Meter Testing Equipments, Laboratory Planning and set up

By:- B M Vyas
Yadav Measurements, Udaipur.

A specifically designed program for
Da Afghanistan Breshna Sherkat (DABS)
Afghanistan
Introduction to

• Meter Test Equipment
• related IEC standards
• Calibration and test lab visit
Test Classification

- Type tests
- Acceptance test
- Routine tests
Why meter testing is required for Utilities?

- Acceptance testing of meters
- Testing of samples for routine or type test
- Periodic re-certification
- Certification in case of disputes
Applicable standards on MTE for Error Testing

- IS 12346 rev 1 (1999)
- IEC 60736…. (1982)
- These shall be read along with relevant metering standard like IS 13010, 13779, 14697
  - For various definitions
  - Acceptable limits
  - Test conditions
What is a MTE?

- A set /assembly of equipments which supply required voltage, current, power factor,
- Measure reference energy / power
- Sequence the tests, test procedures
- Error calculation and reporting/ recording of results
Types of meter test equipments (by function)

• **Manual MTE**: The supply of energy to MUT, its measurement, error calculation, the test sequence and test procedure, are all done manually. These are transformer based source, meter mounting rack, some reference equipment.

• **Semi-automatic**: The supply of energy to MUT and the test sequence are manually controlled. Measurement and error calculation are performed and controlled as well as recorded along with test data, automatically through a computer program (software). These have one or more scanners and electronic reference.
Types of meter test equipments ..contd.

- **Fully automatic** The supply of energy to MUT, (synthesized waveform generator, power amplifiers based source), its measurement, error calculation using single or multiple scanners, the test sequence and the test procedure, are all performed with the aid of electronic devices and controlled automatically as well as recorded along with the test data, through a computer program (software).
MTE types (by Portability)

• Stationary Test benches multi position
  Transformer based,
  Semi-automatic
  Fully automatic

• Portable types
  Single phase, three phase and portable MTE with source
Stationary test equipments

- The principal components of a modern meter test system
  - Power supply Source, which synthesise/generate test voltages and currents to power the meters,
  - a high precision reference standard meter,
  - highly sophisticated software,
  - meter test rack, may include optical scanners
- These components essentially define the quality and efficiency, cost of the test station.
Related considerations

- Types of meters to be tested, LT WC or CT type HT3/4, ct/vt type
- Electromechanical with disc, static with Calib LED, LCD
- Terminal arrangements, quick connection or not
- Load (VA rating), Imax and PF range, typical and max VA rating of type of meters to be tested.
- Input supply, UPS or CV/CF source
- Number of meters to be tested per day.
- One meter at a time or multiple meters.
- Routine or type tests too
- Data recording
- Safety and other considerations
General specification

- **POWER SOURCE**
  - Voltage range, 40 V to 300 V p-n, 3 phase, or single phase only
  - Current range and $I_{\text{max}}$ 1 or 10 mA to 120 A
  - Power factor 0 lag to 0 lead, continuously variable or step selection, 0 or 0 to 360 deg full control, accuracy 1 to 2 Deg.
  - VA rating voltage and current circuit
  - Voltage and current setting accuracy 0.1 to 1 %
  - Voltage and current stability 0.05 % to 1 %
  - Phase sequence selection
  - Distortion factor 0.5% to 1 %
  - Harmonic and arbitrary wave form generation. Possible only on Solid State sources
Meter mounting or suspension rack

- **Stationary meter mounting racks**
  - 10/20/40 positions
  - Can have meters on one side or both sides

- **Gantry type**
  - For high volumes, movable MMR, with plug in connectors

- **Adjustable position, width, height of meters**
Meter mounting contd....

• **Manual connection**
  - Will need screwing in voltage and current wires

• **Quick connection**
  - universal type (adjustable): requirements differ from make of meters or terminal arrangements
  - fixed type ..suitable for a terminal arrangement
  - Helps in aligning and connection in one operation
• MMR has one or more Optical Scanning head
• Scanning heads mounted on a sliding carriage, adjustable in all three axis enables exact positioning and alignment for sensing.
• Scanning heads suitable for scanning the rotor disc of Ferraris meters, light-emitting diode pulses of static meters.
• The use of high-quality optical components results in maximum insensitivity to ambient light
Testing methods

• Optical scanner and CALIB LED/ disk mark sensing based
  One energy at a time

• Energy register based testing thru communication
  Meter Manufacturer specific
  Can test multiple energy types together and save time.
Meters without IP link
Meters with IP link
Testing of whole current meters

• Need to open the links for testing as Voltage and current terminals are shorted

• MSIVT based MTE. Normally used with single phase meters
  
  Very stringent specification for MSIVT, 0.02% error, less than 2 min phase error, 0.02% loading effects, Large and expensive

• Isolating CT based MTE
  
  used with three phase meters, CTs of 100A, rating, 0.1%, 2 min phase error, additional requirement of VA rating
REFERENCE STANDARD

- Electronic power or energy standards of high precision and accuracy. Single or three phase.
- Measurement accuracy 0.01 % to 0.2% on V, I, Power, energy, 2 min on phase angle.
- Voltage input range up to 400 V
- Current 1 mA up to 120 A, either direct or direct up to 20A, and clamp on for higher
- Test frequency range 45 to 55 Hz.
- Ability to measure harmonic power and THD.
REFERENCE STANDARD

- Reference signal frequency output for calibration and error calculator
- Low temperature coefficient, high short term and long term stability
- Multiple working mode like active, reactive, 3 phase 4 wire or 3 wire
Error calculator for multiple scanner

- Error calculator receives reference meter pulses and pulses from each meter thru optical scanner.
- Calculates reference energy for each MUT and errors.
- Communicates to meter and displays locally at MMR if supported.
Software for semi automatic MTE

- Test bench computer s/w for semi automatic normally interfaces with reference meter and controls it and gets error data.
- It helps define test points, like load, power factor, number of pulses or energy, multiplying factors etc.
- Guides user to set the power source and phase shifter, sequences the tests.
- Displays V, I, PF, power and energies phase wise as well as sum of all phases, errors.
- May support communication based error testing.
- Reports pass/ fail status.
Software for fully automatic test-bench

- Fully automatic operation thru computer system.
- Menu driven user friendly software.
- It helps define test points, like load, power factor, number of pulses or energy, multiplying factors etc.
- Interfaces with power source and generates necessary voltage, current and phase relation between V to I.
- Can help program harmonics, arbitrary waveform etc if required.
- Interfaces with reference meter, power source, error calculator and controls it and gets error data.
Software for fully automatic test-bench

- Displays V, I, PF, power and energies phase wise as well as sum of all phases, errors.
- Can display waveforms, vector diagrams, bar charts and analysis data etc.
- Sequences test manually or automatically, performs tests and gets and records results.
- Can have multiple test sequences as per the meters to be tested for future use.
- Meter specific data, SNo., manufacturer, type etc can be recorded. Data can be archived in database.
- Normally has inbuilt checks and protection against wrong operation, conditions to protect MUTs.
Portable or Field calibrators

• Single and/or three phase, portable, simple and easy to use on site, available in range of accuracies
• Universal range type …single instrument for LT/HT use
• LT and HT types separate with wide current range
• Current ranges 1, 5, 10 A and up to 100 A or higher thru Clamp On CTs. Generally clamp on will give one class lower accuracy
• Accuracy class of 0.2 for class 1 meters, 0.1 or better for class 0.5 /0.2 meters, or 0.2 with facility of error correction.
• Certification from a NABL accredited, good lab for consumer confidence.
Requirements for portable MTE

- Small size and weight
- Rugged design so that Calibration of MTE doesn’t shift, can give long life.
- Low influence factors as field conditions are not as controlled as lab conditions. Temperature, voltage, current harmonics, frequency are important ones.
- Must allow fast on site testing, data recording, result printing and storage of data for a number of meters tested. Features like connection check, voltage, current power factor reading are useful ones.
- Communication interface for data downloading and scheduling the test plans and consumer and meter information.
Requirements … continued.

- Manual snap switch or optical pick up for pulse counting. Simple but suitable optical sensor and mounting arrangement.
- Low operating burden for CT/VT based meter testing.
- Adequate sealing and data security of test results is required.
- Safety of persons using it.
Periodic Calibration of MTE

• Basic Measurements
  Measurements for calibration when an MTE commences service.

• Control Measurements
  Measurements for periodical check on the accuracy of MTE while in service.

• Calibration of reference standard
• Calibration of the source
Determination of repeatability – AS per IEC

- At least 5 readings at the 'control point' \( V_c, L_c \), at PF = 1, for each phase. Between successive measurements the controlling switches and controlling devices shall be operated.
- The results of these repeated measurements are used to calculate the values, which is the estimation of the standard deviation:

\[
s = \sqrt{\frac{1}{n-1} \sum (E_i - E)^2}
\]

for \( i=1 \) to \( n \)
- where \( E_i \) = error of the MTE determined by one individual measurement of an sequence of repeated measurement at a certain test point,
- \( E \) = mean value of the errors \( E_i \), and
- \( n \) = total number of individual measurements.
**Allowed values of $s$ for new equipments**

<table>
<thead>
<tr>
<th>Class 1,2</th>
<th>PF 1</th>
<th>PF 0.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{max}$</td>
<td>0.02, 0.05</td>
<td>0.03, 0.07</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class 0.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{max}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class 0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{max}$</td>
</tr>
</tbody>
</table>

MTE in service....twice the above values are allowed
Allowed limits of errors for class 1 / 2

- The error $E$ of an MTE is the overall error of all its components under normal service condition.
- The error of an MTE shall be lower than the error $E_{\text{max}}$ at a set of test points given.

<table>
<thead>
<tr>
<th>Power Factor</th>
<th>1.0</th>
<th>0.5 Lag</th>
<th>0.5 Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_{\text{max}} %$ Class 1 MUT</td>
<td>±0.20</td>
<td>±0.30</td>
<td>±0.40</td>
</tr>
<tr>
<td>$E_{\text{max}} %$ Class 2 MUT</td>
<td>±0.30</td>
<td>±0.45</td>
<td>±0.60</td>
</tr>
</tbody>
</table>
**Allowed limits of errors for class 0.5/ 0.2**

- The error of an MTE shall be lower than the error $E_{\text{max}}$ at a set of test points given.

<table>
<thead>
<tr>
<th>Power Factor</th>
<th>1.0</th>
<th>0.5 Lag</th>
<th>0.5 Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_{\text{max}}%$ Class 0.2 $\text{MUT}$</td>
<td>±0.05</td>
<td>±0.10</td>
<td>±0.15</td>
</tr>
<tr>
<td>$E_{\text{max}}%$ Class 0.5 $\text{MUT}$</td>
<td>±0.10</td>
<td>±0.15</td>
<td>±0.20</td>
</tr>
</tbody>
</table>
What if errors of MTE are not in limits?

- Limited use allowed (yellow sticker) can be used in the restricted ranges.
- Correction of errors, if the errors are within twice the allowed ranges.
New v/s in service MTE

MTE in service....twice the above values of ‘s’ are allowed
Reference conditions required for testing

- Electrical
- Environmental
- Generally specified in the metering standard
Electrical requirements

• Voltage and currents shall be substantially balanced. (V=1 %, I = 2%)
• Phase angle difference (V to I) shall not differ by more than 2 deg, on any pf.
• Voltage setting accuracy 1 %
• Frequency 0.5%
• Distortion in V and I <= 2%
• Current setting not specified
Environmental requirement

- Temperature: 23 +/- 2 Degrees Celsius
- Magnetic induction: <= 0.05 Tesla
- Humidity recommended: < 70%
- EMI/EMC is now being defined in new standards
Other acceptance tests

- Insulation Tests
  - Ac high Voltage test
  - Insulation resistance test
- Starting current and no load test
- Test of meter Constant
- Power Consumption
**Laboratory Planning**

- Total Lab Management System – IEC 17025 : 2005
  - Top Management commitment
  - Trained, qualified, experienced Manpower
  - Right Equipment
  - Complete end to end Traceability
  - Suitable Documentation
  - Systematic Records
  - Standardized methods
  - Continuous Quality Assurance
  - Suitable environment
Questions please??
Thanks