PERFORMANCE OF A PHASE SWITCHED SCREEN AGAINST A PULSE COMPRESSION RADAR SYSTEM

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Introduction

In conventional microwave absorbent materials, the incident electromagnetic energy is absorbed and converted into heat. Several recent papers [1-4], however, have considered an alternative technique for achieving an apparent reduction in the level of the electromagnetic energy reflected from a surface, using the so-called "phase-switched screen" (PSS). At resonance, the ideal single layer PSS presents a periodic reflection coefficient, $\rho(t) = \pm 1$ to an electromagnetic wave incident on its surface in such a way that the time-averaged value of $\rho(t)$ is zero. This is equivalent to applying binary phase modulation to the reflected wave with the result that the energy is redistributed into sidebands with, ideally, none remaining at the original carrier frequency f_c. Hence, by adjusting the frequency of the waveform that controls the surface reflection coefficient, these sidebands may be positioned so that they lie outside the pass-band of a receiver tuned to f_c. A more detailed discussion of the PSS and the optimum choice of switching waveform is given in [3, 4], but the detailed nature of the radar system against which the PSS was operating was not considered. In this contribution, we describe a MATLAB® and Simulink® software package **PSSim** which can be used to demonstrate the operation of a PSS in the presence of signals from generic pulse and pulse compression radars.

General description of PSSim

The basic GUI for **PSSim**, shown in Figure 1, displays four areas dealing with the modulation parameters of the radar and the PSS, the transmitted radar signal spectrum, the spectrum of the signal reflected from the PSS and the receiver correlator temporal output. Pull-down menus enable file handling, specification of basic radar and simulation parameters, choice of PSS and multiple simulations where either the radar carrier frequency or the PSS switching frequency can be swept. In addition, there are two choices of receiver model: ideal, which is essentially a perfect correlator, and real, which is built up from elements in the Simulink® DSP and Communication blocksets. To minimise simulation time and memory requirements, the receiver model runs in discrete-time mode.

Figure 1 shows a simulation of a radar transmitting 13 bit Barker coded 1μs pulses at a carrier frequency of 10 GHz. The single layer PSS is unenergised and so the spectrum of the incident and reflected radar signals is identical. This results in an output from the real receiver correlator of the classical form shown. Figure 2 shows the same case but when the PSS is switched using an 8 MHz periodic square wave control signal. Now the receiver correlator output is reduced by approximately 15 dB, i.e. the PSS is acting as a radar absorbent material with a reflectivity of –15 dB at the radar carrier frequency. More information can be obtained using the Multiple Simulation (MS) capabilities of **PSSim.** In the first MS mode, the PSS is switched at a

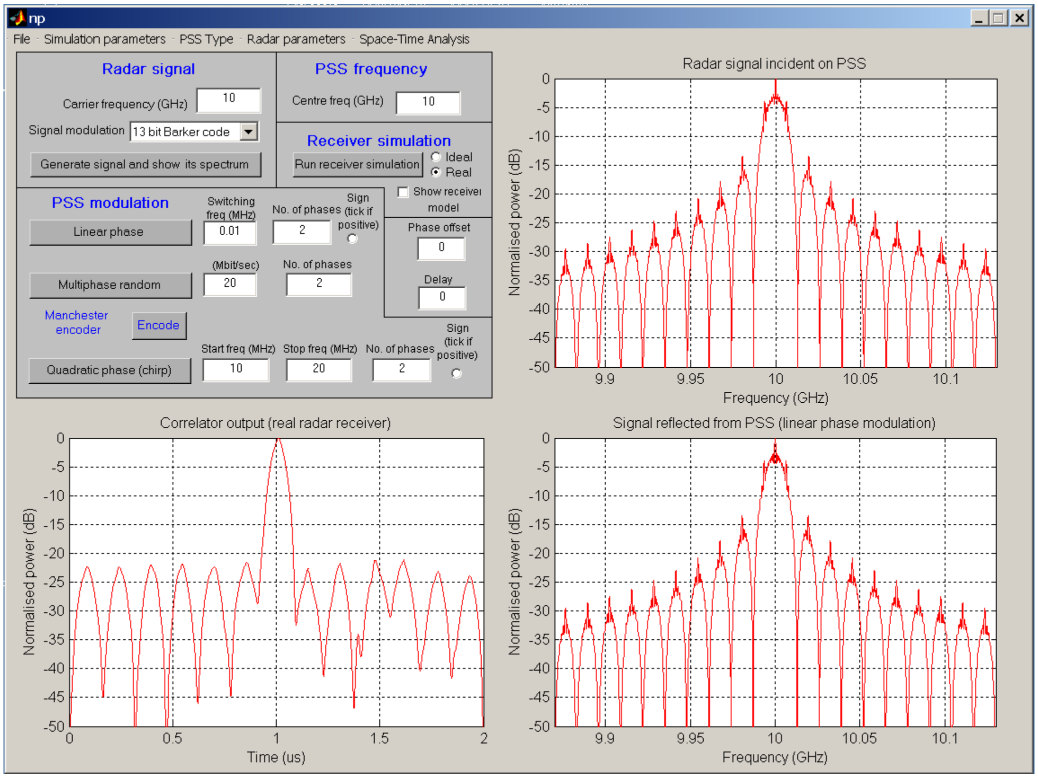


Figure 1 Layout of **PSSim** GUI (simulation of 13 bit Barker coded pulse radar)

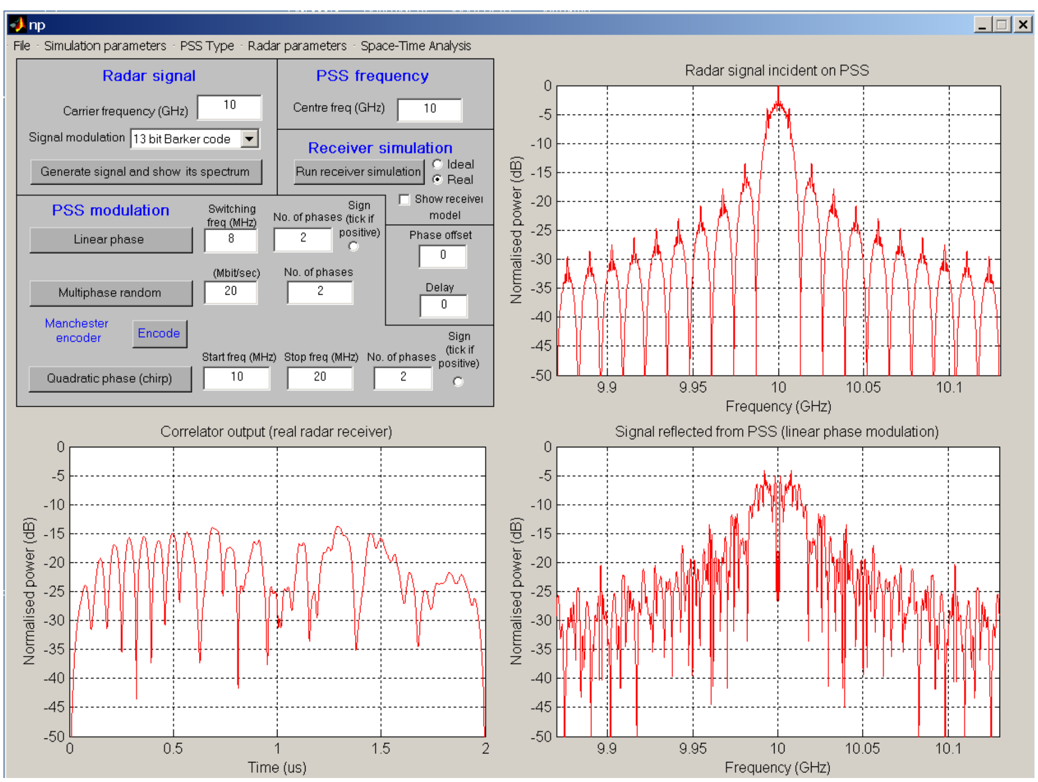
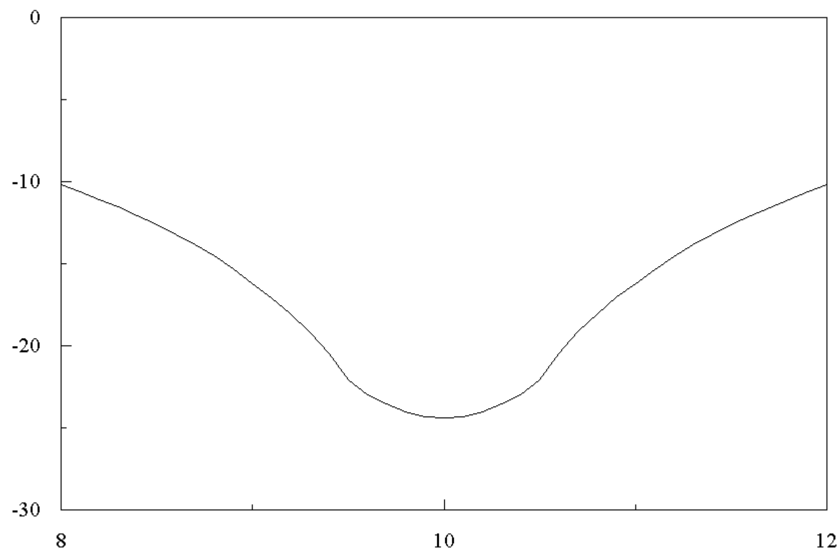


Figure 2 PSS switched at 8 MHz and operating against 13 bit Barker coded pulse radar

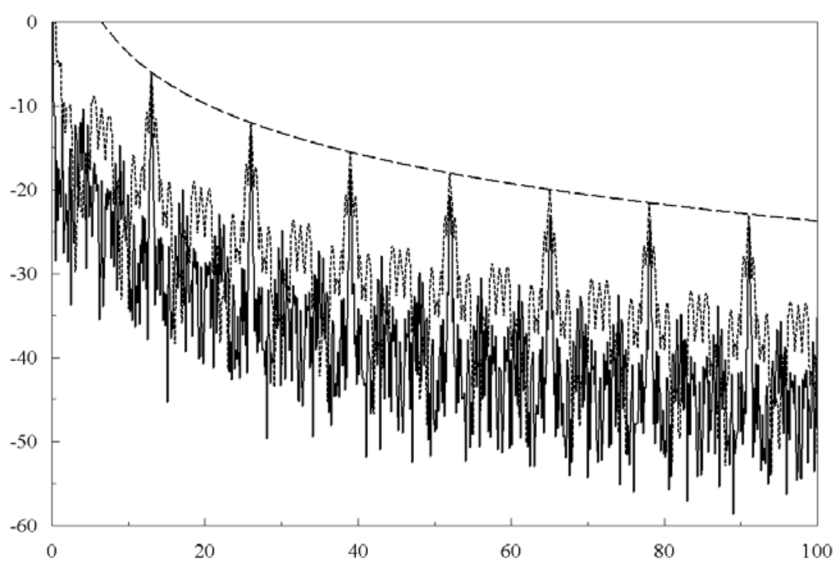
Reflectivity (dB)



Radar carrier frequency (GHz)

Figure 3 Effective PSS reflectivity as measured by pulse compression radar (51 bit code, 30 MHz switching frequency, 10 GHz PSS centre frequency)

Reflectivity (dB)



PSS switching frequency (MHz)

Figure 4 Performance of PSS against radar with uncoded (_ _), 13 bit coded (….) and 51 bit (___) coded pulses constant frequency and its reflectivity characteristics can be determined as a function of the incident radar carrier frequency. Figure 3 shows the variation of reflectivity for a single layer PSS when switched at 30 MHz and operated against a radar whose 1μs pulses are coded using a 51 bit sequence whose peak autocorrelation sidelobe level is –24.7 dB [5]. As expected, the curve is symmetrical about the PSS centre frequency of 10 GHz. In the second MS mode, the radar carrier frequency is fixed and the PSS switching rate is varied. Figure 4 compares the reflectivity performance of a single layer PSS when operated against (a) a simple radar whose pulses are uncoded, (b) one with 13 bit Barker coding and (c) one with 51 bit optimal coding. In all cases, the transmitted radar spectral bandwidth is 26 MHz, which corresponds to pulse lengths of 0.077, 1 and 3.92 μs, respectively, and the PSS switching frequency is varied between 0 and 100 MHz. It can be seen that simple periodic PSS switching is very effective against the coded radar pulses as it disrupts the correlation process in the receiver, but this disruption becomes much less effective at PSS switching frequencies which coincide with the code chip frequency or its harmonics. In practice the PSS performance will be better than predicted in Figure 4, since this assumes perfect synchronisation between the radar and PSS switching pulses. Although not reported here, **PSSim** can be used to investigate effects due to asynchronism between the two signals through the introduction of appropriate phase angles.

PSSim is very versatile since it also enables other PSS switching strategies to be explored, such as chirp, m sequences and Manchester encoding [4] and it can be used to simulate multi-layer PSS and those which produce M'ary phase modulation. Future enhancements will include more realistic radar systems, path propagation and target characteristics and better PSS switching strategies to control the reflected signal spectrum which falls not only within the receiver passband, but also outside it.

References

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