

rise time

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$$\left(\frac{\Delta T}{2}\right)^2 \equiv \frac{\int_{-\infty}^{\infty} t^2 f(t) dt}{\int_{-\infty}^{\infty} f(t) dt} - T_D^2$$

$$\equiv \frac{-\frac{d^2}{d\omega^2} F(\omega)|_{\omega=0}}{F(0)} - \left(\frac{\frac{1}{-j} \frac{d}{d\omega} F(\omega)|_{\omega=0}}{F(0)}\right)^2$$

$$\Rightarrow (\Delta T)^2 = 4 \left[\right]$$

if we cascade 2 system with $h_1(t)$ & $h_2(t)$

$$(\Delta T_{total})^2 = 4 \left[\frac{-\frac{d^2}{d\omega^2} H_1(\omega)H_2(\omega)|_{\omega=0} - (-j)^2 \left(\frac{d}{d\omega} H_1(\omega)H_2(\omega)|_{\omega=0}\right)^2}{H_1(0)H_2(0)} \right]$$

$$(\Delta T_{total})^2 = 4 \left[-\frac{(\ddot{H_1 H_2}) + [\dot{(H_1 H_2)}]^2}{H_1 H_2} \right]$$

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$$\frac{(\Delta T_{\text{total}})^2}{4} = \frac{-[\dot{H}_1 \ddot{H}_2 + \dot{H}_2 \ddot{H}_1]}{H_1 H_2} + \frac{[\dot{H}_1 \ddot{H}_2 + \dot{H}_2 \ddot{H}_1]^2}{H_1^2 H_2^2}$$

$$= \frac{-[\dot{H}_1 \ddot{H}_2 + \dot{H}_1 \ddot{H}_2 + \dot{H}_2 \ddot{H}_1 + \dot{H}_2 \ddot{H}_1]}{H_1 H_2} + \frac{H_1 H_1 \ddot{H}_2 \ddot{H}_2 + 2 H_1 H_2 \ddot{H}_1 \ddot{H}_2 + H_2 H_2 \ddot{H}_1 \ddot{H}_1}{H_1^2 H_2^2}$$

$$\frac{(\Delta T_{\text{total}})^2}{4} = -\frac{\ddot{H}_1 \dot{H}_2}{H_1 H_2} - \frac{\ddot{H}_2}{H_2} - \frac{\dot{H}_1 \ddot{H}_2}{H_1 H_2} - \frac{\ddot{H}_1}{H_1} + \frac{H_1 H_1 \ddot{H}_2 \ddot{H}_2 + 2 H_1 H_2 \ddot{H}_1 \ddot{H}_2 + H_2 H_2 \ddot{H}_1 \ddot{H}_1}{H_1 H_2 H_1 H_2}$$

$$= \cancel{-\frac{\ddot{H}_1 \dot{H}_2}{H_1 H_2}} - \ddot{H}_1 \ddot{H}_2 H_1 H_2 - \cancel{-\frac{\dot{H}_1 \ddot{H}_2}{H_1 H_2}} - \ddot{H}_2 \ddot{H}_1 H_1 H_2 + \frac{H_1 H_1 \ddot{H}_2 \ddot{H}_2 + \cancel{2 H_1 H_2 \ddot{H}_1 \ddot{H}_2} + H_2 H_2 \ddot{H}_1 \ddot{H}_1}{H_1 H_1 H_2 H_2}$$

$$= -\frac{\ddot{H}_2}{H_2} - \frac{\ddot{H}_1}{H_1} + \frac{(\ddot{H}_2)^2}{H_2^2} + \frac{(\ddot{H}_1)^2}{H_1^2} = \left[\frac{\ddot{H}_1}{H_1} + \left(\frac{\ddot{H}_1}{H_1} \right)^2 \right] + \left[\frac{-\ddot{H}_2}{H_2} + \left(\frac{\ddot{H}_2}{H_2} \right)^2 \right]$$

$$\Rightarrow \frac{(\Delta T_{\text{total}})^2}{4} = \frac{\Delta T_1^2}{4} + \frac{\Delta T_2^2}{4}$$