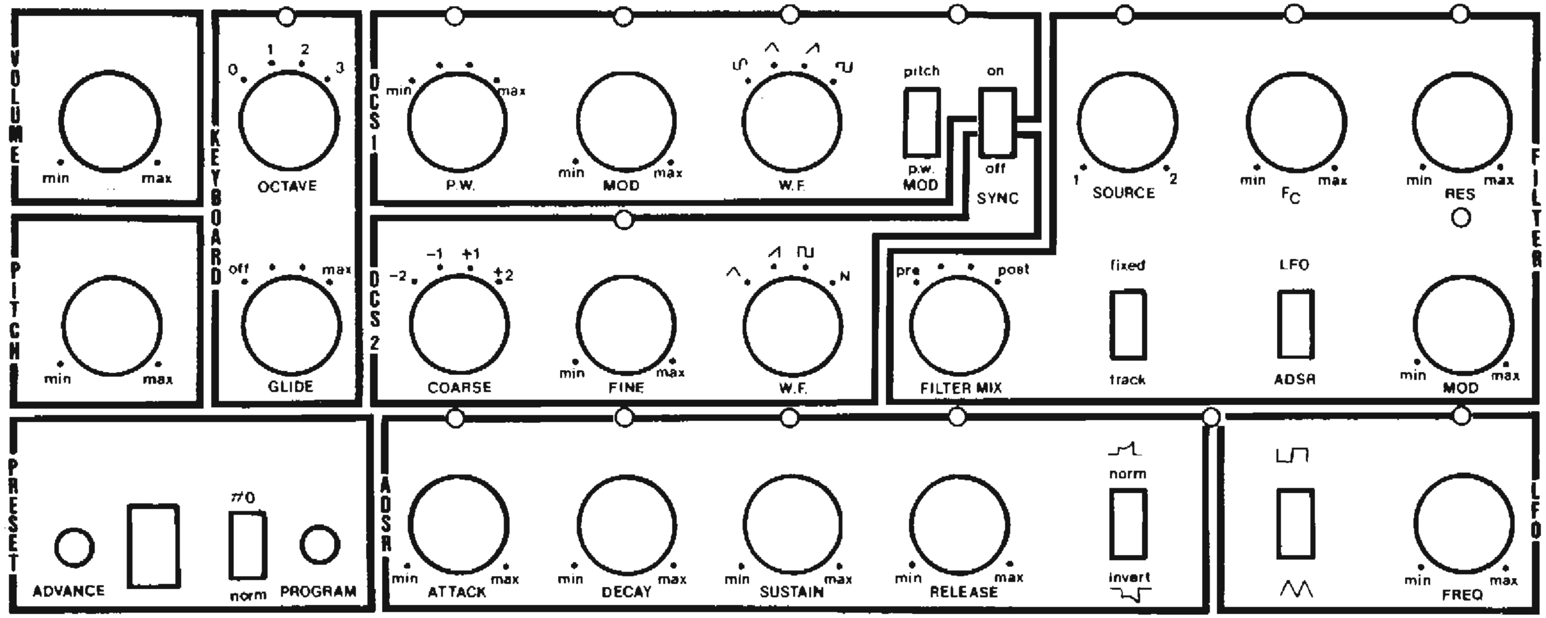
PAiA ELECTRONICS, INC.

8750

PROTEUS I™

CALIBRATION & USING MANUAL



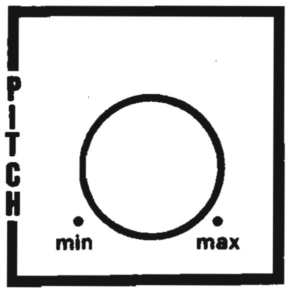
PERMISSION IS GRANTED TO REPRODUCE THIS CONTROL PANEL DRAWING FOR PERSONAL (NON-COMMERCIAL) USE.

FRONT PANEL CONTROLS

VOLUME & PITCH

These two controls are not included in the preset memory, they are intended for real time use.

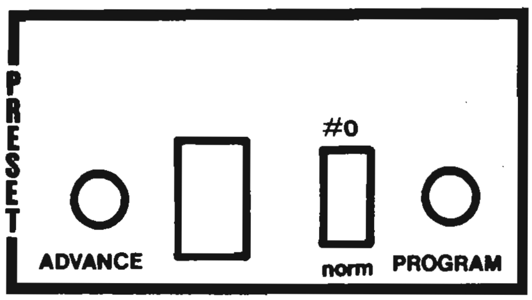
VOLUME- While the waveforms and filter responses have been balanced during design to compensate for the wide variety of subjective volume levels possible, a volume control is still necessary to make final real-time adjustments. Total range of the control is on the order of 30 db.



PITCH- This control provides slightly more than an octave range of control over the final pitch of the voice produced by PROTEUS I. It allows tuning this instrument to others in the band or to previously recorded tracks in the studio. It will almost certainly also be necessary when switching back and forth between Hard sync'd and non-sync'd voicing configurations.

PRESET CONTROL BLOCK

This block controls PROTEUS I's programming and preset selection. PROTEUS I can be thought of as always being in one of two major modes: Invoke Preset or Program Preset. When turned on, the unit always "comes up" in the Invoke Preset mode. Since in this mode data on the settings of the front panel controls is coming from PROTEUS I's internal memory, the front panel (with the exception of the PITCH and VOLUME controls) will be dead. The remaining controls have an effect on PROTEUS I only when in the Program Preset mode and in this mode the data which was stored in the preset indicated by the display is completely changed to reflect the current setting of the controls.



ADVANCE- Pressing this button causes PROTEUS I to count through the available presets. A single quick activation and release advances the preset by one. Pressing the button and holding it down will cause the display to count continuously.

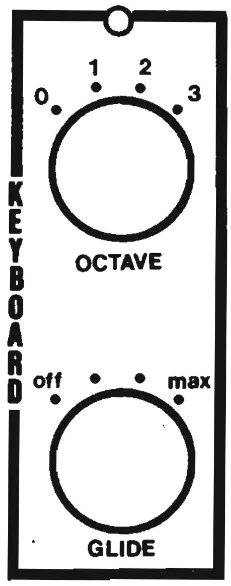
DISPLAY- This seven segment read-out shows the number of the preset currently in force. The display counts in hexadecimal (0-F). The decimal point, when lit, indicates that PROGRAM mode is selected.

#0/NORM- This slide switch allows for the immediate selection of the #0 preset without stepping through any intervening presets.

PROGRAM- When activated, this button puts the PROTEUS I in the PROGRAM mode. In this mode the control panel is "live" and the parameters of the synthesizer may be set using the front panel controls. Programming mode is automaticly terminated by advancing to the next preset.

KEYBOARD CONTROL BLOCK

These controls can be thought of as determining the characteristics of the PROTEUS I keyboard; the initial pitch produced and the time required to change from one pitch to the next.

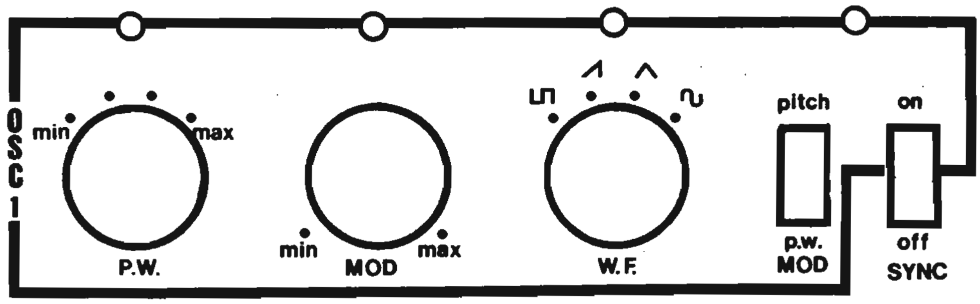


OCTAVE- This 4 position rotary switch transposes the keyboard by octaves. Position #0 is the lowest octave, position #3 the highest. Note that this control will affect not only the pitch of the oscillators, but also the corner frequency of the filter if it has been set to track the keyboard.

GLIDE- This 4 position switch controls the rate at which the keyboard control voltage changes from one note to the next. In its maximum CCW position (off) pitch changes are instantaneous. CW rotation of the knob increases delay. At the "max" setting, on the order of a second is required to cover the three octaves of the keyboard.

OSC 1 CONTROL BLOCK

This is one of the two signal sources which may be mixed together to provide the pitch and harmonic content information which will be processed by the rest of PROTEUS I's circuitry. The normalization scheme employed places primary emphasis on modulation of the parameters of this source - (pitch and pulse width) as well as the large range of tone colors available by virtue of the sync capabilities.



W.F.- This 4 position rotary switch selects the waveform produced by the #1 VCO as indicated by the legends over the switch. Waveforms available are: Pulse (with control of duty factor as described below), Ramp, Triangle and Sine Wave.

P.W.- This control sets the initial width of the pulse waveform. At its extreme CCW position the duty factor of the pulse is low (5% or so). Duty factor increases with CW rotation of the control to a maximum of 50%.

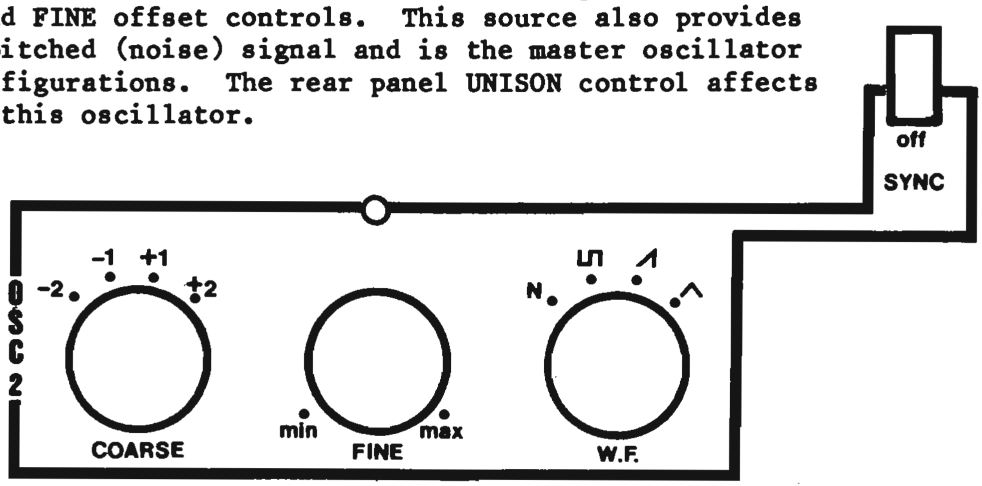
MOD (pitch/p.w.)- This slide switch serves a dual function. First, as its name implies it determines whether the selected modulation source (see FILTER LFO/ADSR switch) will be used to alter the pitch of the oscillator (pitch position) or the duty factor of the pulse waveform output (p.w.).
Much less obvious is that the setting of this switch will determine whether sync (when selected) is Hard Sync or Soft Sync. With the switch in the "pitch" position Hard Sync is selected. The "p.w." setting selects Soft Sync.

MOD(min/max)- This potentiometer controls the amount of modulation signal applied to the #1 VCO. CW rotation increases the modulation.

SYNC- This slide switch bridges the OSC 1 and OSC 2 control blocks to graphicly indicate that it effects both of these elements. When set to the "on" position, this control causes the #1 VCO to be sync'd to the #2 VCO. as mentioned above, Hard Sync or Soft Sync selection depends on the setting of the #1 VCO's MOD select switch.

OSC 2 CONTROL BLOCK

The normalization emphasis for this source is in pitch range as exemplified by the COARSE and FINE offset controls. This source also provides the only un-pitched (noise) signal and is the master oscillator in sync'd configurations. The rear panel UNISON control affects the pitch of this oscillator.



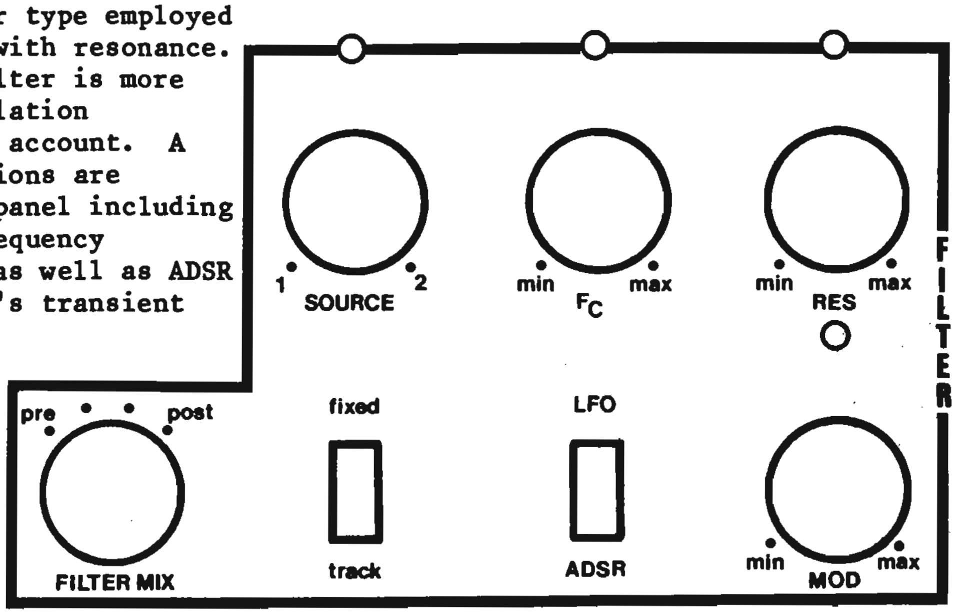
COARSE- The pitch of the #2 oscillator may be offset with respect to the #1 oscillator using this control. Each step of this 4 position rotary switch represents an octave change in pitch. The oscillators are calibrated to be in unison when Coarse is set to "+1" and the FINE potentiometer is at "min".

FINE- This potentiometer works in conjunction wth the COARSE control described above. The control works in semi-tone resolution to produce slightly more than an octave change. Pitch of the oscillator increases from "min" to "max".

W.F.- As with the #1 VCO, this control selects the output waveform of the oscillator. Unlike OSC 1, the shapes available from this source are: Noise, Square (no front panel control of duty factor), Ramp and Triangle.

FILTER CONTROL BLOCK

The filter is the means by which only selected frequencies from the harmonic rich signals provided by the OSC 1 and OSC 2 sources are allowed to pass through to the output. The filter type employed is a 24 db/oct. low-pass with resonance. The total range of the filter is more than 12 octaves when modulation influences are taken into account. A variety of modulation options are available from the front panel including keyboard tracking, Low Frequency triangle and square wave as well as ADSR modulation from PROTEUS I's transient generator.



SOURCE- This potentiometer controls the mix of the OSC 1 and OSC 2 signals applied to the input of the filter. At the extreme CCW end of the rotation only the #1 oscillator is selected. At the extreme CW end only the signal from source #2. Intermediate settings cause the signals from the two sources to be mixed in proportion to the setting.

FILTER MIX- This rotary switch determines how much effect the filter has on the signal by mixing signals from before the filter with signals from the output of the filter. At the "pre" setting the filter is essentially eliminated from the signal path. At the "post" setting the resulting signal is all from the filter. The two settings between these extremes allow filtered and direct signals to be mixed.

RES- This potentiometer controls the resonance of the filter. At the "min" setting the filter is a simple 24 db/oct low pass with no resonance. As the control is rotated in a CW direction resonance increases until at the "max" setting the filter is close to self-oscillation.

Fc- This control sets the initial corner frequency of the filter. Total range of the control is on the order of 8 octaves in approximately half octave steps. CW rotation raises the corner frequency.

FIXED/TRACK- In the "track" position, this slide switch causes the corner frequency of the filter to track the keyboard control voltage with the same 1v./oct. scale factor as that employed by the oscillators. In the "fixed" position, keyboard control voltages do not effect the filter frequency. This switch does not effect any modulation signals which may be routed to the filter.

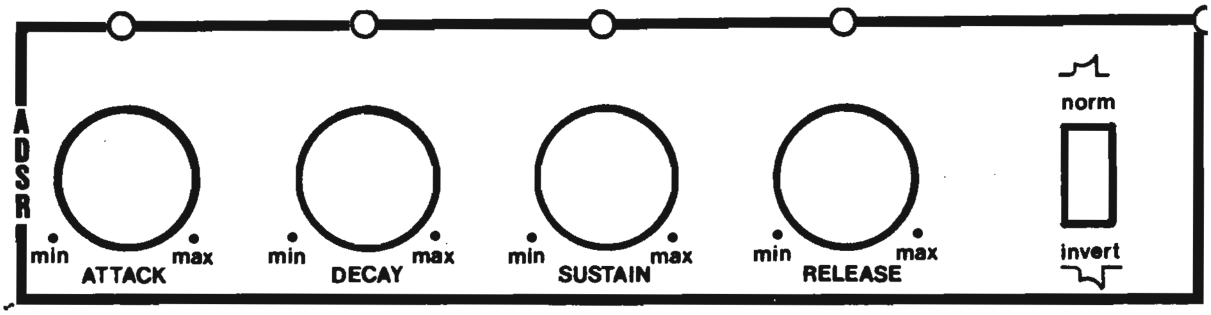
LFO/ADSR- This slide switch selects either the Low Frequency Oscillator or the ADSR (transient generator) as the modulation source for the filter corner frequency. Selection is as marked.

This switch serves the double function of also selecting the modulation source which will be applied to OSC 1. When the LFO is selected as the filter modulation source, the ADSR is applied to VCO #1 and vice-versa.

MOD- This potentiometer determines the amount of the selected modulation signal which is applied to the filter. At the "min" setting there is no modulation and the effect begins and increases as the control is rotated toward "max".

ADSR CONTROL BLOCK

The ADSR (Attack, Decay, Sustain and Release) transient generator provides a signal to PROTEUS I's Voltage Controlled Amplifier for control of dynamics. This signal and its inverted replica are also available for various modulation uses with other processing elements.



ATTACK- This control sets the time required for the attack portion of the transient generator waveform. At the "min" setting of this control, time is on the order of 1 ms. At "max" the time is approximately 7 seconds.

DECAY- Initial decay time is set by this control. Time range of this control is approximately 1 ms to 15 seconds.

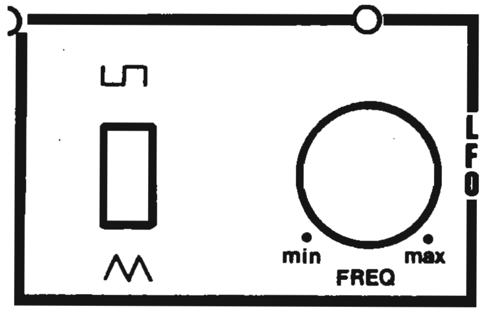
SUSTAIN- Sets the transient generator sustain level from 0 at "min" to a level corresponding to the attack peak at "max".

RELEASE- Controls the final decay time over a range comparable to the DECAY control discussed above.

NORM/INVERT- This slide switch provides for the inversion of the transient generator waveform when it is used as a modulation source to allow for the sweeping of the pitch of OSC 2 or the filter corner frequency either up or down.

LFO CONTROL BLOCK

This block is exclusively a modulation source. Front panels switches give control over waveform selected and destination.



(⊔⊓ / Λ)- Either a sweeping triangle or a trilling square waveform may be selected as the modulation signal using this switch.

FREQ.- This control sets the frequency of the Low Frequency Oscillator from 1 cycle every 10 seconds at "min" to 10 cycles per second at "max".

EDIT LEDS

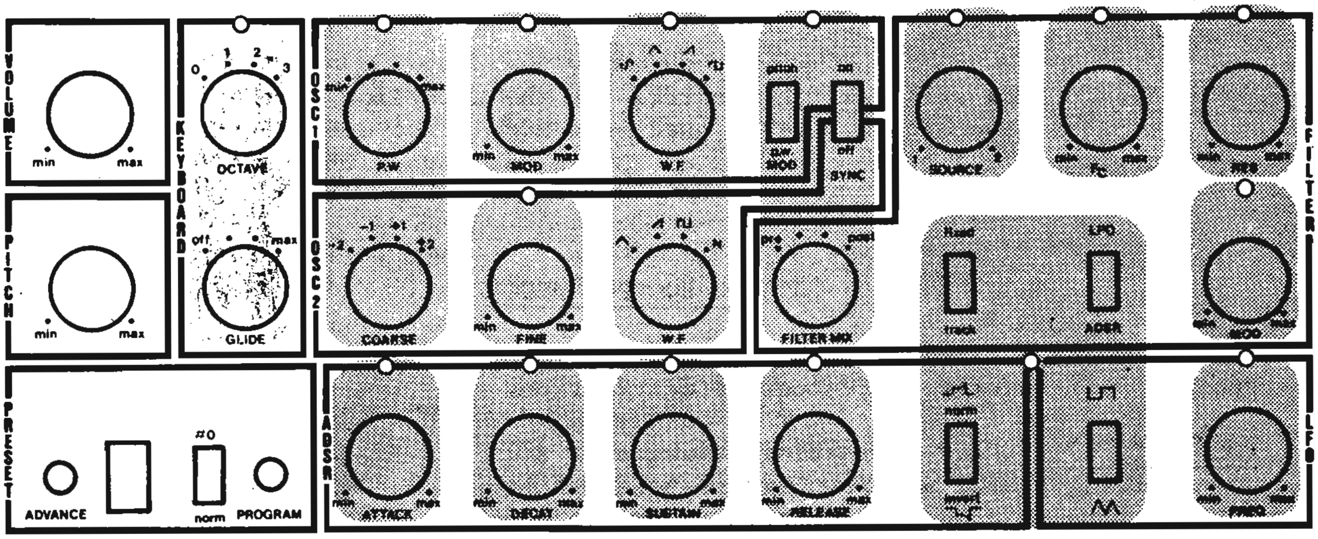
The EDIT LEDs provide a means of setting the PROTEUS I front panel controls so that they correspond to the way the controls were set when the preset was originally saved. This preset editing feature is essential when you want to make a minor change in an existing preset.

While most of the EDIT LEDs indicate the position of a single knob, some cover the settings of two or more switches. In the figure below, shading has been used to indicate the controls which are monitored by specific LEDs. For example, the setting of the ADSR Attack control is monitored by the LED directly above it while the 4 slide switches in the FILTER, ADSR and LFO blocks are all monitored by the single LED in the center of the group.

NOTE: The front panel digitizing process used when preset data is coming from memory is slightly different and somewhat less precise than that used during programming. In some cases this will show up as an EDIT LED being dark even though the control positions have not been changed since the preset was programmed. This is an error in EDIT function only and does not affect the data in memory. Controls with extinguished LEDs may need to be "tweaked" to the right or left slightly to get the EDIT LED to come on.

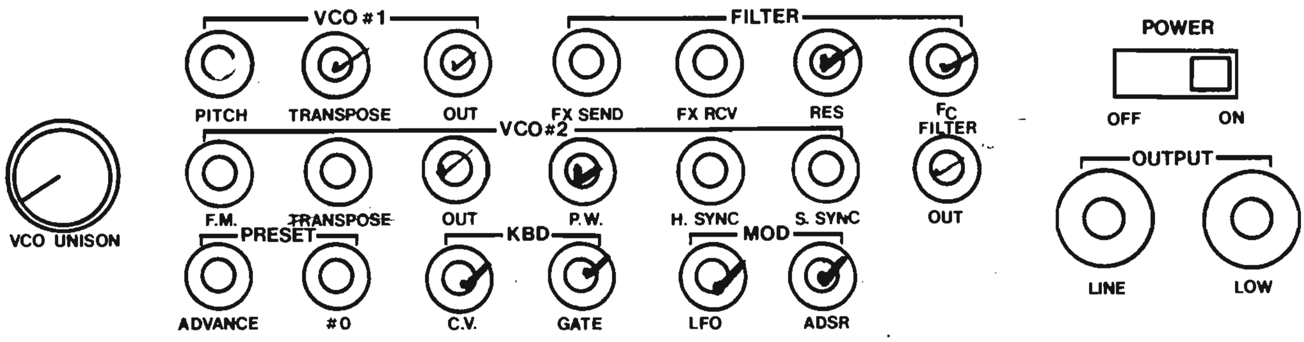
Similarly, you may notice that there is some interaction between the EDIT LED of one parameter and the control knob of some other seemingly unrelated parameter. Again, this error is in the digitizing process of the EDIT mode and does not have a corresponding error in memory. When all EDIT LEDs are lit in the normal (non-PROGRAM) mode, the controls are all set such that they correspond to memory and you can punch into PROGRAM assured that the voice from the controls will be the same as that which was in memory.

In PROGRAM mode the state of the front panel controls is being written into memory at the PRESET shown in the display. You can now edit the preset as desired before ADVANCEing to exit the programming mode, leaving the altered preset at the PRESET number shown during programming.



REAR PANEL PATCH BAY

For those times when the exact voice that you want cannot be configured with the front panel controls, numerous patch-over-hardwire points are provided on the PROTEUS I rear panel PATCH BAY.



UNISON

UNISON- The rear panel UNISON control allows the #1 and #2 VCO's to be set to essentially exact unison (even without sync) or to be slightly out of sync for phasing type effects.

VCO #1

PITCH- Control voltage input, 1v./oct. response, 100k input impedance. Inserting a miniature phone plug into this jack simultaneously interrupts the normal keyboard pitch control voltage and provides an external input point. Anticipated primary use is in FM synthesis techniques where the output of the #1 oscillator (which is running at a frequency other than the keyboard pitch) is used as an FM source for OSC 2.

TRANSPOSE- Control voltage input, 1v./oct. response, 100k input impedance. Similar to the PITCH input described above, but does not interrupt the keyboard control voltage

OUT- Signal output, less than 1k output impedance. This is the direct output of the oscillator as selected by the front panel W.F. select control. Waveforms are compensated for different energy content of selected waveform. Amplitudes are as below.

sine	4v. p-p	0v. offset
triangle	3v. p-p	1.5v. offset
ramp	2v. p-p	1v. offset
pulse	1.5v. p-p	.75v. offset

VCO #2

F.M.- Control voltage input, linear control scale, 10k input impedance. This a.c. coupled linear response input allows a frequency modulating control voltage to be applied to the oscillator. Useful for generating non-harmonic timbres such as chimes. Example - patch the VCO #1 OUT to this F.M. input.

TRANSPOSE- Control voltage input, 1v./oct. response, 100k input impedance. Same as TRANSPOSE on VCO #1. Does not interrupt keyboard control voltage.

OUT- Signal output, less than 1k output impedance.
The direct output waveform of the source as selected by the front panel W.F. select control.

triangle	3v. p-p	1.5v. offset
ramp	2v. p-p	1v. offset
square	1.5v p-p	.75v. offset
noise	5v. p-p	0v. offset

P.W.- Control voltage input, linear control scale, input impedance 10k.
Allows pulse width modulation of the VCO #2 square wave output. -2v. input for 0% duty factor, +6v. for 100% duty factor.

H. SYNC- Signal input, can be used for both negative and positive hard sync, low input impedance.
Provides an external input to the hard sync control for the #2 oscillator.

S.SYNC- Signal input, low input impedance.
Provides an external input to the soft sync control for the #2 oscillator.

FILTER

FX SEND- Signal output, less than 1k output impedance.
This output jack allows the signal chain to be interrupted ahead of the filter and in conjunction with the FX RCV input jack allows for the insertion of processing elements into the signal path. Output level is a function of excitation waveform and filter control settings but is typically on the order of 2v. p-p.

FX RCV- Signal input, 47k input impedance.
This is the companion input jack to the FX SEND output described above. In the signal path it appears ahead of the front panel filter pre/post control. External signals may be applied to this input and mixed with the oscillator signals.

RES- Control voltage input, exponential response. 100k input impedance.
This is the direct input to the resonance control of the filter. Control voltage inputs here are approximately summed with the front panel resonance control.

Fc- Control voltage input, 1v./oct. response, 100k input impedance.
This is a true summing input to the corner frequency of the filter. Response is 1v./oct. Front panel control of Fc is not disabled. Modulation sources selected from front panel are not disabled.

OUT- Signal output, less than 1k output impedance.
This is the direct output from the filter. In the signal chain it follows the front panel pre/post control but is ahead of the VCA input. Output level is dependent on input waveform and filter parameter settings - typically 2v. p-p.

PRESET

ADVANCE- Logic input, wired OR, local 0 activated.
Primary intended use of this control jack is as a foot control of the preset advance feature. Contact closure is to ground.

#0- Logic input, wired OR, logic 0 activated.
A foot switch plugged into this control jack duplicates the action of the front panel #0 PRESET switch. Contact closure is to ground.

KEYBOARD

C.V.- Control voltage output, 1v./oct. control scale, less than 1k output impedance.
This is the keyboard control voltage output after the front panel transpose switch. Selected glide does not affect at this output. Selected keyboard transpose does not affect this output.

GATE- Logic output, logic 0 when no keys, logic 1 when any key down.
This is the gate output from the keyboard. As long as any key on the keyboard is down a 5v. gating signal appears at this jack. When all keys are released this output returns to ground.

MOD

LFO- Control voltage output, less than 1k output impedance.
This is the direct output of the LFO after square or triangle waveform has been selected.

triangle	3v. p-p
square	4v. p-p

ADSR- Control voltage output, 4v. p-p, less than 1k output impedance.
This is the output of the transient generator after the NORM/INVERT selection. 4v. p-p output level with 0.5v. offset.

POWER

ON/OFF- Sliding the bat of this switch to the right turns on the power. Preset memory is preserved when power is turned off whether with this switch or by turning off power to the PROTEUS I line cord.

OUTPUT

LINE- Signal output, less than 100 ohms output impedance.
This is the main PROTEUS I output. Signal level is dependant on the setting of the front panel VOLUME control. Max output level is on the order of 10v. p-p.

LOW- Signal output, less than 1k output impedance.
An attenuated version of the LINE output above. Signal level is on the order of several hundred millivolts.

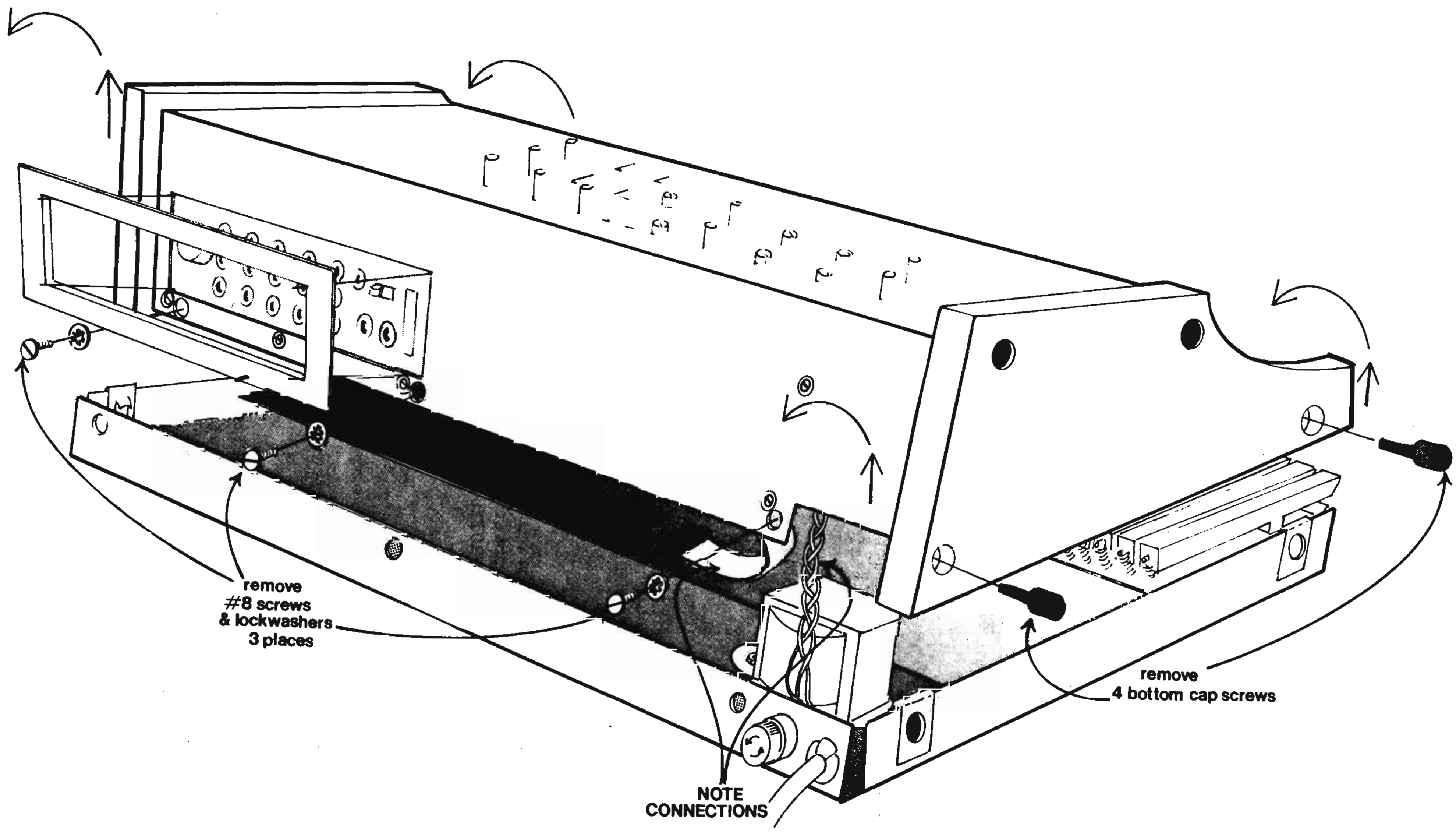


Figure 1: Opening the PROTEUS case

PROTEUS CALIBRATION

Open the PROTEUS I for calibration purposes (see figure 1) following these steps:

1) Remove the bezel around the rear panel patch bay by pulling it away from the case. There is no hardware holding it in place, it simply pops out.

2) Remove the three #8 screws and lockwashers from the bottom of the back panel.

3) Use a 5/16" allen wrench to remove the 4 cap screws from the bottom edge of the wooden end panels (2 screws from each panel).

4) Carefully lift the entire case top and wood-ends away from the case bottom tray. Be careful not to apply excessive force to the cable which connects the transformer in the tray to the Backplane circuit board.

5) The case top may now be tilted up so that it rests on the rear edges of the end panels for access to the internal calibration points.

While the PROTEUS I circuitry is extremely temperature stable, it is still a good idea to turn the equipment on and let it run for 15 or 20 minutes before beginning calibration. Use the time to review the calibration procedure.

Calibration of the PROTEUS I circuitry may be performed using bench quality test equipment (oscilloscope, bench oscillator, etc.) or it may be performed using nothing more sophisticated than a volt-ohm or multimeter and your ears. While the procedure may go slightly more quickly and be more precise when using the more elaborate equipment, in the end it is how the instrument sounds that is important so a strong case can also be made for calibrating by ear. In either case, it is extremely useful to be able to listen to the results of the procedures as you perform them so begin by plugging the output of the PROTEUS I into a suitable amplifier.

You will notice several procedures which use the phrase "balanced about ground". If you are using an oscilloscope this means that it must be DC coupled and set to its DC mode for the results to be valid. Adjust the control specified in the step so that there is as much waveform below ground as above. Equal amplitude negative and positive peaks.

The same result may be obtained with a meter by setting it to the one of its DC VOLT ranges which is closest to 2 volts. Adjust the control specified for a reading of 0 volts on the meter.

In all cases, these readings should be made referenced to ground. The most convenient ground is the bare wire that connects the ground of the output jacks to the (GROUND) point on the backplane board.

Before beginning the procedure, set the front panel controls as shown in figure 2 and punch into PROGRAM so that you are controlling the PROTEUS card from the front panel. See also figure 3 and 4.

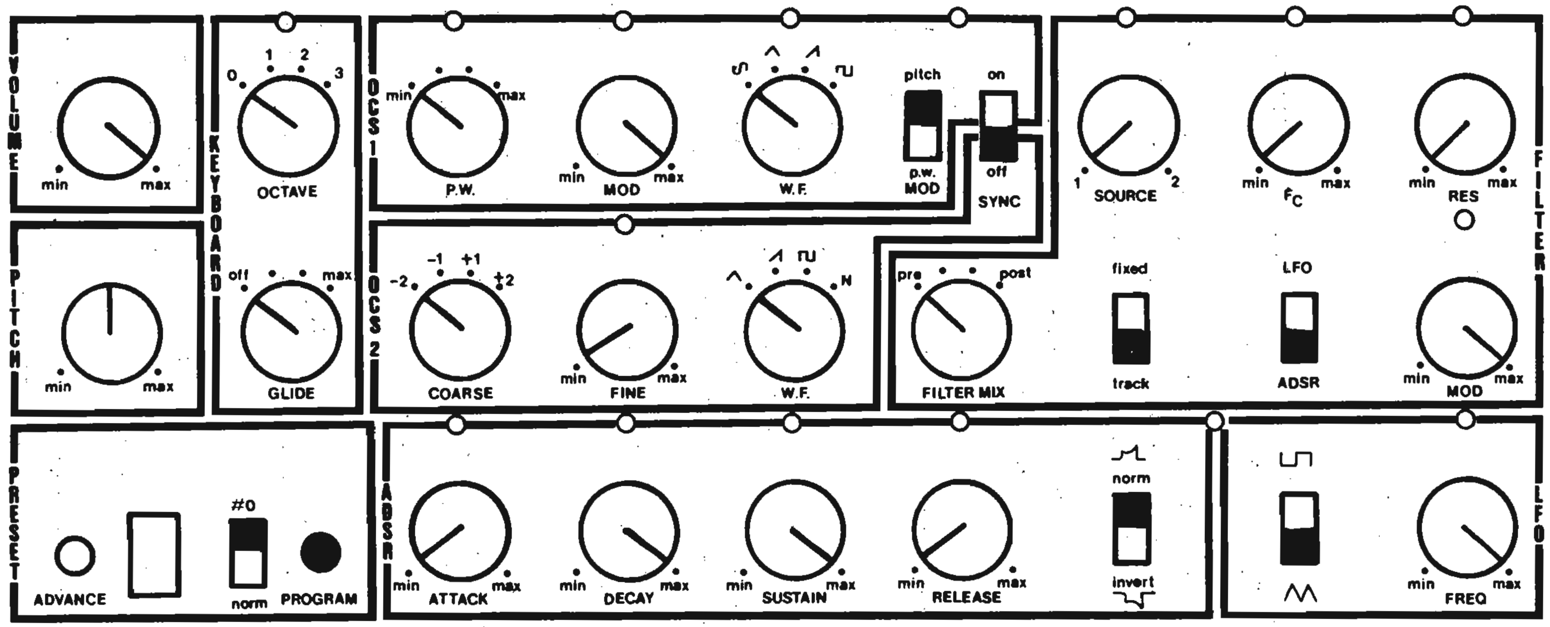


Figure 2: Calibration Start Patch

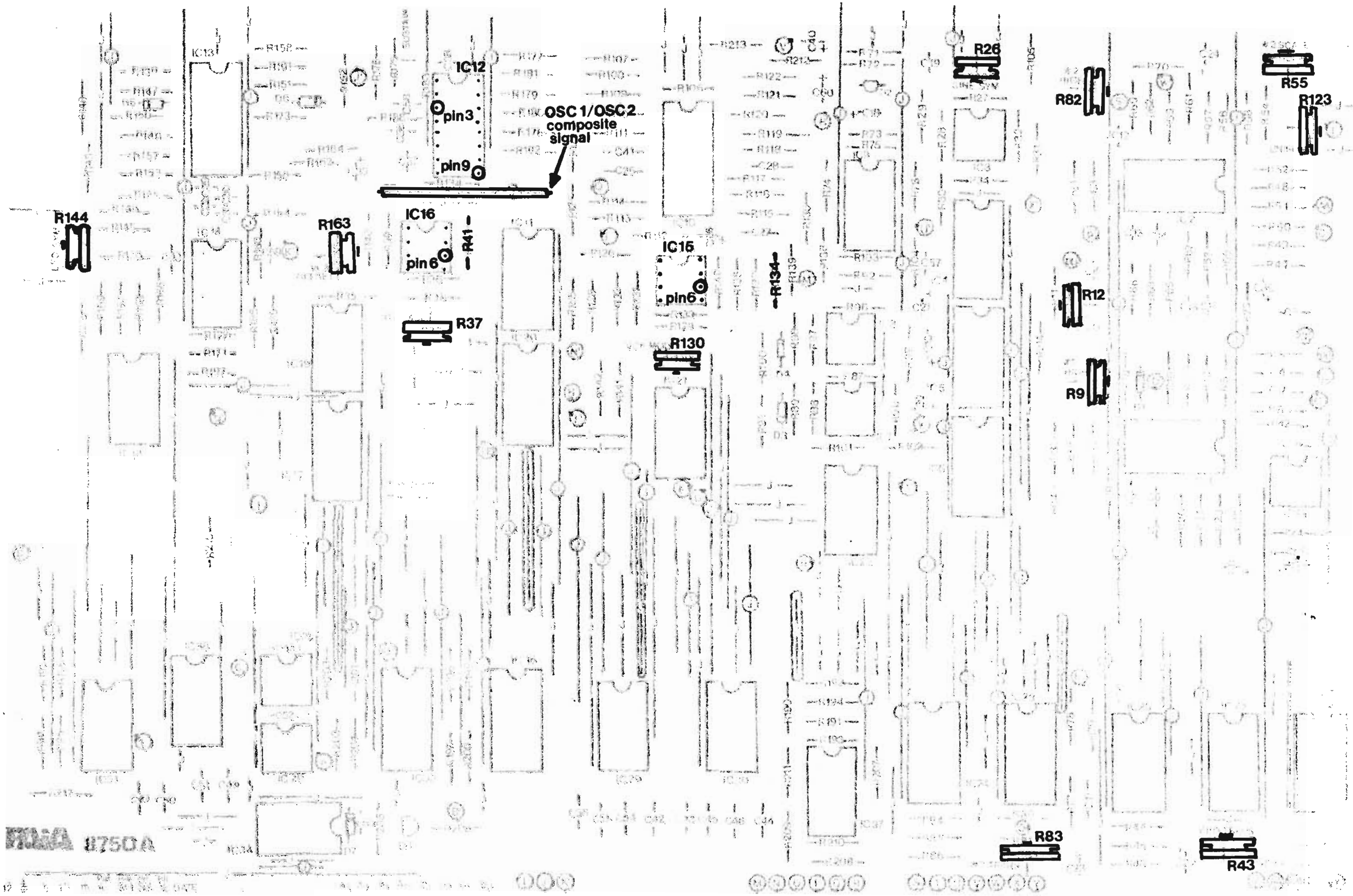


Figure 3: 8750A, PROTEUS card, Location of significant parts

1) SUPPLY RAILS - Begin the procedure by reading the voltage on the 12v. (nominal) supply rails. Adjust R7 and R8 on the backplane board so that these supply lines read 12.5v. (±) 5%.

2) KEYBOARD DAC - Check the calibration of the keyboard by reading the voltage at pin 10 of the Molex edge connector for the PROTEUS card. Note that the front panel pitch control must be disabled by using a clip lead or similar device to short the top lead of R24 to ground. Press the highest G# (second black key from the right) and adjust R20 for a reading of 4 volts on the Proteus connector pin 10.

3) VCO MODULATION - Here we adjust the VCO MOD trimmer R37 (on the 8750A board) so that the output of the modulation attenuator remains symmetrical about ground as the modulation signal level is brought up. This signal may be measured at pin 6 of IC16 or at the top lead of R41. If using a 'scope as your primary test instrument, set for DC coupling and adjust R37 so that the triangle waveform displayed remains balanced about ground when the front panel OSC1 MOD control is rotated fully CW (max). If using a meter, set it to a low DC voltage range (2.5 to 5v.) and adjust R37 for 0 volt reading with the OSC1 MOD control at max.

4) VCF MODULATION - Switch the front panel FILTER ADSR/LFO switch to its LFO setting. This calibration is similar to that of the VCO MOD above. Readings may be made at pin 6 of IC15 or at the bottom end of R134. Adjust VCF MOD trimmer R130 for a waveform which is symmetrical about ground, or for a reading of 0v. on the meter. Return the front panel FILTER MOD control to its min setting when done.

5) LFO SYMMTERY - Since this adjustment is intended to compensate for slight leakages in the LFO circuitry, it must be made at the LFO setting where these leakages have the greatest effect. Set the front panel LFO FREQ control to its fully CCW (min) position and the LFO (∧/⊓⊔) switch to (⊔⊓). This calibration is as easily made by ear as any other way. While holding any AGO key down advance the front panel OSC 1 MOD control until you can easily discern the high and low pitches as the square wave LFO signal modulates the frequency of the VCO. Adjust the LFO SYM trimmer R144 so that the duration of the high pitch and low pitch portions of the LFO waveform are of equal duration.

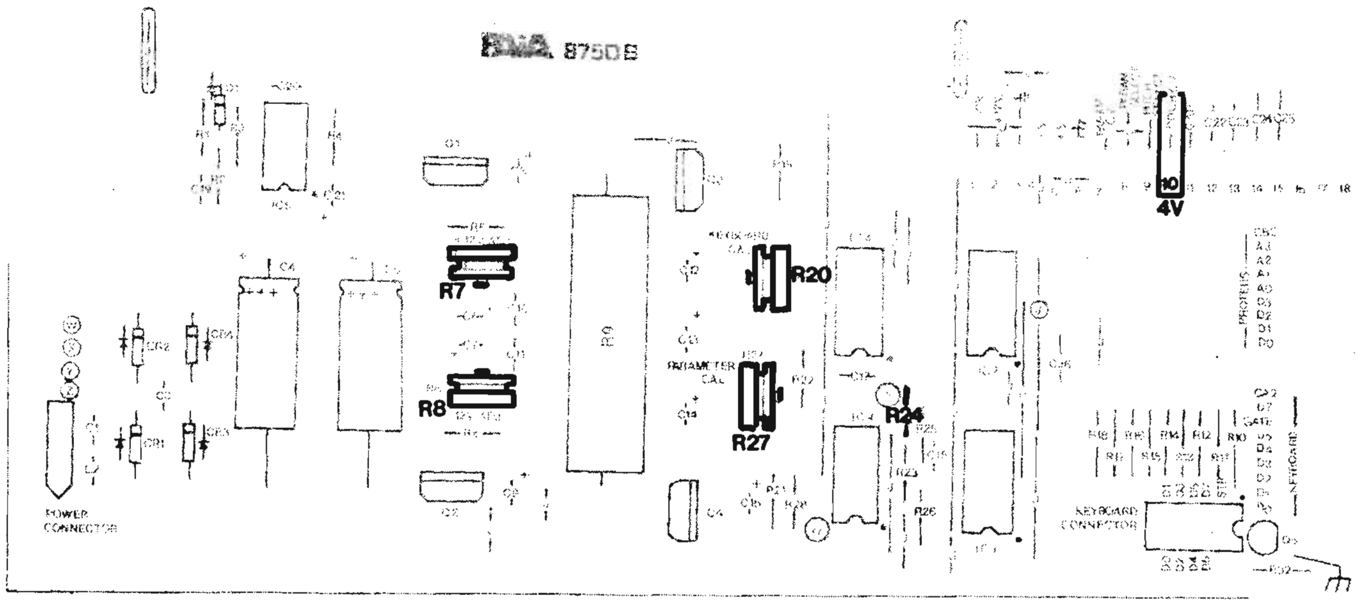


Figure 4: 8750B, Backplane board,

Since the LFO frequency is low at this point, the calibration will take a few minutes. Make small changes in the setting of R144 and then listen to the result for a few cycles before deciding if further adjustment is necessary. At extreme settings of the trimmer, the LFO may stop entirely. Return the front panel OSC 1 MOD control to min when done.

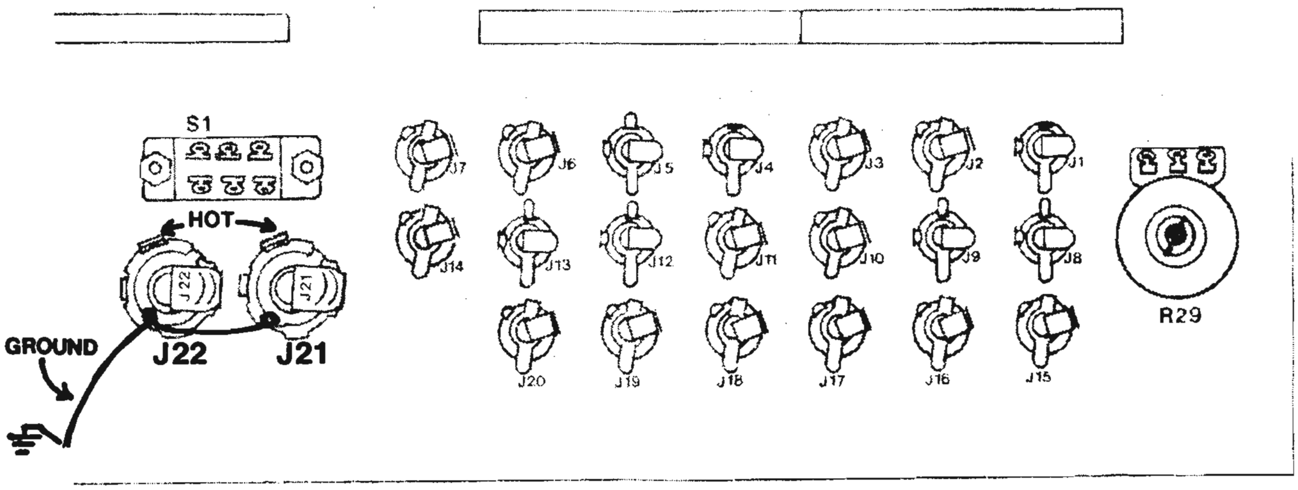
6) VCA OFFSET - While monitoring the signal that appears on the hot lug of the hi-level output jack J21, adjust the VCA OFFSET trimmer R163 so that when an AGO key is pressed the resulting waveform is balanced about ground.

7) SINE SYMMETRY - With any AGO key pressed, adjust the SINE SYM trimmer R26 for the best sine waveform at the hot lug of the hi-level output jack J21. When no oscilloscope is available, adjust for the most mellow possible timbre.

PITCH CALIBRATION

Pitch calibrations may be accomplished either with a bench oscillator and oscillscope or by ear when you have a pitch reference such as an organ or other tuned instrument available.
We will be making adjustments at octavely related frequencies, which are easily ascertained by listening for "beat notes". When two frequencies are very nearly the same, but not quite, a "throbbing" or beat note can be heard. The rate of the throbbing is the difference in frequency of the two signals and when the beat note goes away, the two frequencies are the same. The same phenomenon occurs when the frequencies are very to close to octavely related and while the beat note in this case will not be the exact difference between the two frequencies, when it goes away the frequencies are an exact number of octaves apart. Since less pronounced beat notes can also occur at other musical intervals (third, fifth, etc.) you must be careful that the beat note you are hearing is the octave one.

The visual equivalent of beat notes are the Lissajous figures that are formed when two signals are compared by applying one to the horizontal input of the oscilloscope while the second is applied to the vertical. Assuming that the two signals are more or less sinusoidal and at the same frequency the resulting display will be roughly a circle as shown in figure 6c. Slight differences in the frequency will result in a slow precession or rotation of the display.



Location of significant parts

As the circle rotates, it will at times appear to be elliptical and will finally close into a diagonal line. The open or closed appearance of the display is not important in these procedures. It is only important that the display be stable.

Similarly, the other displays illustrated in figure 6 will spin if the frequencies are slightly different than octave multiples and at various times while rotating will appear to be "W" shaped curves and so on. Here again, the stability of the display is what counts (how slowly it rotates) and not its specific orientation.

Completely stable displays are not a realistic goal. In all cases, go for the slowest rotation you can achieve at all calibration points but do not be overly concerned if the displays go through a complete rotation every few seconds.

An interesting feature of this procedure is that it does not required particularly elaborate or precise equipment. Since we are not concerned about voltage levels, an AC coupled 'scope will do. The only requirement is that there be some provision for a horizontal (x) input. Also, the only requirement of the oscillator is that it have fairly good short-term stability. Since we will not be changing the frequency of the reference, precision is not particularly critical. Lissajous patterns as shown may be produced by connecting the equipment as shown.

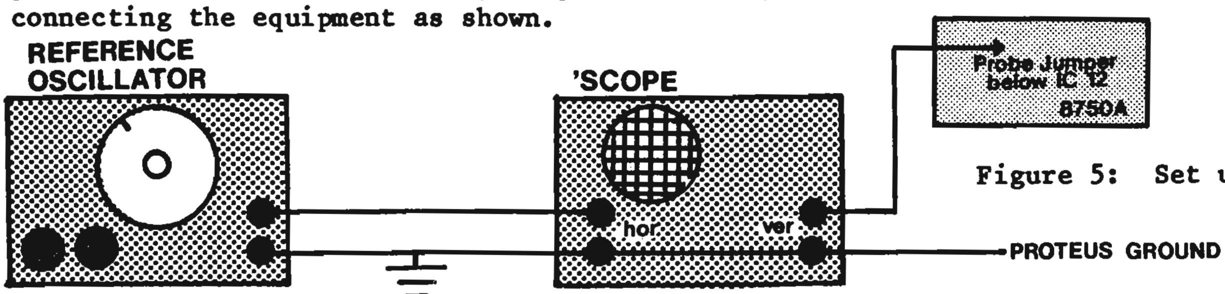


Figure 5: Set up

When using the oscilloscope technique, the easiest point to pick up the signal from PROTEUS I is on the long sleeved jumper which runs horizontally below IC12 (see figure 3) on the PROTEUS card. Monitoring the signal here allows you to observe the oscillator waveforms without having to hold down a key.

The major Lissajous figures which we will be calibrating to and their significance is shown below.

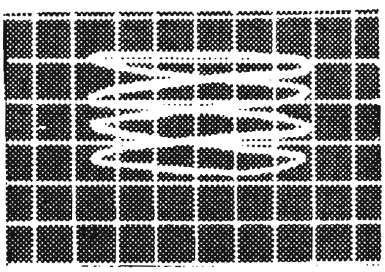


Figure 6a: Reference 2 octaves above Oscillator being calibrated

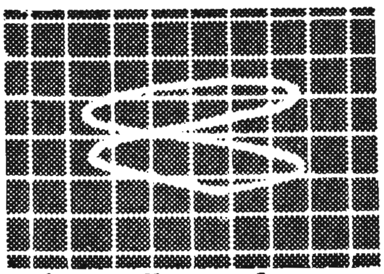


Figure 6b: Reference 1 octave above

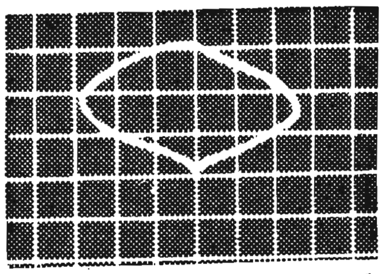


Figure 6c: Reference and Oscillator are the same

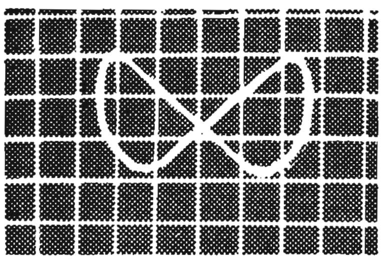


Figure 6d: Reference 1 octave below

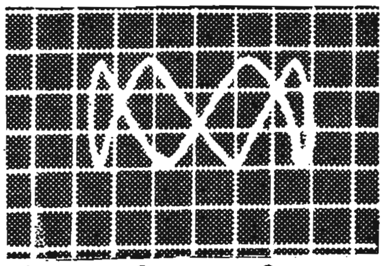


Figure 6e: Reference 2 octaves below

The calibration procedure is written using the oscillator and oscilloscope technique. If you are calibrating by ear, tune to octaves above and below middle C (261.- Hz.)

8) VCO #1 SCALE - Press the lowest C (left-most key) and adjust the front panel PITCH control for a stable lissajous indicating that the frequency of the #1 oscillator is two octave below the reference oscillator as shown in figure 6a.

Press the highest C (right-most key) and adjust the #1 SCALE trimmer R12 for a stable lissajous display showing the oscillator to be an octave above the reference as illustrated in figure 6d.

When you now press the lowest C again, you will undoubtably find that the display is spinning. Readjust the front panel PITCH control to produce a stable display as in figure 6a, and once again press the high C and re-adjust R12. Continue this procedure of hitting the low C and adjusting PITCH and the high C and adjusting R12 until a satisfactorily stable display appears at both keys.

Check the 2nd and 3rd Cs on the keyboard and verify that they produce acceptably stable displays similar to those shown in figure 6b and 6c respectively.

9) KEYBOARD TRANSPOSE - Press the lowest C on the keyboard and verify a stable display as in figure 6a. If necessary, adjust the front panel PITCH control for maximum stability.

Turn the front panel KEYBOARD OCTAVE switch to its most CW position (3) and adjust trimmer R43 for a stable display as illustrated in figure 6d. Verify that the (1) and (2) settings of the KEYBOARD OCTAVE front panel switch produce the displays shown in figures 6a and 6b respectively.

10) VCO #1 HIGH END - With the KEYBOARD OCTAVE front panel control set to its maximum CW position (3), press the highest C on the keyboard and adjust trimmer R9 (#1 HIGH) for a stable display. An example of the display is not shown, but if you are in doubt there will be 16 "points" on the top of the display indicating that the VCO is 4 octaves above the reference oscillator.

Now that one of the oscillators is tuned, the second VCO may be most easily calibrated using the first as a reference. The following procedures will all be performed by ear.

11) VCO #2 SCALE - Center the rear panel UNISON knob. Set the front panel KEYBOARD OCTAVE switch to its 0 position (fully CCW), center the front panel PITCH and FILTER SOURCE controls to the middle of their rotations.

Press the lowest C and adjust the pc mounted UNISON trimmer R123 so that the two oscillators are zero beat at the same frequency.

Press the highest C and adjust the #2 SCALE trimmer R55 for zero beat. Continue the procedure as outlined in the calibration of VCO #1 SCALE. Go back and forth between the low and high Cs adjusting UNISON for zero beat at the low end and R55 for zero beat at the high end.

When the calibration is acceptable at both extremes, check the tuning at the 2nd and 3rd Cs on the keyboard.

12) VCO #2 HIGH END - Rotate the KEYBOARD OCTAVE control fully CW to its highest setting and adjust the VCO #2 HIGH trimmer R82 for zero beat between the two oscillators.

13) VCO #2 TRANSPOSE - Return the KEYBOARD OCTAVE to its CCW extreme and rotate the front panel OSC 2 COARSE control to its fully CW (+2) position. Adjust the #2 TRANS trimmer (R83) so that the VCO #2 signal is zero beat three octaves above the pitch of OSC #1.

14) PARAMETER DAC - Return the OSC 2 coarse to its CCW setting and while listening to the combined output of the two oscillators, rotate the front panel #2 FINE control counting each semi-tone change as it happens. Count 12 changes (the first change is 1) and adjust PARAMETER DAC trimmer R27 on the Backplane board so that the two oscillators are zero beat with the OSC 2 an octave above OSC 1.

15) UNISON - Set the front panel OSC 2 COARSE to its "+1" setting and rotate the OSC 2 FINE control fully CCW. Adjust the pc UNISON trimmer R123 so that the two oscillators are zero beat at the same pitch. Don't spend a lot of time setting this control as it is duplicated by the much greater resolution UNISON control on the rear panel.

16) SUSTAIN - Read the voltage on pin 3 of IC12 and adjust the SUSTAIN trimmer R175 for the same reading on pin 9.

With calibration complete, the PROTEUS I may be reassembled by reversing the disassembly process. Lift the entire case top and wood-ends and place it over the bottom tray. Install the three #8 screws along the rear edge of the case and the four 5/16" cap screws in the bottom edges of the end panels. Securely tighten all hardware.

COMPUTER INTERFACING

The computer port is a standard feature on PROTEUS I, requiring only an appropriate connector to be made operational. Space has been provided on the rear panel patch bay for a DB-25 type connector.

Through this port, a computer or other digitally based controller has access to both the keyboard and the front panel controls and can read or write to either. From the users viewpoint, operation of the port is transparent. No hardware switches need to be thrown to switch from manual to computer control, and in fact even when the connectors between the computer and PROTEUS I are mated, control is manual until the computer signals that it wants control.

PROTEUS I assumes that the computer will be communicating with it through what is commonly refered to as a Peripheral Interface Adapter (PIA). The primary ditinguishing characteristics of a PIA from our point of view are threefold.

1) At least two complete 8 bit wide words are required.

2) The 8 DATA lines of each word must be software configurable to be either input lines or output lines.

3) One output control line (handshaking) is required for each of the two words.

In terms of 6502 based systems, interfaces based on 6520 (or its equivalent) type PIAs are optimum, while the 8255 is an equivalent in the 8080 world.

Of the two eight bit bytes on the computer's interface, one is used for the AGO keyboard and the other for preset memory.

Refer to the backplane schematic figure 32 page 54 of the PROTEUS I assembly manual for parts and circuit point references.

KEYBOARD BYTE

Bits KD0-KD7, Control line CA2

The keyboard may be read by the computer through this port or the pitch latches and DAC may be written to. In either case, the six bits that represent the key pressed or the note to be played are the low order 6 bits of the port (KD0 - KD5). The seventh bit (KD6) is a semaphore which indicates the status of the note/key bits. The eigth bit (KD7) provides a means of disabling the keyboard encoder entirely. The handshaking line CA2 is the strobe to the latches during a write and also allows the keyboard and PROTEUS I to be electrically isolated from one another.

Reading

In some cases, reading the keyboard is no more complicated than setting up the keyboard side of the PIA as all inputs and reading that byte. D6 is tested and if true (a digital "1") the lower six bits are taken to be key that is being pressed. If no keys are down, D6 will be false (a digital "0") and the lower six bits will be some random number.

Many real-world application of the computer interface (arpeggiation programs or keyboard transposed sequencers) require that there be some provision for effectively isolating the keyboard from the rest of the synthesizer. In the PROTEUS I interfacing scheme this is handled by the keyboard port's control bit CA2. When this bit is false it effectively grounds out the line which would ordinarily cause keyboard data to be strobed into the latches. The example driver subroutines at the end of this section are written so that CA2 is set low when they are first entered.

If the keyboard encoder has been turned off (as discussed below) a delay of about 5 ms. is required to assure that the entire keyboard has been scanned. Also note that when D7 is acting as an input, R11 serves as a pull-up to keep the encoder running.

Writing

During a write operation from the computer to PROTEUS I, the low order 6 bits of DATA have the same significance as during a read; they represent the key (note) which is to be played. As before, D6 is the gate semaphore. If the note represented by the low order bits is to be articulated (transient generator triggered) this bit is made true. When this bit is false, the note is treated as a released key would be.

The control bit CA2 is used as a strobe for the PROTREUS I's keyboard latches. When CA2 is true, the latches are in a pass state which allows changes at their inputs to be reflected at their outputs. CA2=0 sets the latches to their hold state.

When writing from the computer, the keyboard encoder should be disabled so that problems are not caused by contentions between the keyboard encoders strobe line and CA2. This function is controlled by DATA bit 8. When this line is false (low) it causes Q7 on the PROTEUS I's backplane to be turned off which effectively breaks the encoder's ground. When the ground is broken, all of the encoder circuitry is pulled to supply and the isolating resistors R12 - R18 act as added pull-ups on the PIA's DATA lines.

In most configurations PIA lines are set to zero when they are selected as outputs, resulting in the encoder being turned off more or less automaticly.

PARAMETER BYTE

PA3-PA0, PD3-PD0, Control bit CB2

Through this part of the port the computer can read or write to the PROTEUS I controller memory all sixteen of the 4 bit parameters which define a preset. The preset being read or written is as shown in PROTEUS I's front panel PRESET # display. The 8 bits of the port are used as two groups of 4 each. The most significant 4 bits (PA3 - PA0) are the address of the parameter while the parameter itself is represented by the least significant 4 bits (PD3 - PD0). The control bit CB2 serves as a low active strobe during write operations.

Reading

To read the parameters, all lines on this side of the port are made inputs and each of the 16 parameters are read into an input buffer. Since there is no strobe during a read to show when stable data is on the parameter lines this must be determined another way.

One workable approach is shown in the example subroutine at the end of the this section. In this routine the port is read and the high order 4 bits tested until they come up 0. When the $0 parameter appears, it is saved in the first buffer location and the port monitored until the address portion of the word is changed to $1, at which time that paramter is saved. The operation is repeated for each of the parameters.

This scheme uses twice as much buffer memory as it "has to" since the address portion of any given parameter byte will be the same each time. But the code required to strip away this portion of the byte and compact the results would almost certainly take up more space than the 8 bytes saved. And the address portion of the parameter would have to be reconstructed when the data was written out to PROTEUS I's controller memory, making this approach even more lengthy and time consuming.

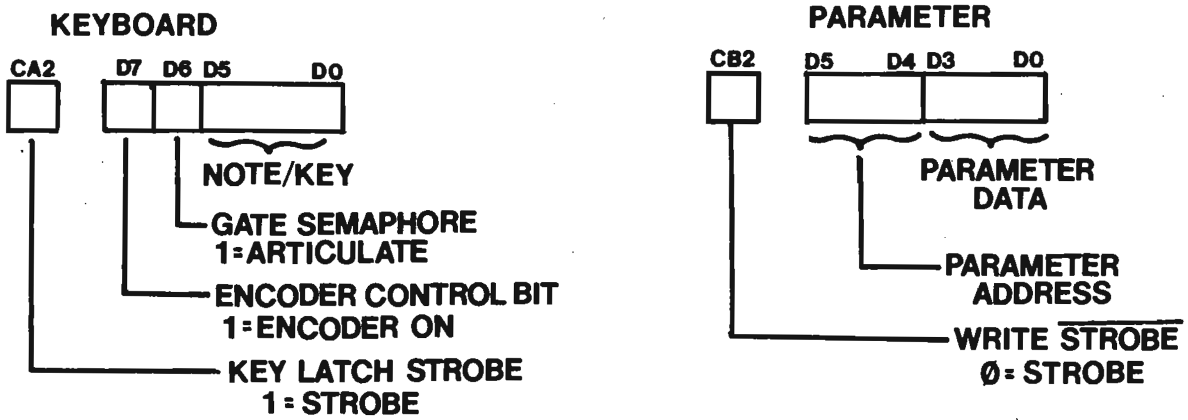
Writing

On write operations, CB2 serves as a strobe for PROTEUS I memory. Writing should be as simple as configuring the data lines as outputs, writing the parameter to the port and pulling CB2 low for a moment.

When using a 6520 PIA, however, the operation is not quite that simple because the outputs of the chip can not source enough current to overide the effect of the isolating resistors R6 - R9. A fairly uncomplicated solution to this is to wait for the 4 address lines to go high ($F) before converting the lines to outputs and writing all parameters in one sequence. As long as the address portion of the parameter is $F, R6 - R9 simply act as additional pull-ups on the PIA line. Since any one address is valid for 10 ms. as determined by PROTEUS I's parameter address counter, there will ordinarly be sufficient time for this. This is the technique used in the sample subroutine.

If the processor being used is not fast enough to write all parameters in the limited time available, an alternative approach would be to read the parameter generated by PROTEUS I until the address portion corresponds to the address portion of the parameter that the computer is to write, at which time the write from the computer can take place without the most significant 4 lines of the PIA having to sink or source any current at all.

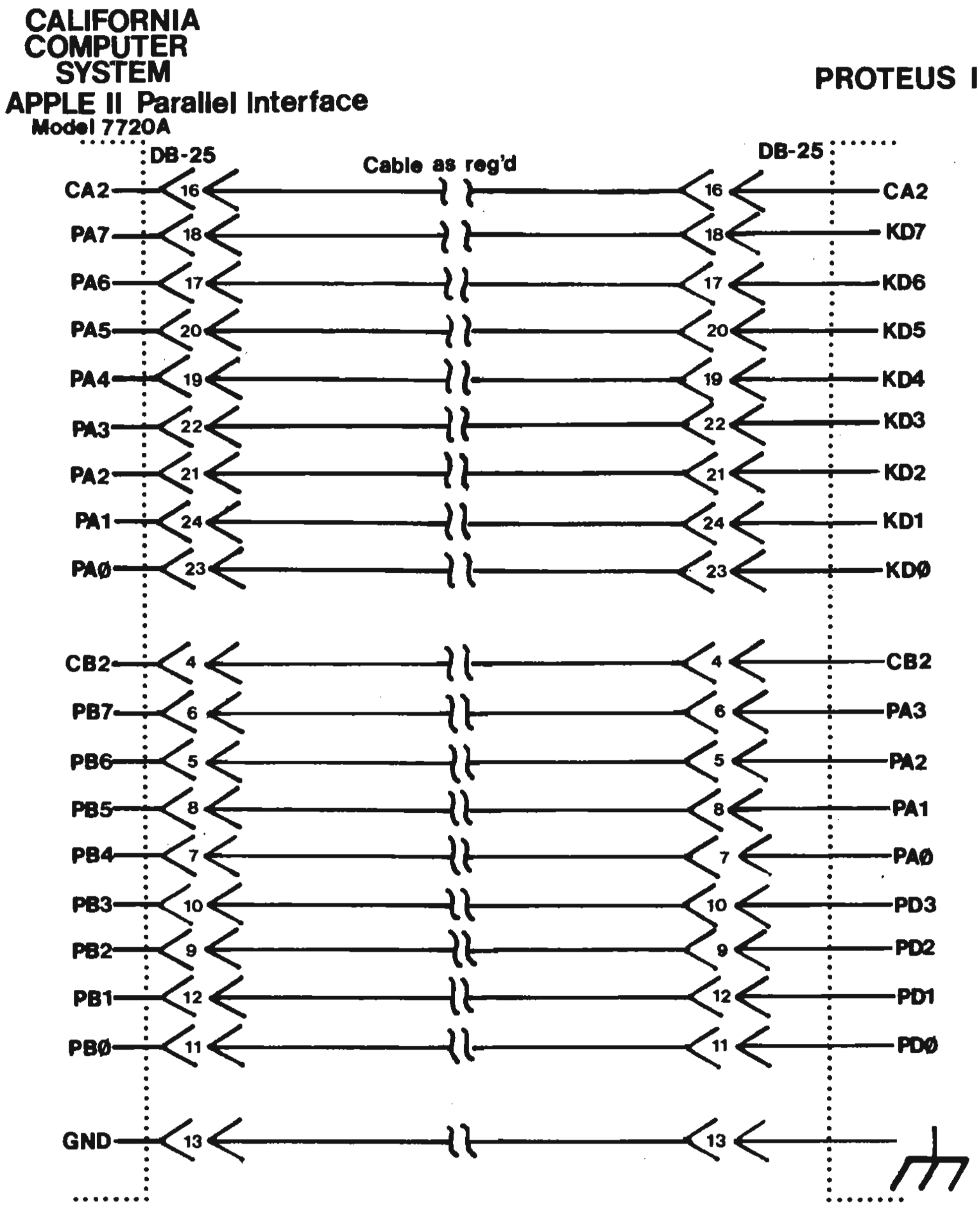
PROTEUS I CONTROL WORDS



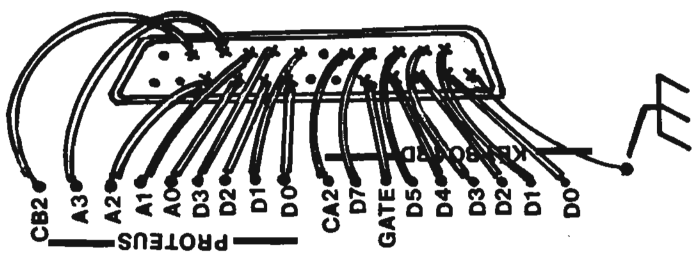
An APPLE/PAiA Example

The subroutines whose listing appears on the following pages were developed with an APPLE II computer using a California Computer Products #7720A parallel interface card.

Cabling between the PROTEUS I and the interface card was as shown below:



A DB-25P connector was selected to be consistent with the connector on the interface card and installed as illustrated below.



```
1000:             **********************************
1000:             *                                *
1000:             *   PROTEUS I COMPUTER PORT      *
1000:             *  FRONT PANEL AND KEYBOARD      *
1000:             *     DRIVER SUBROUTINES         *
1000:             *                                *
1000:             *   BY JOHN S. SIMONTON, JR      *
1000:             *                                *
1000:             *(C) 1981 PAIA ELECTRONICS, INC. *
1000:             *                                *
1000:             **********************************
1000:             *
C0A0:             PORTA   EQU  $C0A0
C0A1:             CMDA    EQU  $C0A1
C0A2:             PORTB   EQU  $C0A2
C0A3:             CMDB    EQU  $C0A3
1000:             *
1000:             *
1000:             *JUMP TABLE
1000:             *
1000:4C 2F 10             JMP  READ
1003:4C 65 10             JMP  WRITE
1006:4C 8C 10             JMP  GETKEY
1009:4C B2 10             JMP  NOTEOUT
100C:             *
100C:             INBUFF  DS   $10
101C:             OBUFF   DS   $10
102C:00           NOTE    DFB  $0
102D:00           KEY     DFB  $0
102E:00           TEMP    DFB  $0
102F:             *
102F:             *
102F:             *     ****** READ PARAMETERS  ******
102F:             *
102F:             * ;THIS SUBROUTINE READS THE PROTEUS CONTROLLER BOARD
102F:             * ;WHEN CALLED AND EXITS WITH THE 16 CONTROLLER
102F:             * ;PARAMETERS IN THE INPUT BUFFER
102F:             *
102F:             * ;BEGIN BY SETTING UP THE "B" SIDE OF THE PIA
102F:             * ;AS AN INPUT PORT.  NOTE THAT THE CONTROL BIT
102F:             * ;CB2 OF THE PIA IS LEFT FLOATING.
102F:             *
102F:A9 00        READ    LDA  #$00
1031:8D A3 C0             STA  CMDB
1034:8D A2 C0             STA  PORTB
1037:A9 04                LDA  #$04
1039:8D A3 C0             STA  CMDB
103C:             *
103C:             * ;SET UP THE X REGISTER AS A POINTER FOR THE 16
103C:             * ;PARAMETER BUFFER LOCATIONS.  WAIT FOR THE #0
103C:             * ;PARAMETER ADDRESS TO START FROM KNOWN POINT IN SEQUENCE
103C:             *
103C:A2 0F                LDX  #$0F
103E:AD A2 C0     READLP  LDA  PORTB
1041:29 F0                AND  #$F0
1043:D0 F9                BNE  READLP
1045:             *
1045:             * ;DOUBLE CHECK TO MAKE SURE THAT THIS IS THE #0 PARAMETER
1045:             * ;AND NOT GLITCH DURING CHANGE OF ADDRESS
1045:             *
1045:AD A2 C0             LDA  PORTB
1048:29 F0                AND  #$F0
104A:D0 F2                BNE  READLP
104C:             *
104C:             * ;NOW READ THE PARAMETER AND SAVE IT IN THE INPUT BUFFER
104C:             * ;LOCATION POINTED TO BY X.  MASK OFF AND SAVE THE ADDRESS
104C:             * ;PORTION (HIGH HALF-BYTE) FOR USE IN NEXT STEP
104C:             *
104C:AD A2 C0     RLOOP1  LDA  PORTB
104F:9D 0C 10             STA  INBUFF,X
1052:29 F0                AND  #$F0
1054:8D 2E 10             STA  TEMP
1057:             *
1057:             * ;NOW LOOP UNTIL THE ADDRESS PORTION OF
1057:             * ;THE PARAMETER CHANGES
1057:             *
1057:AD A2 C0     RLOOP2  LDA  PORTB
105A:29 F0                AND  #$F0
105C:CD 2E 10             CMP  TEMP
105F:F0 F6                BEQ  RLOOP2
1061:             *
1061:             * ;POINT TO NEXT INPUT BUFFER LOCATION
1061:             * ;AND IF ALL ARE USED, LEAVE
1061:             *
1061:CA                   DEX
1062:10 E8                BPL  RLOOP1
1064:60                   RTS
1065:             *
1065:             *
```

```
1065:                 *     ****** WRITE PARAMETER  ******
1065:                 *
1065:                 * ;THE WRITE ROUTINE TAKES PARAMETERS FROM
1065:                 * ;THE OUTPUT BUFFER AND WRITES THEM TO THE
1065:                 * ;MEMORY ON THE PROTEUS CONTROLLER CARD
1065:                 *
1065:                 * ;NOTE THAT IN ORDER FOR THE ISOLATION RESISTORS
1065:                 * ;IN THE PROTEUS CONTROLLER BOARD ADDRESS LINES TO
1065:                 * ;SERVE AS PULL-UPS FOR THE PIA'S TTL OUTPUTS,
1065:                 * ;MUST WAIT FOR ADDRESS "FX" (HIGH HALF-BYTE = $F)
1065:                 *
1065:                 * ;ALSO NOTE THAT THE PORT MUST ALREADY BE
1065:                 * ;CONFIGURED AS INPUTS WHEN ENTERING ROUTINE
1065:                 *
1065:AD A2 C0       WRITE   LDA  PORTB
1068:29 F0                 AND  #$F0
106A:49 F0                 EOR  #$F0
106C:D0 F7                 BNE  WRITE
106E:                 *
106E:                 * ;NOW SET UP THE PORT AS ALL OUTPUT LINES AND
106E:                 * ;USE THE X REGISTER AS OUTPUT BUFFER POINTER
106E:                 *
106E:8D A3 C0              STA  CMDB
1071:A9 FF                 LDA  #$FF
1073:8D A2 C0              STA  PORTB
1076:A2 0F                 LDX  #$0F
1078:                 *
1078:                 * ;RAISE CB2 (NOT-STROBE), GET THE PARAMETER AND
1078:                 * ;WRITE IT TO THE PORT
1078:                 *
1078:A9 3C          WRLOOP  LDA  #$3C
107A:8D A3 C0              STA  CMDB
107D:BD 1C 10              LDA  OBUFF,X
1080:8D A2 C0              STA  PORTB
1083:                 *
1083:                 * ;LOWER CB2 TO WRITE PORT TO PROTEUS CONTROLLER
1083:                 * ;MEMORY.  POINT TO NEXT BUFFER AND LOOP IF MORE
1083:                 *
1083:A9 34                 LDA  #$34
1085:8D A3 C0              STA  CMDB
1088:CA                    DEX
1089:10 ED                 BPL  WRLOOP
108B:60                    RTS
108C:                 *
108C:                 *
108C:                 *     ****** AGO KEY READING ROUTINE  ******
108C:                 *
108C:                 * ;NOTE THAT WHEN YOU LEAVE THIS PROGRAM THE KEY
108C:                 * ;IS IN THE ACCUMULATOR AND THE LOCATION "KEY"
108C:                 * ;IF NO KEYS ARE DOWN, BOTH "KEY" & ACC. =0
108C:                 *
108C:                 * ;BEGIN BY ACCESSING DATA DIRECTION REGISTER
108C:                 * ;AND MAKING ALL LINES INPUTS.
108C:                 * ;$30 AND $34 TO THE COMMAND REGISTER HOLDS CA2 LOW

108C:                 * ;SO THAT A KEY DOWN DOES NOT STROBE
108C:                 * ;KEYBOARD DAC LATCHES
108C:                 *
108C:A9 30          GETKEY  LDA  #$30
108E:8D A1 C0              STA  CMDA
1091:A9 00                 LDA  #$00
1093:8D A0 C0              STA  PORTA
1096:A9 34                 LDA  #$34
1098:8D A1 C0              STA  CMDA
109B:                 *
109B:                 * ;A SHORT DELAY ALLOWS THE ENCODER TO FIND DOWN KEYS
109B:                 *
109B:A0 1C                 LDY  #$1C
109D:20 D7 10              JSR  DLY1
10A0:                 *
10A0:                 * ;GET THE OUTPUT OF THE ENCODER AND ADD $C0 TO SHOW
10A0:                 * ;IF ANY KEYS ARE DOWN
10A0:                 *
10A0:AD A0 C0              LDA  PORTA
10A3:A8                    TAY
10A4:18                    CLC
10A5:69 C0                 ADC  #$C0
10A7:98                    TYA
10A8:B0 04                 BCS  ROUT
10AA:                 *
10AA:                 * ;IF CARRY IS NOT SET, THERE ARE NO KEYS DOWN
10AA:                 * ;MAKE KEY = 0
10AA:                 *
10AA:A9 00                 LDA  #$00
10AC:29 3F                 AND  #$3F
10AE:8D 2D 10       ROUT    STA  KEY
10B1:60                    RTS
10B2:                 *
10B2:                 *
```

```
10B2:           *     ****** NOTE OUTPUT ROUTINE  ******
10B2:           *
10B2:           * ;THIS CODE GETS THE KEY TO BE PLAYED FROM THE NOTE
10B2:           * ;BUFFER, PUTS IT OUT TO THE PORT AND STROBES THE
10B2:           * ;PROTEUS LATCHES. LEAVE WITH ENCODER OFF.
10B2:           *
10B2:           * ;SET ALL LINES AS OUTPUTS - THIS ALSO TURNS
10B2:           * ;THE ENCODER OFF (D7 GOES TO 0).
10B2:           * ;
10B2:A0 30      NOTEOUT LDY  #$30
10B4:8C A1 C0           STY  CMDA
10B7:A0 FF              LDY  #$FF
10B9:8C A0 C0           STY  PORTA
10BC:A0 34              LDY  #$34
10BE:8C A1 C0           STY  CMDA
10C1:           * ;
10C1:           * ;OUTPUT THE NOTE TO THE PORT AND RAISE STROBE.
10C1:           * ;
10C1:AD 2C 10           LDA  NOTE
10C4:8D A0 C0           STA  PORTA
10C7:A0 3C              LDY  #$3C
10C9:8C A1 C0           STY  CMDA
10CC:           * ;
10CC:           * ;TAKE A SHORT DELAY FOR ENCODER TO SETTLE IN OFF
10CC:           * ;STATE, THEN LOWER STROBE BEFORE RETURNING.
10CC:           * ;
10CC:A0 01              LDY  #$01
10CE:8C D7 10           STY  DLY1
10D1:A0 34              LDY  #$34
10D3:8D A1 C0           STA  CMDA
10D6:60                 RTS
10D7:           *
10D7:           * ;DELAY SUBROUTINE
10D7:           *
10D7:A2 20      DLY1    LDX  #$20
10D9:CA         DLOOP   DEX
10DA:D0 FD              BNE  DLOOP
10DC:88                 DEY
10DD:D0 FA              BNE  DLOOP
10DF:60                 RTS

*** SUCCESSFUL ASSEMBLY: NO ERRORS
 C0A1 CMDA        C0A3 CMDB        10D9 DLOOP       10D7 DLY1
 108C GETKEY      100C INBUFF      102D KEY         10B2 NOTEOUT
 102C NOTE        101C OBUFF       C0A0 PORTA       C0A2 PORTB
 102F READ        103E READLP      104C RLOOP1      1057 RLOOP2
 10AE ROUT        102E TEMP        1065 WRITE       1078 WRLOOP
 100C INBUFF      101C OBUFF       102C NOTE        102D KEY
 102E TEMP        102F READ        103E READLP      104C RLOOP1
 1057 RLOOP2      1065 WRITE       1078 WRLOOP      108C GETKEY
 10AE ROUT        10B2 NOTEOUT     10D7 DLY1        10D9 DLOOP
 C0A0 PORTA       C0A1 CMDA        C0A2 PORTB       C0A3 CMDB
```