```
clear
```

Initialize TWPA

```
% load paramp_NbTiN_JPL_mK_short879_259_281_x0.875_taper_highf.mat
load 0714TWPaX.mat

% data =
importdata("C:\Users\klimovich\Downloads\E08_06_750Cells_CAngDeg.csv");

twpa = createTWPA;

% twpa.fsim = data(:,1).*1e9;
% twpa.ksim = -data(:,2)/360*2*pi/twpaLEN;

% data = importdata("C:\Users\klimovich\Downloads\E08_06_750Cells_S21.csv");

% twpa.gsim = -data(:,3)/twpaLEN;
% twpa.gsim = twpa.gsim - twpa.gsim;


twpa.fsim = f;
twpa.ksim = kperm;
twpa.gsim = -log(abs(transpose(S21)));

% Sanitize NaNs
twpa.ksim(isnan(twpa.ksim)) = max(twpa.ksim);
twpa.gsim(isnan(twpa.gsim)) = -100;

% twpa.pumpF = 6.3e9;
% twpa.pumpF2 = 0e9;
twpa.Istar = 4.5*1000;
twpa.Ip = twpa.Istar*0.08;
twpa.Idc = twpa.Istar*0.0;

twpa.len = 110e-6*879*1;
twpa.betanl = 1;     %Josesphon Junction = 0.5
```

Pick Modes

```
maxHarmonic = 9;

twpa.modes = [1 0];
for i=3:2:maxHarmonic
    twpa.modes = cat(1, twpa.modes, [i 0]);
end

disp(twpa.modes)

% Alternative for dual-pump: with each mode being a row of
% [(# of pump1 photons) (# of signal photons) (# of pump 2 photons)]
```

```
% so the example below is "p1, s, p2, 2p1 - s, 2p2 - s
% twpa.modes = [1 0 0; 0 1 0; 0 0 1; 2 -1 0; 0 -1 2];

twpa.I0 = zeros(length(twpa.modes),1);
twpa.I0(1) = twpa.Ip;
% twpa.I0(2) = twpa.Ip.*1e-3;
```

```
     1     0
     3     0
     5     0
     7     0
     9     0
```

Compute Gain

```
% Frequencies over which to calculate gain
fcalc = 0.1e9:0.1e9:5.1e9;

% Positions to sample
zcalc = 0:0.0001:twpa.len;

g = zeros(length(fcalc), length(zcalc), length(twpa.modes));
Iend = zeros(length(fcalc), length(zcalc), length(twpa.modes));

for ii = 1:length(fcalc)
    wn = twpa.modes(:,1)*fcalc(ii);
    twpa.pumpF = fcalc(ii);
%    If using dual pump instead use:
%    wn = twpa.modes(:,1)*twpa.pumpF + twpa.modes(:,2)*fcalc(ii) +
twpa.modes(:,3)*twpa.pumpF2;
    S21 = exp((-twpa.g(wn.') + 1i.*twpa.k(wn.')).*twpa.len);

    Y = solveCME(fcalc(ii),zcalc,twpa);

    g(ii,:,:) = 20*log10(abs(Y(:,:).*S21./twpa.I0(1)));
    disp(ii/length(fcalc))
end
```

```
    0.0196

    0.0392

    0.0588

    0.0784

    0.0980

    0.1176

    0.1373

    0.1569
```

0.1765

0.1961

0.2157

0.2353

0.2549

0.2745

0.2941

0.3137

0.3333

0.3529

0.3725

0.3922

0.4118

0.4314

0.4510

0.4706

0.4902

0.5098

0.5294

0.5490

0.5686

0.5882

0.6078

0.6275

0.6471

0.6667

0.6863

```
    0.7059

    0.7255

    0.7451

    0.7647

    0.7843

    0.8039

    0.8235

    0.8431

    0.8627

    0.8824

    0.9020

    0.9216

    0.9412

    0.9608

    0.9804

     1
```

Plot Results

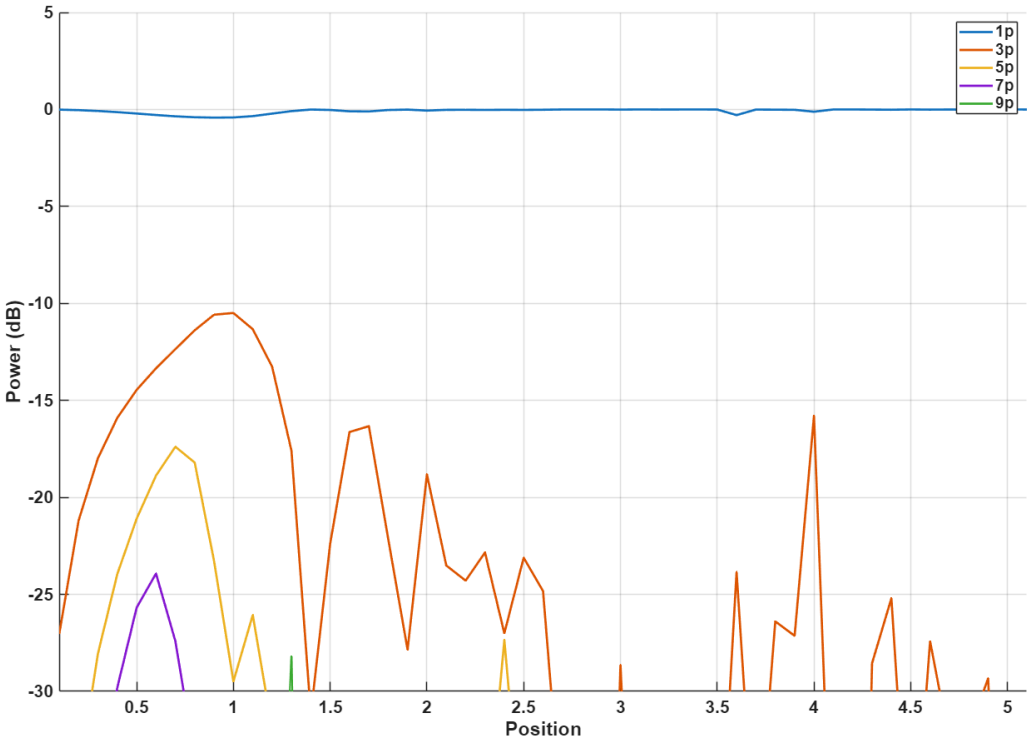
close all

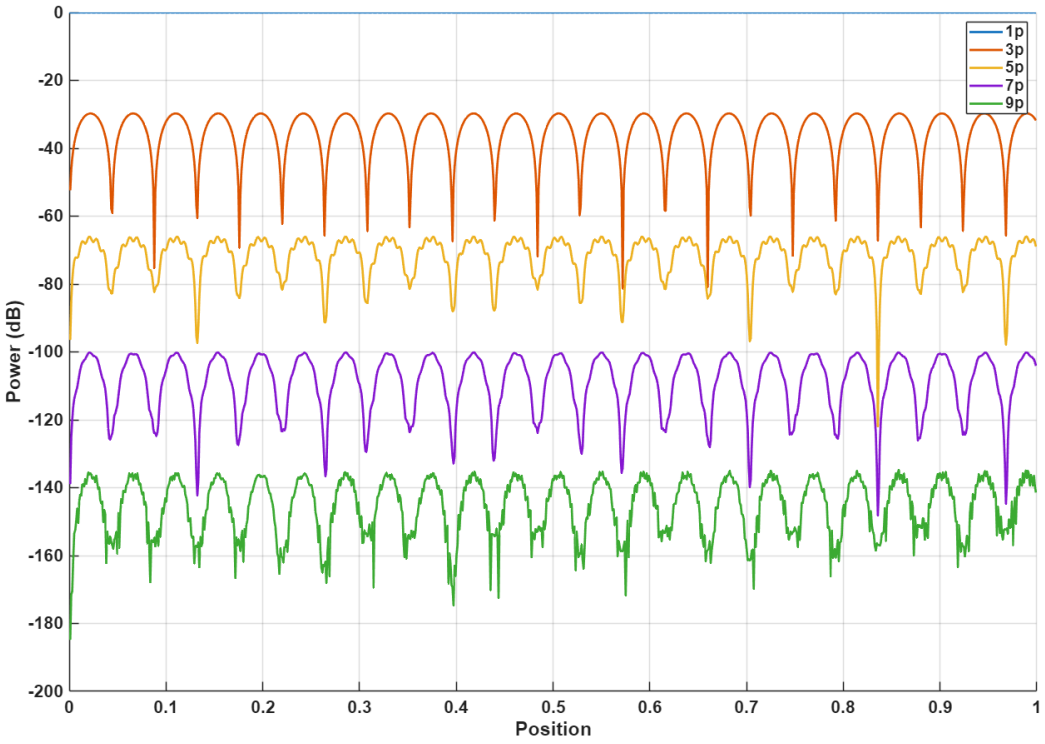
```
figure(1)
hold all
plotLegend = {};
for i=1:ceil(maxHarmonic/2)
    plot(fcalc./1e9,smooth(g(:,end,i),1),'Linewidth',2)
    plotLegend = [plotLegend, {[num2str(1 + 2*(i-1)),'p']}];
end
legend(plotLegend)
grid on
xlim([fcalc(1) fcalc(end)]./1e9)
ylim([-30 5])
xlabel('Position')
ylabel('Power (dB)')
set(gca,'FontSize',16)
set(gca,'FontWeight','bold')
```

```
set(gcf,'Position',[1500 100 1500 1000])
drawnow

index = length(fcalc);

figure(2)
cmap = colormap('turbo');
hold all
for i=1:ceil(maxHarmonic/2)
    plot(zcalc./twpa.len,smooth(g(index,:,i),1),'Linewidth',2)
end
legend(plotLegend)
% plot(smooth(g(1,:,8),1),'Linewidth',2)
% plot(smooth(g(1,:,9),1),'Linewidth',2)
grid on
% xlim([fcalc(1) fcalc(end)]./1e9)
% ylim([-20 0])
xlabel('Position')
ylabel('Power (dB)')
set(gca,'FontSize',16)
set(gca,'FontWeight','bold')
set(gcf,'Position',[1500 100 1500 1000])
drawnow
```





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