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VIEWpoint

Issue #3

Unconventional wisdom.

Why your PI System is perfect for vibration data.

For the better part of three decades, the vibration world has patiently explained to machinery engineers, process control engineers, IT professionals, and everyone else that would listen why its data was *special*. Vibration data, we were told, wasn't like process data or any other type of data that flowed through industrial control networks, and hence it couldn't be stored in a conventional process historian. Instead, it needed its own, very special repository because it was – after all – *special*.

Bandwidth, speed, storage volume requirements, preservation of phase (not just amplitude) data – these are all some of the many reasons given for vibration data's "special-ness". But what happens when technology has experienced such a sea change in its capabilities that our assumptions about what is not just possible – but practical – beg to be revisited?

This is precisely the situation we found ourselves in four years ago when deciding whether SETPOINT's condition monitoring software needed to be like everyone else's or not. Namely, did we need to engineer yet another proprietary database used only to accommodate the special needs of vibration data, or was conventional wisdom in need of revision? What if we could use the real time data infrastructure that most customers were

already using for their process data – the OSIsoft® PI System – to store vibration data? How would this impact security for remote data access? Ease of integration and correlation between process and mechanical condition data? IT support costs? Would it require unacceptable compromises to vibration data resolution and richness while grinding the process historian to a halt by overtaxing it with too much data, too fast?

Turn to page 3 for the answers.

Meet Larry McDonald.

How do you go in the space of three short years from being completely new to the PI System to being one of its foremost power users, harnessing things like "Asset Framework" and "Event Frames" and "Swinging Door Algorithms" to produce the world's first vibration monitoring software that relies entirely on a process historian for its database? You start by being Larry. And then you quietly go about your business as though it's all in a day's work.

Larry at work.
Larry grew up in Vernal, Utah – a small town in the extreme NE corner of the state, about 20 miles from the Colorado border. He holds a degree in computer science from Utah State University and following receipt of that degree, he studied abroad in Austria, obtaining a minor in German. Ja, herr McDonald spricht fließend Deutsch.

Like many of his SETPOINT cohorts, Larry spent a number of years (1996-2012) as an engineer at Bently Nevada, working on various software projects including System 1 data acquisition, wireless, and Plant Payback, an application that generated highly accurate models of combined cycle power plants and allowed "what if" economic analysis for various thermodynamic performance upgrades.

Larry joined SETPOINT in 2012 to help us develop the heart of our CMS software: the SETPOINT-to-PI Adapter, an elegant piece of code that takes SETPOINT data and seamlessly maps it into the PI System in a completely self-configuring manner that relieves the user from having to create PI tags and build asset hierarchies. What does that mean? It means that once you have configured a SETPOINT rack, you can plug it into PI and *it just works* – there's no redundant effort to configure SETPOINT and then do it all over again in PI. Dankeschön, Larry.

Larry at play.
Larry informed us for this article that he likes to bowl. In his usual, unassuming manner, he casually mentioned that he's bowled two perfect games and two near-perfect (299) games. And, his average is 210. Natürlich.

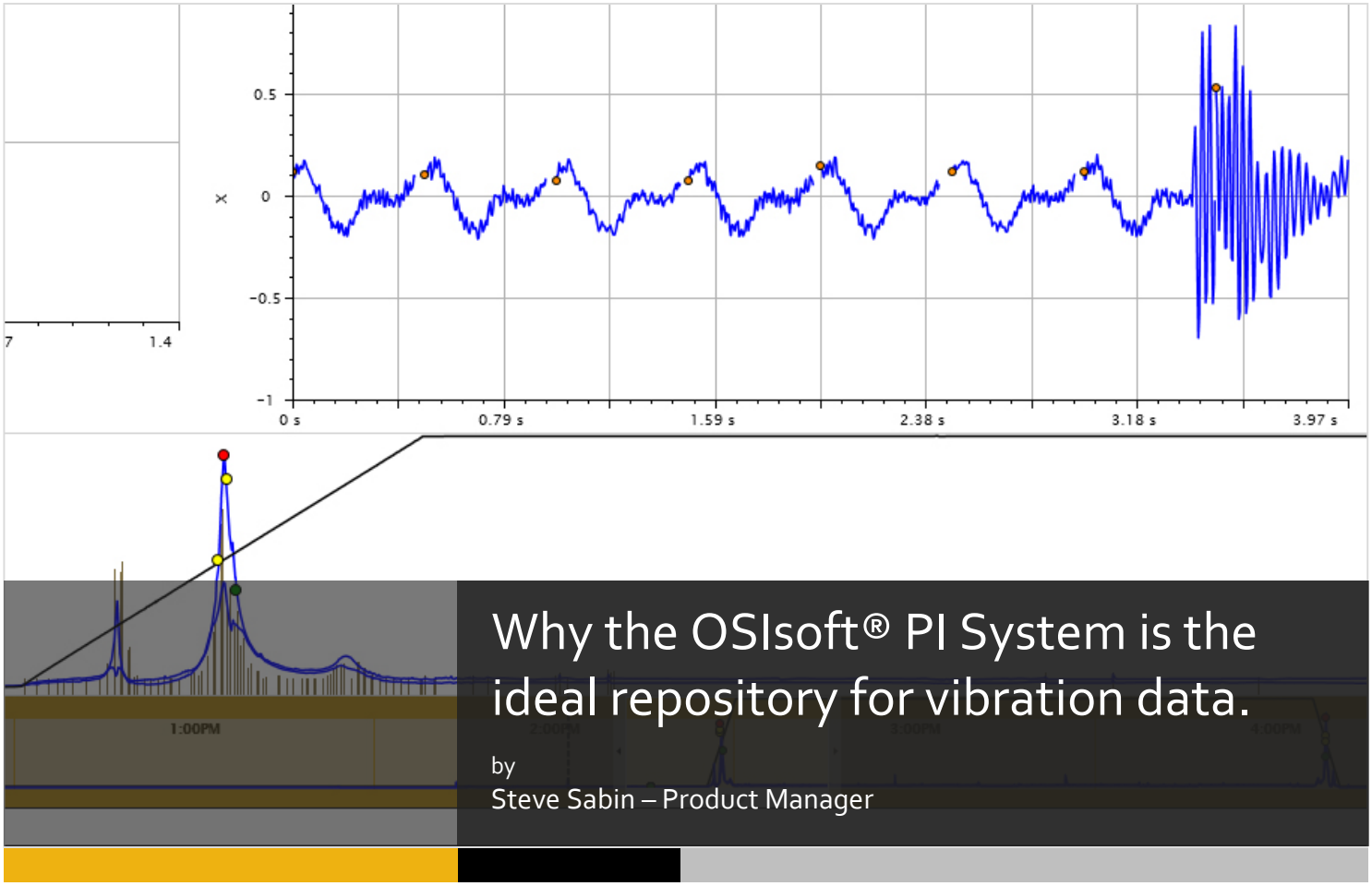
He also likes to hike and his size 9 ½ footsteps can be found on trails throughout Utah, Nevada, and California, followed closely by the smaller footprints of his children (Michael and Madison).

Like many of us, Larry likes to read. His favorite genre is suspense/mystery and a few of his go-to authors are Michael Crichton, Dean Koontz, and David Baldacci. He also enjoys solving puzzles like Sudoku and 2048, which turns out to be a useful skill – not just a hobby – when you write software for a living.

Outside of the office, Larry can be found volunteering in Boy Scouts and as a coach for baseball, soccer, and LEGO® robotics. He's active in his church and his sojourn in Austria actually encompassed two endeavors – one as a student of German and the other as a missionary.

On the topic of volunteering, he has offered to assist us with one other thing: help us choose new SETPOINT shirts the next time we need something for a trade show. Hint: his favorite style rhymes with "rolling" and was a wardrobe staple of Kramer on the TV series *Seinfeld*. Bonus points: what was Kramer's first name and how was it spelled?

Using PI, Larry delivers the data any way we need it. He's so accommodating, we started using the Burger King® "have it your way" slogan when referring to Larry's work. He's got the crown to prove it.



Why the OSIsoft® PI System is the ideal repository for vibration data.

by
Steve Sabin – Product Manager

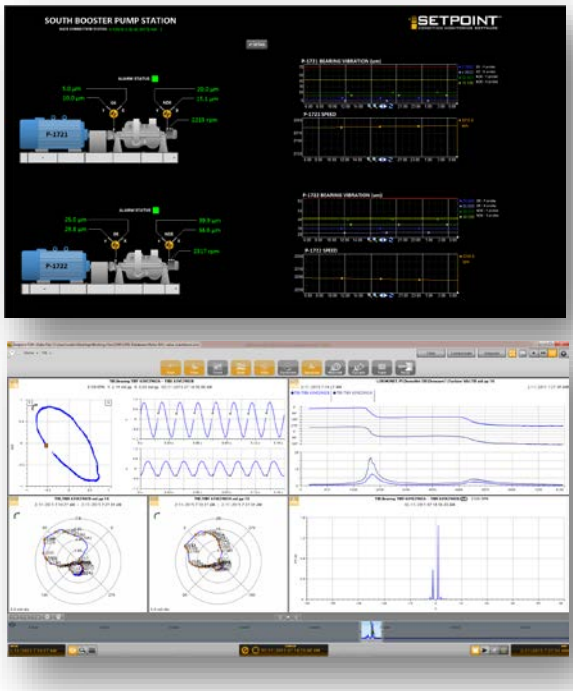
Nowhere is the power of the PI System more apparent than when it comes to storing vibration data – and not just the vibration data you're used to seeing (trends). We're talking about the high-speed waveform data you haven't been able to see until now.

The OSIsoft PI System is unquestionably the world's best known and most widely used process historian. From its origins as a way to historize plant process data on a computer hard drive instead of with analog strip chart recorders, the system has evolved dramatically over the last 30+ years. Today, the system's utility extends far beyond that of an operational data historian and is used in thousands of varied applications, from documenting emissions at power plants to tracking mobile assets like drilling rigs to mapping compressor performance to monitoring energy consumption at cloud-based server farms. However, one application that has historically been considered outside the reach of process historians is that of collecting and displaying high-speed vibration waveform data from rotating machinery. Indeed, I spent the better part of my career explaining to customers why they simply could not entertain doing this in their process historian. The reasons were purely technical - historians were designed for data collected at intervals measured in seconds or minutes or hours - not microseconds. They were simply not fast enough, and even if they could collect the data, they wouldn't be able to visualize it, given the specialized data presentations formats used by vibration analysts and rotating machinery engineers. Things like orbits, spectrums, polar plots, bode plots, shaft centerline, reciprocating compressor cylinder P-V curves, etc.

Fast forward to 2012 as we embarked on our development effort for condition monitoring software to complement our SETPOINT vibration monitoring hardware. We had a choice to make: take the well-traveled path of developing a stand-alone system just for vibration data using a proprietary storage schema and database or take a path nobody had taken before - use a commercial process historian. The decision regarding *which* process historian to use was an easy one: the PI System because of its incredibly widespread use in the industries we serve. But there was a fundamental question to answer first: could it actually handle high-speed data like vibration waveforms where the individual samples were separated by microseconds instead of seconds?

(continued from page 3)

To say we were pleasantly surprised would be an understatement. With the advent of faster and faster processors along with solid-state hard drives, the PI System was more than capable. Indeed, a 300-channel collective of SETPOINT data can generate around 400,000 events per second under worst-case conditions (every channel in transient mode). Today's PI Servers can routinely handle millions of events per second. They are exceptionally good at handling time series data, which was exactly what we needed for vibration waveforms, and they had already proven their suitability for trend data and alarm data. Within a few short months, we had verified that the PI System had everything necessary to fully host vibration data. It meant we did not need to spend man-years developing a place to put our data. We could instead focus on the much easier task of simply visualizing the data we placed into the PI System.



The PI System can be used to deliver not just the things you're used to seeing like trends and current values (top), but also vibration waveforms in all of the specialized plot formats (bottom) used by rotating machinery engineers.

If you are a PI user, the benefits of putting vibration data into PI are numerous and compelling:

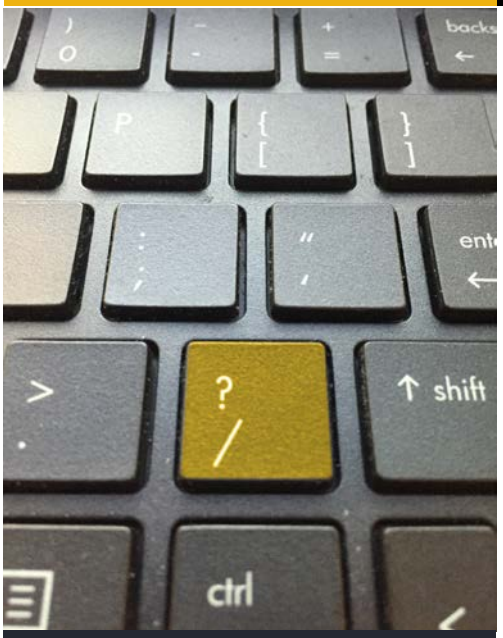
- **PI is secure**. That means remote access to data is no longer a show-stopper.
- **PI is robust**. In many companies, PI is in mission-critical applications and runs on high-availability server arrays with multiple levels of redundancy.
- **PI is IT-approved**. Your IT department will be dealing with a known entity, known software stacks, standard operating systems, and known networking requirements.
- **PI is already in your plant**. The costs to incrementally expand your PI system with tags for vibration data are often an order of magnitude smaller than the costs associate with deployment of a separate silo just for vibration data, with its own operating system requirements, security models, interfaces, and software stack.
- **PI is integrated**. Most machinery problems can be solved more effectively by understanding the process conditions surrounding and impacting the machine - load on a generator, flow through a pump, gas composition in a compressor, and exhaust gas temperature in a turbine are all typical examples. When vibration and process data are in the same repository, it is not necessary to create duplicate databases or perform expensive integration efforts to bring process data into the vibration software. It's *already* together in the same place. PI's outstanding visualization tools for trending and correlating disparate data types can then be used, allowing cause/effect relationships to be understood.

However, in spite of these benefits, PI users are sometimes reluctant to co-mingle vibration and process data collection tasks in the same server. The answer is simple: create another instance of PI and dedicate it to vibration collection. Approximately half of our customers are sharing their PI server used for process data with the vibration collection function while the other half are using a separate instance of PI. Even in these instances of using a separate server, all of the above benefits still apply.

So what if you *aren't* a PI user? Does it really matter what engine was placed under the hood for our condition monitoring software? As a matter of fact, it does. PI is simply superb at handling time series data and it has more than 400 published interfaces to industrial control and automation platforms, meaning it is very easy to get process data into your vibration monitoring environment. PI is also robust and secure, which means that your vibration environment will not be a thorn in IT's side. It is routinely deployed on control-level networks and replicated securely across firewalls and data diodes to give safe access on business networks. Had SETPOINT set out to engineer a purpose-built environment for hosting vibration data, alarm events, process data integration, secure remote access, and to "play friendly" on control and business networks, we could not have done a better job than the hundreds of thousands of man-years that have been invested over the years by OSIsoft engineers in the PI System infrastructure.

We would love to demonstrate for you all the power of the PI System when unleashed on your vibration data. You can learn more in a series of informative videos on our website or by dropping us a note at info@setpointvibration.com and requesting a face-to-face visit or a webinar tailored to your company's specifics.

www.setpointvibration.com



Question of the Month

"How can my 1X amplitude possibly be LARGER than my direct vibration amplitude?"

Intuition suggests that the *sum* of several individual parts will be larger than any one part. It's tempting to think of a vibration waveform in the same way. When we decompose the waveform into its spectral components, we tend to think of the sum of all these components as the direct (overall) amplitude of the waveform. But in the vibration world, when we look at a spectrum, we have to remind ourselves that we are seeing only the *amplitude* of the spectral lines – not the complex *phase* relationships that exist between them. It is these phase relationships that cause individual spectral components to add constructively in some places and destructively in others, yielding occasionally counter-intuitive results – such as a direct amplitude that is actually less than the 1X amplitude. Keep reading for a discussion of the math that substantiates this and an example of a waveform we're all familiar with that exhibits this behavior (1X > direct).

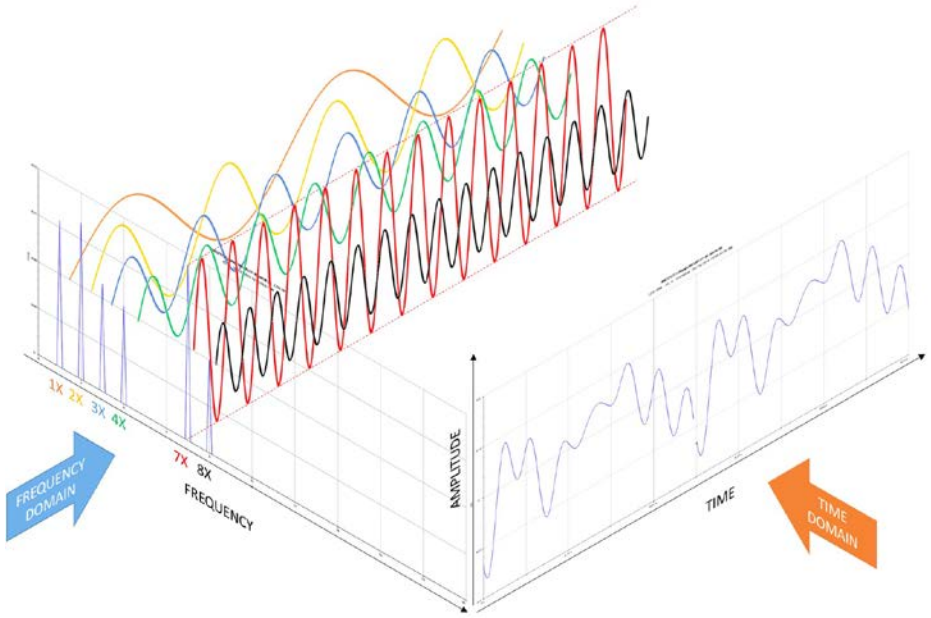


Figure 1: Vibration waveform showing relationship between time and frequency domains.

Figure 1 shows a waveform and its corresponding spectrum displayed with SETPOINT CMS on a recent project in New Zealand. Here, we've broken the waveform out into its constituent sinusoids, showing how two cycles of the waveform appear in the time domain (orange perspective) and in the frequency domain (blue perspective). In this instance, the largest component is actually 7X, the pump's vane passing frequency, and this is shown in red. What we cannot see in the spectrum, however, is the phase relationship between each spectral component. In reality, the sinusoids reinforce one another in some places and partially cancel one another in other places. The result is the complex timebase shown in the figure.

Now, back to our original question. Is it ever the case that the 1X spectral component will have a larger magnitude than the direct (all frequencies) waveform itself? Yes. Although rare, this is occasionally encountered in practice with vibration signals. For an example of a waveform whose 1X component is larger than its direct value, consider the square wave.

Its Fourier series is given by:

$$f(x) = \frac{4}{\pi}\sum_{n=1,3,5\ldots}^{\infty}\left(\frac{1}{n}\sin\frac{n\pi x}{T}\right).$$

Notice that the first term (the 1X component) in the Fourier series has amplitude 4/π, or approximately 1.273. Thus, our square wave has a 1X amplitude that is about 27% higher than its overall (direct) value. Figure 2 shows a square wave and its Fourier series approximations.

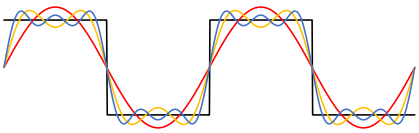


Figure 2: Fourier series approximation of a square wave when one (red), two (yellow), and three (blue) harmonics are included. Notice that the 1X component (red) has an amplitude that is larger than the direct (black) value.

So if you happen to encounter a vibration signal that exhibits a 1X amplitude higher than its direct amplitude, don't immediately assume there's a problem with your instrumentation or with your eyes.

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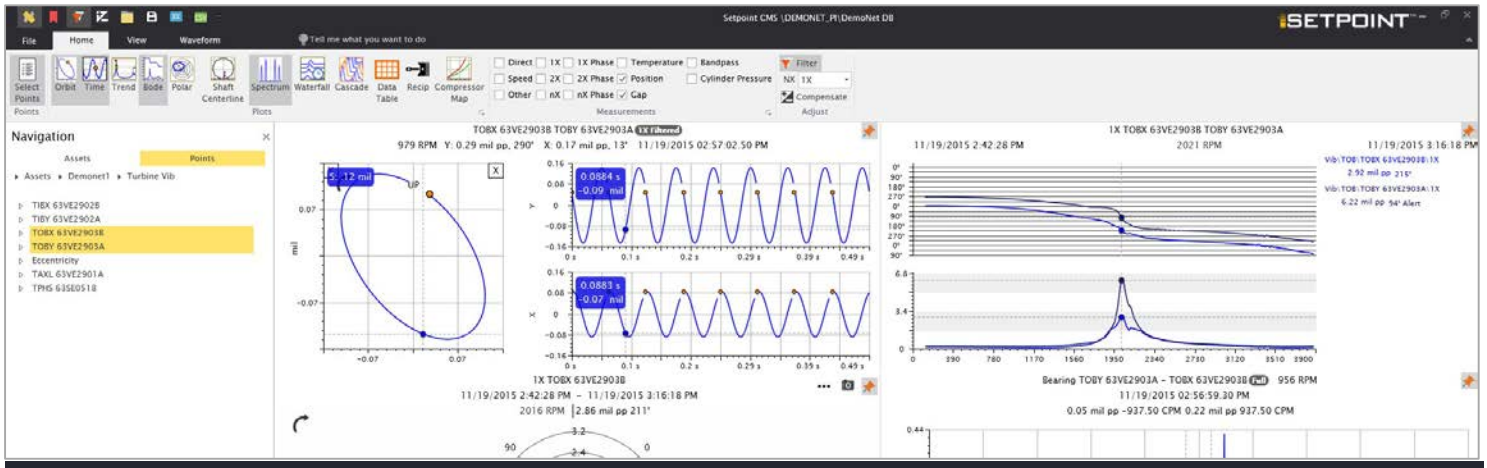

SETPOINT's award-winning CMS software just got even better. Announcing CMS 3.0. Coming soon to a screen near you.

First, we turned the vibration industry on its head by doing what they said couldn't be done – putting everything in the OSIsoft® PI System – *even waveforms*. Then, we made the software so easy to use that you could literally do it from your smartphone. Now, we've added dozens of new features while making it look and work like something you're probably already using: Microsoft® Office. That familiar ribbon interface is just one of the ways we're making condition monitoring software that you'll love to use, and that your IT department will love even more. Coming mid-2016.