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Case Study on Parameter Verification of Energy Meter as Per Indian Standard

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ABSTRACT: With the advent of digitalization, energy meters have evolved significantly. Beyond just measuring energy consumption, these meters now record the critical data and having data downloading capability. An Open Protocol became necessity to achieve the data homogeneity among different makes of meters. One among the many open protocols is the DLMS, which is a standardized service layer protocol to enable energy meter communicate with a commercial head-end system (HES). Further, The Indian Companion Specification (ICS) was evolved by BIS as an Indian Standard IS 15959 which inherits the IEC 62056 series of standards. This paper delineates the parameters for energy meters for Reading, Tariff and Load control of Data exchange protocol as per Indian Standard IS 15959 (Part 1). Testing methodology for these parameters is described along with case study of programming parameter RTC. The purpose of this case study is to analyze and verify that the meters measure and record electrical quantities according to Indian standards which helps utility to maintain data homogeneity for the purpose of billing, load forecasting and analysis of load fluctuations. Additionally, the uniformities of event's data like Event ID and capture parameters supports utilities to analyze any theft and tamper conditions effectively which in turn helps to control commercial losses arising due to consumer's malpractices/ system vulnerabilities.

I. INTRODUCTION

Static Meters are divided mainly in three service categories and further into subcategories for various metering purpose.

TABLE 1: CATEGORIES OF STATIC METERS [1]

Sl. No.	Service category	Metering Purpose
i	A	Category A meters are deployed for Energy Accounting and Audit metering. The installation location could be Distribution Transformer Centers and sub-station feeders.
ii	B	Category B meters are deployed at meter banks and network boundaries. The parameters listed in this category are for import/export of energy. Availability based tariff (ABT) meters are also in this category.
iii	C	Category C comprises HV and LV Consumer meters 3phase 4 wires Whole current / direct connected meter, Single phase wholecurrent meter. The parameters listed for this category is for consumers who drawenergy from the grid.
	C1	Transformer (LT-CT/HT-PTCT)operated meters
	C2	Three Phase Whole current/directconnected meters
	C3	Single phase Whole current meters

Static energy meters record the critical data comprising load profiles, event data, and other relevant metrics which helps utilities to define the tariff structure, to strengthen their financial health and forecast their power requirements. The resilience of power grid is achieved using the load profile data. In essence, energy meters have become far more advanced and capable than originally anticipated. This advancement necessitated the requirement of standard communication protocol for Data exchange for the Electricity Meter in energy ecosystem. Testing and certification ensures that meters adhere to the Indian standard, promoting interoperability and seamless communication within the energy ecosystem. It involves validating the correct implementation of DLMS features and parameter verification in Indian context ensuring data accuracy, and confirming compliance with industry standards.

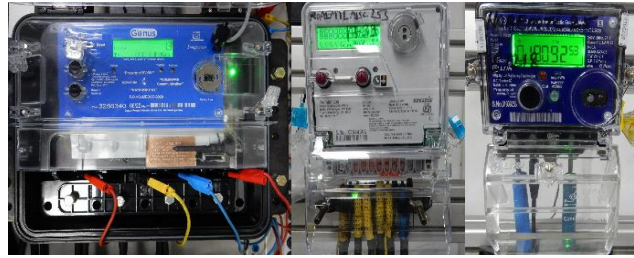


Fig 1: Various Categories of Meters

II. OVERVIEW OF DLMS PROTOCOL TESTING

Testing Procedure:

The Compliance testing is carried out to verify that the Data Exchange Protocol (DLMS Protocol) and requirement of standards implemented correctly in the meter. Meters claiming compliance to Data Exchange Protocol in India needs Conformance to DLMS/COSEM (IEC 62056) Protocol and Parameter Verification as per standard. Data Exchange Protocol testing involves two steps; Conformance testing and Parameter Verification.

1. Conformance Testing:

It is done using an application like Conformance Test Tool (CTT) which automatically performs predefined tests on meter. The purpose of the CTT is to verify that the device implementation conforms to the DLMS standard, and, if not, to show which parts of the standard are not correctly implemented. The text file known as the Conformance Test Information file (CTI file), which contains a description of the pertinent device parameters used during the test, is sent into the CTT. [3] The CTT runs on a host computer and the device under the test is connected to it via optical port or electrical port. The various test cases related to HDLC based Data Link Layer, DLMS/COSEM Application Layer, COSEM Object, Symmetric Keys, Security Policies, Secure Message Exchange, General Block Transfer and Public certificates are performed to verify relevant requirements.

A digitally signed test report indicating which test cases passed and which failed is generated by the CTT as the conclusion of a test run. [3]

2. Parameter Verification: It is carried out as per Indian standard IS 15959 and its Parts 1, 2, & 3 for relevant service category of meters. Parameter verification consists of verification of following parameters:

2.1) SNRM/UA:(Set Normal Response Mode/Unnumbered Acknowledge): It is used to bring the meter in normal response mode. The meter after receiving a correct SNRM frame responds with UA frame.

2.2) Object list download: It is performed to verify the availability of implemented Object list that contains the list of all objects available in the logical device. [4].

2.3) Association Properties: The meter shall support three associations in the management logical device. [1]. Public client association (PC-OBIS-0.0.40.0.1.255), Meter reader association (MR- OBIS -0.0.40.0.2.255) and Utility settings association (US-OBIS -0.0.40.0.3.255).

Public client association (PC): The supported Conformance Block services in One byte and four byte addressing is GET for following parameters:

- Real time clock, date and time
- Current association
- Logical device name
- Meter Serial Number

Meter reader association (MR): The supported Conformance Block services in One byte and four byte addressing are GET, SET, GET with Block Transfer, Selective Access for following parameters in addition to PC association parameters:

- Instantaneous individual, snap shot & profile
- Block Load Profile
- Daily Load Profile
- Billing Profile
- Name Plate details individual & profile



- Event code object, Event log object profile & Scalar profile
- Voltage Related
- Current Related
- Power Related
- Transaction Related
- Other
- Non-Rollover

Utility settings association (US): The supported Conformance Block services in One byte and four byte addressing are GET, SET, Action, GET with Block Transfer, SET with Block Transfer, Selective Access for all the parameters listed under Meter reader association (MR) and programming of following parameters:

- Real time clock, date and time
- Demand integration period
- Profile capture period
- Single-action schedule for billing dates
- Activity calendar for time zones

2.4) Security: Three level of security are verified:

- Lowest Level Security Secret(PC Association)
- Low Level Security Secret (MR and US Association)
- High Level Security Secret (US Association)
- Encryption and Authentication

During this test the host changes the password of the server. The host then checks the password against the original password. The meter responds with HLS secret key not matching. The host then restore the old original password.

2.5) TOU Setting: In this test the default time zones are reprogrammed and check is done for the update of right amount of energy in the allocated time slot with set values of basic current and unity power factor. The event code 155 with date and time is generated after time zone setting.

2.6) Billing Period/ Billing Counter: This is used for accounting/billing purpose. The bill is generated through single-action schedule for each billing the billing period counter increases but no. of available bills depend upon the retention requirements of bills.

2.7) Parameter list:

a) **Instantaneous Parameter:** The most recent updated value will be accessible for download whenever needed, and these will be updated regularly [1]. The instantaneous parameters contain the real-time clock (date and time), current, voltage (phase and Line both), power factor in all three phases, overall power factor, frequency, apparent power (kVA), active power (kW – forward/reverse), reactive power (kvar – lag/lead), number of power failures, power-failure duration, tamper count, billing count, programming count, billing date, cumulative kWh, cumulative kvarh (lag/lead), cumulative kVAh, and maximum demand in kW and kVA.

b) **Block Load Profile Parameters:** This is a collection of load survey data that's been captured as the profile generic. [1] The capture object values will be copied into buffer of this array automatically as per capture period which is usually set as 15 minutes. By downloading these profile complete 96 entries of a day is available. The block load parameters contain the date and time, current and voltage in all phases, block energy in kWh, and block reactive energy in kvarh (lag).

2.8) Daily Load Profile Parameters: This is used to analyse the cumulative energy updated in 24 hours. The data updates at exactly midnight 00:00:00 every day. The daily load profile parameters contain the date and time, cumulative import and export energy in kWh, cumulative kVAh during import and export, reactive energy for high-voltage ($V > 103\%$), reactive energy for low-voltage ($V < 97\%$), and cumulative reactive energy (kvarh) in Quadrants I, II, III, and IV.

2.9) Billing Profile Parameters: Billing profile parameters (TOU) provides the utility to charge the consumer with different rates according to the consumption at different time zones. The billing profile is the profile containing all the data required by utilities for accounting/billing purpose. It contains Cumulative energy updated in each time zone and the corresponding maximum demand. The billing profile parameters contain the billing date, system power factor for the billing period, cumulative kWh, cumulative kWh for time zones, cumulative kvarh (lag and lead), cumulative



kVAh, cumulative kVAh for, maximum demand (MD) in kW, MD in kW, maximum demand (MD) in kVA, and MD in kVA for all time zones.

2.10) Event code & Event logging: Any exceptional condition/fraud/tamper condition is considered as an Event. [1] Meter records the occurrence/restoration of the event with event code and the date and time of occurrence/restoration. By the nature of the events; events are divided into the following categories.

- Voltage related events
- Current related events
- Power failure related events
- Transactional events
- Other events
- Non-rollover events
- Control events

2.11) Selective Access: Any profile buffer in the meter may be accessed by selective access, so that we need not to take a full profile view. In accordance with the standard, each energy meter should be capable of handling either of two types of selective access:

Selective Access by Range: This feature allows us to read a portion of the Profile buffer's rows and columns. This can be used to select any subset of profiles using all the capture items included in the profile. According to Indian standard, block load profile and daily load profile will be subject to selective access by range.

Selective Access by Entry: This method filters information from profiles by using integer values called from value and to value. One can use selective access by entry to take only the first five entries from a meter event profile if there are ten entries total. According to Indian standard, only row-based filtering is relevant for billing data profiles and event log profiles.

2.12) General Purpose Parameters:

a) Name Plate Details: The electrical and non-electrical details that can't be changed comes under Name Plate details. It is used to distinguish between two meters. It's provided by the manufacturer of the meter as per utility requirement. The name plate profile parameters contain the meter serial number, manufacturer name, meter firmware version, meter type (3P–3W / 3P–4W), internal CT ratio, internal VT ratio, and the year of manufacture.

b) Programmable Parameters: These parameters are non-electrical quantities. These parameters can be programmed using the US Associations. The programmable parameters contain the real-time clock (date and time), demand integration period, profile capture period, single-action schedule for billing dates, and the activity calendar for time zones. During the testing, on programming of any parameter corresponding event code is generated and logged with occurrence Date and Time under the Transaction Related Event compartment. Increment in programming count is also verified with every programming.

III. CASE STUDY

1. Objective: The purpose of this case study is to check the programmability of RTC and to verify the capture parameters of this particular event. The testing aimed to verify how the meters are logging event data.

A total of 223 number consumer meters comprising of C1, C2 and C3 categories from various manufactures are taken for studying the behavior and time stamping of Transaction Related Event: Real Time Clock- Date and Time.

2. Methodology: Meter under tests were energized at rated voltage, current parameters using programmable power source MT551 and test tool FET is used for Programming of RTC and reading the event profile of MUT.

Programmable Power Source: MT551 is a programmable three-phase current and voltage source for simulating a load during meter testing up to 500 V and 120 A. It has the functionality of individual load point settings, Programmable phase shift control from 0 to 360 degree, Programmable power factors, configuration of balanced and unbalanced load points and simulation of load conditions via adjustable currents, voltages and angles. The set operation is performed using integrated touchscreen.

About FET: The DLMS Functional Evaluation Tool (FET) is an advanced software-based testing system used to verify the conformance of static and smart meters to the DLMS/COSEM standard and parameter verification as per relevant Indian standard. This tool employs automated testing procedures to evaluate key functions such as communication performance, data structure integrity, and security mechanisms, ensuring that the meter complies with all required technical parameters defined in utility's Specification or in Indian standard. The DLMS FET includes more than 100 comprehensive test cases that assess critical functionalities including load profiles like block load and Daily load profiles, security validation, tamper detection and firmware updates. It supports multiple communication



protocols such as HDLC, UDP, and TCP (across IPv4 and IPv6) allowing it to operate across different network environments. Additionally, the tool validates the accuracy of the COSEM object model and OBIS code structures, ensuring the reliability and accessibility of the meter’s internal data.

Fig 2 represents the visuals of Test Setup at laboratory for case study. Fig 3 shows the Traffic of FET and meter communication during meter event profile downloading.

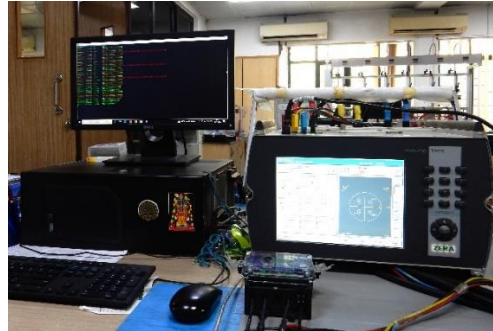


Fig 2: Test Setup

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Channel-0 :: Physical Layer ::
15: 34: 02: 763 <++++> :: 7E AD 07 03 21 53 03 C7 7E
Channel-0 :: Physical Layer ::
15: 34: 02: 807 <++++> :: 7E AD 07 01 03 1F 50 EA 7E |
Channel-0 :: Physical Layer ::
15: 34: 07: 192 <++++> :: 7E AD 23 00 02 04 01 41 93 98 F2 81 80 14 05 02 07 EE 06 02 07 EE 07 04 00
00 07 08 04 00 00 07 4E E9 7E
Channel-0 :: Physical Layer ::
15: 34: 07: 331 <++++> :: 7E AD 23 41 00 02 04 01 73 A5 31 81 80 14 05 02 00 FA 06 02 00 FA 07 04 00
00 01 08 04 00 00 01 1C 5A 7E
Channel-0 :: Application Layer ::
15: 34: 07: 346 <====> :: E6 E6 00 60 33 A1 09 06 07 60 85 74 05 08 01 01 8A 02 07 80 8B 07 60 85 74
05 08 02 01 AC 07 80 05 68 65 6C 6C 6F BE 10 04 0E 01 00 00
00 06 5F 1F 04 00 00 10 1C FF FF
Channel-0 :: Physical Layer ::
15: 34: 07: 346 <++++> :: 7E AD 44 00 02 04 01 41 10 96 27 E6 E6 00 60 33 A1 09 06 07 60 85 74 05 08
01 01 8A 02 07 80 8B 07 60 85 74 05 08 02 01 AC 07 80 05 68
65 6C 6C 6F BE 10 04 0E 01 00 00 06 5F 1F 04 00 00 10 1C FF FF 7A 1C 7E
Channel-0 :: Physical Layer ::
15: 34: 07: 547 <++++> :: 7E AD 3A 41 00 02 04 01 30 CA B5 E6 E7 00 61 29 A1 09 06 07 60 85 74 05 08
01 01 A2 03 02 01 00 A3 05 A1 03 02 01 00 BE 10 04 0E 08 00
06 5F 1F 04 00 00 10 14 02 00 07 BC 85 7E
Channel-0 :: Application Layer ::
15: 34: 07: 547 <====> :: 61 29 A1 09 06 07 60 85 74 05 08 01 01 A2 03 02 01 00 A3 05 A1 03 02 01 00
BE 10 04 0E 08 00 06 5F 1F 04 00 00 10 14 02 00 00 07
    
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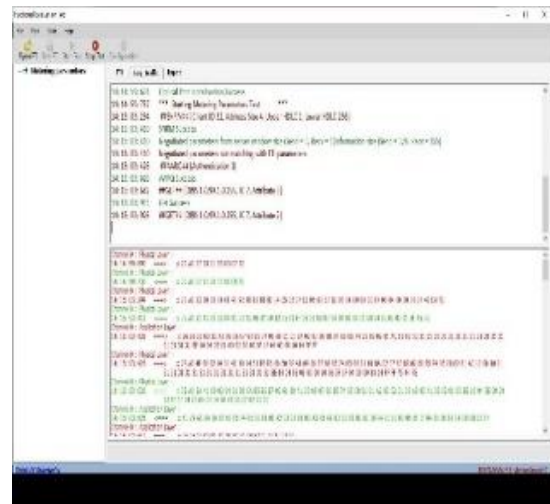


Fig 3: Traffic during testing

3. Observations: During the testing process, it was observed that On Programming of RTC; meter’s RTC has changed and updated with newly set date and time. It has been verified via downloading and reading instantaneous profile and updated RTC is also seen on the LCD display of meter.

All Meters have logged the event id of RTC Programming in similar way. However, the variation is observed in the pattern of logging of capture parameters of event. The meters have shown two different behaviors B1 and B2.

Behaviour B1: meters have recorded actual Date and time of the occurrence of event as capture parameter “Date and time”.

Behaviour B2: meters have recorded programmed Date and time as capture parameter “Date and time”.

The results are shown in **Tabular format** below:

Table 2: For C3 Meters

Manufacturer	Total Samples	Behaviour 1	Behaviour 2
M1	25	25	0
M2	20	12	8
M3	7	5	2
M4	30	0	30



M5	10	6	4
M6	14	12	2
M7	32	0	32
M8	26	26	0
M9	8	8	0
M10	8	8	0

Table 3: For C2 Meters

Manufacturer	Total Samples	Behaviour 1	Behaviour 2
M1	4	4	0
M2	6	6	0
M3	8	5	3
M4	2	0	2
M5	3	0	3

Table 4: For C1 Meters

Manufacturer	Total Samples	Behaviour 1	Behaviour 2
M1	8	8	0
M2	7	7	0
M3	5	5	0

Fig 4, 5 and 6 shows the visual representation of observations made:

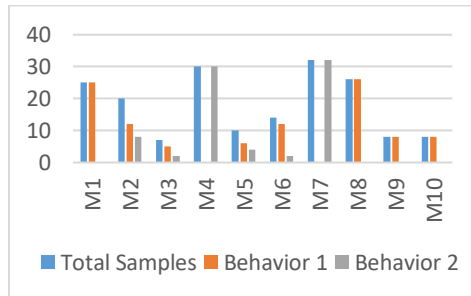


Fig 4: Observations of Each Manufacturer for C3

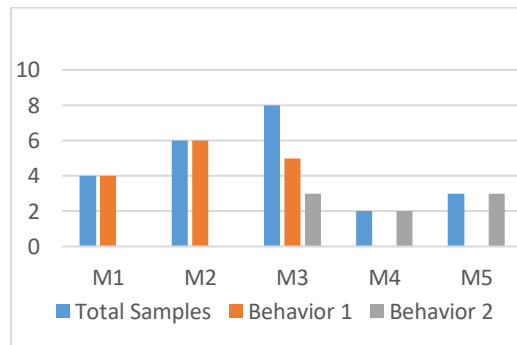


Fig 5: Observations of Each Manufacturer for C2

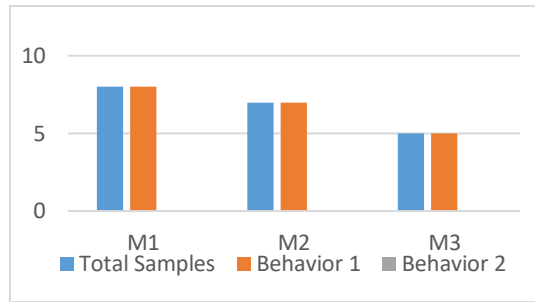


Fig 6: Observations of Each Manufacturer for C1

IV. RESULT ANALYSIS AND DISCUSSION

It is evident from the case study results that meters are exhibiting two different behaviors with reference to logging of date and time of occurrence of event. The table 5 below shows the percentage of Behavior B1 and B2 under each category of meter for all manufacturer meters taken up for case study.

Table 5: Relative Percentage for C1, C2 and C3

Category	C1		C2		C3	
	B1	B2	B1	B2	B1	B2
M1	100%	0%	100%	0%	100%	0%
M2	100%	0%	100%	0%	60%	40%
M3	100%	0%	62.50%	37.50%	71.40%	28.50%
M4	-	-	0%	100%	0%	100%
M5	-	-	0%	100%	60%	40%
M6	-	-	-	-	85.7%	14.2%
M7	-	-	-	-	0%	100%
M8	-	-	-	-	100%	0%
M9	-	-	-	-	100%	0%
M10	-	-	-	-	100%	0%

Category C1 meters have shown only one behavior i. e. behavior B1. Hence category C1 meters have 100% dominance of behavior B1. Same is being reflected in Fig 7 below:

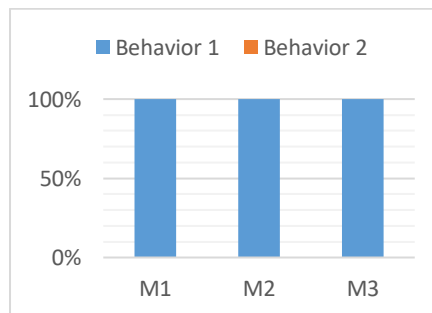


Fig 7: Relative percentage of B1 & B2 for C1 meters

Behavior of Category C2 meters is spread across B1 and B2. Out of total number of C2 meters tested; nearly 65% meters have shown behavior B1 and 35% meters have shown behavior B2. Hence the behavior B1 is relatively dominant under this category of meters. Data is reflected in Fig 8 below:

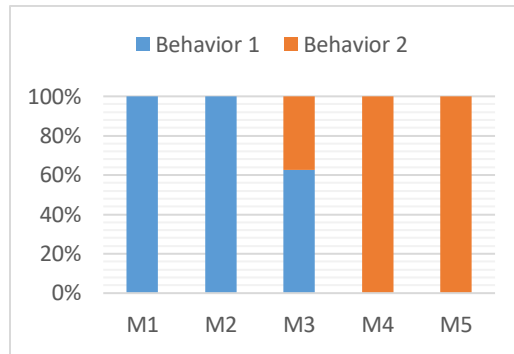


Fig 8: Relative percentage of B1 & B2 for C2 meters

The variation in behaviors is more prominently visible in Category C3 meters across all manufacturers. Out of total number of Category C3 meters tested; nearly 57% meters have shown behavior B1 and 43% meters have shown behavior B2. Less than 15% difference is observed between two behaviors with B1 is on leading side. Data is reflected in Fig 9 below:

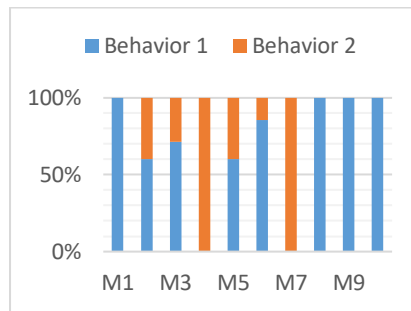


Fig 9: Relative percentage of B1 & B2 for C3 meters

Fig. 10 and 11 show the overall behavior analysis of all categories of meters C1, C2 and C3 for each manufacturer taken up for case study.

In practical scenario, the captured date and time should be the date and time of the event at which the event takes place. The meters which recorded programmed date and time as event occurrence time can lead to confusion at data handling section at HES end, which can further cause ambiguity during event profile analysis of various energy meters.

There could be two reasons behind the variation in behaviors; One is the possibility of misconfiguration in hierarchy of handling of time-based events and the other could be the way delays are introduced in the programming logics at the meter software end.

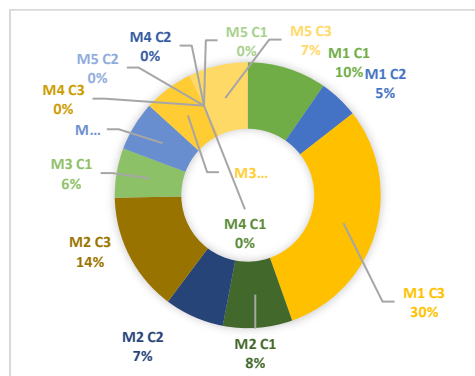


Fig 10: Behavior 1 analysis across all categories of meters for each manufacturer

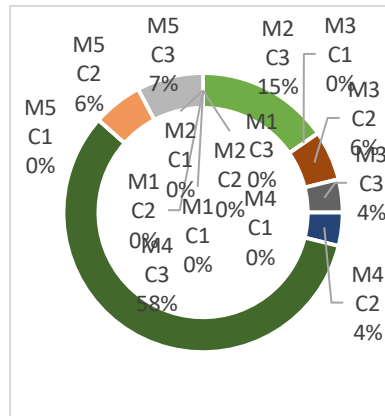


Fig 11: Behavior 2 analysis across all categories of meters for each manufacturer

V. CONCLUSION

The primary objective of adopting the DLMS protocol was to ensure that utilities get data like energy parameters, events, alarms, and other critical parameters seamlessly at HES end for analysis and billing purpose. Testing validates that the meters correctly implement the required features of Indian Standard 15959 and facilitate in achieving interoperability among various manufacturers which is the true essence of the standard.

The presented case study shows the dissimilar behaviour of the meters which will pose the event data handling challenges at the Billing Software at the HES system. Also inaccurate timestamps of events could hinder performance tracking, or troubleshooting in the event of any anomaly.

To ensure the reliability and accuracy of data collected by consumer meters, it is utmost important that all meters adhere to uniform behaviour for programming functionality of RTC and capture parameters of events. The actual time of events occurrence would bring clarity in event profiles. Indian Standards Body should also look into the matter and ensure that there is no ambiguity while bringing up the content of standards to the stakeholders.

As energy meters are data bank of power grid and information available in meters is crucial to the successful deployment of the smart grid, it is essential for all stakeholders to come on common platform as far as interpretation of the Indian standard of DLMS Data Exchange protocol is concerned, benefiting all stakeholders, from utilities to consumers.

VI. ACKNOWLEDGEMENT

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REFERENCES

[1] IS 15959 (Part 1):2016 Data Exchange for Electricity Meter Reading, Tariff and load control-companion Specification.
 [2] IS 15959 (Part 1):2016 Data Exchange for Electricity Meter Reading, Tariff and load control-companion Specification.
 [3] Analysis of DLMS Protocol Technical Report, version 1.0 [Online]. Available <https://www.fit.vut.cz/research/publication-file/11616/TR-DLMS.pdf> (visited on 05.01.2025)
 [4] Review and Case Study of DLMS Protocol Testing on Smart Meter published in “National Conference on Smart Grid, Smart Meter, Communication, Technologies and Cyber Security” [One day workshop on CYBER SECURITY INITIATIVES IN THE POWER SECTOR CPRI Bangalore, 14-15 February, 2024].
 [5] V Suresh and V Arunachalam “Qualitative Testing of DLMS/COSEM ICS compliant Energy Meters”: Electrical India
 [6] Amar Shah, Manan Desai, Sandip Panchal A Study Article of DLMS to IOT Protocol DOI [Online]. Available: <https://doi.org/10.22214/ijraset.2024.60895>



- [7] Zhang Luhua, Yi Zhonglin, Wang Sitong, Yuan Ruiming, Zhou Hui and Yin Qingduo, "Effects of Advanced Metering Infrastructure (AMI) on relations of Power Supply and Application in smart grid," CICED 2010 Proceedings, Nanjing, 2010, pp. 1-5.
- [8] S. Lee, J. Kim, H. Yoo and T. Shon, "Case Studies for Analyzing DLMS/COSEM-Based Smart Meter Vulnerabilities in Korea," 2016 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData), Chengdu, China, 2016, pp. 667-674, doi: 10.1109/iThings-GreenCom-CPSCom-SmartData.2016.145.
- [9] IEC 62056-5-3:2023 Electricity metering data exchange - The DLMS®/COSEM suite - Part 5-3: DLMS®/COSEM application layer.
- [10] IEC 62056-6-2:2023 Electricity metering data exchange - The DLMS®/COSEM suite - Part 6-2: COSEM interface class.

AUTHORS



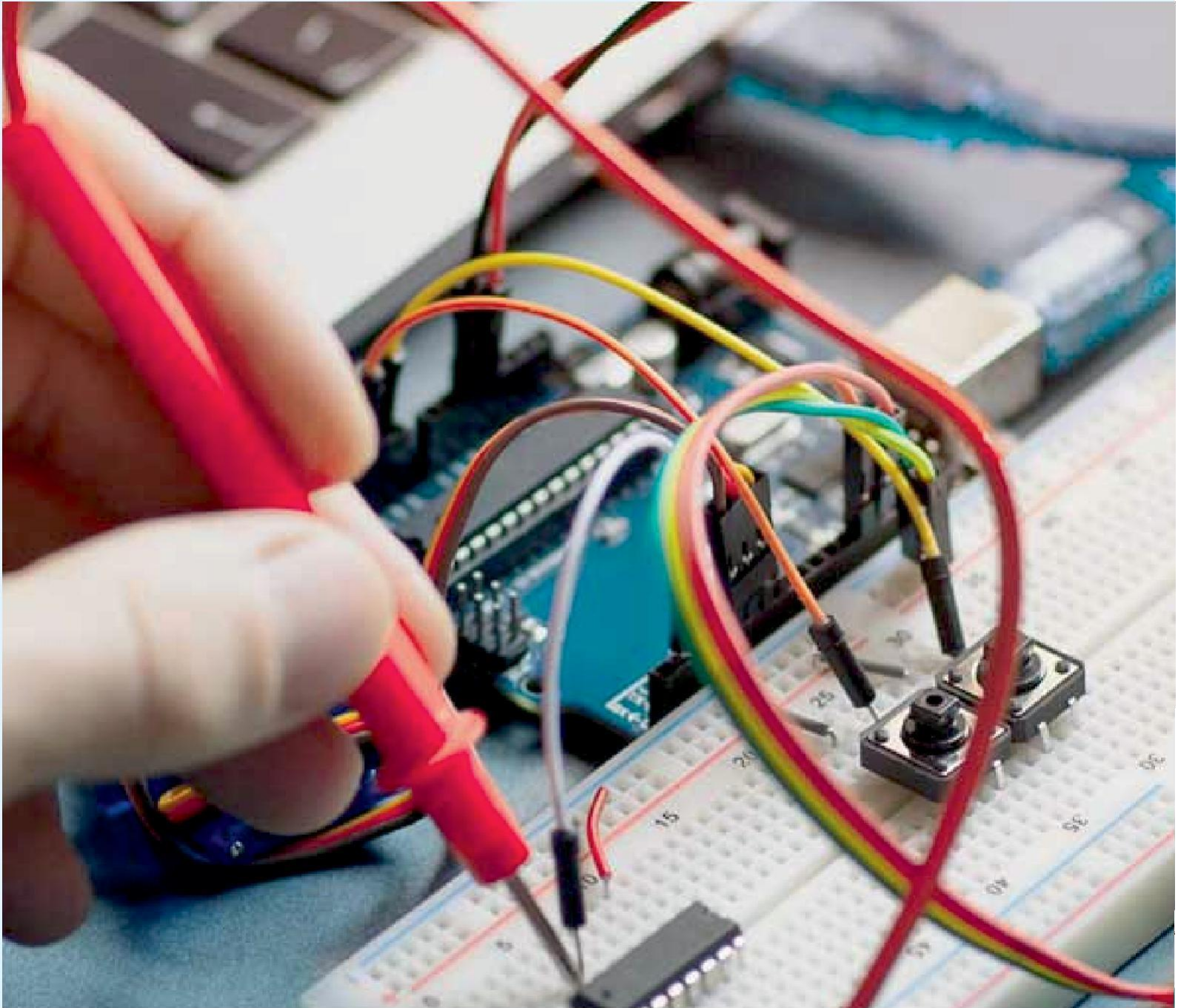
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