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# Smart Vibration Switches for Rotating Machinery

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## Abstract

This paper introduces the IMI USB Programmable Smart Vibration Switch, a cost-effective and precise monitoring device for protecting electric motors, pumps, cooling towers, fans, and compressors from excessive vibration. It explains how this next-generation design expands upon earlier versions by incorporating universal power compatibility, built-in USB programming, and an optional magnetically adjustable threshold feature (MAVT™). Operating principles, installation methods, and strategies for connecting multiple switches in parallel are also addressed, and a concluding comparison demonstrates how this new switch offers a practical balance of cost and reliability. An intrinsically safe model is also available as an option for hazardous areas.



**Keywords:**
Vibration Protection, USB Smart Vibration Switch, Two-Wire Switch, Electronic Switch, Mechanical Switch, Magnetically Adjustable Vibration Threshold (MAVT™), Intrinsically Safe, Machinery Monitoring, Fan and Pump Protection, Cooling Towers


## 1. Introduction: From Mechanical to Electronic Vibration Switches

Vibration switches help protect rotating machinery by prompting an alarm or shutting equipment down when vibration levels exceed safe limits. Historically, mechanical switches have been favored for their simplicity and low cost; they require no dedicated power but rely on a magnet-and-spring mechanism susceptible to shock-induced tripping. These designs often lack built-in time delays, forcing frequent resets and making precise calibration difficult.

In contrast, electronic switches use accelerometers to sense vibration more accurately and can incorporate time delays to reduce false trips. Although they usually cost more and need a specific power source, the heightened reliability and functionality make them attractive for applications where machine downtime is costly or safety is paramount.

Building on these principles, the USB Programmable Smart Vibration Switch (referred to hereafter as the “smart switch”) offers a compact, loop-powered alternative that integrates precise measurement with flexible threshold programming.

## 2. The USB Smart Vibration Switch

Designed for both versatility and simplicity, the smart switch operates on 24–265 VAC or VDC using just two wires, which supply power and carry the switch signal. Housed in stainless steel, it's hermetically sealed to withstand harsh industrial conditions. An embedded piezoelectric accelerometer measures machine vibration in true RMS velocity, while an internal microprocessor and relay manage load switching.

### 2.1 Physical Description

The unit measures around 2.75 inches in height and 1.25 inches across its hex body. This compact form factor simplifies installation on motor housings, fan bearings, and similar mounting points. A standard two-pin connector or integral cable attaches the smart switch to the power/load circuit. For programming, a specialized USB port or adapter can be used to connect the switch to a computer, allowing precise customization of threshold levels and delay settings.


*Figure 1: IMI USB Programmable Smart Vibration Switch.*

### 2.2 Operating Specifications

Typical loads up to 500 mA can be switched, making the device compatible with a range of alarms, relays, and PLC inputs. Its 3–1000 Hz frequency range accommodates the slow-speed fans common in cooling towers, as well as higher-speed industrial motors. Construction in stainless steel ensures corrosion and moisture resistance, while optional intrinsically safe versions are available for hazardous areas requiring special certification.

## 3. Operating Principles

The smart switch is installed in series with the load and power source. By comparing actual vibration measurements to a user-selected threshold, the embedded microprocessor actuates its internal relay when excessive vibration persists for a specified time. This single, loop-powered system eliminates the need for separate power lines.

## 3.1 Programming Thresholds: USB and MAVT™

The smart switch provides two main methods to set vibration thresholds:

- **Direct USB Programming**: If you know the acceptable vibration limit, you can plug the switch into a computer in the field. A simple interface lets you enter exact numeric values for the threshold, along with time delays and other configuration details. This approach is ideal when an established standard or prior analysis dictates a precise limit.

- **MAVT™ (Magnetically Adjustable Vibration Threshold)**: When the required threshold is unknown, a magnet can be used to prompt the switch to measure the machine's current vibration level for about 30 seconds while the equipment is running normally. The microprocessor then averages the measured data and sets the new threshold to twice that vibration level. This eliminates guesswork, enabling a quick calibration to reflect real-world conditions without needing specialized calibration tools or test rigs.

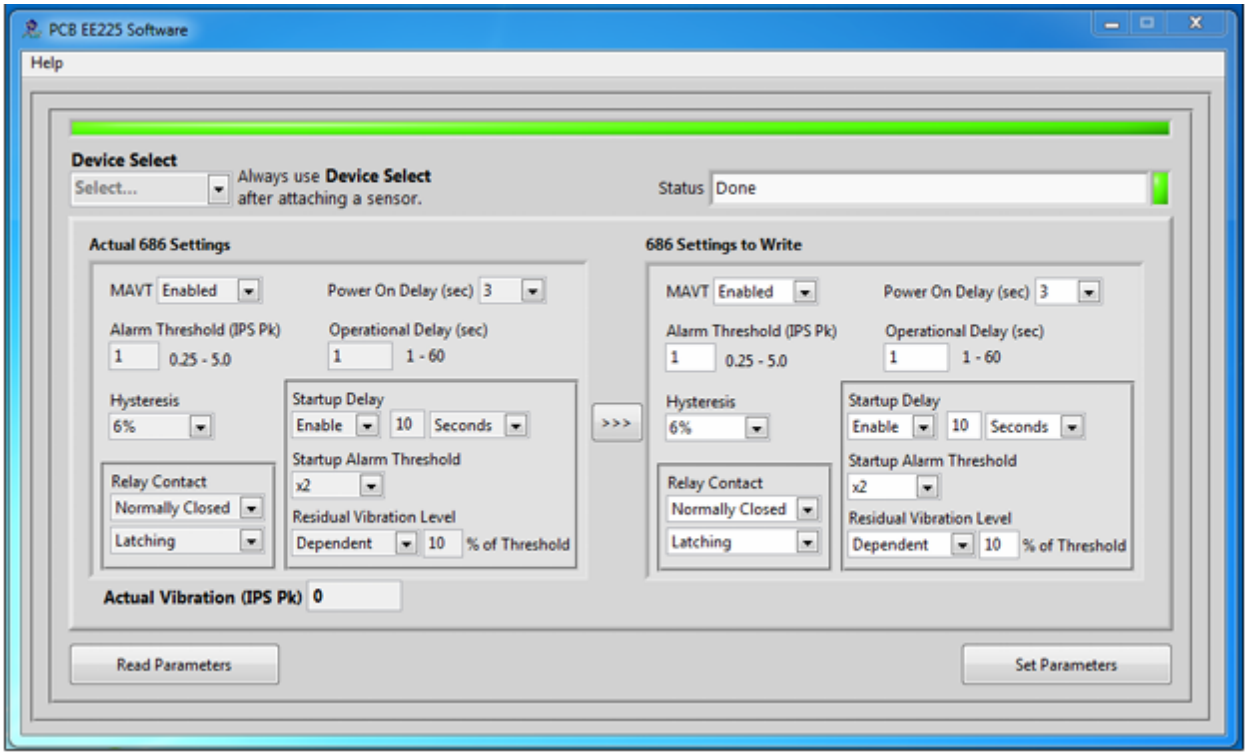


*Figure 2: Programming screen for IMI USB Programmable Smart Vibration Switch.*

### 3.2 Installation and Wiring

Mounting the smart switch typically involves securing it onto a vibration-prone part of the machine, such as a pump casing or fan bearing bracket, using a single stud or bolt. Wiring is straightforward: one conductor runs from the power source to the switch, and another leads from the switch to the alarm or relay coil. Because the switch requires minimal current in its open state, the loop remains stable, and the total circuit current typically stays below 1 mA when the switch is not tripped (though it can handle up to 500 mA upon closure, depending on the load).

### 3.3 Electromechanical Relay Integration

When connecting to an electromechanical relay, it is important to note the small “leakage” current (~1 mA) present when the switch relay is open. Some relays with very low dropout currents may not fully reset unless the circuit is momentarily broken. To address this, the smart switch includes a brief 100 ms current cut that ensures relays de-energize correctly.

### 3.4 Delays and Avoiding False Trips

To prevent nuisance alarms, the switch incorporates adjustable delays for power-on, start-up, and continuous operation. A power-on delay allows both the switch’s electronics and the rotating equipment to reach stable operating conditions before monitoring begins. A start-up delay ignores vibration during machinery run-up, while an operational delay requires vibration to exceed the threshold for a set period before tripping. These features help reduce false alarms caused by normal (but short-term) transients in machines.

### 3.5 Managing Coupled Vibration in Multi-Machine Environments

In some installations, fans are wired in series so that a single switch tripping due to a neighboring fan’s startup vibration can inadvertently cut power to all connected units. By contrast, when smart switches are wired in parallel, each switch monitors its own equipment independently. In this parallel configuration, each switch includes its own electromechanical relay, which isolates its response to transient vibrations. This isolation blocks the propagation of vibration spikes between units, ensuring that a transient event on one machine does not inadvertently trigger the switches on neighboring machines.

## 4. Core Features and Advantages

The smart switch balances loop-powered simplicity with robust functionality. Its built-in accelerometer provides true RMS velocity measurement. The universal housing is stainless steel and hermetically sealed, ensuring reliable performance even in harsh settings. Dual programming options (USB or MAVT™) accommodate users who either know their desired threshold from the start or prefer to base it on in-situ measurements. Optional intrinsically safe versions are also available, making the design

suitable for hazardous areas. The result is a practical yet sophisticated vibration monitoring solution for motors, pumps, fans, and compressors.

# 5. Comparison and Conclusion

The chart below offers a high-level comparison of how mechanical switches, standard electronic switches, and the USB Programmable Smart Vibration Switch meet typical requirements for rotating machinery protection.

**Table Key:**

***** Indicates the relative cost of the units, thus ****** is about twice the cost of *****
**+** The unit has this feature
**-** The unit does not have this feature
**+/-** Some units have the feature and some do not
*Italicized* font indicates the USB Programmable Smart Vibration Switch feature that addresses the requirement.

*Table 1: Comparison of vibration switches to cooling tower requirements.*

| COOLING TOWER REQUIREMENT | MECHANICAL VIBRATION SWITCH | ELECTRONIC VIBRATION SWITCH | SMART VIBRATION SWITCH (NEW) | ICP® ACCELEROMETER TRANSMITTER W/ RELAY | 4-20 mA OUTPUT VIBRATION SENSOR & TRANSMITTER W/ RELAY |
|---|---|---|---|---|---|
| Cost | * | *** | ** | **** | *** |
| Towers are very flexible causing short periods of high vibration *Operating Delay* | - | + | + | + | + |
| Large distance between fan, gear, box, and motor requires multiple switches | + | - | + | - | - |
| High vibration during start-up *Power On Delay* | - | + / - | + | - | - |
| *Start-Up Delay* | - | | + | - | - |
| Neighboring fan start-up effects normally operating fans *Parallel switch operation w/ EM relays block coupled vibrations* | - | - | + | - | - |
| Reversing fans in cold climates *Operating Delay* | - | + | + | + | + |
| Corrosion from bad pH *SS hermetic housing* | - | - | + | + | + |
| Water build-up in blades *High threshold level* | + | - | + | + | + |
| Speeds are slow and based on fan diameter *Monitor vibration & wide frequency response* | - | + | + | + | + |
| Complex gearbox (1800/120 RPM) with high frequency faults *High frequency response of switch and mounting configuration* | - | - | + | + | + |
| Long distances from the switch to the control room *High level signal in the cable allows long cable runs* | + | + | + | - | + / - |

Mechanical switches remain an option where cost takes priority over accuracy and features. Standard electronic switches improve on precision, including time delays and calibration options, but generally require dedicated wiring and have fewer “smart” capabilities. The USB Programmable Smart Vibration Switch—with universal power input, comprehensive delay settings, and a user-friendly programming method (USB or MAVT™)—is an attractive, all-in-one solution for most rotating equipment. Its rugged design, optional intrinsically safe certification, and straightforward installation make it particularly appealing for industrial applications where unplanned downtime is costly and safety is a top concern.

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WPL_106_0325