Phantom power test setup for accuracy measurements of high power DC charging stations

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***Abstract* — This paper describes a test setup for determining the accuracy of energy measurement of high power DC charging stations. To avoid the need for a controllable high power load to set up the test points, a new approach using phantom power is described. The suitability of the test setup is demonstrated by comparing the results of measurements using phantom power with the results of measurements using real power.**

***Index Terms* — high power DC charging, phantom power.**

I. INTRODUCTION

At the UN climate change conference in Glasgow (COP26) a lot of participants declared that they want to accelerate the transition to zero emission vehicles. They declared as a goal, that all sales of new cars and vans will be zero emission globally by 2040 [1]. This target will lead to an increased number of electric vehicles accompanying with an increased demand of public charging structure which is assumed to be mainly DC charging stations in the future.

At these public charging stations, a large amount of energy will be supplied, which must be paid for by the customer. To avoid a collapse of the acceptance of the public charging infrastructure, it is essential that the customer can rely on the delivered and billed energy that he has purchased. Fundamental for the reliability is a correct measurement of the delivered energy. Therefore, the possibility of verifying the correctness of the measurement of the charging station is needed. This results in the need for a compact economic test equipment, which makes it possible to investigate the influences of the charging station on the measurement result. Due to the fact, that the customer should only pay for the energy, which was delivered to his vehicle, the measurement point for the energy must be the plug of the attached charging cable. This avoids, that the losses within the parts of the charging station (rectifier, contactors, cables, etc.) will be billed to the customer.

If the meter measures the energy not at the plug or if the meter cannot be tested separately, because it is completely integrated in the charging station, the verification of the accuracy of the measurement must be done at least with all components of the charging station between the metering part and the plug of the charging cable. Currently this can only be done with real power. For the usage of phantom power, as it is done with electricity meter testing since several decades [2], separate contacts for current and voltage would be necessary at the plug. Especially testing of high power chargers with real energy is difficult because the load has to consume the high power immediately. This becomes quite more difficult, if charging stations must be tested outside a laboratory where the connection and setup of an adjustable high power regenerative load is even more difficult. To overcome these difficulties, we propose a test setup which makes it possible to test charging stations with a phantom power source, even if no separate voltage or current contacts are available.

II. MEASUREMENT SET-UP

In Figure 1 the test setup is shown for a charging station with a meter measuring the energy before the charging cable. This energy can be described with

$$E_{meter}(t) = \int U_{meter}(t) \cdot I_{DC+}(t) \cdot dt. \qquad (1)$$

The reference measurement system is connected at the plug of the charging cable and measures the energy described by

$$E_{reference}(t) = \int U_{deliver}(t) \cdot I_{DC+}(t) \cdot dt. \qquad (2)$$

In this case the voltage drop across the charging cable influences the measured energy and must be considered within the accuracy test. This is done with the extended phantom power test setup shown in Figure 1.

The current source IDC+ and the voltage source HV are necessary to get the meter counting. This setup corresponds to the classical phantom power setup. To also address the losses in the DC- path, the second current source IDC- is needed.

To perform tests with this test setup it is necessary, that the DC power supply of the charging station can be separated, the current sources can be connected to the DC+ and DC- path before the meter and that the meter can be set in operation mode in this configuration. The requirement for the current source in the DC+ path is also, that the outputs of the source can operate on a potential of up to 1000 V. For the current sources the TSD10-900/380+LXI from Magna Power are used. These sources provide currents up to 900 A and voltages up to 10 V. The outputs are isolated up to 1000 V. To keep the ripple, defined in [3], of the signal below 1% additional resistors as a base load have been inserted in the current paths directly at the current sources to avoid an influence on the voltage measurement. These resistors are marked with "RS" in Figure 1 and have a value of 73,3 mΩ respectively. They are included within the current paths for currents below 70 A. As voltage source a Heinzinger EVO 1500-1400 is used which can provide DC voltages up to 1500 V.

With this setup the normal operation of the charging station can be simulated for every combination of voltage and current, without the necessity to absorb the real power defined by the voltage und current. For the measurements the power analyser LMG 641 from ZES Zimmer is used with two measurement channels L60-CH-A1. As current transducers the PCT600 from ZES Zimmer are used. The measurement system was calibrated revealing a highest uncertainty of the energy measurement in the relevant operating area of around 0.066 % (k=2).

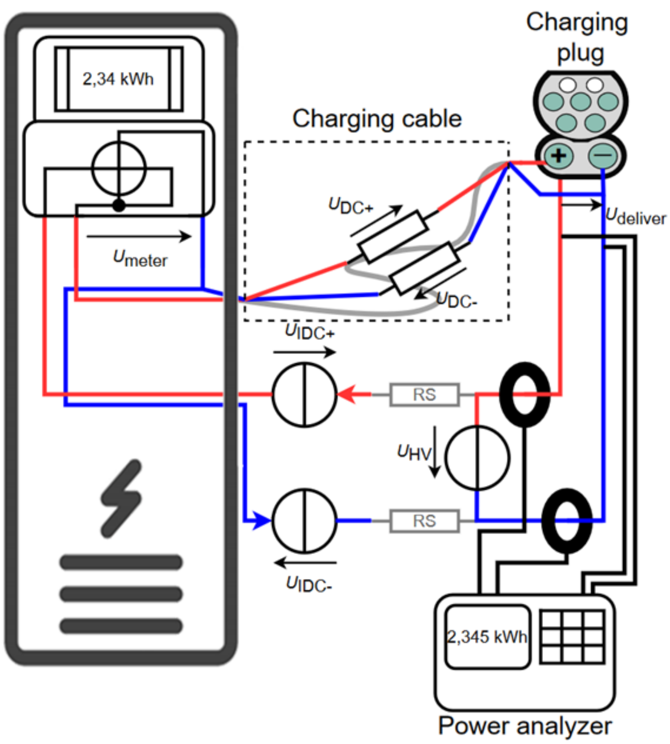

Fig. 1. Connection of a DC charging station with the proposed phantom power test setup with two current sources.

III. Measurement results

To evaluate the new phantom power setup, the accuracy of a DC charging station was measured. These results were compared to the measured accuracy of the charging station, using real power. This was done with currents of 20 A, 40 A and 70 A at 200 V and 420 V respectively. Fig. 2 shows the deviation of the energy measurement of the charging station compared to the result of the reference measurement with the power analyser. One point in the chart represents the mean value of two measurements. The uncertainty of the measurement points represents the expanded uncertainty of ± 0.066 % (k=2) of the reference system.

Considering the uncertainty of the reference measurement system together with the repeatability of the electricity meter inside the charging station, which must be below 0.1% [4], and the resolution of the electricity meter which leads to an additional uncertainty of 0,01%, Figure 2 shows, that the measurements performed with real power and phantom power produce similar results.

Above a current of 70 A it was not possible to perform tests with real power due to the limited power of the DC converter of the charging station, which was limited to 30 kW for laboratory usage. With the phantom power setup it was possible to extend the measurements up to currents of 400 A which is the limit of the charging cable, without the necessity of a high power supply. The energy consumption of the test setup at the test point with 420 V and 400 A, representing a phantom energy of 168 kW, was only around 3 kW.

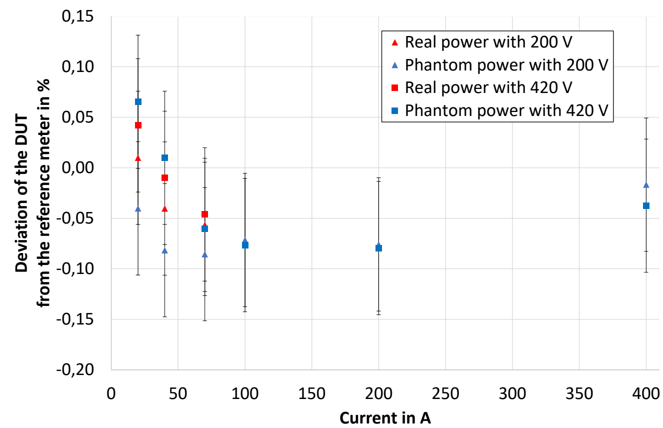

Fig. 2. Comparison of accuracy measurement with real and phantom power of a 200 kW DC charging station

VI. Conclusion

We presented the new approach for a test setup for testing high power DC charging stations using phantom power. The phantom power test setup leads to similar results compared to measurements using real power. Therefore, it could be shown that the usage of a phantom power source for accuracy tests of charging stations is possible. This has the advantage, that the complete metrological relevant part of a charging station can be tested with a compact and economic test setup without the necessity of using the internal high power supply of the charging station and an equivalent high power load as energy sink.

References

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