MID-BAND INSTABILITY

A step motor is highly resonant because it is a mass-spring system. The “mass” portion is the rotor and load moment of inertia while the “spring” portion is restoring torque of the magnetic field that drags the rotor along. Because of this velocity lags torque by 90 degrees.

The drive is a current source in the constant torque region and adds no additional phase lag. In the constant power region however the drive is a voltage source, so it introduces an additional 90-degree phase lag. The total phase lag now approaches 180 degrees, which is a setup for sustained, and building motor oscillation. This oscillation is commonly called mid-band instability or mid-band resonance.

The drive remedies this instability by adding a second-order, or viscous damping. This damping decreases the total phase lag so the motor cannot sustain oscillation, much in the same way shock absorbers damp the mass-spring suspension of a vehicle.

The figure below shows the effect of uncompensated mid-band resonance. Though it is possible to accelerate through the resonant region, it is not possible to operate the motor continuously in that speed band. This is because the oscillation that causes the motor to stall takes from half a second to 10 seconds to build to an amplitude sufficient to stall the motor.