Performance Considerations for Pulsed Antenna Measurements

David S Fooshe, Nearfield Systems Inc.

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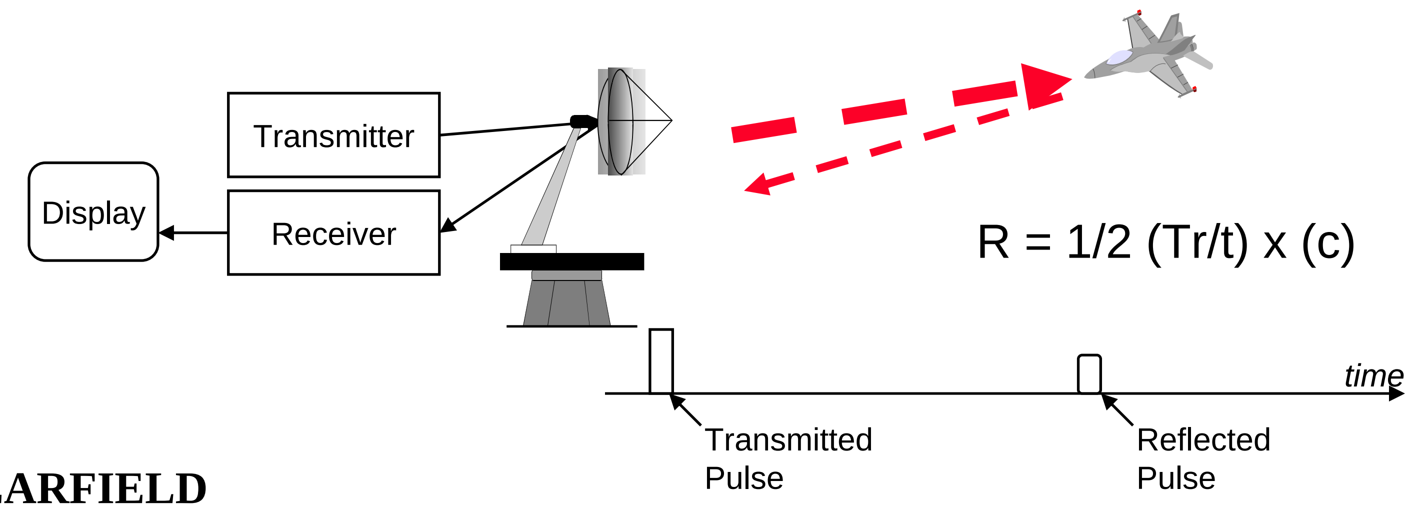
Agenda

- Why pulse mode?
- Pulse parameters and receiver performance
- Pulsed near-field measurements
  - Pulse synchronization
  - Pulse timing vs scan speed
  - Positional accuracy in pulse mode
  - Intra-pulse averaging
- Pulse profile measurements
- CW vs Pulsed comparison
- Summary

Why Pulse Mode?

- Radar systems operate in pulse mode:
  - AUT CW testing often not an option,
  - Power limitations may dictate PRF,
  - AUT pattern should be same for CW or pulse testing,
- AUT may be integrated with active radar antenna,
- Pulse mode affects NF system operation.

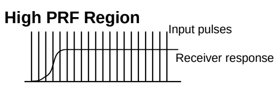


Requirements for Pulse Mode

- Resources needed for pulsed antenna measurements:
  - High-speed receiver with wideband IF input,
  - High-speed beam controller,
  - Beam-steering computer (BSC) interface (AUT dependent),
  - Timing and synchronization,
- Measurement system must be able to simulate the control & timing of the radar system in a manner that provides a realistic test of the antenna while maintaining control over the measurement process.

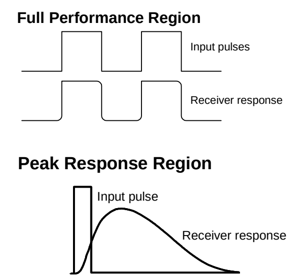
Receiver Performance

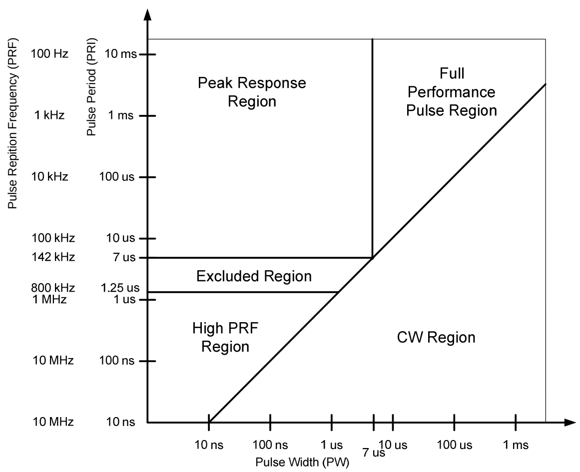
- Narrowband receiver may be used without synchronizing to the pulse,
  - Requires high PRF,
  - Dynamic range decreases with increased PRI,
  - Called Narrowband since receiver measures 'narrowband' CW component of pulse train,
  - Offers little control over measurement process,
- Wideband receiver is synchronized to pulse,
  - Must wait for RF pulse to make measurement,
  - Delay can effect measurement,
  - Dynamic range limited by pulse width.



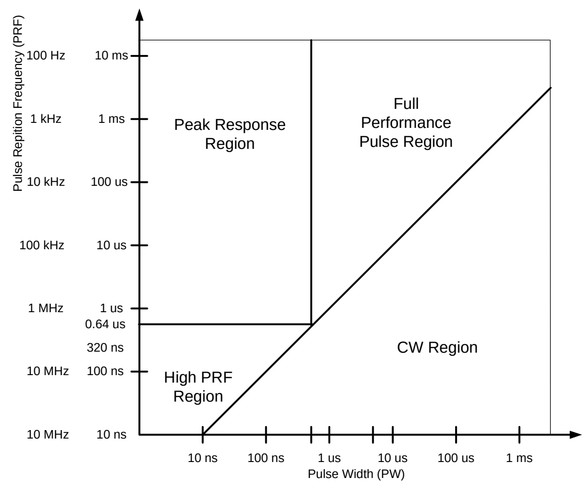
Pulse Parameters

- Receiver integration time (speed) and IF BW are key parameters in determining pulse mode performance.
- Operating region determines receiver performance:
  - If PW > Ts (7 µs (P6K), 0.32 µs (P9K)), measurement response = full performance.
  - If PW < Ts, measured response < full performance (Peak Response Region).





Panther 6000



Panther 9000

Receiver Pulse Considerations

- Both the Panther 6000 and Panther 9000 receivers use a beam controller and beam table to specify timing,
- A beam is defined as a single parameter, i.e. frequency, port, beam-steer, etc, to be measured.
- Each beam has two timing parameters: dwell time, and measurement time.
- Panther 6000/Beam Controller uses software timing loop:
  - Trigger delay timing uncertainty created by software.
  - Several µs jitter in receiver trigger timing.
- Panther 9000/Beam Controller uses hardware timing:
  - Receiver ‘window’ starts and stops measurement with quantizing accuracy of 10 ns.

NSI2000 Beam Table

- Specifies dwell timing,
- Frequency, port, polarization to be measured,
- Provides control interface to BSC,
- Coordinates test flow & timing with AUT,
- Provides real-time feedback for pre-scan test.

Multi-beam list: 21 Single-pol beams: 21 inner-loop beams, Pol: Outer-loop

Beam	Dwell	Frequency	Azimuth	Phi	Pol	Amplitude	Phase	S/N	Max Amp	Delta
1	0.262400 mSec	1.000000 GHz	Azimuth	Phi	Single-pol	-27.584 dB	-90.68 deg	61. dB	-27.554 dB	0.049 dB
2	2.688000 mSec	1.000300 GHz	Azimuth	Phi	Single-pol	-27.598 dB	-104.06 deg	61. dB	-27.566 dB	0.052 dB
3	0.812800 mSec	1.100000 GHz	Azimuth	Phi	Single-pol	-27.971 dB	105.29 deg	61. dB	-27.938 dB	0.064 dB
4	2.464000 mSec	1.150000 GHz	Azimuth	Phi	Single-pol	-28.894 dB	29.82 deg	61. dB	-28.876 dB	0.060 dB
5	0.492800 mSec	1.233330 GHz	Azimuth	Phi	Single-pol	-29.443 dB	-92.63 deg	61. dB	-29.420 dB	0.053 dB
6	2.092800 mSec	1.250000 GHz	Azimuth	Phi	Single-pol	-29.705 dB	-115.17 deg	60. dB	-29.662 dB	0.064 dB
7	0.812800 mSec	1.300000 GHz	Azimuth	Phi	Single-pol	-28.894 dB	169.66 deg	62. dB	-28.865 dB	0.050 dB
8	0.812800 mSec	1.350000 GHz	Azimuth	Phi	Single-pol	-30.667 dB	99.21 deg	60. dB	-30.646 dB	0.053 dB
9	0.812800 mSec	1.400000 GHz	Azimuth	Phi	Single-pol	-35.056 dB	30.00 deg	57. dB	-35.017 dB	0.080 dB
10	0.812800 mSec	1.450000 GHz	Azimuth	Phi	Single-pol	-37.710 dB	-24.32 deg	54. dB	-37.663 dB	0.112 dB
11	12.441600 mSec	1.500000 GHz	Azimuth	Phi	Single-pol	-35.681 dB	-76.37 deg	55. dB	-35.643 dB	0.095 dB
12	0.595200 mSec	1.550000 GHz	Azimuth	Phi	Single-pol	-34.391 dB	-126.16 deg	56. dB	-34.356 dB	0.083 dB
13	0.595200 mSec	1.600000 GHz	Azimuth	Phi	Single-pol	-38.604 dB	-155.87 deg	52. dB	-38.512 dB	0.137 dB
14	0.595200 mSec	1.650000 GHz	Azimuth	Phi	Single-pol	-40.125 dB	121.71 deg	51. dB	-40.125 dB	0.179 dB
15	0.595200 mSec	1.700000 GHz	Azimuth	Phi	Single-pol	-37.783 dB	93.08 deg	53. dB	-37.711 dB	0.122 dB
16	0.595200 mSec	1.750000 GHz	Azimuth	Phi	Single-pol	-45.103 dB	3.33 deg	47. dB	-44.996 dB	0.256 dB
17	0.595200 mSec	1.800000 GHz	Azimuth	Phi	Single-pol	-46.139 dB	-41.81 deg	45. dB	-46.047 dB	0.301 dB
18	0.595200 mSec	1.850000 GHz	Azimuth	Phi	Single-pol	-38.322 dB	-128.28 deg	51. dB	-38.267 dB	0.150 dB
19	0.595200 mSec	1.900000 GHz	Azimuth	Phi	Single-pol	-37.379 dB	38.43 deg	52. dB	-37.321 dB	0.143 dB
20	0.595200 mSec	1.950000 GHz	Azimuth	Phi	Single-pol	-38.696 dB	-119.38 deg	51. dB	-38.607 dB	0.170 dB
21	0.262400 mSec	2.000000 GHz	Azimuth	Phi	Single-pol	-42.174 dB	80.62 deg	49. dB	-42.049 dB	0.229 dB

ILT settings
- [x] Show Amplitude, Phase
- [x] Show S/N, Max, Delta
- [x] Continuous readings

Auxiliary beam information
- [ ] Show Amp/Phase offsets
- [ ] Show Ref params

Clear Amp/Phase Offsets | Clear Ref Params

Insert row above | Insert column right | Edit table
Delete current row | Delete current column | Apply
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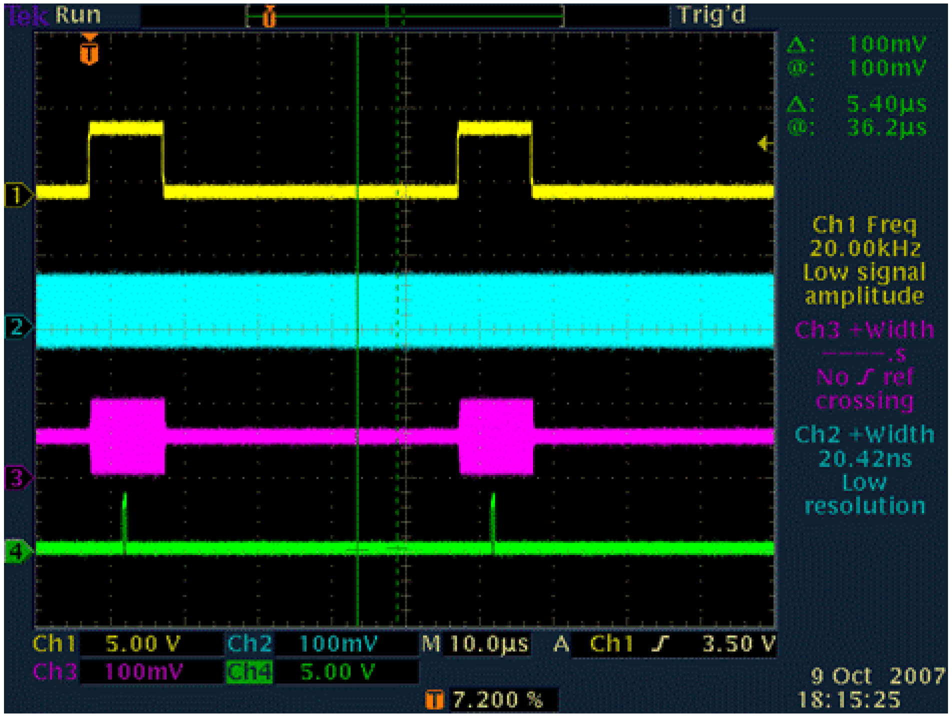
Pulsed Near-Field Measurements

- Pulsed near-field measurements are same as CW, except:
  - Pulse synchronization & timing must be considered when choosing a receiver,
  - Near-field scan speed may need to be reduced to match pulse rate, possibly increasing test time,
  - Positional accuracy may be affected by pulse timing,
  - Intra-pulse averaging may be used to maximize receiver utilization and possibly reduce test time.

Pulse Synchronization

- Trace 1 is 20 kHz PRF with 10 µs pulse,
- Trace 2 is CW IF Ref,
- Trace 3 is CW IF Signal,
- Trace 4 is receiver trigger with delay of 5 µs from leading edge of pulse.
- Receiver integration period (1 ave) is 320 ns.

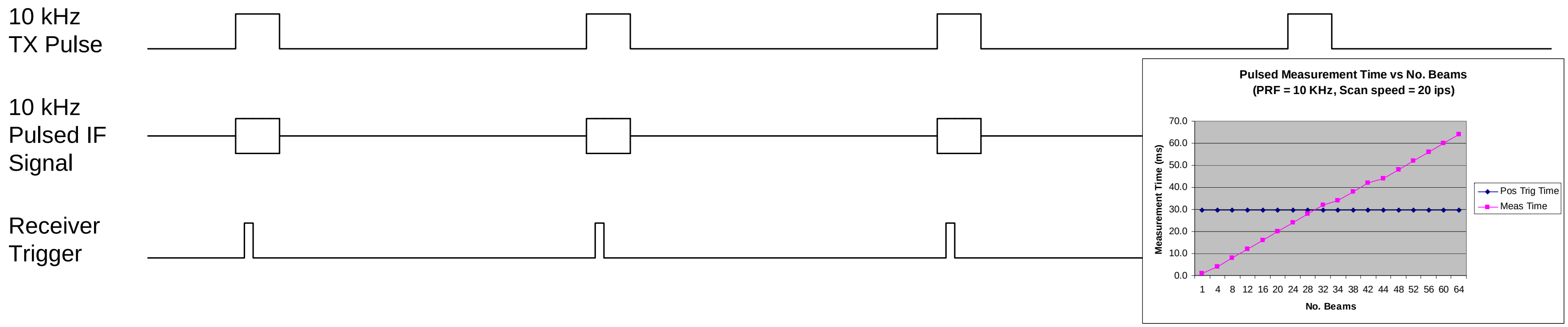


Pulse Timing vs Scan Speed

- In pulsed NF, scan speed must accommodate the pulse rate:
  - All beams are measured between position triggers, typically ½ lambda, so frequency dependent,
  - Factors include: frequency, scan speed, receiver speed, no. of frequencies, no. of beams.
- For multi-frequency measurements, RF source speed is a factor. May require additional pulses for source settling time resulting in fewer beams possible.
- Example shows X-band system with ½ lambda spacing of 0.6", 20 ips scan speed, 30 ms per ½ lambda point.

PRF vs Scan Time Examples

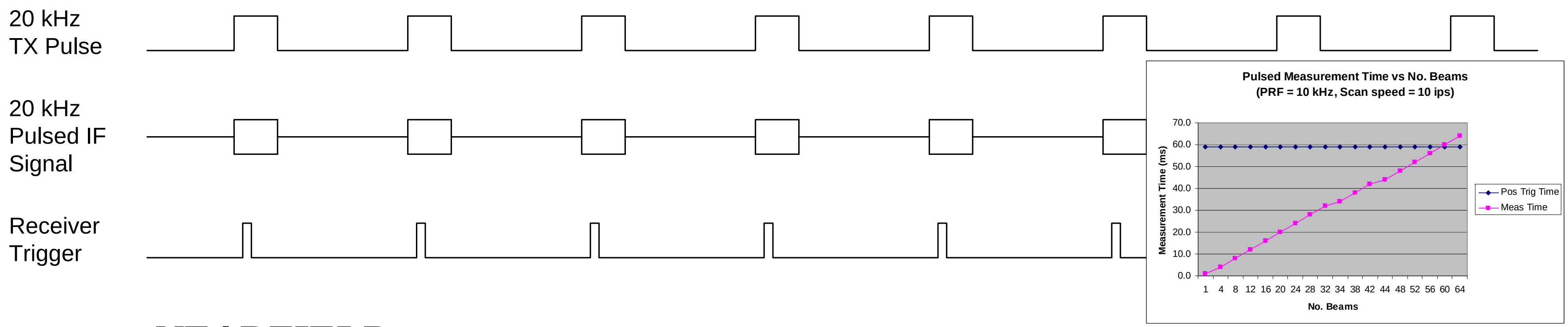
CASE1: 10 kHz Pulse, 20 ips scan speed, 0.030 s/pt, 28 beams/pt.



Time per pt. vs No. Beams

CASE2: 20 kHz Pulse, 20 ips scan speed, 0.030 s/pt, 56 beams/pt.

CASE3: 20 kHz Pulse, 10 ips scan speed, 0.060 s/pt, 112 beams/pt.



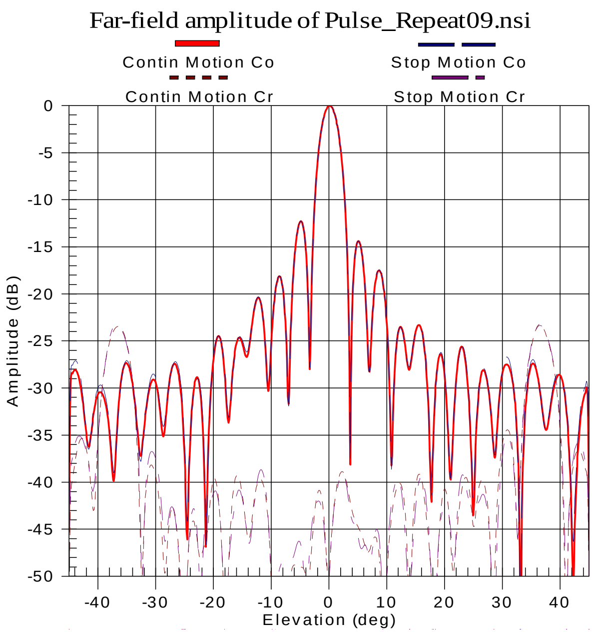
Time per pt. vs No. Beams

Positional Accuracy

- Pulsed measurements are subject to positional uncertainty (pulse jitter) due to receiver delay for pulse synchronization,
- May be quantified by comparing continuous motion and stop motion scans.

Example:

Scan speed = 4 ips,
PRF = 3.33 kHz,
11 Beams:
- 7 Frequencies,
- 2 Polarizations,
- 2 AUT Ports,



Continuous vs Stop Motion Scans

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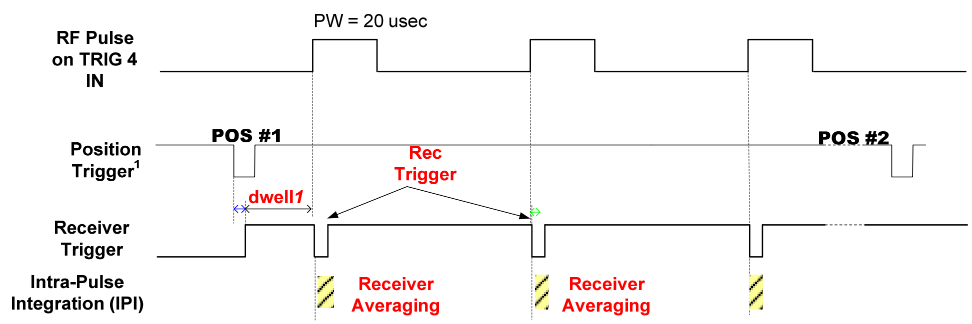
Intra-Pulse Averaging

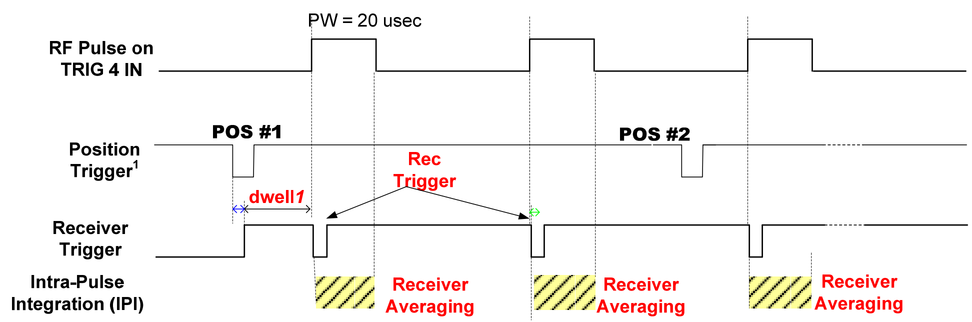
Without IP Averaging:

- Single average per pulse,
- Measurement time highly dependent on PRF.



With IP Averaging:

- Multiple averages per pulse,
- More efficient use of pulse,
- Fewer pulses needed.



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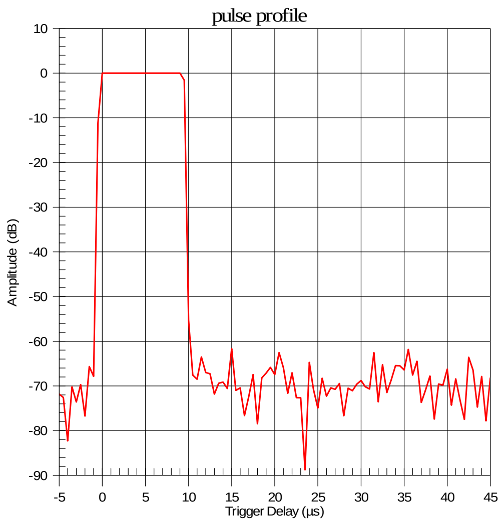
Pulse Profile

- Used to characterize antenna or pulse performance,
- Not a NF measurement, done w/o scanner,
- Trigger delay is varied to generate pulse profile plot,
- Fast synchronous receiver is needed.

Pulse profile using Panther 9000 Receiver:

- 10 µs pulse width,
- 60 dB SN,
- 1 µs rise time.

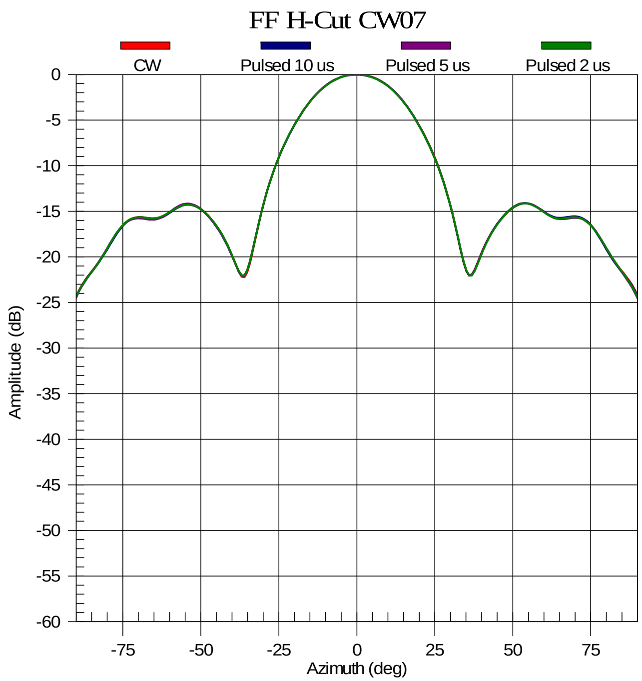


Pulse vs CW Comparison

- If possible, a pulse CW comparison can be used to validate beam/pulse timing and quantify errors discussed,

Four scans using NSI-700S-80 SNF and Panther 9100 receiver:

- CW
- 10 µs pulse width,
- 5 µs pulse width,
- 2 µs rise time.



Summary

- Pulsed antenna measurements require understanding of receiver performance, pulse parameters, timing & synchronization,
- Information needed to specify pulse mode measurement:
  - Size, power and frequency of transmit antenna,
  - Maximum PRF, pulse width and duty cycle,
  - Number of frequencies and beams,
  - Receiver speed and IF BW,
  - Source speed,
  - Beam controller timing,
  - RF interface to AUT,
  - Beam steering control (BSC) interface (if applicable)
  - Scanner speed

- Contributors to paper: Bruce Williams, Bert Schluper, Dan Slater, Greg Hindman