Dual-Antenna RADAR System

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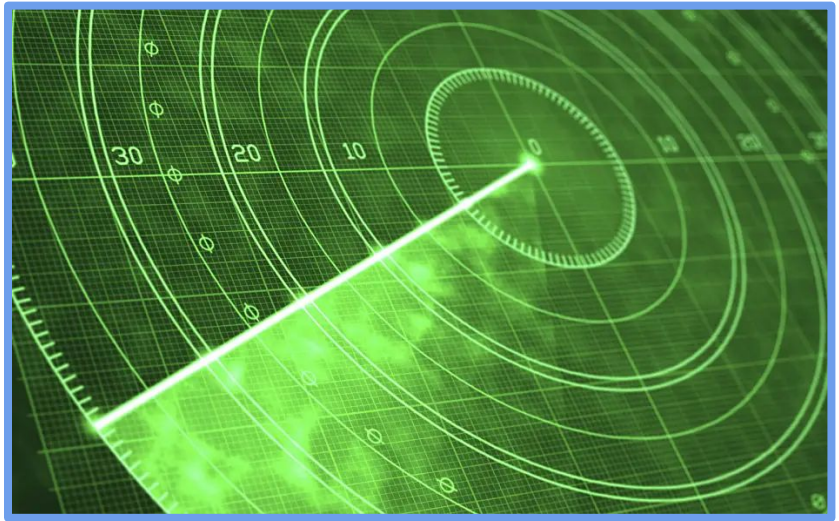
Why Dual-Antenna RADAR?

- Exploration of new antenna designs
  - Altering directivity, gain
- Advantages:
  - Close distance
  - Adjustable
  - Accessibility



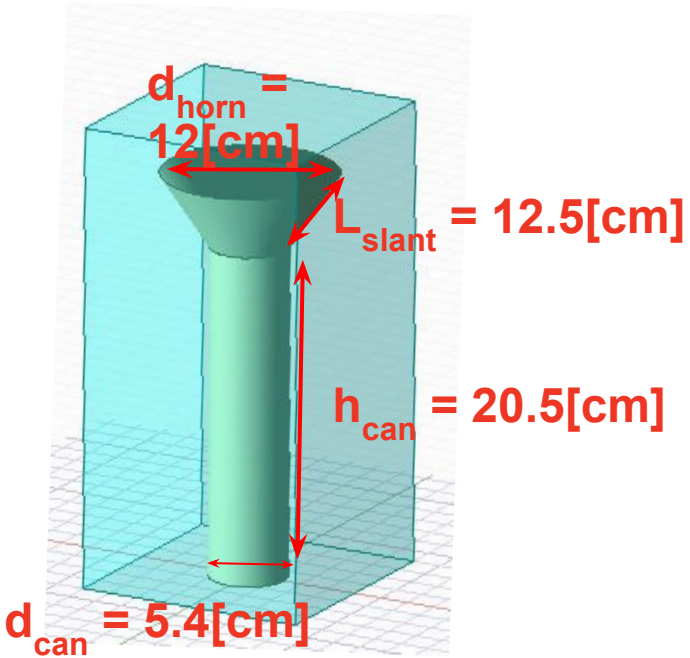
Under the Radar: How to Protect Against the Insider Threat (securityintelligence.com)

Antenna Design

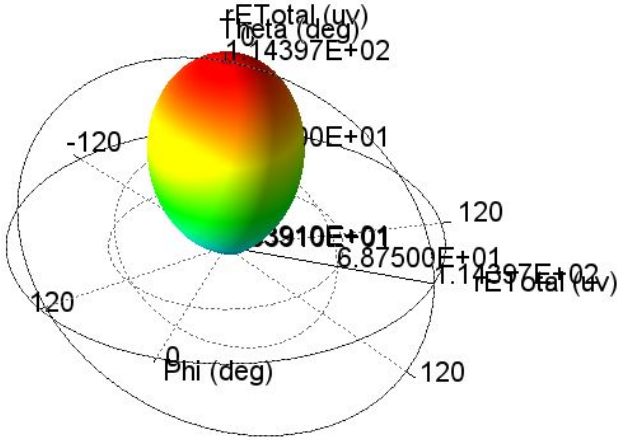
Conical shape:

- high directivity, geometrically-simple design
- For optimal gain, diameter = $\sqrt{3\lambda L}$
  λ = wavelength
  L = slant length

Waveguide:
supports 3.246GHz resonance



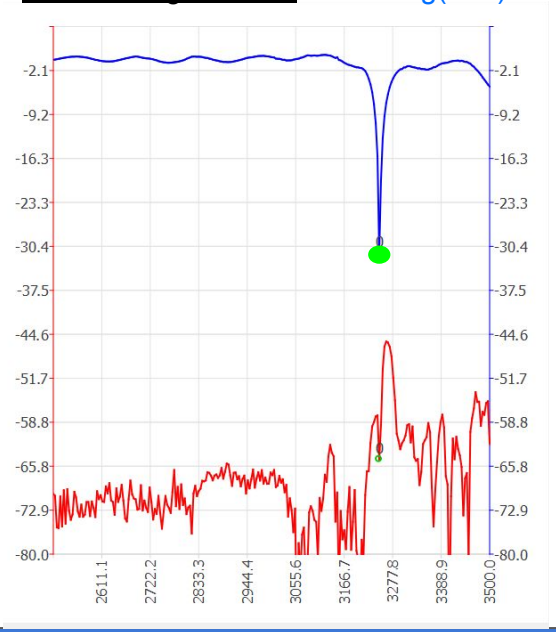
E-field radiation pattern



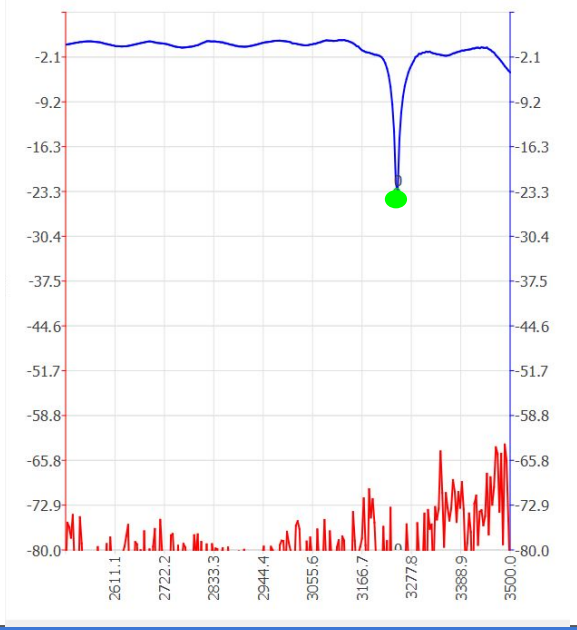
(Ansys HFSS)

Fabricated Waveguide Measurements

Transmitting antenna Blue=mag(S11)

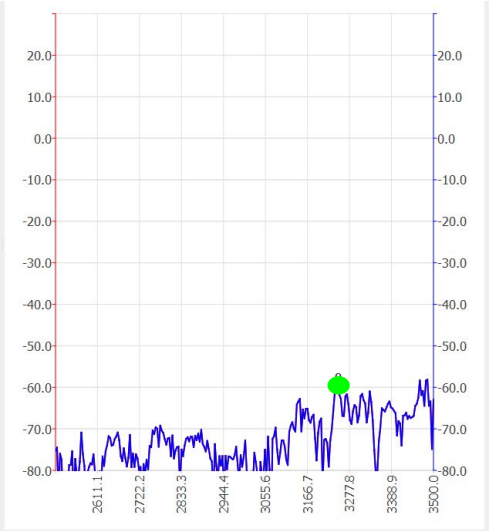


Receiving antenna Blue=mag(S11)

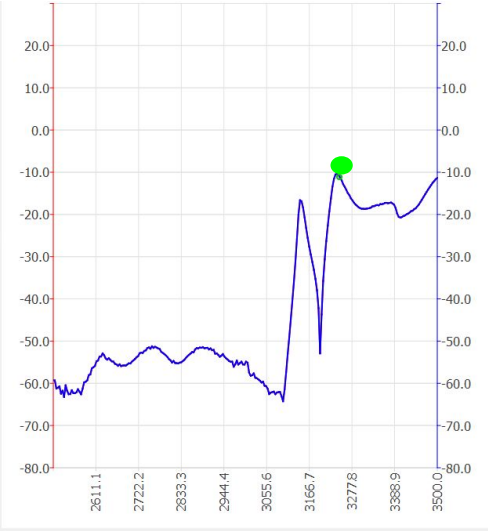


Object Detection and Distance (Frequency Domain)

No object Blue=mag(S21)

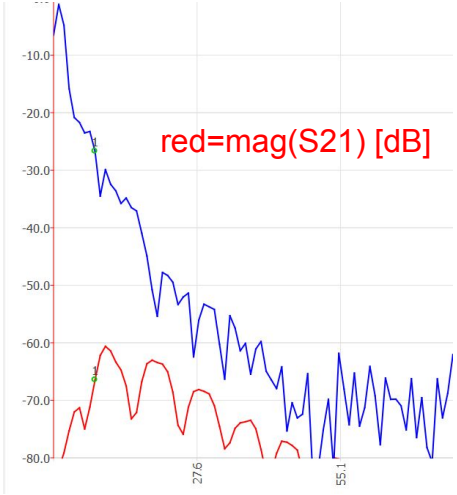


Object Blue=mag(S21)



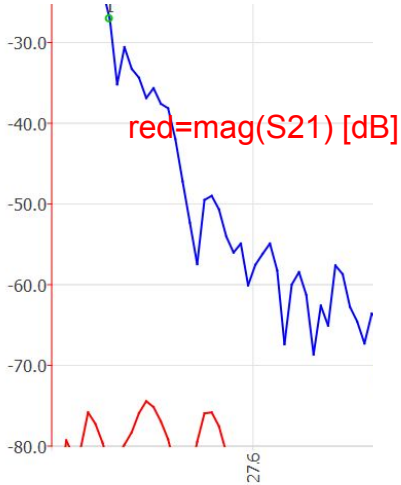
Object Detection and Distance (Time Domain)

Item detected



Time (ns)

Item Indistinguishable



Time (ns)

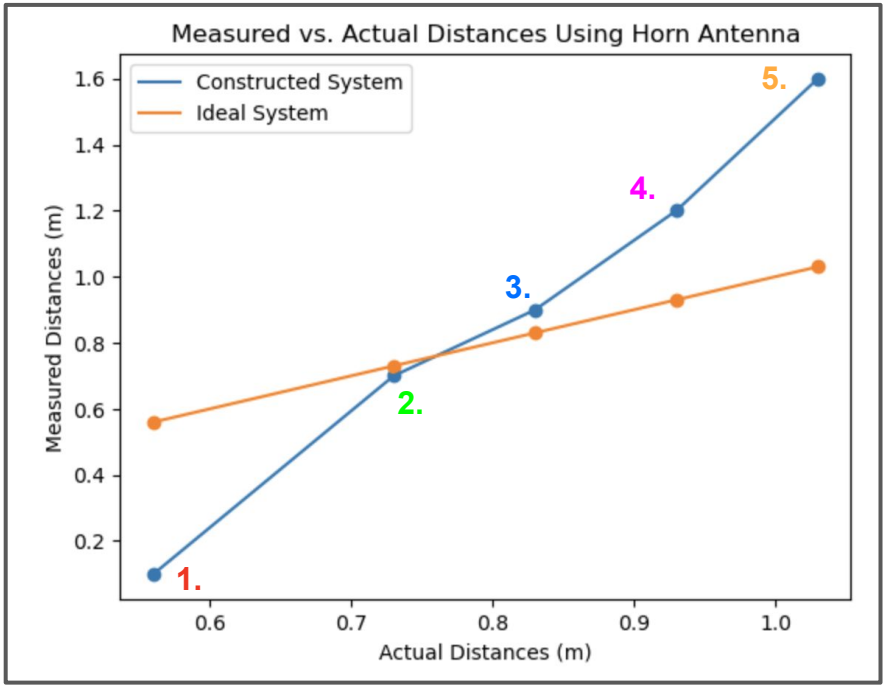
Distance calculation:

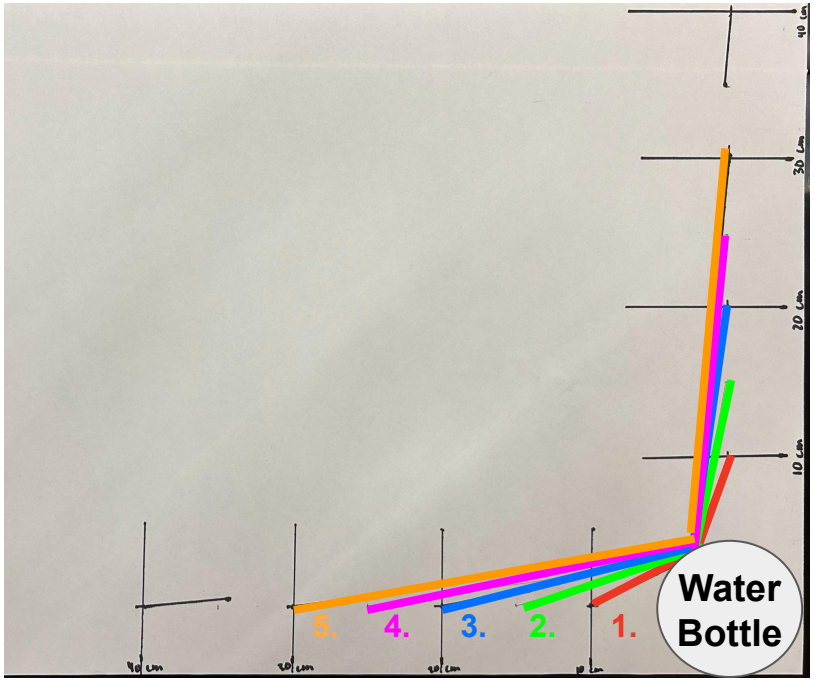
$$d = \frac{\text{Distance travelled by wave}}{2} = \frac{c\Delta t}{2}$$

Δt based on peak of S21 on time domain

Live Demo!

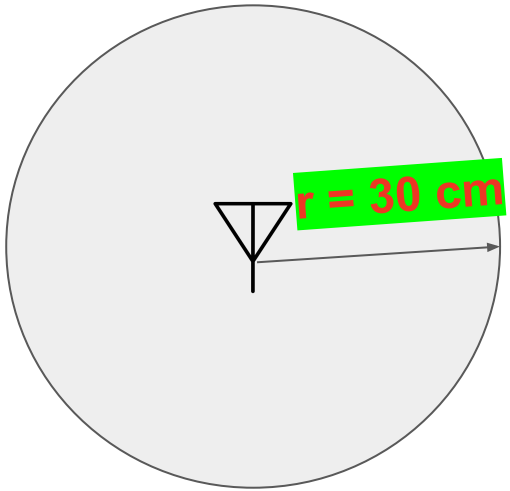
Actual vs. Expected Distance



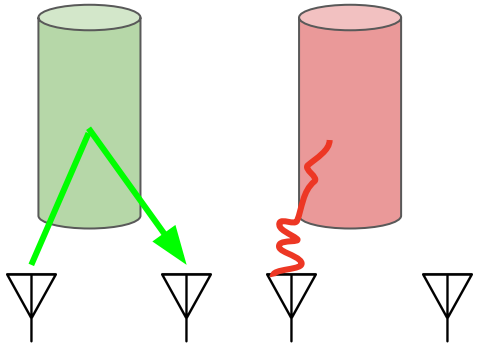


System Limitations

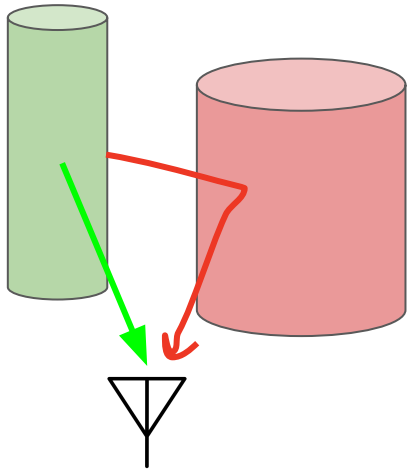
range of detection



objects must reflect well to be detectable



interference from other objects

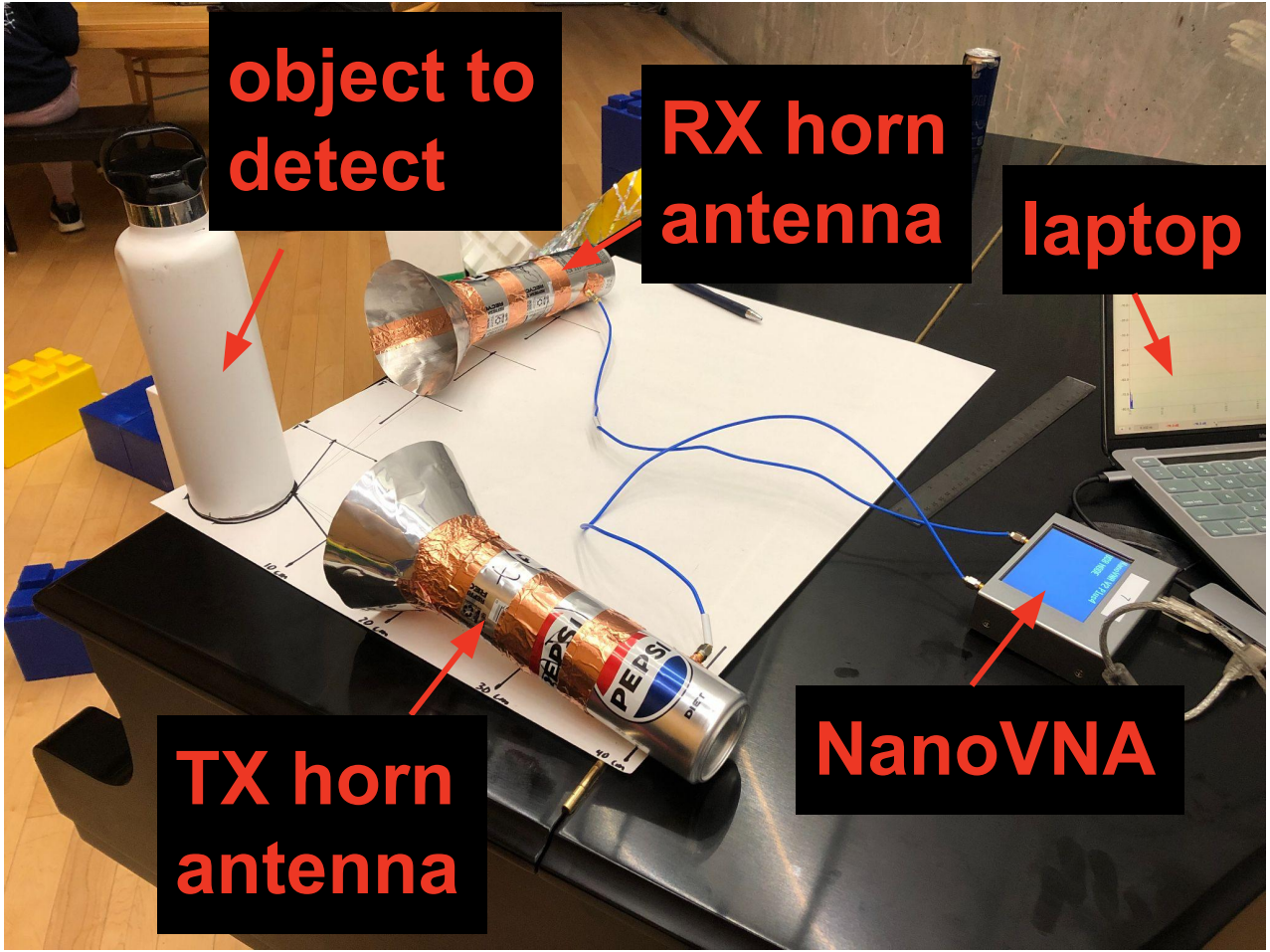


Backup slides

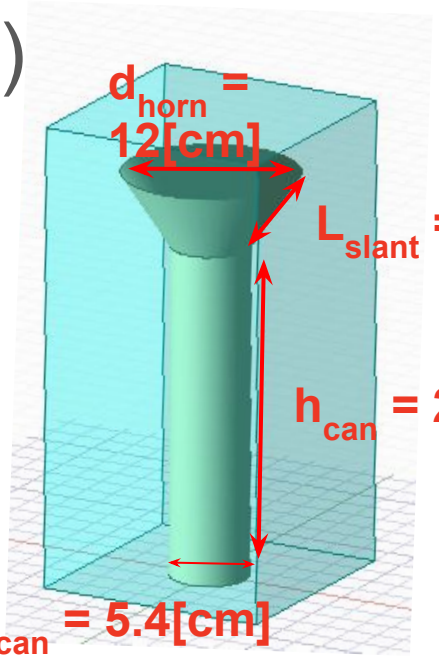
Allowed Frequency Band

2.9-3.26 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Automatic Vehicle Identification Systems	3,000 µV/m per MHz of bandwidth @ 3 m	A	15.251
	Any	500 µV/m @ 3 m	A	15.209

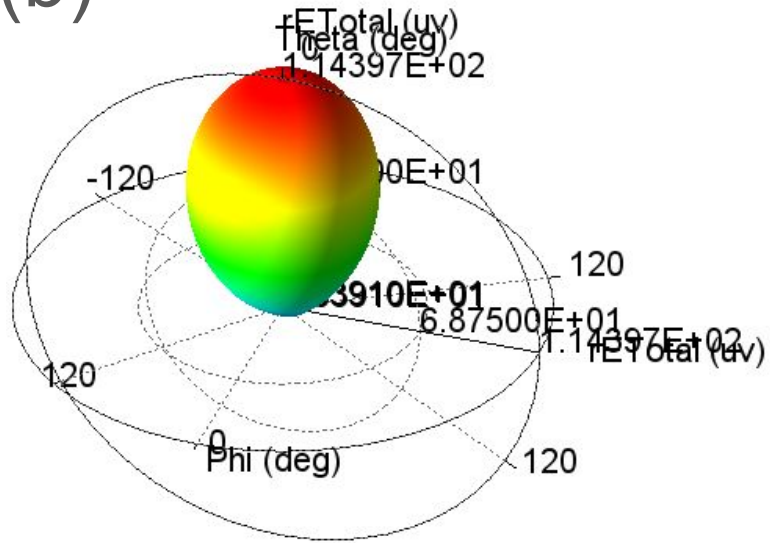
Federal Communication Commission


object to detect
RX horn antenna
laptop
TX horn antenna
NanoVNA

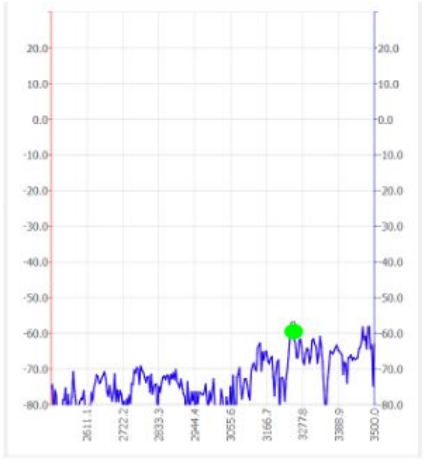
(a)


d_{horn} = 12[cm]
L_{slant} = 12.5[cm]
h_{can} = 20.5[cm]
d_{can} = 5.4[cm]

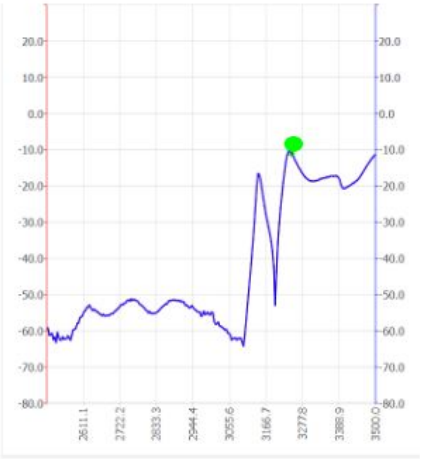
(b)


rETotal (uv)
Theta (deg)
1.14397E+02
-120
120
6.87500E+01
120
Phi (deg)
0
120

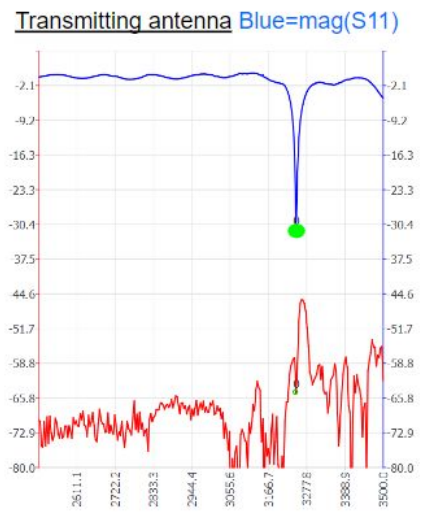
(a) No object Blue=mag(S21)



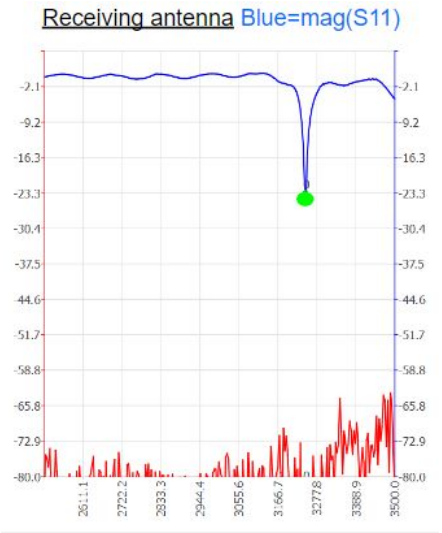
(b) Object Blue=mag(S21)



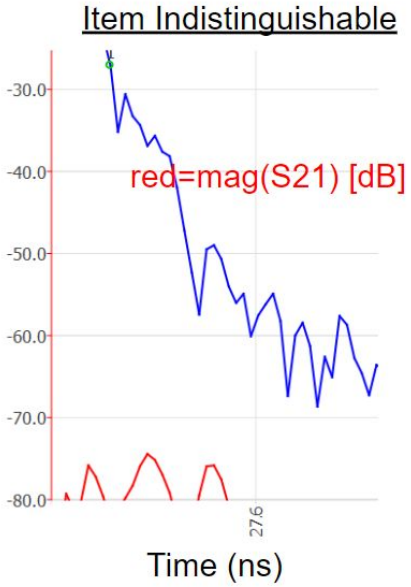
(a)


Transmitting antenna Blue=mag(S11)
-2.1
-9.2
-16.3
-23.3
-30.4
-37.5
-44.6
-51.7
-58.8
-65.8
-72.9
-80.0
2611.1
2722.2
2833.3
2944.4
3055.6
3166.7
3277.8
3388.9
3500.0

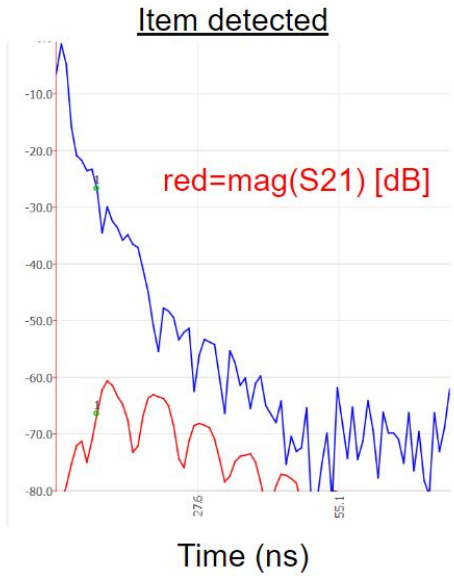
(b)


Receiving antenna Blue=mag(S11)
-2.1
-9.2
-16.3
-23.3
-30.4
-37.5
-44.6
-51.7
-58.8
-65.8
-72.9
-80.0
2611.1
2722.2
2833.3
2944.4
3055.6
3166.7
3277.8
3388.9
3500.0

(a)


Item Indistinguishable
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
red=mag(S21) [dB]
27.6
Time (ns)

(b)


Item detected
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
red=mag(S21) [dB]
27.6
55.1
Time (ns)