The Industry Experience
Topics of Discussion
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- Aeroflex Lintek, Corp.
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- Aeroflex Lintek, Corp.
- How things work in industry
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- How things work in industry
- Modeling with MATLAB
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- Aeroflex Lintek, Corp.
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- Example MATLAB model
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- Discovery through modeling
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- Some Advice
Aeroflex Lintek, Corp.
Aeroflex Lintek, Corp.

- Radar Cross Section Measurements
Aeroflex Lintek, Corp.

- Radar Cross Section Measurements
- Satellite Testing
Topics of Discussion

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- Aeroflex Lintek, Corp.
- How things work in industry
How Things Work in Industry
How Things Work in Industry

- Slowly
How Things Work in Industry

- Slowly
- Inefficiently
How Things Work in Industry

- Slowly
- Inefficiently
- Monetarily
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- Modeling with MATLAB
Modeling with MATLAB
Modeling with MATLAB

- It’s not what you think!
Modeling with MATLAB

- It’s not what you think!
- It’s easy
Modeling with MATLAB

- It’s not what you think!
- It’s easy
- Learn how to model!
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Multipath Ellipse Model
Multipath Ellipse Model

- What is Multipath?
Multipath Ellipse Model

- What is Multipath?
- Signals reflected from something to the target then the receiver
R+R is the minimum path to the target
A+B+R is the maximum possible multipath path for some parameters
Multipath Ellipse Model

- What is Multipath?
- Signals reflected from something to the target then the receiver
- Transmitted Pulse has finite width in time
What is Multipath?
Signals reflected from something to the target then the receiver
Transmitted Pulse has finite width in time
What are we really sampling?
Multipath Elllipse Model

- What is Multipath?
- Signals reflected from something to the target then the receiver
- Transmitted Pulse has finite width in time
- What are we really sampling?
- How do we eliminate multipath?
Multipath Ellipse for Max Target Length = 212.132 at Range = 2500 Rotated about DnRg 2606.066
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- Discovery through modeling
Discovery Through Modeling
Discovery Through Modeling

Hughes Space and Satellite: “Our satellites have random phase.”
Discovery Through Modeling

- Hughes Space and Satellite: “Our satellites have random phase.”
- SNR Improvement Model: Coherent versus Non-Coherent Integration
The Signal is Voltage
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- Voltage is complex: magnitude and phase of signal measured
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- $V = \sqrt{\text{Re}(\text{sig})^2 + \text{Im}(\text{sig})^2}$
The Signal is Voltage

- Voltage is complex: magnitude and phase of signal measured
- \( V = \left[ \text{Re}(\text{sig})^2 + \text{Im}(\text{sig})^2 \right]^{1/2} \)
- SNR = Signal Power : Noise Power
The Signal is Voltage

- Voltage is complex: magnitude and phase of signal measured
- \[ V = \sqrt{\text{Re}(\text{sig})^2 + \text{Im}(\text{sig})^2} \]
- SNR = Signal Power : Noise Power
- Recall \( P \propto V^2 \)
The Signal is Voltage

- Voltage is complex: magnitude and phase of signal measured
- \[ V = \left[ \text{Re}(\text{sig})^2 + \text{Im}(\text{sig})^2 \right]^{1/2} \]
- SNR = Signal Power : Noise Power
- Recall \( P \propto V^2 \)
- Power: \( \text{Re}(\text{sig})^2 + \text{Im}(\text{sig})^2 \)
Coherent Integration
Power: \((\sum_n \text{Re})^2 + (\sum_n \text{Im})^2\)
Coherent Integration Power: \((\sum_n \text{Re})^2 + (\sum_n \text{Im})^2\)

- The phase of the return signal is meaningful
Coherent Integration

\[ \text{Real} \]

\[ \text{Imag} \]

\[ \phi \]
Coherent Integration

Power: $\left(\sum_n \text{Re}\right)^2 + \left(\sum_n \text{Im}\right)^2$

- The phase of the return signal is meaningful
- Signal power increases as the number of integrations, squared
Coherent Integration
Power: $(\sum_n \text{Re})^2 + (\sum_n \text{Im})^2$

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Coherent Integration

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- Noise power increases as the number of integrations
- SNR then increases as the number of integrations
Coherent Integration

Power: \((\sum_n \text{Re})^2 + (\sum_n \text{Im})^2\)

- The phase of the return signal is meaningful
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- The berries
Non-Coherent Integration Power: $\Sigma_n (\text{Re})^2 + \Sigma_n (\text{Im})^2$
Non-Coherent Integration
Power: $\Sigma_n (Re)^2 + \Sigma_n (Im)^2$

- Phase information of the return signal is meaningless.
Non-Coherent Integration

Magnitude

Samples

Signal ± Noise
Non-Coherent Integration Power: $\sum_n (\text{Re})^2 + \sum_n (\text{Im})^2$

- Phase information of the return signal is meaningless
- Signal power increases as the number of integrations
Non-Coherent Integration Power: $\Sigma_n (\text{Re})^2 + \Sigma_n (\text{Im})^2$

- Phase information of the return signal is meaningless
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Non-Coherent Integration Power: $\Sigma_n (Re)^2 + \Sigma_n (Im)^2$

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- The pits
SNR Improvement Model
SNR Improvement Model

- Generate a signal with random noise and coherently and non-coherently
SNR Improvement Model

- Generate a signal with random noise and coherently and non-coherently
- Model works as expected
<table>
<thead>
<tr>
<th>Number of Integrations</th>
<th>SNR (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
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<td>60</td>
</tr>
<tr>
<td>6</td>
<td>65</td>
</tr>
<tr>
<td>7</td>
<td>70</td>
</tr>
<tr>
<td>8</td>
<td>75</td>
</tr>
</tbody>
</table>

**SNR versus Number of Integrations**

- **Coherent Integration**
- **Non-Coherent Integration**
SNR Improvement Model

- Generate a signal with random noise and coherently and non-coherently
- Model works as expected
- Time for some real data!
Random Phase!?
What’s going on here?
What’s going on here?

- Hughes’ system has a 5 kHz sampling rate
What’s going on here?

- Hughes’ system has a 5 kHz sampling rate
- Our system has a sampling rate of 5 MHz.
What’s going on here?

- Hughes’ system has a 5 kHz sampling rate
- Our system has a sampling rate of 5 MHz.
- Slow sampling rate led Hughes to believe their system’s phase was random and/or unstable
So, now what?
So, now what?

- We characterize the change in phase with time, $d\phi/dt$
So, now what?

- We characterize the change in phase with time, \( \frac{d\phi}{dt} \)
- We apply a phase correction factor: \( e^{(\pm i \times t \times \frac{d\phi}{dt})} \)
So, now what?

- We characterize the change in phase with time, $d\phi/dt$
- We apply a phase correction factor: $e^{-itd\phi/dt}$
So, now what?

- We characterize the change in phase with time, $\frac{d\phi}{dt}$
- We apply a phase correction factor: $e^{-i*t*d\phi/dt}$
- Coherent integration is possible
So, now what?

- We characterize the change in phase with time, $d\phi/dt$
- We apply a phase correction factor: $e^{-i*t*d\phi/dt}$
- Coherent integration is possible
- Our obnoxious sampling rate has been justified
Discovery Through Modeling

- Hughes Space and Satellite: “Our satellites have random phase.”
- SNR Improvement Model: Coherent versus Non-Coherent Integration
- Random Phase?
- Non-Coherent Integration? We don’t need no stinking Non-Coherent Integration!
Some Advice
Some Advice

- Work in industry if you can put up with the inefficiencies
Some Advice

- Work in industry if you can put up with the inefficiencies
- Become proficient in modeling