Technical Article

IoT, Wearables and Other New Applications Create Need for Super-sensitive Sensors

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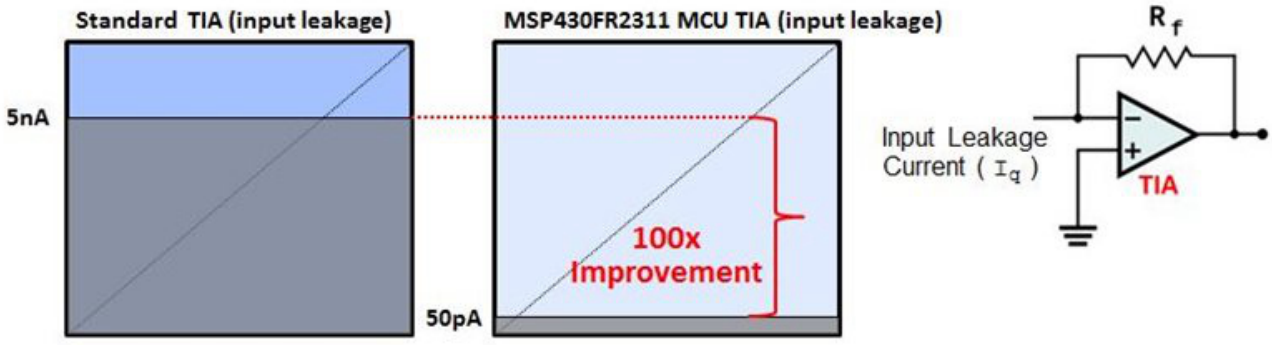
The many new applications coming about because of the Internet of Things (IoT), as well as a slew of standalone portable devices and personal electronic gadgets, are creating a huge need for next-generation intelligent sensing and measurement capabilities. These applications share a number of requirements, such as increased sensitivity, extremely low current detection, ultra-low power consumption – since many of these applications will be battery-operated – and very small form factors.

In addition, many of the advanced sensor and measurement devices generate a very low current as an output signal, which must eventually be processed digitally. Before that can happen, the low-current signal must be amplified and converted into a voltage-oriented signal, which is then processed by an analog-to-digital converter (ADC) and output to a processor of some sort. In most cases, this will be a microcontroller (MCU).

Most off-the-shelf operational amplifiers (op-amps) simply cannot amplify or convert the low-current output signals generated by many of these new sensors, so a transimpedance amplifier (TIA) is best suited to the needs of these applications. Unfortunately, many discrete TIAs have a high level of input leakage and this effectively sets the lower limit on the current that the TIA can amplify and convert to a voltage signal.

So, for example, many standard TIAs have an input leakage of approximately five nano-Amperes (5nA). As a result, any output current from a sensor that is below 5nA could not be converted and amplified by any of these standard TIAs. A promising solution to this dilemma would be to optimize the TIA with a focus on low leakage in the microcontroller. This can improve the input current leakage of the TIA by a factor of 100x if leakage as low as 50 pico-Amperes (pA) could be achieved. Coupling this type of solution with a sensor that generates a low-current output signal can result in an intelligent, super-sensitive sensing subsystem capable of monitoring very small amounts of current. The slightest change in the parameter being monitored by the sensor would trigger a very small alteration in the sensor's output current. In other words, the sensing subsystem becomes more sensitive than ever before.



Such an MCU + TIA solution is a very good fit for a wide range of applications. Environmental sensing systems, like smoke detectors or poisonous gas detectors for carbon monoxide or carbon dioxide, would be very sensitive to the slightest wisp of smoke or CO in the air. Of course, such detectors might find their way into building automation systems where other applications could incorporate the same sort of MCU +TIA technology. Smart thermostats could monitor for both temperature and humidity, for example, or a wireless switch could monitor and control the power consumed by the lights in a room. Even wearable electronic devices like smartwatches or

fitness activity trackers could incorporate a sensing subsystem. For instance, someone with sensitive skin might be interested in a smartwatch capable of sensing the ultraviolet light level to prevent sunburn. Power monitoring is another application that is becoming particularly important for the many battery-operated devices that are so popular today. An MCU + TIA-based solution could sense the current flowing out of a battery, gauge the power remaining in the battery and then send an alert to the user when the battery needed to be recharged.

Obviously, the range of applications is quite extensive. Over the next few weeks or months we will take a closer look at how some of these applications could be implemented.

By the way, if you think an MCU with an integrated TIA might be a good fit for your application, take a look at the MSP430FR2311 MCU.

Additional Resources

- Get started developing with the MSP430FR2311 MCU LaunchPad™ development kit
- Read our white paper about enabling sensing applications with smart analog MCUs.
- Learn all about the TIA in *Electronic Design* "What's All This Transimpedance Amplifier Stuff, Anyhow?" article
- Follow along with our other blog posts:
  - Reach new low-power levels for any sensor based design with new MSP430FR2311 MCU
  - Air quality monitors and smoke detectors put on a new face
  - Smart buildings get smarter with ultra-low-power MCUs
  - When green meets the IoT
  - Health monitoring devices get a jolt from MCUs
  - Value line MCUs bring more analog to personal electronic products

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