

# OVERFORCE DESIGN CONSIDERATIONS

Technical Note

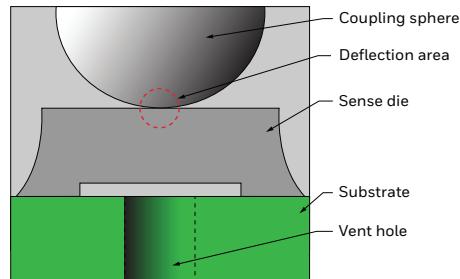
Honeywell FMA Series MicroForce Sensors are piezoresistive-based devices which use direct mechanical coupling through a stainless-steel sphere mounted directly over a silicone sense die. This package is designed for repeatable and reliable mechanical interface to maximize the accuracy of the sensor's output. To achieve the best possible reading, it is recommended to utilize the sensor's entire full-scale span, as well as to consider the constraints of the sensor's overforce and burst force. This Technical Note addresses design considerations and coupling techniques for potential applications where overforce outside of a sensor's specified range may occur.

## 1.0 DESIGN CONSIDERATIONS

It is imperative to understand the sensor's specification limits in order to fully utilize the sensor for its intended function. Honeywell's MicroForce sensor maximizes the sensitivity of each sensor to its specified range. This is accomplished by measuring the stress of the sense die deflecting from the coupling sphere as shown in Figure 1. The deflection of these two components only travels a couple of microns.

- **Overforce:** The absolute maximum force that may safely be applied to the sensor for it to remain within specification once the force returns to the operating force range. Exposure to higher forces may cause permanent damage to the sensor. Unless otherwise specified, this applies to all available force sensors at any temperature within the operating temperature range.
- **Burst force:** The maximum force that may be applied to the sensor without causing mechanical damage. The sensor is not be expected to function after exposure to any force beyond the burst force.

**FIGURE 1. CLOSEUP OF MICROFORCE SENSOR INTERNAL COUPLING**



## 2.0 COUPLING TECHNIQUES

In a design where overforce is possible, the following examples serve as common, generic coupling references to assist with brainstorming concepts that could be used in any design. Additional design considerations such as mounting, package forces, and coupling may affect the sensor's output performance. (See the Technical Note "MicroForce Sensor Coupling" for further details.)

One technique to safely handle overforce involves using a spring and a mechanical stop. The spring allows the force to scale over a distance that is large enough to be applied correctly before reaching a feature that will prevent the application of any additional force greater than the sensor's specified overforce. This may be accomplished by using different mounting configurations or spring types, depending on the design and space requirements.

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### 3.0 EXAMPLE 1: TORSION SPRING AND LEVERS

Figure 2 shows the use of a torsion spring attached to a lever mechanism. This configuration allows additional freedom for scaling the force magnitude and adjusting the force direction. The force moves along a constant radius from the center axis of Lever A. The torsion spring then transfers the force to Lever B, which is coupled to the sensor. Lever A has a pin stop which prevents rotation at a determined point past full scale, before overforce can occur. This solution does add travel to the system; however, it reduces the overall stiffness. It also allows for some preload which may reduce the chatter seen at lower sensor ranges.

The following equation relates the force pressed against Lever A to the transferred force to the sensor from Lever B as well as the spring's deflection.

$$F_1 X_1 = K\theta = F_2 X_2 + f + G$$

Where:

$F_1$ : Force on Lever A

$X_1$ : Distance from axis of rotation to  $F_1$

$K$ : Torsion elastic modulus

$\theta$ : Angle of twist from equilibrium

$F_2$ : Reaction force of sensor

$X_2$ : Distance from axis of rotation to the sensor contact point

$f$ : Friction in the system

$G$ : Gravity of components on the sensor

FIGURE 2. USING A TORSION SPRING AND LEVERS TO PREVENT OVERFORCE

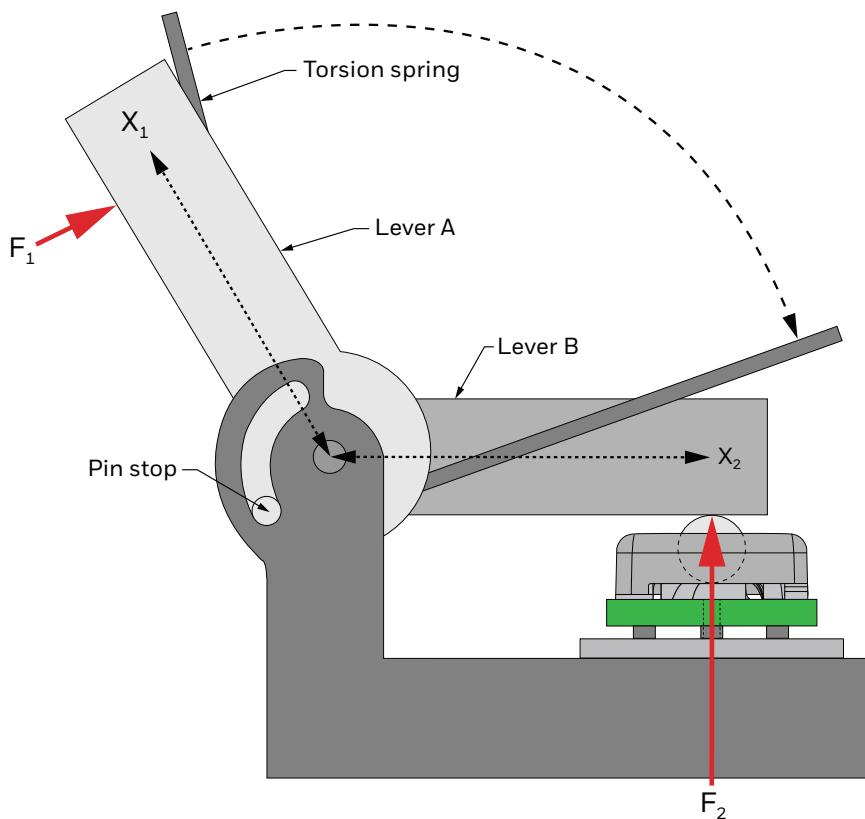
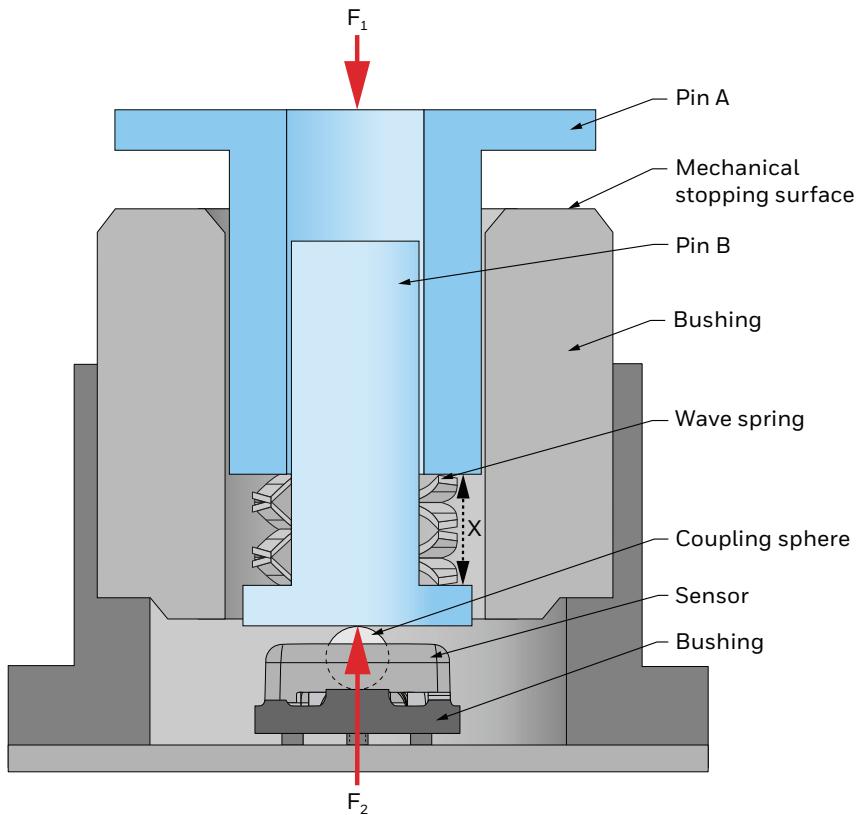


FIGURE 3. USING A WAVE SPRING AND BUSHING TO PREVENT OVERFORCE



## 4.0 EXAMPLE 2: BUSHING AND WAVE SPRING

Figure 3 shows a linear coupling strategy using a bushing with two interlocking pins separated by a wave spring. This method allows the force to contact Pin A and compress it to the desired range until it bottoms out on the bushing. Ideally, this method would allow the wave spring to closely approach its maximum compression and apply a load slightly larger than the sensor's full-scale span. This solution does add travel to the system; however, it reduces the overall stiffness. This solution also allows a preload which can reduce the chatter seen at lower sensor ranges.

The equation to the right relates the force pressed against Pin A to the transferred force to the sensor from Pin B, as well as the deflection of the wave spring.

$$F_1 = KX + f = F_2 + f + G$$

Where:

$F_1$ : Force on Pin A

X: Deflection

K: Spring elastic modulus

$F_2$ : Reaction force of the sensor

f: Friction in the system

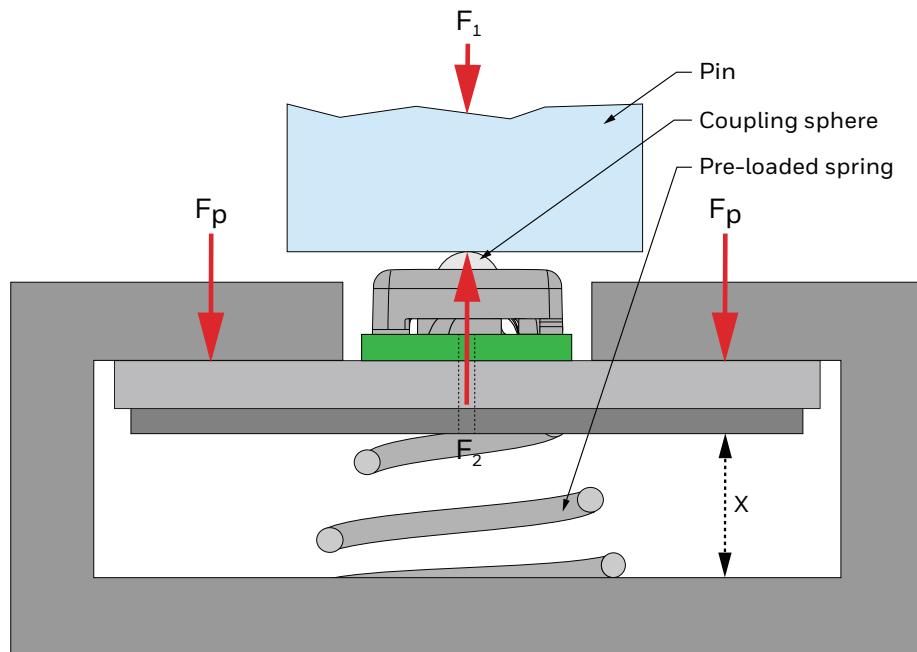
G: Gravity of components on the sensor

## 5.0 EXAMPLE 3: LINEAR COUPLING

Figure 4 shows a linear coupling design that uses a pre-loaded spring located under the sensor. This design allows the force to contact the sensor and relieve a pre-loaded force until it reaches a force where the sensor can move and the pin bottoms out. The advantage of this design is that it does not add extra movement until the sensor is outside the operating range. The system still needs to bottom out at a stop before the overforce rating occurs to avoid damaging the sensor. Also, results may be skewed after the pre-load is overcome if the system is not aligned along the sensor's center axis.

The equations to the right relate the coupling forces and the pre-load forces to the spring force as shown in Figure 4.

**FIGURE 4. USING LINEAR COUPLING TO PREVENT OVERFORCE**



$$F_1 + F_p = KX + f$$

$$F_1 = F_2$$

Where:

$F_1$ : Force on actuator

$F_p$ : Force from pre-load

X: Deflection

K: Elastic modulus

f: Friction in the system

$F_2$ : Reaction force of the sensor

### NOTICE

*It is up to the customer to design a solution to meet the specific needs of the potential application.*

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