Transfer Function Derivation

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Third Damper Transfer Function Derivation

$$\frac{F_{m_s} + m_s g}{V_{in} b_1}(s) = \frac{1}{b_1} \cdot \frac{F_{m_s} + Se_{m_s g}}{V_{in}} = \frac{1}{b_1} \cdot \Big(\frac{F_{m_s}}{V_{in}} + \frac{Se_{m_s g}}{V_{in}} \Big) \tag{1}$$

Since $F_{m_s} = \dot{p_{m_s}}$, after a Laplace transform $F_{m_s}(s) = p_{m_s}(s) * s$, Substituting into Eqn. (1):

$$\frac{1}{b_1} \cdot \Big(\frac{p_{m_s}}{V_{in}} \cdot s + \frac{Se_{m_s g}}{V_{in}} \Big) \tag{2}$$

Then to rewrite $\frac{Se_{m_s g}}{V_{in}}$ in terms of state-variables transfer functions, the transfer function is decomposed into $(\frac{p_{m_s}}{Se_{m_s g}})^{-1} \frac{p_{m_s}}{V_{in}} = \frac{Se_{m_s g}}{p_{m_s}} \frac{p_{m_s}}{V_{in}} = \frac{Se_{m_s g}}{V_{in}}$ Therefore the Transfer Function can be rewritten in terms of state variables with:

$$\frac{F_{m_s} + m_s g}{V_{in} b_1}(s) = \frac{1}{b_1} \cdot \Big(\frac{p_{m_s}}{V_{in}}(s) \cdot s + \Big(\frac{p_{m_s}}{Se_{m_s g}}(s) \Big)^{-1} \frac{p_{m_s}}{V_{in}}(s) \Big) \tag{3}$$