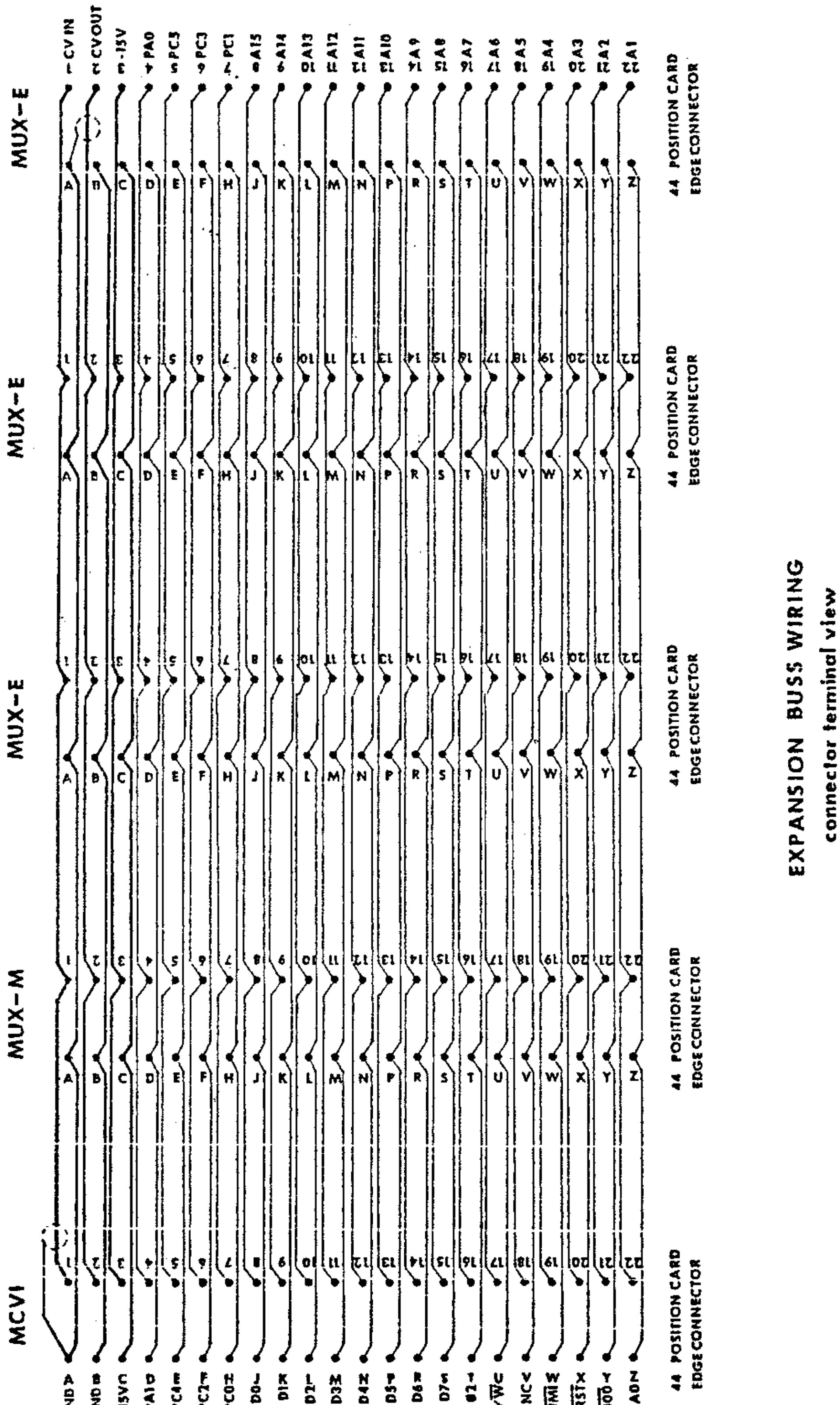


FIGURE 15
EXPANSION BUSS WIRING

MUX TO REAL WORLD INTERFACING

In most applications, the control voltage and trigger inputs and outputs available from the MUX cards can be connected directly to the equipment being controlled. But, since there are always exceptions and applications which were unanticipated at the time that the equipment was designed, the following interfacing and conditioning circuits are included to assist you in meeting exotic requirements. While these circuits have all been built and tested by PAIA, they can also be thought of as examples of designs to be customized for specific applications.

CONTROL VOLTAGES

In the early days of electronic music synthesis, some equipment (specifically, early PAIA, Korg and some Yamaha synths) required control voltages which increase exponentially to produce proper pitches from their linear response oscillators and filters.

The MCVI and MCVI/MUX systems output a linearly varying CV. This restricts synthesizer interfacing use to the exponentially responding type. Circuits exist that will convert a linear CV to an exponential one, but it is more practical and better results can be obtained by replacing linear VCO's with exponential VCO's in older modular systems. PAIA's EKx series of modules work well for these purposes.

CV MODIFIER

There may be applications where the nominal 0-10v. control voltage output range supplied by the MCVI/MUX systems is inappropriate for one or more control voltages in a piece of equipment. This CV modifier circuit can be used to invert, offset and/or scale the range of the MUX output voltage.

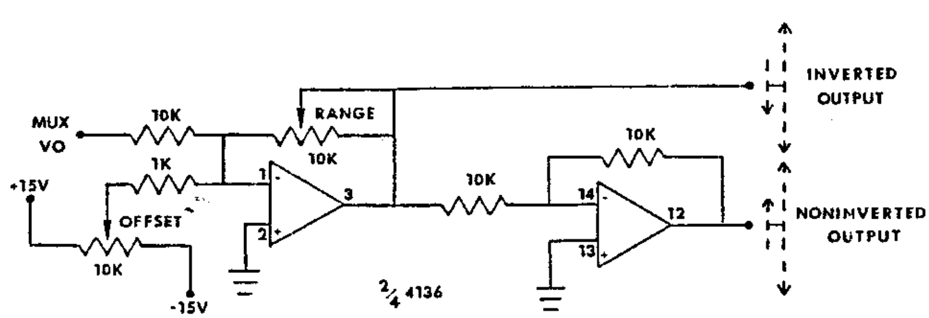


Figure 16
CV MODIFIER

LIGHT CONTROLLER

This "brute force" Lighting Controller circuit utilizes the modifier described above for adjustment of the offset and range of a MUX CV output to match the off to on (approx. 2-3v) control requirements of the transistor current source driving the optocoupler LED. The triac optocoupler provides low current control to the larger high current triac that controls the AC line power through the light. This is a relatively inexpensive solution to the problem of lighting control, but where budgetary considerations allow, commercially available phase modulation systems will provide more stable control in environments which vary in temperature and line voltage.

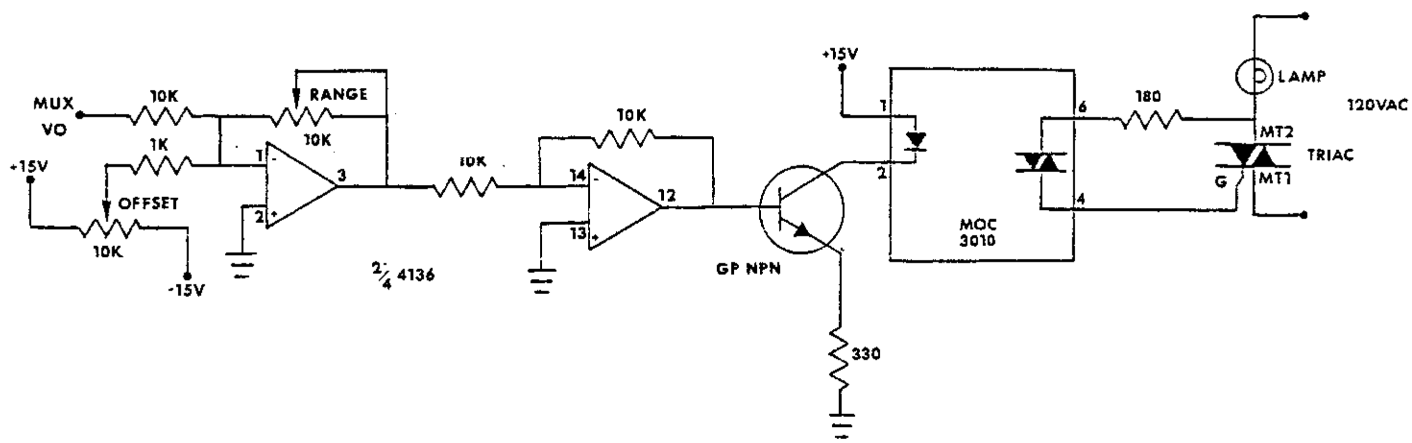


Figure 17
SIMPLE LIGHTING CONTROLLER

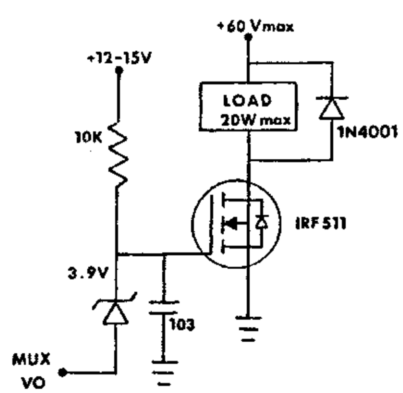


Figure 18
DC POWER CONTROL

DC POWER CONTROL

This DC Power Control circuit can be used to vary the intensity of a DC lamp or LED array, or to control the speed of small DC motors. The circuit employs a simpler means of offsetting the CV range than the universal CV modifier shown in figure 15. The zener diode will maintain a difference in the voltage between its terminals which is equal to its zener voltage specification. Using a 3.9V zener shown, the voltage appearing at the MOSFET gate is in the range of 3.9V to a maximum of 13.9 (offsetting the normal 0-10V range by 3.9v.).

In this application, the MOSFET works like a voltage controlled resistor. When the CV goes positive, the resistance decreases and as the CV goes toward 0V, the resistance increases.

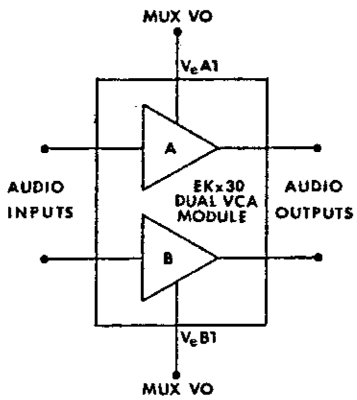


Figure 19
DUAL VOLUME CONTROL

DUAL VOLUME CONTROL

Mixing consoles which come from the manufacturer with faders controlling Voltage Controlled Amplifiers are fairly easy to MIDIfy by interrupting the control voltage path and inserting a MUX. They also are unfortunately rare.

Controlling or automating consoles which are lacking this provision is somewhat more difficult but they can generally be retro-fitted with outboard Voltage Controlled Amplifiers or attenuators. The most appropriate place for these circuits in the signal path is directly on the line inputs.

Here a PAIA EKX-30 Dual VCA module connects to MUX card CV outputs (0-5V) to provide low-distortion, low noise variable attenuation of audio signals. With 5V of CV applied to the EKx-30's CV inputs, the signal passes at unity gain. As the CV decreases, so does the signal output level until at 0V there is approximately 80 db of isolation between input and output. The EKx-30 provide up to 12 volts of headroom before clipping distortion when powered from a bi-polar 15v. power supply.

Remember that Operating modes M1 and M2 are specifically tailored for this kind of application.

CONTROL VOLTAGE SOURCE

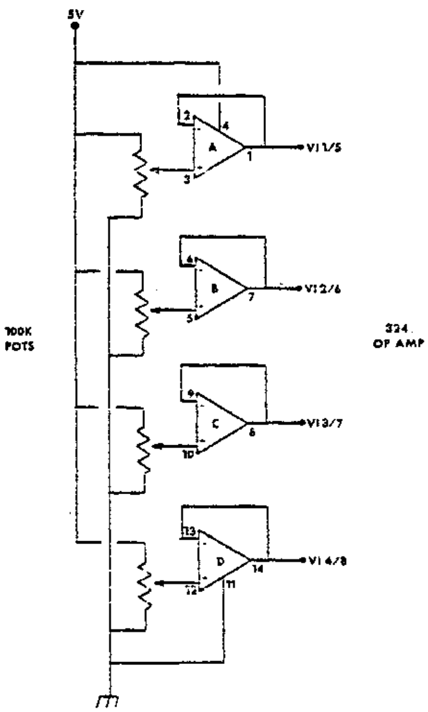


FIGURE 20
CV SOURCE X 4

Control Voltage inputs (such as the corresponding input part of the MIDIfied mixing console discussed previously) can be provided by potentiometers wired as variable voltage dividers. The two outer terminals of the pot are connected across a voltage source and the middle (wiper) lug taps off a voltage anywhere in between. The CV Source example circuit can be built twice to provide eight operational amplifier buffered variable voltages for connection to a MUX card's inputs. The op-amps are not absolutely necessary but provide consistent drive to the voltage available at the wipers of the pots, improving the immunity to noise and interference.

GATES

The GATE outputs on MUX cards switch between ground and +5 volts. In many cases, both GATE and (not)GATE inputs and outputs are provided. GATE I/O's are "true high" and (not)GATEs are "true low". An example should make the difference between these two clear: when a MIDI Note-On message is received, a GATE output transitions from ground (0v.) to +5v. A (not)GATE output under the same circumstances goes from +5v. to ground. Similarly, a GATE input which rises to 5v. will cause a Note-On messages to be sent while a (not)GATE input which falls to ground will be regarded as a Note-On. These complementary state transitions are provided because in some cases they will allow for a simpler interface design.

OPEN COLLECTOR CIRCUIT
for MOOG "s" triggers

To Moog, the trigger to a synth when a.key goes down is a switch which grounds the input to the electronic circuitry. The "S" stands for switch trigger. This nomenclature has stuck largely to differentiate it from most other synthesizer manufacturers who regarded the trigger (or some call it gate) as an electrical pulse which indicates that a key is down

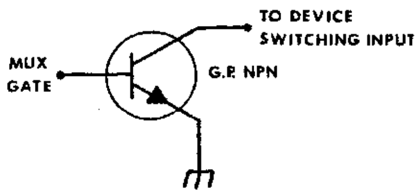


Figure 21
OPEN COLLECTOR

The open collector circuit shown can be added to trigger outputs of the MUX and provides an electronic equivalent of the switch contacts closing. No load resistor is needed from the collector of the transistor to supply because this load is part of the circuitry being switched (hence, open collector). The circuit is not sensitive to the voltage which will be present at the equipment input (12v. for a mini-Moog, 5v. in the case of a MOOG Source, etc).

Essentially this same circuit can be used to translate the 5 volt MUX gate outputs to levels greater than 5v. simply by adding a pull-up resistor (2.2K or so) from the collector to a power supply voltage corresponding to the high level output desired, e.g. if you want to switch from ground to 15v., connect the resistor to a 15v. supply line. This circuit cannot be used to switch negative voltages (see following circuit for that). Note that in this level translating application the transistor inverts the sense of the output i.e. a high gate signal causes the output of the transistor to go low. This is an application where the (not)GATE outputs of the MUX come in handy and their use keeps you from having to add another transistor to invert the action of the first transistor.

AUDIO MUTE

In terms of applications like automated mixing, by far the most useful function for the GATE outputs is muting or quieting a channel on command. This is so useful that you might consider simply implementing automated mutes as a first step to console automation. You may find that complete automation isn't as necessary as you had first thought and

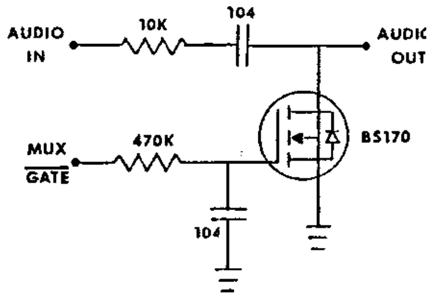


Figure 22
AUDIO MUTE

save the dollars that would have otherwise gone into VCAs. The simple circuit shown below will perform well for most mute applications and works by simply shunting the audio signal to ground when the MOSFET is turned on with a (not)GATE input.

BI-POLAR GATE OUTPUTS

In the years pre-MIDI, the attitude of some manufacturers seemed to be that users should be actively discouraged from using equipment from their competitors. A manifestation of this was equipment which in some cases had strange interfacing requirements; for example, gates which switch between a positive and negative voltage. While this is rare, such situation do arise and the circuit shown can deal with these situations.

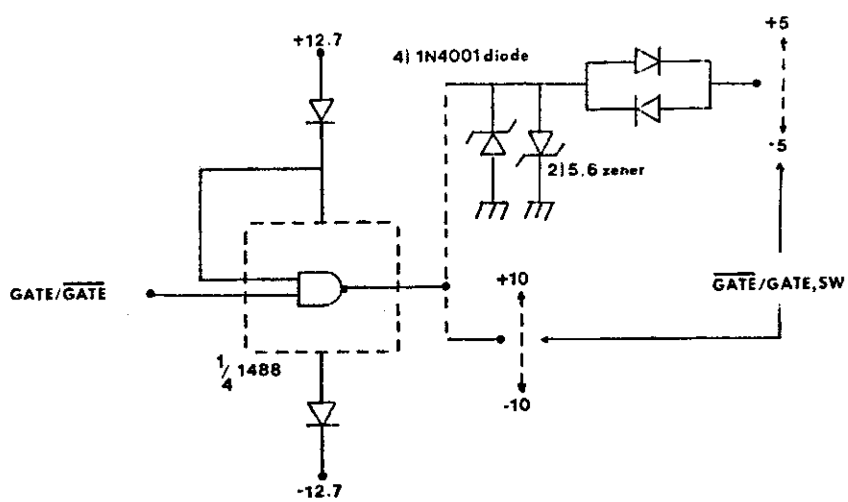


Figure 23
CHANGING GATE OUTPUT LEVELS

The 1488 Line Driver IC is good choice here for a number or reasons, not the least of which is that its output is internally current limited by a 300 ohm resistor, minimizing the risk of blowing something up if the voltages output are not exactly right.

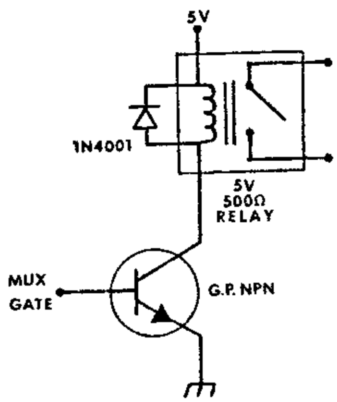
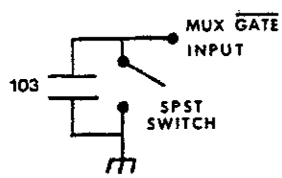


Figure 24
RELAY INTERFACE

RELAY INTERFACE

Even with todays advanced MOS and photo-coupled semiconductor switching devices, there are times when it's hard to beat relays. Their metal-to-metal contacts don't care whether they're switching AC or DC or what offsets are involved. There is very little danger of transients from the controlled equipment sneaking back and zapping components on the MUX cards. Tape recorder transports in particular are generally much easier to handle with relays than with any of the other options.



SWITCH WIRING

Figure 25
USING SWITCHES

SWITCH INPUTS

By far the easiest way to interface switches or push buttons to the MUX is as shown below. Notice that this is another case where the availability of a (not)GATE input may save a transistor or other active element. Here, grounding the (not)GATE input has the same effect as applying a 5v. triggering signal to a GATE input. The capacitor across the switch contacts filters out any contact bounce noise.

Keep an open mind. If you are connecting a switch to a MUX in a mode which has only Gate inputs and the "on" position of the switch needs to provide 5v. to the input, simply turn the switch upside-down so that the position labeled "on" corresponds to the contacts being open.

INPUT PROTECTION

Gate voltage inputs applied to MUX cards should be kept within the 0-5V range. If voltages provided by a specific piece of equipment differ from this, the resistors shown below should be used to limit input current. If the voltage swings negative, the diodes should be added to clamp negative voltage excursions to ground.

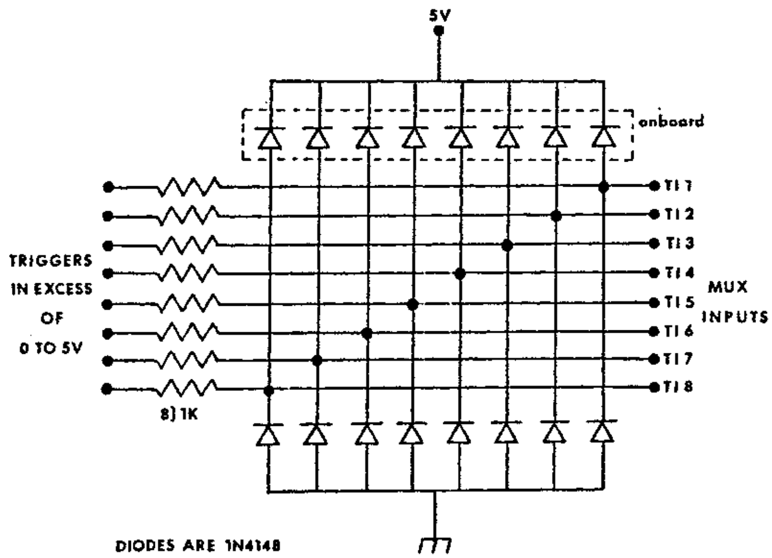


Figure 26
INPUT PROTECTION

EKx VOICE APPLICATION EXAMPLE

If you don't happen to have an old analog synthesizer laying around, you can always build one. Using the PAIA EKx series of modules that's not as daunting a proposition as it may first sound. These modules are the best kept secret in the audio industry. They're quiet, precise, easy to build and use and the series includes VCO (EKx-40), VCF (EKx-20), Envelope Generator (EKx-10) and dual VCA (EKx-30).

The diagram on the next page illustrates the use of these modules to duplicate the configuration and characteristics of the classic analog synths of the 70's. The only thing lacking is the finicky sensitivity to temperature, humidity, power line variations and alignment of the planets that could sometimes lead to hours of tweaking and twiddling to get proper tuning.

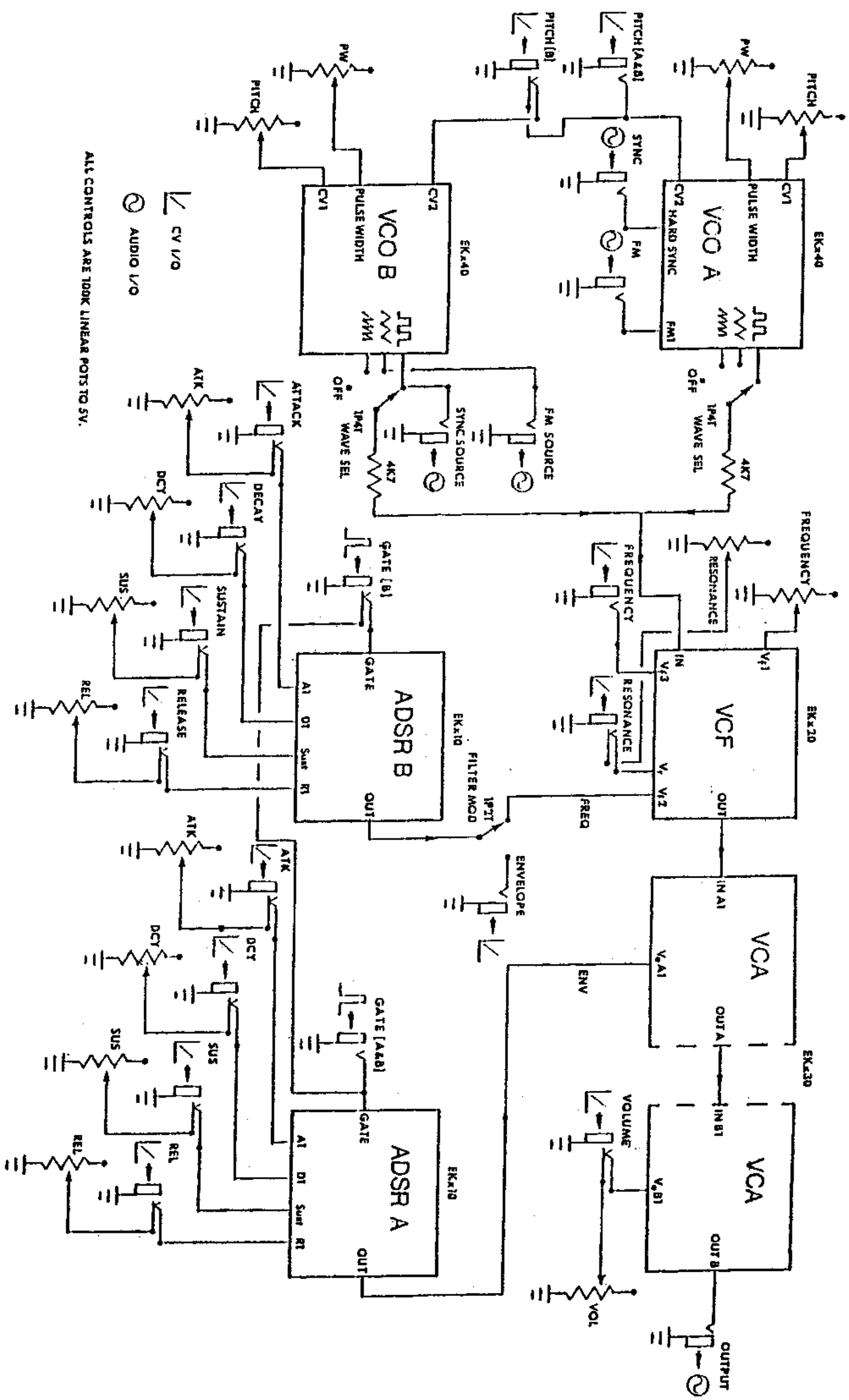


Figure 27
EKx VOICE

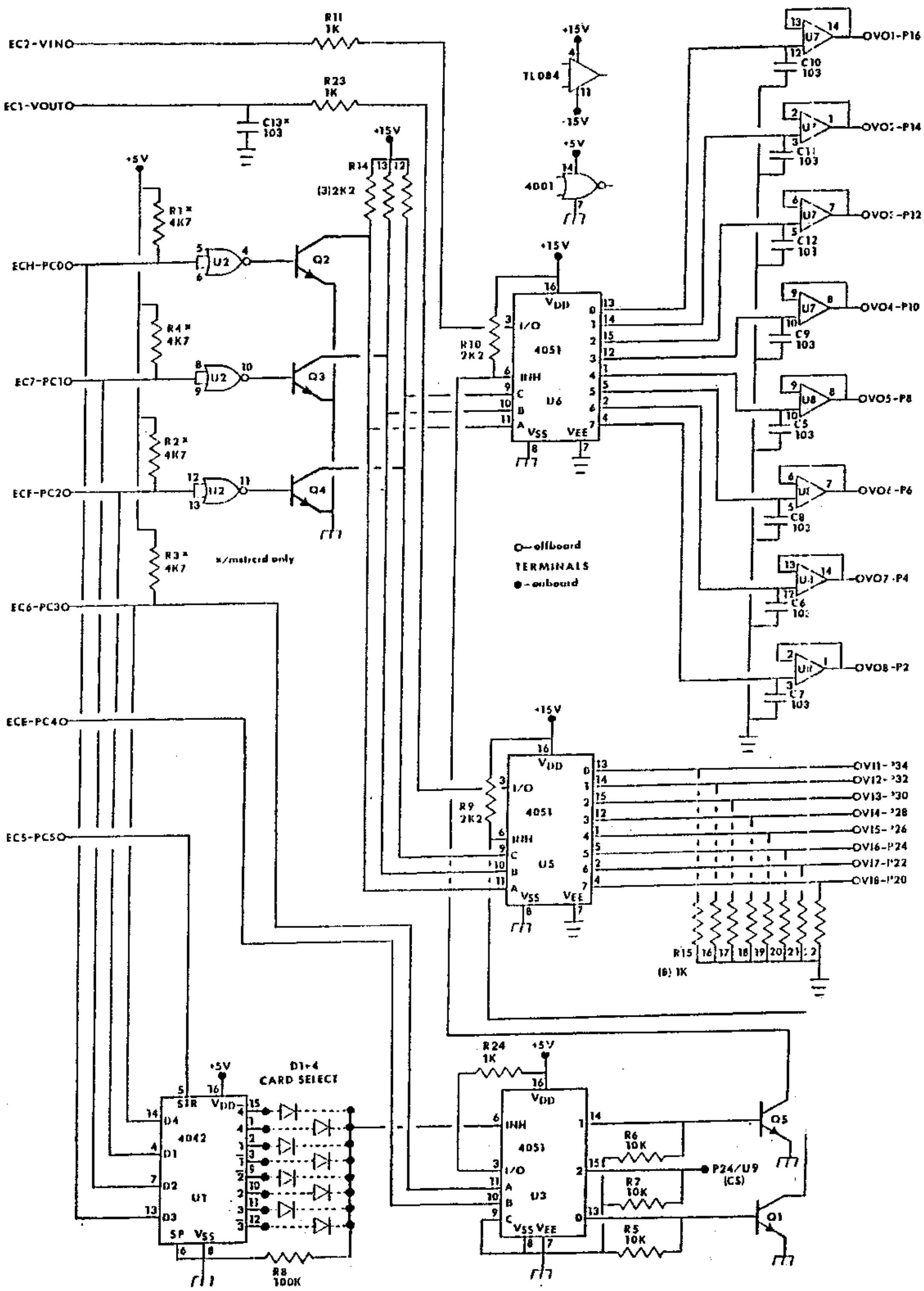


Figure 28-a
MUX EXPANDER SCHEMATIC DIAGRAM

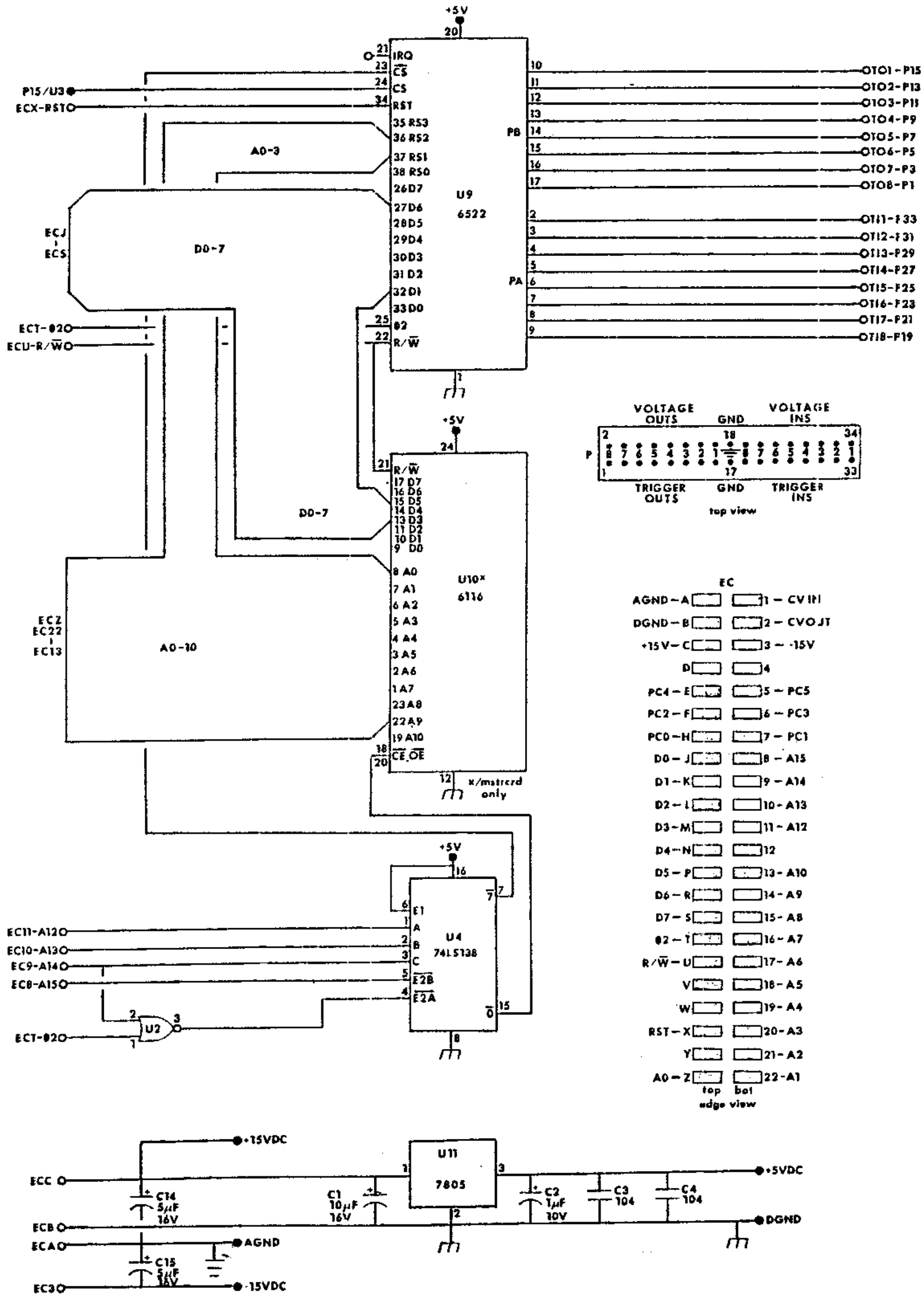


Figure 28-b
MUX EXPANDER SCHEMATIC DIAGRAM