The Certification of Railway Electricity Meters

The separation of railway systems into networks and operators led to the introduction of electrical meters on-board electrical trains. The energy can be consumed anywhere in the European railway network as well as at any given time. Building on its long experience with the certification of power energy meters, METAS has made inroads into railway conformity testing of meter according to standard EN 50463.

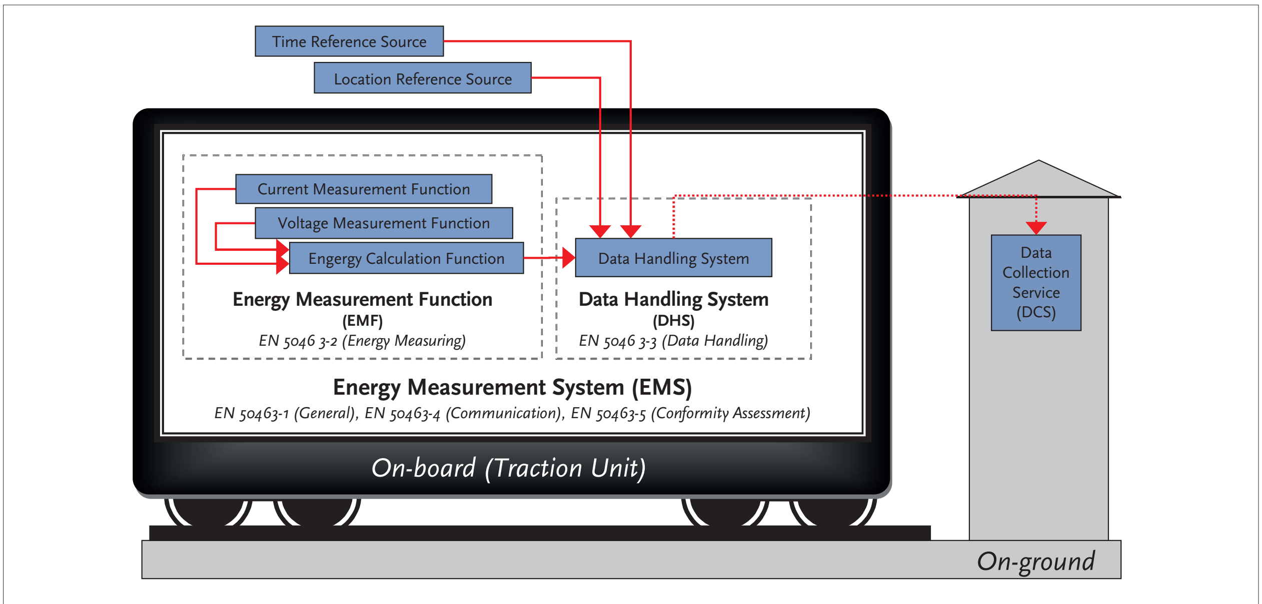
Christian Santschi and Jean-Pierre Braun

In 1991, the Council of the European Communities issued the directive 91/440/EEC on the development of the Community's railways in order to integrate the various national train systems into an efficient and competitive transport system. Railway systems throughout Europe have developed separately in each country and were generally operated as monopolies. These vertically integrated organisations made it virtually impossible for private or regional enterprises to operate their own trains on these national networks. To circumvent this situation, the directive 91/440/EEC called for the separation of infrastructure management and transport operation as well as ensuring the open access of the network to railway undertakings (passenger or freight). To achieve this daunting task, the European Union created a collection of legislation, often referred to as railway packages, in which the various issues are addressed. This led to the opening of the railway market on 1st January 2010.

The separation of railway systems into networks and operators led to the need to regulate, among many others issues, the cost allocation of infrastructure usage to the operators. Among the consideration for the establishment of railway access charges were the access, operating, reservation and load component, use of traction current and use of electricity. The aim of these charges is to ensure the coverage for maintaining and developing the railway network. They must be transparent, fair and non-discriminatory. Among the many charge components, the charging of the electricity used by electrical trains presented a particular difficulty. Contrary to the fixed location of most power energy consumers, the energy is consumed anywhere in the European railway network as well as at any given time. This led to the introduction of electrical meters on-board electrical trains and the creation of standard EN 50463 which stipulates all aspects of such meters.

Railway metering systems

Contrary to fixed installation revenue meters, train meters must have the knowledge of time and geographical position and require a communication standard that can be understood throughout the European railway network. Figure 1 shows the block diagram of a meter used in rolling stock. In addition to the traditional components such as voltage and current transducers and energy calculators, the metering system must be capable to establish the load profile of the electricity consumptions and its corresponding geographical locations so that the relevant tariffs can be applied.



Reproduced from SN EN 50463-2:2012 with permission of Electrosuisse/CES

1: Energy management system for electrical trains.

In addition to cost recovery, such metering systems enable a better management of the energy consumed by railways and possibly significant savings. The SBB-CFF is presently equipping their locomotives with electricity meters with the aim to reduce their energy consumption by 20 % by the year 2025. But, while the use of meters contributes towards the realisation of energy savings and the realisation of an integrated European railway network, such devices are more complex to realise and to certify than those used for consumers. The following sections present some of the difficulties.

The certification of railway meters

With its strong experience in metering, METAS undertook the challenge to make an inroad into the railway metering. The metrological certification of two ECFs (Energy Calculation Function), the railway equivalent of domestic meter according to the standard EN 50463-2 was undertaken. This standard defines tests required for the certification of Energy Measurement System on board of trains. The other four standards of EN 50463 cover following functions:

1. EN 50463-1 General
2. EN 50463-3 Data Handling System
3. EN 50463-4 Communication
4. EN 50463-5 Conformity Assessment

In the future, METAS envisages the certification of voltage and current transducers with the intent to become a certification partner to railway meter manufacturers.
The two certified ECFs could handle both DC as well as AC power:

Characteristics of the first device:

	DC	AC
Voltage Input	3000 V / 100 mA	25 kV / 100 mA
Current Input	3000 A / 2 A	500 A / 2 A
Power	Active	Active, Reactive
Power flow	Import, Export	Import, Export

Characteristics of the second device:

	DC	AC (16.7 Hz)
Voltage Input	750 V / 37.5 mA	15 kV / 100 V
Current Input	2000 A / 2 A	200 A / 5 A
Power	Active	Active, Reactive
Power flow	Import, Export	Import, Export

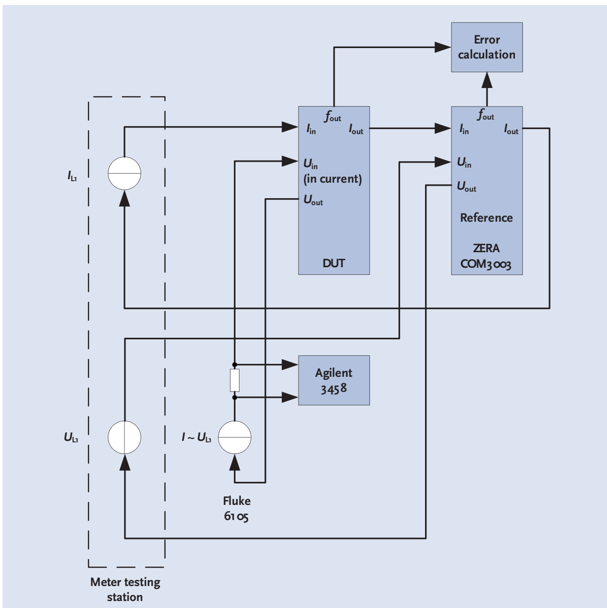
Particularities of railway meters testing

The above meters challenged METAS' expertise. Firstly, DC metering experience and infrastructure had to be acquired. Secondly, some of the ECFs had current inputs for both the voltage and the current circuits. This contrasts with traditional

2: Railway meter equipped with 2 ECFs (Energy Calculation Function).

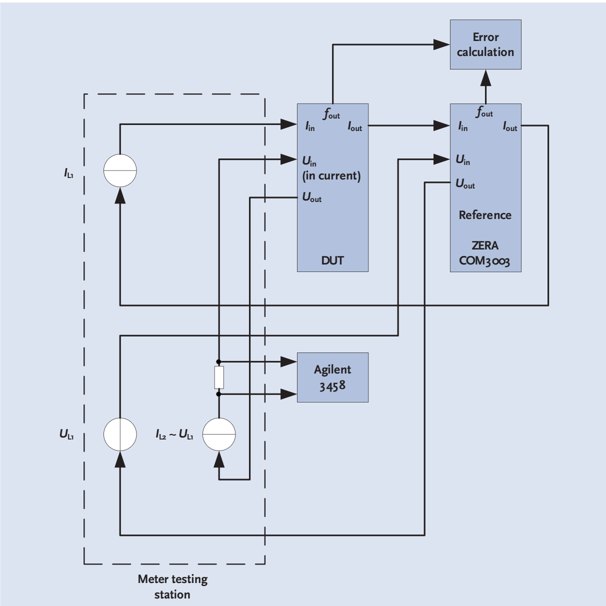
meters where the voltage and the current circuits have respectively voltage and current inputs. Thirdly, the railway environment is much harsher than revenue metering in stationary applications and placed new demands on the testing. Finally, the voltage swing on the catenary is much larger than in traditional power systems.

The DC metering function requires traceability for DC voltage, current and power. While the meter testing station is capable of providing DC voltages and currents, its reference had to be retrofitted for DC power measurement functionality. This was implemented by the manufacturer. Once modified, METAS calibrated the device for DC voltage, current and power.
To address the issue of the voltage input of the meter being replaced by a current signal, a current source is used in place of the voltage generator built in the meter testing station. The difficulty consisted in establishing a traceable proportionality factor. Figure 3 and 4 show the conversion principle.



3: DC measurement set-up where the voltage input of the DUT requires a current.

Figure 3 shows the principle for DC, where a calibrator used as current source is used in place of the voltage generator. The current was measured with a shunt and a HP3458 precision multimeter while the voltage was measured with the power comparator of the meter testing station. As the uncertainty of the power reference, multimeter and shunt are known, the uncertainty of the current/voltage ratio could be established. The same difficulty of establishing a current/voltage ratio existed in AC when the meter required a current representing the voltage. Figure 4 shows how this non-conventional use of the meter testing station.



4: AC measurement set-up where the voltage input of the DUT requires a current.

The current generator corresponding to the phase L2 in the meter testing station was used as an image of the voltage applied to the reference meter. The proportionality factor was established by the direct measurement of the voltage and current in the power comparator. Contrary to the DC case, the phase angle had to be taken into consideration.

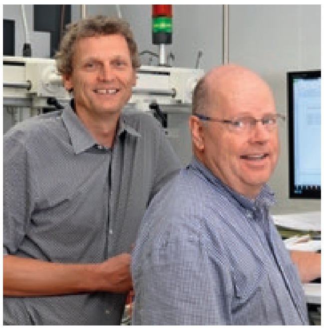
In regard to the environmental tests conducted at METAS, three parameters were different from traditional meters. Firstly, the temperature range an ECF must operate in is much larger than the one of a traditional revenue meter. Secondly, the environmental test is the measure of the influence of the

5: Magnetic induction influence up to 2 mT, compared to 0.5 mT in traditional meters.

DC and AC magnetic induction requiring 2 mT compared to 0.5 mT for traditional meters. This required the replacement of the current source driving a Helmholtz coil.
Finally, due to the large voltage variations present on the catenary, the ECF is exposed to higher fluctuations than a traditional revenue meter. As a result, the tolerance placed on the accuracy is segmented both along the current and the voltage range. Figure 6 compares the percentage error limits for both an ECF and a revenue meter.

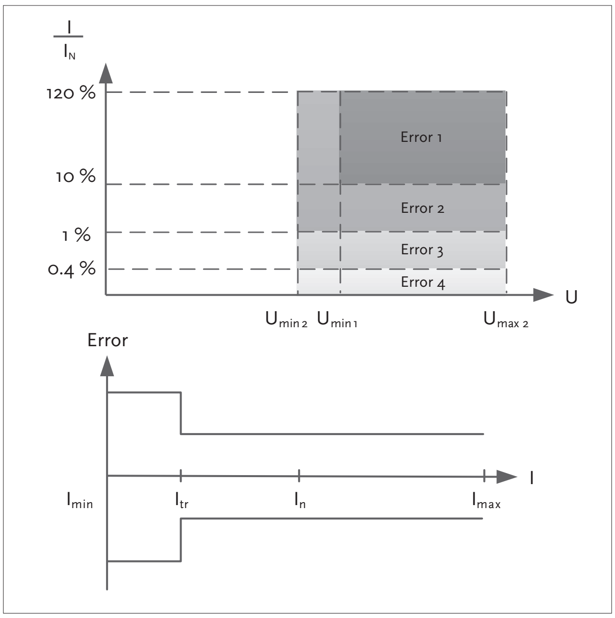
In the case of an ordinary revenue meter (right graph), the percentage error allowed depends only on the current, while for a railway meter (left graph), the dynamic fluctuations of the voltage between U_{min2} (smallest non-permanent voltage) and U_{max2} (highest non-permanent voltage) is also taken into account.

The experience gained in the certification of two ECFs according to the standard EN 50463-2 broadened the capability of the Power and Energy Laboratory and paved the road to the acquisition of further expertise in the field of railway metering.



Contact:
Christian Santschi
Electrical Energy and Power
christian.santschi@metas.ch
+41 58 387 02 20

Jean-Pierre Braun
Electrical Energy and Power
jean-pierre.braun@metas.ch
+41 58 387 03 07



6: ECF permissible error is segmented along current intensity and voltage range.