May 2016

Issue #4

VIEWpoint

Less is more.

Why fewer modules is better.

Ever notice how the world is converging when it comes to devices? Gone are the days of a GPS, a camera, a calculator, a phone, a video recorder, a voice recorder, a daytimer, a portable gaming console, a portable scanner, a travel alarm clock, and an MP3 player. Chances are, you now carry only a single device – your smartphone – capable of all this and more.

Industrial instrumentation has taken a while to catch up the consumer market where a single device can have multiple utilities. But that was our inspiration in 2011 when we began designing SETPOINT hardware. We took a look at what was in our pockets – our smartphones – and reasoned that our product should work the same way: as few hardware modules as possible (to make spare parts as simple as possible) and a reliance on different apps rather than different hardware. The result was the world's simplest API-670 compliant continuous monitoring system, consisting of only 4 module types: power, communications, temperature channels, and all other channels via our Universal Monitoring Module. The UMM is the workhorse of our system, representing more than 40 different channel types.

They say that imitation is the sincerest form of flattery and we've noticed that our competitors are beginning to copy the numerous innovations we've brought to this industry in the last five years. We smile every time it happens because it validates that our approach is resonating where it matters most: with customers.

Turn to page 3 for a deeper look at the innovation and simplicity that makes our approach so compelling.

Meet Jeremiah Ferguson.

His palette is firmware – the software that's buried deep inside SETPOINT's real time processors. And like painting, there's an art to it – using digital brushstrokes as efficiently as possible. After all, CTRL-ALT-DEL simply isn't an option when you're doing something as important as real time machinery protection. Jeremiah's our go-to guy for this mission critical code. Oh, and he's also our resident sword fighter.

Jeremiah at work.
Jeremiah is truly a local, born and raised in Reno, Nevada - just 45 minutes north of our SETPOINT offices.

Not surprisingly, he chose the University of Nevada, Reno to pursue a degree in Electrical Engineering, obtaining both his Bachelor's and Master's degree from there. Like many engineers, he wasn't sure where he wanted to specialize initially. But exposure to programming and signal processing was all it took for him to lock and load. He may not have known it at the time, but it was the perfect preparation for developing firmware for vibration monitoring systems where lightning fast digital signal processing is required along with highly efficient coding for real time operating systems. If you want to talk shop about 14-pole IIR filters, 105 dB SNRs, 51.2 kHz sampling with decimation, and C-NET bandwidth optimization, Jeremiah's your man. Translation: it's his code that makes the DSP engine inside our UMMs and TMMs the equivalent of a race-ready Formula One car.

Like most of his SETPOINT colleagues, Jeremiah cut his teeth in this business as an engineer at Bently Nevada – first as an intern and then as a full-time employee in 2002. There, he worked on portable data collectors, wireless systems, tachometers, the 1900/65A balance-of-plant monitoring platform, and custom products for the 3500 platform. He joined SETPOINT in 2010 as our firmware czar, back when the product was still just a gleam in our eye. One of the beauties of SETPOINT's design is that a custom product almost never means soldering irons and new circuit board components – it means a couple days of Jeremiah's coding prowess to develop the firmware equivalent of an app for a new channel type.

Jeremiah at play.
With two small children, Jeremiah and his wife Chantal don't have an abundance of spare time that isn't focused on Elric (3) and Bronwyn (1). They are active in their church and Jeremiah volunteers extensive time to both Boy Scouts and local missions projects. As to pastimes, there are some totally unsurprising ones like board games, video games, and reading. But there's also an unexpected little gem to be found amidst the pebbles. "How", you ask, "might parents of a preschooler and a toddler spend the occasional free afternoon?" Why, engaged in *historical fencing*, of course. Yup, when they're not wielding pacifiers and picture books, they can be found flourishing medieval weaponry with the skilled hand-eye coordination that comes from being trained in the style of 16th century master, Salvator Fabris. Tip #1: do not challenge Jeremiah to a duel unless the weapons at-hand consist only of empty gift wrap tubes. Tip #2: if dueling with Chantal, refer to tip #1. Tip #3: do not ask Jeremiah for a haircut – and particularly not "a little off the sides".

Jeremiah and his wife Chantal are trained in the fencing style of Italian master, Salvator Fabris. His 1606 treatise on the rapier, *Lo Schermo, overo Scienza d'Arme* was a bestseller for more than 100 years.

How a simpler hardware architecture lowers lifecycle costs.

by
Steve Sabin – Product Manager

The first thing you'll notice about SETPOINT hardware is that there aren't very many module types. That's by design, as we thought a single module type that did pretty much everything (40 different channel types and counting) was going to make a big impact on the industry. And we were right.

Turns out, our Universal Monitoring Module (UMM) tapped into more than a few important customer needs. We kept the same approach elsewhere in the system by designing universal hardware at every turn. The result was a system that requires only four different modules: one to accept power, one to provide communications, one to monitor temperature inputs, and one to monitor every other type of input. That's it. Four simple modules that deliver every aspect of API 670-compliant machinery protection and condition monitoring. Let's start by looking at each one in detail and describing what it does. We'll then explain how this simplicity benefits you.

1. **Rack Connection Module (RCM)**

The RCM is an exceedingly simple module because it has an exceedingly simple job: take power from an external source and route it to our instrument's backplane. Because it is so simple, it has very little active circuitry, and this results in an exceptionally high MTBF (365 years) which is exactly what you want in the module that is going to route power to the rest of the system. It accepts up to two independent 24Vdc external power sources. Unlike systems with centralized power supplies that reside inside the rack, SETPOINT keeps power supply heat outside the rack, were it belongs. We also eliminated common mode failure points by abandoning the practice of regulating voltages centrally, instead leaving this task to each independent monitoring module so that in the unlikely event of a regulator failure, it would affect only one module, not the entire rack. The RCM also accepts rack control signals like Trip Multiply, Inhibit, Reset, and Special Alarm Inhibit (used primarily as part of the start-up permissive logic with aeroderivative gas turbines). Finally, it provides the System's OK relay, indicating the global health of all parts of the SETPOINT rack and its connected transducers.

2. **System Access Module (SAM)**

The SAM is not part of the critical protection path and is therefore not required in the simplest possible machinery protection deployment. However, when digital communications are required between the rack and the outside world, the SAM provides this via 5 connection ports:

i. MODBUS TCP communications (100 Mb Ethernet)
ii. MODBUS serial communications (RS-232, 422, and 485)
iii. Condition Monitoring Software (CMS) (1 Gb Ethernet)
iv. Touchscreen display communications
v. SD Card

(continued from page 3)

The information written to the SD Card is identical to the information written out of the CMS port and turns the SETPOINT rack into an embedded "flight recorder" capable of holding approximately one month of data on just 32GB of removable memory media. In contrast, the CMS port is used when connecting to our online condition monitoring software, based entirely on the OSIsoft PI System as its database. The SAM utilizes two processors - one for Modbus communications and the other for all other communications (touchscreen, SD Card, and CMS). Its design means that protocols other than Modbus (such as OPC-UA) can be easily introduced without the need for a different module type, nor are different module types for communications with internal or external displays required. The SAM is thus a "universal" communications module.

3. Temperature Monitoring Module (TMM)

The TMM is a fully self-contained 6-channel monitor specifically intended for thermocouples and RTDs. By self-contained, we mean that separate relay modules and I/O modules are not required. In fact, the module can be removed from the rack and act as an independent 6-channel monitor with its own embedded relays, signal conditioning, analog 4-20mA outputs, and configuration port (USB) – all it needs is external 24Vdc power. In the SETPOINT architecture, the rack itself serves as little more than a mechanical "container" for the individual monitoring modules and as a way for them to send data to and from the SAM. It is this design that gives the system such an excellent MTBF and suitability for safety instrumented applications where SIL 2 or SIL 3 must be achieved.

4. **Universal Monitoring Module (UMM)**

We've saved the best for last as the UMM is an amazingly powerful piece of hardware. Like the TMM, the UMM is completely self-contained, providing four channels of independent monitoring with its own on-board relays, signal processing, waveform capture, buffered signal connections, config port, and analog 4-20mA outputs. The UMM is unique in the industry in that it doesn't provide just *many* of the various speed, position, vibration, and other measurements used on rotating and reciprocating machinery - it provides *all* of them.

Why it matters.

Other systems have recently appeared with modules that are mostly universal in nature, so why is SETPOINT special? For starters, most other systems use different I/O modules for each different transducer type – even if they have a common monitor module. This means dozens of different types of I/O modules and the corresponding spare parts burden. In contrast, SETPOINT integrates the I/O module and the monitor module. Like everything else about SETPOINT, it's simple. No mismatches to worry about. Your spares for vibration channels consist of precisely one module type. Like we said, simple.

Second, SETPOINT is flexible. Because SETPOINT relies on universal hardware, field changes to tailor your system to your exact needs are done with a laptop and a few mouse clicks.

Third, enhancements to the system consist of firmware upgrades, meaning your SETPOINT system continually gets better with time, but without requiring you to upgrade your hardware. And because the hardware doesn't need to be changed to extract more functionality, you don't have to worry about impacts to hazardous area approvals. The only thing that changes is your palette of available apps. In fact, since inception, our UMM and TMM hardware hasn't changed, but we've meanwhile introduced more than a dozen firmware upgrades, each one introducing new channel types and new capabilities, and each one provided at no charge to our customers. Simply download it from our website.

Fourth, SETPOINT hardware's universality means it can be very easily scaled from critical machinery applications - where a full-suite of API 670 functionality is necessary - down to less-critical applications. The same hardware can even be used in safety-critical applications where TMR (triple modular redundancy) is warranted. While most everyone else in the industry is busy fragmenting their product line into different hardware with different capabilities, we've made SETPOINT so simple and so scalable that it is quite practical to use on everything from a 13-bearing steam turbine generator train with 50+ channels to a small motor/pump set requiring only 2-3 channels. Unlike others, we also use the same system and same cards for condition monitoring, rather than protective systems using one set of hardware and condition monitoring systems (communications processors) using entirely different hardware. It's part of our fundamental design philosophy: one size truly fits all.

We hope we've whet your appetite here for a different kind of hardware experience than you may be used to. And in case you're wondering whether all of this hardware was designed by people with requisite real-world vibration monitoring experience, it might interest you to know that the people that envisioned and designed all of these Bently Nevada systems...

3300 | 2201 | 1900/65 | 3701 | 990 | ADRE 208 | System 1 | Trendmaster DSM | 1701 | 3500

... are the same people that design, build, and stand behind SETPOINT. That's experience you can rely on.

Question of the Month

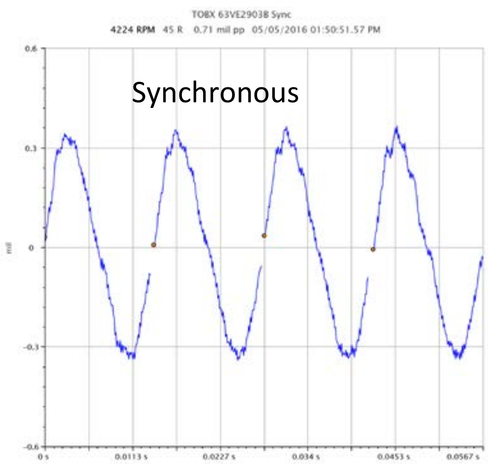
"Why are both synchronous and asynchronous waveforms collected and how are they used?"

By Matt Nelson, Engineer Director

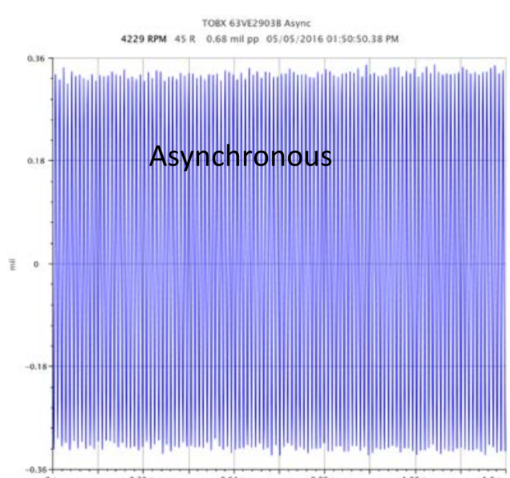
Asynchronous sampling does not require a phase reference transducer and samples the waveform at a fixed rate (samples/second) regardless of machine speed. In contrast, synchronous sampling does require a phase reference transducer because it samples the waveform at fixed intervals of *phase* (not time) over each machine revolution. For example, a synchronous waveform collected at 128 samples/revolution will take a sample every 2.8125 degrees of rotation. Synchronous sampling automatically changes the number of samples per second collected as the shaft speed changes. There are advantages to each sampling method depending on the shaft speed, speed changes, and harmonics that you need to see. Let's examine how these sampling methods affect plot types.

Orbit / Timebase Plot

Since the synchronous sample rate changes automatically with the machine speed, the detail remains consistent regardless of speed. For example, the plot below shows a synchronous timebase collected at the machine's running speed of 4224 rpm. A second synchronous timebase (not shown) was collected at slow-roll conditions of 121 rpm and looks nearly identical. Both reflect the same number of samples per shaft revolution.



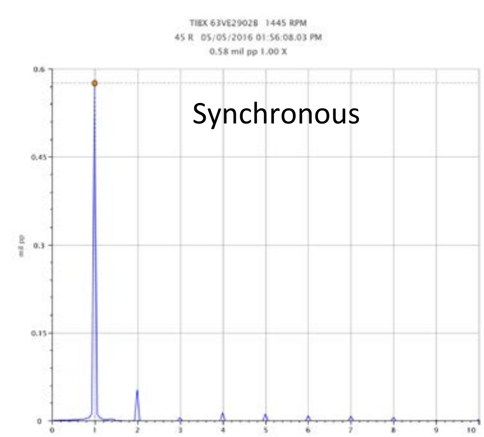
Now consider the asynchronous timebase (bottom). Like the synchronous timebase above, it was also collected at the machine's running speed of 4224 rpm; however, it was configured for 1280 samples/sec and 2048 total samples; it thus shows many more shaft revolutions, but far fewer details for each revolution. Zooming in will simply not reveal the level of detail from a single revolution that we obtained from our synchronous samples.



Spectrum Plot

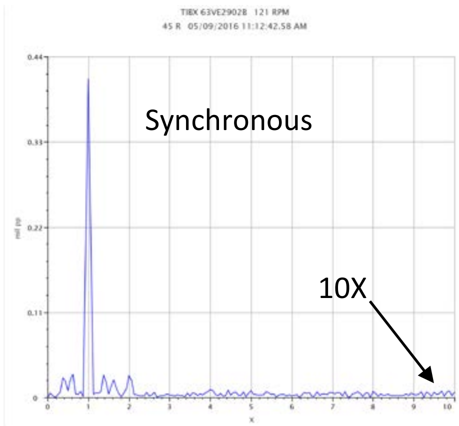
The benefit of synchronous sampling is particularly visible on the spectrum plot when the shaft speed is changing rapidly. When the speed is changing while collecting samples for the spectrum, asynchronous fixed-rate sampling can split the energy between spectrum "buckets" resulting in significant amplitude errors. Synchronous sampling, by changing the sampling rate with speed, keeps the data in the same spectral bucket and results in a much more accurate amplitude reading. This is shown in the two plots below for a machine undergoing a speed change of 160 rpm/second. In the asynchronous spectrum (top), the speed change smears the spectral energy over several spectral buckets resulting in a lower amplitude. The synchronously sampled data (bottom) keeps the energy in the 1X and 2X buckets and accurately matches the waveform amplitude.

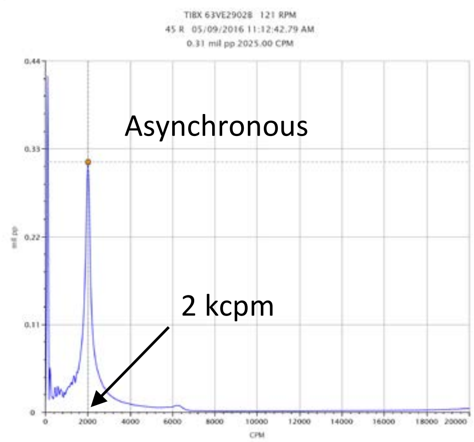
(continued on page 6)



Applying a window (e.g. Hanning) to the data will improve the asynchronous spectrum accuracy to a point, but it will still be significantly less accurate than the synchronous data. Likewise, choosing a lower spectrum resolution will improve the asynchronous spectrum as the buckets will be wider and since the spectrum is calculated over a shorter time interval the speed will have changed less.

Using two sample rates is very useful when there are frequency components that are very far apart. Consider the following case where a low-speed machine running at 121 rpm is impacted, causing ringing at its resonant frequency near 2000 cpm. The synchronous spectrum (top right) is configured to provide data only to 10X running speed. As such, it does not show the resonance harmonic at 2000 cpm (16.5X) while the asynchronous spectrum (bottom right) clearly shows the 2 kcpm resonance. At low speeds the lower synchronous sample



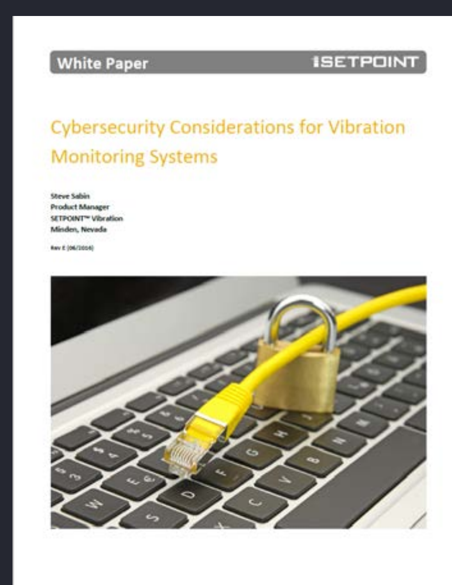


rate still provides good resolution around running speed and the asynchronous spectrum provides information out to higher resonances, blade passage frequencies, etc.

In general, synchronously sampled data provides the best orbit, timebase, and spectrum plots whereas asynchronously sampled data will show harmonics out to the configured spectrum span regardless of shaft speed. The most capable condition monitoring systems will thus provide *both* sampling methods and allow *both* to be used simultaneously.

SETPOINT™
2243 Park Place, Suite A
Minden, NV 89423 USA
+1 775.552.3110
www.setpointvibration.com
info@setpointvibration.com

Check out our new white paper: *Cybersecurity Considerations for Vibration Monitoring Systems.*


White Paper SETPOINT

Cybersecurity Considerations for Vibration Monitoring Systems

Steve Sabin
Product Manager
SETPOINT™ Vibration
Minden, Nevada

Maroochy. Davis-Besse. Stuxnet. These and other incidents may not be household words, but they opened the world's eyes to the vulnerability of Industrial Control Systems (ICS) to cyberattacks and malicious software. But while much has been written about ICS cybersecurity, nothing exists in the literature specific to vibration monitoring systems and their vulnerabilities. That's why we've authored a new white paper addressing the subject, available for download from our website. From our homepage, navigate to Downloads >> Documents.

www.setpointvibration.com