a closer look at.....
DIGITAL DRONEZILLA

by Philip Loarie

Digital Dronezilla is an electronic device that I designed to achieve a precisely tuned four-voiced drone with programmability. Basically, the circuit consists of a reference frequency which is fed into four different digital multipliers. In turn each multiplier has four binary load inputs. Depending on whether these inputs are high (connected to the positive voltage supply) or low (connected to ground) will determine which of sixteen possible multiples the reference frequency will go to (see figure 'A'). This circuit utilizes a digital multiplier that composer David Behrman showed me. David uses this multiplier together with digital dividers to derive intervals of the 'just'* intonation system in his collaborative piece with Bob Watts and Bob Diamond, *Cloud Music*.

With modern digital circuits precise tuning is no longer a dream, with a single reference tone thousands of frequencies can be derived accurately. This technique is used in 'state of the art 'Citizens Band Radios in which digital frequency synthesizers with one crystal replace what use to take 23 or more crystals, saving both material and labor costs. However, one cannot get ratios as found in the 'just' intonation system with digital frequency synthesizers or digital dividers alone. It is necessary to incorporate both digital dividers and multipliers for ratio styled tunings. To date there is not a discrete device available on the market known as a digital multiplier as there are digital dividers and so what is described here is a circuit composed of several discrete devices to perform the function of a digital multiplier.

Truth Table for Programming One Voice of Digital Dronezilla

binary load inputs on 8281	*decimal equivalent*	*actual multiplier in the phase locked loop configuration*	*output frequency in cycles per sec.*	*intervalic name*
1111	*15*	*1*	*440*	*fundamental*
1110	*14*	*2*	*880*	*octave*
1101	*13*	*3*	*1320*	*octave +P5th*
1100	*12*	*4*	*1760*	*2nd octave*
1011	*11*	*5*	*2200*	*2nd octave +M3rd*
1010	*10*	*6*	*2640*	*2nd octave +P5th*
1001	*9*	*7*	*3080*	*2nd octave + 7th*
1000	*8*	*8*	*3520*	*3rd octave*
0111	*7*	*9*	*3960*	*3rd octave +M2nd*
0110	*6*	*10*	*4400*	*3rd octave +M3rd*
0101	*5*	*11*	*4840*	
0100	*4*	*12*	*5280*	*3rd octave +P5th*
0011	*3*	*13*	*5720*	
0010	*2*	*14*	*6160*	
0001	*1*	*15*	*6600*	*3rd octave + 7th*
0000	*0*	*16*	*7040*	*4th octave*

Given the reference frequency 440 cycles per second, 0=low=connected to ground
1=high=connected to +5 vdc

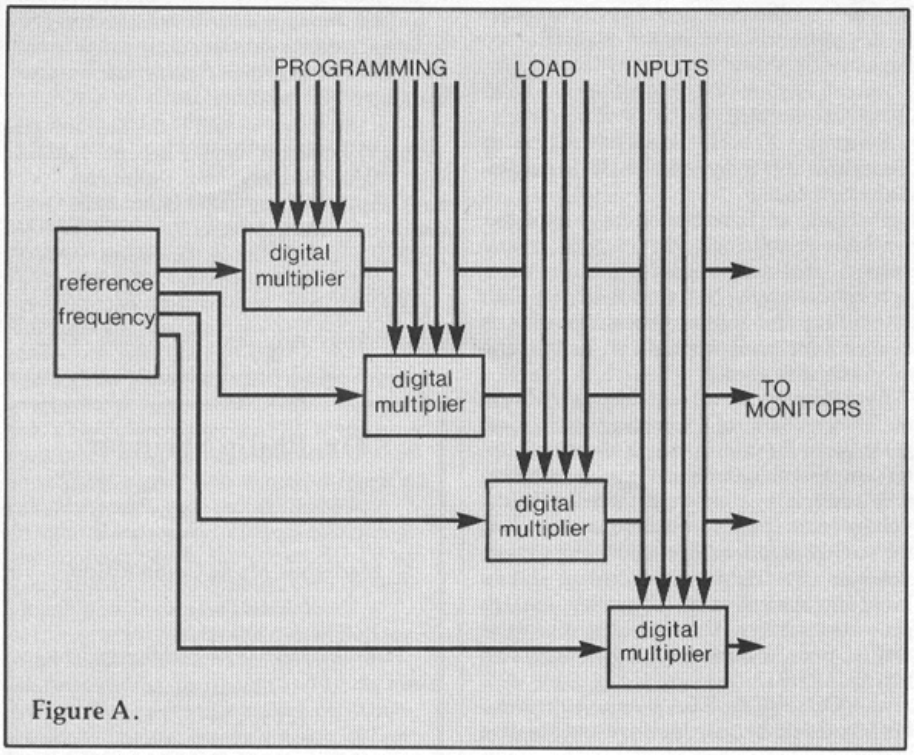

Figure A.

The digital multiplier in Digital Dronezilla is composed of a CMOS PLL (complimentary metal oxide semiconductor, phase-lock loop) notably the RCA CD4046 and a TTL (transistor transistor logic) programmable binary divider, National's 8281 (see figure 'B'). In this fashion the programmable divider is actually a programmable multiplier—as David Behrman says "the phase-lock loop is tricked into multipling". If you are interested in finding out how the 'trick' works, consult the RCA COS/MOS Data Book under application note ICAN 6101. In the 1975 edition this appears on page 471.

When a new pitch is activated by changing the load inputs there are some interesting results such as pulse width modulation, phase shifting, and a glide or glissando from the last pitch assignment to the current pitch as-