Nichols Diagrams

also reffered as nichols charts

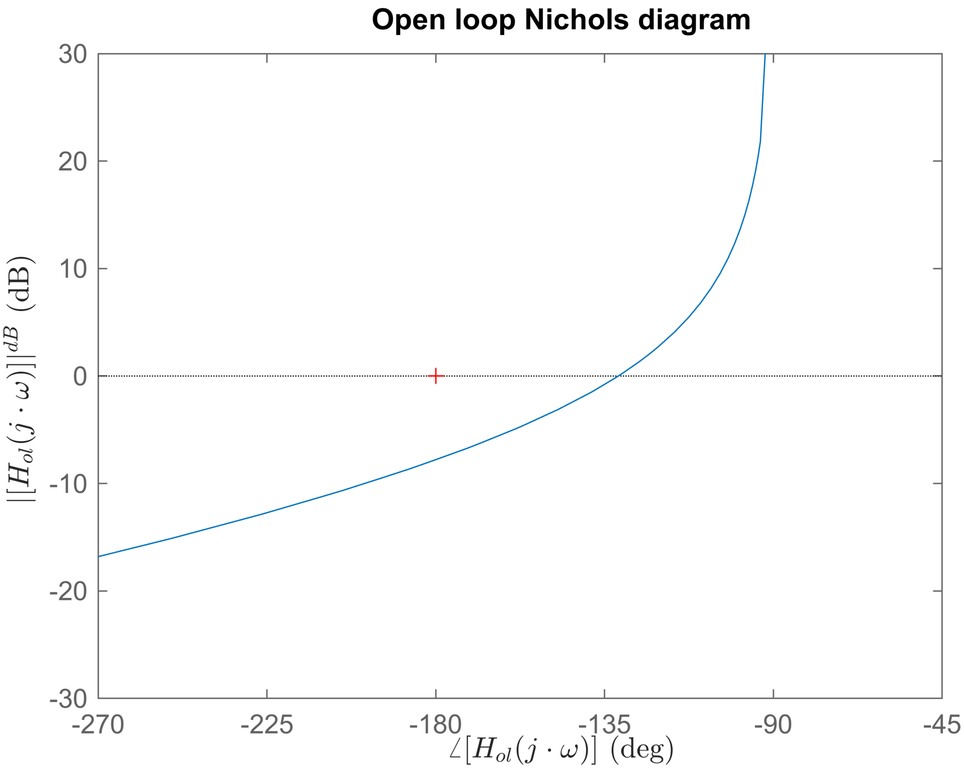
```
k = 0.05; %proportional controller (gain)
tm = 0.015; %delay time
H = tf(9e4,[1 135 0],'IODelay',tm) %process transfer function
```

```
H =

                    90000
  exp(-0.015*s) * -----------
                  s^2 + 135 s

Continuous-time transfer function.
Model Properties
```

Plot the nichols diagram

- recognize what is represented on nichols

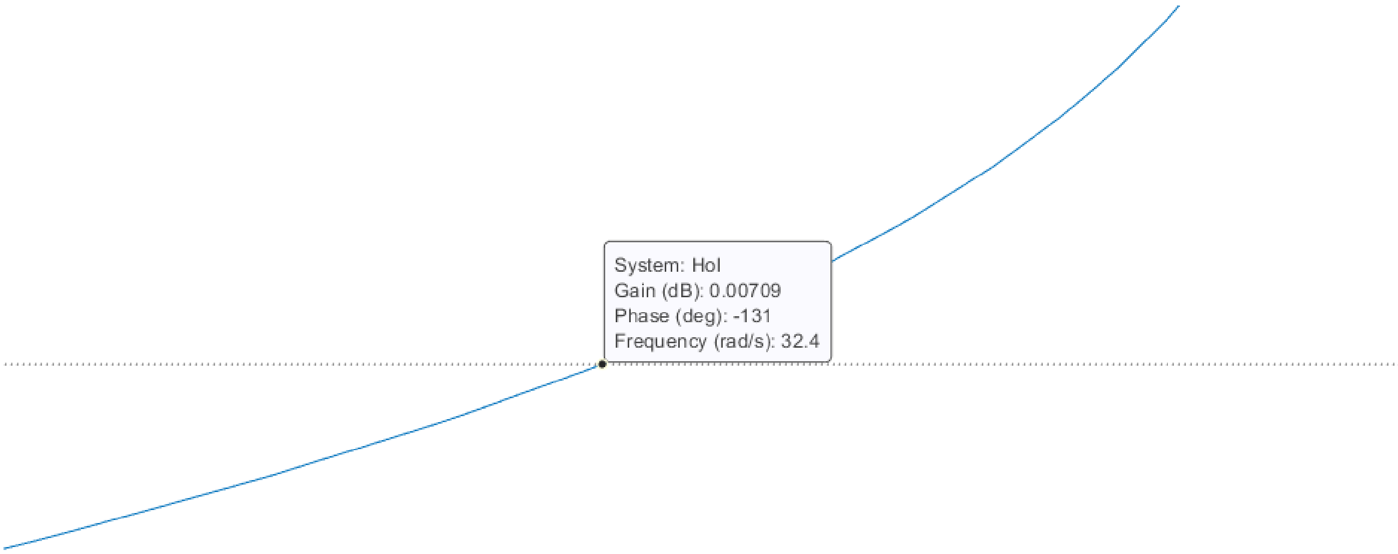
```
Hol = k*H; %open loop transfer function
nichols(Hol);
title('Open loop Nichols diagram');
xlabel('$\angle [H_{ol}(j\cdot \omega)]$', 'interpreter','latex');
ylabel('$ |[H_{ol}(j\cdot \omega)]|^{dB}$', 'interpreter','latex'); shg
% zoom the diagram in order to center the "critical point from Nyquist (-1, 0j)"
% point (-180 degrees 0dB)
axis ([-270,-45 -30 30]); shg
```



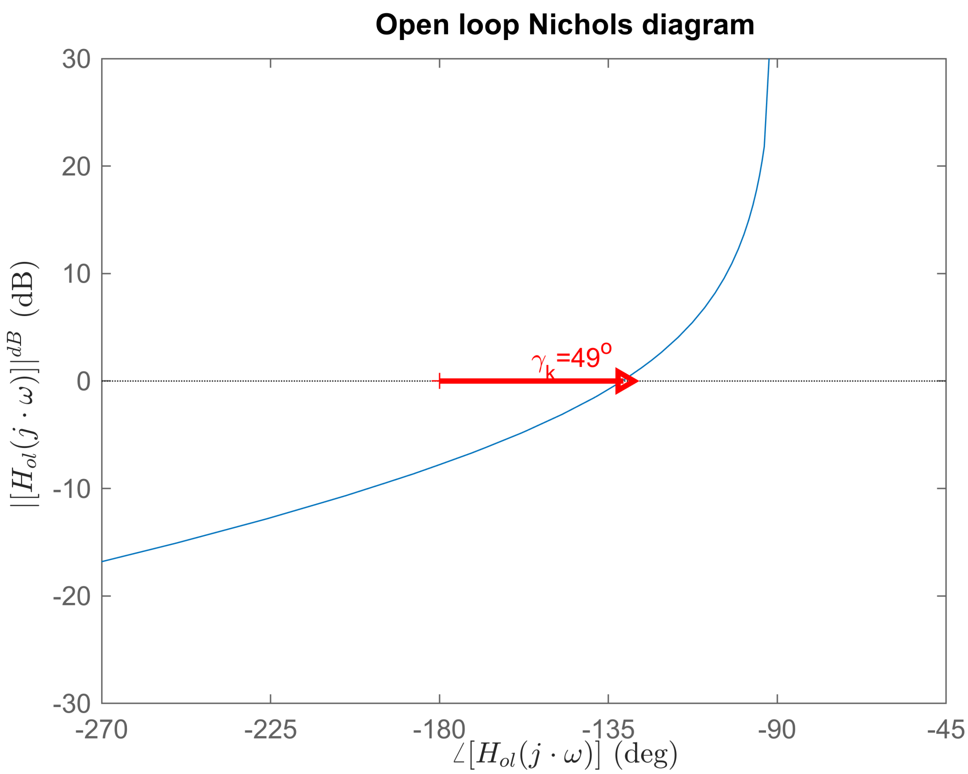
Stability analysis of closed loop

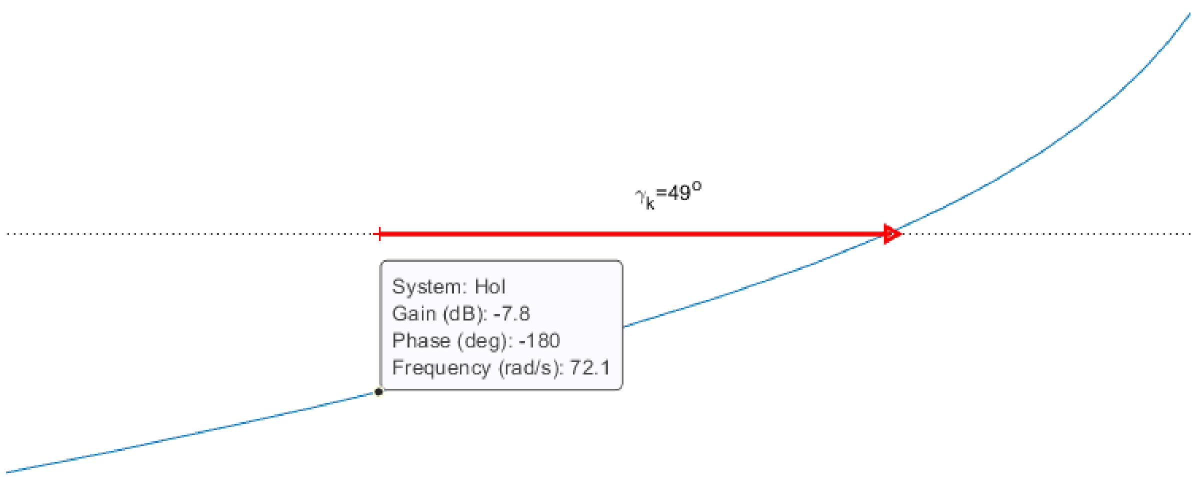
```
% draw the gain and phase margin (Symplified Nyquist criterion)
% for the phase margin, the cuttof frequency and the phase at the cutoff
% frequency is needed
```

$\gamma_k = \pi + \angle|H_{\text{ol}}(j\omega_c)|$




```
wc = 32.4; %the cutoff frequency
pwc = -131; %the open loop argument evaluated for the cutoff frequency
hold on;
plot([-180 pwc],[0 0],'r-','LineWidth',2);
plot(pwc,0,'r>','LineWidth',2);
%place a text above the arrow indicating the phase margin with the
%resulting value for the phase margin
pm = 180 + pwc; %the phase margin
text(-180+pm/2,2,['\gamma_k=',num2str(round(pm)),'^o'],'Color','r')
```



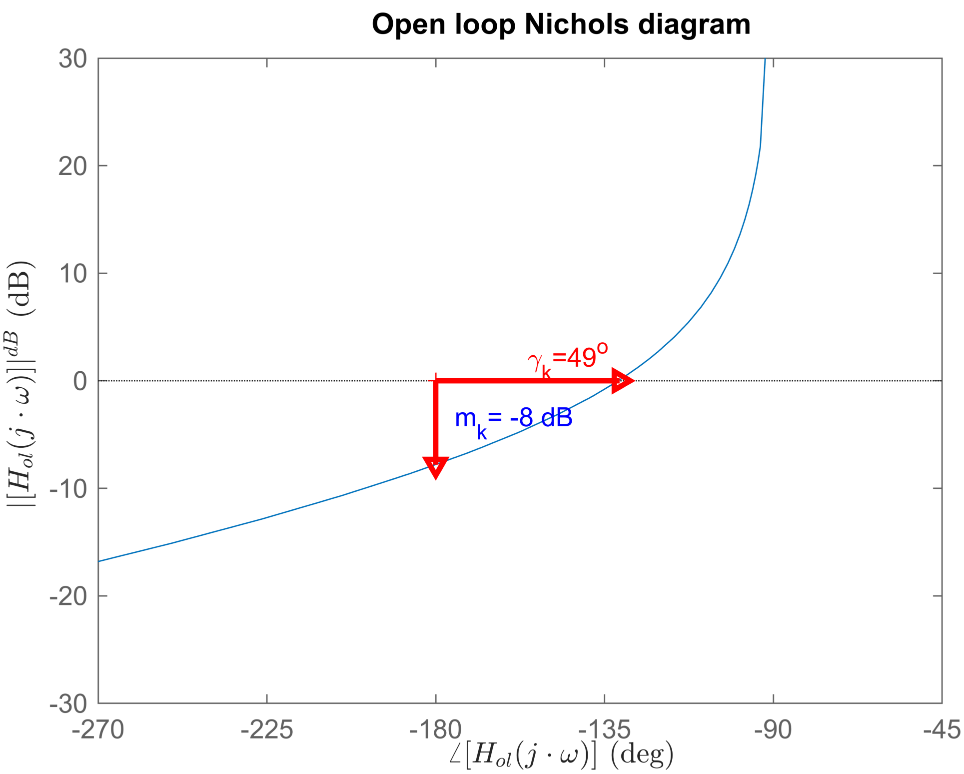



```
wpi = 72.4; mwpi = -7.8;
plot([-180 -180],[0 mwpi],'r-','LineWidth',2);
plot(-180, mwpi, 'rv','LineWidth',2);
text(-175, mwpi/2,['m_k= ',num2str(round(mwpi)),' dB'],'Color','b');
```

And stability conclusions :

$m_k^{\mathrm{dB}} < 0$ and $\gamma_k > 0$ are both true, so the closed loop system results asymptotically stable

```
hold off;
```

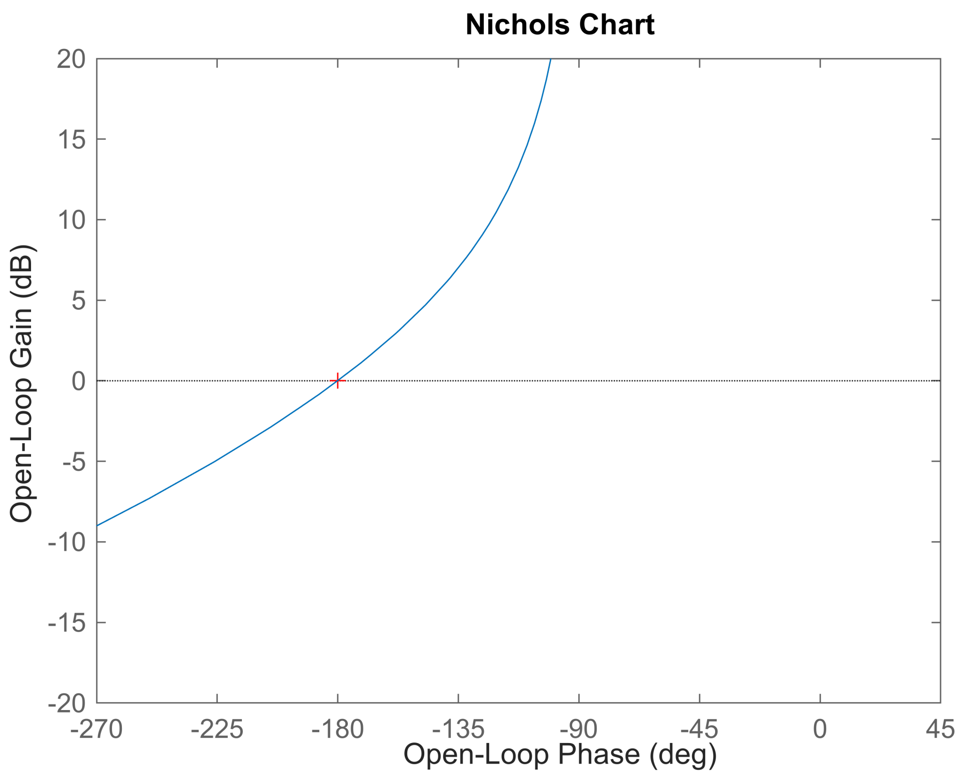


Stability analysis depending on k, k$\epsilon(0, \infty)$

```
kc = 10^(-mwpi/20) % kc =db2mag(mwpi), k = 0.05
```

```
kc = 2.4547
```

```
%closed loop stable for k in(0,0.05*2.466)
% the max value of k
k = 0.05*2.4547;
nichols(k*H)
axis([-270 45 -20 20])
```



Stability analysis depending on time delay (τ_m)

$\gamma_k > 0$

$\pi + \angle(\mathrm{Hol}) = \pi - \frac{\pi}{2} + \mathrm{atan}\left(\frac{\omega}{135}\right) - (0.015 + \mathrm{delay\ margin})\omega > 0$

$\frac{\pi}{2} - \tau_m\omega > \mathrm{atan}\left(\frac{\omega}{135}\right)$

$\frac{\pi}{2} - \mathrm{atan}\left(\frac{\omega}{135}\right) > \tau_m\omega$

$\tau_m < \frac{\left[\frac{\pi}{2} - \mathrm{atan}\left(\frac{\omega}{135}\right)\right]}{\omega_c}$

```
taum = (pi/2-atan(wc/135))/wc
```

```
taum = 0.0412
```

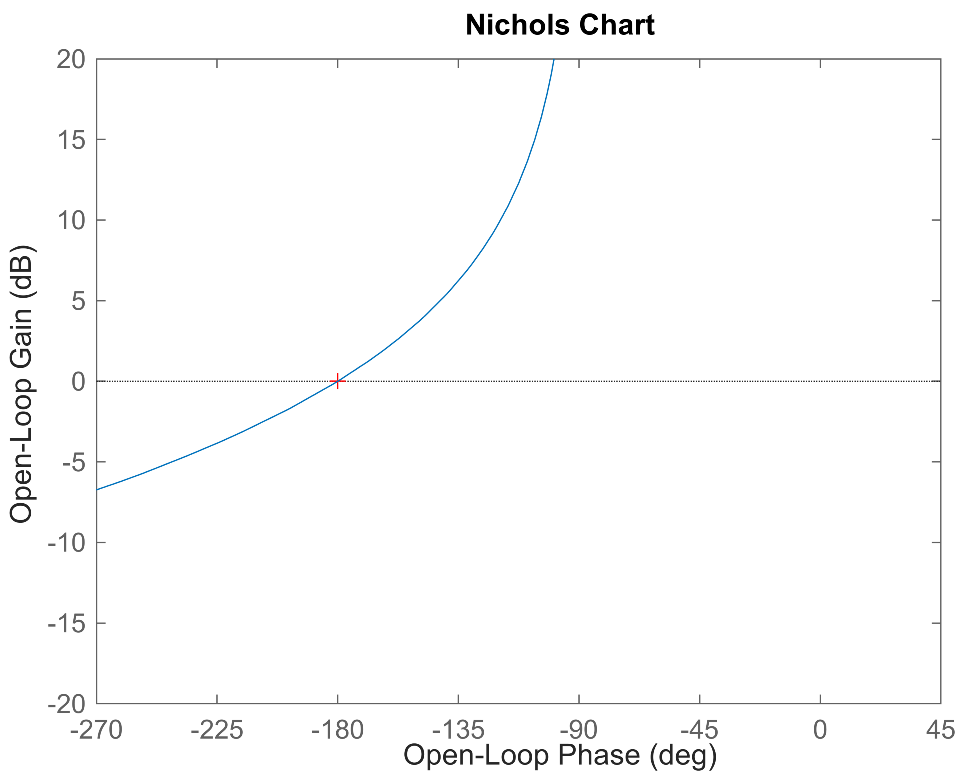
```
%delay margin
dm = taum - tm
```

```
dm = 0.0150
```

```
k = 0.05; %proportional controller (gain)
tm = 0.0412; %delay time
H = tf(9e4,[1 135 0],'IODelay',tm) %process transfer function
```

```
H =

                       90000
  exp(-0.0412*s) * -----------
                   s^2 + 135 s

Continuous-time transfer function.
Model Properties
```

```
nichols(k*H);
axis([-270 45 -20 20])
```



$\tau_m \epsilon (0, 0.0412)$ for stable closed loop