# TIME-DOMAIN RADAR TARGET DISCRIMINATION USING S-PULSE WAVEFORMS

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The E-pulse radar target identification scheme uses an aspect-independent waveform (E-pulse) which when convolved with the late-time scattered signal of an expected radar target eliminates the natural resonance spectrum of the target. An S-pulse, or single mode extraction waveform, is a related signal which eliminates all but one mode, leaving behind a single damped sinusoid. Interaction of an E-pulse or S-pulse with an unexpected target results in the excitation of the entire target modal spectrum, thus allowing discrimination between expected and unexpected targets.

The theory of S-pulse waveforms is well developed [1, IEEE AP-34, pp. 896-904] but its application has been hampered by lack of an efficient means of interpreting the convolved signal. That is, it is relatively difficult to distinguish a single damped sinusoid of an expected frequency from a sum of damped sinusoids of unexpected frequencies. This paper suggests a simple means of quantifying S-pulse discrimination.

Consider the convolution of an S-pulse with a return from the expected target. During a finite time period between the onset of late-time and the end of the measured return the convolved output will be a single damped sinusoid of unknown amplitude and phase (depending on target aspect) but known complex frequency. Using the synthesis scheme outlined in [1] it is possible to create both sine and cosine S-pulses which result in output convolutions with identical unknown amplitudes and unknown phases differing by 90$^o$. These outputs are analyzed for expected single-mode content in an approach inspired by the matched filtering concept. Define DSR, the "S-Pulse discrimination ratio", as

$$DSR = \frac{\left[\int_{-\infty}^{\infty} |C(\omega)||F(\omega)|\,d\omega\right]^2}{\int_{-\infty}^{\infty} |C(\omega)|^2\,d\omega \int_{-\infty}^{\infty} |F(\omega)|^2\,d\omega}$$

where $C(\omega)$ is the Fourier spectrum (obtained via the FFT) of the sine and cosine single mode outputs combined to form a complex exponential, and $F(\omega)$ is the analytic spectrum of the expected complex exponential, taken over the same finite time interval. It is apparent that the DSR takes on a maximum of unity when the convolved output matches the expected signal. Thus, the DSR quantifies discrimination between expected an unexpected targets. Note that the unknown phase of the convolved output is inconsequential since only the spectral magnitude is involved.

S-pulse discrimination will be demonstrated using measurements made from several scale-model targets as well as actual full-scale targets. It will be shown that by using several S-pulse waveforms, designed to extract different modes from each target, discrimination can be enhanced markedly over that allowed using only E-pulses.