Smart Sensors for Grid Modernization

Grid modernization initiatives are gaining momentum around the globe. Upgraded energy grids enable the integration of conventional energy sources with renewables and energy storage, as well as creating resiliency in the face of cyber-attacks and climate challenges. Low-inductance thick-film resistors play a vital role as sensing elements in these applications. **R. Ratzi, Miba Energy Holding Austria; A. Klein and T. Zimmerman, EBG Austria and USA**

Modernizing the grid is an opportunity for many players across the value chain. A major growth area is in metering and monitoring smart grid applications, which in the long run smooth out the power flowing to and from the grid, and cut waste by enabling optimal generation. If we know how much power is being produced, then less power needs to be produced. Today precise measurements can be taken at the point of transmission and distribution, but to accomplish this, smart grid sensors are needed.

Huge opportunities for sensors

There are a multitude of metering / monitoring points that are being upgraded with smart grid optimization, from point of use to transmission and distribution, both using the same types of technology just on different scales. In regards to transmission and distribution, in the past, very rudimentary tools were used to test and monitor the grid. Flashing lights, for example, were used on Fault Current Indicators, repair personnel had to be dispatched in multiple areas to find one fault by visual confirmation. Then the industry moved to wireless data locators.

These types of locators would give a position of the fault, in return would reduce the time and efforts in locating the fault thus a faster repair. Today precise measurements can be taken at the point of transmission and distribution, but to accomplish this, smart grid sensors are needed.

Market researcher IHS tracked Smart Grid Sensors as a stand-alone category in the Distribution Automation (DA) market and predicted that by 2021, demand for new Smart Grid Sensor technology will grow 1,200 %, making it one of the fastest growing segments in DA. It will surpass its earliest predecessor, non-communicating Fault Current Indicator (FCI) sensor technology.

Another important application of voltage sensors are intelligent transformer substations. There are used in the medium voltage secondary distribution grid. This is a key application which allows the grid to counterbalance voltage variations caused e.g. by local PV systems or fast charging stations for electrical vehicles.

The voltage divider

With this opportunity comes a challenge. The grid typically operates at a high voltage, but measurement equipment such as sensors should not exposed to this high voltage as it could pose both a reliability and a safety issue. So a voltage divider is used to reduce the voltage to a much lower level. If, for example, the grid is at 5,000 volts, you might use a 100:1 divider, so the sensor only sees 50 V maximum.

Voltage dividers can be made with capacitors (a capacitive divider) or with resistors. It is in the voltage dividers that accuracy becomes important. If a capacitor has a tolerance of +/- 2 %, and it used as a component in the divider, at the high end that 2 % error could give 51 V, or at the other end 49 V. Either way, with a 2 % error like this the grid voltage is between 4900 and 5100 V, because the divider is no more accurate than this. A second and even more important factor is thermal stability. Over a typical temperature range of 0 to 50°C, for example, a capacitor may drift by 0,5 %. On a cold day, the voltage is going to measure a different value than on a hot day. This is not because the grid voltage is any different, but because of the inaccuracy of the sensor due to thermal drifts.

Viewing it mathematically, if a resistor has a thermal coefficient of 50 parts per million (ppm) over a 50 K range that is 2500 ppm is an accuracy of 2500/1000000 = 0,25 %. This makes the sensor with a resistive divider is twice as accurate over temperature as a capacitive divider. The more accurate the real-time data is the more efficient and cost effective the grid can become. This is a prerequisite for functionalities like intelligent power grid with active load management or intelligent transformer substations, which are integrated in an overall smart grid power system management by remote signaling and control.

Thick-film resistors

EBG Resistors is a manufacturer of low-inductance thick-film resistors that can be used for high voltages, up to 90 kV on a single resistor. Higher voltage loads are possible if the resistor is potted. The EBG resistor product lines consist of an extensive variety of metal oxide products made with an exclusive METOXFILM formulation (see Figures 1 and 2).

METOXFILM or Thick Film resistors are the main choice for the high voltage needs of smart grid sensors, which will be used to monitor and measure transmission lines that operate at voltages from 20 kV to 230 kV (medium to high voltage grid) and even higher. The other main types of resistor technologies, such as wire wound, carbon film, bulk, etc., are not meant to handle such high continuous voltages. EBG resistors have been used for years with the move to digital and controllable power monitoring, where long-term stability and low-to-no drift is a goal. The resistors used for metering applications are typically flats and smaller cylindrical with tight tolerances and tight temperature coefficients. Typically in these point-of-use metering locations, such as industrial and commercial smart meters, the resistors have the same job as sensing, as voltage dividers, dividing the voltage to a usable and manageable level for all of the other internal circuitry.

In sensing applications, EBG's resistors are used in sensors applied directly to the voltage transmission lines, where it's necessary for them to be able to withstand high voltage loads and maintain tight tolerances and low drift under load. In the past, these sensing applications have been performed with a capacitive load. However, with more precise measurements required by power

Figure 1: **MTX type high-voltage resistor (divider)**

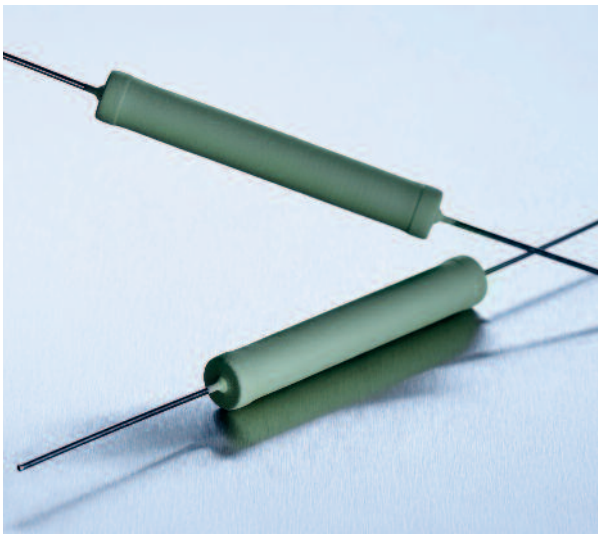

Figure 2: **Ultra-stable SHP high-voltage resistors**

generation companies, the capacitive load divider can no longer be used and resistive loads are now required.

EBG can customize its high voltage resistors for exacting TCR and stability requirements over wide operating temperature range. The company can produce them with tolerances as low as +/-0.1 % and down to 15 ppm on flats - even lower (down to < 5 ppm) on cylindrical parts. Ongoing development aim at even lower thermal coefficients in temperature ranges starting from -10 °C to 85 °C. In addition, EBG can also customize mechanical dimensions of flats and cylindrical resistors as well as producing with custom terminals and terminations with multiple types of protective coatings to fit the application. Therefore, these resistors are made to order and typically highly customized.

Some of these applications are in other areas that are linked to the Grid, such as; E-Mobility in fast charging stations and EV busses, green power generation in Solar and wind, the medical market, (CT scans, MRIs and X-ray machines, to name a few). They're also used in motor drives, welders, power supplies, and instrumentation, within the industrial market where the EBG power resistors absorb high energy pulse loads and protects the machinery from failing due to unexpected voltage spikes.

/// WE MANAGE
PRECISION AND STABILITY

EBG RESISTORS
A Miba Group Company

/// THE SMART CHOICE FOR SMART GRID SENSORS

Highest precision over a wide temperature range (overall stability <5ppm)
Low Inductance
Cylindricals and Flats
Leadfree Option

High voltage resistors from EBG

/// EBG – YOUR FLEXIBLE DESIGN PARTNER FOR TAYLOR-MADE THICK-FILM RESISTORS.

www.ebg-resistors.com