LEVEL III

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RFSS

SPECTOGRAMS DERIVED FROM HELICOPTER BLADE MODULATION PROGRAM

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DAAK40-78-C-0031

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A spectrogram is the output of a bank of filters (e.g., an FFT) as a function of time. It can be plotted as a 3-D surface, amplitude or power vs. frequency and time.

The helicopter blade modulation signal as modeled in MRI-149-19 (and as simulated with the Fortran program) was used to create several spectrograms. The parameters of the simulation are

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General	Hub	Blade
$N=3$	$L_e=0$	$L_e=.2m$
$\alpha=0°$	$L_c=.5m$	$L_c=4m$
$\lambda=.02m$	$\rho=1.$	$\rho=.3$

where N is the number of blades, α is the angle between the LOS and plane of rotation, λ is the wavelength, f_r is the pulse (sample) repetition frequency, L_e is the effective blade length (or effective length of the hub section), L_c is the distance of the phase center from the axis of rotation, and ρ is the ratio of scattering on the lagging and leading edges of the blade (or hub section).

In Figure 1 we show a spectogram of the hub modulation signal (without the skin return). The horizontal axis represents the instantaneous Doppler response at the time given by the vertical axis (the pulses are spaced by $1/f_r = .1$ msec). We can clearly see the sinusoidal Doppler modulation traced

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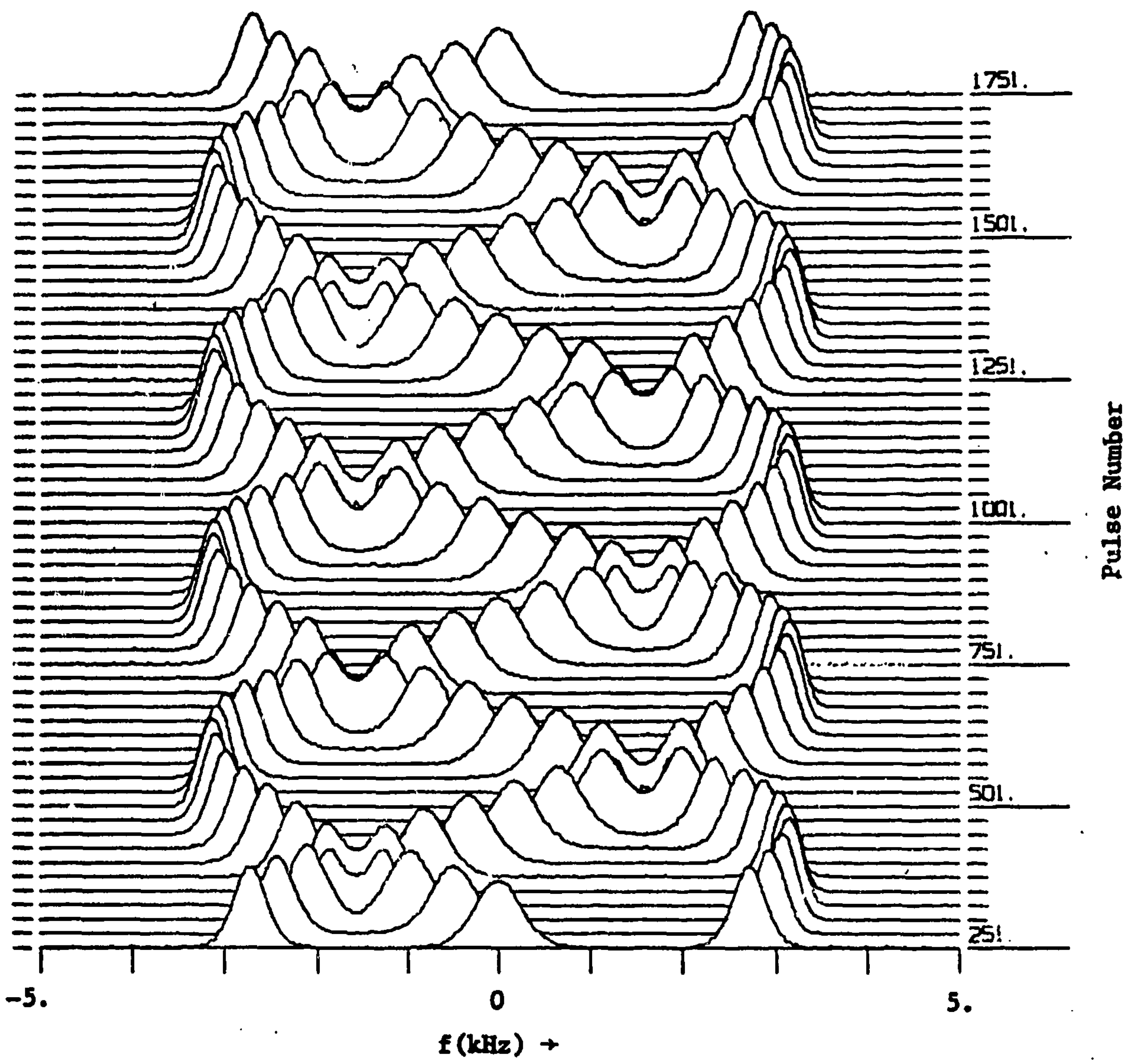

Figure 1. Spectogram of Hub Modulation Signal

out by the tip of each of the three blades. In Figure 2 we repeat the simulation of the hub with a dc component corresponding to the skin return.

In Figure 3 we show a spectrogram of the blade modulation signal in the Doppler interval from 20 to 30 kHz. The maximum Doppler of the phase center is

$$f_{max} = 4\pi f_s L_c/\lambda = 25.1 \text{ kHz} .$$

The response is essentially that of the specular flash, with some low-level signal that follows the sinusoidal curve. In Figure 4 we have repeated the simulation in Figure 3 except with $L_e = 0$, which means the scattering is isotropic from the blade tip. The sinusoidal response is more visible here.

In the simulation for Figures 3 and 4, all signal components that were out of the Doppler band from 20 to 30 kHz were suppressed. Note that no significant effect of this suppression can be observed at the lower edge of the band (at f = 20 kHz) in Figure 4, but since the 10 kHz band corresponds to one PRF interval, the right edge (at f = 30 kHz) is essentially a wrapped around version of the left edge. In other words, there is some signal energy there that is due to foldover (no signal components exist there from the original modulation signal). The effect is not significant, however, because the energy will be small if there is any directivity associated with the blade reflection ($L_e > 0$) as in Figure 3.

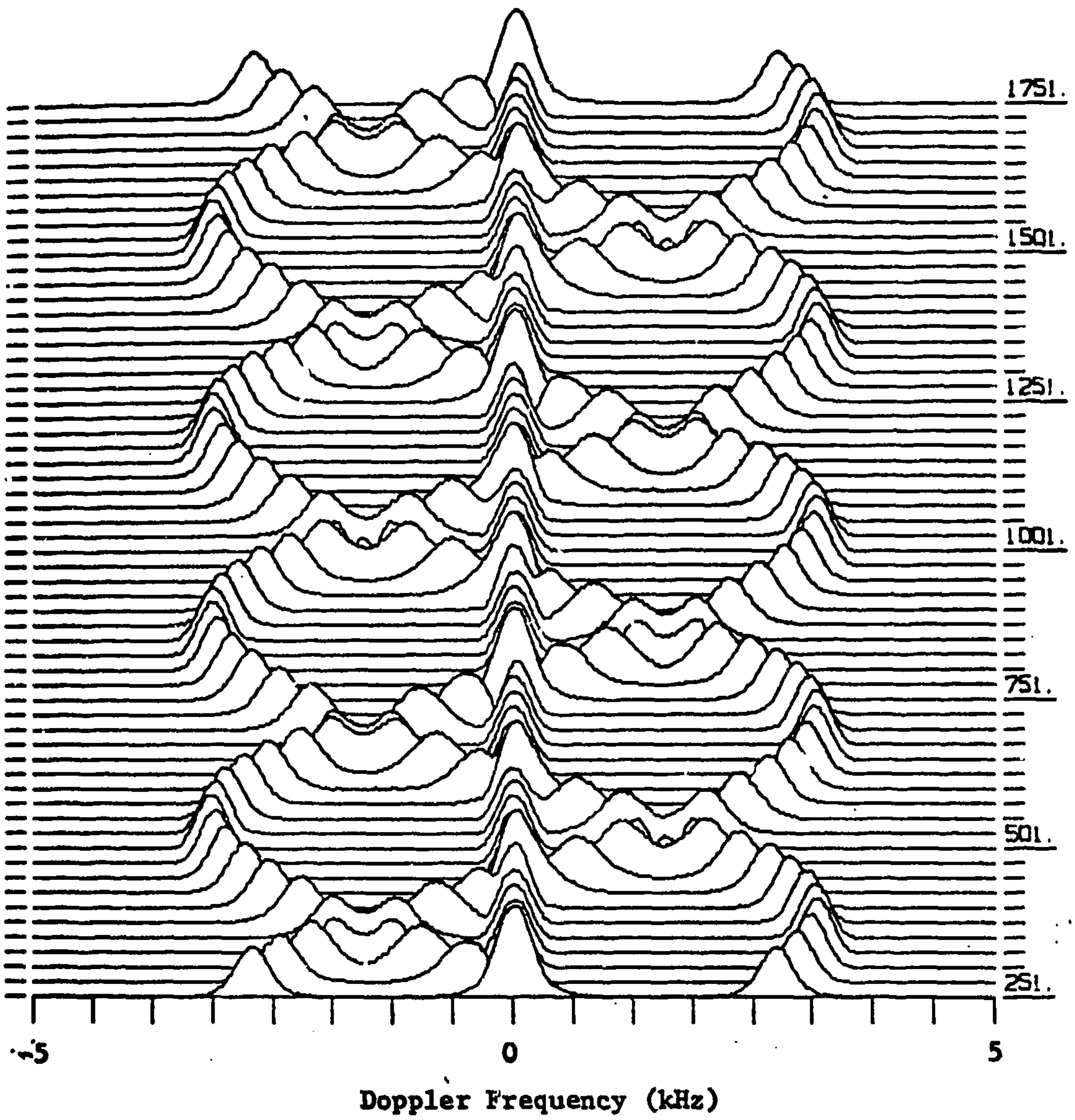

Figure 2 Spectogram of Hub Modulation Signal with Skin Return

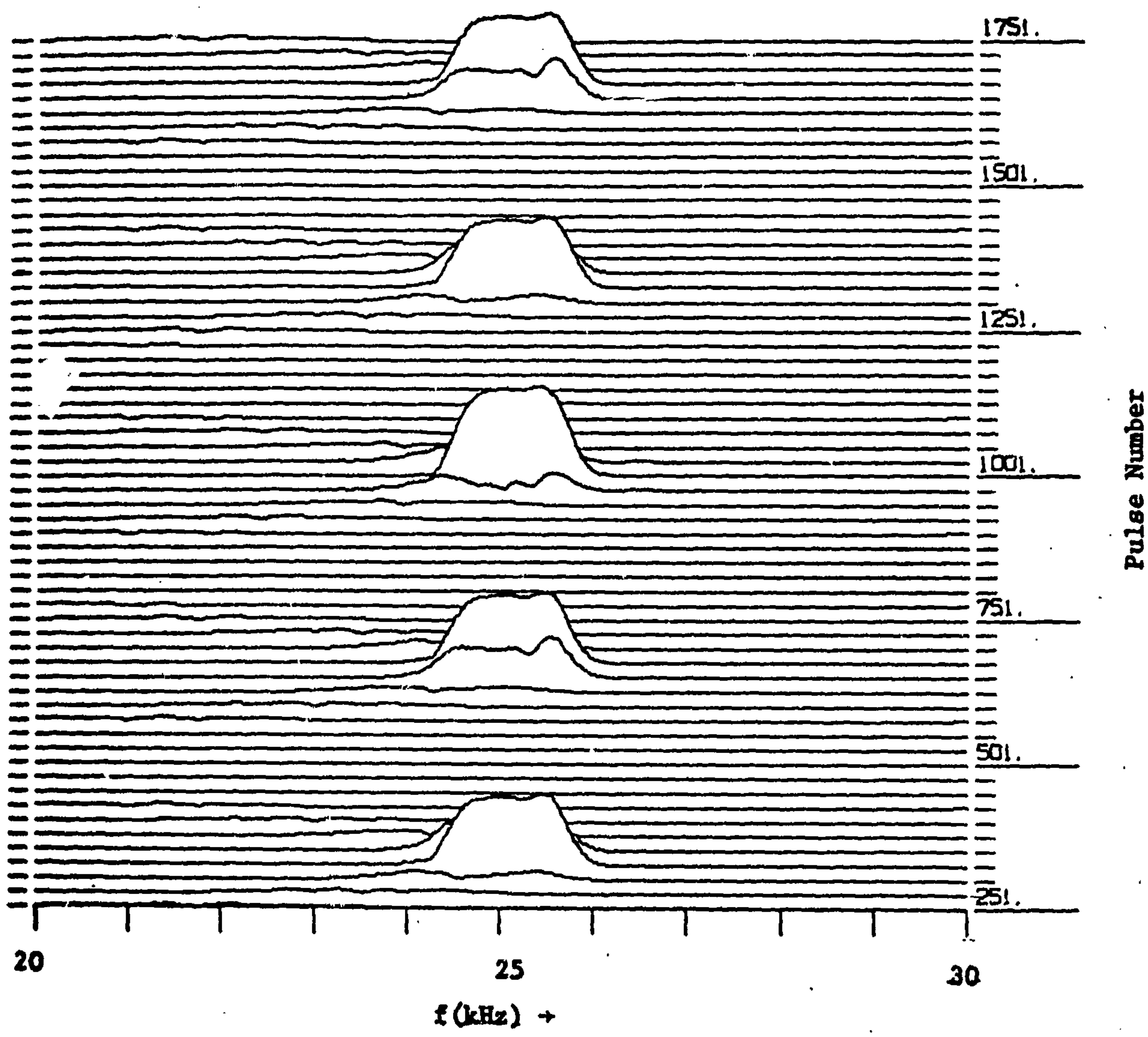

Figure 3. Spectogram of Blade Modulation Signal

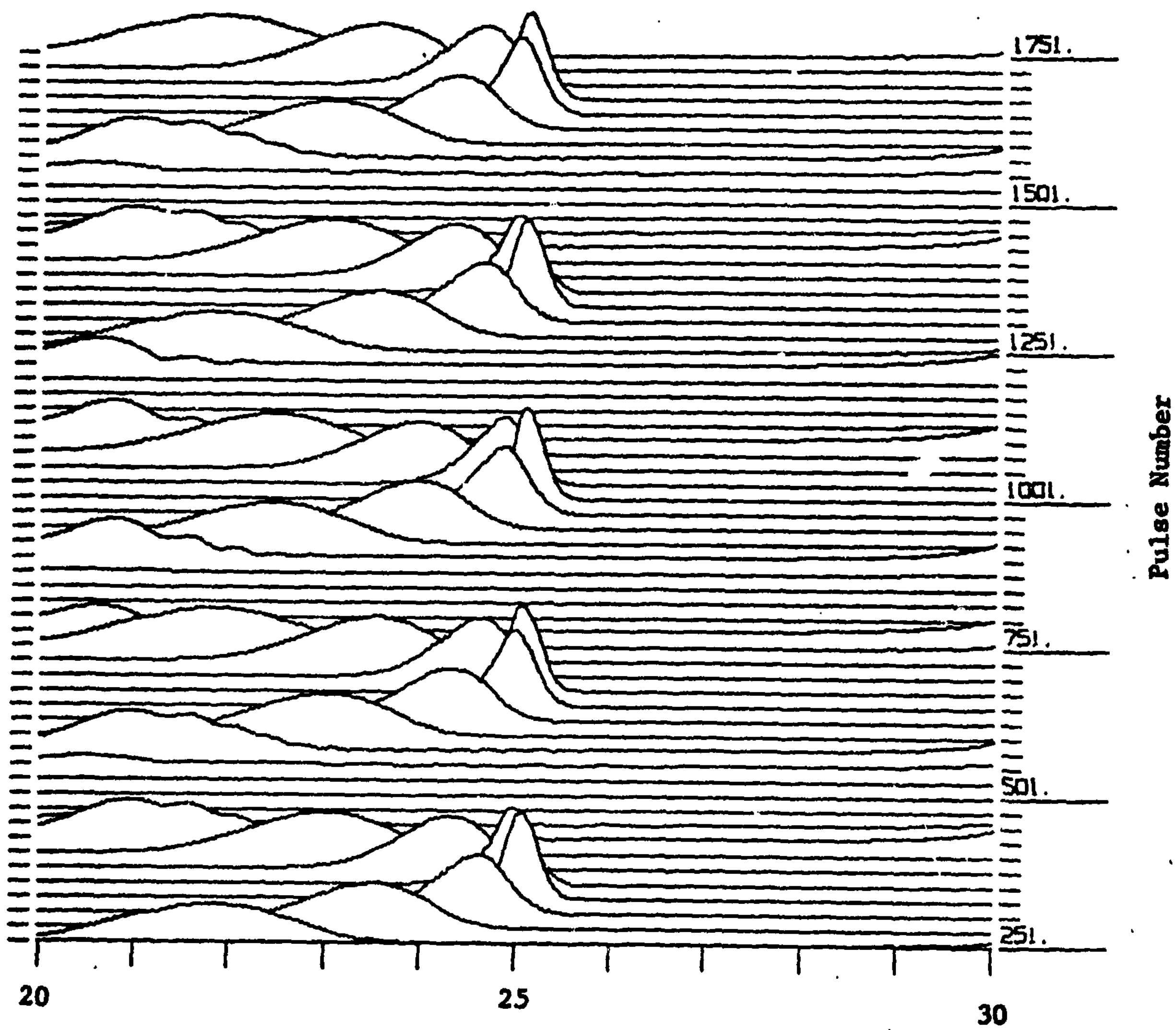

Figure 4. Spectogram of Blade Modulation Signal ($L_e = 0$)