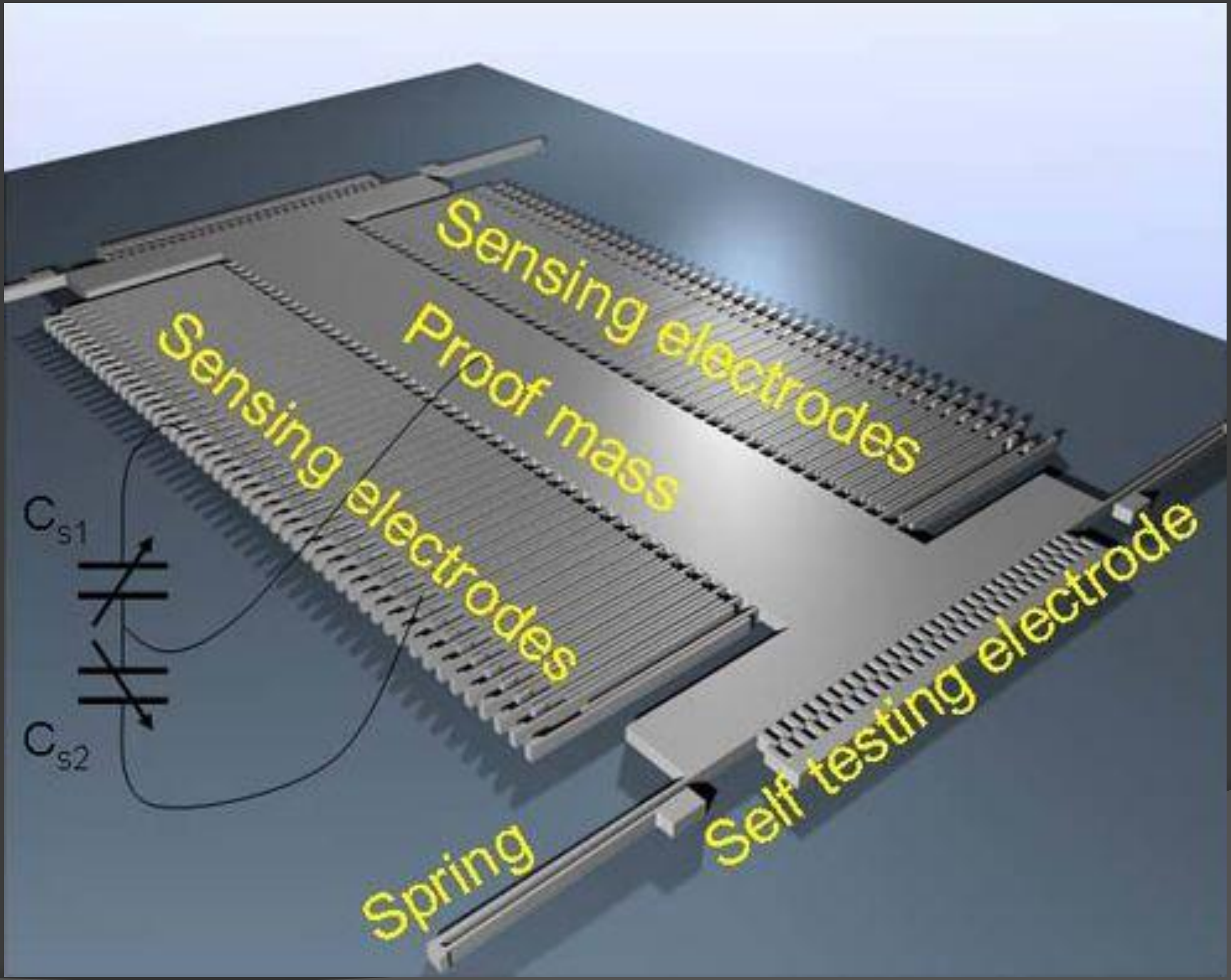
FAMA TECHNOLOGY

ACCELEROMETER FEEDBACK

MEMS Technology

MEMS Accelerometer



MEMS Accelerometer

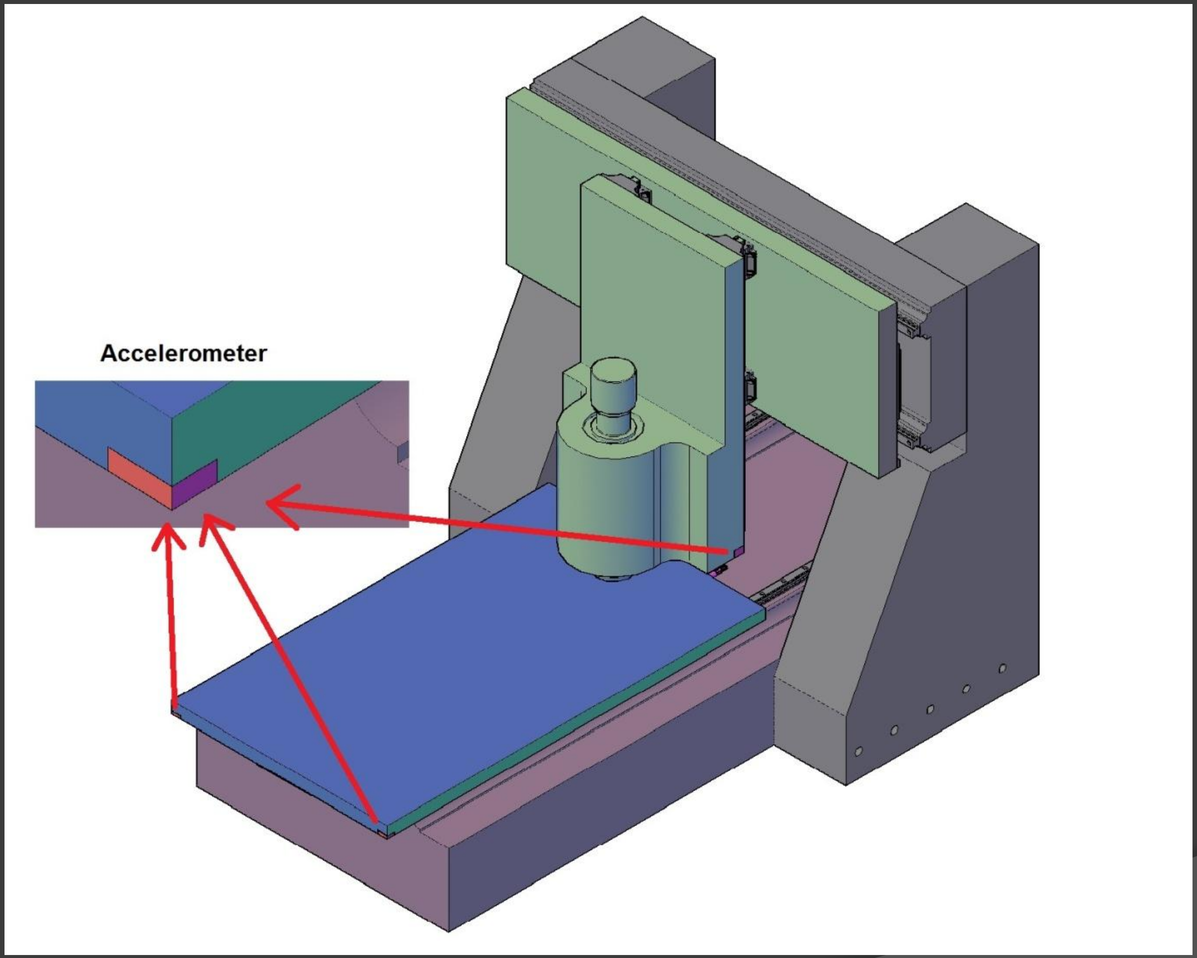
- Inexpensive
- Small
- Low Inertia, Minimum Phase Lag
- High Range of Operation (1mg to 6g)
- Six measurements with only one chip (X-Y-Z axis Acceleration and Gyro)
- Variety of applications (Mobile, Auto . . .)

The Idea

"Utilizing MEMS Accelerometers on CNC machines."

(PATENTED)

Accelerometers Makes the Body of the machine SMART.



Utilizing Accelerometers on a CNC

- Vibration Monitoring and Compensation
- Optimizing Servo Loops by Acceleration Feedback
- Increasing the surface Quality
- Increasing the machining speed
- Reducing Mechanical Impact due to vibration

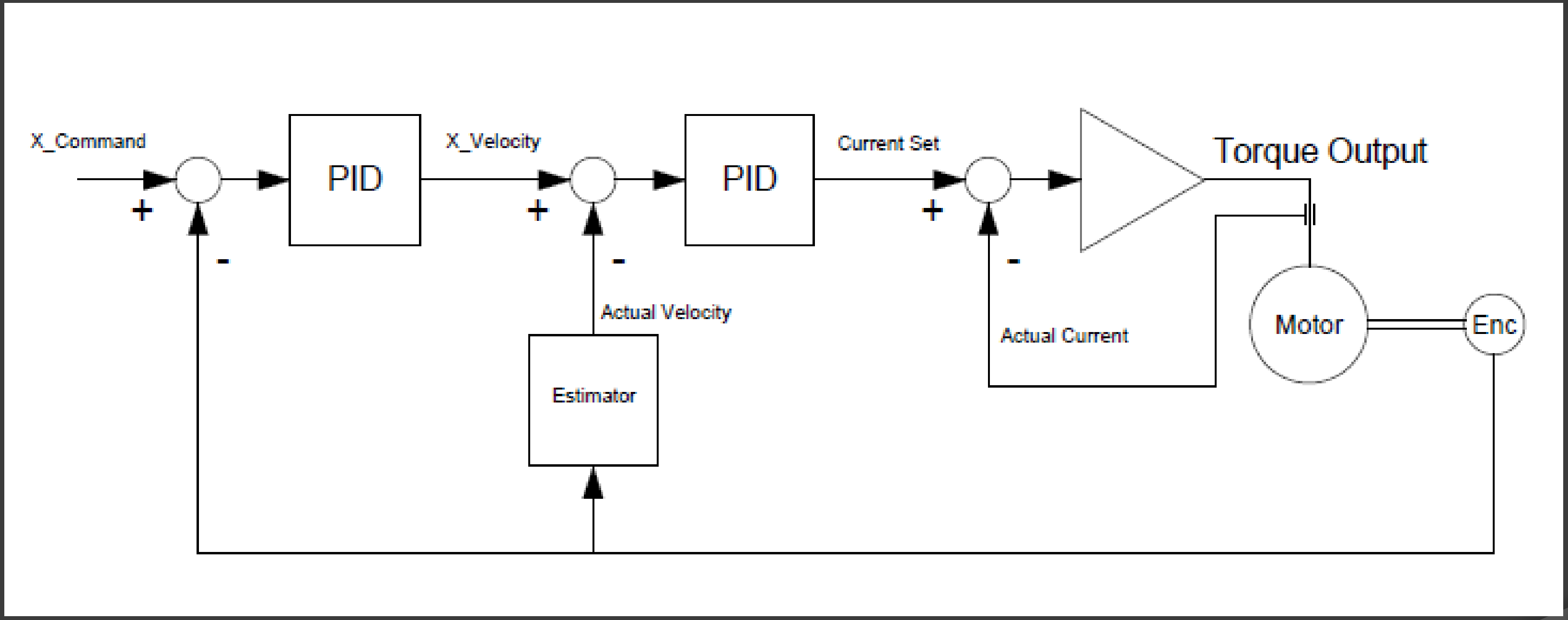
Accelerometer Feedback

- Real Time Vibration Control
- Improving the performance of Low Rigidity CNC Machines
- Increasing the machine’s Stiffness
- Increasing the surface quality
- Decreasing the Machining Time
- Less Computational Stress for Look-ahead algorithms

Servo Loops

- Conventional Servo Loops
  - Position Feedback (Scale, Encoder)
  - Velocity Feedback (Tacho or Constructed)
  - Current Feedback (Drive)
  - Rigidity of the machine is assumed (X_Spindle = X_Encoder)
  - Acceleration and Jerk Control to overcome the vibration

Rigid System Servo Loop



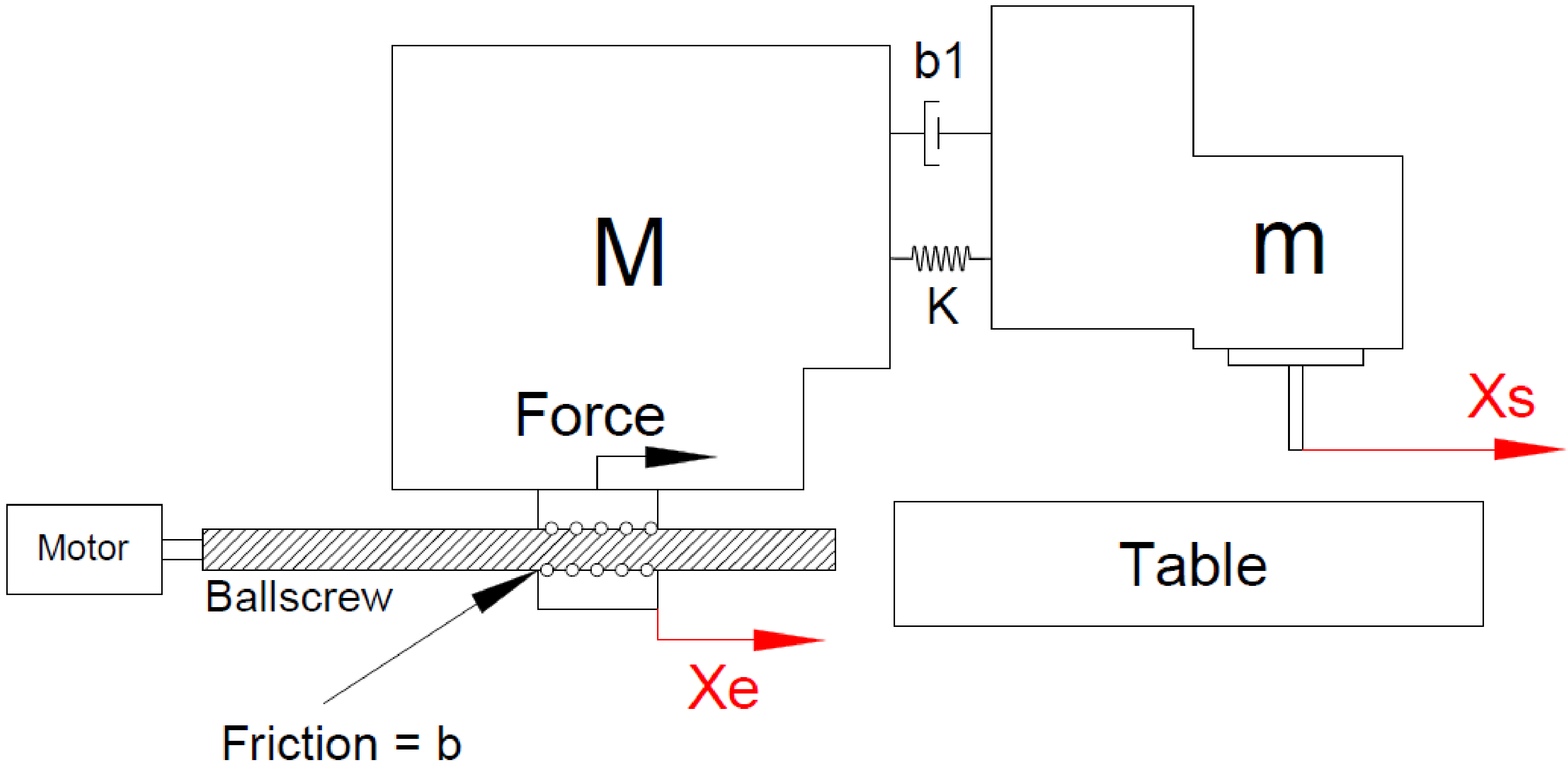
Non Rigid Machine

- Tool Tip Position and Velocity are NOT necessarily equal to Encoder Position and Velocity
- Vibration may create error on the position of the tool tip
- Vibration Error cannot be compensated with volumetric compensation.
- Accelerometer provides additional information to estimate the tool tip position more accurately
- The CNC Body must be modeled to utilize the accelerometer feedback

Non Rigid System Preliminaries

- Accelerometer Alignment & Calibration
- Estimation of the Model of the CNC Body
- Special Filtering is required based on the estimated model
- Collecting Information for Model Estimation
- Computer Simulation

Two Mass System Model

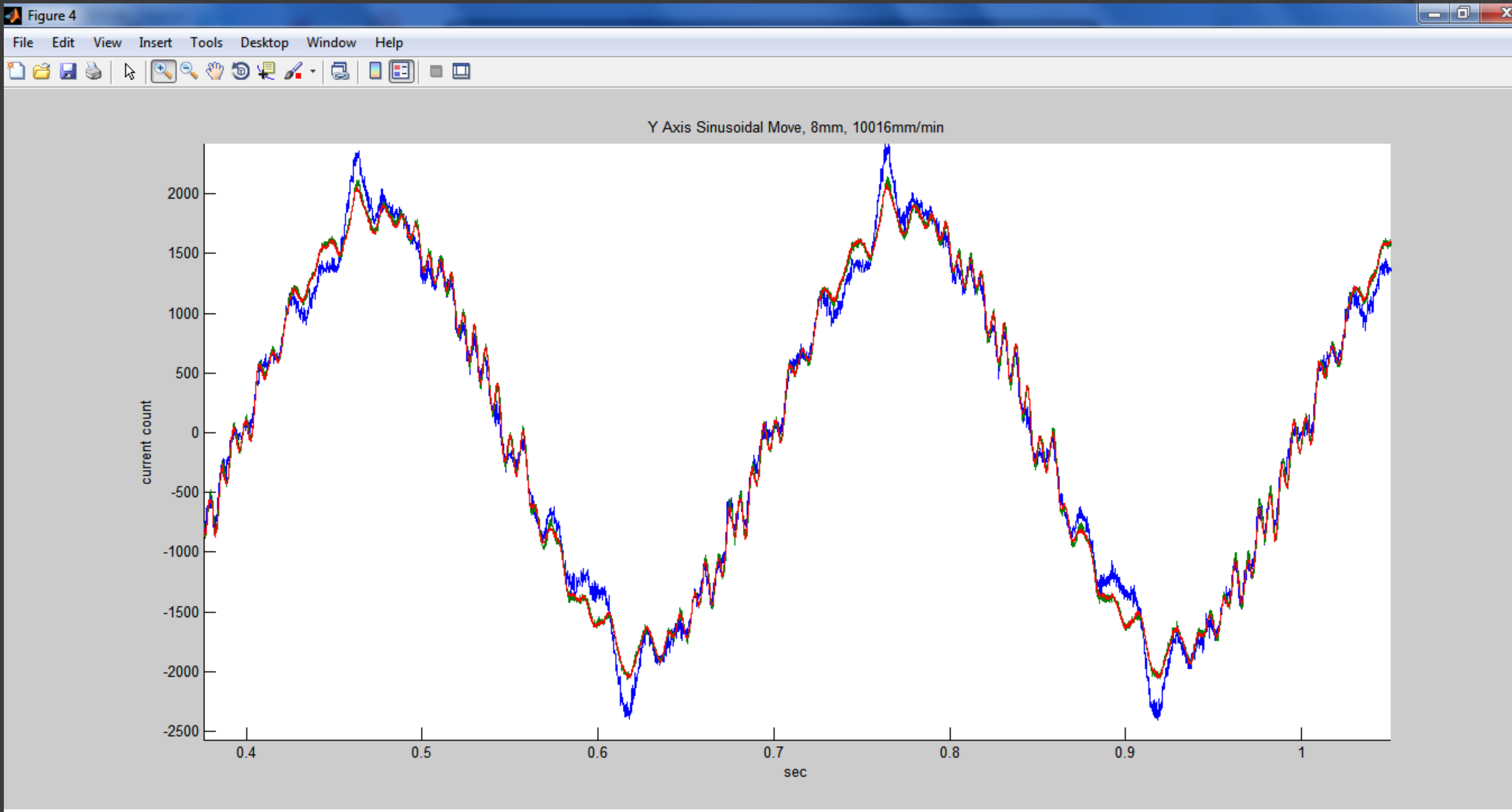


$$M\ddot{x}_e + b_1(\dot{x}_e - \dot{x}_s) + K(x_e - x_s) + b\dot{x}_e = F$$
$$m\ddot{x}_s + b_1(\dot{x}_s - \dot{x}_e) + K(x_s - x_e) = 0$$

Two Mass System Assumptions

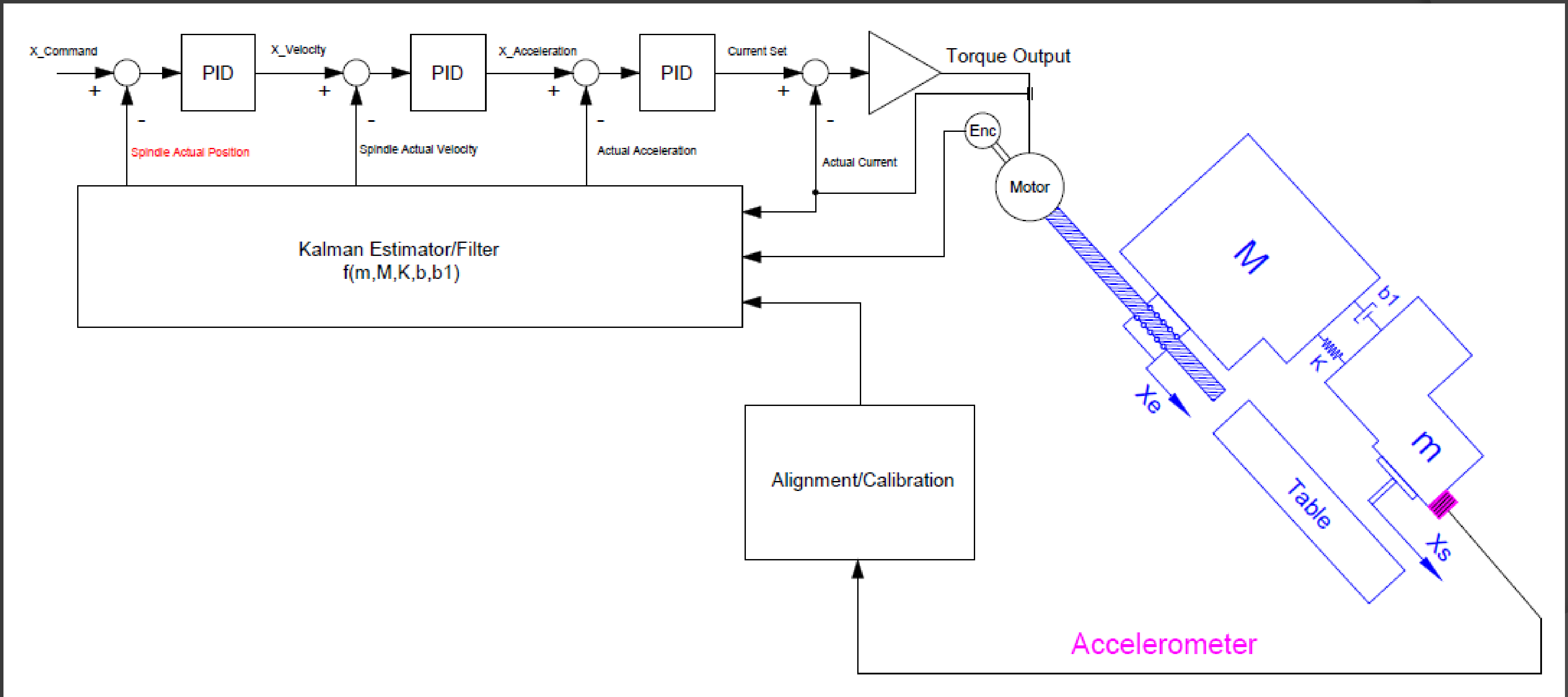
- Spindle Position and Velocity are NOT necessarily equal to Encoder Position and Velocity
- M = First Mass
- m = Second Mass
- b = Friction Coefficient
- K = Body Spring Constant
- b1 = Body Damping Constant
- F = Moving Force is proportional to motor’s current

Current vs. Calculated Force



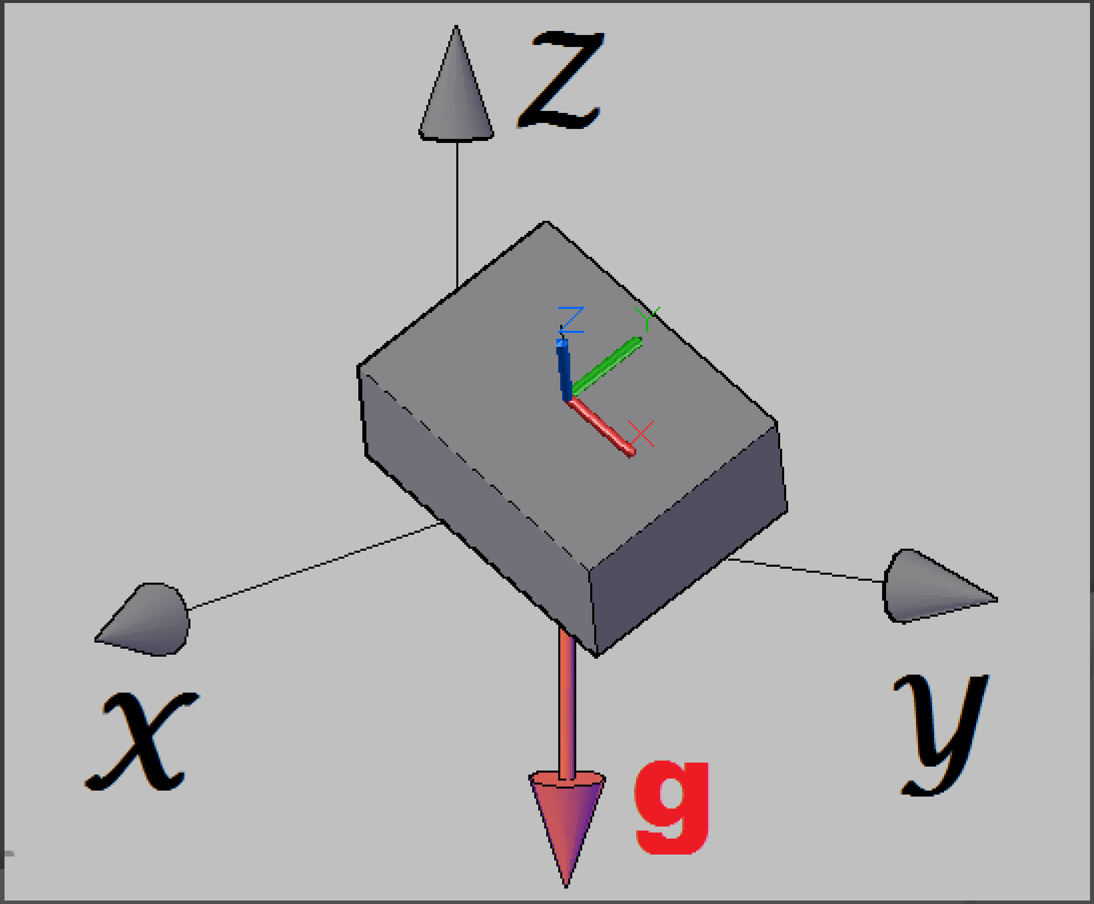
$$M\ddot{x}_e + b_1(\dot{x}_e - \dot{x}_s) + K(x_e - x_s) + b\dot{x}_e = F$$
$$M\ddot{x}_e + m\ddot{x}_s + b\dot{x}_e = F$$

Two Mass Servo System



Accelerometer Alignment

- Biases: Gravity Effect on Accelerometer Outputs



Thank You