Contents

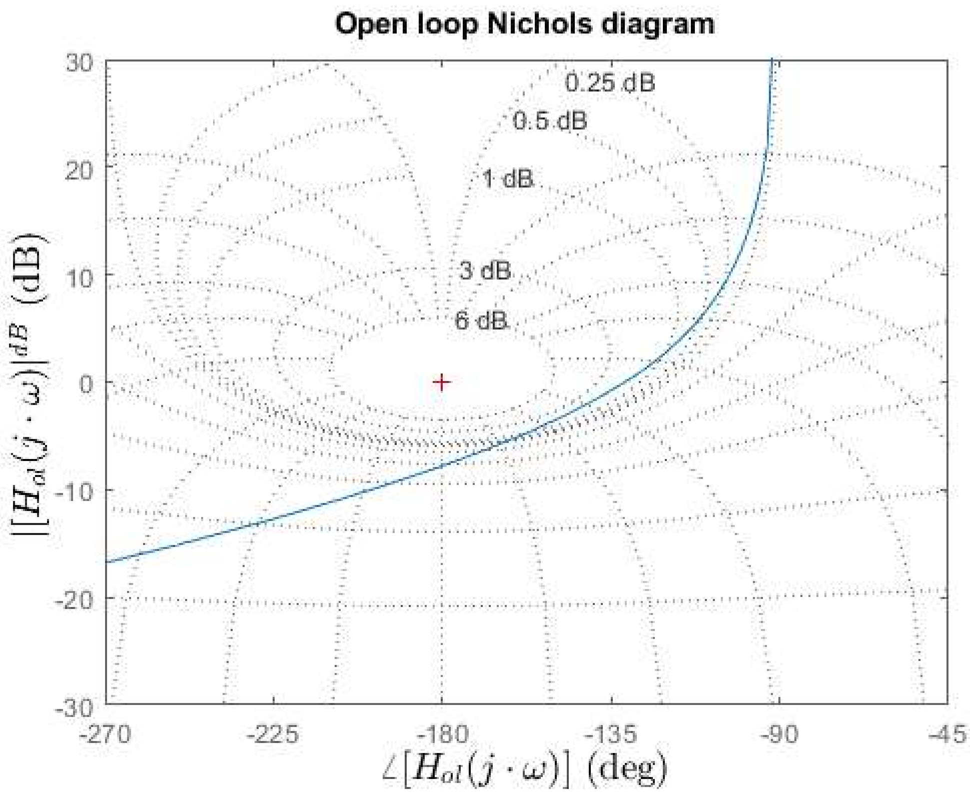
Nichols diagrams

```
close; clc; clear;

% defining the system
k = 0.05;        %proportional controoller
tm = 0.015;     %time delay
H = tf(9e4, [1 135 0], 'iodelay', tm);
display(H);

Hol = k*H;
display(Hol);
```

```
H =

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

Continuous-time transfer function.


Hol =

                     4500
  exp(-0.015*s) * -----------
                  s^2 + 135 s

Continuous-time transfer function.
```

Ploting the nichols chart

```
figure;
nichols(Hol)
title('Open loop Nichols diagram');
xlabel("$\angle [H_{ol}(j\cdot\omega)]$", 'interpreter', 'latex','FontSize',14);
ylabel("$ |[H_{ol}(j\cdot\omega)|^{dB}$", 'interpreter', 'latex','FontSize',14);
shg; grid;

% Centering the critical point (-1, 0j) from Nyquist (-180, 0dB)
axis([-270 -45 -30 30]);
```

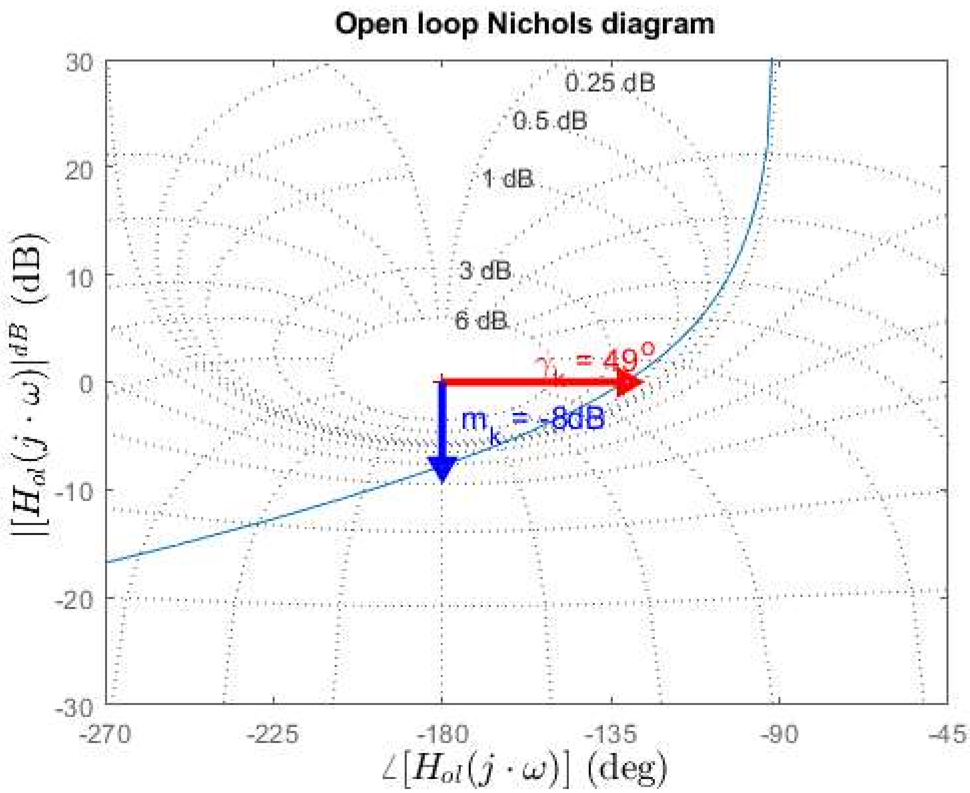


Drawing the gaion and phase margins

1. Phase margin we need: -cutoff frequency -phase at cutoff freq.

```
% reading from the graph
wc = 32.4;
phase_wc = -131;

% adding it to the graph
hold on
plot([-180, phase_wc], [0 0], 'r-', 'LineWidth', 3);
plot(phase_wc, 0, 'r>', 'LineWidth', 3);

pm = 180 + phase_wc; %the phase margins
text(-180+pm/2,2, ['\gamma_k = ' num2str(round(pm)), '^o'], 'Color', 'r','FontSize',12);
hold off;

% 2. Magnitude margin
%         we need:
%             -frequency in pi
%             -gain in pi

% reading from the graph
wpi  = 72;
mwpi = -7.78;

% adding it to the graph
hold on
plot([-180 -180],[0 mwpi], 'b-',LineWidth=3 );
plot(-180,mwpi,'bv',LineWidth=3);
```

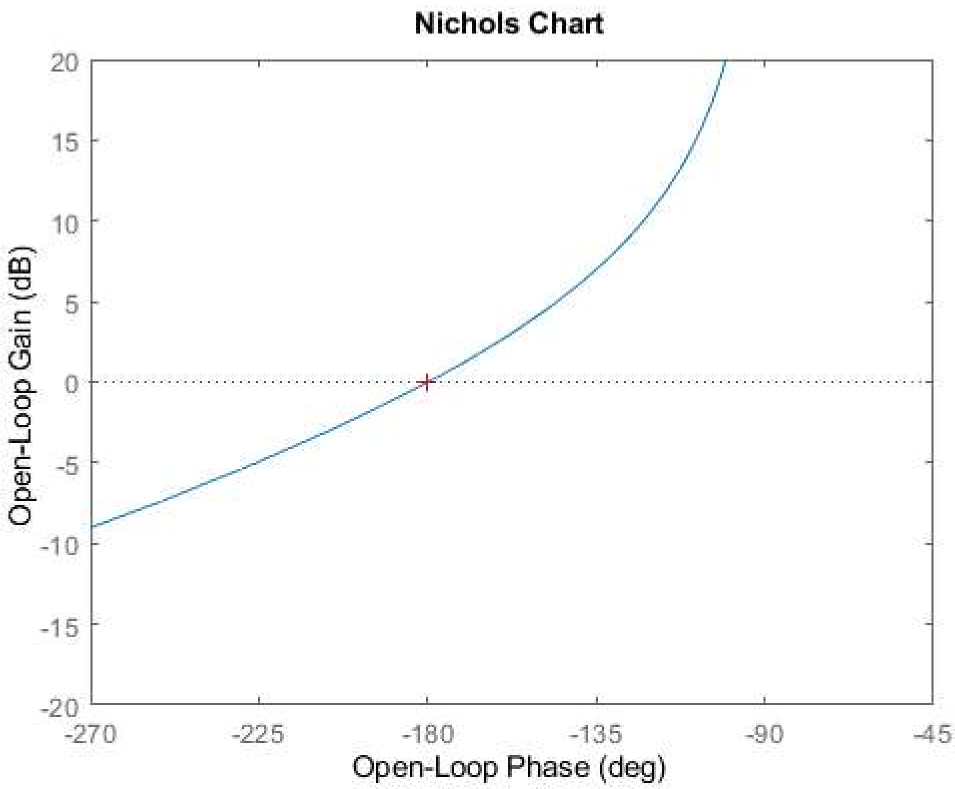
```
text(-175,mwpi/2,['m_k = ' num2str(round(mwpi)) 'dB'], 'color', 'blue','FontSize',12);
hold off
```



Stability anlaysis depending on k , k from (0,inf)

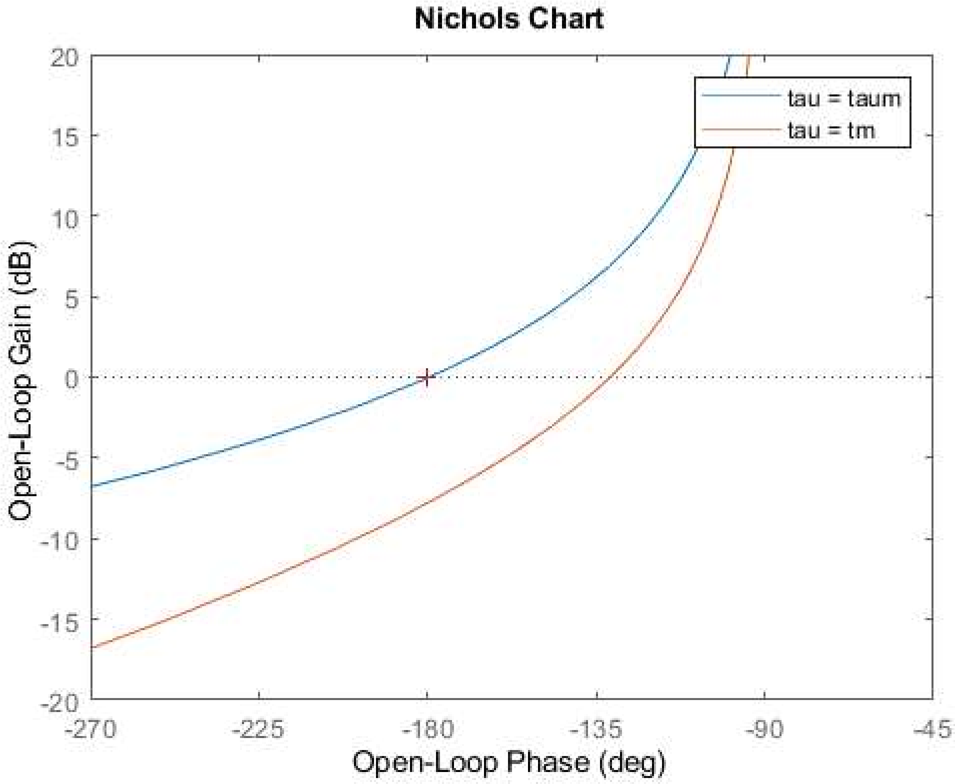
```
kc = 1/10^(mwpi/20);
display(kc)

%-> the system is closed loop stable for k in (k*kc) = (0.05*2.4491)
% the max value of k:
k_max = k*kc;
display(k_max);

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

```
kc =

    2.4491


k_max =

    0.1225
```



Stability analysis depending on time delay

```
taum = (pi/2-atan(wc/131))/wc;

%delay margin
dm = taum-tm;
tm_max = taum;
H = tf(9e4, [1 135 0], 'iodelay', tm_max);
nichols(k*H);
axis([-270 -45 -20 20])
hold on
H = tf(9e4, [1 135 0], 'iodelay', tm);
nichols(k*H);
hold off
legend("tau = taum", "tau = tm");
```



Published with MATLAB® R2022b