# DC CURRENT SENSORS FOR REVENUE-GRADE METERING

A recent report by the US Electric Power Research Institute (EPRI) predicts that by 2020, the DC distribution market will account for 50% of the total load, as the use of microgrid and other digital loads increases globally.

However, for use in conjunction with existing AC distribution systems, it is necessary to convert AC power to DC power, or DC power to AC power, which inevitably results in power loss.

To remedy this situation, there is an increasing trend to utilise DC distribution systems. Within a DC distribution system, power conversion is not needed, which leads to increased energy efficiency. Furthermore, since DC has no frequency, there is the added advantage of eliminating reactive power loss and inductive interference on the line (refer Figure 1).

To enable the construction of DC distribution systems, components for low-voltage DC (LVDC) power distribution infrastructure systems are being developed all over the world. As part of that effort, a new standard is currently being determined for DC metering and monitoring for LVDC distribution systems. IEC62053-41 Ed.1, the standard for DC electric meters, is currently under development by the project team TC13, and the standard is scheduled for completion in September 2019. In parallel, a NEMA DC sub-metering ANSI standard for DC electric meters is being established as part of a separate project called ESM1. The EMerge Alliance announced in 2016 the formation of a new committee to establish revenue-grade DC metering requirements for low and medium-voltage applications. Currently, the requirements for this task are being updated.

In South Korea, KEPCO has defined LVDC for DC voltages of 1500V with single polarity and 750V with dual polarity. Based on this definition, KEPCO is currently pilot testing LVDC distribution lines at the Gochang Power Testing Centre. In particular, KEPCO is conducting research on power devices for microgrids that can use DC and AC power distribution as well as energy storage systems (ESS) and EV fast chargers. Also, LG Electronics is accelerating the development of home appliances for DC.

KEPCO is developing a new standard for the Korean market based on two existing standards – the EMerge Alliance standard for DC distribution systems, and the IEC62053-41 standard for DC power billing in electricity meters.

Since March 2016, J&D has begun three projects to develop new products for DC metering (refer Figure 2).

The first project is to develop two types of DC electricity meters with accuracy per the 1.0 and 0.5 class. One meter is a single meter for EV fast chargers, and the other one is a transformer-operated meter for ESS.

The single meter is designed with an internal DC current sensor, whereas the DC voltage is obtained using a resistive voltage divider. The DC power is calculated based on signals from both sensors. The DC voltage sensor has a measuring range of 150V~500V and combining it with a DC current sensor for 100A and 200A enables a DC electricity meter capable of DC power billing for EV fast chargers with 50kW and 100kW capacity.

The transformer-operated meter under development uses a J&D DC high-voltage sensor and a DC high-current sensor. It will be used primarily for ESS and DC microgrid applications.

The second project is the development of a high-precision DC current sensor to be used for DC single meters and transformer-operated meters. Currently, most of the DC current sensors on the market are specified for full-scale accuracy. Naturally, these sensors are not suitable for DC electric meters, since these require accuracy relative to the measured current. Sensors specified for full-scale accuracy result in increased errors at lower currents (refer Figure 3).

Sensors with sufficient accuracy are usually not competitive for the meter market due to their high price and high-power consumption. Due to the large size required for a suitable power supply, it is not easy to develop a compact DC electric meter.

For DC current sensors, three technologies are usually used:

- The first one is the Fluxgate technology, which is highly accurate but not competitive in price.
- The second one is a closed-loop technology that can have a medium level of precision but is not very competitive in price.
- Finally, the open-loop technology has adequate precision. However, this technology is vulnerable to magnetic fields.

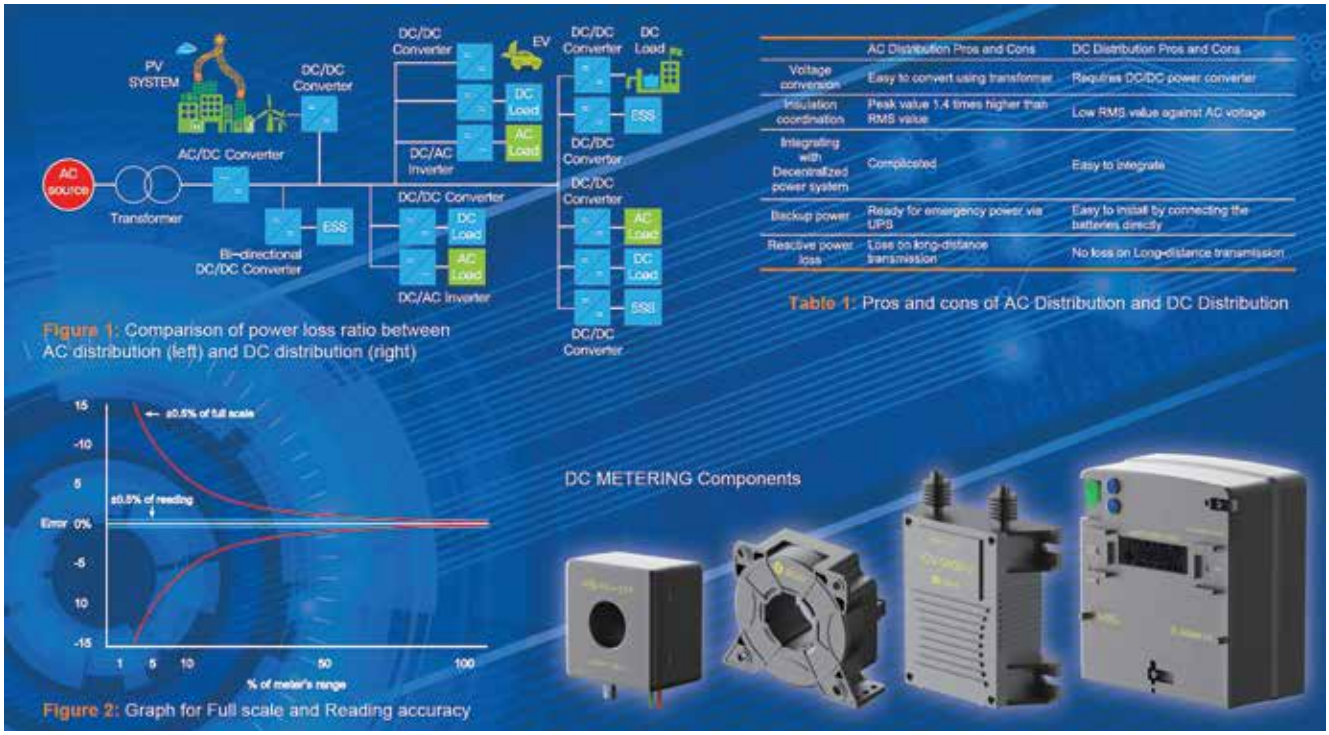


Figure 1: Comparison of power loss ratio between AC distribution (left) and DC distribution (right)

| | AC Distribution Pros and Cons | DC Distribution Pros and Cons |
|---|---|---|
| Voltage conversion | Easy to convert using transformer | Requires DC/DC power converter |
| Insulation coordination | Peak value 1.4 times higher than RMS value | Low RMS value against AC voltage |
| Integrating with Decentralized power system | Complicated | Easy to integrate |
| Backup power | Ready for emergency power via UPS | Easy to install by connecting the batteries directly |
| Reactive power loss | Loss on long-distance transmission | No loss on Long-distance transmission |

Table 1: Pros and cons of AC Distribution and DC Distribution




Figure 2: Graph for Full scale and Reading accuracy

J&D has analysed the three technologies described above and found a way to design an optimal DC current sensor that could be applied to DC electricity meters. For the design of a compact DC electricity meter with the lowest possible power consumption, the DC current sensor must have adequate reading accuracy with minimal power consumption. To have a competitive advantage, research is focused on developing an optimal DC current sensor that is also economical.

The results for this intense research are the JOM and JCM series of sensors:

- The JOM series is a DC current sensor designed for DC single meters with a 1.0 accuracy class. It is also designed to achieve a 0.5 accuracy class by applying open-loop technology. It uses a zero-drift operational amplifier and a high-permeability core to minimise DC offset and to achieve a compact size. Also, it has been designed to operate at low power. Therefore, it is possible to design a compact DC single meter for 100A and 200A, using the JOM series of sensors.
- The JCM series is a product for DC single meters with 0.5 accuracy class (100A and 200A), and for transformer-operated meters with 1.0 accuracy class (200A~4000A). Using AOCT technology to remove the DC offset from the hall sensor front-end circuit and the differential amplifier, based on closed-loop technology, and using high-permeability cores, the JCM series support accuracy class 0.2 meters. The design minimises voltage loss caused by the DC resistance and inductance of the feedback coil. Notably, the JCM series sensors have been designed to have low operating power. Therefore, by using the J&D JCM series CTs, it is possible to develop a compact DC transformer-operated meter.

The third project was to develop a DC voltage sensor for DC transformer-operated meters. J&D's new DC voltage sensor is a closed-loop product utilising a stable isolation design and the AOCT technology from the DC current sensor. This sensor achieves accuracies of 0.3% in the 1500V~5000V DC range.

Based on the advances of DC voltage accuracy and DC current sensor accuracy, J&D developed a high-precision DC electricity meter that addresses the growing demand for LVDC distribution systems.

When J&D discovered at the development stage that conventional metering ICs could not meet the requirements for DC electricity meters, J&D engineers consulted Silergy Corp, a leading metering IC manufacturer for support, which resulted in a fruitful phase of cooperation.

MAX71315C, a single-phase metering IC was selected as the best solution for the application. Silergy provided J&D with broad technical support and assistance. We want to take this opportunity to send our gratitude to Silergy.

The accuracy and overall performance of J&D's DC electric meter has been evolving, and its first solution will be presented at European Utility Week 2018 (Vienna, November 2018).

J&D's strategy is to lead by preparing ahead of the market rather than following it. We would like to cooperate with leaders from around the world in developing DC electric meters or DC distribution systems. With J&D's leading technology, it will be possible to enable our partners to capitalise on the new market trend. SEI

**ABOUT THE COMPANY**

J&D is a world leader for high technology, high-performance current sensora that perfectly meet the needs of the metering sector.

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[i] The EMerge Alliance, is a not-for-profit industry association founded in 2008 with the goal of setting standards for industrial LVDC distribution.

**J&D are exhibiting at European Utility Week. Visit them at booth A.k40**