ELL-702: NON-LINEAR SYSTEMS

ASSIGNMENT – 3

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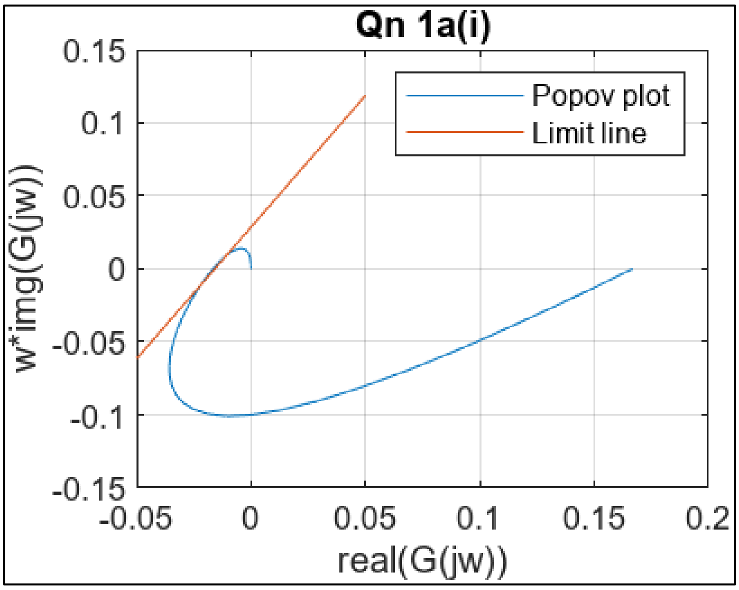
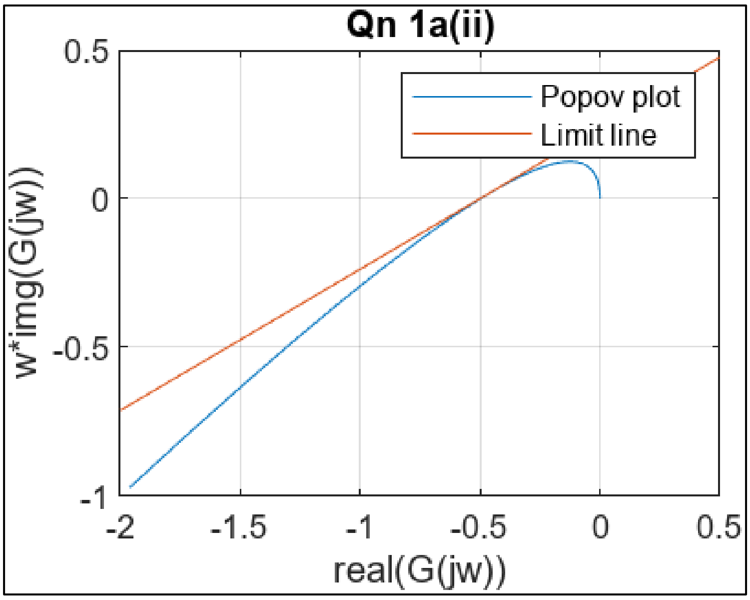
```
% Qn 1

%Defining transfer function
num = [1];
den = [1,6,11,6];

lim = 1000;
d = 0.1;
len = (2*lim/d)+1;
wr = linspace(-lim,lim,len);
Grl = zeros(size(wr)); % Real part of G(jw)
Gimag = zeros(size(wr)); % Imag part of G(jw)
Gimag_popov = zeros(size(wr)); % w*Imag(G(jw))
iter = 1;
w_zero_x = 0;
w_iter = 0;


img = 1i;

if size(num,2)>= size(den,2)
    disp("G(s) is not strictly proper!!");

else
    Gs = tf(num,den);
    for w = -lim:d:lim
        Grl(iter) = real(evalfr(Gs,w*img));
        Gimag(iter) = imag(evalfr(Gs,w*img));
        % To identify the point of x-intercept
        if iter>1
        if Gimag(iter)*Gimag(iter-1)<=0
            w_zero_x = Grl(iter);
            w_iter = iter;
        end
        end
        iter = iter+1;
    end
    Gimag_popov = wr.*Gimag;
```

```
    k = -(1/w_zero_x);  % Sector limit(Based on intercept of curve)
    %Slope of limit line
    slope = ((Gimag(w_iter)*wr(w_iter))-(Gimag(w_iter-1)*wr(w_iter-1)))/(Grl(w_iter)-Grl(w_iter-1));
    x_line = -0.05:0.01:0.05;
    y_line = slope*(x_line-(-1/k));
    plot(Grl,Gimag_popov,x_line,y_line);
    xlabel("real(G(jw))");
    ylabel("w*img(G(jw))");
    legend('Popov plot','Limit line')

end
```



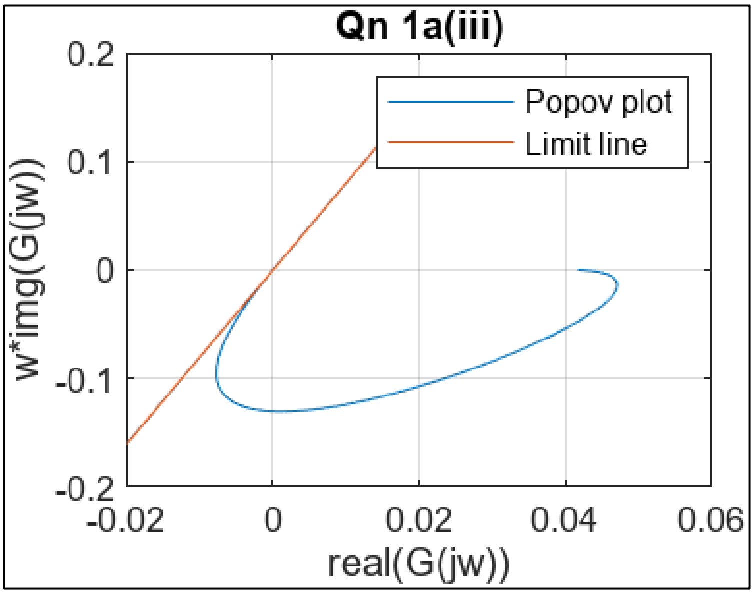
We get:

- **K = 63.4172**
- **Slope = 1.8020**



We get:

- **K = 1.9921**
- **Slope = 0.4751**



We get:

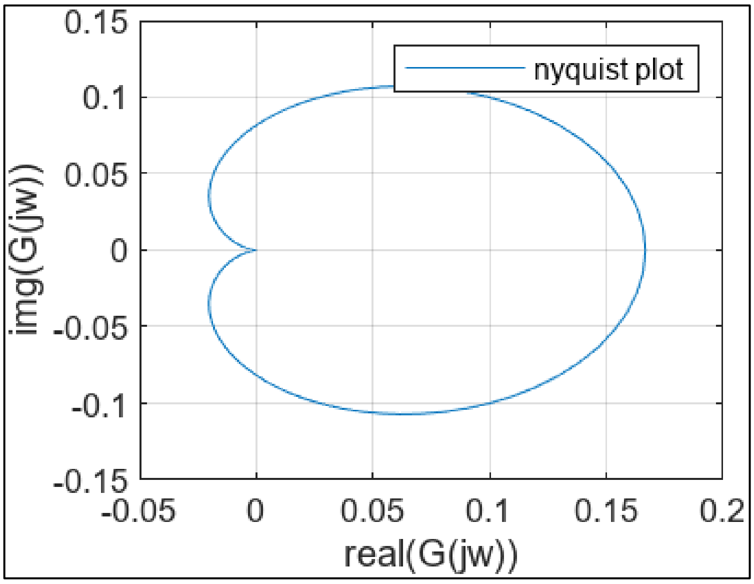
- **K = 10^6 ≈ +(infinity)**
- **Slope = 0.4751**

  The Slope and intercept of the limit line was taken based on the Popov plot's intersection with x-axis. Then the sector limit was calculated using $(-1/x_{intercept})$.

Qn 2)

Considering the transfer function from 1a(i):

We get the Nyquist plot of the system as



Since the system is Hurwitz(all the poles of G(s) lies in the LH plane), We can consider the limit of non-linearity as (α,β) where α<0 and β>0.

Then according to circular criterion, the Nyquist plot must lie in the interior of Disc(α,β).

If we consider the center of our disc to be the origin, then we will have our limits to be

$(-\gamma_2,\gamma_2)$. And if we take γ_1 to be max(real(G(jw)), we can find γ_2 using $(\gamma_1 \gamma_2)<1$.

From Nyquist plot we get γ_1 as 0.16667, thus we get γ_2 to be 5.99

Thus the limits for non-linearity for exponential stability will be (-5.99,5.99).