

4-20 mA LPS™ series transducer selection guide



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Introduction

With the availability of 4-20 mA vibration transducers, plant personnel can now input vibration information directly to their Programmable Logic Controller (PLC) or Distributed Control System (DCS). This capability allows plant personnel to trend overall vibration data on their machines and correlate vibration data to plant operating conditions, and allows plant operators to schedule maintenance tasks on machinery.

A trained vibration analysis technician has traditionally been the person to evaluate the mechanical condition of machinery in a Condition Based Maintenance (CBM) program. Now, transducers that can provide plant personnel with an indication of the overall vibration levels can help guide a CBM program even when there is no vibration technician available to determine machinery condition.

Wilcoxon's loop powered sensors (LPS™) are self-contained 4-20 mA vibration transmitters. LPS™ transducers can directly input a 4-20 mA signal to a plant's control system and make the vibration condition of machines available to operating personnel. Machinery critical to the operation of the plant can be monitored continuously. This data can then be used to aid and assist the operating personnel in determining when to perform maintenance, as well as direct them to machines with the most severe vibration problems.

This selection guide will help in choosing the proper range and type of transducer.

It is not the purpose of this document to provide detailed instructions for analyzing machinery vibration problems. There are many other useful publications that can aid in diagnosing vibration problems. Links to such useful information can be obtained from www.wilcoxon.com, by emailing info@wilcoxon.com or by calling Wilcoxon at (301) 330-8811.

Predictive maintenance and vibration monitoring

Using predictive maintenance (PdM) technologies to track machine health is a proven industry best practice. Vibration monitoring is a critical part of any effective PdM strategy. Monitoring plant machinery health reduces outages and downtime, improving cost-efficiency.

Wilcoxon Sensing Technologies supplies an extensive line of vibration monitoring sensors and monitoring instruments that provide a multitude of machinery condition information. Wilcoxon 4-20 mA loop powered sensors makes machine health monitoring a convenient, reliable and cost-effective option for a wide array of plant assets. The LPS™ series of sensors outputs a signal between 4 mA and 20 mA that correlates directly to the average vibration of the machine being monitored. This provides a simple means to trend the relative level of vibration and drive your maintenance strategy only as needed for a cost-effective operation and help you to prevent machine failures before they occur.

Using vibration monitoring, PdM can detect:

- shaft misalignment
- rotor imbalance
- gear failure
- bearing faults

LPS series transducers are available with a host of features to meet the requirements of every application:

- Configured with peak, true peak or RMS output signals, representing either velocity or acceleration.
- Dual output of temperature and 4-20 mA vibration signal provide critical data for temperature-sensitive operations.
- Dual output of dynamic and 4-20 mA vibration signal units provide an effective way to trend vibration data (4-20 mA signal) and still have access to the dynamic vibration signal for more extensive analysis.
- For very harsh environments, many units are available with intrinsically safe operation or explosion-proof cases.

Selection considerations

Velocity is the primary measurement of machinery vibration. While there are some applications that require displacement limits, velocity is most often used for vibration measurements on the external case of machines. Since Wilcoxon LPS series transducers are mounted on the external case of machines, velocity would be the best measure to use for condition assessment. The LPS series is available in units that measure vibration in terms of velocity or acceleration for condition assessment.

LPS series transducers are purchased with a specific full-scale setting. The full-scale is not adjustable by the user. Condition evaluation and the ISO 10816 standard for vibration measurement should be used to determine the best full-scale range for a particular monitoring environment.

Full scale selection guidelines

>> What is the normal overall vibration level of the machine?

When the normal vibration level of a machine is used to guide selection, the transducer will be able to give a reliable reading with enough resolution to determine minor variations from normal vibration levels. The normal level of vibration should fall within 10% to 20% of the full-scale range of the transducer. For example, a machine that has a normal overall vibration velocity of 0.15 inches per second (ips), peak, might be monitored best with a transducer having a full-scale range of 1.0 ips peak.

>> What is the limit for unacceptable vibration?

Manufacturer specified limits for the machine's vibration should be used as a guide to selecting the proper range for an LPS series transducer. When the manufacturer has not specified limits, the ISO standard can be used as a guide. For example, the ISO standard indicates that a 200 HP (150 kW) motor with a rigid rotor would have an unacceptable vibration at 0.25 in/sec (peak) which is 4.5 mm/sec (RMS).

>> Is over-range capability for trending desired?

The standard ranges available in the LPS™ Series will allow for some over-range capability, but some users may wish to have more. Consider a 50 HP motor driving a fan with a history of cracks. When cracked, the fan may exhibit vibration of 1 to 2 IPS. Here it may be desirable to use a transducer with a full-scale range of 2.0 IPS to accommodate measuring the fan imbalance when cracked blades occur.

ISO 10816 guidance

Assistance in determining rotating machinery condition is now available within the ISO 10816 Standard, "Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts". The portion of the ISO 10816 that is most useful for helping to determine vibration limits and, hence transducer selection, is part 3, "Industrial machines with nominal power above 15 kW and nominal speeds between 120 revolutions per minute and 15,000 revolutions per minute when measured in situ."

Machines are classified into groups according to machine type, rated power or shaft height. Additionally, the group vibration zones are separated according to whether the machines operate above or below 80% of the first shaft critical speed. Machines that have their main excitation frequency (usually running speed) below 80% of the first critical speed in the direction of measurement are considered to be operating in the rigid rotor mode. Machines with their main excitation frequency above 80% are considered to be operating in the flexible rotor mode.

Equipment groups

- **Group 1:** Large machines with rated power above 300 kW (~400 HP); electrical machines with a shaft height at or above 315 mm (12.4"). These machines normally have sleeve (journal) bearings.
-
- **Group 2:** Medium-size machines with a rated power above 15 kW (~20 HP) up to and including 300 kW (~400 HP); electrical machines with a shaft height between 160 mm and 315 mm (6.3" to 12.4"). These machines usually have rolling element bearings and run at speeds above 600 revolutions per minute.
-
- **Group 3:** Pumps with multivane impeller and with separate driver (centrifugal, mixed flow, or axial flow) with rated power above 15 kW.
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- **Group 4:** Pumps with multivane impeller and with integrated driver (centrifugal, mixed flow, or axial flow) with rated power above 15 kW.

Evaluation zones

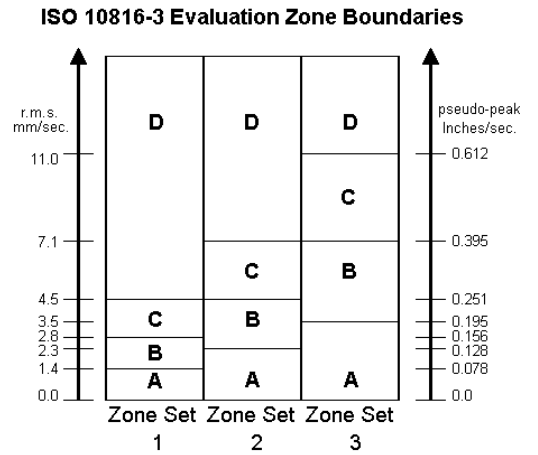
The following evaluation zones are defined to permit a qualitative assessment of the vibration of a given machine and provide guidelines on possible actions.

Zone A: The vibration of newly commissioned machines would normally fall within this zone.

Zone B: Machines with vibration levels within Zone B are normally considered acceptable for unrestricted long-term operation.

Zone C: Machines with vibration levels within Zone C are normally considered unsatisfactory for long-term continuous operation. Generally, the machine may be operated for a limited period in this condition until a suitable opportunity arises for remedial action.

Zone D: Vibration values within this zone may be of sufficient severity to cause damage to the machine.



The ISO 10816-3 recommended evaluation zone boundaries for the various groups of equipment, referring to the table of Zone Set boundaries, as follows:

Equipment	Rotor mode: rigid	Rotor mode: flexible
Group 1 machines over 300 kW	Zone set 2	Zone set 3
Group 2 machines between 15 and 300 kW	Zone set 1	Zone set 2
Group 3 pumps, separate driver, >30 kW	Zone set 2	Zone set 3
Group 4 pumps, integrated driver, >30 kW	Zone set 1	Zone set 2

Output types available

All Wilcoxon broadband LPS series transducers are available with output calibration in terms of peak, RMS or true peak. The frequency banded versions only offer peak or RMS output calibration.

Figure 1 shows a simulated pulse of 10 g amplitude and 2.5 ms duration. This kind of pulse will not produce a significant change in the output of the tradition root-mean-square (RMS) output transmitter. The RMS energy in such a short duration pulse is not significant enough to produce much charge in the output loop current.

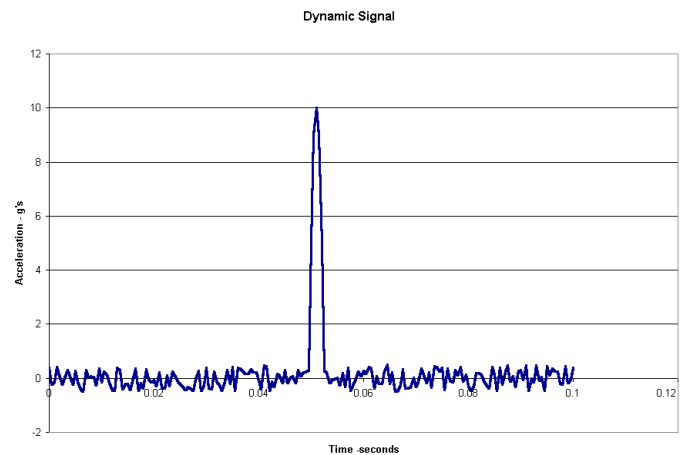


Figure 1

Figure 2 shows the difference between the response of an RMS transmitter, a peak transmitter, and the Wilcoxon true peak transmitter to the same simulated pulse. The RMS and peak outputs change very little as a result of the transient acceleration pulse. However, the true peak signal captures the pulse level very accurately.

Capturing the peak is only one part of the function of true peak detection. If the transmitter were to simply track the true peak, the output would be changing rapidly all during the sampling process of the PLC/DCS system. Most PLC/DCS systems will sample input just once per second. So how can the system know when a transient signal has occurred?

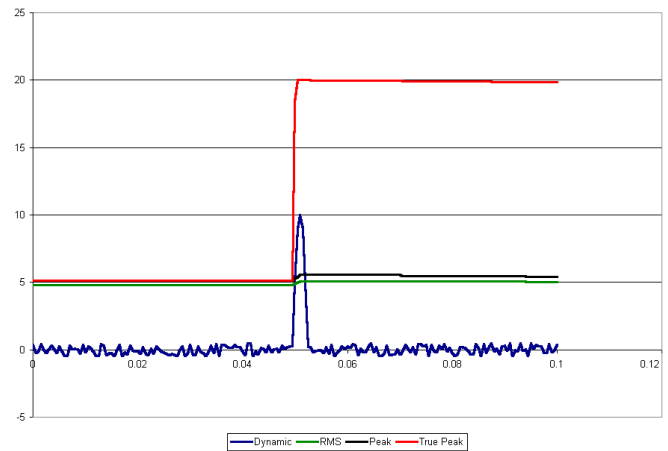


Figure 2

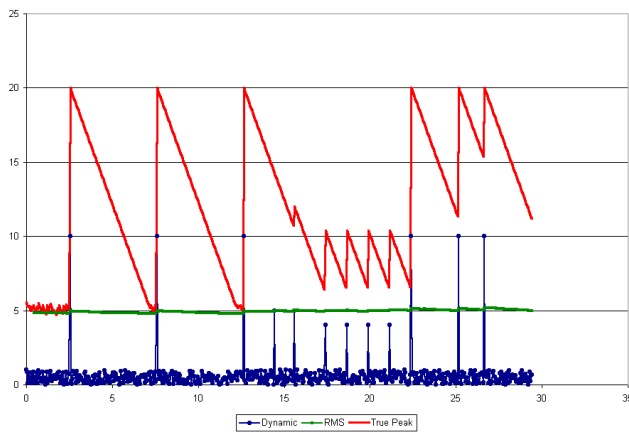


Figure 3

The Wilcoxon true peak detector will capture the peak, then ramp back to the ambient vibration peak level at 20% of full scale per second. Figure 3 illustrates that the output current went up to 20 mA at the occurrence of the peak.

It then ramped back down over a time period of almost 5 seconds. During this “ramp down” the PLC/DCS has multiple opportunities to sample the signal and record the transient event.

So how do these peak detecting transmitters handle multiple transient signals such as those caused by loose components or parts? Figure 3 illustrates the relative difference between the RMS and true peak transmitters.

As more and more transient pulses are detected, the true peak output tends to “remain” at a high level. As long as the incoming new pulse exceeds the current value being output from the transmitter, the output will rise to the new level before ramping down.

This capability allows for use of the true peak detection units for detecting the beginning of impacting events resulting from loose components. It is also useful for monitoring other transient events that produce high acceleration spikes during operation. Pump cavitation often produces a sound characterized as “pumping rocks” when cavitation occurs. The “water hammer” of piping systems can also be monitored, since the peak detection unit is sensitive enough to capture those events as well.

Vibration transmitters generally compute the RMS value of the vibration signal. Peak output transmitters simply use the convention of multiplying by the ratio of the RMS to peak in order to calibrate their output. This results in a “pseudo-peak” output in that it is a peak value if the entire energy of the vibration were a single sinusoidal signal. In a traditional transmitter calibrated for 1.0 ips peak, on the 4-20 mA output, an RMS sinusoidal signal at 0.707 ips RMS will produce the full 20 mA of loop current.

The true peak detection method overcomes the insensitivity of transmitters to short-duration transient events. The peak and RMS calibrated models produce an output signal representative of the overall vibrational energy of the machine. The overall vibration is often the value that should be trended to maintain a good picture of overall machine health. The ISO standard, in fact, is based on measuring the overall RMS value of the machine vibration. However, when fault conditions for a particular machine can be associated with looseness of components, it may be better to use an LPS series transducer with true peak detection (see Figure 4).

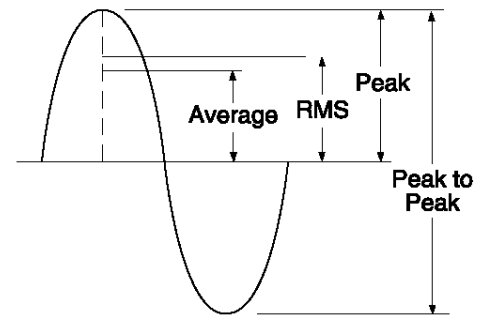


Figure 4

Frequency banded transducers

The broad frequency range that the typical 4-20 mA vibration transmitter monitors does not allow for using the typical 4-20 mA transducers for machinery diagnostics. That is because the output is a sum of the total energy of vibration. Machinery diagnostic work requires knowing more about what is happening with the vibration within a narrow range of frequencies.

Frequency banded low frequency velocity sensor

Most work orders generated within plants for maintenance actions are to re-balance or realign machines. The frequency components generated by balance and alignment problems are at the running speed of machines or twice the running speed (see Figure 5). Most plant heavy machinery is motor-driven and the motors typically run at speeds between 600 RPM (10 Hz) and 1200 RPM (20 Hz). Using a transducer that is focused on the frequency span encompassing imbalance or misalignment frequencies can have a great benefit for maintenance actions.

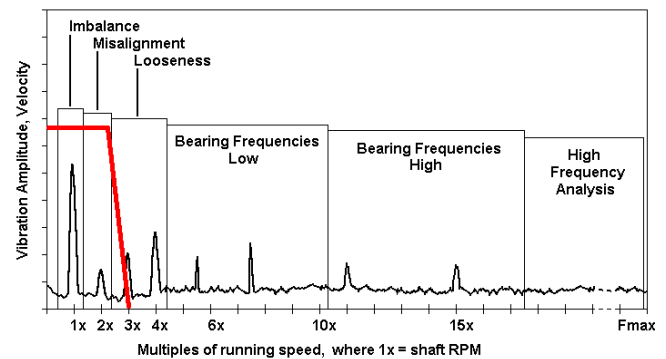


Figure 5

Wilcoxon offers special frequency banded 4-20 mA transducers. The PC420VP-10-B3041 uses high-pass and low-pass filters before the detection circuitry to focus the output detection to the range between 3 and 40 Hz (180 and 2400 CPM) to process and compute the vibration level output to the 4-20 mA process loop. This focus of analysis enables users to trend only the low frequencies of vibration associated with balance or alignment problems on most heavy machines.

The PC420VP-10-B3041 transducer gives plant personnel the opportunity to trend the vibration level at the fundamental running speed for a wide variety of machines. For example, a motor or pump running at 1200 RPM has its fundamental speed at 20 Hz. When using the PC420VP-10-B3041 to measure horizontal vibration levels at the bearings, the major contributor to the output vibration level of the frequency banded transducer will be the 1200 RPM (1x) component of shaft vibration.

Separating this 1x running speed value from all the other potential contributors to the overall vibration level allows plant personnel to determine the effect of imbalance. This can be particularly important in fan operation. Using the PC420VP-10-B3041 along with a PC420VP-10 transducer will allow the user to distinguish the 1x vibration from other possible vibration frequencies present.

For plants wanting to fully monitor the balance and alignment condition of machines, three PC420VP-10-B3041 transducers should be used. Figure 6 illustrates a motor-pump set, where the inboard bearing of the pump has thrust bearing capacity. It will be the position that will best indicate any alignment problems. One transducer should be mounted there in the axial direction. Two more should be used to monitor for imbalance, one on each of the shafts. The outboard pump bearing is the best location on the pump. Either the inboard or the outboard location on the motor can be used, but the choice of mounting location should be guided by historical failure data. Many users favor the inboard location as it can assist in detecting radial vibration problems with the inboard pump bearing.

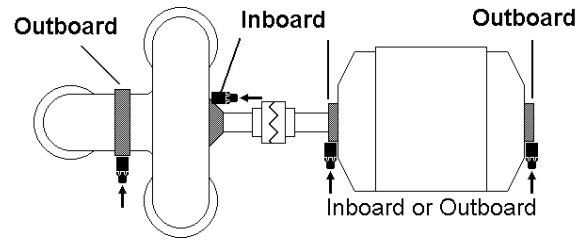


Figure 6: Top view of a motor-pump set with recommended mounting locations

Frequency banded high frequency acceleration sensor

Wilcoxon also offers a special high frequency banded 4-20 mA acceleration sensor. The PC420AR-10-3223 uses high-pass and low-pass filters before the detection circuitry to focus the output detection to the range between 300 and 2,000 Hz (18,000 and 120,000 RPM). The transducer uses only the frequencies in this range to process and compute the vibration level output to the 4-20 mA process loop. Focusing the analysis enables users to trend only the higher frequencies of vibration associated with pump cavitation problems.

Dual output 4-20 mA transducers

The dual output transducers have both a 4-20 mA loop signal output and a broadband dynamic signal output. These types of transducers are useful where plant personnel have portable spectrum analyzer equipment. With the dual output type, the user has access to the dynamic vibration signal that is being used to drive the 4-20 mA output loop. This has been very beneficial to personnel using a portable FFT analyzer to check the spectrum of the signal. This option is often used in plants with on-site vibration technicians since it permits both operating and maintenance personnel to access the type of data each needs with a single transducer. The dynamic output can be either 100 mV/g (acceleration) or 100 mV/ips (velocity).

One of the benefits of the Wilcoxon LPS series is the choice of either acceleration or velocity output for the dynamic signal, regardless of the type of 4-20 mA loop signal. For velocity loop output transducers, the dynamic output can be acceleration or velocity; the same is true of the dynamic signal output for acceleration loop output transducers.

Hazardous area installations

Wilcoxon provides 4-20 mA transducers certified for hazardous area installations. The transducers carry CSA approvals for the US and Canada, as well as ATEX certification. Models are available for intrinsically safe and explosion-proof installations.

	Approval agency	Installation areas
Intrinsically safe model (PC420-IS)	CSA	Class I, Div 1, Groups A, B, C, D T3C Ta = 85°C max
	LCIE - ATEX	II I G Ex ia IIC T4 Ga -40°C ≤ Ta ≤ +85°C
	IEC	IECEX
Explosion-proof model (PC420-EX)	CSA	Class I, Div 1 Groups A, B, C, D Class II, Div 1 Groups E, F, G Class III T3C Ta = 85°C max
	LCIE - ATEX	II 2 G Ex d IIC T3 II 3 G Ex nA IIC T3 -40°C ≤ Ta ≤ +85°C

Intrinsically safe models

Velocity			Acceleration		
Top connector	Side connector	Integral connector	Top connector	Side connector	Integral connector
PC420VP-05-IS	PC421VP-05-IS	PC423VP-05-IS	PC420AP-05-IS	PC421AP-05-IS	PC423AP-05-IS
PC420VP-10-IS	PC421VP-10-IS	PC423VP-10-IS	PC420AP-10-IS	PC421AP-10-IS	PC423AP-10-IS
PC420VP-20-IS	PC421VP-20-IS	PC423VP-20-IS	PC420AP-20-IS	PC421AP-20-IS	PC423AP-20-IS
PC420VP-30-IS	PC421VP-30-IS	PC423VP-30-IS	PC420ATP-05-IS	PC421AR-05-IS	PC423AR-05-IS
PC420VP-50-IS	PC421VP-50-IS	PC423VP-50-IS	PC420ATP-10-IS	PC421AR-10-IS	PC423AR-10-IS
PC420VTP-05-IS	PC421VR-05-IS	PC423VR-05-IS	PC420ATP-20-IS	PC421AR-20-IS	PC423AR-20-IS
PC420VTP-10-IS	PC421VR-10-IS	PC423VR-10-IS	PC420AR-05-IS		
PC420VTP-20-IS	PC421VR-20-IS	PC423VR-20-IS	PC420AR-10-IS		
PC420VTP-30-IS	PC421VR-30-IS	PC423VR-30-IS	PC420AR-20-IS		
PC420VTP-50-IS	PC421VR-50-IS	PC423VR-50-IS			
PC420VR-05-IS					
PC420VR-10-IS					
PC420VR-20-IS					
PC420VR-30-IS					
PC420VR-50-IS					

Appendix – model number ordering guide

Not all models have all options available. To see available options, go to buy.wilcoxon.com/vibration-sensors-4-20ma.html and review the data sheet for a particular model.

Loop powered sensors	PC420	top exit
	PCC421	side exit, small size
	PC421	side exit
	PCC423	side exit with integral cable, small size
	PC423	side exit with integral cable
	PC425	side exit with temperature sensor
	PC427	side exit with temperature sensor and integral cable

PC42 _ _ - _ - _ - _
PCC42 _ _ - _ - _ - _

Model	4-20 loop output		Ranges		Optional configurations	Cabling / connections options
			A	V		
PC420	AP AR ATP	VP VR VTP	-05 -10 -20 -30 -50	-05 -10 -20 -30 -50	DA, DV, IS, EX	-
PCC421	AP AR	VP VR	-05 -10 -20 -30 -50	-05 -10 -20 -30 -50	-	R6 M12-4
PC421	ATP	VTP	-05 -10 -20 -30 -50	-05 -10 -20 -30 -50	DA, DV, IS	-
PCC423	AP AR	VP VR	-05 -10 -20 -30 -50	-05 -10 -20 -30 -50	-	J9T2A J10
PC423	ATP	VTP	-05 -10 -20 -30 -50	-05 -10 -20 -30 -50	DA, DV, IS	-
PC425	AP AR ATP	VP VR VTP	-05 -10 -20 -30 -50	-05 -10 -20 -30 -50	DA, DV	-
PC427	AP AR ATP	VP VR VTP	-05 -10 -20 -30 -50	-05 -10 -20 -30 -50	DA, DV	J9T4 J9T4A J95

AP Acceleration peak
AR Acceleration RMS
ATP Acceleration true peak

VP Velocity peak
VR Velocity RMS
VTP Velocity true peak

DA Dynamic acceleration, 100 mV/g
DV Dynamic velocity, 100 mV/ips

IS Intrinsically safe unit
EX Explosion proof unit