1 One Pole

$$
\begin{aligned}
H(s) &= \frac{1}{s/p - 1} = \frac{p}{s - p} \\
|H(j\omega)|^2 &= \frac{p^2}{\omega^2 + p^2} \\
\int_0^\infty |H(j\omega)|^2 d\omega &= \frac{p}{4}
\end{aligned}
$$

2 Two Poles

$$
\begin{aligned}
H(s) &= \frac{1}{(s/p_1 - 1)(s/p_2 - 2)} \\
&= p_1 p_2 \frac{1}{s^2 - s(p_1 + p_2) + p_1 p_2} \\
|H(j\omega)|^2 &= (p_1 p_2)^2 \frac{1}{(p_1 p_2 - \omega^2)^2 + \omega^2 (p_1 + p_2)^2} \\
&= (p_1 p_2)^2 \frac{1}{\omega^4 + \omega^2 (p_1^2 + p_2^2) + (p_1 p_2)^2} \\
&= (p_1 p_2)^2 \frac{1}{p_2^2 - p_1^2} \left(\frac{1}{\omega^2 + p_1^2} - \frac{1}{\omega^2 + p_2^2} \right) \\
\int_0^\infty |H(j\omega)|^2 d\omega &= \frac{(p_1 p_2)^2}{p_2^2 - p_1^2} \left(\frac{1}{4p_1} - \frac{1}{4p_2} \right) \\
&= \frac{p_1 p_2}{4(p_2^2 - p_1^2)} (p_2 - p_1) = \frac{p_1 p_2^2 - p_1^2 p_2}{4(p_2^2 - p_1^2)}
\end{aligned}
$$

3 Two Poles, One Zero

$$
\begin{aligned}
H(s) &= \frac{s/z - 1}{(s/p_1 - 1)(s/p_2 - 2)} \\
&= \frac{p_1 p_2}{z} \frac{s - z}{s^2 - s(p_1 + p_2) + p_1 p_2} \\
|H(j\omega)|^2 &= \left(\frac{p_1 p_2}{z}\right)^2 \frac{\omega^2 + z^2}{(p_1 p_2 - \omega^2)^2 + \omega^2 (p_1 + p_2)^2} \\
&= \left(\frac{p_1 p_2}{z}\right)^2 \frac{\omega^2 + z^2}{\omega^4 + \omega^2 (p_1^2 + p_2^2) + (p_1 p_2)^2} \\
&= \left(\frac{p_1 p_2}{z}\right)^2 \frac{1}{p_2^2 - p_1^2} \left(\frac{z^2 - p_1^2}{\omega^2 + p_1^2} - \frac{z^2 - p_2^2}{\omega^2 + p_2^2}\right) \\
\int_0^\infty |H(j\omega)|^2 d\omega &= \frac{(p_1 p_2)^2}{z^2 (p_2^2 - p_1^2)} \left(\frac{z^2 - p_1^2}{4p_1} - \frac{z^2 - p_2^2}{4p_2}\right) \\
&= \frac{p_1 p_2}{4z^2 (p_2^2 - p_1^2)} \left(z^2 (p_2 - p_1) + p_1 p_2^2 - p_2 p_1^2\right)
\end{aligned}
$$