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Further Analysis of Dynamic Measurement Function of Electrical Energy Meter for Type Approval Tests

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Abstract — **The dynamic function of electrical energy meters is further analyzed and presented. It can be verified through a type approval. Test. The corresponding measurements and guidelines are discussed. Harmonic standards, and the sine modulated waveform can be used to verify the function.**

Index Terms — **Dynamic function, electrical energy meter, harmonic, type approval, verification, uncertainty.**

I. Introduction

In recent years the dynamic function of the electrical energy meter is receiving a lot of attention due to the increased development of the electrical power industry. Large-scale application of nonlinear loads such as the increased use of electrical trains that caused substantial dynamic currents to be drawn from the electrical system supply.. The distributed energy resources e.g. solar cell will result in a reverse flow of power from the user to the electrical power networks. In these cases the dynamic function of the meters becomes an important project that would be of interest to the user, including the utilities.

A project proposal was described in [1], followed by experimental results described in [2]. These presentations generated interests and responses from relevant stakeholders, such as research organizations and manufacturers of standard instruments. Further analysis of dynamic measurement function of electrical energy meters is discussed and presented.

II. PROJECT Objectives

A type approval test can be done to verify the dynamic function of the electrical energy meter. The results would assist the corresponding meter manufactures to improve the performance characteristics of the energy meters, such that the meters would meet an uniform performance standards acceptable to the users/utilities.

The type approval tests and performance verifications should follow the requirements as per IEC standards and other guides. However, most standards and national/international recommendations are addressing only stable and static conditions. In practice performance verifications of installed meters, including their reference standard meters maintained at national metrology institutes (NMIs) have only been evaluated in the stable and static conditions.

In order to realize the verification of the dynamic function of energy meters, the type approval test methods (item, test signal, instrument, and criteria) should be further studied and investigated, including discussions with the relevant stake holders.

III. Guideline

The test method should follow the following guidelines:

(1) the meter should be in actual operating conditions;

(2) test methods should not be expensive and not requiring many new additional equipment;

(3) the requirements of the new proposed tests should be checked of the meters that have already passed the existing standards or regulations.

IV. Test Signal and Experiment Analysis

The kind of test signals used to evaluate whether the meter has the proper dynamic function are most important.

The impulse waveform would be a signal to verify the speed response of the circuit. However, such waveform would be difficult to generate with high precision as a metrology standard waveform.

The high frequency signal can be used to evaluate the dynamic function. However, in practice power systems have insignificant high frequency power. Therefore, it would not be necessary to have high frequency test facility, since this would increase the cost of the meter. The industrial power frequency test is essential. The harmonic voltage/current/power standard is just a combination of the industrial power frequency component as the main component and the high frequency component as a minor component. This power frequency signal can be used to verify the dynamic function of the meter. Of course, other parameters should be considered, such as the highest order limit and the ratio of every harmonic to fundamental component. Power standard equipment for sinusoidal/non-sinusoidal testing have been developed by many NMIs[3－7]. The basic principle would be to select one or several appropriate waveforms as the test signals. The square wave has been referenced in some standard guide as a test signal of harmonic measurements. This waveform can be used for performance evaluation of the dynamic function of energy meters.

The sine modulated waveform proposed by the Authors [1, 2] can be regarded as another kind of the harmonic evaluation test. The current form can be written as

$$i = a(b + \sin(2\pi ft / m)]\sin(2\pi ft). \quad (1)$$

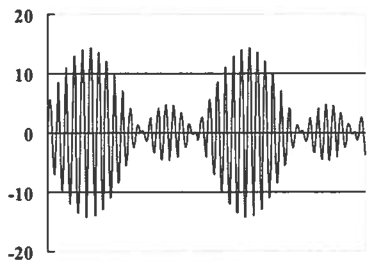

Fig.1 a sine modulated waveform with a=10, b=0.5, m=10

Fig. 1 is a sample waveform. It includes the fundamental frequency f, and two other frequencies $(1 \pm 1/m)f$ where m is an integral number larger than 1. However, they belong to inter- and sub-harmonic signals, different than the existing harmonic standard, but they do appear in the actual situation. The power flow with such current waveform and a sine voltage will change the power/energy flow direction twice in a cycle over m periods of the industrial power frequency. This experiment has indicated that the meter under test is not performing as it should [8]. That is that the positive and negative energy readings are mistaken, but the total energy readings are still correct. This is a phenomenon which has not appeared in the other previous experiments.

The reason is that these meters can correctly measure the instantaneous power, but they have an intrinsic longer measuring time constant and could not follow the changes of power/energy flow of the test signal. Therefore, the meter readings do not display the correct positive and negative energy values.

In existing standard guides, the performance verification is performed under a stable and static signal. Some manufacturers take a digital average over a longer time for a better accuracy. Obviously, these meters have no dynamic function. It is important for situations where the positive and the negative energy need to be measured properly. For example in the case of solar cells, one meter should be able to measure the two directions of the power/energy flow with different energy billing cost for each direction. Several other short comings are found using the sine modulated waveform. In principle the meter manufacturers should properly evaluate and improve their meter products accordingly.

This sine modulated waveform belongs to a stable dynamic signal, so that it can produce a highly accurate and calculable output. It is an important advantage for properly developing a higher level of metrology standard.

Another waveform, namely the trapezoidal modulated one is also proposed and studied. However, no significant short comings are discovered. It is proposed to proceed with further investigations. The negative current direction can be considered to be an inserted waveform to check other possible issues.

V. Other Proposals

Several proposals have been mentioned, one of them is that the voltage dynamic signal should be considered too. For example harmonic power (produced by the same order voltage and current) will mix with the fundamental power to appear together so that it will become a dynamic factor.

In the type approval test, the sine modulated waveform (and others) can be employed for the dynamic performance evaluations. However for a separate dynamic measurement it should include also the general sine waveform test and the harmonic test. A very important matter is the question whether this issue could be considered as final. Perhaps there are still other factors that should be considered as necessary test items. These should be based on actual operating conditions of the energy meters encountered in practice.

VI. Conclusion

The dynamic function of the electrical energy meter should be verified through type approval tests. The applicable standards and the corresponding guidelines are discussed. The existing harmonic standards can be used to check the dynamic function of the energy meters. The sine modulated waveform is a suitable new test signal. Further research for actual operating conditions of the energy meters is proposed.

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