

Poles & Zeros

Electrical Engineering

Where the poles sit, what that says about stability, and what zeros can and cannot do.

Poles are the roots of the denominator of $H(s)$; zeros are the roots of its numerator.

DAMPING RATIO 1

Critically damped

BELOW 1

Overshoot and ringing

ABOVE 1

Slow, no overshoot

- A pole in the right half plane means instability
- Poles on the imaginary axis oscillate forever
- Distance from the origin sets natural frequency
- Angle from the real axis sets the damping
- A zero shapes the response but cannot destabilise
- Complex poles always come in conjugate pairs

LOOK FOR IT

A pole pair at $-1 \pm j10$ rings near 1.6 Hz and decays with a one-second time constant.

Stability rests on the poles alone. Zeros change the shape of the response, never whether it converges.