ELECTRONOTES 72-A
Newsletter of the Musical Engineering Group
203 Snyder Hill Road
Ithaca, N. Y. 14850

ELECTRONOTES MID-MONTH LETTER NUMBER 0 DECEMBER 20, 1976

This is the second of our "warm up" letters which is being sent as a companion to the second group of application notes (AN-11 to AN-20).

MORE ON THE RINGING BANDPASS: We have what we think is the correct answer to the problem posed in EN#71 (11), 2nd paragraph from the bottom. We asked there if anyone might suggest why the output spectrum of a bandpass filter peaks at ω_o when excited with white noise (ω_o being the frequency of maximum response) while the total response should apparently be composed of the superposition of individual decaying sinusoidals which have zero crossings corresponding to ω_d (ω_d being damped frequency which is lower than ω_o). In a nutshell, we made compensating errors, one theoretical, and the other experimental. However, the full explanation is quite revealing, and you will see that the damped frequency really does exist under certain excitations.

In the first place, we should have kept the complete solution [Equation 21 on page 9] and not thrown away half of it. If you do keep both parts, you do get back to the original frequency ω_o. We claimed the solution corresponding to ω_d based on numerous results in analogous physics problems, and on an actual experimental observation. We actually did observe a damped response corresponding to ω_d rather than to ω_o. Here's why: To measure the impulse response, you need an actual δ-function, which is essentially in instantaneous insertion of energy. Practically, you have to settle for a very narrow pulse. The narrower the pulse, the less energy you get in for a given pulse height, so you can't make it to short or the time constants of the input will completely reject the pulse. Now, to make matters worse, we were looking for a detuning which is significant only at low Q. This means that decay is so rapid that you have to start observing right away (on the first cycle of decay). We found that a pulse with enough width to insert enough energy to ring the filter at an observable amplitude was too wide to prevent confusion in the first cycle (you get a double transient). Seeing this problem, we made the experimental error. We used a low-frequency square wave to excite the filter, assuming that any old decay would do. Since the square wave frequency is very low compared to the characteristic frequency of the filter in such a case, the square wave edge looks like an isolated step. Here is what happens with the step:

The Laplace transform (LT) of a δ-function is just 1, so the transfer relation in the s-domain is just:

$$E_{out}(s)_{impulse} = T(s)\cdot E_{in}(s) = T_B(s)\cdot L[\delta(t)] = T_B(s)\cdot 1 = T_B(s)$$

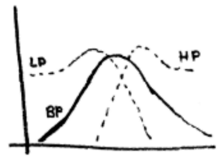
where L is the Laplace transform operator, and $T_B(s)$ is the bandpass transfer function:

$$T_B(s) = \frac{s}{s^2 + (1/Q)s + 1}$$

But the LT of a step function is not 1 but 1/s, so the output is:

$$E_{out}(s)_{step} = T_B(s)\cdot(1/s) = T_L(s) = \frac{1}{s^2 + (1/Q)s + 1}$$

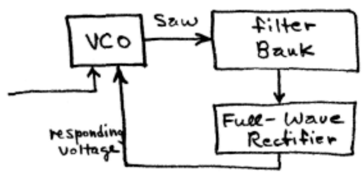
where $T_L(s)$ is a low-pass filter transfer function. Thus, by using the step, we are essentially looking at the impulse response of a low-pass. We know that for a state-variable filter for example, we get a set of curves that are similar to those shown at the right. Clearly the low-pass response peaks at a frequency that is lower than the peak of the bandpass. To see what we actually would get, we can of course take the inverse LT of $T_L(s)$, and this should bear out the fact that the damped oscillation of a bandpass to a step response corresponds to a frequency ω_d, which is what we did observe.



The final and possibly the most interesting point is that while we are not able to create δ-functions, we can do testing with δ-functions if we consider a test signal to be composed of a superposition of δ-functions, and allow for overlap. Thus, white noise is evidently composed of random impulses, and since the impulse response of the bandpass is actually at ω_o and not at ω_d, there is no conflict of the type we first thought.

We are greatful to Dave Dunetz of Cornell Univ. for calculating the complete impulse response of the bandpass and generally for helping to piece together the parts of this problem. Thanks also to all who sent suggestions.

A "RESPONDING" FILTER BANK IDEA: Filter banks are often used to add a richness to electronically produced tones. They give some sort of formant structure to the sounds. If we think of formants (resonances) in traditional acoustic instruments, it seems that in some cases the formants react with the excitation source and alter it. In a trumpet for example, the vibrating lips send a pulse train down the tubes where it strikes the bell, and is reflected back to the lips, altering the rate of excitation so as to produce a standing wave in the tube. Suppose we had a filter bank with peaks tuned to certain positions (which might be an equally tempered scale) which represent resonant modes. We apply a waveform of high harmonic content as shown at the right. The output of the filter bank is rectified and fed back to the VCO. If the VCO moves in a direction such that the harmonics line up better with the resonances, the output is increased. As shown, the VCO frequency could be expected to move up to the first stable position it encounters. It seems that there are a number of ways of using this sort of thing. As suggested above, it could be used to produce complex transients. In this way, the VCO would seek out certain of the resonant positions, or a stable position relative to the resonances. Thus, the device is also a sort of "quantizer" or a device which alters or warps the VCO response curve. This type of device is on the drawing board now.



CHALK ON THE BLACKBOARD! Recall the sound of chalk squeeking on the blackboard. It is known that this is a "stick and slip" phenomenon. Why is it unpleasant? How would you synthesize this type of sound? Is it some sort of dissonance, as we also cringe in the same way at dissonance? There is a pitch contour that changes during the squeek - is this a factor? Is some sort of transient generated each time the chalk bounces that conflicts with the rate of the bounces? Why is this more unpleasant to the squeekee than to the squeeker? Is it possible to squeek the chalk in an agreeable manner? Any comments?

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ELECTRONOTES MID-MONTH LETTER NUMBER 6 JUNE 20, 1977

In preparing the paper for the Acoustical Society of America meeting, I had to leave out a number of things simply because they did not fit into the main theme of the paper (even though they do belong under the title as stated - "New Approaches to Analog Music Synthesis"). Below, we want to call your attention to these by giving references which you can add to the list given. The written version of the paper is available as our supplement S-014 (see mailing sheet with this issue).

Harald Bode & Robert Moog, "A High-Accuracy Frequency Shifter for Professional Audio Applications, " J. Aud. Eng. Soc. Vol. 20, No. 6, July/Aug. 1972, pg. 453

B. Hutchins, "Experimental Electronic Music Devices Employing Walsh Functions," J. Aud. Eng. Soc., Vol. 21, No. 8, Oct. 1973, pg. 640

C. Hovey & David Seamans, " A Polyphonic Keyboard for a Voltage-Controlled Music Synthesizer," J. Aud. Eng. Soc., Vol. 23, No. 6, July/Aug. 1975, pg. 459

B. Hutchins, " Application of a Real-Time Hadamard Transform Network to Sound Synthesis," J. Aud. Eng. Soc., Vol. 23, No. 7, Sept. 1975, pg. 558

D. R. Curtis, "A Monolithic Voltage-Controlled Amplifier Employing Log-Antilog Techniques," J. Aud. Eng. Soc., Vol. 24, No. 2, March 1976, pg. 93

J. A. Moorer, "The Synthesis of Complex Audio Spectra by Means of Discrete Summation Formulas," J. Aud. Eng. Soc., Vol. 24, No. 9, Nov. 1976, pg. 717

J. G. Simes, "An Almost Locked Oscillator for Electronic Music Synthesis," J. Aud. Eng. Soc., Vol. 25, No. 6, June 1977, pg. 394

B. Gabrielsen, "A Patchable Electronic Music Percussion Synthesizer," J. Aud. Eng. Soc., Vol. 25, No. 6, June 1977, pg. 395

W. M. Hartmann, "The Electronic Music Synthesizer and the Physics of Music," Amer. J. of Physics, Vol. 43, No. 9, Sept. 1975, pg. 755

T. D. Rossing, "Resource Letter MA-1: Musical Acoustics," Amer. J. of Physics Vol. 43, No. 11, Nov. 1975, pg. 944

BELLS: We have in the past been pretty well satisfied with the bell sounds and other percussion sounds you can get from FM synthesis techniques. However, we can also consider a more direct method of bell-sound synthesis. In this method, we would use a set of High-Q VCF's (probably constant bandwidth - constant ring time) in parallel. A set of 5 would be nice. The frequencies of the VCF's would be independently set to initial values. Keyboard control to move all the filter frequencies without changing the relative positions could also be used. The different VCF's would all be rung in parallel and their outputs would be summed, probably not all equally. The signal to ring the filters would be an impulse and/or perhaps a short burst of white noise. Most likely all the filters would not have the same ring time even though they would be in a constant ring time mode themselves. This constant ring time mode is achieved by controlling frequency and Q by the same voltage. The frequencies, ring times, etc. would all be set experimentally. Has anyone played with this type of setup?

ORGANS: Whenever we start to explain the lack of expressive control in some electronic music instruments we tell about the small amount of information that is present in a single switch closure such is we have on a keyboard (the key is either up or down). Of course, some controllers improve on the simple single switch idea and sense force, velocity, pressure, etc., but most simple synthesizers use only the single closure. What if someone then asks you what is the difference between the situation with the synthesizer and with a pipe organ where no information other than a key down is used? With the pipe organ, the switching is mechanical rather than electrical, but otherwise the situation may be the same. Is the organ more expressive? Probably there are some differences that are due to the fact that the mechanical-acoustic system is in many ways less precise and exactly repeating than the electrical synthesizer, and the pipe organ does not have to be presented to the listener through a transducer that is not the actual sound radiating mechanism, but this only adds to the traditional feeling for realism. Is a Bach fugue played on a large pipe organ expressive or impressive? How much expression can be achieved with just control over the timing of the notes? Any comments?

BIRDS: Most of us would agree that birds sing, but do they sing music? Well, it all depends on what you consider music, and certainly a lot of bird songs are very pleasant to listen to. Certainly bird calls have been used in music (imitatively by many many composers, directly by Respighi -"Pines of Rome," and inspirationally by who knows how many others. They seem to be useful musical elements to be considered for whatever type of music you may be into. However, do birds use their songs as music? Probably not - they have more to do with the business of survival. If you saw the PBS "Nova" TV segment on bird calls, you learned much about the many varieties and purposes of bird calls. From this, and the great amount of work that goes on concerning bird songs, we know that birds are quite efficient at producing songs for whatever their purpose, and in many cases, their time scale is faster than ours. If you slow down some tape recordings of rapid "shirks" you find that they are fast high pitched songs of appreciable structure. Some songs suggest only general forms, but others are complex duets between mated pairs of birds which are in their way as beautiful as they are remarkable. But do birds sing in our pitch scale? In EN#35, Sebastian von Hoerner told us much about what "intelligent" beings with certain degress of resolution might choose as a musical scale if they do in fact choose discrete pitches for their "music." How well do birds who choose discrete pitches in their songs fit this pattern? Not very well. Charles Dobson and Robert Lemon report in "Bird Song as Music" in J. Acoust. Soc. Amer. Vol. 61, No. 3, March 1977 (letters) pg. 888 that their pitches do not fit our musical scales very well. The researchers gave the birds a margin of error approaching a quarter tone, and yet found that they did not find it necessary to sing in western musical scales. Yet humans tend to hear bird songs as actual scale based songs, which may be bad for naturalists, although possibly useful for musicians. This particular topic presented here was in part inspired by a bird across the street who was singing the main phrase from "Le Ku-Ku-Ra-Cha" (if that's how it's spelled) for me all one afternoon (with Le Ku-Ku Ra ___ as a variation). Unfortunately I could not locate the bird for interview or at all. Even though birds may not sing "our" music, they do sing and influence musicians. Messiaen's fascination with bird calls is perhaps the best known. I have heard that when Messiaen met a member of the Cornell Univ. music faculty he immediately related his familiarity with Cornell Univ. through the set of bird call records produced by the ornithology department. Probably few in the field of music are not influenced by bird sounds or other animal sounds in some way. We in electronic music certainly have a part to play in bringing bird calls and interested musicians together. Of course, there are also those who suppose electronic music is for the birds in the first place!