EC5811-Project-2
Design of Electronically steered phased array antenna for the detection of UAV

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Outline

Objective

- To design a radar system using MATLAB Software for detecting drones/UAV's using beamforming technique.

Matlab toolbox

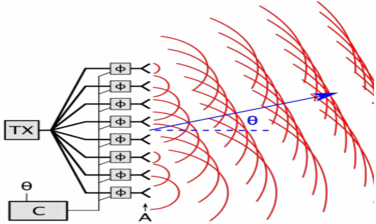
- RF toolbox:
  This provides functions, objects, and apps for designing, modeling, analyzing, and visualizing networks of radio frequency (RF) components. The toolbox supports wireless communications, radar, and signal integrity projects.
- Antenna toolbox:
  This provides functions and apps for the design, analysis, and visualization of antenna elements and arrays.
- Phased Array System toolbox:
  This Toolbox provides algorithms and apps for designing and simulating sensor array and beamforming systems in wireless communication, radar, sonar, acoustic, and medical imaging applications.
- These are used in our project for designing various RF components and to design the RADAR system.

Phased array antenna

- Computer controlled array of radiating elements that electronically steers the beam in the required direction
- Uses phase shifters and attenuators to control the phase and amplitude of individual antenna elements
- Due to the constructive interference(superposed) of all the antenna element output, the beam is pointed in a particular direction and can be changed by modifying the phase shift and the amplitude.
- The beamwidth can be controlled to point more accurately by changing the no. of antenna elements in the design.

Beamforming

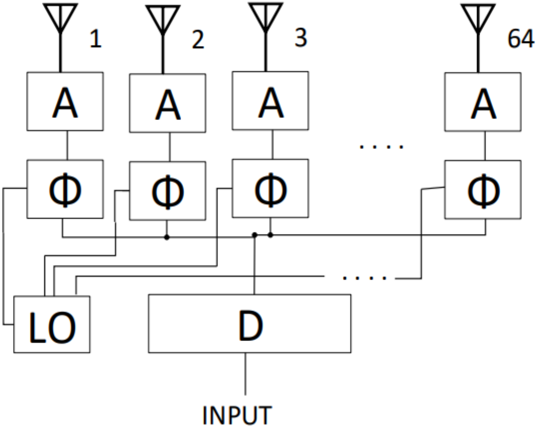
- Beamforming is used in this application to focus our transmitted signals in particular direction so that interference of signals from other directions can be avoided.
- To overcome the physical difficulty of manually moving the antenna to scan the entire region of view.
- More power is transmitted in a given direction as it is highly important.



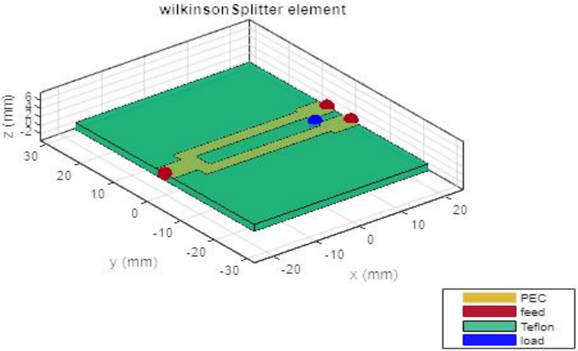
Methodology

- Design of single radiating element (dipole antenna) that can be replicated
- Design of divider circuit
- Representation of Amplitude and phase shift value for each radiating element
- Integration of all the parts as phased array antenna

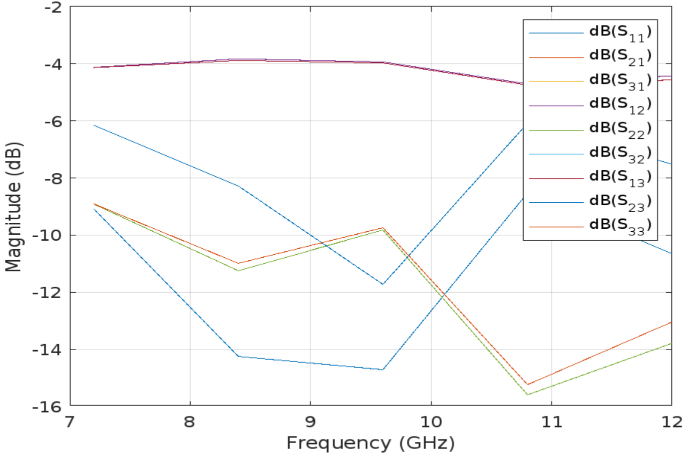
Schematic representation



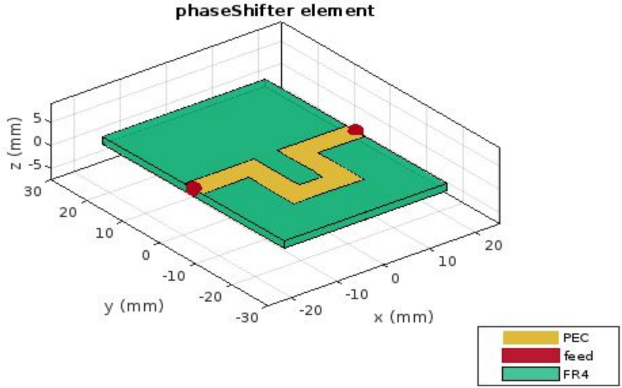
Wilkinson power divider



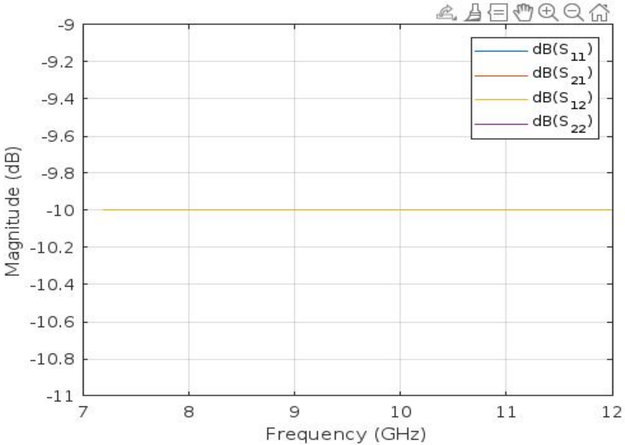
Wilkinson power divider



Phase Shifter

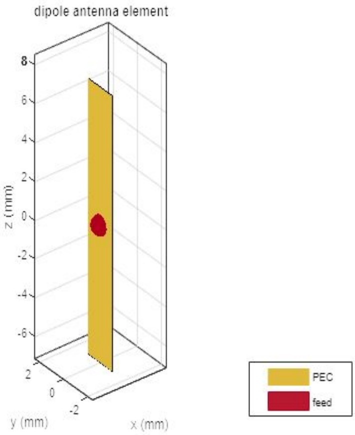


Attenuator

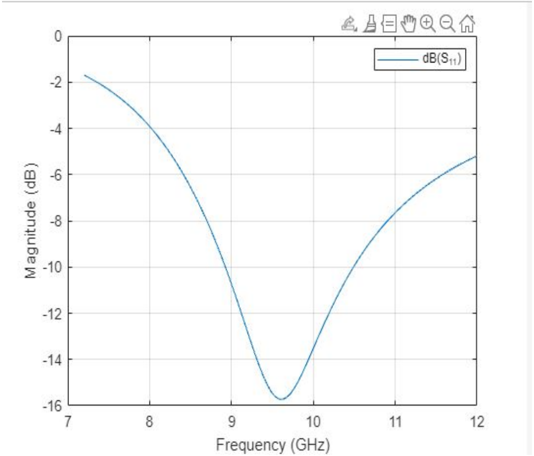


dB(S11)
dB(S21)
dB(S12)
dB(S22)
-9
-9.2
-9.4
-9.6
-9.8
-10
-10.2
-10.4
-10.6
-10.8
-11
Magnitude (dB)
7
8
9
10
11
12
Frequency (GHz)

Dipole antenna



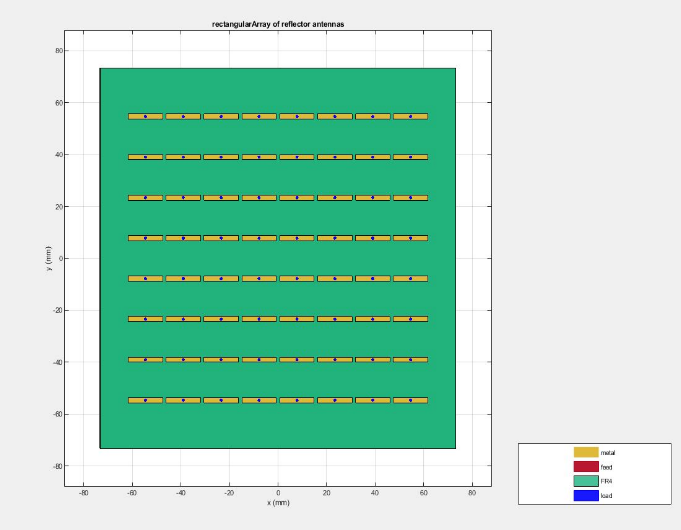
Dipole antenna



Antenna Array Designer Application

- Designed dipole array antenna using this application.
- backing as rectangular structure
- The operating frequency is set and the number of elements in the array is initalized and the design is accepted.
- The dimensions of the dipole array,reflector with exciter and the substrate are mentioned to get the design.

Dipole antenna array



Dipole antenna array

▼ rectangularArray - Geometry

Size	[8 8]
RowSpacing (m)	0.015614
ColumnSpacing (m)	0.015614
Lattice	Rectangular
AmplitudeTaper (V)	1
PhaseShift (deg)	0
Tilt (deg)	0
TiltAxis	[1 0 0]
Element	reflector

▼ reflector - Geometry

GroundPlaneLength (m)	0.018334
GroundPlaneWidth (m)	0.018334
Spacing (m)	0.0016
EnableProbeFeed	0
Tilt (deg)	0
TiltAxis	[1 0 0]

▼ reflector - Exciter - dipole

Length (m)	0.0142
Width (m)	0.002
FeedOffset (m)	0
Tilt (deg)	90
TiltAxis	Y

Dipole antenna array

▼ dipole - Load

Impedance (ohms)	50
Frequency (Hz)	9600000000
Location (m)	feed

▼ reflector - Substrate

Catalog	FR4
Name	FR4
EpsilonR	4.8
LossTangent	0.026
Thickness (m)	0.0016

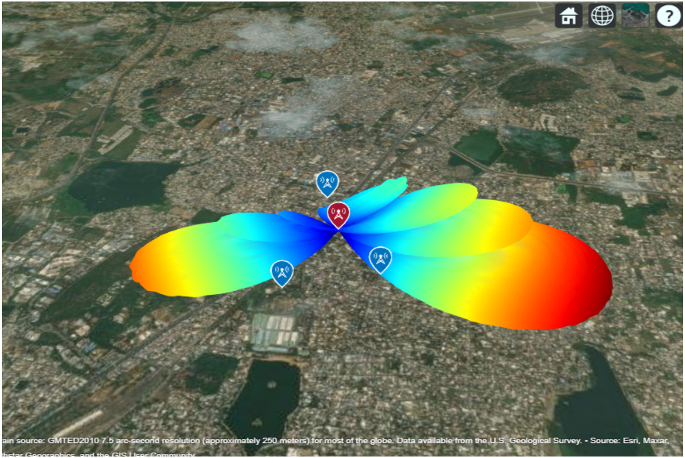
▼ reflector - Load

Impedance (ohms)	50
Frequency (Hz)	9600000000
Location (m)	feed

Apply

Beamforming realtime simulation

Beamforming realtime simulation



Parameters Evaluation

- Design Requirements
- Signal parameters
- Target Parameters
- Radar Parameters

Parameters Evaluation

Parameters	Value
Frequency of operation	8.925 GHz
Wavelength	33.61 mm
Range Resolution	50 m
Maximum Range/ Unambiguous range	10 km
Probability of Detection	0.9
Probability of False Alarm	1e-6
Transmitting Power	2.5 MW
Bandwidth	3 MHz
Sample rate	6 MHz

Parameters Evaluation

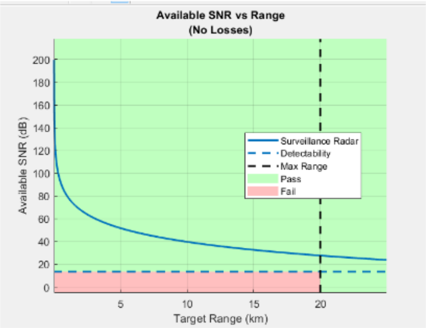
Gain	31 dB
RCS of Target	1 m^2
Target Height	1km
Target Initial Position	9 km
Radar height from ground level	10 m
Azimuth range	[-60 60]
Elevation Range	[0 30]
No of Full scans	30

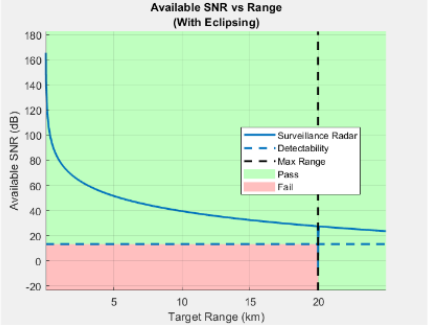
PROGRESS THROUGH KNOWLEDGE

Modeling Radar Detectability

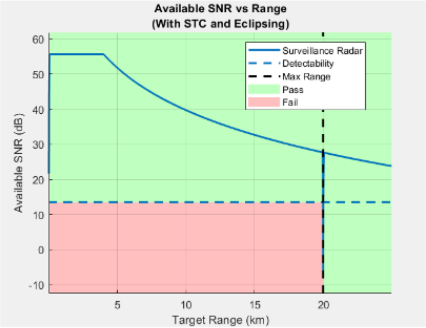
$$SNR = \frac{P_t G_t G_r \tau \lambda^2 \sigma}{(4\pi)^3 k T_s R^4 L}$$

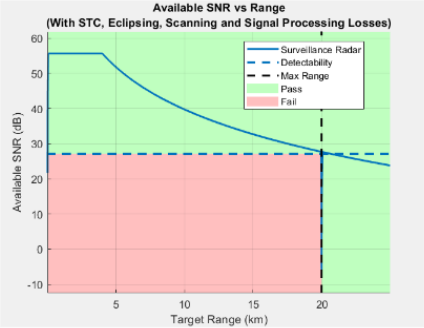
Modeling Radar Detectability





Modeling Radar Detectability

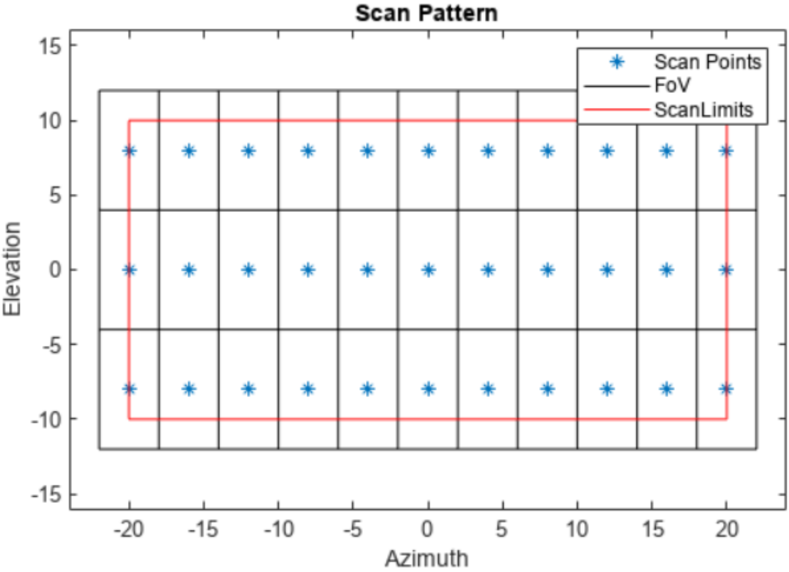




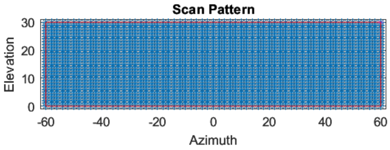
Radar Scenario and Platforms

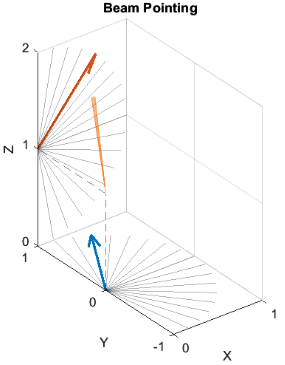
- Scanning parameters – Azimuth Scan Points; Elevation Scan points
- Evaluating Range - Angle Resolution cells
- Scenario
- Platforms – Radar, Target

Radar Scenario and Platforms

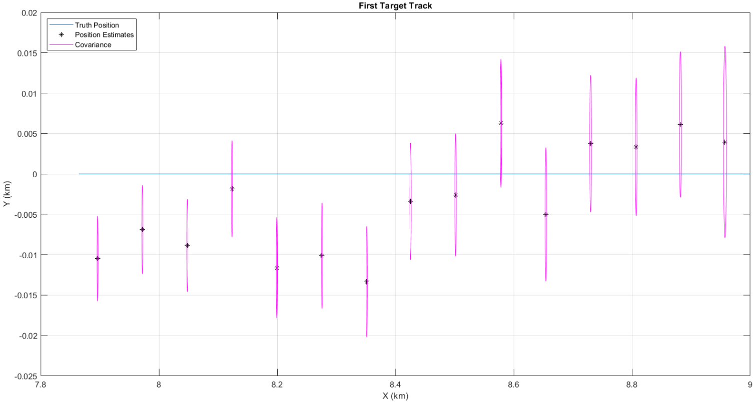


Radar Scenario and Platforms





Tracking Target



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