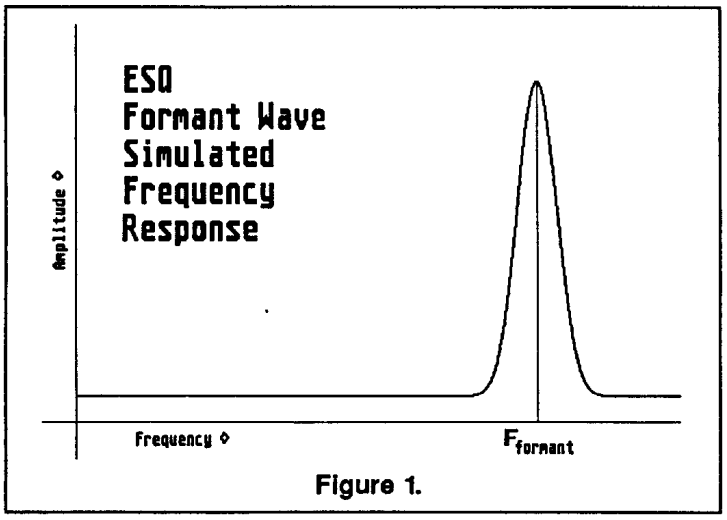

Figure 1.

Realizing the utility of formant filtering but faced with the realities of digital circuitry, the designers of our favorite synthesizer came up with a technological compromise that provides ESQ programmers with some of the benefits of true formant filtering, without the need for exotic digital filters. The five FORMT waves on the ESQ were created by using a computer program to calculate the waveform created by a burst of sine waves passed through a high Q digital bandpass filter, and then storing multiple samples of this waveform in the synth's ROM. (According to Bill Mauchley, who designed the FORMT waves for Ensoniq, there are actually only 10 samples, which are shared by all five FORMT waves.) The end result is that when a FORMT wave is selected on an oscillator, that oscillator becomes the equivalent of a oscillator connected in series with a bandpass filter. Since the waveform is slightly distorted by the ESQ's pitch shifting process, the formant frequencies for these waveforms aren't perfectly stable, but they are fairly constant. According to Bill, the FORMT waves are split at every eighth key, which indicates that their frequencies may deviate by about + or - 25% from the frequencies listed in the ESQ manual. Figure 2 shows the actual waveform you'd see if you observed one of the ESQ's FORMT waves on an oscilloscope.

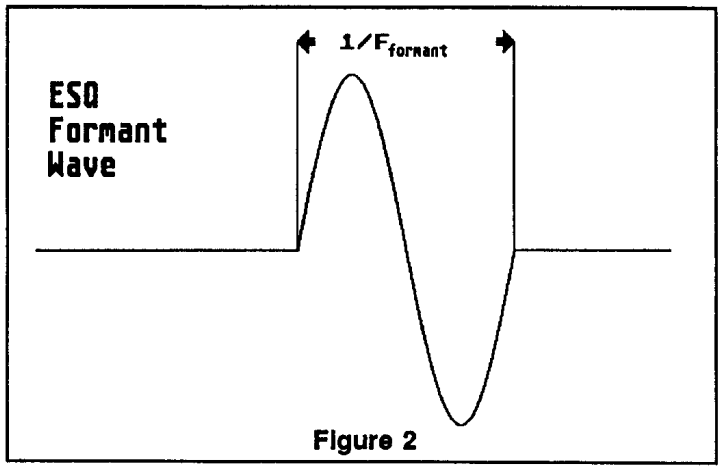

Figure 2

The following patch is a classic example of the use of formants in the creation of an instrumental sound. According to the references listed at the end of this article, the sound of the oboe is characterized by two very strong formants: one at around 1100 Hz, and one at about 3000 Hz. The lower formant is close to the 1 kHz formant frequency of the FORMT2 wave, but the highest formant frequency on the ESQ (FORMT5) is only 2.25 kHz, so the upper formant is not as well matched. Since the higher formant is less prominent, the level of DCA3 is somewhat lower than DCA1. The velocity sensitivity of ENV3, which controls DCA3, emphasizes the higher formant on louder notes.

This patch also employs a number of other tricks that aren't related to the use of formants. OSC2 provides a raspy, reed-like waveform which gives the sound a little extra bite, especially at higher key velocities. ENV1 creates a slight upward pitch bend at the beginning of each note, which simulates the inertia of the oboe's reed when the note is first blown. According to Wendy Carlos, the oboe has a very limited dynamic range in terms of amplitude, so the velocity sensitivity on ENV4 is quite low.

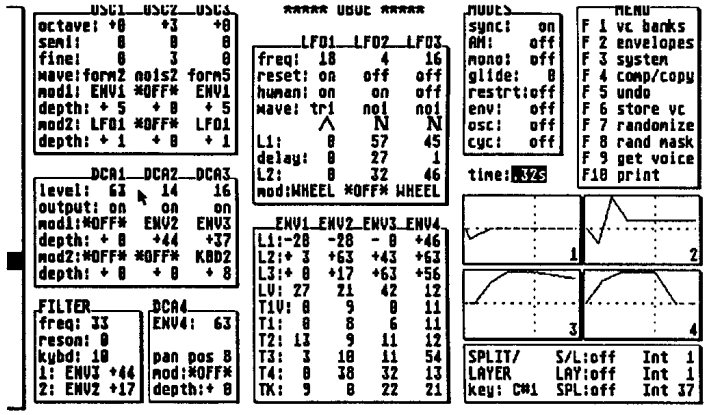

Figure 3

This patch illustrates a rather heavy handed usage of the formant waves, since the foundation for the sound is the FORMT2 wave. In most cases, you'll want to mix the FORMT wave much lower than the "primary" wave, so that it colors the sound without dominating it. The following table lists formant frequencies for a few brass and reed instruments. Try spicing up a stock SAW brass or REED clarinet with a carefully chosen FORMT wave, using this table as a guide.

Trumpet:	1200 Hz
Muted Trumpet:	2000 ~ 2500 Hz
Trombone:	475 Hz
Tuba:	300 Hz
French Horn:	500 Hz
Bassoon:	550 Hz and 1150 Hz
English Horn:	600 ~ 900 Hz and 2000 Hz

Incidentally, the literature on the subject that I have found emphatically states that there is no predominant resonance in the overtone structure of the clarinet, but I have found that one key to a good clarinet on the ESQ is to mix in just a dash of the FORMT3 wave, along with a SQUARE or SQR 2 wave for the bulk of the sound. This just goes to show that the best sounds aren't created by either a rigorous "academic" approach, or by blind stumbling, but by an enlightened combination of the two.

References:

Carlos, Wendy, "Additive Synthesis", *Keyboard*, June 1985
Lancaster, Don, "Imitating Acoustic Instruments with Electronic Sound", *Popular Electronics*, August 1975
Howard Massey, Alex Noyes, and Daniel Shklair, *"A Synthesist's Guide to Acoustic Instruments"*, Amsco Publications ■