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# Maximize Predictive Maintenance with Careful Selection of MEMS Accelerometers

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## Question

When selecting a MEMS accelerometer for condition-based monitoring, what are some critical, yet commonly overlooked parameters?

## Answer

Critical parameters that are frequently underestimated in the selection process for a MEMS accelerometer are the *g*-range, the bandwidth, and the resonant frequency of the sensor. If these parameters are too low or barely sufficient, undesired measurement effects can occur.

## Introduction

MEMS accelerometers are essential for detecting fault conditions and helping to prevent unexpected outages or other costly events. As an engineer who is tasked with selecting and installing the right sensors for condition-based monitoring (CbM) applications, there are numerous critical parameters that require careful consideration before making your selection, but these factors can be easily overlooked. In this article, we'll discuss some of the most important criteria you should bear in mind when making your choices.

## Condition-Based Monitoring

CbM is a process of using sensors to monitor mechanical systems for potential defects or damage that might arise. CbM is used to monitor defects in ball bearings, gears, pumps, and in many other applications. It is common practice to employ a multitude of different sensors to ensure optimal monitoring. With such sensors, it is possible to detect any anomalies early on and take preventive measures to avoid possible damages or breakdowns. One approach is predictive maintenance (PdM), which can be employed for forecasting potential faults within the system based on data collected from the sensor readings. This helps reduce downtime and increases efficiency in operations. While CbM employs a variety of sophisticated sensors, such as accelerometers, temperature sensors, magnetometers, and MEMS microphones, this article focuses specifically on MEMS accelerometers.

## MEMS Accelerometers

MEMS accelerometers convert mechanical vibrations into an electrical voltage or a digital value. The MEMS sensor is made up of movable and fixed silicon elements that are interlocked to form a capacitor as shown in Figure 1a. Mechanical movement causes the movable element to shift toward the fixed element. The structure can be described mathematically as a mass-spring system in which the acceleration can be calculated from the measured force. In an analog MEMS sensor (Figure 1b), this can then be converted to a voltage. A digital sensor additionally utilizes an integrated analog-to-digital converter, which outputs a digital value as shown in Figure 1c. Analog Devices offers a wide range of MEMS accelerometers—for example, with low noise floors, high bandwidths, and multi-axis sensors.

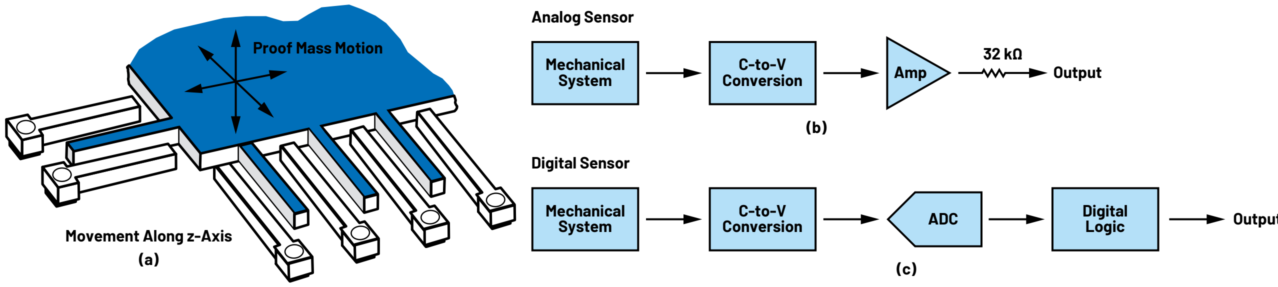


*Figure 1. (a) MEMS structure with movement along the z-axis; (b) MEMS analog output; and (c) MEMS digital output.*

## Critical Parameters of MEMS Accelerometers for CbM

### The *g*-Range

The *g*-range of a MEMS sensor should be selected to cover all occurring accelerations in the system. If the sensor's *g*-range is too small, the signal can be clipped. This can then lead to an asymmetrical signal/offset in the measurement result and thus the interpretation of incorrect accelerations. The gravitational acceleration, which the sensor sees as 1 *g*, is often neglected here.

### The Bandwidth

In addition, the frequencies at which accelerations occur in the system should be considered in combination with the bandwidth. The early detection of defects, such as those related to ball bearings, pumps, etc., is essential in CbM applications. The first signs of defects usually appear at high frequencies. If the selected bandwidth is too small, the defects will not even be detected. In these applications, the acceleration is a function of the square of the frequency. For example, at a displacement of 250 nm and 1 kHz, the actual acceleration is 1 *g*. If this displacement occurs at 10 kHz, it results in an actual acceleration of 100 *g*, or a factor of 100 higher. This means that to enable the early discovery of defects in a system, one must select a sensor with a sufficiently large bandwidth and an adequate *g*-range. For highly critical applications, ADI offers sensors with bandwidths of up to 24 kHz and 500 *g*.

### Sensor Resonance Frequency

Another factor to consider when selecting the bandwidth is the specific resonance of the sensor. If accelerations occur at the resonant frequency of the sensor, they are amplified and, in the worst-case scenario, can distort the usable signal and thus falsify the measurement result. Mechanical damping/filtering of the system can provide a remedy to this problem. Besides bandwidth, a low noise floor is also important for enabling early detection of faults or deviations. Good MEMS accelerometers have noise floors of <100 $\mu g/\sqrt{\text{Hz}}$.

For a complete overview of MEMS accelerometers specifications, see Accelerometer Specifications - Quick Definitions.

## Conclusion

MEMS-based accelerometers now offer a good alternative to piezoelectric sensors. With high bandwidths of up to 24 kHz and low noise floors, MEMS accelerometers are well suited for predicting and detecting the onset of defects, thereby reducing system failure rates as well as associated costs. ADI provides a wide variety of sensors for CbM applications, including the ADXL100x and the ADXL356/ADXL357. For additional information on available MEMS accelerometers, visit our accelerometers page.

## References


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## About the Author


Benjamin Reiss has been working at Analog Devices in Munich, Germany since April 2017. He graduated in 2016 from the Friedrich-Alexander University in Erlangen with a master's degree in nanotechnology. After completion of the trainee program at Analog Devices, he joined the regional team as a field applications engineer supporting several broad market accounts.