GP265/EE355 Handout #9

Solutions for Homework Set No 1

1. a) wavelength: 24 cm

Signal to Noise Ratio dB Table

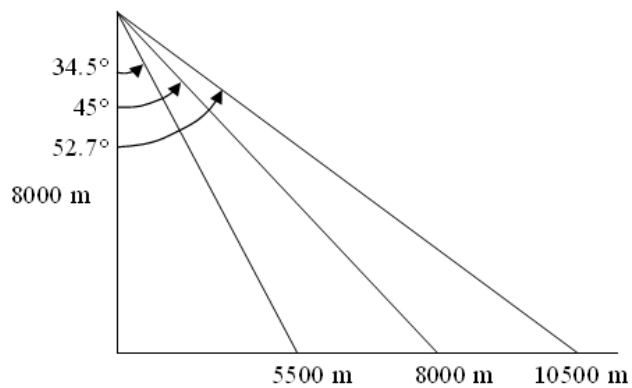
	Value	dB
Wavelength	0.24	
Transmit power	2500	34.0
Cable losses	0.7943	-1.0
4π	12.5664	11.0
Antenna efficiency	0.5	-3.0
Antenna size	0.5	-3.0
$1/\lambda^2$	17.3611	12.4
$1/4\pi$	0.0796	-11.0
$1/R^2$	4.44E-09	-83.5
Object size	50	17.0
Object σ^0	0.0316	-15.0
$1/4\pi$	0.0796	-11.0
$1/R^2$	4.44E-09	-83.5
Antenna efficiency	0.5	-3.0
Antenna size	0.5	-3.0
Cable losses	0.7943	-1.0
Signal power		-143.7
Boltzmann's constant	1.38E-23	-228.6
Noise temperature	900	29.5
System bandwidth	1.00E+06	60.0
Noise power		-139.1
Signal to noise ratio	0.34	-4.7

b) wavelength: 3 cm

Signal to Noise Ratio dB Table

	Value	dB
Wavelength	0.03	
Transmit power	2500	34.0
Cable losses	0.7943	-1.0
4π	12.5664	11.0
Antenna efficiency	0.5	-3.0
Antenna size	0.5	-3.0
$1/\lambda^2$	1111.1111	30.5
$1/4\pi$	0.0796	-11.0
$1/R^2$	4.44E-09	-83.5
Object size	50	17.0
Object σ^0	0.0316	-15.0
$1/4\pi$	0.0796	-11.0
$1/R^2$	4.44E-09	-83.5
Antenna efficiency	0.5	-3.0
Antenna size	0.5	-3.0
Cable losses	0.7943	-1.0
Signal power		-125.7
Boltzmann's constant	1.38E-23	-228.6
Noise temperature	900	29.5
System bandwidth	1.00E+06	60.0
Noise power		-139.1
Signal to noise ratio	21.92	13.4

For a fixed size antenna, gain goes as $\frac{1}{\lambda^2}$, hence the increase in SNR.



2. a) The antenna must illuminate from 34.5°-52.7°, a beamwidth of 18.2°. Calculate antenna width:

$$18.2^\circ = 0.32rad = \frac{\lambda}{D} \rightarrow D = 0.75m$$

Antenna gain = $\frac{4\pi A}{\lambda^2} = \frac{4\pi \times 0.75 \times 2}{0.24^2} = 327.25$ or 25.2 dB

Using the value to the center of the swath as the distance, the range is 11,312 m.

How about the scattering area? The along-track dimension is

$$\frac{r\lambda}{l} = \frac{11312 \times 0.24}{2} = 1357m$$

In the across-track dimension, we use the projected area of the pulse. The pulse length is $1\mu s$, so the transmit pulse length in meters is

$$T = \frac{c\tau}{2} = \frac{3 \times 10^8 \times 1 \times 10^{-6}}{2} = 150m$$

Based on our incidence angle of 45°, projected on the ground we have a length of

$$\text{length} = \frac{\text{pulse length(m)}}{\sin \text{i}} = \frac{150}{\sin 45^\circ} = 212\text{m}$$

So the total scattering area is $1357 \times 212 = 287,684 m^2$.

My dB table looks like this (yours may differ): Note I easily achieve a very high SNR.

Signal to Noise Ratio dB Table

	Value	dB
Wavelength	0.24	
Transmit power	1000	30.0
Cable losses	0.7943	-1.0
4π	12.5664	11.0
Antenna efficiency	0.5	-3.0
Antenna length	2	3.0
Antenna width	0.7680	-1.1
$1/\lambda^2$	17.3611	12.4
$1/4\pi$	0.0796	-11.0
$1/R^2$	7.81E-09	-81.1
c (speed of light)	3.00E+08	84.8
pulse length	1.00E-06	-60.0
$1/(2\sin\theta)$	7.07E-01	-1.5
$R\lambda$/Antenna length	1.36E+03	31.3
σ^0	0.0316	-15.0
Antenna efficiency	0.5	-3.0
Antenna area	1.5360	1.9
Cable losses	0.7943	-1.0
$1/4\pi$	0.0796	-11.0
$1/R^2$	7.81E-09	-81.1
Signal power		-95.4
Boltzmann's constant	1.38E-23	-228.6
Noise temperature	1000	30.0
System bandwidth	1.00E+06	60.0
Noise power		-138.6
Signal to noise ratio	20710.15	43.2

b) If we change the wavelength to 6 cm, a factor of four, we must decrease the antenna width by the same factor to keep the beamwidth the same. Hence the antenna is now $2 \times 0.19m$. Note that this changes the antenna gain and the scattering area:

Signal to Noise Ratio dB Table

	Value	dB
Wavelength	0.06	
Transmit power	1000	30.0
Cable losses	0.7943	-1.0
4π	12.5664	11.0
Antenna efficiency	0.5	-3.0
Antenna length	2	3.0
Antenna width	0.1920	-7.2
$1/\lambda^2$	277.7778	24.4
$1/4\pi$	0.0796	-11.0
$1/R^2$	7.81E-09	-81.1
c (speed of light)	3.00E+08	84.8
pulse length	1.00E-06	-60.0
$1/(2\sin\theta)$	7.07E-01	-1.5
$R\lambda$/Antenna length	3.39E+02	25.3
σ^0	0.0316	-15.0
Antenna efficiency	0.5	-3.0
Antenna area	0.3840	-4.2
Cable losses	0.7943	-1.0
$1/4\pi$	0.0796	-11.0
$1/R^2$	7.81E-09	-81.1
Signal power		-101.5
Boltzmann's constant	1.38E-23	-228.6
Noise temperature	1000	30.0
System bandwidth	1.00E+06	60.0
Noise power		-138.6
Signal to noise ratio	5177.54	37.1

Signal to Noise Ratio dB Table

	Value	dB
Wavelength	0.02	
Transmit power	1000	30.0
Cable losses	0.7943	-1.0
4π	12.5664	11.0
Antenna efficiency	0.5	-3.0
Antenna length	2	3.0
Antenna width	0.0640	-11.9
$1/\lambda^2$	2500.0000	34.0
$1/4\pi$	0.0796	-11.0
$1/R^2$	7.81E-09	-81.1
c (speed of light)	3.00E+08	84.8
pulse length	1.00E-06	-60.0
$1/(2\sin\theta)$	7.07E-01	-1.5
$R\lambda$/Antenna length	1.13E+02	20.5
σ^0	0.0316	-15.0
Antenna efficiency	0.5	-3.0
Antenna area	0.1280	-8.9
Cable losses	0.7943	-1.0
$1/4\pi$	0.0796	-11.0
$1/R^2$	7.81E-09	-81.1
Signal power		-106.2
Boltzmann's constant	1.38E-23	-228.6
Noise temperature	1000	30.0
System bandwidth	1.00E+06	60.0
Noise power		-138.6
Signal to noise ratio	1725.85	32.4

c) For a fixed swath, decreased antenna area lowers performance with increasing frequency. In question (1) performance increased because the target filled greater percentage of the physical antenna beam.