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# Performance Evaluation of Smart Meters as per Indian Standard

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## Abstract

Smart Meter is one of the most significant devices of the smart grid. It is an AC static watt-hour meter with time-use registers and internal connect and disconnect switches with two-way communication. Conventional static meters are being replaced with smart meters to reduce Aggregate Technical and commercial (AT and C) losses and improve the quality, reliability and affordability of power supply which is the main objective of the Revamped Distribution Sector Scheme (RDSS). To ensure the reliability of smart meters, they have to be tested under various influence quantities in testing laboratories as per National/International standards before being installed in the field. The Standards stipulate various test conditions to which the Smart Meters are to be subjected to ensure their withstanding capacity and accuracy. During the type test, it is observed that a few meters fail to withstand such simulated conditions. This paper presents the performance of smart meters during metrological tests as per Indian standards.

**Keywords:** Accuracy, Performance Evaluation, Permissible Limit, Smart Meter, Test Condition

## 1. Introduction

The Smart Meter is an important component of Smart Grid. They are the building blocks in the smart grid network. A smart meter connects the consumer to the utility with two-way communication. It helps in accurate data measurement, computation, analysis, storing, controlling and transferring information through communication modules. Smart grid applications mainly depend only on smartmeters for their data and information. Two-way communication smartmeter helps the Consumer to receive their consumption pattern, tariff and alerts from the distributor[1,2]. This enables them to plan their usage to minimize their bill amount. Implementation of a smart meter program will significantly improve the billing and collection efficiencies of distribution companies provided they are thoroughly tested in testing laboratories before being installed at consumer premises.

## 2. Architecture

Advanced Metering Infrastructure has a smart meter as its integral part. It consists of the metering zone to measure and compute electrical parameters, the load switch which reconnects/disconnects the load, the metering protocol as per open standard and NAN or WAN as the communication module for communicating with the Data Concentrator Unit (DCU) or Head End System (HES).

## 3. Test for Metrology

Metrology test includes Type, Routine and Acceptance test. Same-type meters with identical characteristics are chosen by the manufacturer to perform a series of tests called type tests. This test is performed to prove compliance with standard requirements for the relevance class of meter. This test is used to check the design and general characteristics of the meter selected for the test[1,2]. To test the standards in the manufacturing process all meters are passed through routine tests, this test checks for the compliance standards during manufacturing in the manufacturer site[1]. The acceptance test is performed for a sample in a lot to certify the acceptance of the lot[1].

Both acceptance tests and type tests are carried out at CPRI. It is observed that most of the smart meters comply

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with the requirement of standard in the acceptance test whereas fail in few tests during the type test.

## 4. Performance Evaluation

Large quantities of smart meters are being installed for the reliable and intelligent reading of power consumption by users[3]. Testing involves measuring the electrical parameters of smart meters and also testing communication between smart meters and other points of smart metering data network[4]. Smart Meters are tested in the laboratory with an automatic test bench with a source of higher stability and a reference meter of 0.05% or 0.02% accuracy as shown in Figure 1 and Figure 2[4,5].

**Figure 1.** Test set up with 0.02% class reference meter.

**Figure 2.** Test set up with 0.05% class reference meter.

Twenty sets of single phase and three phase smart energy meters submitted by different manufacturers were type tested and their results are indicated in Table 1[6,7].

**Table 1.** Schedule of type tests for smart meters

| Test of Insulation Properties | Observation/Remark |
|---|---|
| Impulse voltage | 1 set of meter failed |
| AC High voltage | |
| Insulation resistance | No failure observed |
| **Test of Accuracy Requirements** | |
| Error Limits | No failure observed |
| Meter Constant | |
| Starting | |
| No-load | |
| Ambient temperature | |
| repeatability of error | |
| **Test of Electrical Requirement** | |
| Power consumption | 1 set of meter failed |
| Supply voltage | No failure observed |
| Short-time overcurrents | |
| Self-heating | |
| Heating | |
| Earth fault immunity | |
| **Electromagnetic compatibility Test** | |
| Fast transient burst | No failure observed |
| Radio interference | |
| Electrostatic discharges immunity | 1 set of meters failed |
| Electromagnetic HF field immunity | 4 sets of meters failed |
| Surge immunity | No failure observed |
| **Test for Climatic Influence** | |
| Dry heat, Damp heat cyclic, Cold | No failure observed |
| **Mechanical Requirements Test** | |
| Shock | 1 set of meters failed |
| Vibration | No failure observed |
| Spring hammer | No failure observed |
| Dust and water penetration | |
| Heat and fire resistance | |

## 5. Impulse Voltage Test

The significance of this test is to check whether the dielectric properties are maintained by the meter and its auxiliary devices. The test is performed under a normal setting which includes the effect of ambient air and various voltages the meter is exposed.

**Test condition:** Ten times 6kV impulse of 1.2/50μs is applied and repeated the same with other polarity with a

3s minimum between the impulses. The Impulse Voltage test for electric circuits is conducted under two conditions: between the circuits and concerning earth.

The meter should hold up to the above test condition and function accurately.

**Test result:** It was observed that there was a flashover and the meter didn't function(there was no display in the meter) and did not comply with the requirement of the standard.

## 6. AC Voltage Test

While the test is performed disruptive discharge, no flashover, and puncture should occur when applied with a one-minute test voltage of Protective class 1/2: 2 /4kV

(i) All the voltage, current and auxiliary circuits are earthed.

(ii) Between the circuits not intended to be connected in service.

The Meter should withstand the above test condition and function accurately.

**Test result:** It was observed that the meter didn't withstand high voltage and there was no display in the meter.

## 7. Test of Power Consumption

The voltage circuit power consumption test is carried out under two conditions.

(i) In idle mode with a reference voltage at 50Hz.

(ii) During active communication mode with a reference voltage at 50Hz.

It should not be more than 3W and 10VA including the auxiliary power supply consumption. During data communication, the power consumption was more than the permissible limits specified in the standard.

**Power Consumption in the current circuit:**

Test carried out with a maximum current of 50Hz and the power consumption in the current circuit should not exceed a VA equivalent to 0.08%*Vref*100%*Imax and shall be within the permissible limits[8-10]. It was observed that the meters were recorded accurately in the current circuit.

## 8. Test of Immunity to Electromagnetic HF Fields

The purpose of this test is to check the immunity of smart energy meters against Electromagnetic fields generated by sources such as hand-held radio transceivers(walkie-talkies) that are used by operating, maintenance and security personnel, television and vehicle radio transmitters and electromagnetic industrial sources. The strength of the Electromagnetic field determines the EM environment[11].

The test procedure for this test is defined in IS 14700 (Part 4/Sec 3) standard.

**Severity Test Levels**

*Radio Frequency band:* 80MHz to 2GHz with Amplitude Modulation (AM) 80% in depth, 1kHz sine wave, Sweep rate:1%.

*Polarization:*

1)Horizontal

2) Vertical

Test field strength:10V/m

Test severity level:3

The immunity of smart energy meters shall be verified for two test conditions.

**Table 2.** EMHF Test condition and observation

| Test Condition | Qualifying Requirements | Observation/ Result |
|---|---|---|
| (i) Voltage and auxiliary circuits energized with ref. voltage | Test output will not yield a signal > x units, and the RF field application will not change the register > x units. | The change in the register was more than the allowed unit. |
| (ii) Voltage and auxiliary circuits energized with ref. Voltage with basic current and upf. | During the test, at sensitive or dominant frequency % error is measured, % error variance should be within the permissible range. | % error variation exceeded permissible limits as specified in the standard. |

The value x is

$x = 10^{-6}.m.V_{ref}.I_{max}$

where, m, $V_{ref}$ and $I_{max}$ represent several measuring elements, Reference Voltage (V), and Maximum current (A).

*Test Result:* It is observed that 4 sets of meters failed in this test. There was no display in the meter and didn't emit any pulse output.

## 9. Test of Immunity to Electrostatic Discharge (ESD)

ESD is the release of accumulated static discharge by a human or an object abruptly. ESD get coupled into

a smart energy meter directly or indirectly through radiation.

Any user-accessible entry points, including switches, knobs, input/output ports, and equipment housings, are included in direct coupling. The discharge between two external bodies to the system causes radiated coupling. Direct contact (contact discharge method) or shortly before contact (air discharge method) can be used to discharge into a smart energy meter. Smart energy meters when employed in service, must be proven for ESD immunity to assure non-failure when open to sensible ESD levels[11].

The test procedure for this test is defined in IS 14700(Part 4/Sec 2) standard.

*Severity test levels:* ESD Test Voltage: 8kV Contact discharge, 15kV Air discharge, two Shocks in both directions of three mutually perpendicular axes.

The meter should not show damage or cumulative kWh change after the test completion. At basic current meter error allowed is 50% of class index accuracy, 5% of maximum current at power factor = 1.

*Test result:* Physical damage was observed.

*Causes of failure:* The causes of failure could be due to poor mechanical strength.

## 10. Conclusion

The performance evaluation of smart meters during metrological tests under various influence quantities is discussed. Independent testing ensures that smart meters meet the same requirements, allaying utility and customer concerns.

EMI/EMC test influence plays a major role. Most of the manufacturers get acceptance tests done instead of full-type tests. The acceptance test does not cover the EMI/EMC test, environmental test mechanical test and communication test. To evaluate the performance of smart meters, they should be type-tested before being installed in the field. Type testing as per National/International standards ensures reliable products from meter manufacturers, accurate and quality meters to utilities and reliable billing to consumers. This provides the idea of identification of problems in the design and also helps improve the quality design of the smart meter and meet future challenges in the implementation of smart meters.

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