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RFSS

SIMULATED TRACK PERFORMANCE OF EXTENDED TARGET MODEL IMPLEMENTED VIA TAPPED-DELAY LINE

TECH NOTE 105-030

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MRI REPORT 149-2

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Summary

A simulation was conducted of an extended target model implemented by means of a tapped-delay line with a tap spacing of 50% of the receiver range resolution. An early/late gate track was also simulated, both with and without the "dither" scheme used to reduce glint. The results are positive: very little tracking error is introduced by the discrete tap arrangement.

The Experiment

An extended target model of 60 ft in length as shown in Figure 1 flies over a straight and level course as shown in Figure 2. There are 8 scatterers on the target, all isotropic with amplitudes as indicated. The target velocity is 600 ft/sec, the radar is assumed to be stationary, and the minimum distance of the trajectory is 3 kft.

In an actual tracking radar, the estimated range is a function of the present measurement and the past history. We will deviate somewhat from this situation and assume that the radar is tracking the target c.g.; the measurement of range is thus a pure indication of glint referenced to the target c.g. With the introduction of the "dither" scheme, the tapped-delay line concept will be thoroughly exercised and the above assumption will have no significant impact on proving the validity of the tapped-delay line concept.

Every 0.01 sec a measurement of range is performed by means of a conventional early/late gate. The estimate of range referenced to the crossover point is

$$\hat{r} = \frac{\Delta r}{2} \frac{L-E}{L+E} \tag{1}$$

where E and L are the magnitudes of the early and late gates, respectively, and Δr = 60 ft is the separation of the gates. Each gate is assumed to have the responses to a point target as shown in Figure 3.

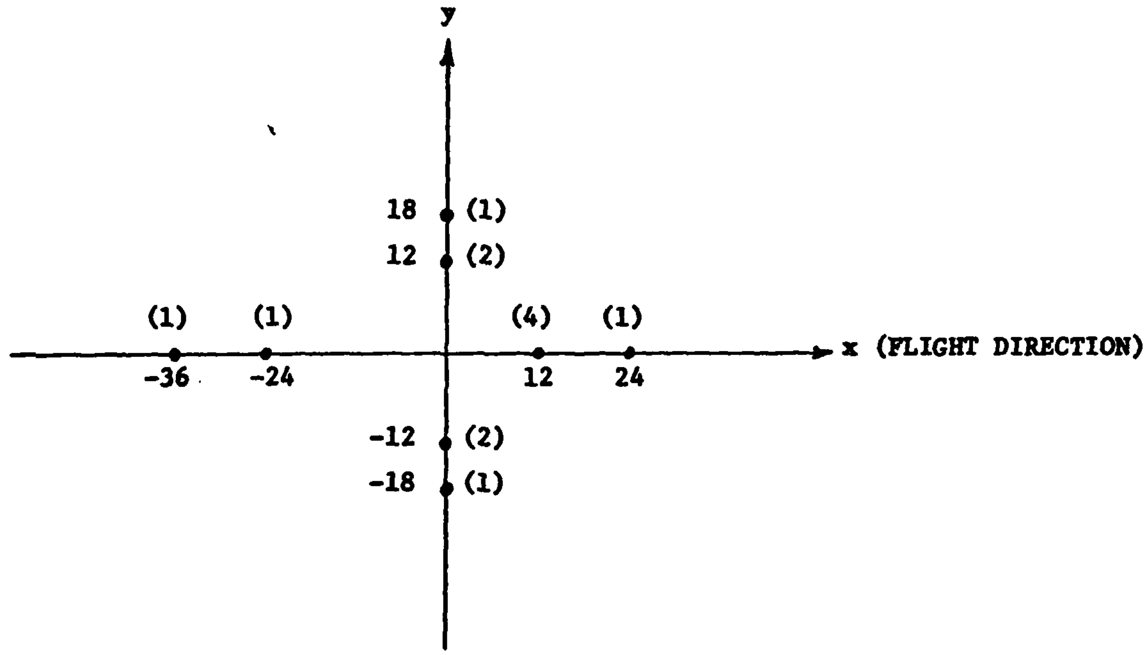

Figure 1. Target Scattering Geometry (distances are in feet, amplitudes are shown in parentheses)

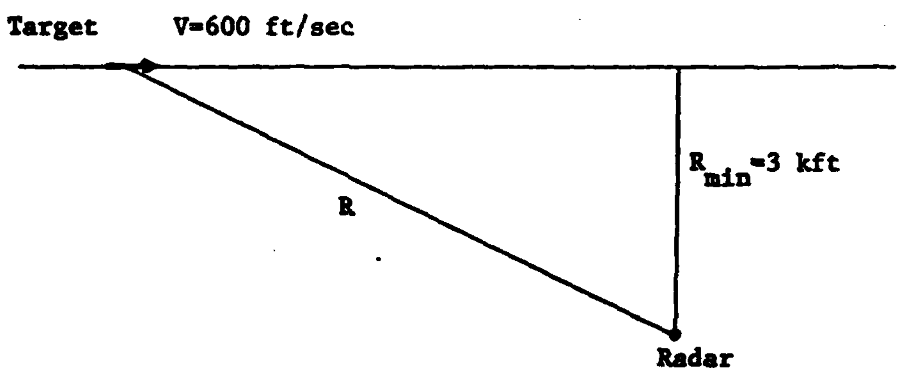

Figure 2. Target Flight Geometry.

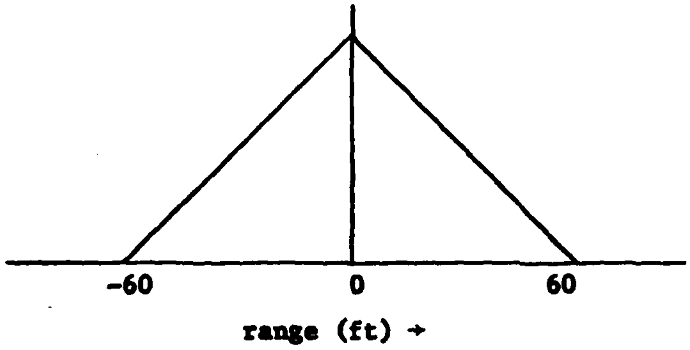

Figure 3. Range Gate Response (voltage).

The "dither" consists of driving the tracking gate center (crossover point) with a sinusoidal signal of peak-to-zero amplitude of 60 ft. The period of the sinusoid is assumed to be 0.1 sec.

Two basic experiments are performed. One is based on an exact response where rays are traced to each scatterer and proper weighting is used to superimpose the phasors according to their amplitude and relative position in the tracking gate. For the second experiment the target model is resampled in range so that a new set of scatterers is created with a spacing of 30 ft (corresponding to the taps of a tapped-delay line). As is discussed in Reference 1, for a scatterer that is a distance ρ from one tap, that tap will be assigned a weight $(1-\rho/\Delta)$ where Δ is the tap spacing; the next tap will be assigned a weight ρ/Δ. The phase must also be adjusted to account for the shift in range. The taps are also referenced to the target c.g., implying the use of a finely controllable delay device.

For the following results, the start and stop times for the experiment are 15 and 13 seconds, respectively, before the target reaches the point of minimum range.

[1] Mitchell, R. L., and I. P. Bottlik, "Design Requirements for Simulating Realistic RF Environment Signals on the RFSS," MRI Report 132-44, 23 Sept 1977.

Results

In Figure 4 we show the measured range glint vs. time for the case where there is no dither. The top curve represents the actual glint (no resampling), while the bottom curve represents the glint with resampling and the tapped-delay implementation. Both curves are essentially identical.

In Figure 5 we show the case where the dither signal is applied to the tracking gate. The signal plotted is given by $d(t) + \hat{r}(t)$ where $d(t)$ is the sinusoidal dither signal and $\hat{r}(t)$ is Equation (1). Note that $d(t)$ has a peak-to-zero value of 60 ft, while $\hat{r}(t)$ is constrained in absolute value to 30 ft. In other words, 50% of the dither signal leaks through the tracker. In Figure 6 we compensate for only half of the dither signal, so that $0.5d(t) + \hat{r}(t)$ is plotted. The top curve represents the actual glint (no resampling), while the bottom curve represents the resampled case. The differences here are greater than in Figure 4, but the error introduced by resampling is still much smaller than the glint itself.

The conclusion is that the resampling required for the tapped-delay line is entirely satisfactory, as long as the tap spacing does not exceed 50% of the receiver gate spacing.

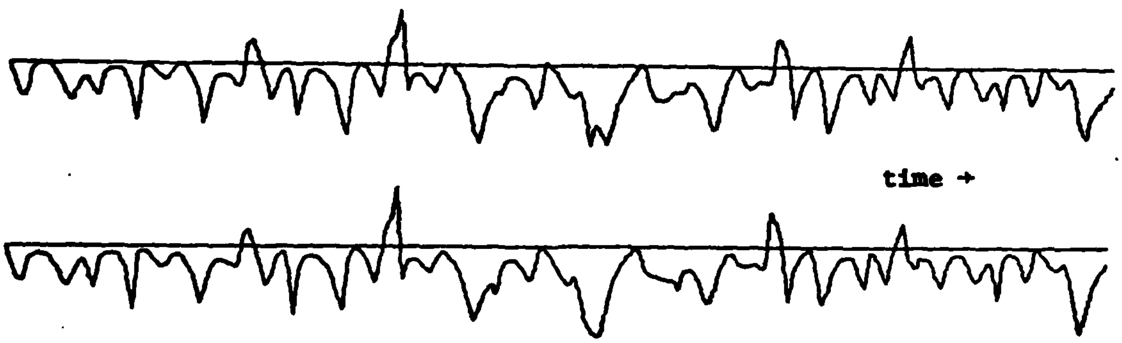

Figure 4. Measured Glint Signal for Case with No Dither (top curve is actual glint, bottom curve is glint for tapped-delay line approach; the vertical scale is 1 in = 60 ft).

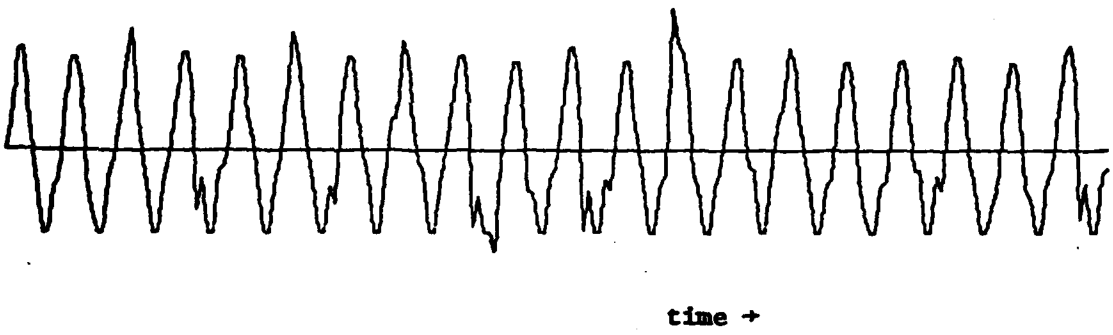

Figure 5. Measured Glint Signal with Dither (dither signal fully compensated; the vertical scale is 1 in = 60 ft).

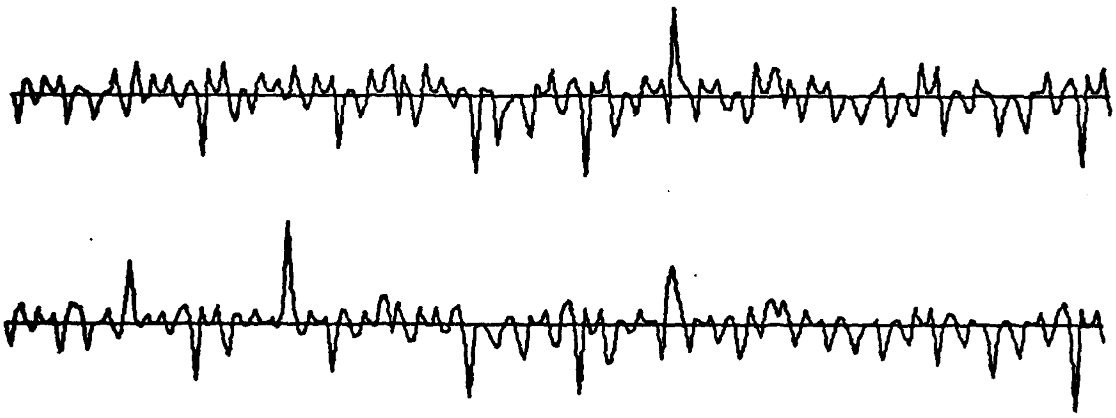

Figure 6. Measured Glint Signal with Dither (dither signal 50% compensated; top curve is actual glint, bottom curve is glint for tapped-delay line approach; the vertical scale is 1 in = 60 ft).