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August 17, 2023 by Steve Taranovich

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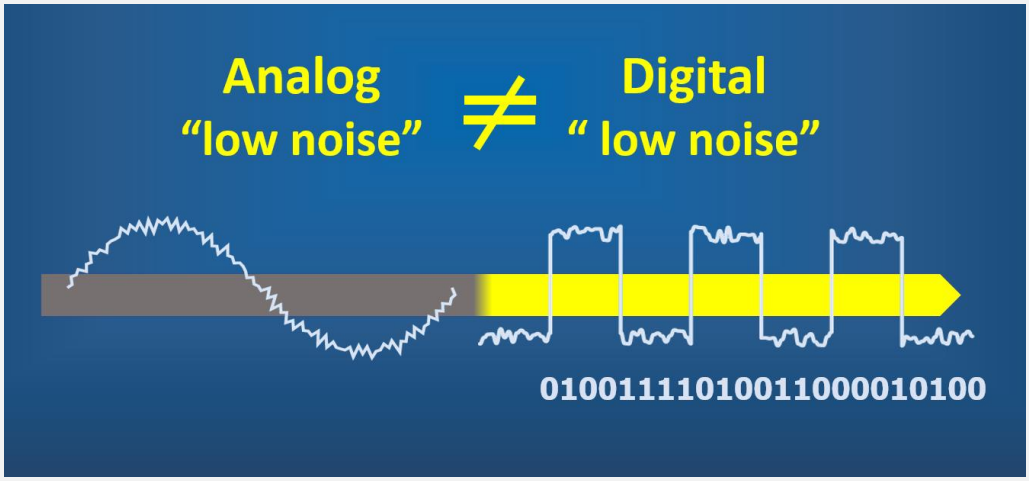

Steve Taranovich has been a Freelance Tech Journalist since 2019. He was Editor-In-Chief of EETimes/Planet Analog as well as a Senior Tech Editor at EDN running the Analog and Power Management Design Centers from 2012 to 2019. He has a history in electronic circuit design and applications for 40 years, and 10 years of technical writing/editing. BEEE from NYU Engineering, 1972/MSEE from Polytech University in 1989. From 1972 to 1988 was a circuit design engineer in audio (8 years) and microwave (8 years).

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INDUSTRY ARTICLE

Understanding and Minimizing Switching Noise Jitter (SNJ)

August 17, 2023 by **Steve Taranovich, TransSIP**

Switching noise jitter (SNJ) is an important concept to digest and a tricky problem to manage. Learn the background of SNJ and how employing innovative filtering technology can smooth the way.

As an analog and power circuit designer for 50 years, I have designed my share of switching power supplies. It was a 'black art' to me back in 1972, as well as for many other fledgling power designers (Figure 1).

I designed a standard passive filter technology for the switching power supply input and output which helped minimize switching noise and I also enclosed the switching supply within a metal cage with holes for added shielding and air circulation. Back in the 70s, I didn't even know what switching noise jitter (SNJ) was!

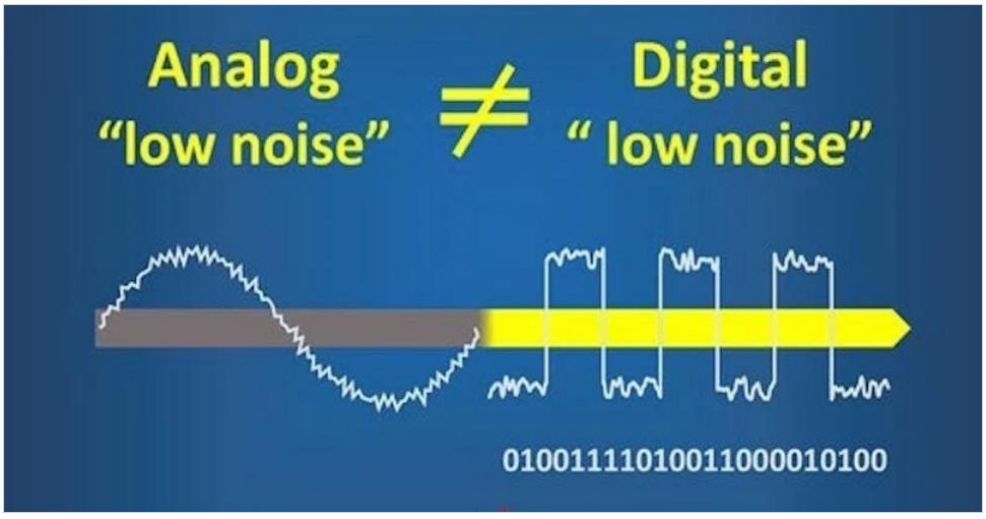

***Figure 1**. Noise in the analog and power realm is quite different from noise in the digital world.*

With all that in mind, let's take a look at what SNJ is and how we can minimize it.

Switching Power Supplies and Noise

A switching power supply can be a major source of noise. This includes noise that flows through power supply lines in the form of conducted noise. The noise becomes radiated noise (harmful electromagnetic radiation) and this adversely affects not only the power supply itself, but also other electronic equipment. Switching power supplies would be almost useless without addressing these issues with EMC measures.

Many system and circuit designers are not aware that switching power supplies in their designs have something known as switching noise jitter. This kind of noise is “noise on noise” and conventional noise filters have only a very minimal effect on SNJ.

In this article, we will discuss the significance of switching noise jitter (SNJ) and why the solution of the Harmony PI Filter is an effective solution for so many electronic system applications. We will also delve into one of the largest areas of need for this technology: 5G and 6G wireless communication. Connection strength in those applications depends heavily on signal clarity.

What is Switching Noise Jitter (SNJ)?

Switching noise jitter is essentially noise on noise in a switching power supply that results in the movement of noise in the time domain. Let’s take a 5G clock example in which power supply noise can severely curtail 5G clock phase noise performance (Figure 2 and Figure 3).

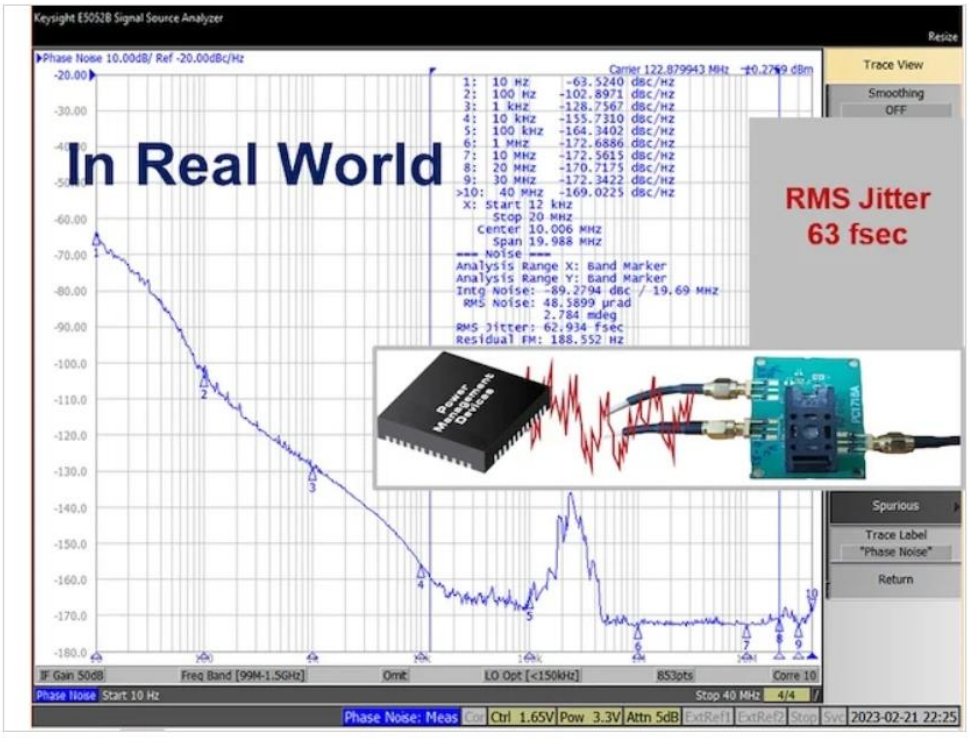

***Figure 2**. A typical 5G clock phase noise performance without Harmony filters*

Circuit designers need the best dynamic range performance possible for their products. The solution needs to be simple, small size, and best performance that will help filter out any power supply noise, thus allowing for the best signal-to-noise ratio (SNR) in the system design.

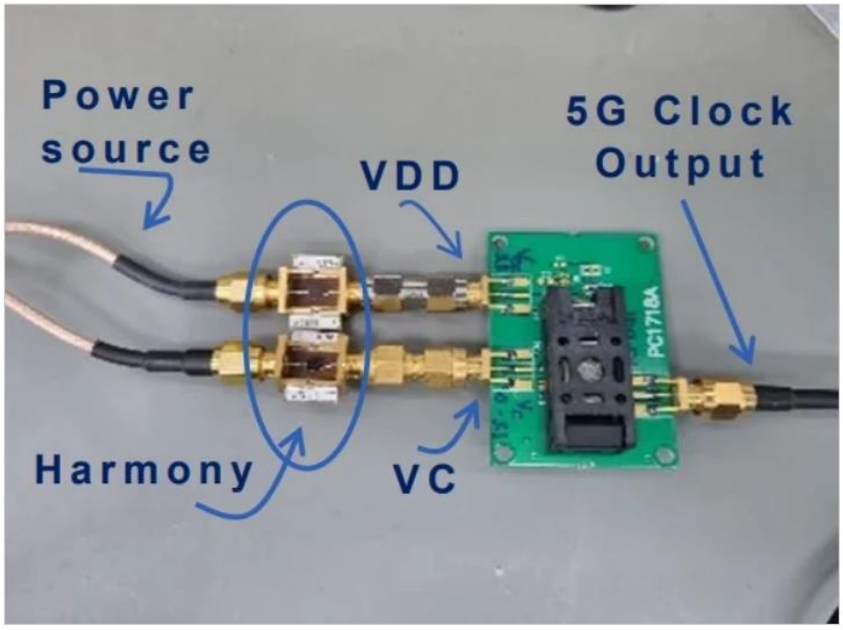

***Figure 3**. Harmony PI filters added to the power supply inputs of a 5G clock circuit*

Along just those lines, a system's dynamic range can be significantly improved using TransSIP's Harmony PI filters for the 19 fsec RMS jitter, which is equivalent to the ideal RMS jitter of 17 fsec (Figure 4).

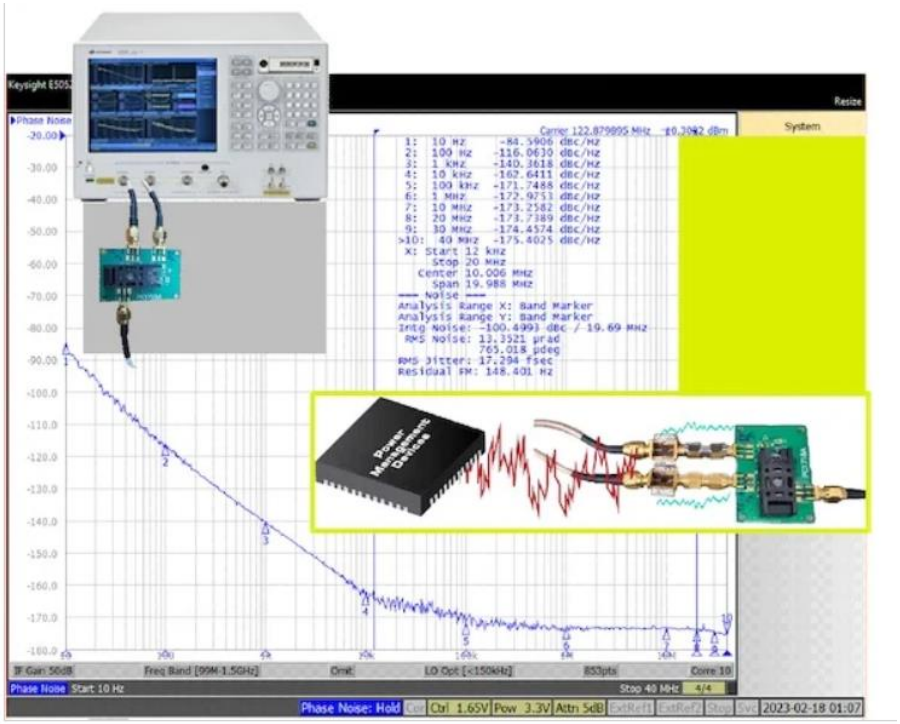

***Figure 4**. A typical 5G clock phase noise performance with Harmony PI filters*

Reducing Board Space and Component Count

Designers can add a Harmony PI filter—which is as small as a grain of rice (2.2 mm × 2.6 mm)—to each of the power supplies in their design. This filter also can reduce the number of PCB total components, by as much as 80%, needed for a design with a total of 93% savings of PCB real estate.

Also, a typical board design with three discrete filters, having 15 components each, can be reduced to a size of 7.7 mm^2 from 112 mm^2. As a bonus, there will be a noise rejection improvement of more than 10 dB across a 6 GHz spectrum (Figure 5).

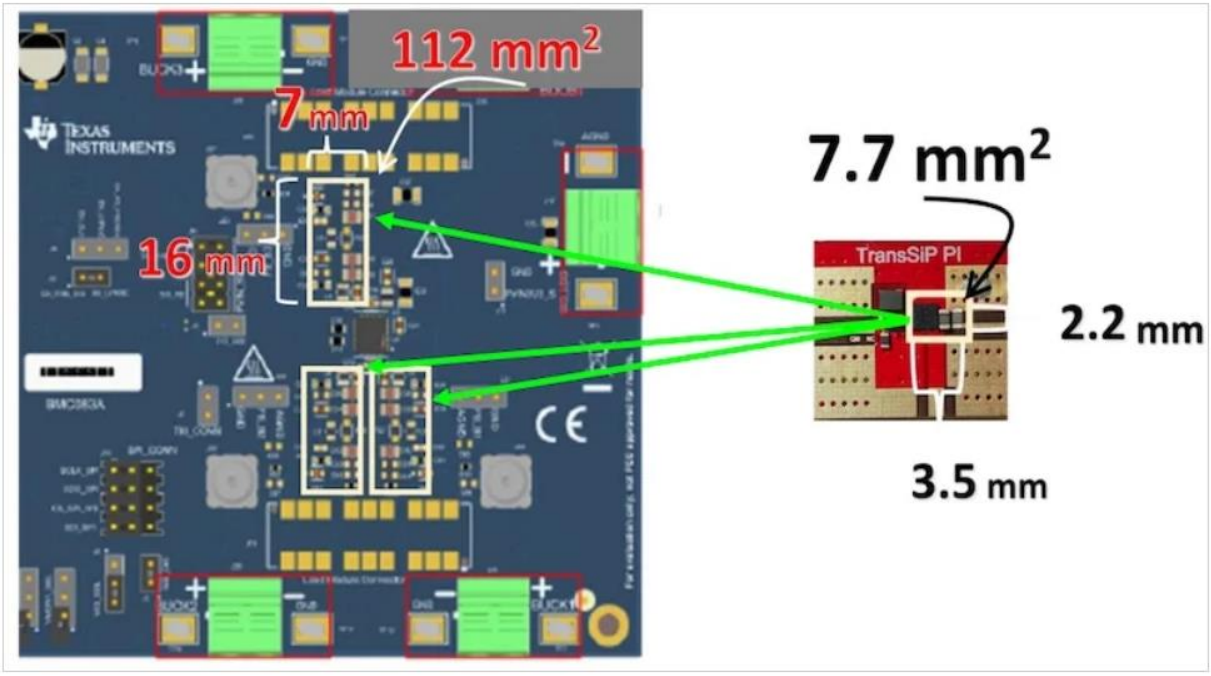

***Figure 5**. Circuit board (left) consists of three discrete filters, each with 15 components sized at 112 mm^2, which can be reduced to only 3 components (right) at 7.7 mm^2, a 93% board space savings in real estate.*

The Harmony PI filter also has applications in high power and control systems such as battery management systems (BMS) and power control units (PCUs) (Figure 6).

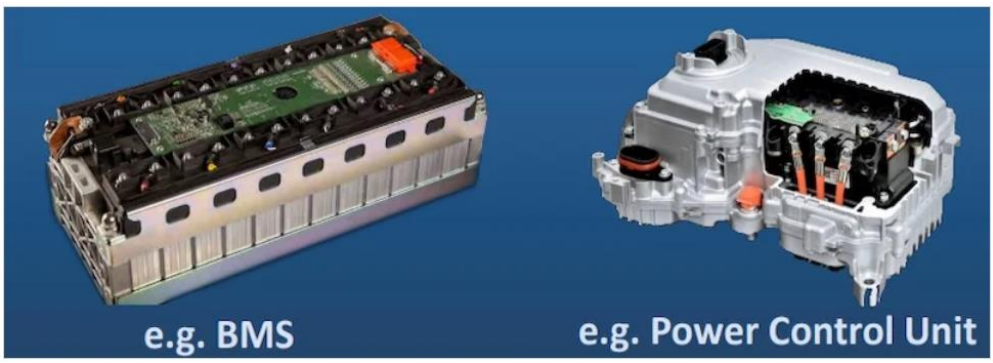

***Figure 6**. Zero-power signal processing can be achieved via the use of Harmony PI filters.*

Consuming Less Energy in Renewable Energy Designs

Harmony PI filters are being extensively used in many energy harvesting-based systems such as Global Positioning Systems (GPS)/Global Navigation Satellite Systems (GNSS). A GNSS application is shown in Figure 7.

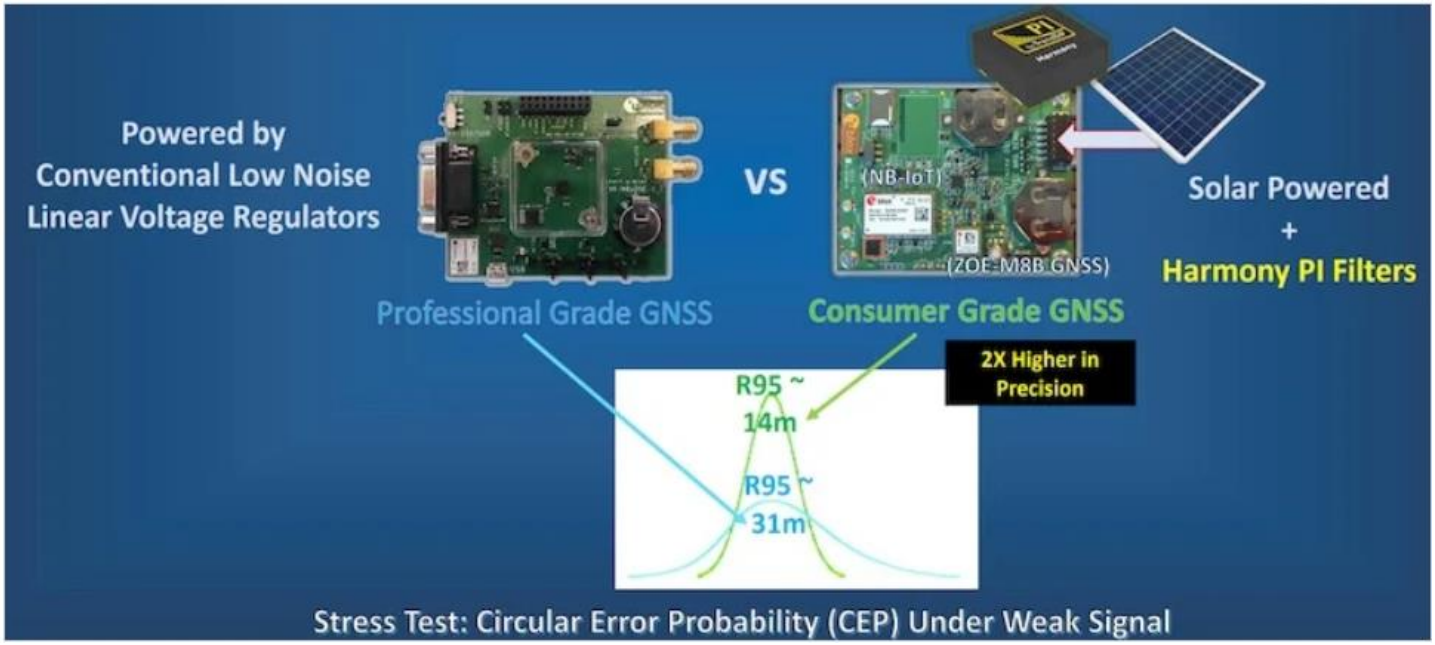

***Figure 7**. The filters excel in performance in energy harvesting-based systems for Global Navigation Satellite Systems (GNSS)*

A GPS/GNSS receiver battery life is governed by the speed of "The Time To First Position Fix" or TTFF." This is a quite high-power process. Each time the GPS is powered ON, the TTFF process will consume 5× to 10× of the power typically used for satellite navigation. When a design is made faster, the TTFF will expend less energy wasted for the digital processing.

A GPS Sports Watch Application

The TTFF will usually be slow under real-world weak signal conditions and one or two minutes is commonplace and can be even longer. A good example is a GPS watch that was modified to include a TransSiP PI-enabled power supply, thus enabling the watch to be significantly faster in TTFF than other GPS watches. The TransSiP PI enables the GPS sports watch to have 5× more battery life. GPS and GNSS positioning devices will also become 10× better in accuracy (Figure 8).

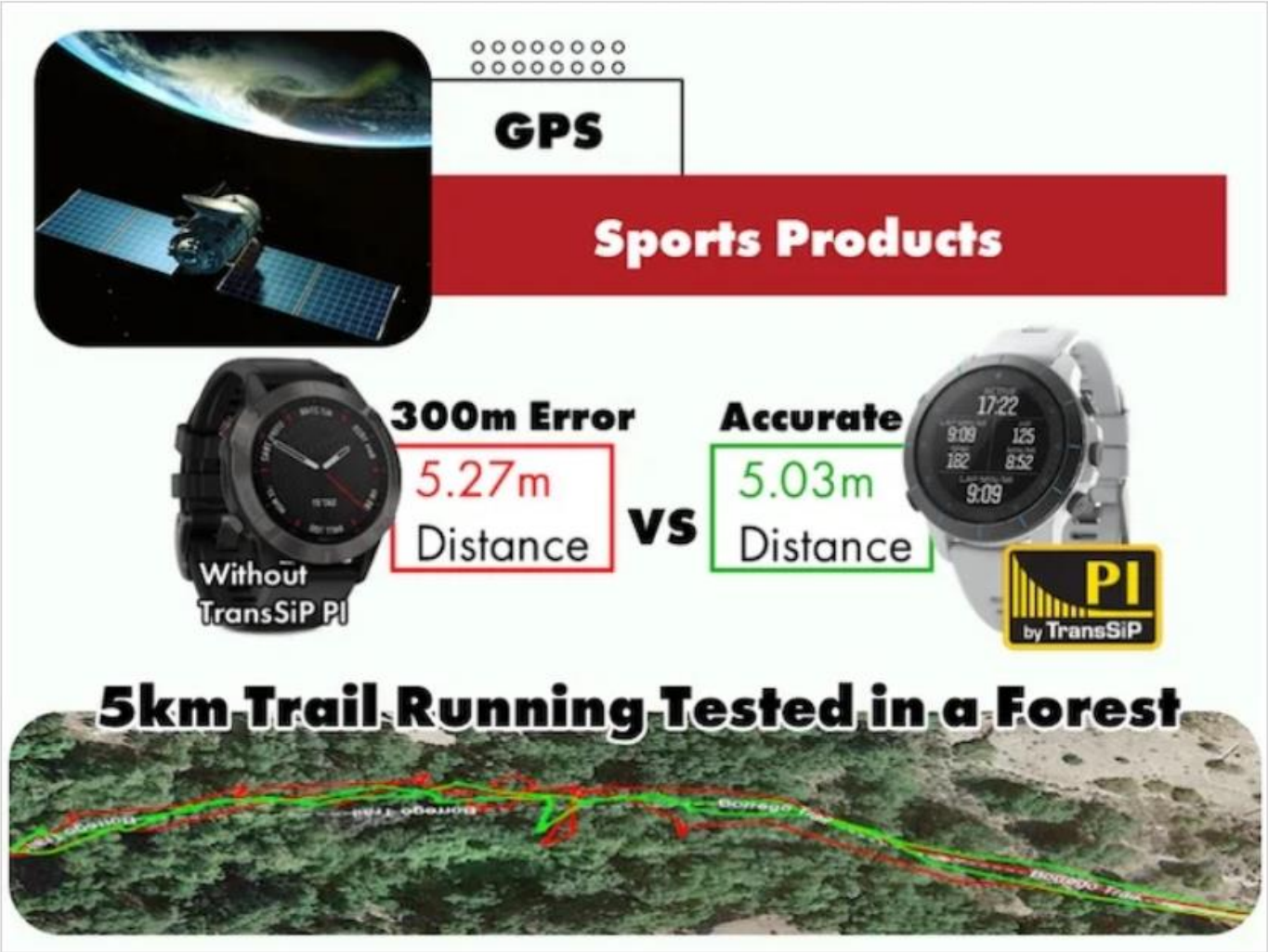

***Figure 8**. Here, the PI technology enables the GPS/GNSS positioning to be 10x more accurate.*

A Biomedical Application

Biomedical optical heart-rate monitors (OHRMs), which can be worn on the wrist, have been typically less accurate than chest strap versions, and are usually designed with multiple LEDs and photodetectors using complex, advanced algorithms.

TranSiP PI enhanced OHRMs achieve an accuracy that is equal to widely used chest straps with just a single LED and photodetector. The Harmony PI filter is able to remove all the noise in the power supply bias to the LED, photodetector, analog front end (AFE), and current ADC (Figure 9).

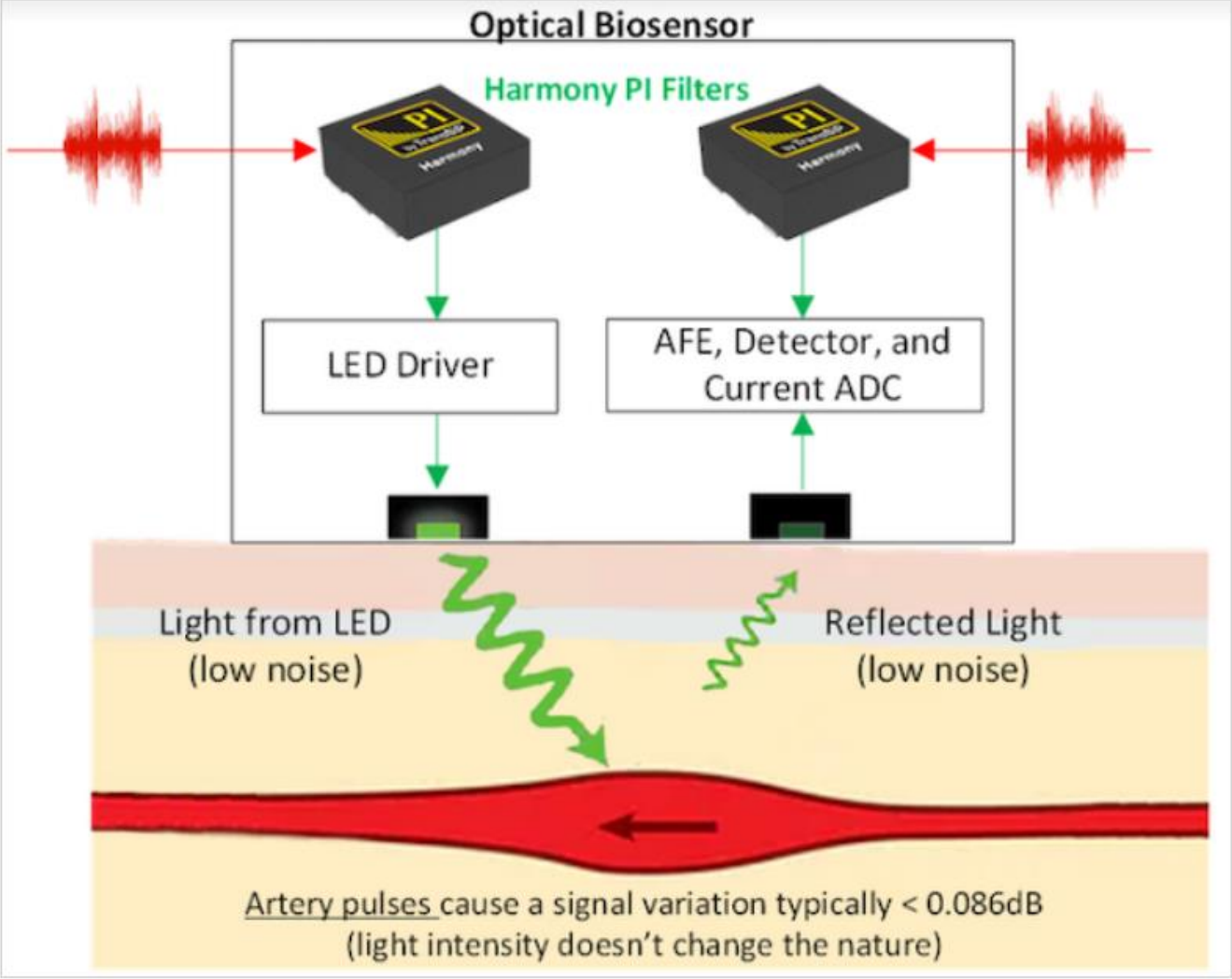

***Figure 9**. A TransSiP PI designed into a biosensor with a photodetector and only one LED*

Designing for a Positive End User Experience

TransSiP PI products include the Symphony PI DC-DC chipset and the Harmony PI filter. The Symphony PI DC-DC enables the best noise quality in a switching mode DC-DC buck converter.

The Harmony filter will function with many different DC power sources, and it will eliminate a broad spectrum of noise in the frequency and time domains. This enables filtering that can enable systems to reach high levels of signal clarity, sensitivity, accuracy, reliability and—most importantly—a positive end user experience.

All images used courtesy of TransSIP

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