

EK-1 TOP OCTAVE EXPERIMENTER'S KIT

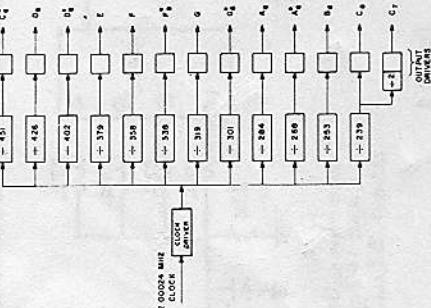
I just discovered Top Octave Dividers!

I know, they've been around for years.

I've had them in my "junk box" for years but thanks to a shove from Craig Anderton I finally got around to powering one up to see what it would do. Hey, surprise; you don't have to build organs out of them - they'll do some neat stuff too. You see, it's not that I don't like organs; though in all honesty they too often sound like they should be accompanied by thousands of whirling ball bearings. It's just that it always seemed like there wasn't a whole lot of imagination and creativity involved in taking a top octave chip, combining it with a crystal and liberal doses of dividers to come up with a musical instrument.

FUNCTIONAL DIAGRAM

For those of you who have not yet been exposed to them, here is a top octave chip:



This particular one is called a 50240 and it's made by Mostek and AMI.

They're a lot more expensive than they need to be but other than that they're OK.

They're called "top-octave" dividers (or chips to pro's like you and me) because when you put a 2 mHz. clock frequency into the pin marked

"CLOCK", a full octave (plus one note) of equally tempered semi-tones come flowing out of the rest of the pins. Oh yes, V_{ss} and V_{dd} are where the power goes in (V_{dd} is ground, V_{ss} is the positive supply point).

The "top" part comes from the fact that with the recommended 2 mHz. clock frequency the highest note from the chip is C₈ (about 369 Hz.) and the rest go down from there. If you're building an

organ the normal procedure is to apply each semi-tone output to a string of bi-stables to get the corresponding note in the lower octaves. Then you use all the standard organ tricks of summing the square waves to get ramps or triangles or whatever before going through filters for harmonic control. And so on.

If you're interested in this sort of thing, and it is interesting the first time, American Micro-Systems, Inc. (AMI) used to put out a little pamphlet called "MOS MUSIC" which may or may not still be in print and which they may or may not send to you - depending, I think, on the phase of the moon and whether or not the month has an "r" in it. Be that as it may, it certainly wouldn't hurt to try.

American Micro-Systems, Inc.

3800 Homestead Rd.
Santa Clara, CA 95051

If you are building organs, these things are obviously something you would trade your sister for because all of the notes are derived (some ad men simply can't resist the temptation to say "computed") from a single reference frequency - there's no way that you can get just one note out of tune. If any one is right then the rest have to be right.

There are a couple of tricks to using these things that you would discover for yourself after working with them for a while, but why re-invent the wheel.

First, like most digital stuff, you are going to need to by-pass the power supply to the circuit itself as close to the chip as possible. That means a .01 mfd. disk right at the V_{dd} and V_{ss} pins. Unlike most other digital goodies, I recommend putting about a 5 mfd. electrolytic cap. in parallel with the disk. This larger capacitor de-couples tones that will otherwise be wandering around on the ground line waiting to spring out and cause difficulties.

Second, you can make simple organ type things just by closing switches to mixing resistors BUT, make sure that the switches close to a point that is about half of the top octave's supply voltage. If you don't, you will not only get square waves out but also the average value of the square wave which will be heard as an objectionable "thump" that will eventually drive you berserk. By closing to a point that is already at the average value of the waveform you eliminate this transition.

Last (and best of all) these chips are static, which means that you don't have to clock them at that 2 mHz. frequency if you don't want to. It should go without saying that the lower the clock frequency, the lower the pitch of the semi-tones will be that come out of the chip. But, thanks to our old friend the equally tempered scale, the notes will all be chromatic no matter what the clock frequency.

These points are incorporated in this drawing of a simple 1 octave organ:

Shown on following page

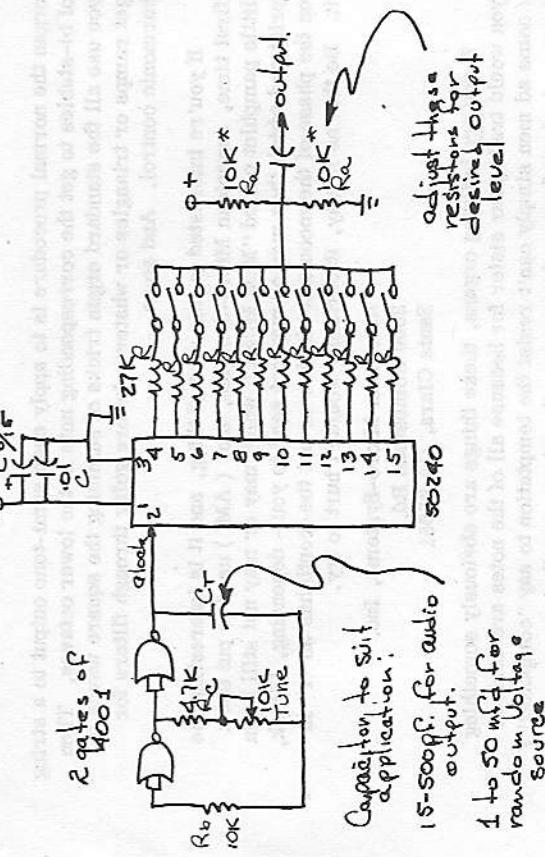


Figure 2

With this simple arrangement you may still notice some slight keying pops but they're not caused by DC level shifts, they come from bouncy switch contacts not switching the output waveforms cleanly on and off.

When you're through playing with that, you can re-arrange the parts like this:

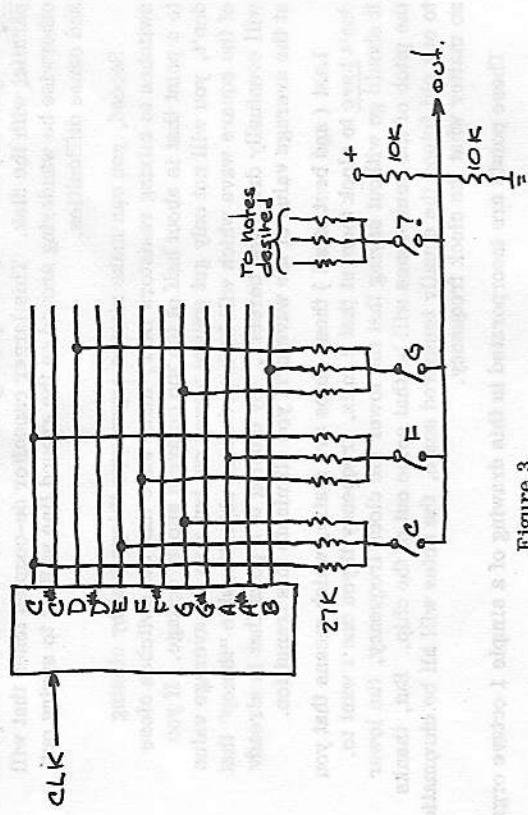


Figure 3

and now you've got (for lack of a better name) a "chord box" with individual switches that select chords instead of single notes. You can make the chords as simple or complex as you wish but since you're working with a single octave of notes some of the chords you want will undoubtedly have to be done as inversions (as are F and G in the example). This kind of thing would be slick in some sort of box that goes on the floor (like a pedal bass only for chords). This would make a nice kit if we had a source of foot switches. Maybe I'll start looking for some.

So, those kinds of things are alright, but they're not really breaking any new ground; they're pretty much what the manufacturers had in mind in the first place.

Here's something they didn't have in mind. Remember that I said that these chips are static and can be pumped by any sort of low frequency clock you want? Because of that you can turn a top octave chip into a pretty credible random voltage source just by lowering the clock frequency to a few hundred Hz. (or lower). Changing the clock frequency is simply a matter of substituting a capacitor in the mid, range for the pf. job shown in the second set of drawings. By the way, this capacitor must be non-polarized or if you don't happen to have a 1.0 mfd, or so non-polarized capacitor around a couple of back to back electrolytics will work. The top-octave pseudo-random voltage source looks like this:

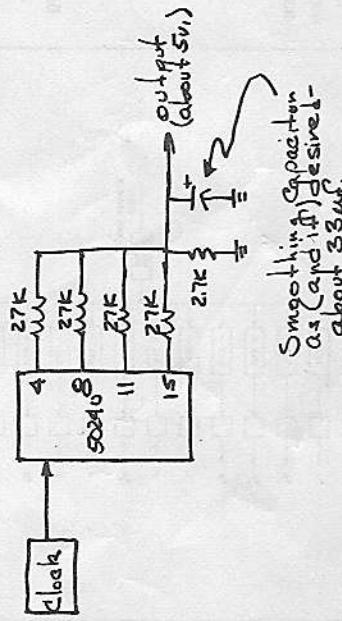


Figure 4

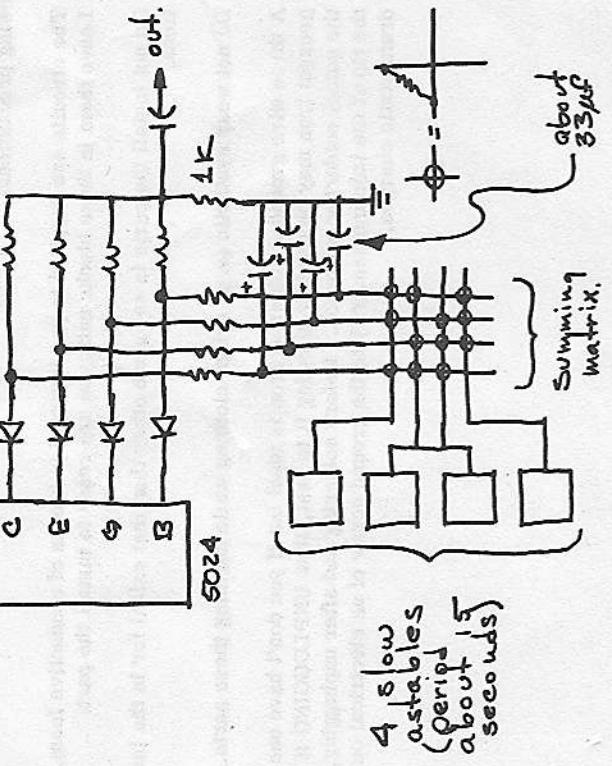
To see why this works, assume that at some time t_0 we turn on the chip and that at that time pins 14 and 15 of the chip are both high. After 239 clock cycles the voltage at pin 15 goes low and 14 cycles after that (at the 253rd cycle) pin 14 goes low. These two outputs will continue going high and low, apparently asynchronously until 239×253 (or a little over 65 thousand) clock cycles later when they will both simultaneously go high again. At a clock frequency of 200 Hz, it's going to be a little over 327 seconds before we get back to the starting point of both outputs transitioning high at the same instant. Throwing a third and fourth output into this mess gives another two terms to form the product so you can see that it's going to be a while before the cycle repeats. This is approximate, of course, because under most conditions the pattern will repeat in a period that is an integral division of what would appear to be the actual period; but, even then, it's a long time. The configuration that I've shown is one that I like but there are a lot of combinations of 13 things taken

from 2 to 13 at a time, even when you throw out the combinations that are trivial. Any of you that are math buffs (as I am, a little) will really have fun with this.

I can see that I'm getting carried away - Marvin and Linda Kay will scream about the length of my copy - again.

Quickly, quickly -- one more.

Environment machines, like our Surf Synthesizer, Wind and Wind Chimes are really my favorite kinds of products. Even I can work them since all you do is plug them in and let them do their thing. We're getting ready to do one (it's done, actually, but instructions take forever) that uses a top octave chip and is based on an idea originated by Craig Anderton called a "Chord Egg". It's a lot like the "chord box" thing that we looked at earlier except that it's got a random voltage source that provides 4 independent control voltages to a like number of voltage controlled attenuators. The voltage controlled attenuators are in the lines going to the notes that make up a major 7th chord. It looks a lot like this:



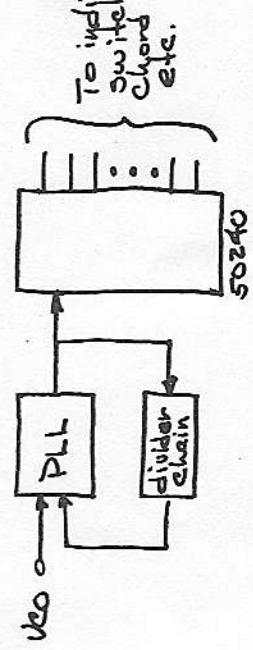
All resistors about 10K
except as marked.

Figure 5

and the idea is that as the random voltage sources change, the notes that you hear change - but slowly. And they are always notes that make up that major 7th spelling. This is a simplified drawing; the final unit also includes a circuit that randomly selects one of four chords: C⁷, A⁷, G⁷ and/or F⁷. This has got to be the ultimate meditation machine; and I think that we'll be able to sell it for about \$25.

Just one more, I promise.

We can't take the output of a VCO and use it directly as the clock signal for a top-octave chip (at least not with any useful result) but we can come up with a frequency multiplier built out of a phase locked loop and use that as the top octave clock like in this block diagram:



The result is that we have a complete octave of semi-tones tracking along with the VCO and we can pick those semi-tones up as intervals or complete chords. This sort of thing would have been prohibitively expensive 10 years ago when the only PLL's you found were in ground stations for satellite communications; but now that you can get them from just about any surplus house it's a different story. If you try to build one of these to play with you might get by with a 565 type PLL but you'll find the tracking range prohibitively small. A much better choice is an RCA 4046.

Figure 6



THE EK-1 PRINTED CIRCUIT BOARD

The EK-1 circuit board has been laid out to provide the maximum versatility possible. Labeled component locations refer back to the parts labeled in the simple organ circuit (figure 2.) Unlabeled locations and holes are for discretionary use by the experimenter. Note that a "spare" location has been provided for an integrated circuit. Potential uses for this position include phase-locked-loops, multiple stage dividers (for range switching), etc. Note also that the two stages of the 4001 type quad NOR gate have been brought to circuit board points. These two NOR gates may be used as required.

WARNING: CMOS CIRCUITS

The remainder of the integrated circuits used in this kit are Complementary Metallic Oxide Semiconductors (CMOS). While state of the art internal protection is provided, these circuits are still susceptible to damage from STATIC ELECTRICITY. You should not experience any difficulties if you observe the following precautions:

- 1) The circuits are supplied to you inserted in blocks of conductive foam. Leave them in these blocks until you are ready to install the part.
- 2) Do not install the parts in sequence other than that called for in the instructions.
- 3) Do not wear synthetic (e. g. nylon) clothing while handling these parts.
- 4) A three wire grounded soldering iron is ideal but if you don't have one your present iron may be used by allowing it to heat, then UNPLUGGING it during the actual soldering operation. Before soldering and after unplugging, touch the tip of the iron momentarily to the ground screw of an electrical outlet to drain static charges.

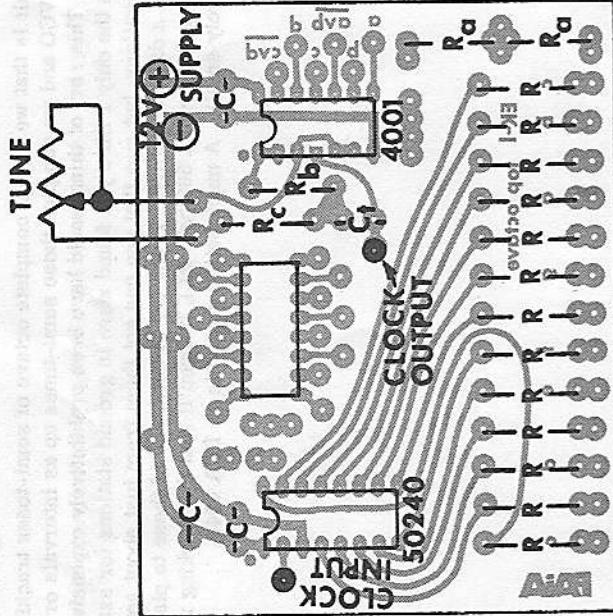


Figure 1