Mobile On-Line Testing Setup (OLTS) for HT Consumers Metering System

Ramesh B Patel
Former Head, GPRD Cell,
GUVNL, Gujarat

Jatin B Upadhyay
I/C Head, GPRD Cell,
GUVNL, Gujarat

Sachin P Rathod
Junior Engineer, GPRD Cell,
GUVNL, Gujarat

ABSTRACT

The electrical energy measurement system is playing a very important role in the Power System to assess energy efficiency and accountable losses. Specifically, the accuracy and the correctness of electrical energy measurement systems installed at HT consumers are very important. For any DISCOM, these consumers generate reasonable revenue, and hence, it is imperative to regularly confirm the accuracy of the entire HT consumer metering system. As this are high consumption consumers, any deviation other than the limit specified will incur huge loss. As per prevailing practice in DISCOM, the accuracy of the HT CTPT unit at actual loading is not being checked on-site due to current technical limitations, unlike in the LT Consumer metering system. The Accuracy of the HT CTPT unit may change with time due to various influences and stresses. In order to assess the correctness of the HT consumer's whole metering system, without interrupting the power supply, the GPRD (Gujarat Power R&D) Cell developed a vehicle-mounted mobile HT testing device. The Mobile HT testing system named On-Line Testing Setup (OLTS) consists of a Panel Enclosure with two no's 11 KV VCB, 0.05 Class resin cast CTs & PT, Hotline clamps for clamping, Flexible HT Copper Cable, Hotline sticks, etc. The 11 kV OLTS is an innovative product that helps utilities to identify the error in the HT metering system and confirms any revenue leakages.

1 INTRODUCTION

As we all know, HT consumers are crucial to any DISCOM since they are a significant source of their income. In every DISCOM, accurate and error-less HT Metering are very crucial. The main elements of the HT consumer metering system are the Current Transformer, Potential Transformer, energy meter, and control wire. According to current practice and GERC regulations, all DISCOMs are obligated to regularly examine and confirm the accuracy of each HT metering installation every six months. Therefore, the accuracy of all the important components of the HT metering system must be periodically checked, especially during the actual electrical loading conditions. However, as per standard testing procedures, it is not possible to assess the accuracy of the combined HT CTPT unit and the condition of the secondary cable during actual loading without cutting off the power. Furthermore, due to numerous factors such as continuous excessive harmonics conditions, switching transient, frequent faults, CTPT core design limitations, ageing, constructional/operational defects and higher VA burden than recommended, etc., the accuracy of CT and PT may at any time differ [1].

The accuracy of the CT/PT unit depends on the aforementioned numerous factors, hence the accuracy tested in unloading conditions can occasionally differ significantly from that tested under actual loading conditions. Sometimes, the CT-PT unit having some constructional / operational defects went unnoticed during its whole operating life time; which after its failure been replaced by healthy CT-PT unit. In such scenario, the accuracy of such measuring instruments goes unknown permanently. This might result in a significant revenue loss for the DISCOMs. As per the prevailing practices, the Combined CTPT units are tested under standard conditions at utility laboratories or at the HT consumer installation sites using the primary injection method or secondary injection method. However, using these two alternatives under conventional testing conditions at frequent interval will not only causes the force outages to the potentially high revenue HT consumers and thereby creating dissatisfaction but also due to these methodology errors of actual loading conditions went unnoticed.

When there is a major inaccuracy observed by utility engineers in the metering system such as CT-PT missing, heavily unbalanced Current or voltage parameters; in such cases utility

engineers compare the energy recorded by the HT consumer's tariff meter to the energy measured from the low voltage side to determine the measurement error. For this, hypothecation calculations are made to account for losses in secondary cables and transformers. However, the same method is inaccurate since the computation for transformer and cable losses are inaccurate. Occasionally, the installation site might not have the necessary feasibility for detecting low voltage side energy, assessing the evaluation of error even more challenging.

Thus, there is the requirement of a precise and authenticate testing system set up which works on real loading conditions. For the same, the GPRD team has taken up a very innovative research project to address the aforesaid limitations in the accuracy measurement system and developed an innovative product named 11 kV “ONLINE TESTING SETUP” (OLTS)“ for HT Consumers metering system.

2 About OLTS

To overcome the limitations of the existing practice of the testing and confirmation of the complete HT Metering testing at the site and in the real loading conditions, GPRD Cell innovated and developed one proto unit of vehicle-mounted mobile testing setup for the HT metering system as an 11 kV “**ONLINE TESTING SET(OLTS)”.**

The OLTS is a complete set of the vehicle-mounted testing panel to test on-site and in the actual electrical loading conditions of the installations. The OLTS panel is comprised of its key components viz. two no’s of HT (11KV) Motorised Vacuum circuit breakers for incoming and outgoing circuits, HT Single core EPR Insulated Flexible copper cable, Hot Line Clamps, Three no’s of resin cast HT current transformers of 0.05s accuracy class and having two different ratios of 200/5 and 40/5 Amps, resin cast three-phase HT PT of 0.05 accuracy Class of ratio 11000/110 Volts, earthing cable and other auxiliary components, safety equipment for operation. Additionally, other required equipment for satisfactory operation of the OLTS such as portable earthing rods, HT ERS, HT telescopic rod, and other required devices.

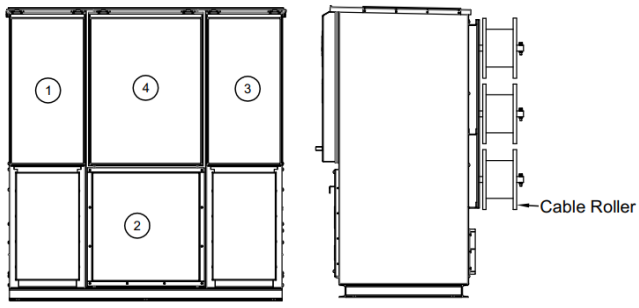

Fig.1 OLTS panel

1. Incoming 11 KV VCB

2. 11 KV CT & PT Unit

3. Outgoing 11 kV VCB

4. Test Terminal Block (TTB), Control & Aux. wiring

5. 11 KV Single core EPR Insulated Flexible copper cable for incoming and outgoing circuits provided on phase-wise cable roller.

3 Testing Methodology with OLTS:

The vehicle-mounted 11 kV OLTS van is developed to test the HT consumer system at the installation site and during the actual electrical loading conditions. Thus, this OLTS van is taken to the factory premises of DISCOM’s HT consumer. The general testing setup with OLTS shall be as shown in Fig. 2 below,

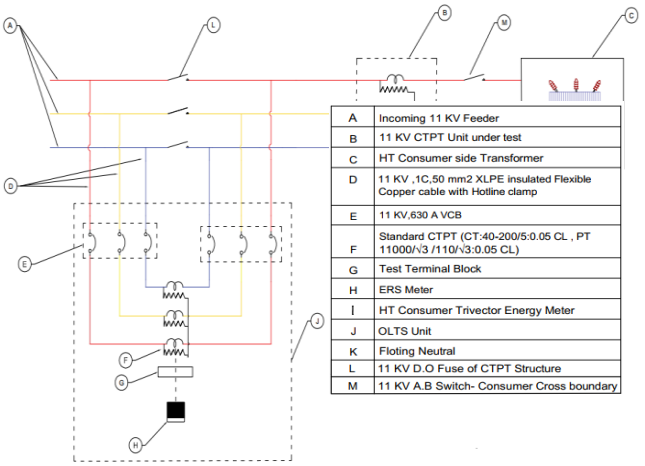

Fig.2 Schematic connection diagram for HT Consumer metering system testing arrangement using OLTS

As per prevailing practice of the Gujarat DISCOMs, the HT combined metering CTPT unit is installed on the double pole structure with a D.O. fuse as a Primary Protection.

The connection arrangement of OLTS with the HT Consumer Metering system is displayed in fig.2. The connections shall be made such that the OLTS and the HT consumer CTPT unit remain in a series during testing. The detailed connection and testing methodology is described as follows,

- For the electrical safety of testing staff, two portable earth electrodes are used to locally earth the body of OLTS through separate earthings.
- According to the contracted demand of the HT consumer under test, the operator of the OLTS shall select the measuring CT ratio from 40/5 OR 200/5 Amps using the selector switch provided on the front panel of the OLTS.
- In live conditions, the Power terminal of an incoming cable of the respective phase of OLTS is clamped on the incoming side of the AB switch / DO Fuse of the CTPT structure.
- The terminal of the outgoing cable is clamped on the outgoing side of the AB switch / DO Fuse. Telescopic Hot line sticks are used to complete the terminations, which shall be done from the ground level. The OLTS cable connections with overhead lines are attached and detached using a unique form of hotline clamps that are prefixed with cable terminals.
- The proper phase matching shall be ensured during the clamping operations using the colour coding of the cables.
- Once, the phase matching is confirmed the incoming VCB is turned “ON” followed by confirmation of the phase-wise voltage presence indicators. Two sets of VPIs are provided before and after the current circuit of each VCB.
- The outgoing VCB is turned “ON” once the incoming side VCB status is confirmed. In these conditions, the two electrical circuits i.e. the OLTS current circuit and the DISCOM network circuit come in parallel and share the current in accordance with their respective circuit impedances.
- Then, after removing/opening the DO fuses/AB switch, the OLTS, and CTPT shall be connected in series so that the entire installation's primary current can begin flowing through the OLTS without cutting off the consumer's power supply.
- Thus, after connecting OLTS in the primary circuit, the current shall pass through the incoming cable, incoming VCB, OLTS CTs, outgoing VCB, outgoing cable, DISCOM CTs that are being tested, and the consumer transformer.
- The High accuracy Electronic Reference Standard (ERS) meter is used with OLTS to measure and record all instantaneous electrical parameters of the installation and to compare the recorded energy with the energy recorded by the consumer tariff meter with installed combine CT-PT unit under actual loading conditions. The precise accuracy and error measurement of the complete HT consumer metering system can be easily ascertained using this technology.
- For the measurement of the combined accuracy, A dial test OR a pulse measurement test are the two main techniques. In the case of measuring the accuracy using the pulse measurement method, a cable is used to transmit the energy detected by the HT-TVM pulse scanner to the OLTS ERS. Once the measurement is complete, the OLTS ERS displays the measurement deviation of the device being tested. While In the dial test, the energy measured by the consumer metering set under test and energy flowing through the ERS of the OLTS unit shall be compared and the deviation in the readings can be calculated to find out the error.

4 Safety measures

The complete Standard Operating Procedure (SoP) is prepared by GPRD Cell for testing of HT consumer metering systems by 11 kV OLTS. The SoP and the vehicle-mounted OLTS have been approved by the Chief Electrical Inspector of the Government of Gujarat. All necessary visual, mechanical, and electrical interlocks are provided to ensure the complete safety of the OLTS operating staff during the testing of the HT consumer metering installation.

Other operational safety measures are,

- The mandatory provisions for isolating the testing area by utilizing traffic cones, safety chains, and warning & safety sign boards.

- During the Hot Line clamping of incoming and outgoing circuits cables of the OLTS High Voltage earth mats must be used.
- Mandatory use of all required PPE including safety shoes and hand gloves by the operational staff during the testing.

5 Key Features and Advantages

- A testing solution that can be used on-site under actual loading conditions without interrupting the consumer's power supply.
- The DISCOMs can do the testing on their own, without outside assistance or outsourcing.
- It is possible to prevent massive hidden revenue leakages by identifying hidden defects in the CTs and PTs.
- Economically & technologically viable solution.
- HT Consumers connected to an 11 kV system can be live tested using OLTS.
- Compare to the conventional method, it offers accurate testing results for the entire metering system in case of hidden defects of CTPT units.

6 Outcomes and way forward

- Through extensive R&D and a prolonged process, the prototype of 11 kV OLTS was designed and developed, as per industrial standards.
- Based on the weight and size of the OLTS panel, the appropriate vehicle was chosen, and the first prototype OLTS unit was deployed in the jurisdiction of UGVCL.
- The DISCOM staff has been using OLTS in accordance with their needs for more than six months. Over 40 no's of HT customer installations were tested and analyzed using OLTS on site in the actual loading conditions without any prolonged power outages.
- The major outcome from the OLTS testing is that 5 HT installations from them had % combined error beyond the permissible limit of accuracy which leads to the supplementary bills amounting to approximately Rs. 35 lacs. Additionally, by using OLTS, the precise energy loss of a specific section of a distribution line can be calculated, and the need to augment the conductor can then be decided upon in order to minimize revenue leakages caused by an energy loss in a specific section as a result of overloading.
- Presently, the prototype is designed for 11 KV test unit only, but the same can be designed and developed for any capacity from 11 KV onwards.

Furthermore, GPRD Cell, IIT Gandhinagar, GUVNL has invented and developed this innovative solution. As a result, GPRD has already applied for its patent rights at IPR Mumbai. The patent got provisionally approved by IPR, India vide registration no. 201821011764.

7 Challenges

During the operation of OLTS in the prevailing power distribution system, several suggestions, ideas, and operational problems were noticed and identified for the design improvements of OLTS.

There are some locations, where it can be very challenging to do hotline clamping of the OLTS cables under live loading conditions and keep them connected throughout the testing period due to variation in switchgears installations in field and other non-standard installation practices.

In such cases, In order to attach the incoming and outgoing cables of the OLTS in various field situations, GPRD Cell has designed and developed universal clamps which can carry a continuous rated current of 250 Amps. These clamps shall be installed on the existing HT installations prior to testing with OLTS.

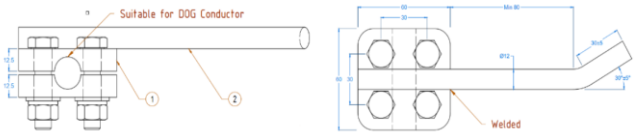

Fig.3 Universal clamps for Testing

8 Conclusion

Using 11 kV OLTS for the testing of HT consumer metering, the error of the metering CTPT unit and Tariff Meter can be worked out in combination OR separately. Using this method no component of the existing HT consumer metering arrangement shall be untested and

precise accuracy confirmation may be achieved. In a nutshell, the leakage of the DISCOMs' revenue, due to hidden errors (which otherwise can never be measured & assessed) in the metering CTPT unit can now be easily & precisely verified. The effect of live loading parameters, constructional defects and ageing effects which earlier went unnoticed can be tracked upon more accurately and precisely to prevent revenue leakages. Additionally, based on the results obtained with the help of OLTS, the DISCOM may feel more confidence in their metering system of HT consumers. All in all, The OLTS is full-proof solution which can collectively solve all the problems related to testing and accuracy confirmation of HT metering.

Author: Biodata

8 REFERENCES

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[1] Shri R. B. Patel

Sh,R.B. Patel graduated in Electrical Engineering, and later he passed the examination of Energy Auditor in First class with Distinction in 2009 through BEE. He had more than 30 Years of experience in power Transmission & Distribution and also monitoring different electricity schemes. He was the former head of the Gujarat Power Research and Development (GPRD) Cell, GUVNL and also the In Charge Chief Engineer (Tech), GUVNL, at Vadodara. He retired from the duty in May-2021. He worked as a team member in the development of technical specifications for many items related to the DISCOM business, like Transformers, Energy Meters, RMUs, 11KV capacitors, Cables, and Solar systems with its communication software. He has developed various equipment independently, like Special Designed Transformer (SDT), Planned Load Management Transformer (PLMT), HT Metering Cubicle, and HT-ABS. He has awarded by IUCAN National Award in 2014 for the Invention of Special Design Transformer for single phase power supply to Agriculture Farm.

[2]Shri J. B. Upadhyay

Sh. Jatin B Upadhyay (Head of Gujarat Power Research and Development Cell, GUVNL, IIT Gandhinagar) – MBA (Finance), B.E (Electrical), ACPDM He is currently working as an I/C head & Superintending Engineer(R&D) at GPRD Cell, GUVNL. He has in total of 22 years of operational and managerial experience in power distribution at various stages. He joined PGVCL in the year 1998, in which he was assigned the various role & responsibilities of Operation and Maintenance engineer at the subdivision level. After promoting to the next carder in the year 2008, he has experience of New HT/EHT consumer activities, HT consumer installation testing, Lab testing, power system improvement, various scheme implementation and monitoring, Energy audit at distribution feeder level, substation level, etc. In, April 2017, he was selected at GPRD cell, GUVNL through internal recruitment in which he was assigned the role of R&D Engineer where he has been working on various research base projects for power quality issues like Harmonics, Over and under voltage at MV feeder level, Reactive Power requirement of the power grid, Distributed RE Solar PV base generation scheme and its monitoring tool, Accurate testing of HT/EHT consumer metering, Substation automation and Feeder level interruption monitoring system, etc.

[3] Shri S.P.Rathod

He is currently working as an R&D Engineer at GPRD Cell, GUVNL. He has in total nine years of experience. In the early phase of his carrier, he served a Welspun Corp as a junior engineer for around 1 year in which he worked in areas of Level-1 Automation, Drives, Field sensors, SCADA, and automation system troubleshooting activities. Then, he joined UGVCL where he was assigned the role of O&M Junior engineer overseeing the operation and maintenance activity of power distribution lines,

Transformers, energy meters, etc. Also, Overseeing various Power quality and Reliability issues related to the Power distribution system and Consumers. Then he was selected at GPRD cell, GUVNL through internal recruitment in which he was assigned the role of R&D Engineer in which he has done research in the field of Various Power quality related issues of DISCOMs, automation, and SCADA of the Distribution system, Development of metering scheme for Grid-connected Agriculture consumers having solar installations, Renewable Energy projects, Smart feeder monitoring system and Development of Onsite CTPT Unit testing facility, etc.