Low-Observable Reflectors Using Perfect Pulses

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Outline

- Introduction / Motivation
- Perfect Pulses
- Reflectors
- Simulation Results

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Introduction

- Interested in potential new methods for suppressing the *spectral reflection* of an impinging wave.
- Presents a controlled alternative to corrugated surfaces.
- Examines the potential for "digitized surfaces" and the properties of *perfect pulses* in a hardware representation.

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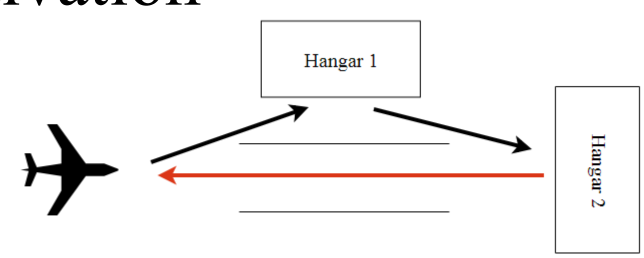
Motivation

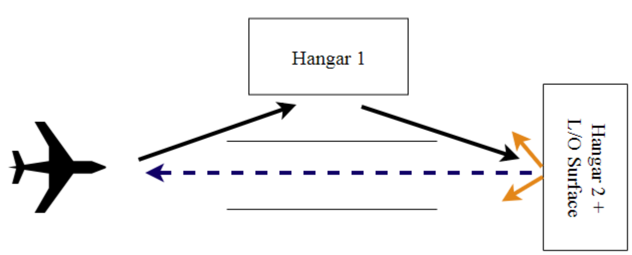
Undesired Radar Scenario

- An "unknown" multipath environment is established.
- Airplane receives erroneous and possibly dangerous readings in the cockpit.



Low Observable Surface

- Nulls/Reduces the power of the specularl reflection
- Dissipates specular reflection in other directions



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Far Field Radiation

Fourier Transform

$X(\omega)=\int x(t) * e^{-j\omega t} dt$

Solution to Inhomogeneous Vector Potential Eqn

$A(r,\varphi,\theta)= \iiint_v J * e^{-j*k*R} / R \, dv$

Far Field Approximations

$E_\varphi = j\omega A_\varphi$

$E_\theta = j\omega A_\theta$

The Fourier Transform of the current distribution represents the far-field radiation characteristics.

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Perfect Pulses

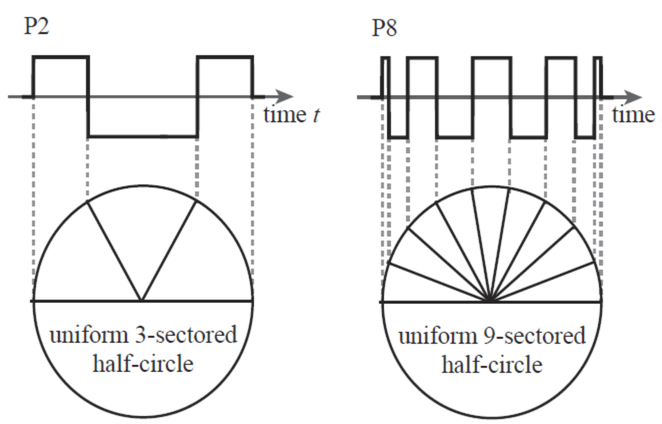
- Binary Antipodal Waveforms
- Unique DC Nulling Properties
- Radial projection gives transition locations. Described via Chebyshev polynomials.

Note:

Can be manufactured on a PCB Mill.

Transition times can be irregular. Result in imperfect null.

$$x_n(t) = \mathrm{sgn}\left(\cos\left(n \cos^{-1}\left(\frac{2t}{T_b} - 1\right)\right)\right)$$



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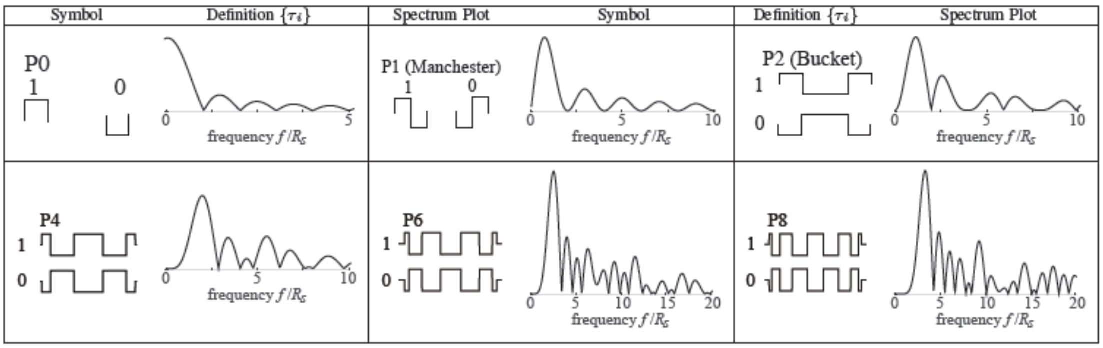
Perfect Pulses

Increased number of transitions *deepens* the spectral null



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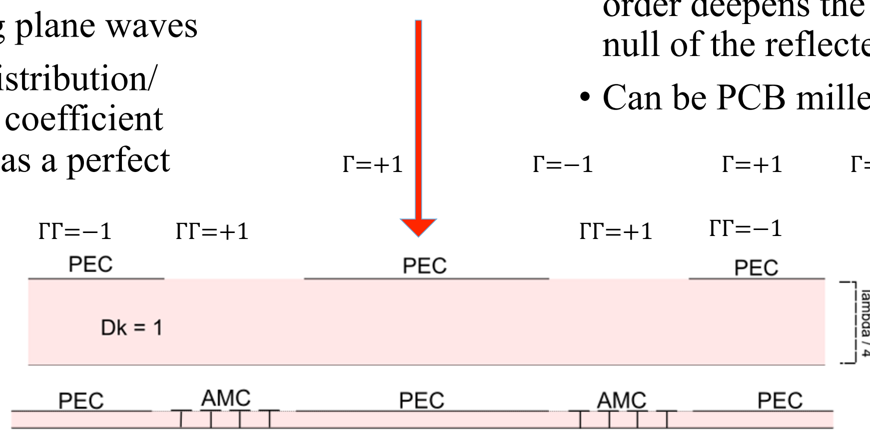
Reflectors & "Digital Surfaces"

- The PP reflector rejects spectral reflection of impinging plane waves
- Current distribution/ reflection coefficient patterned as a perfect pulse

- Increasing Perfect Pulse order deepens the spectral null of the reflected wave.
- Can be PCB milled



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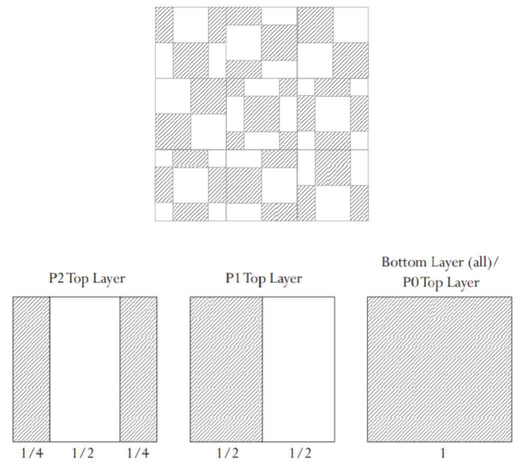
Reflectors & "Digital Surfaces"

- A top-down view of the reflector surfaces.
- Transitions from metallic to dielectric boundaries occur at "zero-crossings" of the perfect pulse equation
- Large surfaces can be composed of a collage of small perfect pulse reflectors.



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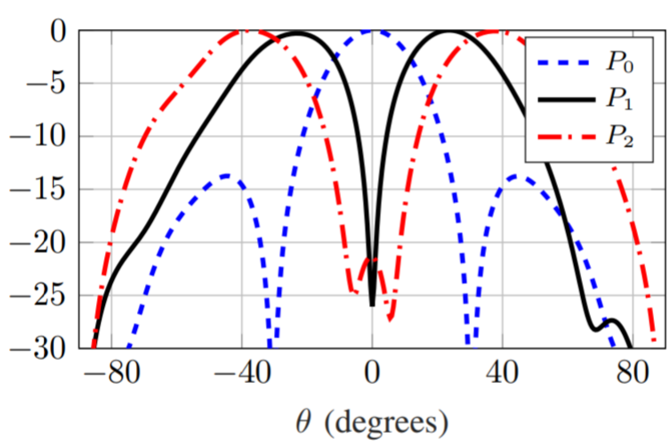
Simulation Results

- Comparing P0, P1, and P2 radar cross sections for broadside illumination.
- As order of the reflector increases, the null deepens.



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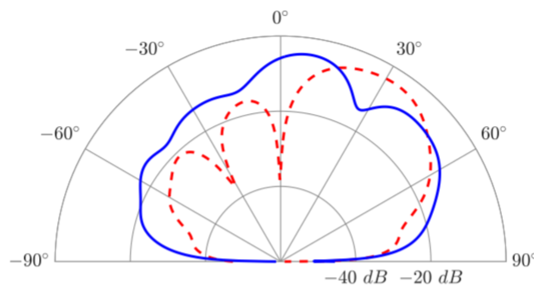
Simulation Results

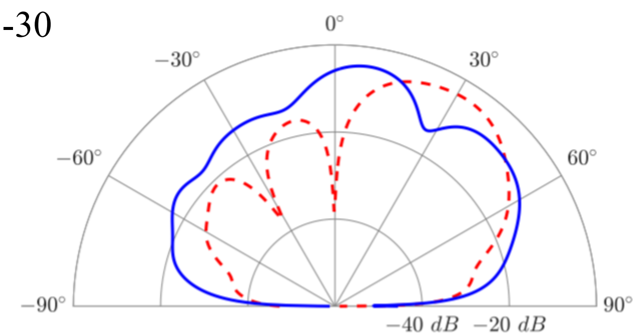
- Comparison of Radar Cross Sections of the P1 Reflector (Blue) and the P0 [PEC Surface] (Red)

- Overserving interrogation angles of -30, -20, -10, and 0 degrees respectively



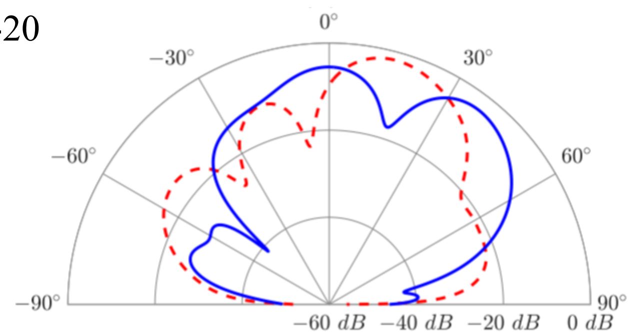
Simulation Results

Θ = -30



Simulation Results

Θ = -20



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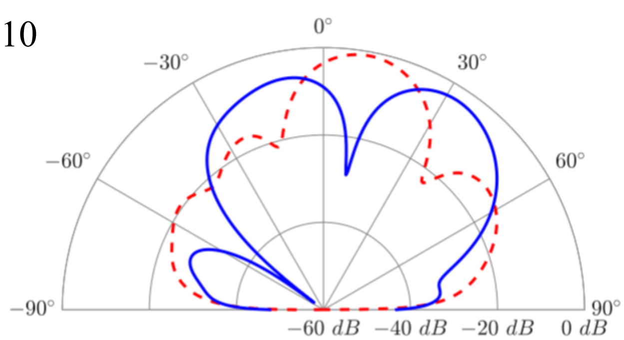
Simulation Results

Θ = -10



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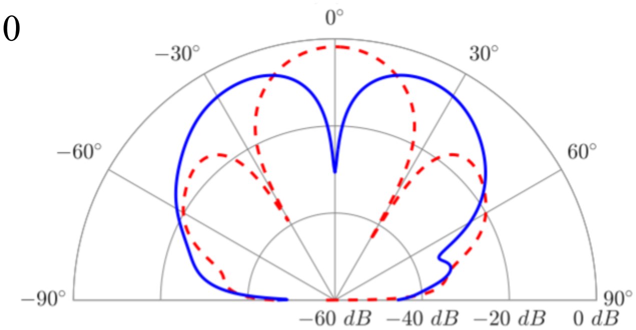
Simulation Results

Θ = 0



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Conclusions

- Depicted an original and efficient technique for minimizing specular reflection.
- Future work:
  - Measurements of single perfect pulse reflector cells.
  - Determine the effects of building large layout reflectors using collage of perfect pulse reflector cells.

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Questions?