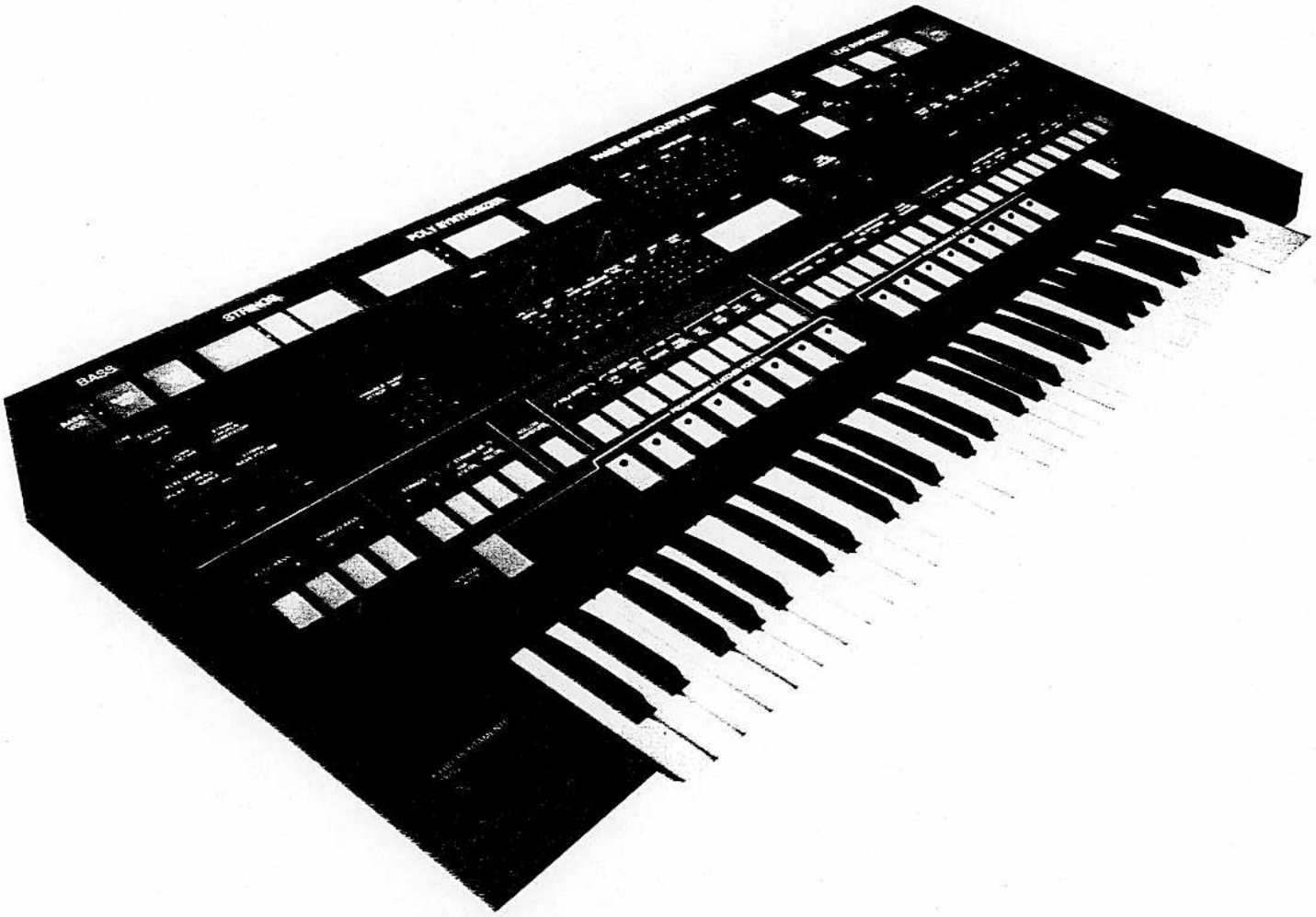
ARP QUADRA



SERVICE MANUAL

MODELS 2461, 2463

CONTENTS

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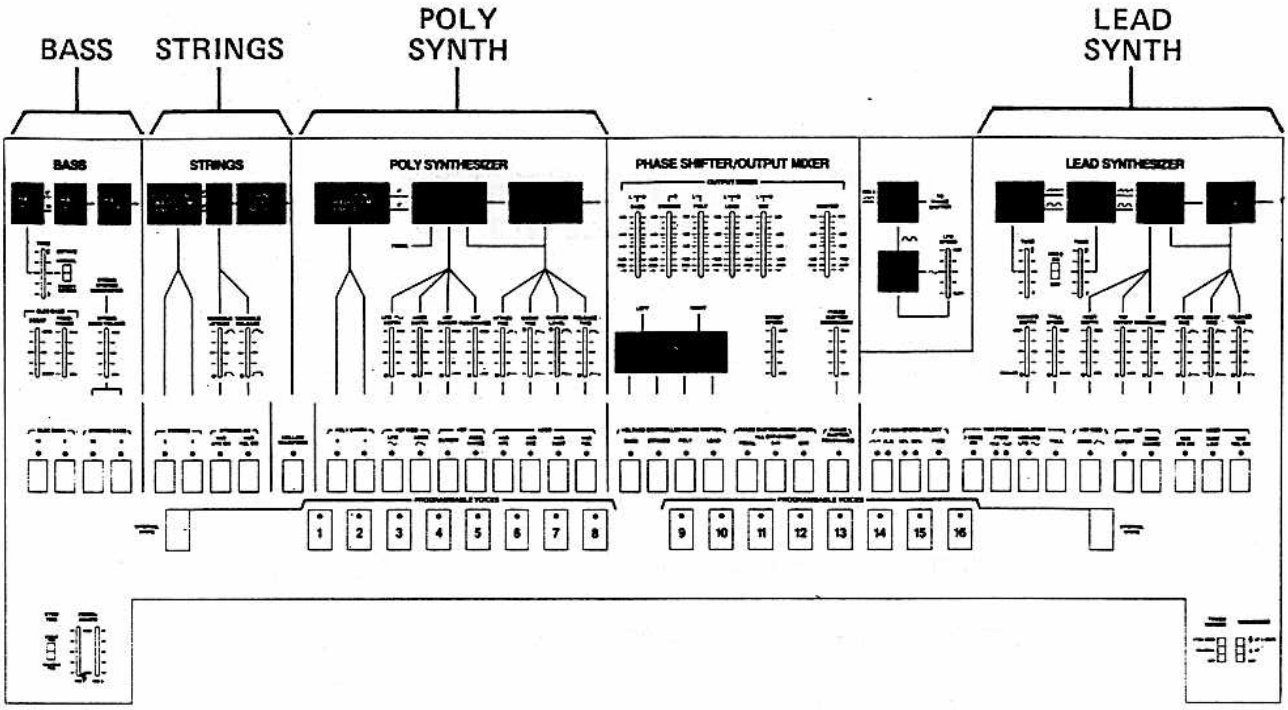


1.1 Product Description

The ARP QUADRA combines the unique versatility of microprocessor computer technology with analog signal processing for synthesizer sound modification. The Quadra contains four independent synthesizer sections: BASS, STRINGS, POLY SYNTH, and LEAD SYNTH.

The BASS section includes the String Bass and Electric Bass, both produce monophonic 8' and 16' pitches which are keyed from the first two octaves of the Quadra's 61 note keyboard. The Electric Bass section contains its own envelope which has preset attack, variable decay, and resonance. The String Bass section contains a separate bass volume slider which is mixed together with the STRING section at the final output. Both Electric Bass and String Bass can be transposed down one octave.

The STRING section produces polyphonic 4' and 8' pitches, starting from the second octave. It also contains preset or variable attack and release, which is controlled from the front panel touch switches.

The POLY SYNTH section also begins at the second octave and contains the same source pitches (4' and 8') as the STRING section. A preset or variable ADSR is used to control the Poly VCF and VCA.

The LEAD SYNTH contains two VCOs which can be transposed to any pitch with the use of the microcomputer Interval Write switch. The LEAD SYNTH VCOs are fed to the Lead VCF and VCA which is controlled by a preset or variable ADS/ASR. More information on the operation of the Lead ADS/ASR can be found in the circuit descriptions listed in Section 3.

The Quadra touch panel switches are hermetically sealed and built into a thin flexible adhesive mylar that is placed over the Quadra's top panel. In the unlikely event of a switch failure the switch panel can be replaced. With the use of the Microcomputer, the touch panel switches control audio routing paths as well as activating some of the control sliders on the front panel.

Included in the Quadra is an Intel 8048 Microcomputer. The primary role of the microcomputer is to control the synthesizer functions from the 40 parameter switches. It also monitors the keyboard to determine if a key has been depressed and assigns the pitch information to the appropriate synthesizer section. Among the three basic building blocks of a synthesizer (SOUND SOURCE, SOUND MODIFIER, and CONTROLLER), the role of the Microcomputer in the Quadra can be defined as a controller. The Quadra's Microcomputer section also has the capacity to memorize 16 different programs which are selectable by the user; 40 different switch settings and Lead VCO pitch information are programmable and retained in memory, even after the instrument has been turned off.

1.2 Specifications

VCO (BASS)

Frequency Range: 65Hz to 250Hz
Waveform: Pulse

VCO (LEAD)

Frequency Range: 16Hz to 16KHz
Waveforms: Sawtooth, Square, 10% Pulse
Maximum Vibrato Depth: Approximately +1 semitone
Maximum Trill Depth: 5 octaves
Pulse Width Modulation Range:
10% mode, 25%-60%
50% mode, 60%-80%

VCF (POLY SYNTH)

Type: Low Pass, 24db/octave
Frequency Range: 16Hz to 16KHz
Resonance: Maximum usable Q=30
Maximum LFO Modulation: +1 octave
ADSR Sweep: Minimum 5 octaves, Maximum 8 octaves

VCF (LEAD)

Specifications similar to above except: ADSR Sweep: Minimum 2 octaves, Maximum 8 octaves

LFO

Frequency Range: .5Hz to 15Hz
Waveforms: Sine, Square (via S/H)

TRILL

Trill Speed Range: 2Hz to 20Hz

ENVELOPE GENERATOR (BASS)

Maximum Decay Time: 5 seconds

ENVELOPE GENERATOR (STRINGS)

Maximum Attack Time: 6 seconds
Maximum Decay Time: Variable option, 3 seconds; Present option, 1 second

ENVELOPE GENERATOR (POLY SYNTH)

Maximum Attack Time: 1 second
Maximum Decay Time: Variable option, 2 seconds; Preset option, 2 seconds
Maximum Sustain Level: Variable option, 3 volts; Preset option, 3 volts
Maximum Release Time: 3 seconds

ENVELOPE GENERATOR (LEAD)

Maximum Attack Time: 1 second
Maximum Decay Time: SUST LOW off, .4 seconds; SUST LOW on, 2 seconds
Maximum Release Time: 2.5 seconds

PORTAMENTO

Minimum Speed: 1.5 seconds/octave

S/H

Maximum Frequency Deviation in Phase Shifter: 1 octave

TOUCH SENSOR

Maximum Pitch Deviation: +3 semitones

PHASE SHIFTER

Sweep Speed Range: .1Hz to 5Hz

INTERFACE JACKS

CV IN/OUT: 1V/octave
GATE IN: Minimum 2.5V (Lead & Bass)
GATE OUT: Approximately 10V (Lead & Bass)
TRIG IN: 8V Pulse, 10 microseconds minimum duration
TRIG OUT: 10V Pulse, 60 microseconds duration

EXTERNAL AUDIO IN

Input Specifications: 7V input=5V maximum output

AUDIO OUTPUTS

Impedance: 680 ohms, all audio outputs

MONO OUT (XLR & ¼" phone):
High=10VP-P maximum
Low=1VP-P maximum

QUAD OUT
Bass=5VP-P maximum
Strings=10VP-P maximum
Poly Synth-12VP-P maximum
Lead=3VP-P maximum

STEREO OUT (Left & Right): 10VP-P maximum

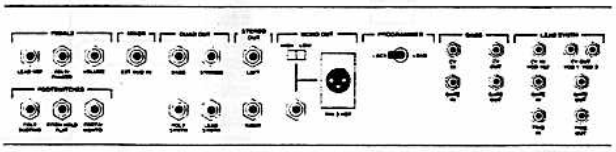


Fig. 2.3 A Instrument Structure and Evolution

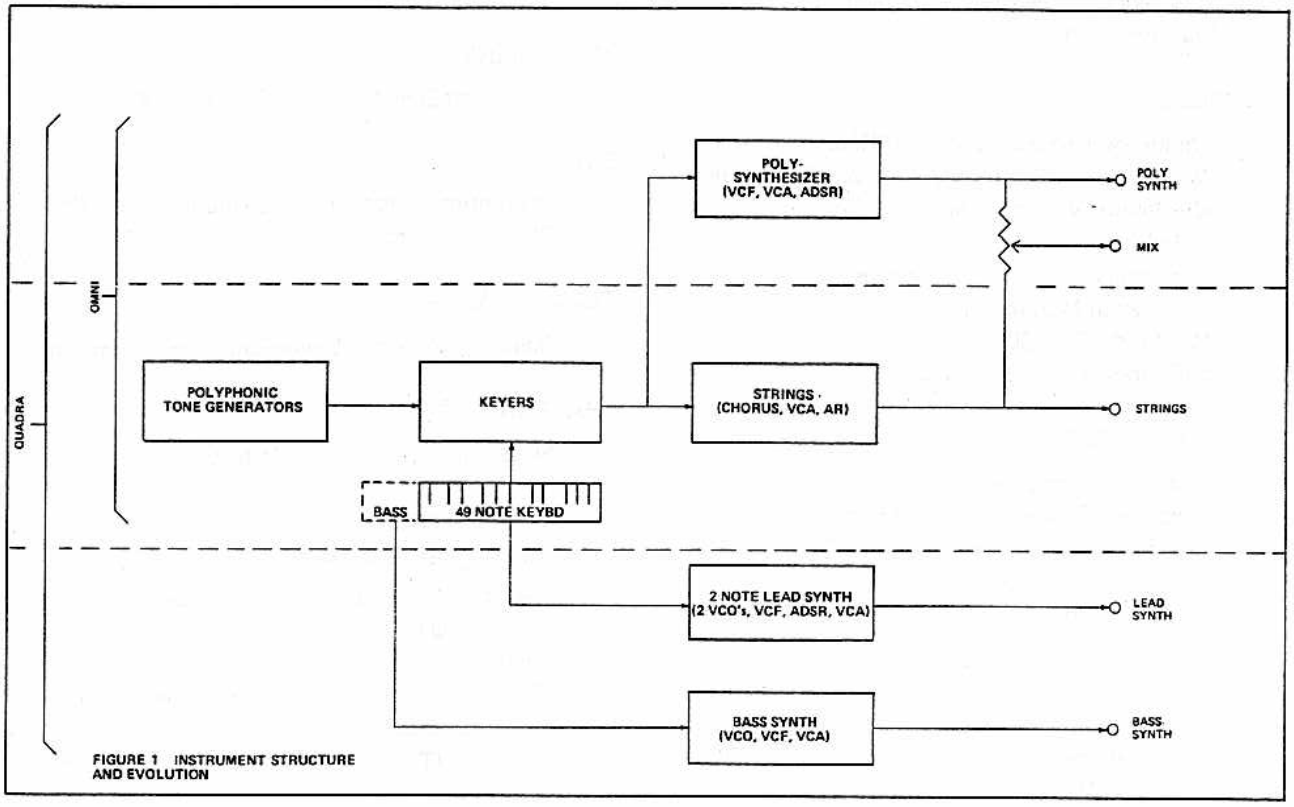


FIGURE 1 INSTRUMENT STRUCTURE AND EVOLUTION

Fig. 2.3 B Functional Block Diagram of Microcomputer Controller

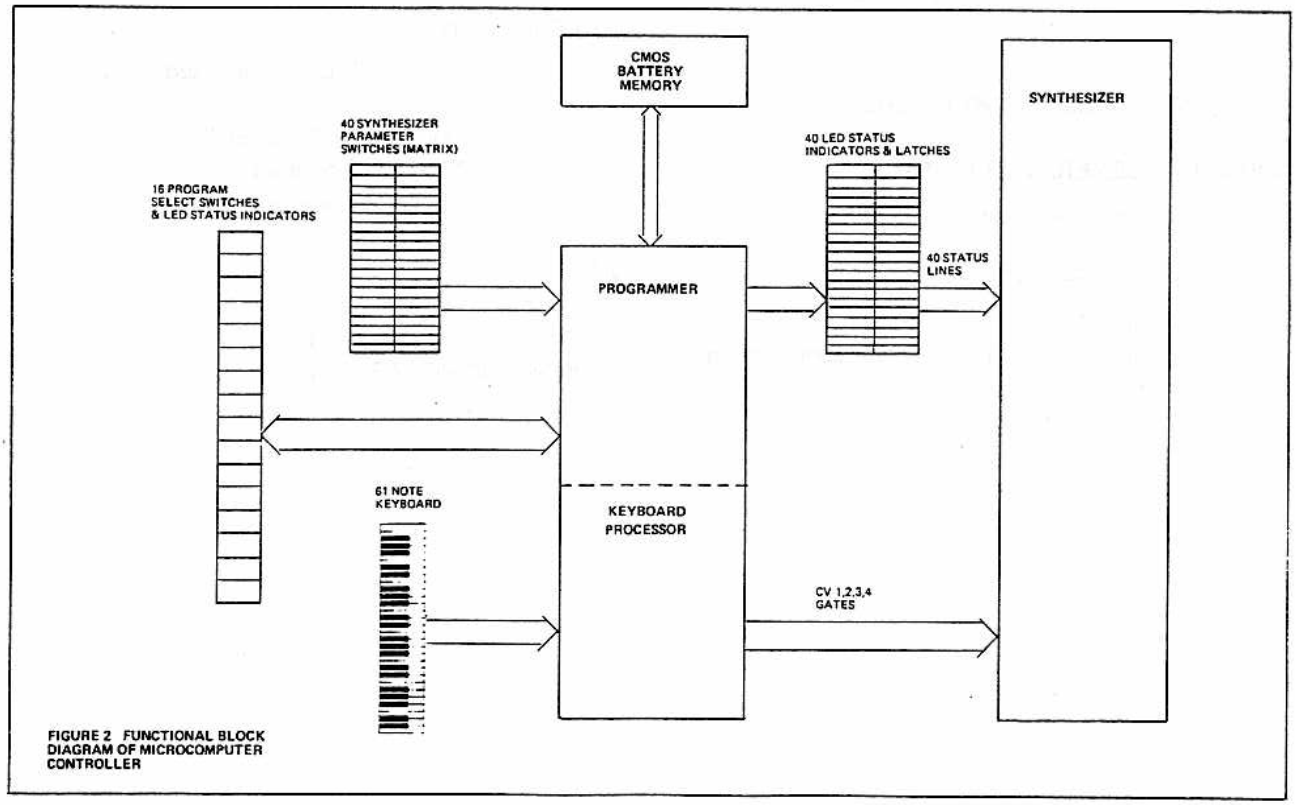


FIGURE 2 FUNCTIONAL BLOCK DIAGRAM OF MICROCOMPUTER CONTROLLER

2.1 Function Description

Figure 2.1 describes some of the Quadra's front panel controls. More information on the specific operation of the circuits can be found in the circuit descriptions in Section 3.

The ARP Quadra has been designed so that the variable option sliders are normally positioned at mid-range. This way, the user can obtain two distinct effects when selecting the touch switch, thus eliminating the need to change the slider setting to achieve a different effect. The orange dots on the front panel indicate the preset position of the slider.

2.2 Simplified Block Diagram

The SIGNAL FLOW BLOCK DIAGRAM shown in figure 2.3 shows the arrangement of the Quadra's four synthesizer sections and their audio paths, plus each block contains in the lower right hand corner a quick page reference to the location of the schematics.

The MICROCOMPUTER BLOCK DIAGRAM shown in figure 2.4 shows the extent of which the 8048 Microcomputer is used in the analog section. It is similar in layout to the actual schematic found on page 27-28 . From the block diagram it can be noted that the two primary outputs of the Computer section are via the "Digital to Analog" circuits which provide keyboard control voltage data and via the "LED Latches and Switches" which are used to control the 40 synthesizer parameters. The following section on Microcomputer Theory has been provided to furnish background on the operation and organization of Microcomputers, especially as applied to the ARP Quadra.

2.3 Microcomputer Theory

The Quadra's Microcomputer section has been designed to operate many of the instrument's controllers. It has been mentioned previously that the two chief functions of the Microcomputer are: 1) Read the 40 parameter switches and write the appropriate data which corresponds to the switch selected, and 2) Read the keyboard and note any keys depressed so that this data can be written to the appropriate synthesizer section.

These operations are called routines; the Quadra's microcomputer performs eight sequentially executed routines, and are shown in the Solftware Flow Chart, figure 3.3. Note that all eight routines are performed within a 20ms. period, the time it takes to perform one full program cycle. The Microcomputer is operated by a 6mhz crystal oscillator; all timing is derived from this clock.

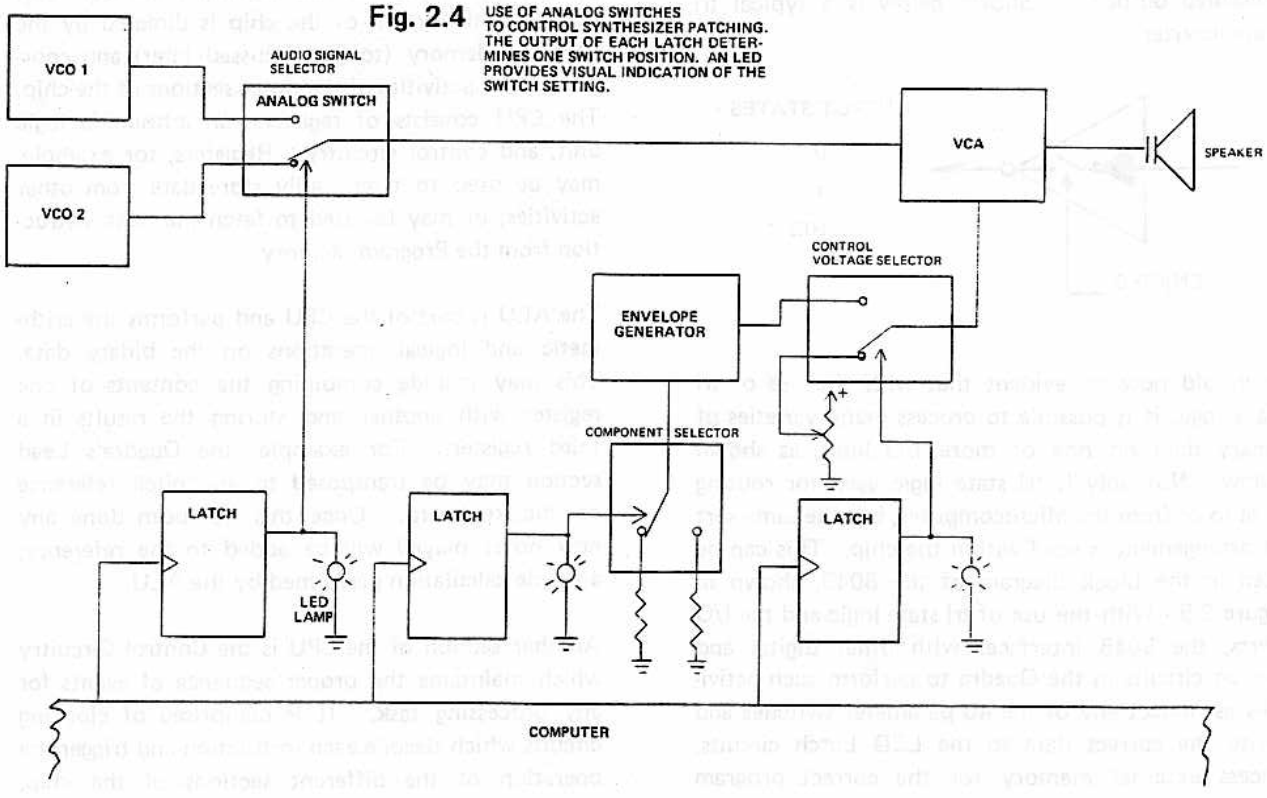


Fig. 2.4 USE OF ANALOG SWITCHES TO CONTROL SYNTHESIZER PATCHING. THE OUTPUT OF EACH LATCH DETERMINES ONE SWITCH POSITION. AN LED PROVIDES VISUAL INDICATION OF THE SWITCH SETTING.

The device which directs many of the controlling features on the Quadra is the Intel 8048 Microcomputer. It is called a microcomputer instead of a microprocessor because it contains an "on chip" program READ ONLY MEMORY. This ROM has been programmed by our factory to perform a specific set of routines and is, therefore, unique in its performance. A standard microprocessor chip, such as the popular 8080, requires the use of an "outboard" memory to perform a fixed set of routines.

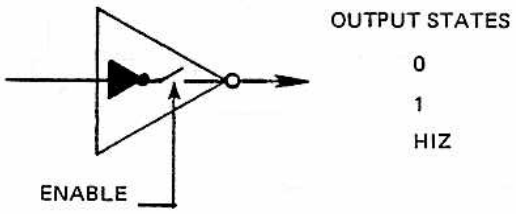
Following is a short description of microcomputers emphasizing the 8048 and how it is used in the Quadra.

Like most computer systems the Intel 8048 Microcomputer contains:

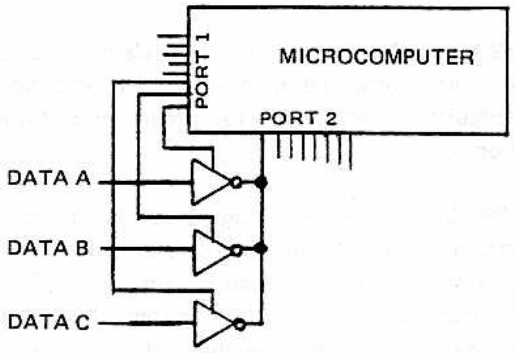
1. Input/Output Ports (24)
2. A Central Processor Unit (CPU)
3. Data Memory (64 X 8)
4. Program Memory (1024 X 8)

2.3.1 I/O PORTS

The I/O Ports connect the 8048 to the outside world; they route data to or from the microcomputer and are thus bidirectional. With the use of TRI STATE LOGIC, it is possible to connect many devices to the same I/O line. A Tri State device can produce three possible output states: logic 1, logic 0, or with the use of a special enable pin, it produces a high "Z" output (sometimes called "disabled output"). Shown below is a typical tri state inverter:



It should now be evident that with the use of tri state logic it is possible to process many varieties of binary data on one or more I/O lines, as shown below. Not only is tri state logic used for routing data to or from the Microcomputer, but the same sort of arrangement is used within the chip. This can be seen in the block diagram of the 8048, shown in figure 2.5. With the use of tri state logic and the I/O Ports, the 8048 interfaces with other digital and analog circuits in the Quadra to perform such activities as detect any of the 40 parameter switches and write the correct data to the LED Latch circuits, access external memory for the correct program selection, and scan the 61 note keyboard for any keys depressed.



Shown above, Port 1 is being used to access data on to one of the I/O lines of Port 2. It can be said that Port 2 is "time shared," since only one activity will be processed on the I/O line at a time.

It is possible for the 8048 to process a greater amount of data on its I/O lines with the use of an 8243 Port Expander: this allows 4 of the 8 bits of Port 2 of the 8048 to be expanded to 16. The 8243 Port Expander contains 4 groups of 4 bits each, which according to the instructions provided by the 8048, can route one of its 4 bit ports to the Microcomputer. More information on the 8243 Port Expander is listed in the circuit descriptions in Section 3.1.

2.3.2 CPU

Data which enters the microcomputer via the I/O ports is processed by the Central Processor Unit (CPU). This section of the chip is directed by the Program Memory (to be discussed later) and coordinates the activities of the other sections of the chip. The CPU consists of registers, an arithmetic logic unit, and control circuitry. Registers, for example, may be used to temporarily store data from other activities, or may be used to fetch the next instruction from the Program Memory.

The ALU is part of the CPU and performs the arithmetic and logical operations on the binary data. This may include combining the contents of one register with another and storing the results in a third register. For example, the Quadra's Lead section may be transposed to any pitch reference on the keyboard. Once this has been done any new notes played will be added to the reference, a simple calculation performed by the ALU.

Another section of the CPU is the Control Circuitry which maintains the proper sequence of events for any processing task. It is comprised of clocking circuits which decode each instruction and trigger the operation of the different sections of the chip.

2.3.3 DATA AND PROGRAM MEMORY

The Data Memory is a special kind of addressable register which contains 64 locations of 8 bit words, called bytes. Any one of the 64 locations can be "read" or "written." It usually holds intermediate data that will be called up by an address register at a later period.

Program Memory, on the other hand, is data that has been programmed by the Factory and contains 1024 locations of 8 bit words. It is addressable by a program counter and is responsible for sequentially executing the software routine shown in figure 2.6.

2.3.4 MICROCOMPUTER SUMMARY

The CPU, 64 X 8 Data Memory, 1K X 8 Program Memory, and Control Circuitry descriptions were presented for the purpose of familiarizing the repair technician with the contents and features of the 8048 Microcomputer. From a troubleshooting standpoint, it provides little insight for identifying a particular problem. However, it should be noted that the basic components of the microcomputer are arranged for the purpose of accepting data for processing (referred to as READ cycle) and sending data for controlling (referred to as a WRITE cycle), all of which is performed via the microcomputer's I/O lines. The 8048 Microcomputer contains 24 I/O lines, arranged in 3 groups of 8 bits. A read or write cycle is often performed in two steps: first an address is presented which is binary data used for selecting a particular location, then data is presented which could be going to or coming from that location.

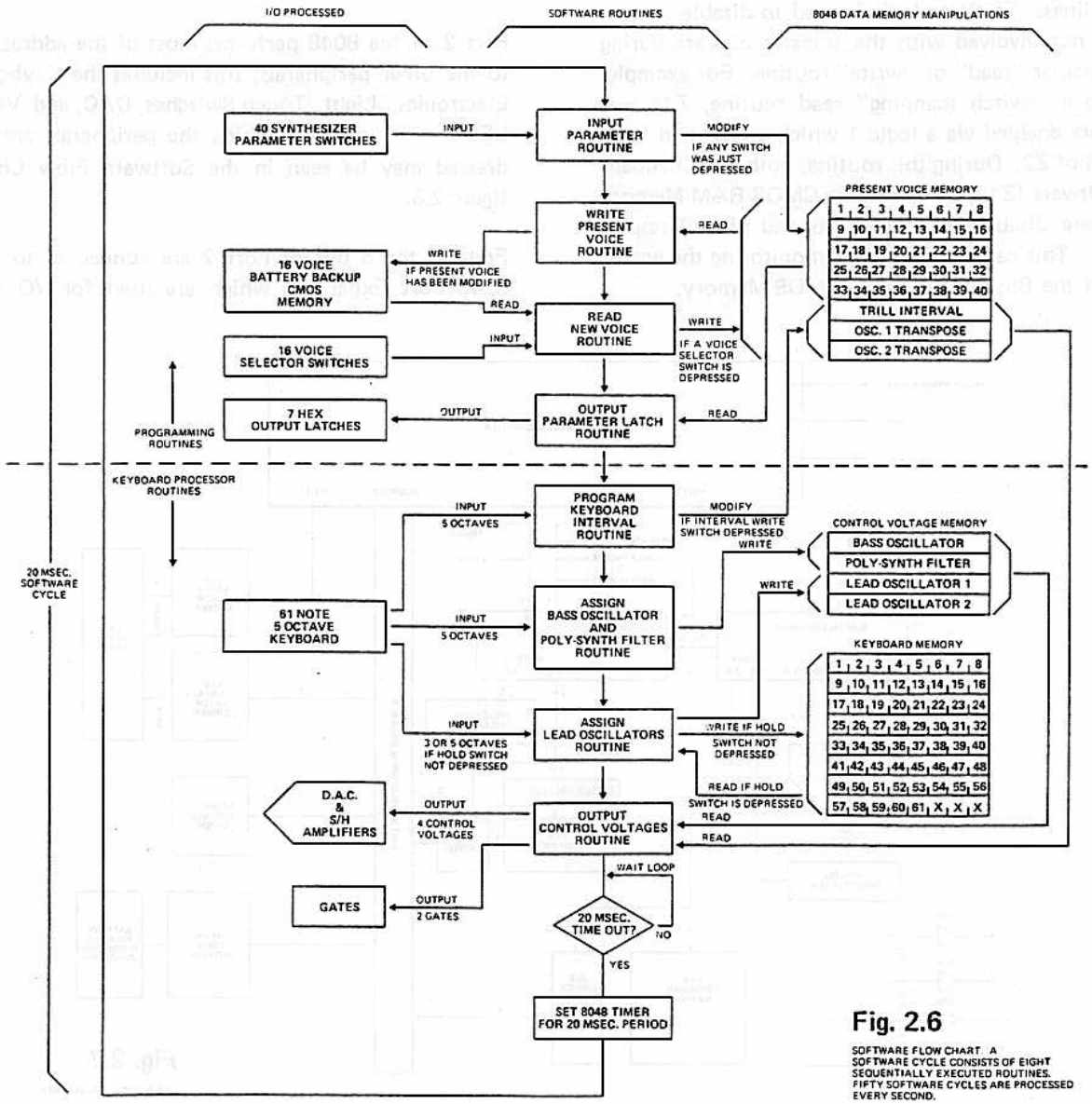


Fig. 2.6

SOFTWARE FLOW CHART. A SOFTWARE CYCLE CONSISTS OF EIGHT SEQUENTIALLY EXECUTED ROUTINES. FIFTY SOFTWARE CYCLES ARE PROCESSED EVERY SECOND.

3.1 Microcomputer

The Intel 8048 Microcomputer and associated peripherals, Light Touch Switch Panel, Keyboard Electronics, DAC Circuits, and Hex Latch Circuits make up the computer control system for the Quadra. Most of these peripherals can be seen on the Microcomputer Block Diagram shown below.

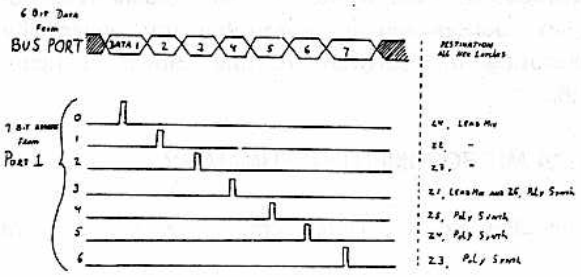
The 8048 Microcomputer, which performs the routines in the order listed in figure 2.6, contains 3 groups of 8 bit ports: Bus Port, Port 1, and Port 2. (More information on the 8048 can be found in Section 2.3 of this manual or from the "Intel MCS-48 Users Manual.")

3.1.1 BUS PORT

The 8 bit Bus Port is bi-directional, meaning data can be transferred to or from the Microcomputer on these lines. Tri State logic is used to disable components not involved with the transfer of data during a particular "read" or "write" routine. For example, during a "switch scanning" read routine, Z11 and Z12 are enabled via a logic 1 which is supplied from Port 6 of Z3. During this routine, both the Keyboard Bus Drivers (Z12, Z13) and the CMOS RAM Memory (Z7) are disabled via pin(s) 16 and pin 19 respectively. This can be verified by monitoring the enable line of the Bus Drivers or the CMOS Memory.

3.1.2 PORT 1

Port 1 of the 8048 is singularly dedicated to clock the 6 bit data from the Bus Port to the Hex Latches. Note that only seven of the 8 bits are used from Port 1 and that each bit is connected to a different Hex Latch. A timing diagram is presented below which shows the changing switch data on the Bus Port and which hex latch is used.



3.1.3 PORT 2

Port 2 of the 8048 performs most of the addressing to the other peripherals; this includes the Keyboard Electronics, Light Touch Switches, DAC, and Voice LEDs. The order in which the peripherals are addressed may be seen in the Software Flow Chart, figure 2.6.

Four of the 8 bits of Port 2 are connected to two 8243 Port Expanders which are used for I/O port

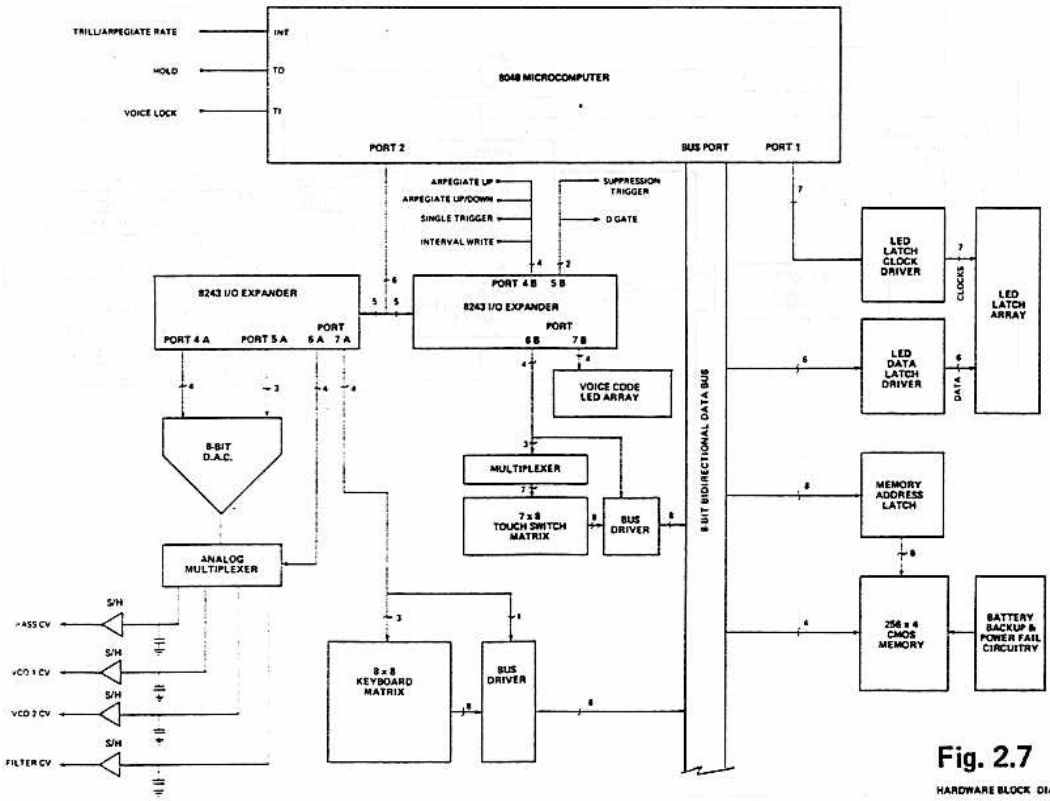


Fig. 2.7
HARDWARE BLOCK DIAGRAM

expansion. With the use of the "chip select" and a special input pin labeled "PROG," data can be READ or WRITTEN to one of 8 different 4 bit ports.

Each transfer of data consists of two 4 bit nibbles. The first nibble contains the OPERATION CODE and ADDRESS, the second nibble contains the actual DATA.

With the exception of Z3 Port 4, all Microcomputer data on Port 2 is "outgoing." The three remaining bits of Port 2 are used for enabling the Port Expanders and the CMOS RAM Memory (Z7). The purpose and destination of the Port Expanders is described below.

3.2 Keyboard Electronics

The Keyboard provides (for the Microcomputer) a series of digitally generated data which is later converted to control voltages with the use of an "outboard" digital to analog converter (referred to as DAC). The Microcomputer arranges the keyboard data so that multiple control voltages can be generated that correspond to the notes on the keyboard. The keyboard is scanned by the Microcomputer once every 20ms., the time it takes to complete one program cycle. Keyboard data is fed to the Microcomputer via the 8 Bit BI-DIRECTIONAL DATA BUS. The Microcomputer can only "read" 8 keys at a time. Therefore, the 61 keys are arranged in matrix form (see sample keyboard matrix below), whereby the keyboard is grouped into 7 sections of 8 keys each, plus one section of 5 keys. Each of the 8 keys in a section is fed to one of the 8 Bit Bus Lines, the same is done for the next section, and so on.... During one designated portion of the Microcomputer 20ms. cycle time, each of the 8 sections of keys are "read" one at a time, until all the keys are read. Note that only one section of keys are read at a time while the other 7 sections are disabled from the 8 Bit Data Bus with the use of tri state drivers (Z12-Z22, CD4503-see Computer Theory section for explanation of this device). It should now be obvious that although certain groups of keys are tied together with other sections and connected to the same Bus Line, only one key will be active on that line at a time.

The 8 sections of the keyboard are enabled by a CMOS multiplexer (Z3, CD4051) which is driven by 3 bit binary data generated by the Computer, via Z2 (8243 Port Expander, Microcomputer Board). The keyboard data which is read by the Microcomputer is labeled MNEMONICS E-M and enters the Microcomputer bus as mnemonics KDO-KD7. The data used to address the keyboard electronics is labeled KDADDO-KDADD2 and enters the keyboard electronics via Z24A, Z24B, and Z24C.

3.3 Lead Mix

3.3.1 LEAD AND SWITCH LATCH

The LED and Switch Latch circuitry provides digitally generated information from the Microcomputer which will be used to control certain synthesizer parameters, and turn on the appropriate LED indicator. When the Microcomputer detects a depressed switch, it will "write out" via bus "A through F" the appropriate logic level to the D input of four hex D-type flip flops (Z1-Z4). This information is then strobed (transferred) to the Q outputs of the appropriate D-type flip flop by a strobe pulse; only six functions are initiated from each strobe pulse, and only one hex D flip flop is strobed at a time. A logic 0 on the Q output of the hex D flip flop indicates that a synthesizer function is enabled.

3.3.2 PHASE SHIFTER SWITCH MATRIX AND PREMIX

This circuit controls the final destination of the four audio sections: LEAD, POLY, STRINGS, and BASS. These audio signals may be routed to the Phase Shifter circuits or directly to the output mixers and VCAs. The audio routing is controlled by four FET switches (Z13, Z14). A logic 1 (+5V) on the gate input of a FET switch routes the audio signal to the output mixer and VCA. A logic 0 (ground or 0V) routes the audio signal to the Phase Shifter circuits via Z15B. NOTE: All FET switches are shown in the de-energized position (logic 0).

3.3.3 PHASE SHIFTER SWEEP GENERATOR

The Sweep Generator circuits provide a low frequency triangle waveform control voltage which is used to regulate the speed of the phase shifter network. The sweep generator is a standard low frequency oscillator. The LFO produces a triangle and square wave which ranges in frequency from about .1Hz to 25Hz. C17 and Z12B are an integrator which charges from current passing through R70, R72 and Z13A. NOTE: The speed of the LFO is controlled by R70 (Phase Shifter Sweep Speed Slider). Z12A is a hysteretic switch whose output switches from -12 to +12V. This reverses the direction of current passing through R70 which changes the direction of integration at the output of Z12B. When the output of Z12B reaches -5V, the output of Z12A switches from +12, back to -12 which reverses the direction of current through R70 and thus the cycle repeats. Z13A is used to slow the speed of the LFO when

resonance is selected. This is accomplished by applying +5V to the gate input of Z13A which switches in feedback current to the integrater via R71 (220K resistor) instead of R72 (120K resistor).

3.3.4 PHASE SHIFTER SAMPLE AND HOLD

The Sample and Hold circuit provides a semi/random DC control voltage which is used to vary the tuning of the Phase Shifter.

VCO 2 is applied to Z56A and is sampled and stored on C114 when Z59A-13 is triggered by the LFO square wave. The LFO is fed to Z59A via C112 and R308 which results in producing two trigger pulses for only one cycle of LFO squarewave. The result is: VCO 2 is sampled both on the positive and negative swing of the LFO. Z60 provides this DC control voltage to the Phase Shifter Modulation Select Circuit.

3.3.5 AS/ASR ENVELOPE GENERATOR

The ADS/ASR Envelope Generator produces a positive going DC control voltage which is used to control the Lead VCF cutoff and the Lead VCA. It is initiated from the Lead Gate voltage which is also used to initiate a second gate. This second gate, which is delayed approximately 1.5 seconds from the Lead Gate, is used to create a second "attack" envelope, thus producing an envelope as shown below (fig. A) It should be noted that this second attack envelope can be eliminated by selecting the VAR DECAY touch switch, thus producing a new envelope as shown below (fig. B).

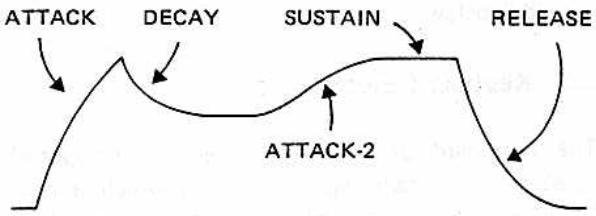
As in any envelope generator, the time constant is controlled by providing certain charge and discharge paths for the envelope's charge capacitor, in this case, C115. Note that only one charge or discharge path will be enabled at a time.

ATTACK

The Lead Gate enters the ADS/ASR circuit from the GATE/TRIG PROCESSOR, via Z64D, which switches from 0 to +12 volts; thus Z73C-11 goes from logic 1 (+12 volts) to logic 0 (0 volts). Z73C, in turn, shuts off switch Z72C (release path) and a logic 0 is routed to Z73B-5. Z73B-6 is logic 0, thus Z73B-4 goes to logic 1 which closes switch Z71D and C125 charges toward 12 volts via R376 (attack slider) or via Z71C. For example, if the VAR ATTACK touch switch is selected, switch Z71C opens and C125 charges via R376. The ADS/ASR output is taken from Z70A and routed to the VCF, via Z70A-1 (TP-16), and VCA, via Z70B-7.

DECAY

The decay path is controlled by switch Z72D, which in turn is controlled by Z69A. Z69A is used as a peak voltage detector, its output is connected to Z73B-6 and Z72D (decay path switch). Z69A-3 is connected to the ADS/ASR output so that when the voltage on pin 3 exceeds approximately 8 volts, Z69A-1 goes high which opens switch Z71D (attack path) via logic 0 at Z73B-4. At the same time, switch Z72D closes, thus C125 discharges to the voltage level set on Z68A-6 which is determined by the VAR DECAY touch switch (see VD, sustain low) which closes either switch Z71A or Z71B.



ATTACK-2

Approximately 1.5 seconds after the Lead Gate enters the envelope generator, the DELAYED gate enters the envelope generator circuit via Z73A. The delayed gate is used to recharge C125 to approximately 8 volts, thus creating a second attack voltage (NOTE: if the VAR DECAY touch switch is selected, the second attack voltage is disabled via Z74A, thus preventing Z74B from switching to logic 0). Z74A-3 (delayed gate output) is set to logic 1 which is fed directly to Z74B, whose output is set to logic 0; this delatches Z72D (which was held on via Z69A) and C125 charges back up to 8 volts via logic 1 (12 volts) on Z74C-10, R378, CR50, and R381.

VAR DECAY SLIDER SWITCH

Note that when this switch is selected, Z74A prevents Z74B from switching to logic 0, thus Z72D (decay path switch) is held closed via Z69A and the ADS/ASR envelope is allowed to decay to a lower sustain level which is set on Z68A-6. This sustain level is determined by Z74A which closes either switch Z71A or Z71B, thus providing one of two possible voltages to Z68A. For example, when the VAR DECAY slider switch is selected, the lower sustain level is selected (via Z71B).

RELEASE

Once a key is released, Z73C returns to logic 1 which turns on switch Z72C (via GATE) and thus allows C125 to discharge to ground via Z72C, Z72B and R383. If the VAR RELEASE slider switch is

selected, C125 discharges to ground via Z72C, Z72A and R383. Also note that when a key is released, Z69A is "clamped" to 0 volts via GATE (12 volts) to CR55 and R387, thus switch Z72D opens which insures only one release path is provided for C125.

3.3.6 WAVEFORM GENERATOR AND SWITCHING

VCO 1 and VCO 2 are summed together at the Waveform Generator and Switching circuit before being processed by the Lead VCF. Z61A and Z61D are open collector comparators which monitor both sawtooth and pulse wave summing junctions for VCO 1 and VCO 2. For example, note that if logic 1 (+5 volts) is present at saw enable, the sawtooth summing junctions for VCO 1 and VCO 2 are grounded, via Z61D-13. Pin 4 of Z61A and pin 10 of Z61D are connected to the LED and Switch Latch circuits, which are controlled by the computer. (Note that pulse enable and saw enable will always be opposite logic states.) Z61B and Z61C convert the sawtooth of VCO 1 and VCO 2 to pulse waves. The pulse width (comparator switching point) is determined by the voltage level on Z56B-7. This voltage level is determined by the selection of the CD4016 switches in the Pulse Width CV Generator circuit. The selection of the CD4016 is determined by the LED and Switch Latch circuits, which is controlled by the Computer.

3.3.7 PITCH/HOLD FLAT

This circuit, which is only operated with the footswitch, is used to either disavle the computer from acquiring new pitch and gate information for the Lead synthesizer, or is used to shift the Lead CV down one semitone from its originally acquired voltage.

If the Hold/Flat switch is selected for "Flat," Z54B-7 provides a rising control voltage when J22-4 (footswitch voltage) switches from approximately +1 volt to 12 volts. CR58 is reverse biased and Z55B is switched on via R306. R306 is connected to the LED and Latch circuit (shown as H). Thus when the footswitch is depressed, C132 charges to 5 volts, and Z54B routes this voltage to the VCF CV processor (sht. 4 of 4) and Lead VCO CV Sum circuits.

If the Hold/Flat switch is selected for "Hold," the junction of R306 and Z59D-11 is logic 0 (0 volts) and Z59D is switched on when the voltage on Z59-12 switches to +12 volts; thus the Computer does not "write" new Lead CV or Lead Gate information when the footswitch is depressed, but continues to output the last note or sequence of notes that was played. The Computer receives this "hold" information via J18-3.

3.3.8 MODULATION SELECT

The voltage controlled phase shifter may be modulated from 4 separate control voltage sources: LFO SWEEP GENERATOR, SAMPLE AND HOLD, ENVELOPE GENERATOR, and FOOT PEDAL. The last three may be selected simultaneously. If no modulation is selected from the front panel, the sweep generator is automatically selected. Z26 (CD4016) is used to switch the desired control voltage to the Phase Shifter; the control voltage typically ranges between 0 and 25 mV.

3.3.9 POLY VCF CONTROL

Pedal and keyboard control voltages are routed to the Poly VCF via Z17A. Note that the pedal CV is routed to the Poly VCF only when the Phase Shifter is selected for pedal control. The maximum control voltage output from ZI7A with full pedal control is volts.

3.3.9 INPUT BUFFERS

The Quadra's four section outputs are capacitively coupled to separate buffer amplifiers before they are routed to the quad output jacks, phase shifter, and output mixers. Each output can be individually adjusted for amplitude at Z9 and Z10. The typical output level ranges from 3 to 12 volts P-P. Z19A is used for accepting external audio signals from other instruments and is routed directly to the output mixers.

3.3.11 LEAD LFO

The LFO produces a triangle and square wave output in frequency ranging from .1Hz to 25Hz. Z67B and C127 are an integrator switch whose output switches from -12 volts to +12 volts when the output of Z67B reaches +5 volts. This change in output polarity reverses the direction in current passing through R399 and the rate control slider (R397) and thus the direction of integration at Z67B. When the output of Z67B reaches -5 volts, the output of Z67A switches back to -12 volts and the cycle repeats. Z65C, Z65D, and Z66B comprise a standard differential VCA which passes the LFO triangle wave when a negative voltage is applied to R403. The negative going voltage reappears approximately 1sec after the initial key depression, thus producing a delayed LFO triangle of approximately 5 volts P-P at Z66B.

The triangle wave output at Z66B is fed directly to both Lead VCOs while the square wave output at Z67 is fed directly to the Phase Shifter Sample & Hold.

3.3.12 LEAD VCA

Audio signals of approximately 2 volts P-P from the Lead VCF enter the VCA circuit via R345. Z66B and Z66A comprise a standard differential voltage controlled amplifier whose output is determined by the amount of negative voltage applied to R417 and R347. Once equal current is adjusted through Z65A and Z65B with R350 (control voltage rejection trimmer). changes in voltage at the base of Z65A cause a change in differential current at Z66A. This is amplified by Z66A and converted to a voltage. The typical output at Z66A (TP14) of .5 volts P-P, is fed to the input buffer circuits (page 11) and then the final output mixers.

3.3.13 LEAD VOLTAGE CONTROLLED FILTER

Two Lead VCOs are summed into the audio input of the VCF (M1, pin 1). M1 is a 4075 low pass voltage controlled filter which has a 24db/octave cutoff with manual control of resonance. The VCF accepts negative control currents on pin 4 to control the filter cutoff point. Z63 sums and inverts all voltages used to control the cutoff point. The output of Z63 ranges from -8 to -11 volts. R340, control voltage rejection trimmer (CVR), is adjusted to prevent DC control voltages from mixing with the filtered audio output at pin 10. The VCF output is typically 1.5 volts P-P.

3.3.14 PHASE SHIFTER ENVELOPE GENERATOR

This envelope generator produces a preset fast attack/long decay envelope which is used to vary the tuning (when selected) of the Phase Shifter Network. It can be initiated from either Bass Gate (first 25 keys only) or Lead Gate (all 61 keys). For example, if the Bass is routed through the Phase Shifter, the rising edge of the Bass Gate is capacitively coupled via C28 to Z18C, thus producing a negative going pulse on pin 10 of Z18C. This negative going pulse (approx. 20ms.) momentarily turns on Q1, via Z18D, which charges C30 to -12 volts. C30 then slowly discharges through R149 and R150 to ground. If the Phase Shifter Bass Voice is not selected, the rising edge of the Lead Gate is capacitively coupled through C29 to Z18A, generating a similar negative going pulse on Z18C-10.

3.3.15 OUTPUT MIXERS AND VCA

Three special VCA circuits are employed in the final mix section of the Quadra. They are: LEFT OUTPUT, RIGHT OUTPUT, and MONO OUTPUT. All three VCAs are controlled by Z11B (Volume Pedal Buffer) which produces a variable voltage from 0 volts (no gain) to -11 volts (maximum gain).

For the purpose of explanation, the LEFT OUTPUT VCA will be discussed.

A standard differential amplifier is employed, made up of Z24B, Z20A, Z20B and Z20E. Audio signals enter the VCA circuit at Z20A via Z19A. The gain of the VCA is determined by the amount of current drawn through Z20E and R120, which is controlled by the voltage on Z11B-7. One leg of the differential amplifier is tied to the inverting input of Z24B, while the other leg is tied to the noninverting input. This means that the difference in the voltage caused by the overall changes in current drawn through Z20E will cancel, and only the difference in voltage caused by the application of audio to one leg of the differential amplifier will be amplified. This VCA circuit also employs four additional transistors (Z19A, Z19C, Z20C, and Z20D) and is commonly referred to as a "Gilbert Cell" VCA. This circuit provides a wider range of distortion-free amplification than the standard differential amplifier.

Note that if one of the Phase Shifter Voices is selected, the signal is rerouted to the Phase Shifter, via P40-16, and summed directly to the LEFT, RIGHT and MONO VCA input, via P40-14 and P40-15.

3.3.16 VOLTAGE CONTROLLED OSCILLATORS

The Lead VCOs and the Bass VCO operate identically, therefore, references will be made to VCO 1 only.

Control voltages from the Pitch Bend, Keyboard, and Pitch Flat are summed to the inverting input of Z52A and are used to control the frequency of the VCO. Only positive control voltages are supplied to the base of Q5/Q6, (linear voltage to exponential current generator). For every volt applied to the control input, Q6 will conduct twice as much, the result: the frequency of VCO 1 will double per one volt applied. C108 is the integrating capacitor, it is initially charged from Q7 and discharges through Q6 to ground. The conduction of Q6 determines the rate of discharge and, therefore, the period of oscillation. Q8 buffers the discharging voltage from C108 and supplies it to a hysteretic comparator, Z57A and Z57B. Pin 2 of Z57A is normally at +6 volts; when the voltage on pin 4 of Z57B drops below this 6 volt threshold, Z57A conducts, Q9 turns on Q7, pin 2 of Z57A rises to 11volts, and C108 rapidly charges back up until pin 4 of Z57B also reaches 11 volts, switching Z57A, Q9 and Q7 off. Then, C108 discharges through Q6 and the cycle repeats.

The resulting sawtooth waveform at pin 4 of Z57B is fed to a high speed op amp consisting of Z57C and D and Q10. This op amp inverts and level shifts the sawtooth. A 12 volt P-P sawtooth can be monitored at the emitter of Q10 (TP-7).

3.3.17 TRILL OSCILLATOR

The Trill Oscillator is used to set the rate at which VCO 1 and VCO 2 pitches alternate between two notes.

A low frequency 5 volt P-P square wave oscillator (comprised of Z54A, feedback resistors and C105) is fed to the Microcomputer, via Q17 and J18-6. Z54A produces a plus and minus 12 volt P-P square wave whose output depends on whether the reference voltage at pin 3 is greater or smaller than the voltage level on C105 which is being charged via the feedback current through R282 and R279. The output of Z54A changes state when the voltage on C105 exceeds the reference set on pin 3. Consequently, C105 charges to a new voltage level and the cycle repeats.

3.3.18 GATE/TRIG PROCESSOR

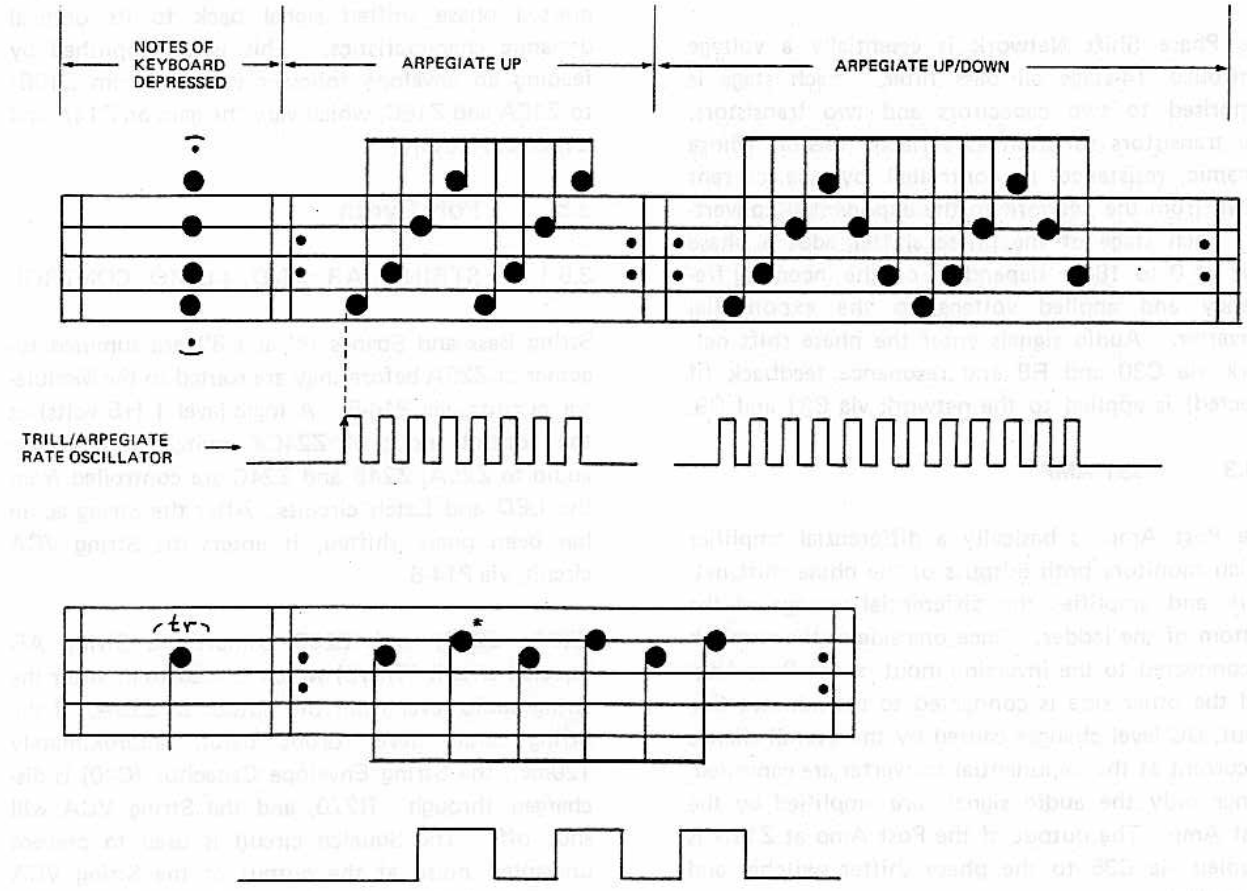
D GATE, which is provided from the Microcomputer, is used to develop both LEAD GATE and TRIGGER.

When a key is depressed, D GATE goes from 5 volts to ground, thus producing a +12 volt gate at Z64A. The output of Z64A is routed to the Gate Output jacks, via J31-6, (rear panel) and Phase Shifter Envelope Generator and reenters the Gate/Trig Processor, via J31-5. Z64B produces a -12 volt gate which is used to initiate both the Delayed Gate G Generator (via C116) and Lead ADS/ASR Envelope Generator (via R364 to Z64D). Z64C produces a +1ms. 12 volt pulse which is fed to the Trigger Output jack (rear panel).

3.4 Phase Shifter

The Phase Shifter consists of a compressor, phase shifter ladder network, amplifier, two expanders and mixing and routing circuitry. A voltage controlled current generator is also used to vary the amount of phase shifting from external sources such as the LFO.

Fig. 2.8 Keyboard Arpeggiate and Trill Functions



Sample and Hold, Pedal or Envelope. Resonance feedback may be switched in or out and its depth is manually controlled from the panel.

3.4.1 COMPRESSOR

The purpose of the compressor circuit is to provide constant signal levels to the phase shift network so that the optimum signal to noise ratio is achieved. The compressor circuit is comprised of a variable gain amplifier (Z12A), full wave bridge rectifier (Z12B), voltage follower circuit (C39, R32, and Z12B), and voltage controlled resistor circuit (Z16B, Z13A).

Audio signals enter the Compressor from J40 pin 16 and are amplified at Z12A and are inverted at Z12B. The inverted signal is routed to the phase shift network (via C30 and R8), while the noninverting signal at Z12A is routed to the phase shifter switcher and post mixer. Signals entering the compressor are automatically attenuated via C36 and Z16B. The equivalent resistance of Z16B is dependent on the level of envelope follower voltage from Z13B, hence constant signal levels are maintained at Z12A. Z13A is used to maintain the linear operation of Z16B.

3.4.2 PHASE SHIFT NETWORK

The Phase Shift Network is essentially a voltage controlled 14-stage all pass filter. Each stage is comprised to two capacitors and two transistors. The transistors function as variable resistors whose dynamic resistance is controlled by the current drawn from the network to the exponential converter. Each stage of the phase shifter adds a phase shift of 0 to 180 depending on the incoming frequency and applied voltage to the exponential converter. Audio signals enter the phase shift network via C30 and R8 and resonance feedback (if selected) is applied to the network via C31 and R9.

3.4.3 POST AMP

The Post Amp is basically a differential amplifier which monitors both outputs of the phase shift network and amplifies the differential voltage at the bottom of the ladder. Since one side of the network is connected to the inverting input of the Post Amp and the other side is connected to the noninverting input, DC level changes caused by the overall change in current at the exponential converter are cancelled. Hence only the audio signals are amplified by the Post Amp. The output of the Post Amp at Z11A is coupled via C35 to the phase shifter switcher and post mixer.

3.4.4 EXPONENTIAL CONVERTER

The purpose of the Exponential Converter is to vary the tuning of the phase shift network. Control voltages from J40 pin 7 are applied to the Exponential Converter via Z2A which, in turn, regulates the currents drawn through the two sides of the ladder. The center frequency is trimmed by R5.

3.4.5 PHASE SHIFTER SWITCHER AND POST MIXER

The purpose of the Phase Shifter Switcher and Post Mixer is to remix the signals from the compressor with the phase shifted signals from the phase shift network via the post amp. Note that the inverted and noninverted audio signal levels from the compressor are coupled to Z1C and Z1B respectively. The phase shifted signal from the post amp is also coupled to Z1C and Z1B via R54 and R53. If resonance is selected the phase shifted signal from the post amp is routed to Z1A via J40 pin 13, through the resonance slider to J40 pin 12, via R51. The phase shifted signal is also routed back to the phase shift network via R47, Z1D, Z11B.

3.4.6 EXPANDER

The purpose of the Expander is to restore the compressed phase shifted signal back to its original dynamic characteristics. This is accomplished by feeding an envelope follower voltage (from Z13B) to Z16A and Z16C, which vary the gain on Z14A and Z14B respectively.

3.5 Poly Synth

3.5.1 STRING AR AND AUDIO CONTROL

String Bass and Strings (4' and 8') are summed together at Z25A before they are routed to the Modulator circuits, via P14-5. A logic level 1 (+5 volts) at the control input of Z24C-6 switches the String audio to Z25A; Z24B and Z24C are controlled from the LED and Latch circuits. After the String audio has been phase shifted, it enters the String VCA circuit, via P14-6.

Z26A, Z26B, and Z25B comprise a String AR Squelch circuit (TP-12) which is used to monitor the string audio level from the output of Z25A. If the String audio level drops below approximately 120mv., the String Envelope Capacitor (C40) is discharged through R270, and the String VCA will shut off. The Squelch circuit is used to prevent unwanted noise at the output of the String VCA when the String audio decays below a certain level.

The String Envelope Capacitor (C40) charges from the AR Gate, via Z26C. Z28A routes this voltage to the String VCA (TP-13).

The lower section of the circuit (comprised of Z24D, Z24A, Z26D, and Z27A) is used to momentarilly discharge the residual voltage left on C40 from previously sustained notes. This assures a new envelope will be initiated for new keys depressed. This circuit is disabled when the Sustain Footswitch has been depressed (via 0 volts at Z24D-10). Z24D-10 is normally +5 volts.

3.5.2 STRING BASS WAVEFORM GENERATOR

The String Bass Waveform Generator operates similarly to the Electric Bass Waveform Generator. The difference is: the String Bass AR may vary in amplitude (depending on the position of the String Bass Volume Slider), where the Electric Bass Gate is a fixed voltage level. Therefore, the String Bass may be separately controlled for volume. The String Bass Output is fed to the String AR and Audio Control circuit, via R126 and R125.

3.5.3 GATE LOGIC

The purpose of the Gate Logic circuit is to determine, from the voices that have been selected, which envelope generator should be enabled. This is accomplished by combining the appropriate voice select logic levels with the Bass and Lead gates that are generated from the Computer. For example, the Poly ADSR will only be initiated if the Poly Synth 4' or 8' voice has been selected. The voice select logic levels enter the gate logic circuit from the LED and Switch Latch circuits and are labelled 4' Poly, 8' Poly, etc.... A logic 0 (zero volts) indicates the voice is selected. The 2nd Octave Gate and the Poly Gate enter the Gate Logic circuit from the Gate Generator circuit (Lower Voice Board). The Octave 1 Gate enters the Gate Logic circuit from the Keyboard Electronics circuit (Z24D).

3.5.4 ELECTRIC BASS WAVEFORM GENERATOR

The purpose of the Waveform Generator circuit is to shape the 8' and 16' pulse waves before they are processed by the Bass VCF. An 8' sawtooth signal enters the Waveform Generator from the Bass VCO and is converted to a pulse wave via Z14D. Z14D, an open collector comparator, provides a pulse wave only if the Electric Gate voltage (E.G. viz R22) and the 8' Electric Bass (8' EB via Z11C) is selected. The 16' square wave signal (which was divided from the 8' signal via Z13A) enters the Waveform Generator via Z11D when the 16' Electric Bass switch is selected. The pulse width of both the 8' and 16' Electic Bass is determined by the voltage on Z15 which sets the comparator threshold level of Z14D and Z14C. The voltage on Z15A varies with the AD envelope voltage, therefore, causing the pulse wave of the 8' and 16' electric to vary slightly in width with the AD voltage. The Electric Bass signals are summed together at C14 and are sent to the Bass VCF via Z15B.

3.5.5 TRIGGER LOGIC

The Trigger Logic circuit provides two timed pulses (Suppress Pulse and Blank Pulse) which are generated from the Computer's Suppress Trigger. The Suppress Trigger is a negative going 5 volt 15ms. pulse which is initiated upon every key depression, and enters the Trigger Logic circuit, via P15-9. It is used to generate the Suppress Pulse and Blank Pulse.

3.5.6 SUPPRESS PULSE

The Suppress Pulse is used to shut off the previously sustained notes when new notes are played in the String and Poly section. The Suppress Pulse is derived from Z16A-7, which produces a negative going 5 volt 25ms. pulse that is routed to the Suppression Trigger circuit (Lower Voicing Board).

3.5.7 BLANK PULSE

The Blank Pulse is used to limit the retriggering speed of the Poly ADSR. Z16B-10, which produces a positive 5 volt 20ms. pulse, is routed to the Poly ADSR.

3.5.8 BASS VCF

The Bass Voltage Controlled Filter, comprised of Z18 and C25, form a single pole low pass filter. The Electric Bass Waveforms (8' and 16') are routed to Z18 via R207. Z18 acts as a voltage controlled resistor, whose transconductance is controlled by the voltage at the gates (pins 3, 10). This initial conduction (or initial cut off frequency) is regulated by a closed loop stabilization circuit, comprised of Z17 and associated resistors. However, the dynamic operation of the filter cut off frequency is controlled by the application of positive envelope control voltage at the Z18, pin 3 and 10. The Bass VCF output (typically 1.5 volts P-P at TP-9) is routed to the final mix section via P15-3.

3.5.9 BASS AD GENERATOR

The Bass Attack/Decay Generator provides a positive envelope at TP-11 (5 volts) which is used to vary

the Bass VCF cutoff frequency and pulse width of the Bass Audio signal (Electric Bass Waveshape circuit).

A positive 12 volt gate enters the AD Generator at P15-6. Z22A produces a +12 volt gate which sets Z13B Q to 0 volts. This, in turn, switches on the P channel FETs at Z23 and capacitor C33 charges via R240. Z21B routes the positive envelope voltage (volts peak) to a comparator (Z22D). This causes Z22D-10 to go high which resets Z13B Q high. The result: Z23 P channels turn off the N channels turn on. C33 discharges through R243 (decay slider) and the N channel FETs to ground. When a key is released, Z22C turns on the lower N channel FET, which will quickly discharge the remaining voltage on C33 through R242 to ground. This means a complete new envelope is initiated when a new bass key is depressed.

3.5.10 STRING AND POLY OUTPUT VCAs AND FILTERS

Standard Gilbert Cell VCAs are employed here. Their operation is identical to the output VCAs on the Lead Mix Board. The String VCA control signal enters through R289, and the Poly VCA control enters through R318 from ADSR.

3.5.11 POLY ADSR

The Poly ADSR produces a positive going DC control voltage which is used to control Poly VCF and VCA. The ADSR is initiated from the ADSR Gate, which is derived from the Gate Logic circuit (sht. 2 of 2). Capacitor C61 is used to provide the variable RC times which make up the ADSR's envelope. As in the lead ADS/ASR, the Poly ADSR has fixed or variable charge and discharge paths which are controlled by the Computer, via LED and Switch Latch circuits. The fixed or variable ADSR settings may be selected from the touch switches on the front panel. The Poly ADSR uses a triple channel multiplexer/demultiplexer (CD4053BD) to provide the variable charge and discharge paths for C61. A quad CMOS bi-lateral switch (CD4016) is also used to select the appropriate discharge path of C61 during key RELEASE.

ATTACK

The ADSR Gate (logic 1 when selected) enters the ADSR circuit, via Z43C, which switches from logic 1 (5 volts) to logic 0 (0 volts) when a poly key (top three octaves) has been depressed. A logic 0 to the "inh" input of Z39 allows Z39-15 to switch to pin 1 or pin 2, depending on the logic level set on pin 10. In this case, the logic level on pin 10 of Z39 is presently 0, which allows C61 to charge via R363 (if Attack is set for A VAR), Z39-2, Z39-15 and R378. Also note that during the ATTACK portion of the ADSR, the RELEASE paths for C61 are disabled, via Z43D, which provides a logic 1 to Z42B and Z42C, which disables switch Z40B (variable RELEASE path) and Z40D (fixed RELEASE path). The ADSR output is routed to the Poly VCA and VCF Modulation Control circuit, via Z38A-1 (TP-19).

DECAY

The Decay path is controlled by Z39A-1 which, in turn, is controlled by Z41. Z41 is a peak voltage detector which monitors the ADSR output at TP-19; its threshold is set at approximately 3 volts so that when the ADSR output reaches this level, Z41-6 switches from low to high, thus providing a logic 1 to Z39-10. This, in turn, switches in the Decay path, via R367, R368 (if DECAY is set for D VAR), Z39B and Z39A. Note the DECAY path for C61 is via R365 (fixed DECAY) or R367 (variable DECAY), depending on the logic level on Z39B-9.

SUSTAIN

The Sustain level is determined by Z39C, which switches in a voltage level for Z38B, via R372 (variable SUSTAIN) or R371 (fixed SUSTAIN). Z38B is used to determine the level at which C61 is allowed to discharge to.

RELEASE

When a key is released, the Z43C-10 switches to logic 1 which "inhibits" Z39A, thus disabling the Attack and Decay paths for C61. Also, Z43D-11 returns to logic 0, thus enabling Z42B or Z42C, which provides the release path of C61 to ground, via switch Z40B (variable RELEASE) or Z40D (fixed RELEASE). (Maximum RELEASE time is dependent on the setting of the String Release slider and touch switch.) Z40C and Z40A are used in conjunction with the sustain footswitch which when selected (logic 1 to Z40C-6), provides a Release path via R386, Z40A and R375.

MULTIPLE TRIGGER

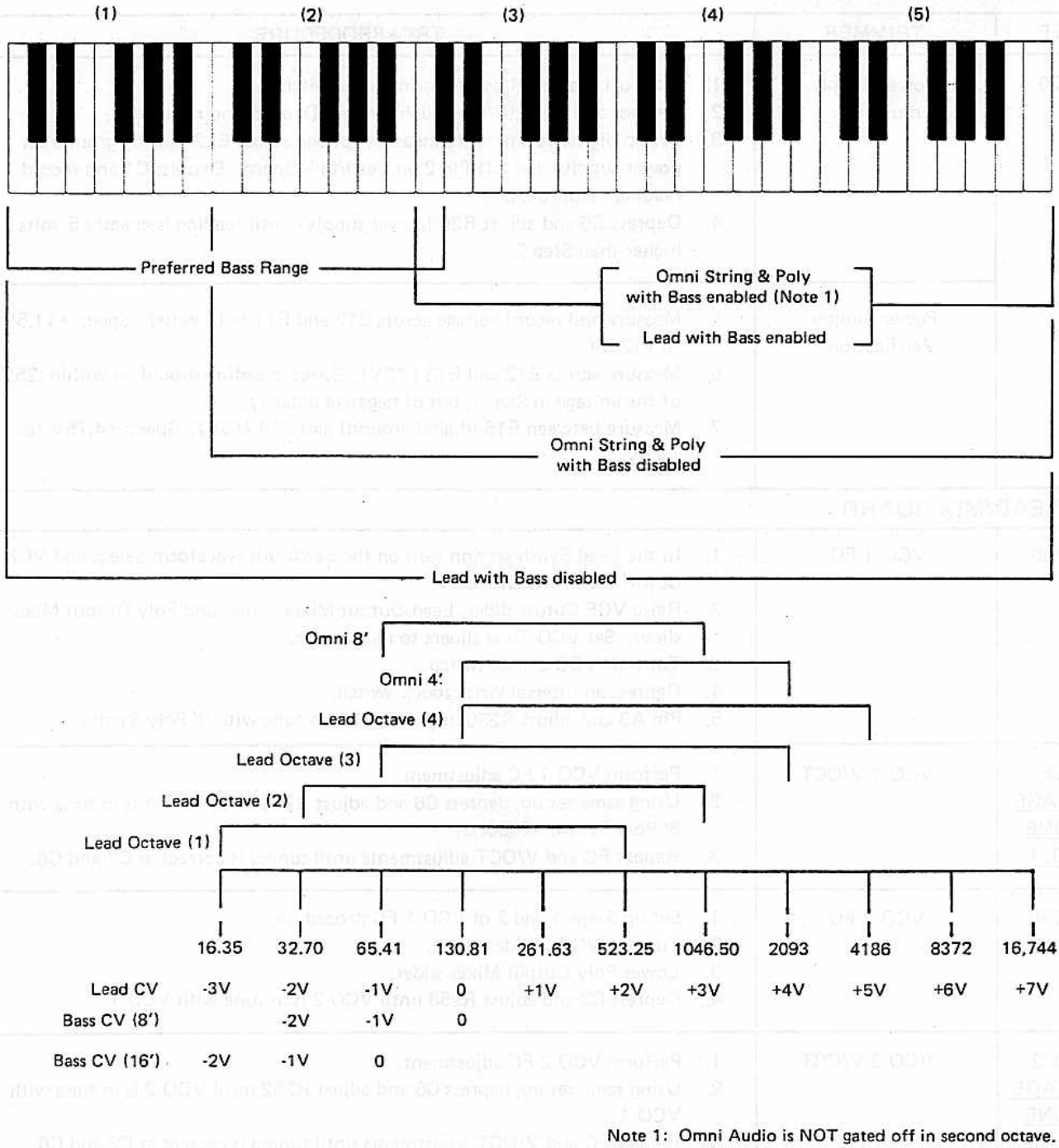
The Poly ADSR can be initiated on the first key depression only (single trigger) or multiple key depression, which depends on the logic level to Z42A-5. This level is selected by the Sing/Multi switch on the front panel. Z42A is disabled if the level at Z42A-5 is logic 1. If it is logic 0, Supp Trig and Blank momentarily produce a positive pulse which interrupts the ADSR Gate Voltage at Z43C, thus the ADSR cycle repeats.

3.5.12 BASS AR

The Bass AR Generator is initiated from the Bass Gate, which enters the circuit from Z22B-4. A +12 volt gate charges C31 from CR26 and R226. R227 (String Bass Volume Slider) routes the Bass voltage to Z21A-1 (TP-10) which, in turn, is fed to the String Bass Waveshaping circuit via mnemonic Bass AR.

3.5.13 POLY VCF

Both 4' and 8' poly signals are summed into the audio input of the VCF (M1, pin 1) via Z35A and Z35B. Z35A and Z35B are operated as SPDT switches whose control pins are pin 10 and 9, respectively. Z37B sums and inverts all voltages used to control the filter cut off point. The output of Z37B ranges from to volts. R356, control voltage rejection trimmer (CVR), is adjusted to prevent DC control voltages from mixing with the filtered audio output at pin 10. The VCF output (TP-17) is typically 1.5 volts P-P and is routed to the final mix section via mnemonic VCF to VCA.



Note 1: Omni Audio is NOT gated off in second octave.

SECTION 4 TRIM PROCEDURES

INCLUDED IN THE FOLLOWING TRIM PROCEDURES ARE FOUR "STAGE TUNING" PROCEDURES (MARKED STAGE TUNING NOS. 1, 2, 3 & 4). THESE CALIBRATIONS MAY BE PERFORMED TO "TOUCH UP" AN INSTRUMENT QUICKLY WHEN A FULL CALIBRATION IS NOT DEEMED NECESSARY (SEE PAGE 21).

POWER SUPPLY BOARD

REF.	TRIMMER	TRIM PROCEDURE
R20	Power Supply Adjust	1. Turn off Electric Bass and String Bass switches. 2. Depress an Interval Write touch switch. Depress and release C4. 3. Set up digital voltmeter to measure voltage across E12 (analog ground on power supply) and J31-Pin 2 on Lead/Mix Board. Depress C1 and record reading. (approx. 0V) 4. Depress C6 and adjust R20 (power supply) until reading is exactly 5 volts higher than Step 3.
	Power Supply Verification	5. Measure and record voltage across E12 and E11 (+12 volts). Spec: +11.5V to +12.5V. 6. Measure across E12 and E13 (-12V). Spec: Reading should be within .25V of the voltage in Step 7, but of negative polarity. 7. Measure between E15 (digital ground) and E14 (+5V). Spec: +4.75V to +5.5V.

LEAD/MIX BOARD

R230	VCO 1 FC	1. In the Lead Synth section turn on the Sawtooth Waveform Select and VCF Cutoff touch switches only. 2. Raise VCF Cutoff slider, Lead Output Mixer slider, and Poly Output Mixer slider. Set VCO Tune sliders to mid-position. 3. Turn off VCO 2 slide switch. 4. Depress an Interval Write touch switch. 5. Pin A3 and adjust R230 until VCO 1 is in tune with 8' Poly Synth.
R223 STAGE TUNE NO. 1	VCO 1 V/OCT	1. Perform VCO 1 FC adjustment. 2. Using same set up, depress C6 and adjust R223 until VCO 1 is in tune with 8' Poly Synth. (2080Hz) 3. Repeat FC and V/OCT adjustments until tuning is correct at C2 and C6.
R258	VCO 2 FC	1. Set up Steps 1 and 2 of VCO 1 FC procedure. 2. Turn on VCO 2 slide switch. 3. Lower Poly Output Mixer slider. 4. Depress C2 and adjust R258 until VCO 2 is in tune with VCO 1.
R252 STAGE TUNE NO. 2	VCO 2 V/OCT	1. Perform VCO 2 FC adjustment. 2. Using same set up, depress C6 and adjust R252 until VCO 2 is in tune with VCO 1. 3. Repeat FC and V/OCT adjustments until tuning is correct at C2 and C6.

LEAD/MIX BOARD (Continued)		
REF.	TRIMMER	TRIM PROCEDURE
R301	VCO 2 PW	1. Turn on VCO 2 slide switch. 2. Set VCO Waveform Select touch switches to square, 50%, PWM off. 3 Monitor TP-10 and adjust R301 for proper square wave (50% duty cycle).
VCF ADJUSTMENT SET-UP *(Necessary for the following three trims only)*		1. In Lead Synth section, turn on VCF Resonance touch switch only. Raise Resonance slider and Lead Output Mixer slider. 2. Depress an Interval Write touch switch. Depress and release C2. 3. Monitor Mono Output jack with frequency counter. 4. Turn on VCF Cutoff touch switch. 5. With a clip lead, short TP-17 (VCO Output) to chassis ground.
R338	VCF FC	1. Perform Steps 1, 2 and 3 only of VCF adjustment set up. 2. Depress C1 and adjust R338 for 40Hz.
R333	VCF V/OCT	1. Perform Steps 1 through 5 of VCF adjustment set up. 2. Depress C1 and adjust VCF Cutoff slider to 100Hz. 3. Depress C4 and adjust R333 to 800Hz. 4. Repeat Steps 2 and 3 until correctly tuned.
R341	VCF RES	1. Perform Steps 1 through 5 of VCF adjustment set up. 2. Adjust VCF Cutoff slider to 500Hz. 3. Monitor TP-13 with an oscilloscope. 4. Adjust R341 for 2.5V P-P sine wave.
R340	VCF CVR	1. Turn off all touch switches in Lead Synth section. 2. Depress an Interval Write touch switch. Depress C6, then C1, then release both keys. 3. Again depress an Interval Write, then the Trill touch switch. Depress and release C5. 4. Turn on Trill touch switch. Raise Trill Speed slider. 5. Monitor TP-13 with an oscilloscope. 6. Depress C2 and adjust R340 for null (less than 100MV AC ripple).
R350	VCA CVR	1. Perform Steps 1 and 2 of VCF CVR adjustments. 2. Raise Decay Time slider (ADSR). 3. Monitor TP-14 with an oscilloscope. 4. While repeatedly depressing a key, adjust R350 for minimum deflection (less than 80MV P-P).
PHASOR BOARD		
R120	HFO CAL 1	1. Connect ground to TP-4. 2. Monitor TP-5 (Z106) with a frequency counter. 3. Adjust R120 for a period of 13.3 s (75kHz).
R220	HFO CAL 2	1. Connect ground to TP-9. 2. Monitor TP-10 (Z206) with a frequency counter. 3. Adjust R220 for a period of 21.5 s (46.5kHz).
R320	HFO CAL 3	1. Connect ground to TP-14. 2. Monitor TP-15 (Z306) with a frequency counter. 3. Adjust R320 for a period of 12.2 s (82kHz).

POLY SYNTH BOARD		
REF.	TRIMMER	TRIM PROCEDURE
R61	BASS VCO FC	1. Insure that VCO 1 is properly tuned, as this will be our reference for Bass tuning. 2. Depress an Interval Write touch switch. Depress and release C1. 3. Raise Bass Ouptut Mixer and Lead Output Mixer sliders. 4. Turn on Lead VCF Cutoff and 8' Electric Bass touch switches. Raise Lead VCF Cutoff and Electric Bass Decay sliders fully. 5. Set Octave slide switch to normal and Bass Tune slider to mid-position. 6. Pin C1 and C3. 7. Adjust R61 until Bass VCO is in tune with VCO 1.
R64 STAGE TUNE NO. 3	BASS VCO V/OCT	1. Perform Bass VCO FC adjustment. 2. Using same set up, Pin B2 and B4. 3. Adjust R64 until Bass VCO is in tune with VCO 1. 4. Repeat FC and V/OCT calibration until correctly tuned.
R1	BASS PW	1. Monitor Bass Quad output jack with an oscilloscope. 2. Set Bass Resonance slider at minimum. 8' Electric Bass on. 3. Depress a key and adjust R1 for 20% pulse width.
R302	STRING VCA CVR	1. Turn on 8' String Bass only. Raise String Output Mixer slider. 2. Monitor Mono Out jack. 3. Adjust R302 for minimum "thump" on key depression.
R326	POLY VCA CVR	1. Turn off all Poly Synth touch switches. 2. Raise Poly Output Mixer slider. 3. Monitor Mono Out jack. 4. Adjust R326 for minimum "thump" on key depression.
R356	POLY VCF CVR	1. In Poly Synth section, turn on ADSR and VAR DEC touch switches only. Raise ADSR Depth slider fully and Decay Time slider to ¾ position. 2. Monitor TP-17 with an oscilloscope. 3. Adjust R356 for minimum deflection on key depression.
R349	POLY VCF FCO	1. Turn off all Poly Synth touch switches. 2. Depress an Interval Write touch switch. Depress and release C1. 3. Connect a 33K OHM resistor from Pin 10 to Pin 2 of M1 (Poly VCF Module). 4. Turn on VCF Resonance touch switch and raise slider fully. 5. Monitor TP-17 with a frequency counter. 6. Depress C6 and adjust R349 for 20Hz sine wave. 7. Remove 33K resistor from M1.
R358	POLY VCF RES	1. In the Poly Synth section, turn on VCF Cutoff touch switch only. Raise VCF Cutoff slider fully. 2. Monitor TP-17 with an oscilloscope. 3. Depress and release C5 while adjusting R358 for no oscillations.

PHASE SHIFTER BOARD

REF.	TRIMMER	TRIM PROCEDURE
R5	PHASE SHIFTER TUNE	1. In the Phase Shifter/Output Mixer section, turn on Phase Shifter Resonance touch switch only. Raise Phase Shifter Resonance slider fully. 2. Monitor TP-2 with an oscilloscope. 3. Set R19 fully clockwise. 4. Adjust R5 for no "hang up" at ends of sweep. 5. Perform gain adjustment.
R19	GAIN	1. Perform Phase Shifter Tune adjustment. 2. Adjust R19 for no oscillations.

UPPER VOICING BOARD

L1	Master Oscillator Coil	1. In the Poly Synth section turn on 8' Poly Synth, VCF Cutoff, and Hollow Waveform touch switches only. 2. Raise VCF Cutoff slider and Poly Output Mixer slider. 3. Monitor Poly Synth out jack with frequency counter. 4. Depress A3 and adjust L1 (through hole in rear panel) for 440Hz.

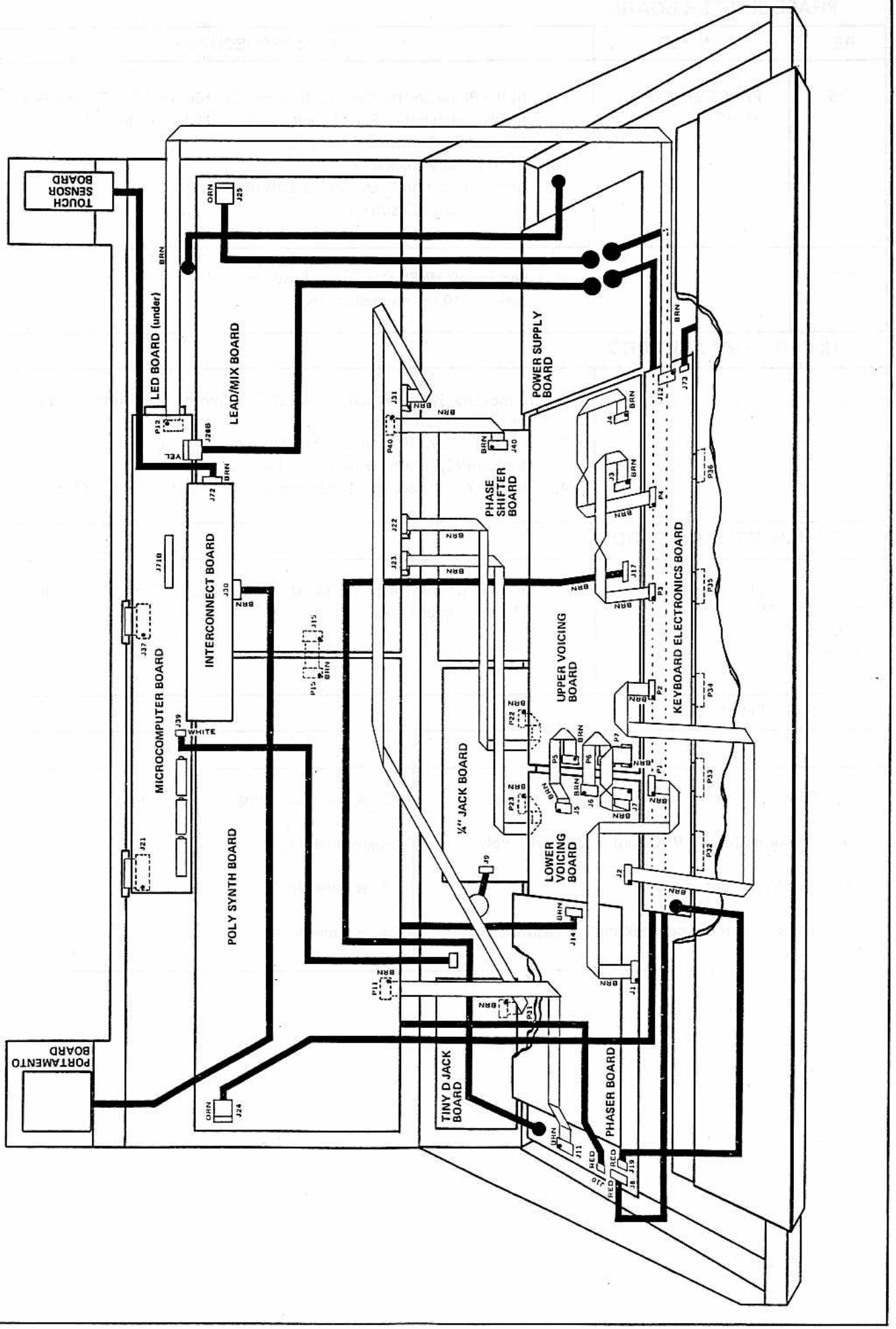
TOUCH SENSOR BOARD

R1 STAGE TUNE NO. 4	TOUCH SENSITIVITY TRIM	1. While activating Touch Sensor effects on the Lead Synth VCOs, adjust R1 to customer's taste.

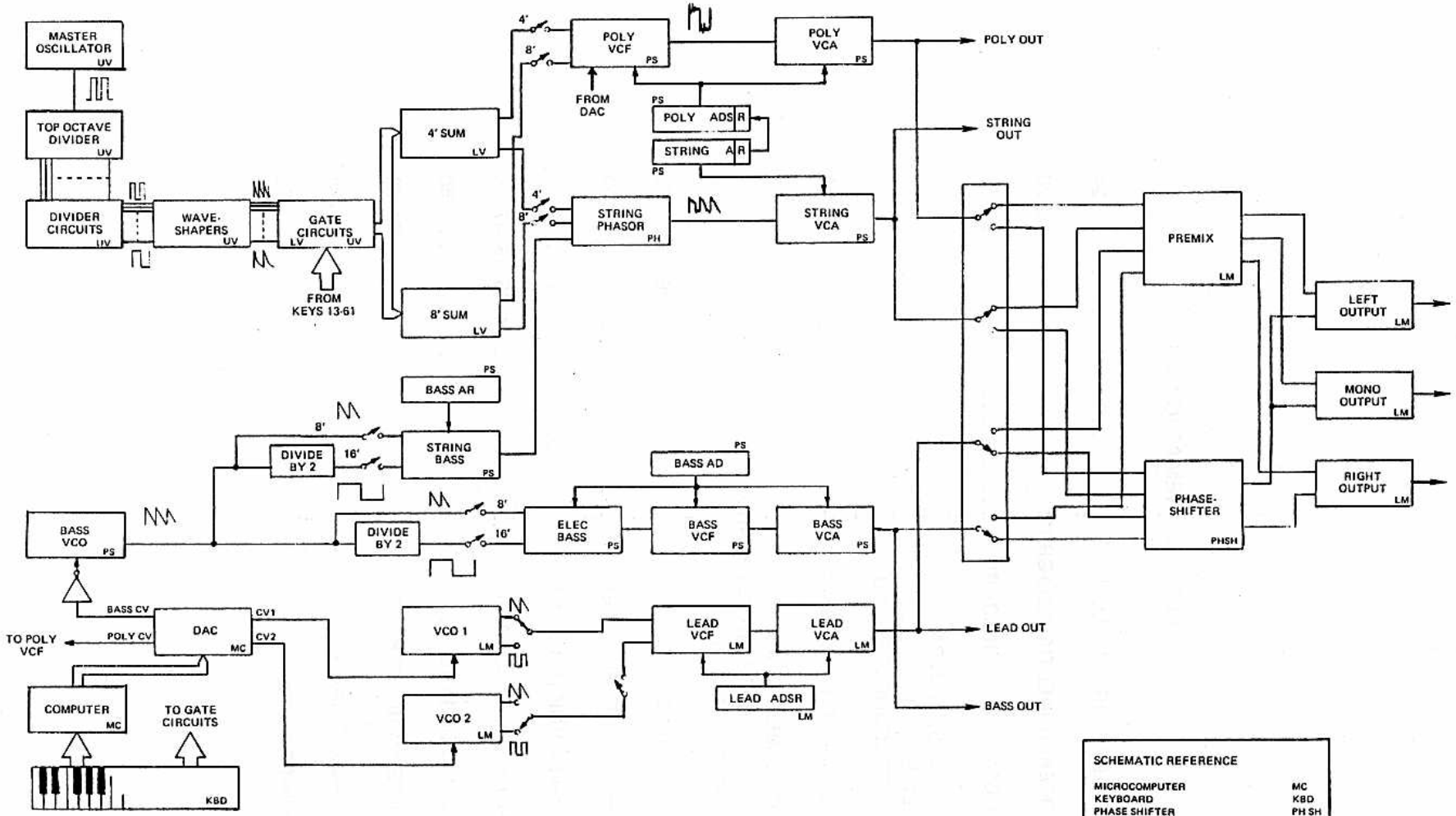
STAGE TUNING

SYMPTOM:	TRIM
1. Poly Voice out of tune with other keyboards:	Stage Tune No. 1 (may necessitate doing all stage tunings).
2. One or both Lead VCOs out of tune with Poly:	Stage Tune No. 2.
3. Bass Voices out of tune:	Stage Tune No. 3.
4. Touch Sensor effects weak or too sensitive:	Stage Tune No. 4.

INTERCONNECTION DIAGRAM



QUADRA SCHEMATIC LIST



QUADRA SIGNAL FLOW
Simplified Block Diagram