AN ULTRA VCO FROM THE 4720

By: Gary Bannister

The 4720 Voltage-Controlled Oscillator does a super job as it comes from the factory. While guaranteed to go from 16 Hz to 16KHz, they typically perform much better. Several units I have tested ran from 4Hz to 20KHz. This is not really amazing, considering the design of the unit. With regulated power supplies, the combination of precision current source, and temperature-compensated integrator produce an oscillator of exceptional range and stability.

However, PAIA does not yet produce a voltage-controlled CONTROL oscillator. Requirements of such a unit would be low frequency (typically 0.5Hz to 50Hz), DC coupling (no blocking capacitors), and compatible signal level (0 to 5 volts). A super unit would include both positive-going and negative-going signals useful for panning or dual filter sweeps.

The obvious difference between this and the 4720 is the super low frequencies. The design of the 4720 makes it easy to produce such a response by simply replacing capacitor C2. If the original capacitor and the new one are placed on a single pole double throw switch, each range may be easily selected. (See Fig. 1) The value of the new capacitor is selected to give the desired range. Changing the value by a factor of ten (to .1 uf) will drop the frequency for a given voltage by ten, also. Using a 1 uf cap will drop the frequency to 100. At this rate, a typical oscillator will produce a lowest frequency of .04Hz, or ONE CYCLE EVERY 25 SECONDS! Be sure to use good quality capacitors, preferably mylars and NOT electrolytics. Maybe a tantalum would be good for VERY LOW frequencies.

With a range switch suitably installed, a new problem develops. The new low frequency waveforms viewed on an oscilloscope begin to get a peculiar distortion, especially when both the control voltage and range pot are at maximum. (See Fig. 2) In fact, this same distortion appears with the normal capacitor in place as well.

This is obvoiusly a form of harmonic distortion-the waves are not pure. This distortion is also a sign of linearity error. This means that the oscillator goes slightly out of tune with the range pot maximum. We don't notice this as much when the oscillator is in the audio range because the harmonic distortion is too high to hear, and the slight detuning actually produces sometimes pleasing "phasing" effects. (Please note that this distortion appears only above about 10KHz in the audio range.)

However, it should be easy to see (hear?) what this distortion would do if we were to use the sine output for vibrato. The results would be less than musically pleasing.

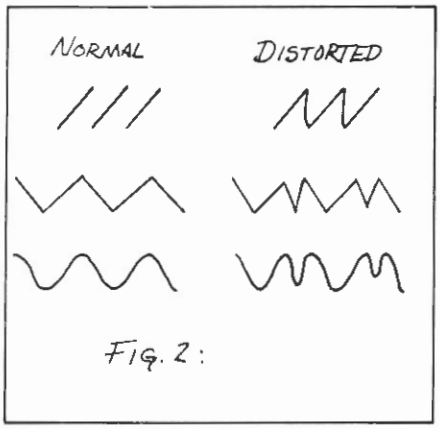

FIG. 2:

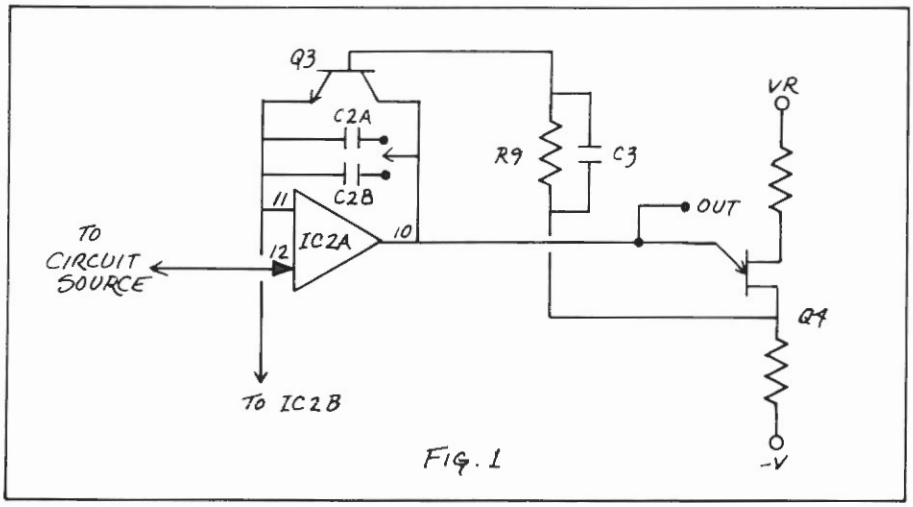

FIG. 1

Since we also find that this distortion appears in the low range (but at a frequency about 10 times lower-approximately 1000Hz), we have a clue to its cause, and therefore its remedy.

Without repeating the operation of an integrator (which is covered in the 4720 Owners Manual), let it be said that if a large current flows into the integrator, a suitable large current must flow out of the integrator. The problem lies in the fact that Q3 cannot short out this current fast enough. This means that the fall time of the sawtooth is no longer infinitely short, but now is a good portion of the total waveform. Not only this, but the amplitude becomes less, and a DC offset is produced which ultimately affects the triangle and sine, and makes the pulse width unstable.

The remedy for this problem is to find a transistor which CAN short this current fast enough. What makes a transistor suitable for this purpose is known as High Frequency Cut-Off (f_T in transistor substitution manuals). A good suitable replacement is 2N3641. This has an f_T of about 300MHz (300,000,000Hz!). A special aircraft transmitter transistor was also tried with more than excellent results. Its f_T is better than 1 Gigaherz-1,000,000,000Hz! Also of slight importance is the combination of R9 and C3 (See Fig. 1). Some improvement is made by removing C3 and changing R9 to 10K.

Now, with some minor realignment of the Pitch Range and Triangle Symmetry controls, the 4720 is capable of a frequency range of about 20 OCTAVES in two overlapping ranges. As a fringe benefit the oscillator stays better in tune through its total range.

These low frequencies are not really of much use since we can't hear them. At least, if we can't hear them, then we should be able to hear their effects. Vibrato is obvious, but a good low frequency sine wave is great for sweeping a Phlanger.

To get these effects we need an oscillator with 0-to-5 volt swings. The normal output of the 4720 is .5 volts, but there is an easier way.

When building the 4720 the set-up is to adjust the sawtooth for a 4.5-volt swing. VOILA!! Here is one output that needs no amplifying, only simple buffering. By measurement, we find that there is a pulse wave available that is also 5 volts. Further measurement finds a 2.5-volt triangle and a 2-volt sine. Fig. 3 shows where in the circuit these are available.

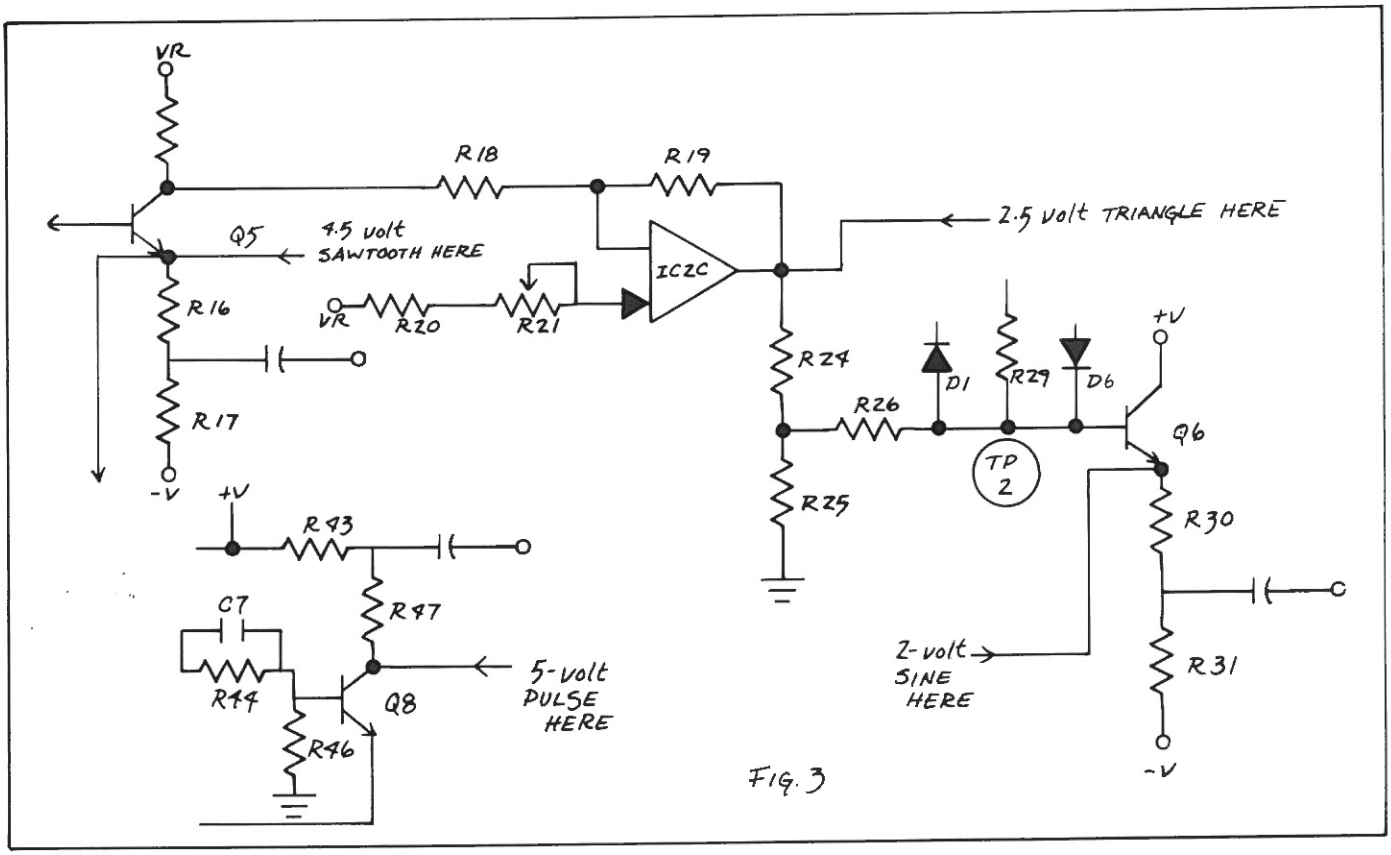

Fig. 3

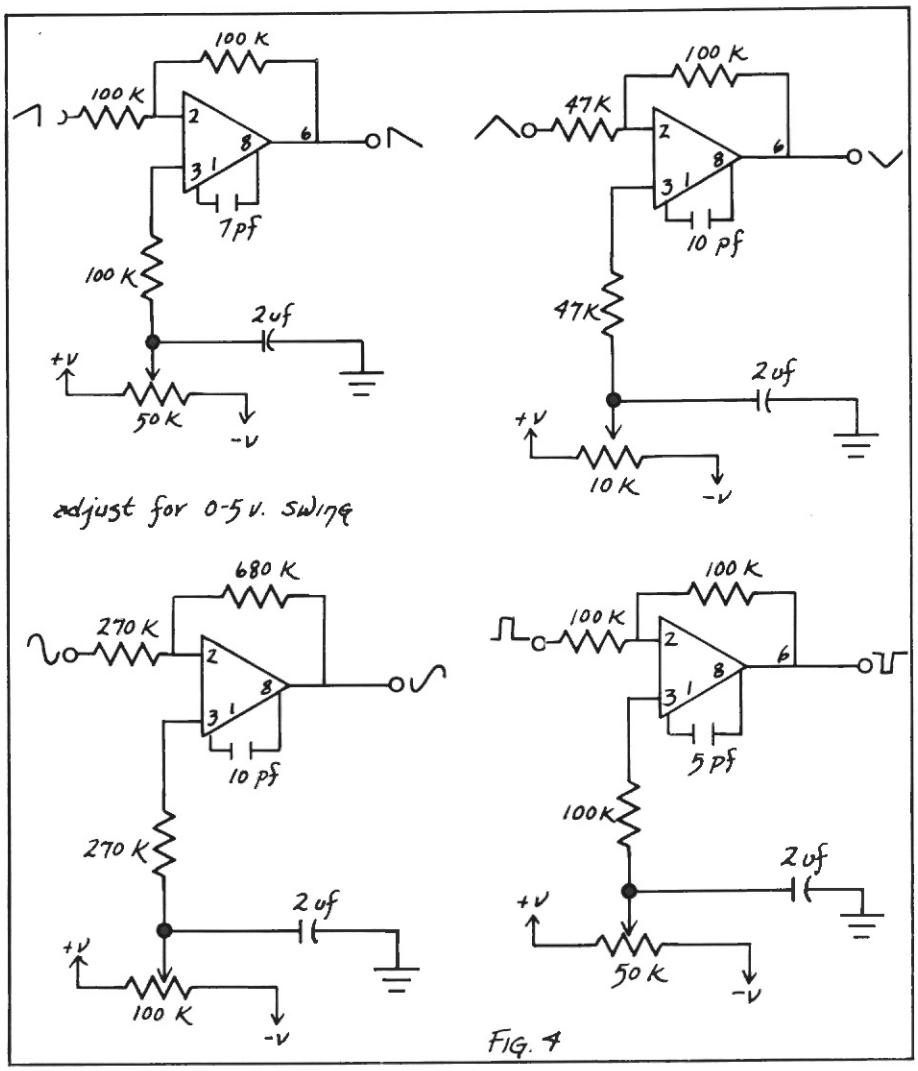

Fig. 4

Now, all we need is some simple amplification to get th 5-volt swings, and some level shifting to get the swing to go from 0 to 5 volts. Fig. 4 shows four such circuits. Note that all op-amps are of the 748 variety. Some non-standard frequency compensation is used to keep the fall times short. When finished, each unit should be adjusted so that the waveform swings from 0 to 5 volts. The 2uf Capacitors are optional, but may be necessary to keep any hum in the power supplies from getting in and being amplified.

Notice that all the buffers in Fig. 4 are inverters. This is the easiest form to work in with this use, and the upside-down waveform is of little importance.

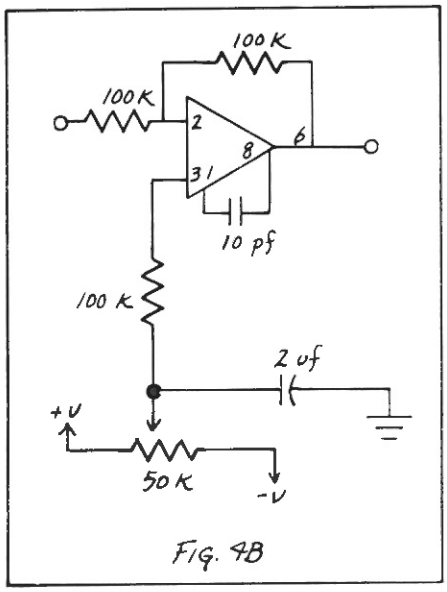

Fig. 4B

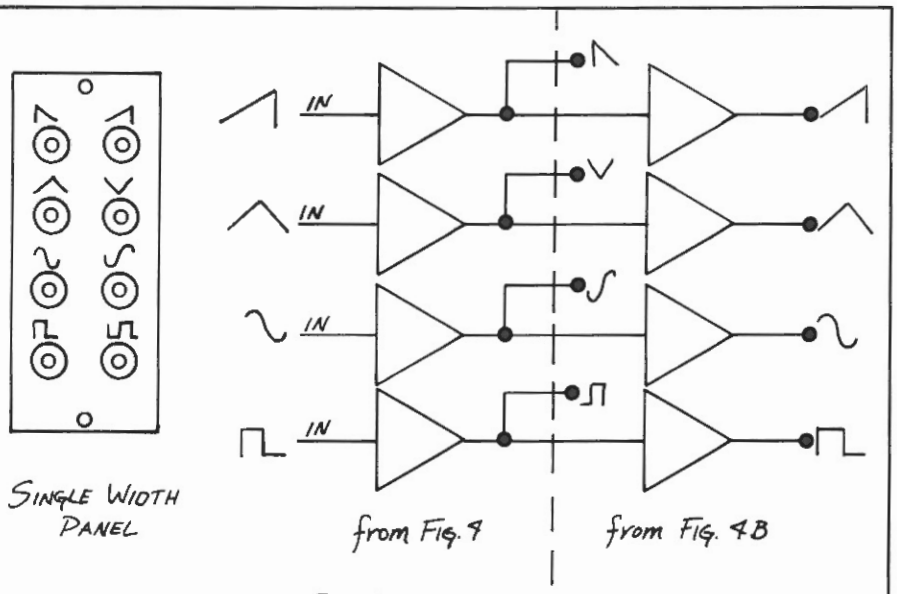

FIG. 5A

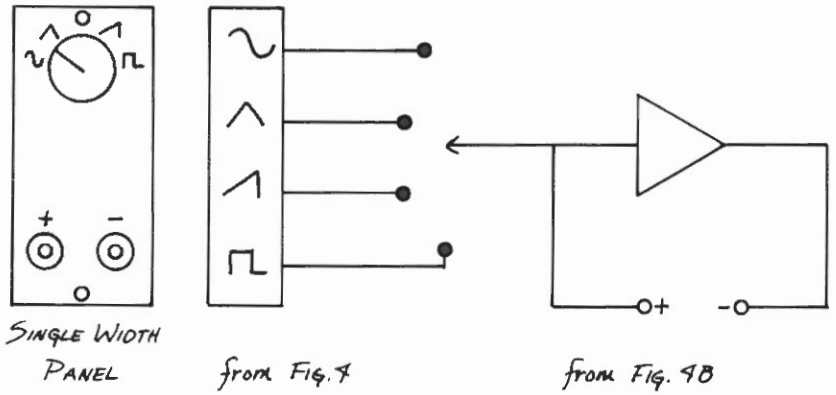

FIG. 5B

sion. This needs 5 op-amps. In either case there is no provision for variable output, but a 5Kohm pot to ground is a simple chore.

Other units suggest themselves. I am using a separate container and power supply for a super unit. Audio, control, and inversions are available. A bias supply is included so that the oscillator may be run by itself. Shut off the bias and the normal VCO response is available. The outputs are variable, and an offset switch is planned so that the outputs will swing 0 to 5, 2.5 to 2.5, or 0 to -5.

Uses of this VCO are varied. Easily done is a vibrato that increases as the played pitch increases. A super-slow sweep for the Phlanger is possible, and may also be applied to the filters as well. How about sweeping the filter at an AUDIO rate? Unbelievable phasing, rolling timbres are possible if the oscillators track each other at a harmonic interval. Gongs and chimes do not detune through the ring modulator. By producing vibrato at an audio rate that tracks the pitch oscillator, even thicker chimes may be produced. The thickness of the chime depends partly on how much the pitch is modulated. With two of these oscillators some ultrasonic effects may be possible through the ring modulator, giving rise to eerie shortwave sounds.

Truly, the 4720 is a super oscillator.

SOME QUICK THOUGHTS: Can you computer musicians see a way to digitally select the range capacitor? If so, how about computer selection of octaves by using several capacitors and range trimmers for R8?

If the original form of the wave is necessary, it is a simple matter to add another inverter. Fig. 4B is such a unit. Any waveform may be put in, and the offset pot adjusted for 0 to 5 volt output (without it the swing would be 0 to -5 volts). A quad op-amp such as a 4136 would be useful in this application.

Now, our goal is reached. We have a super oscillator with a 20-octave range, control voltage outputs, and inversions available (known as differential outputs). All this and we can still use all four AUDIO outputs at the same time.

How do we use it? Several additional modules suggest themselves, all of them similar to the Sine converter for the 2720-2A. Fig. 5A is a control voltage module. It needs 8 op-amps, but all waves and their inversions are available at the same time. Fig. 5B has a rotary switch to select one wave and its inver-

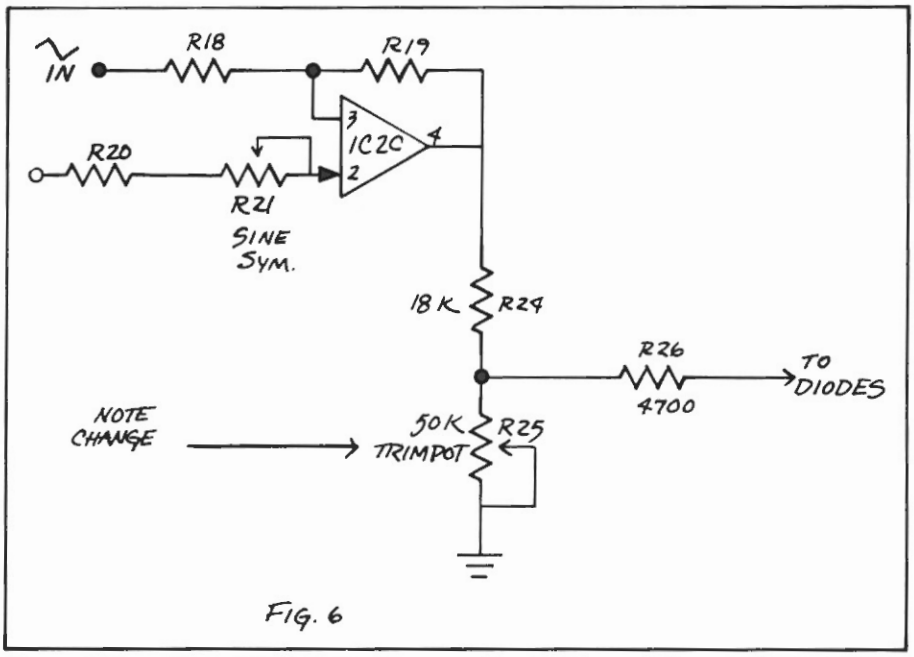

FIG. 6

LETTERS!

"DEFENDING DIGITAL"

Dear Editors,

Your magazine is really getting slick! I thought I was getting Contempory Keyboard from the feel of the front cover. Your printing of pictures has really improved.

I'm afraid that I must take issue with the "back to music" letters in the Feb. 1978 issue. Such thoughts crop up many times in discussions I have with friends, and technology vs. music vs. musician is a hot subject.

I DO NOT feel that the magazine OR the company has left the idea. While you seem to have gone strongly digital, and the analogue seems to have slowed down, the goal is still the same - - MAKE MUSIC. Whether I do it by fingers or microprocessor is irrelevant. The beauty of your system is that I can do it EITHER WAY. Or both at the same time.

Audio is strongly going digital. Who cares? Anybody who likes music should. I call your attention to the "reworked" Carruso record, which in effect amounts to a remix job without a master tape. How about the digital tape and discs showing up at the trade shows? These show promise for previously unheard of levels of distortion and noise (namely NONE) and dynamic range almost exceeding natural events. How about the 'environmental' experiments (by JVC?). With proper processing and speaker placement, et al, walls seem to 'disappear'.

The point is, that anybody involved with the technical side of music (or sound), be he (she) synthesist, recording engineer, performing musician, or composer, etc., MUST keep up with the advances in his area of interest. If they deal with your company, they must be into synthesis, and synthesis is strongly digital, by nature.

But why should we have to learn digital electronics? I just want to PLAY! To answer a question with a question (A questionable idea at best): Why should the brass player know the harmonic response of a brass tube, and the results of changing its length? Why should the string player understand the vibration pattern of a taut string or

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CORRECTION

for "An Ultra VCO from a 4720" by Gary Bannister, Polyphony February 1978

The drawing of the conversion circuit for the Sine output shown in figure 6 should have shown the new 50K trimpot replacing both R24 and R25. The 4700 ohm R26 should then be connected to the wiper of the trimmer. This control allows an extra fine adjustment for minimum sine distortion. To set the control, you should first adjust R21 for proper symmetry. Then use the new 50K trimmer to adjust for minimum distortion, or the smoothest curve as viewed on a 'scope.

The 2 mfd bypass capacitors shown in figure 4 were non-polarized in the original prototype, however polarized electrolytics could be used if you first note the voltage which has been selected at the wiper of the offset trimpot and then install the electrolytic with the appropriate polarity. ■