# Measurement of Harmonics & Establishing Traceability of Power Analyser as Per SI Units

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**Abstract:-**Now a days, power quality & harmonics measurement is most important in modern power systems due to power electronic converters which are being widely used in the solar power grid. It is mandatory to measure the harmonics in the system through accurate harmonic and power analyser to fulfil the requirements of IEC 61000-4-30. Power analyser in measure mode and harmonic generator in source mode need to be calibrated to establish the traceability of the harmonic parameter measurement. In this paper, the calibration method and traceability along with uncertainty of harmonic parameter are discussed in detail. The various contributing factors in the harmonic parameter was analyzed to improve the uncertainty of measurement up to the 100$^{th}$ order of harmonic for voltage up to 500 V & 10 A.

## 1. INTRODUCTION

In power Quality measurement, harmonics is key parameter needs to be measured. That can be measured using accurate power/Harmonic analyser. Accuracy limit of Harmonic parameter using power analyser needs to be identified through calibration technique to generate the traceability in line with ISO/IEC: 17025 which can be generated through calibrator [3] [4]. The calibrator has been used as "Electrical Power Master standard, Fluke, 6105A having specification of 0 -1000 V, 0 - 80 A, harmonic order: 1st to 100th order. The harmonic voltage and current is to be sourced through calibrator to calibrated precision digital Multimeter, Fluke 8508A which is calibrated for range of 0 -1000 V AC & 0 – 20 A AC at frequency range of 0.5 Hz to 1 MHz.Using calibrated calibrator harmonic are to be sourced to power analyser, Yokogawa, WT 3000 from 1$^{st}$ order to 100$^{th}$ order at range of 0 – 500 V AC & 0 -10 A AC. The uncertainty for the voltage & current harmonic parameters to be identified based on the measurement [2].This paper is regarding the generating traceability of harmonic parameter as per SI units considering different harmonic order value measurement for range of 0 – 500 V AC & 0 – 10 A AC.

## 2. METHODOLOGY

Appropriate connection will be carried out as per connection diagram in fig. 1 for calibration of Electrical Power Master Standard (calibrator) using reference Multimeter. Select appropriate range and mode on Electrical power standard master. Select the 500 V RMS voltage & 10 A RMS current on Electrical power standard master, at fundamental frequency of 50 Hz sequentially. Edit the Voltage and current in absolute value of voltage and current of % of fundamental for different individual harmonic component from fundamental to 100 harmonic on Electrical power standard master and measure voltage & current along with frequency on calibrated Reference Multimeterand record the value simultaneously of calibrator as well as reference Multimeter. Calculate the % error / deviation for harmonic amplitude. By getting the appropriate calibration of calibrator, traceability of power analyser can be achieved.[1]Appropriate connection will be carried out of calibrator along with digital power analyseras per fig.2.

Select the relevant range and mode on Electrical power standard master and digital power analyser. Select the absolute voltage / current / % of fundamental harmonic no. 1 to 100 harmonic on Electrical power standard master and measure on digital power / harmonic analyser. Record the measured value inrecording format and calculate the % error / deviation for harmonic amplitude.

## 3. EQUATIONS AND SYMBOLS

$$Deviation\ (\%) = CR - SR \quad (1)$$

Where CR = Calibrator reading,
SR = Standard (Reference Multimeter) reading

$$Deviation\ (\%) = PR - SR \quad (2)$$

Where PR = Power Analyser reading,
SR = Standard (Calibrator) reading

Calculated harmonic, H can be obtained from the below equation

$$H = \sqrt{(V_n/I_n)^2 - (V_1/I_1)^2} X100 \quad (3)$$

Where $V_n$ and $I_n$ represents the harmonic orders of voltage and current respectively,
$V_1$ and $I_1$ represents fundamental harmonic value of voltage and current respectively.

## 4. ILLUSTRATIONS

Fig.1.Calibrator calibration connection diagram

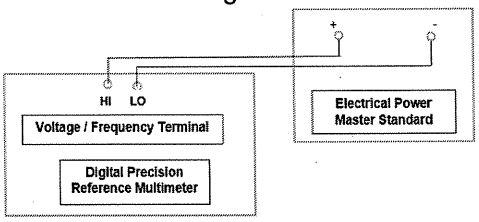
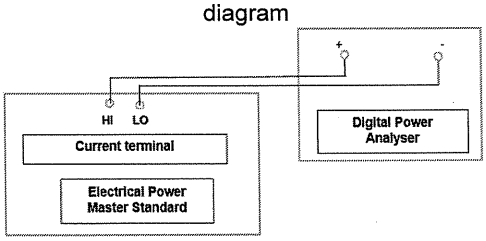



Fig.2.Power Analyser calibration connection diagram




### 4.1 Tables

The detailed calibration procedure for voltage & current harmonic measurement up to 100th order for 500 V & 10 A with uncertainty measurement will be presented in the paper.

Table 1. Power AnalyserVoltage Harmonics measurement at 500 V

| VOLTAGE HARMONICS at 500 V AC | | | |
|---|---|---|---|
| Harmonic Order | Power Analyser Reading in % | Calibrator Reading in % | Deviation in % |
| 1 | 100.000 | 100.000 | 0.000 |
| 3 | 33.320 | 33.320 | 0.000 |
| 5 | 19.980 | 19.980 | 0.000 |
| 7 | 14.250 | 14.250 | 0.000 |
| 9 | 11.070 | 11.070 | 0.000 |
| 11 | 9.040 | 9.040 | 0.000 |
| 13 | 7.626 | 7.626 | 0.000 |
| 15 | 6.590 | 6.590 | 0.000 |
| 17 | 5.795 | 5.795 | 0.000 |
| 19 | 5.165 | 5.165 | 0.000 |
| 21 | 4.653 | 4.654 | -0.001 |
| 23 | 4.230 | 4.230 | 0.000 |
| 25 | 3.872 | 3.872 | 0.000 |

Table 2. Power AnalyserCurrent Harmonics measurement at 10 A

| CURRENT HARMONICS at 10 A AC | | | |
|---|---|---|---|
| Harmonic Order | Power Analyser Reading in % | Calibrator Reading in % | Deviation in % |
| 1 | 100.000 | 100.000 | 0.000 |
| 3 | 33.321 | 33.320 | 0.001 |
| 5 | 19.981 | 19.980 | 0.001 |
| 7 | 14.250 | 14.250 | 0.000 |
| 9 | 11.071 | 11.070 | 0.001 |
| 11 | 9.040 | 9.040 | 0.000 |
| 13 | 7.626 | 7.626 | 0.000 |
| 15 | 6.589 | 6.590 | -0.001 |
| 17 | 5.794 | 5.795 | -0.001 |
| 19 | 5.164 | 5.165 | -0.001 |
| 21 | 4.653 | 4.654 | -0.001 |
| 23 | 4.230 | 4.230 | 0.000 |
| 25 | 3.870 | 3.872 | -0.002 |

## 5. REFERENCES


[1] NABL-121 Specific Criteria for Calibration Laboratories in Electro–Technical Discipline, Issue No. 05, NABL, 2016.

[2] IEC: 61000-4-30, Testing and measurement techniques – Power quality measurementMethods, 2015

[3] IEC: 61000-3-2, Limits for harmonic current emissions (equipment inputcurrent ≤ 16 A per phase).

[4] IEC: 61000-3-12, Limits for harmonic currents produced by equipmentconnected to public low-voltage systems with input current >16 A and ≤75 A perphase.