d & q axis controller design :

Open Loop : $i_{sd}^* \longrightarrow \boxed{G_c(s)} \longrightarrow \boxed{\dfrac{1}{R_s + s\sigma L_s}} \longrightarrow i_{sd}$

Open Loop T.F., $G(s) = G_c(s) \cdot \dfrac{1}{R_s + s\sigma L_s} = \cancel{G_c(s)}$.

Final open loop T.f. we want is of form $G(s) = \dfrac{1}{1+s\tau}$

$$\Rightarrow \frac{1}{1+s\tau} = G_c(s) \cdot \frac{1}{R_s + s\sigma L_s}$$

$$\Rightarrow \boxed{G_c(s) = \frac{R_s + s\sigma L_s}{1+s\tau}}$$

Scanned with CamScanner

s-domain to z-domain:-

$$G_c(s) = \frac{R_s + s\sigma L_s}{1+s\tau}$$ T_s = sampling period

$\Rightarrow$ pole of $G_c(s)$ at $s = -1/\tau$ $\Rightarrow$ pole of $Z\{G_c(s)\} = G_c(z)$ at $z = e^{-T_s/\tau}$

$\Rightarrow$ zero of $G_c(s)$ at $s = -\frac{R_s}{\sigma L_s}$ $\Rightarrow$ zero of $G_c(z)$ at $z = e^{-\frac{R_s}{\sigma L_s} T_s}$

$$\Rightarrow \boxed{G_c(z) = \frac{K\cdot\left(z - e^{-\frac{R_s}{\sigma L_s}T_s}\right)}{z - e^{-T_s/\tau}}}$$

To find K $\Rightarrow$ $G_c(z)\big|_{z=1} = G_c(s)\big|_{s=0}$

$$\Rightarrow \frac{K\left(1 - e^{-\frac{R_s}{\sigma L_s}T_s}\right)}{1 - e^{-T_s/\tau}} = \frac{R_s + 0\cdot\sigma L_s}{1+0\tau} = R_s$$

$$\Rightarrow \boxed{K = \frac{R_s\left(1 - e^{-T_s/\tau}\right)}{\left(1 - e^{-\frac{R_s}{\sigma L_s}T_s}\right)}}$$

$$\Rightarrow \boxed{G_c(z) = R_s \cdot \frac{\left(z - e^{-\frac{R_s}{\sigma L_s}T_s}\right)}{\left(1 - e^{-\frac{R_s}{\sigma L_s}T_s}\right)} \cdot \frac{\left(1 - e^{-T_s/\tau}\right)}{\left(z - e^{-T_s/\tau}\right)}}$$

$$\Rightarrow G_c(z) = \frac{Y_c(z)}{X_c(z)} = \frac{K\left(z - e^{-\frac{R_s}{\sigma L_s}T_s}\right)}{z - e^{-\frac{T_s}{\tau}}}$$

$$\Rightarrow zY_c(z) - \left(e^{-\frac{T_s}{\tau}}\right)Y_c(z) = K\cdot\left(zX(z) - \left(e^{-\frac{R_s}{\sigma L_s}T_s}\right)X(z)\right)$$

$\Rightarrow$ Taking z common from both sides & cancelling

$$Y_c(z) - z^{-1}\left(e^{-\frac{T_s}{\tau}}\right)Y_c(z) = K X(z) - z^{-1}K\left(e^{-\frac{R_s}{\sigma L_s}T_s}\right)X(z)$$

Taking inverse Z-transform,

$$y_c(n) - \underbrace{e^{-\frac{T_s}{\tau}}}_{K_1}\cdot y_c(n-1) = K\, x_c(n) - K\overbrace{\left(e^{-\frac{R_s}{\sigma L_s}T_s}\right)}^{K_2} x_c(n-1)$$

$$\Rightarrow \boxed{y_c(n) = K_1\cdot y_c(n-1) + K x_c(n) - K K_2\, x_c(n-1)}$$

New Training Set

1	2	3	4	5	6	7	8	9
i_{sd}^*	i_{sq}^*	i_{sd}	i_{sq}	$y_{cd}(n-1)$	$y_{cq}(n-1)$	ω_m	phi	$d\phi/dt$

$\underbrace{\qquad\qquad}_{i/p}$ $\rightarrow +$

10	11
$e_d past$	$e_q past$

without decoupling		with decoupling	
V_{sd}'	V_{sq}'		
$y_{cd}(n)$	$y_{cq}(n)$	V_{sd}	V_{sq}
12	13	14	15

$\underbrace{\qquad\qquad}_{o/p}$