Assignment 2 – Antenna Arrays

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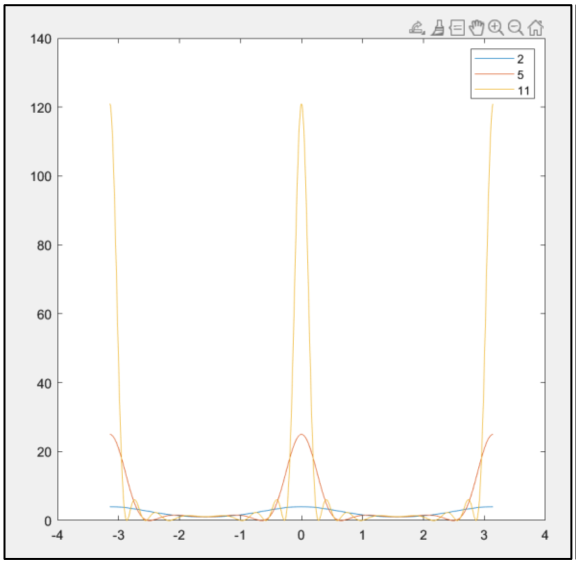
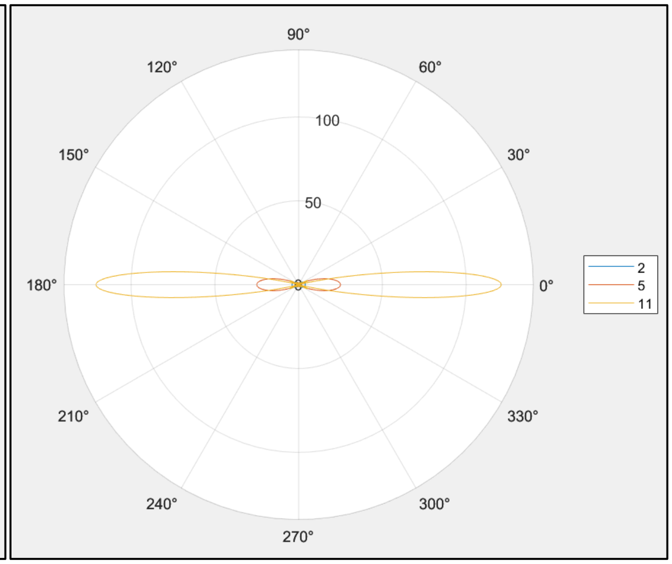
1. Cartesian and Polar Plots for Different Numbers of Antennas



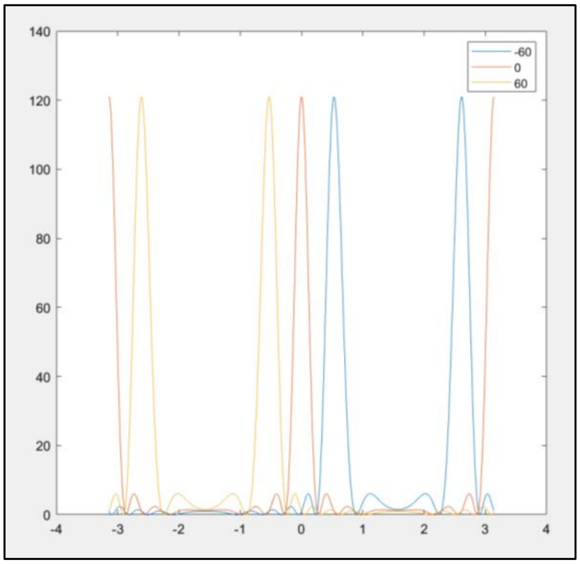


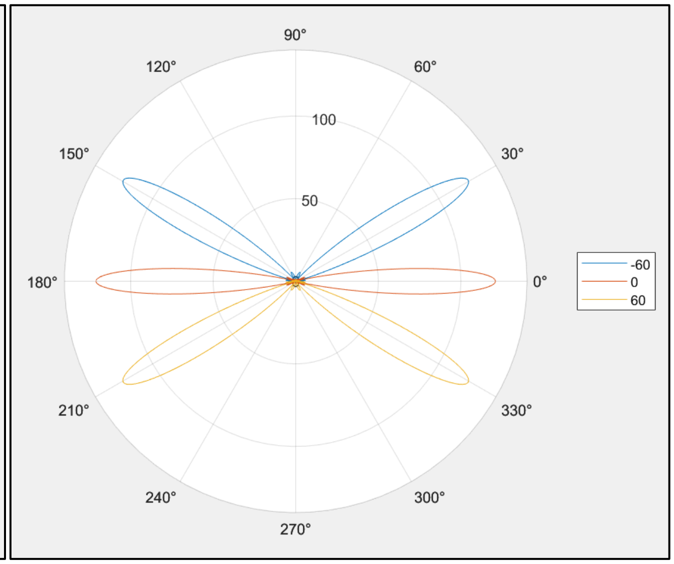
These graphs show the effects of increasing the number of antennas in an antenna array. The more antennas in the array the stronger the signal is.

```
freq_5G = 6e9; % Common 5G midband frequency 6GHz
lambda = 3e8 / freq_5G;
N0 = 8; % Student number
d = (0.25 + 0.01*N0) * lambda;

step = 0.01;
theta = -pi:step:pi;

E_N2 = phasedArrayMagSquared(theta, 0, 2, d, lambda);
E_N5 = phasedArrayMagSquared(theta, 0, 5, d, lambda);
E_N11 = phasedArrayMagSquared(theta, 0, 11, d, lambda);

plot(theta, E_N2, theta, E_N5, theta, E_N11)
legend('2', '5', '11')
figure
polarplot(theta, E_N2, theta, E_N5, theta, E_N11)
legend('2', '5', '11')
```

```
function E = phasedArrayMagSquared(THETA, PHI, N, D, LAMBDA)
    E = (abs(sin((N/2) * ((2*pi*D*sin(THETA)/LAMBDA) + PHI)) ...
        ./ sin((pi*D*sin(THETA)/LAMBDA) + (PHI/2)))).^2;
end
```

2. Cartesian and Polar Plots for Varying Delays for Antennas

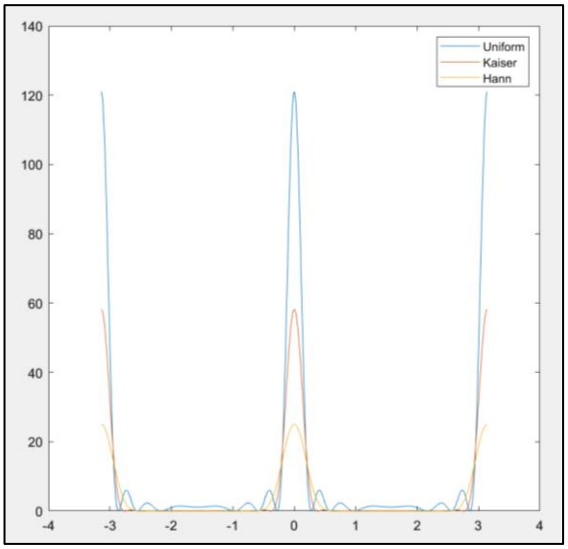


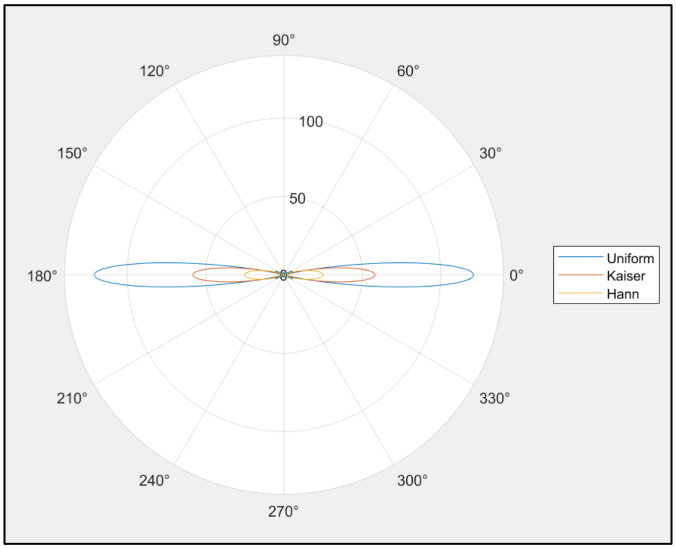


These graphs show the effects of changing the phase of the signal. This can be used to steer a signal electronically. This is a desirable effect as this removes the need for mechanical components which are more susceptible to failure after prolonged use.

```
E_PN60 = phasedArrayMagSquared(theta, deg2rad(-60), 11, d, lambda);
E_P0 = phasedArrayMagSquared(theta, deg2rad(0), 11, d, lambda);
E_P60 = phasedArrayMagSquared(theta, deg2rad(60), 11, d, lambda);

figure
plot(theta, E_PN60, theta, E_P0, theta, E_P60)
legend('-60', '0', '60')
figure
polarplot(theta, E_PN60, theta, E_P0, theta, E_P60)
legend('-60', '0', '60')
```

4. Cartesian and Polar Plots for Different Weighted Windows





The effect of adding a Kaiser window results in a reduction in the size of the side lobes. As seen in the above graphs. The Hann window provides a good balance between the main lobe width and the level of side lobe attenuation. The Hann window provides a wider main lobe than the Kaiser window. This can be applied in specific antenna applications.

```
E_U = weightedBeamForming(theta, 0, 11, d, lambda, windowFunc("uniform", 11));
E_k = weightedBeamForming(theta, 0, 11, d, lambda, windowFunc("kaiser", 11));
E_h = weightedBeamForming(theta, 0, 11, d, lambda, windowFunc("hann", 11));

figure
plot(theta, E_U, theta, E_k, theta, E_h)
legend('Uniform','Kaiser','Hann')

figure
polarplot(theta, E_U, theta, E_k, theta, E_h)
legend('Uniform','Kaiser','Hann')
```

```matlab
function window = windowFunc(type, length)
    switch type
        case "uniform"
            window = ones(length, 1);
        case "kaiser"
            window = kaiser(length, 2.5);
        case "hann"
            window = hann(length);
        otherwise
            error("Not a correct window function")
    end
end

function Ew = weightedBeamForming(THETA, PHI, N, D, LAMBDA, WIN)
    E = 0;
    for n = 0:N-1
        E = E + (WIN(n+1)*exp(2j*pi*n*D*sin(THETA)/LAMBDA + 1j*n*PHI));
    end

    Ew = (abs(E)).^2;

end
```