RST Coefficients for LHC Power Converters with Control Delay

Regulator		System	
sampling period	T	inductance	L
single mode	ω_1	series resistance	R_s
paired mode	ω_2, ζ_2	parallel resistance	R_p
minimum zero location	$-\alpha$	control delay fraction	d

$$\tau = \frac{L}{R_s} + \frac{L}{R_p} \tag{1}$$

$$g_0 = \frac{1}{R_s + R_p} \tag{2}$$

$$g_1 = \frac{1}{R_s} - \frac{1}{R_s + R_p} \tag{3}$$

$$R_p = \infty \Rightarrow \qquad \tau = \frac{L}{R_s}, \qquad g_0 = 0, \qquad g_1 = \frac{1}{R_s}. \tag{4}$$

$$\alpha \approx 0.2 \tag{5}$$

$$d \leq \frac{1}{1+\alpha}\left(\alpha + \frac{g_0}{g_1}\frac{\alpha + e^{-T/\tau}}{1 - e^{-T/\tau}}\right) \approx \frac{\alpha}{1+\alpha} + \frac{g_0}{g_1}\left(\frac{\tau}{T} - \frac{1}{1+\alpha}\right) \tag{6}$$

$$a_1 = -e^{-T/\tau} \qquad \approx -(1 - \tfrac{T}{\tau}) \tag{7}$$

$$b_0 = g_0 + g_1(1 - e^{-T/\tau})(1-d) \qquad \approx g_0 + g_1 \tfrac{T}{\tau}(1-d) \tag{8}$$

$$b_1 = -g_0 e^{-T/\tau} + g_1(1 - e^{-T/\tau})d \qquad \approx -g_0(1 - \tfrac{T}{\tau}) + g_1 \tfrac{T}{\tau} d \tag{9}$$

$$c_1 = e^{-\omega_1 T} \tag{10}$$

$$d_1 = -2e^{-\zeta_2 \omega_2 T}\cos(\sqrt{1-\zeta_2^2}\omega_2 T) \tag{11}$$

$$d_2 = e^{-2\zeta_2 \omega_2 T} \tag{12}$$

$$r_0 = 1 \tag{13}$$

$$r_1 = (b_1 - 2b_0)/b_0 \tag{14}$$

$$r_2 = (b_0 - 2b_1)/b_0 \tag{15}$$

$$r_3 = b_1/b_0 \tag{16}$$

$$s_0 = (c_1 + d_1 - a_1 + 2)/b_0 \tag{17}$$

$$s_1 = (c_1 d_1 + d_2 + 2a_1 - 1)/b_0 \tag{18}$$

$$s_2 = (c_1 d_2 - a_1)/b_0 \tag{19}$$

$$s_3 = 0 \tag{20}$$

$$t_0 = 1/b_0 \tag{21}$$

$$t_1 = (c_1 + d_1)/b_0 \tag{22}$$

$$t_2 = (c_1 d_1 + d_2)/b_0 \tag{23}$$

$$t_3 = c_1 d_2/b_0 \tag{24}$$