THE DRIVE TO GO FROM WIRED TO WIRELESS

WIRELESS VIBRATION SENSORS FOR CONDITION MONITORING

Condition-based monitoring of rotating equipment assets is a proven method of managing plant reliability and safety that has been practiced for decades. Vibration monitoring is a dominant portion of that. Traditionally, vibration sensors have been installed on the machine and hardwired back to a central machinery protection system (e.g. vibration monitor). While reliable, this technique is expensive and therefore usually reserved for large rotating machines; typically steam driven turbines or large combustion (gas) turbines, deemed "critical" to the plant's operation. For less critical assets (the so-called balance-of-plant machines), such as centrifugal pumps and compressors, the business case for installing such a condition monitoring system is less clear, or even untenable. The loss of availability of such machines, however, are in some cases no less important to the safe, reliable operation of a plant. There still exists, then, a need to economically condition monitor balance-of-plant machines.

As a solution, wireless vibration sensors have been proposed for over a decade. Many commercial implementations have met with mixed results, for a number of reasons. TE Connectivity (TE) feels that technology and market forces have converged sufficiently, however, to introduce such a wireless sensor. We see at least four drivers shaping this market space:

1. Driver 1: Ever-increasing demand for data by plant operators at an economical price
2. Driver 2: Continued electrification has dramatically improved battery performance
3. Driver 3: The rise of the Internet of Things (IoT) has improved digital radio performance
4. Driver 4: Edge computing in IoT devices further enhances wireless communications

FIGURE 1. 8911 WIRELESS ACCELEROMETER FOR PROOF OF CONCEPT* FROM TE CONNECTIVITY

*This device has not been authorized as required by the rules of the Federal Communications Commission.

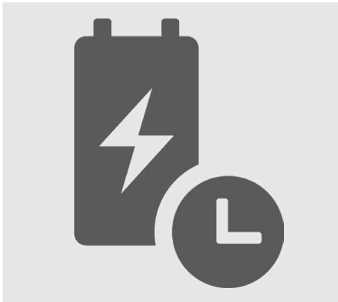
DRIVER 1: EVER-INCREASING DEMAND FOR DATA BY PLANT OPERATORS AT AN ECONOMICAL PRICE

As the march towards digitization continues unabated, one lesson that becomes clear is that the demand for data is never satisfied. Supplying this data, however, must be done economically. Condition monitoring of plant assets is no different.

Conventional installations require a multi-conductor, shielded cable to be connected to the sensor installed on the machine and run all the way back to a central machinery protection system. The total cable run length could be hundreds of feet long. Every sensor requires this. With multiple sensors, thousands of feet of cable are required. Further, to meet National Electrical Code® and local plant requirements, typically the first tens of feet of cable from the sensor at the machine is required to be installed in conduit. The remaining length back to the central station is often bundled in larger conduits or cable trays. All of this adds up to expensive labor and materials and it is not easily scalable.

Wireless sensors solve this problem. The wireless gateway is hard-wired back to a central station. But many wireless sensors are handled by a single gateway, thus eliminating the cable and conduit from the machine. Now the single cable from the gateway back to the central station is carrying data from many sensors, not just one. This is an easily scalable architecture, as the gateway can likely handle additional wireless sensors, or an additional gateway could be installed to accommodate an additional double or triple the number of sensors – a task that would be impossible to do the conventional way at the same cost.

DRIVER 2: CONTINUED ELECTRIFICATION HAS DRAMATICALLY IMPROVED BATTERY PERFORMANCE



Wireless sensors obviously require batteries to perform as expected. The most significant factor in the success or failure of utilizing wireless sensors is the battery's performance. Having to frequently replace depleted batteries chips away at the economic business case for using wireless sensors, not to mention loss of data while the sensor is left unpowered.

Technological improvements in battery performance have not kept up with other performance improvements in electronics, until recently. The drive for electrification in the transportation sectors (electric vehicles) and aerial drones has dramatically lowered the cost of batteries and improved their performance. Lithium based batteries, still the best technology and preferred choice for wireless applications, has come down in price significantly, from about $1,200 per kWh in 2010 to about $175 per kWh in 2018. The day is not far off when operating an electric vehicle will be cheaper than operating a gas-powered vehicle.

Availability of improved battery life makes operation of wireless sensors feasible economically. Going from replacing batteries every few months, to every year, to every two years and beyond suddenly makes operation of wireless sensors cost competitive with wired sensors.

DRIVER 3: THE RISE OF THE INTERNET OF THINGS (IOT) HAS IMPROVED DIGITAL RADIO PERFORMANCE

The Internet of Things (IoT), connecting devices to the Internet so they can be controlled and managed remotely, has dramatically driven improvements in digital radio communications, both the radio hardware and communications protocols. With the rise of smart phones and always-connected tablets and PCs, radio hardware costs have been driven continuously downward. Mobility requirements have demanded ultra-low power radio chipsets, to extend battery life. The sheer volume of data generated from all these devices has demanded efficient, economical use of wireless bandwidth.

LoRaWANTM is emerging as the most promising of the low power wide area networks (LPWANs) available.

- Utilizes sub-gigahertz unlicensed radio spectrum
- Ultra-low power that extends battery life
- Long range between sensor and gateway (5 km or greater depending on local conditions)
- Flexible deployment and able to penetrate deep in mixed environments
- Allows data to be sent asynchronously (only sent when necessary), further extending battery life

DRIVER 4: EDGE COMPUTING IN IOT DEVICES FURTHER ENHANCES WIRELESS COMMUNICATIONS

Many years ago, Gordon Moore famously predicted that performance in digital devices would double approximately every 18 months (known as Moore's Law). This prediction has generally held true, to the point where there is now tremendous computing power in the palm of your hand, or in your wearable device (e.g. smart watch). This has enabled Edge computing; the ability to process data at or near the end of the network (the "edge" of the network), rather than send that data in raw form all the way back to a central station to be processed there.

For a wireless vibration sensor, a perhaps obvious application of Edge computing is calculating the FFT (Fast Fourier Transform) of a sampled vibration waveform at the sensor itself. In a conventional system, the raw vibration waveform would be sent to the central station (as an analog signal) and the FFT calculated there. With Edge computing, the FFT can be calculated in the sensor and the processed data sent back. Rather than sending back raw vibration signals, this reduces bandwidth overhead and usage of battery power. But this is only a simple example. Ultimately much more computing could be done at the sensor. Given the appropriate algorithms, the sensor could "learn" about the machine it is installed on and when it is running well and when it is not. The building blocks are in place for a truly smart condition-monitoring vibration sensor.

CONCLUSION

With these market drivers at play, TE Connectivity designed the model 8911 wireless proof of concept vibration sensor. The 8911 satisfies plant operators demand for machine condition data, with an easily scalable wireless architecture. With a built-in LoRa™ radio and using the LoRaWAN™ protocol to communicate back to a wireless gateway, the 8911 achieves up to a 10-year battery life depending on the sampling rate. The 8911 can be installed in a complex plant environment with little worry about signal integrity issues; and Edge computing ability to calculate processed machine data. The 8911 wireless vibration sensor is the condition-monitoring sensor you need for your 21st Century plant.

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