The response of the PC420 LPS™ to transient data

The PC420 LPS™ series sensors are designed to interface to a plant Distributed Control System (DCS) or Programmable Logic Controller (PLC). These systems typically interface to sensors using a current loop, where the sensor controls the current flowing in the loop and varies it between 4 and 20 mA depending on the property being measured by the sensor. The sensor power is provided from a DC voltage source between 12 and 36 volts. The DCS/PLC measurement circuit measures the current in the loop by measuring the voltage developed across a load resistor, as illustrated in figure 1. The load resistor is typically 250 Ω, but may have different values depending on the particular DCS or PLC system.

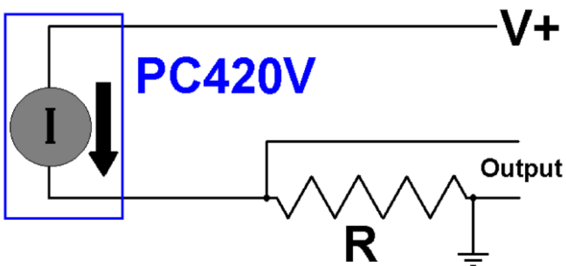


Figure 1 – a typical LPS™ installation current.

The PC420 LPS™ will control the loop current. The PC420A is an acceleration sensor and will set the loop current to represent the peak acceleration measured. When there is no vibration input to the sensor, the loop current will be 4.0 milliamperes. When the vibration is 10 g (peak), the current in the loop will be 20 milliamperes. The PC420V is a velocity sensor and will set the loop current to represent the peak velocity measured. When there is no vibration input to the sensor, the loop current will be 4.0 milliamperes; when the vibration is 1.0 inches/sec (peak), the current in the loop will be 20 milliamperes.

When the vibration level is relatively constant, the output of the PC420 LPS™ sensor will also be constant. However, when the vibration level is changing rapidly or is subjected to system vibration transients, the output will not be constant and will be changing to represent the changing vibration levels being measured.

In order to convert the AC vibration signal into a DC loop signal, the PC420 LPS™ contains an averaging circuit. This averaging circuit, like all averaging circuits, has a time-constant of averaging that will influence the response time of the PC420 LPS™ to transient or changing vibration.

To explain this phenomenon better, we will study examples of the PC420 LPS™ response to some transient signals. These examples will illustrate the idealized response of the sensor. An actual sensor in field use may be slightly different in its response, but these examples will serve to explain the responses seen in actual use.

First, let us consider how the PC420 LPS™ sensor responds to steady-state signals. Figure 2 illustrates a steady-state signal being measured by the PC420 LPS™.

Wilcoxon Sensing Technologies
8435 Progress Drive
Frederick, MD 21701
USA

Tel.: +1 (301) 330 8811
Fax: +1 (301) 330 8873
Email: info@wilcoxon.com
www.wilcoxon.com

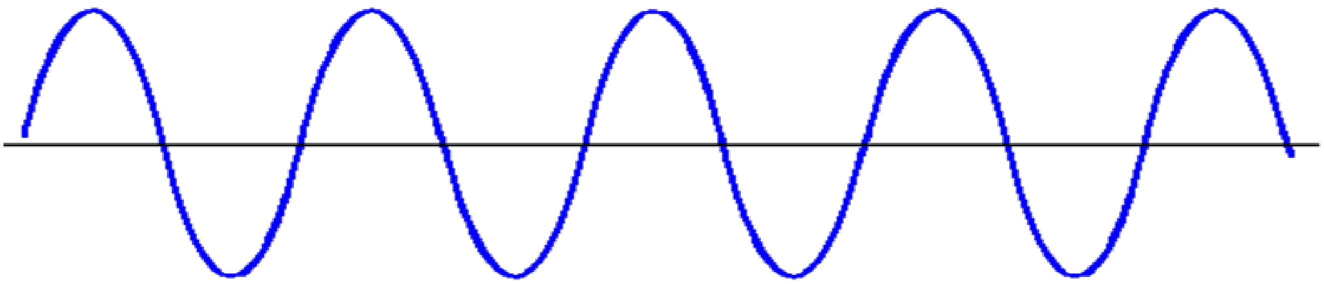


Figure 2 – Steady-state vibration signal.

The PC420 LPS™ will acquire this signal and process it through internal circuitry. This signal is eventually applied to a rectifier circuit and results in an internal signal that is "smoothed" by the averaging circuit. After further processing, the output of the PC420 LPS™ is a constant DC signal proportional to the peak vibration level experienced by the sensor. This constant output is illustrated in figure 3 by the top thick line.

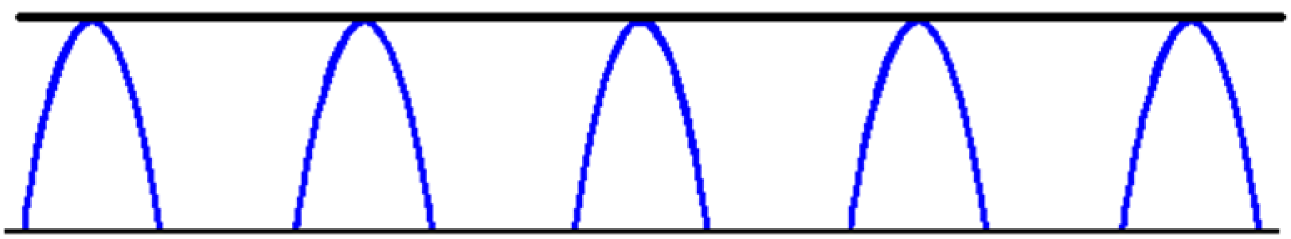


Figure 3 – The thick, top line illustrates PC420 LPS™ output.

So far, we have discussed what the PC420 LPS™ response will be for steady-state vibrations. Now we will consider what happens when the vibration is changing. We will look at a "step" change in the vibration level and show how the PC420 LPS™ responds in an idealized example. Figure 4 illustrates a step change in vibration that occurs and then later returns to the original vibration level.

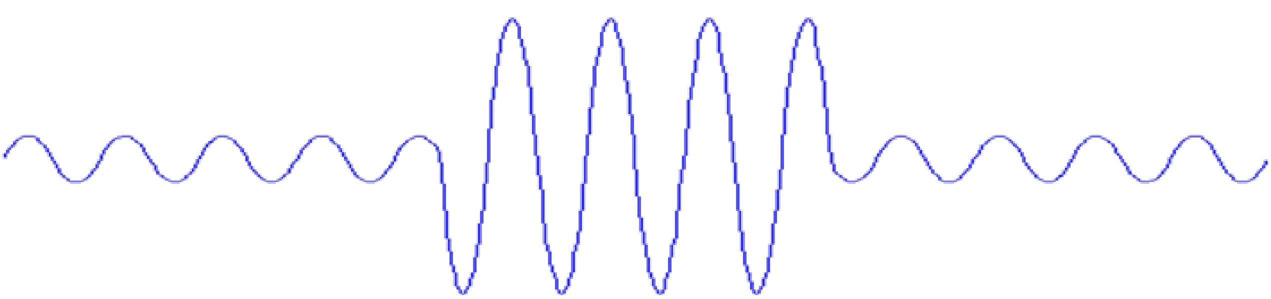


Figure 4 – A step change in vibration level, then a return to original level.

Figure 5 illustrates the idealized output of the sensor if there were no averaging or smoothing of the output signal. However, it is not possible to have a sensor yield this idealized output. Because of the rectification, averaging and smoothing, there will be some lag in the response of the sensor to such step changes in the input vibration.

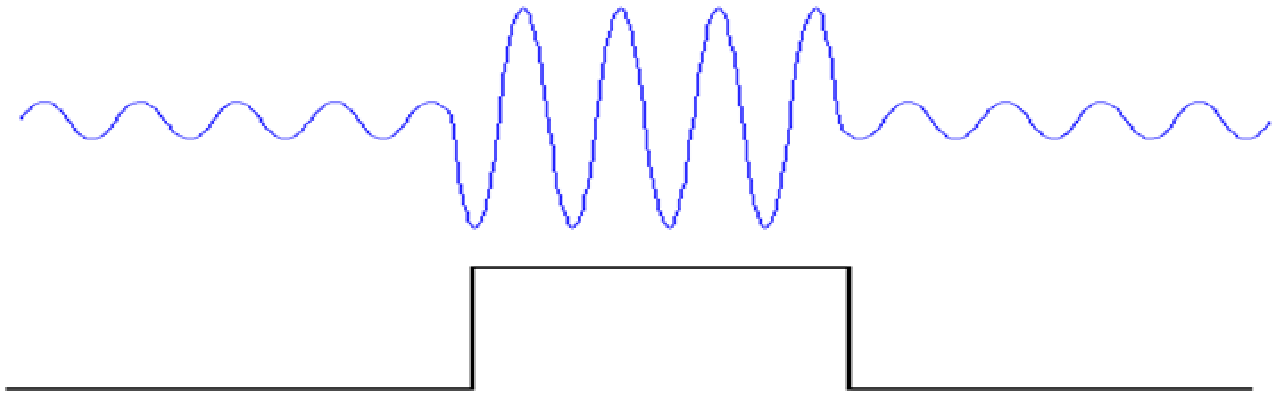


Figure 5 – Idealized output of sensor with no averaging.

Figure 6 shows an approximation of the sensor's actual response to a step change in vibration and the response after it returns to the original vibration level. In this example, the length of the step change was assumed to be 1 second.

As figure 6 shows, the sensor will not respond immediately to a step change in the input. Rather, there is a finite amount of time required for the sensor to respond and "close in" on the final value. In fact, the response of the circuit has a "time constant" of approximately 1 second. In a practical sense, this means that the output signal will close 63% of the difference in levels each second.

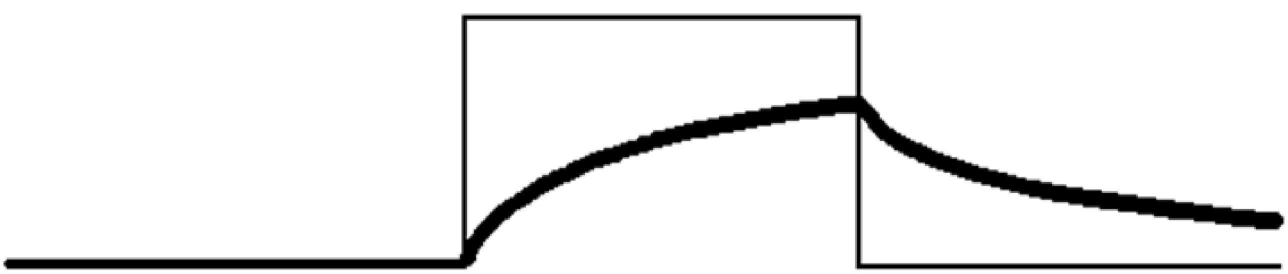


Figure 6 – The thick line illustrates "actual" response vs. idealized thin line.

What does this mean in numbers? Here is a small table that will illustrate how the sensor would respond to a step change of vibration and remain at the new level indefinitely. Immediately after the zero (0) second time the input changes to 0.75 inches/second (ips) and remains at that level.

Time	0 sec.	0.00001 sec.	1 sec.	2 sec.	3 sec.	4 sec.
Input	0.25 I.P.S.	0.75	0.75	0.75	0.75	0.75
Output	0.25 I.P.S.	0.25	0.565	0.682	0.725	0.74

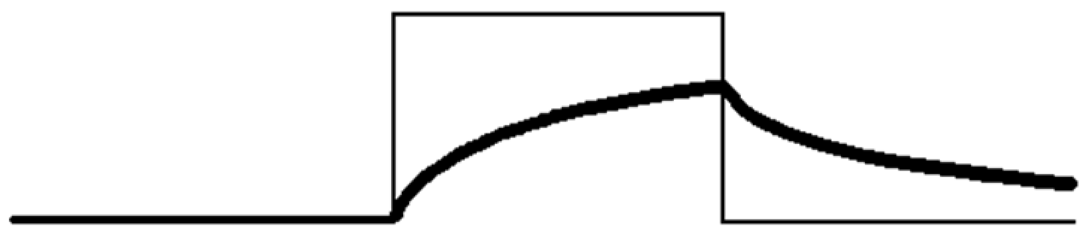
Table 1 – Sensor response to a step change in vibration.

Wilcoxon Sensing Technologies
8435 Progress Drive
Frederick, MD 21701
USA

Tel.: +1 (301) 330 8811
Fax: +1 (301) 330 8873
Email: info@wilcoxon.com
www.wilcoxon.com

As Table 1 illustrates, the output will close 63% of the difference between the two vibration levels in one second and will have closed 95% of the difference in three seconds.

As a second example, let us consider a step change in vibration where the level changes, but only stays at the higher level for one second. After one second the vibration level returns to the original level and remains there indefinitely. Table 2 illustrates the results for this one-second "transient."



Time	0 sec.	0.001 sec.	1 sec.	1.001 sec.	2 sec.	3 sec.	4 sec.
Input	0.25 I.P.S.	0.75	0.75	0.25	0.25	0.25	0.25
Output	0.25 I.P.S.	0.25	0.565	0.565	0.367	0.293	0.266

Table 2 – Sensor response to a 1-second transient.

As this example shows, the change in vibration was 0.5 ips. However, only 0.315 of that change (0.25 + 0.315 = 0.565) was processed through the sensor circuitry when the input step decreased back to its original value. After the step returned to its original value of 0.25 ips, the circuit took three seconds to allow the output to drop back to 0.266 ips and will eventually reach the level of 0.25 ips. Figure 7 is a graphical representation of this one-second transient response of the PC420 sensor.

Summary

The PC420-series LPS™ are designed to aid plant personnel in trending the vibration condition of their important machines. The ability of the DCS/PLC systems to acquire, trend and alarm overall vibration data from machines will assist in the predictive maintenance function. Vibration monitoring can be extended to many machines that need more frequent monitoring than traditional data collection routes can provide. Vibration technicians can focus on analyzing the condition of machines that have already shown increasing vibration levels, rather than having to walk a route to all machines regardless of condition.

Displaying the vibration trend data to plant operating personnel will help them become aware of the vibration condition of their machinery, and focus their efforts on those machines that show signs of impending failure.

Wilcoxon Sensing Technologies
8435 Progress Drive
Frederick, MD 21701
USA

Tel.: +1 (301) 330 8811
Fax: +1 (301) 330 8873
Email: info@wilcoxon.com
www.wilcoxon.com