New Power Transistors Need New Sensors

Whether it is a power train of an electric vehicle or an electrical system of a spacecraft, a new breed of semiconductor power transistors known as wide bandgap (WBG) find their way to power these machines much more efficiently. The efficiency improvements attribute to lower power conversion losses, extreme temperature operation capability, lower component counts, and higher power density or lower volume of the system. New supporting circuitry and new materials have been developed for drivers, inductors, transformers, and capacitors used in WBG-based systems. Voltage and current sensors can be the last components needed to unleash superior features of WBG semiconductors. Tell-i Technologies, Inc. was established to address sensing needs of emerging WBG power electronics systems.

Power throughput increases by using WBG semiconductors because they permit devices to operate at much higher voltages, frequencies, and extreme temperatures than conventional silicon. Tell-i introduces new generations of sensors that are ultrafast, contactless, and non-invasive. The ultrafast sensors can measure fast switching transients seen in WBG transistors and/or high switching frequency WBG-based systems. The measurements can be used as feedback in closed-loop control at elevated frequencies or a fault detector in WBG power supplies and controllers. The contactless sensors provide voltage and thermal isolation. The non-invasive sensors (derived from the contactless feature) provide flexibility in optimizing high frequency/speed circuit layouts.

Tell-i offers three distinct families of products as follows:

1. ***Ultra***: a family of discrete ultrafast sensors for DC and AC current measurements,
2. ***Ultrac***: a family of discrete sensors to measure ultrafast AC currents measurements,
3. ***SensAI***: a family of sensing platforms for power and health management.

Table 1. Tell-i Offerings.

Ultra	*Ultrac*	*SensAI*
		

The **Ultra** family were developed to measure both DC and AC currents needed to control DC/DC and DC/AC switch-mode power supplies. The Ultra sensors are typically placed in series with the filter inductor with minimal parasitic inductance and resistance. Its contactless feature provides isolations more than 1kV as well as minimal requirements for thermal management unlike other sensors. The rise time (an indicator of the bandwidth) is tunable from 35nsec to 300nsec allowing accurate and efficient control of emerging multi-MHz switching power converters. Ultra-sensors are also appealing in sub-MHz switching power converters with reduced inductor size and sharp rising and falling current through advanced switching algorithms. These power converters are used in a variety of systems including automotive, data centers, industrial, energy, and aerospace.

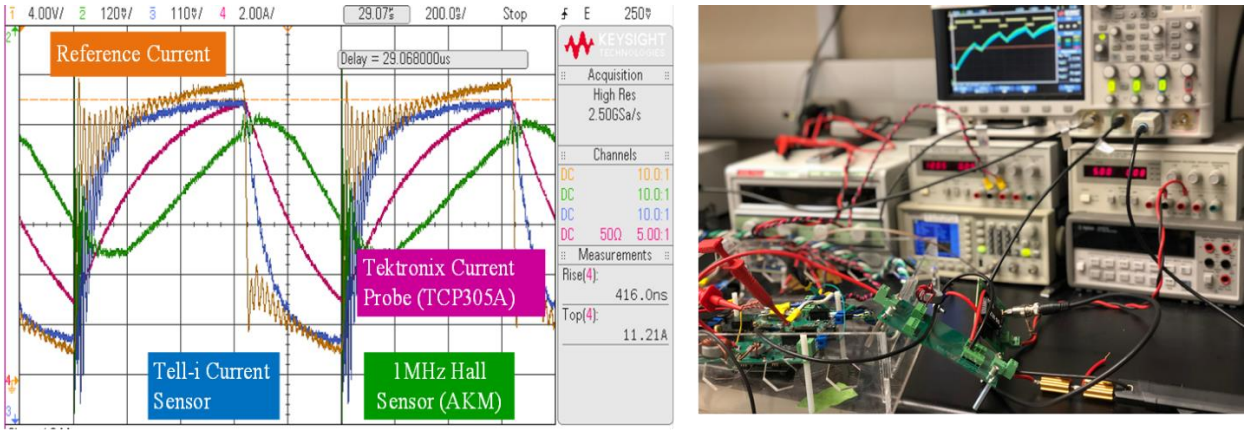

Figure 1. Comparative performance of Ultra 10.2 current sensor in 1MHz switching power converter with minimal filter inductance.

The **Ultrac** family of sensors were developed to measure very fast transients in the current seen during unwanted short-circuit fault conditions. WBG semiconductors enjoys very fast inherent switching capability. However, the fast switching during fault lets the excessive fault current rise. The goal is to have the ability to detect and deter a fault before power builds up to damaging levels that may induce cascading failures. To detect such fast events and to protect the system accordingly, a sensor with a bandwidth of greater than 10MHz is needed.

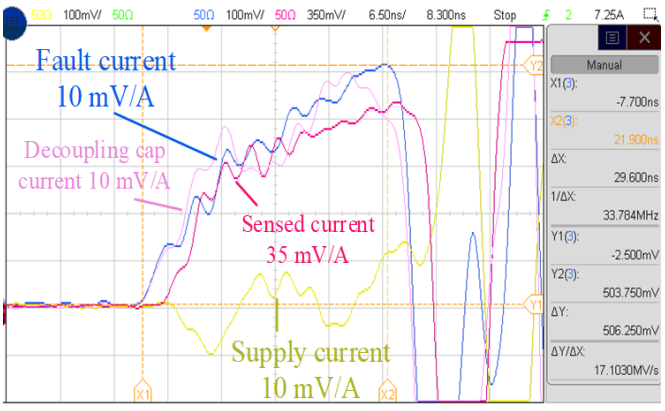

Figure 2. Performance of Ultrac 30.1c current sensor in a GaN power converter under short-circuit fault carrying 50A/40nanosec, five times the nominal value.

Commercially available sensors such as Hall-effect and CTs are limited to 1MHz bandwidth. Ultrac sensors are designed to have the bandwidth of 10MHz-30MHz and can measure 100s of ampere within 50 nanoseconds. Ultrac sensors are best suited in 1-10kW GaN converters and >50kW SiC converters.

The **SensAI** family of sensors are specialized voltage and current sensors for power and health management in electric powered systems such as electric vehicles, drones, and electric aircrafts. The measured voltage and current by SensAI are used to estimate the most critical characteristics of WBG power devices such as on-state resistance during dynamic and steady-state conditions. Tell-i SensAI sensing platform accompanied by deep-learning software can be used to *accurately* model the most critical components of power electronics converters over their life cycles. Real-time modeling of power converters known as digital twin are used in health monitoring and predictive maintenance scheduling of the system. High accuracy and high resolution of data processing extends the features of the platform to power management of complex and critical of mostly mobile electric powered systems.

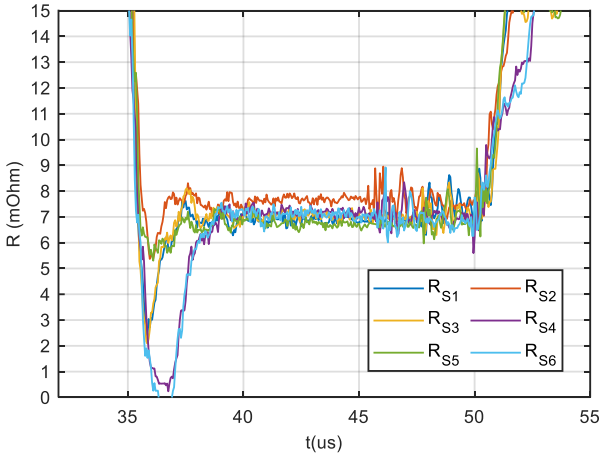

Figure 3. Real-time estimated dynamic on-resistance values of SiC MOSFETS in a 75kW 1000VDC power converter using SensAI VCS1000iso.1 sensor.

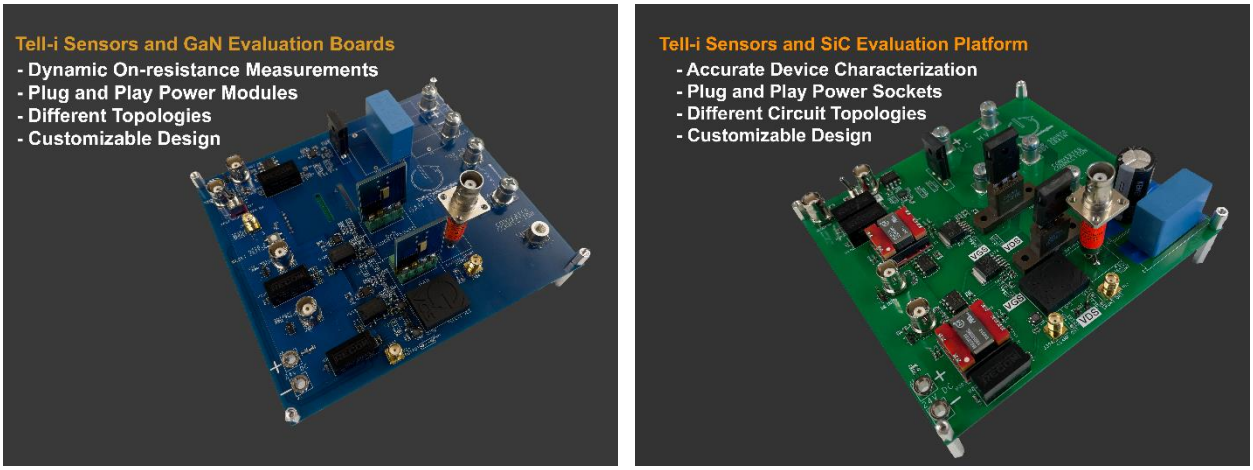

Figure 4. Samples of system design kits to evaluate different WBG (SiC and GaN) devices and Tell-i sensors.

Tell-i introduced transformative voltage and current sensors with an order of magnitude performance improvement over state-of-the-art technologies. The developed sensing solutions enable more reliable, efficient, and compact power electronics systems. Power electronics is an integral part of today's power delivery systems such as renewable energy systems, electric vehicles, electric aircrafts, spacecrafts, small satellites, data centers and most consumer electronics. The impact of such sensors is to enable systems and circuits that will be miniaturized and be made more efficient by using wide bandgap semiconductors and high switching frequencies. Additionally, the availability of high-resolution current and voltage measurement information will lead to greater reliability and prognostic capability. Tell-i and its engineering team have developed several system design kits (SDK) for fast prototyping and evaluation of its sensing solutions. Tell-i seeks to expand its partnership with semiconductor manufacturers, system developers, and end-users to unleash the potentials of wide bandgap semiconductor transistors. Yes, new transistors need new sensors.

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