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# Power Quality Assessment of Debremarkos Town Water Pump Station Found In Ethiopia

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**ABSTRACT**

Electric distribution system power quality is a growing concern. Customers require higher quality service due to more sensitive electrical and electronic equipment's. The effectiveness of a power distribution system is measured in terms of efficiency, service continuity or reliability, service quality in terms of voltage profile and stability and power distribution system performance. In the context of Debre Markos water pump station, electric power interruption is becoming a day to day phenomenon. Even there are times that electric power interruption occurs several times a day for short and long period of time. This research presents a method for power quality assessment by considering the 23MVA, 230/15 kV transformer with one 15 kV outgoing transmission feeder line at Debre Markos substation to supply two water pump booster stations.

Keywords : Booster, Current, Feeder, Google Earth, Distribution Transformer, Power Quality, Sag, Swell, Unbalance, Voltage.

## I. INTRODUCTION

Currently Ethiopian electric power system have 400kV, 230kV, 132kV primary transmission systems and 66kV, 45kV as sub transmission system and 33kV and 15kV as a primary distribution system. At all the 66 or 45kV substations power transformers of various ratings like 25 /12 /6.3/3MVA are installed for step down of voltage to 15kV. The voltage is then further reduced by distribution transformers to the utilization voltages of 380 volts three-phase or 220 volts single-phase supply required by most users here in Ethiopia [1, 2].

The case study of radial distribution system power quality assessment is carried out on Debre Markos Substation system which consist only the 15kV outgoing feeder line-3 that supplies power to both Booster-1 and Booster-2 at Debre Markos water pump station. The power quality assessment analysis through 230/15KV, 23MVA transformer is done on a single 15kV feeder (feeder-3) system to assess the performance of existing system to power quality indexing parameter analysis considering customer and system configurations.

Recent and unpublished important information and data have been collected from Debre Markos Substation. Primary data measurement and interviews with respective professionals at substations and Electric utility office have been considered. The collected data are; the voltage, current, frequency, power and power factor at both sending end terminal of line-3 and both boosters.

## II. DATA MEASURMENT AND RECORDS

In order to identify the power quality problems exist in Debre Markos water pump station, two water boosters pump loads are selected for detail analysis. And also feeder-3 is considered at the substation sending end terminal. At the supply sending end terminal (substation) and the water pump station, the power supply parameters are recorded for five months throughout the day (24 hours) because the problem is very series in this area. Therefore, the voltage, current, active power, power factor and frequency of the two boosters are recorded and its average value is presented here in 24 hour base. Also a similar period of feeder 3 sending end terminal average data is recorded and presented in 24 hour bases.

Table 2.1: Monthly Average Hourly Recorded Data of Booster 1

| Hour | Voltage (kV) | | | Current (A) | | | Power (kW) | | | Power Factor (pu) | | | Freq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AM/PM | R-S | R-T | S-T | R | S | T | R | S | T | R | S | T | (Hz) |
| 7AM | 395 | 394 | 390 | 268 | 274 | 269 | 52 | 54 | 52 | 0.85 | 0.86 | 0.86 | 50 |
| 8AM | 404 | 404 | 399 | 265 | 273 | 266 | 52 | 54 | 53 | 0.84 | 0.85 | 0.85 | 50 |
| 9AM | 396 | 396 | 360 | 267 | 273 | 270 | 52 | 54 | 53 | 0.84 | 0.85 | 0.86 | 50 |
| 10AM | 395 | 396 | 393 | 259 | 266 | 260 | 63 | 65 | 51 | 0.85 | 0.73 | 0.72 | 50 |
| 11AM | 392 | 391 | 388 | 263 | 271 | 264 | 53 | 55 | 54 | 0.79 | 0.8 | 0.8 | 50 |
| 12AM | 394 | 394 | 391 | 263 | 270 | 263 | 47 | 48 | 47 | 0.85 | 0.86 | 0.86 | 50 |
| 1PM | 392 | 391 | 388 | 263 | 271 | 264 | 51 | 53 | 52 | 0.85 | 0.86 | 0.86 | 50 |
| 2PM | 384 | 387 | 384 | 264 | 270 | 264 | 51 | 53 | 52 | 0.86 | 0.87 | 0.87 | 50 |
| 3PM | 394 | 394 | 393 | 256 | 263 | 257 | 51 | 52 | 51 | 0.86 | 0.86 | 0.87 | 50 |
| 4PM | 400 | 399 | 398 | 258 | 266 | 259 | 51 | 53 | 52 | 0.84 | 0.86 | 0.86 | 50 |
| 5PM | 397 | 396 | 394 | 259 | 266 | 260 | 52 | 53 | 52 | 0.85 | 0.86 | 0.86 | 50 |
| 6PM | 398 | 398 | 395 | 255 | 263 | 256 | 51 | 52 | 51 | 0.85 | 0.86 | 0.87 | 50 |
| 7PM | 392 | 392 | 388 | 262 | 268 | 261 | 51 | 53 | 51 | 0.85 | 0.86 | 0.86 | 50 |
| 8PM | 402 | 403 | 397 | 266 | 272 | 268 | 52 | 54 | 53 | 0.85 | 0.84 | 0.86 | 50 |
| 9PM | 396 | 395 | 391 | 270 | 276 | 269 | 52 | 54 | 53 | 0.85 | 0.86 | 0.86 | 50 |
| 10PM | 4001 | 397 | 397 | 262 | 270 | 262 | 51 | 53 | 54 | 0.84 | 0.85 | 0.86 | 50 |
| 11PM | 400 | 399 | 395 | 263 | 272 | 264 | 47 | 54 | 53 | 0.84 | 0.85 | 0.86 | 50 |
| 12PM | 404 | 403 | 401 | 261 | 270 | 263 | 51 | 54 | 52 | 0.84 | 0.85 | 0.85 | 50 |
| 1AM | 403 | 402 | 400 | 263 | 270 | 263 | 51 | 54 | 52 | 0.84 | 0.85 | 0.86 | 50 |
| 2AM | 403 | 402 | 399 | 262 | 270 | 263 | 51 | 54 | 52 | 0.84 | 0.85 | 0.85 | 50 |
| 3AM | 400 | 400 | 395 | 263 | 270 | 263 | 51 | 54 | 52 | 0.85 | 0.85 | 0.86 | 50 |
| 4AM | 399 | 399 | 392 | 249 | 269 | 261 | 51 | 54 | 52 | 0.84 | 0.85 | 0.85 | 50 |
| 5AM | 397 | 397 | 392 | 262 | 269 | 262 | 51 | 53 | 52 | 0.84 | 0.86 | 0.86 | 50 |
| 6AM | 396 | 396 | 392 | 262 | 271 | 263 | 48 | 50 | 49 | 0.85 | 0.86 | 0.86 | 50 |
| Average | 397 | 397 | 392 | 262 | 270 | 264 | 52 | 54 | 5 2 | 0.84 | 0.85 | 0.85 | 50 |

Table 2.2: Monthly Average Hourly Recorded Data of Booster 2

| Hour | Voltage (V) | | | Current (A) | | | Power (kW) | | | Power Factor (pu) | | | Freq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AM/PM | R-S | R-T | S-T | R | S | T | R | S | T | R | S | T | (Hz) |
| 7AM | 386 | 385 | 381 | 247 | 253 | 246 | 48 | 49 | 48 | 0.86 | 0.85 | 0.87 | 50 |
| 8AM | 388 | 388 | 384 | 252 | 258 | 250 | 49 | 50 | 49 | 0.86 | 0.87 | 0.87 | 50 |
| 9AM | 395 | 395 | 390 | 251 | 258 | 250 | 49 | 50 | 49 | 0.84 | 0.85 | 0.86 | 50 |
| 10AM | 395 | 395 | 391 | 246 | 252 | 245 | 48 | 49 | 48 | 0.85 | 0.85 | 0.85 | 50 |
| 11AM | 390 | 391 | 386 | 248 | 256 | 248 | 48 | 50 | 48 | 0.85 | 0.86 | 0.86 | 50 |
| 12AM | 392 | 392 | 387 | 248 | 255 | 248 | 48 | 50 | 49 | 0.85 | 0.86 | 0.86 | 50 |
| 1PM | 397 | 395 | 386 | 243 | 252 | 244 | 47 | 49 | 48 | 0.85 | 0.86 | 0.86 | 50 |
| 2PM | 393 | 393 | 382 | 248 | 255 | 247 | 47 | 50 | 48 | 0.85 | 0.86 | 0.86 | 50 |
| 3PM | 394 | 395 | 390 | 250 | 257 | 250 | 49 | 50 | 49 | 0.85 | 0.86 | 0.86 | 50 |
| 4PM | 397 | 397 | 392 | 249 | 255 | 249 | 48 | 50 | 49 | 0.85 | 0.85 | 0.86 | 50 |
| 5PM | 394 | 395 | 389 | 248 | 254 | 247 | 48 | 50 | 48 | 0.85 | 0.85 | 0.86 | 50 |
| 6PM | 392 | 393 | 387 | 249 | 255 | 247 | 48 | 50 | 44 | 0.85 | 0.85 | 0.85 | 50 |
| 7PM | 388 | 387 | 383 | 250 | 257 | 249 | 48 | 50 | 48 | 0.86 | 0.86 | 0.86 | 50 |
| 8PM | 395 | 390 | 390 | 248 | 254 | 246 | 47 | 49 | 48 | 0.85 | 0.85 | 0.86 | 50 |
| 9PM | 389 | 389 | 385 | 258 | 261 | 252 | 49 | 51 | 50 | 0.85 | 0.86 | 0.86 | 50 |
| 10PM | 393 | 393 | 392 | 249 | 257 | 248 | 48 | 50 | 48 | 0.85 | 0.84 | 0.86 | 50 |
| 11PM | 398 | 398 | 364 | 250 | 254 | 249 | 49 | 50 | 49 | 0.84 | 0.85 | 0.85 | 50 |
| 12PM | 402 | 402 | 396 | 248 | 255 | 248 | 47 | 50 | 49 | 0.84 | 0.84 | 0.84 | 50 |
| 1AM | 404 | 404 | 398 | 247 | 254 | 247 | 48 | 51 | 49 | 0.84 | 0.84 | 0.85 | 50 |
| 2AM | 405 | 405 | 399 | 247 | 254 | 247 | 48 | 50 | 49 | 0.84 | 0.84 | 0.85 | 50 |
| 3AM | 401 | 402 | 397 | 249 | 255 | 248 | 49 | 50 | 49 | 0.85 | 0.85 | 0.86 | 50 |
| 4AM | 399 | 399 | 395 | 251 | 259 | 251 | 49 | 51 | 50 | 0.86 | 0.86 | 0.86 | 50 |
| 5AM | 395 | 395 | 391 | 250 | 257 | 248 | 49 | 51 | 49 | 0.86 | 0.86 | 0.86 | 50 |
| 6AM | 386 | 386 | 381 | 251 | 259 | 250 | 49 | 50 | 48 | 0.86 | 0.86 | 0.87 | 50 |
| Average | 394 | 394 | 388 | 249 | 256 | 248 | 48 | 50 | 48 | 0.85 | 0.85 | 0.86 | 50 |

Table 2.3: Monthly Average Hourly Recorded Data of Feeder_3 Sending End Terminal

| Hour | Voltage (kV) | | | Current (A) | | | Power (kW) | | | Power Factor (pu) | | | Freq |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AM/PM | R_S | R_T | S_T | R | S | T | R | S | T | R | S | T | (Hz) |
| 7AM | 15.0 | 14.98 | 15.0 | 70 | 73 | 73 | 487 | 502 | 550 | 0.8 | 0.8 | 0.87 | 50.00 |
| 8AM | 15.0 | 14.98 | 15.0 | 66 | 71 | 71 | 457 | 490 | 537 | 0.8 | 0.8 | 0.87 | 49.98 |
| 9AM | 15.0 | 14.98 | 15.0 | 71 | 73 | 73 | 488 | 505 | 548 | 0.8 | 0.8 | 0.87 | 50.01 |
| 10AM | 15.0 | 14.98 | 15.0 | 71 | 74 | 73 | 490 | 511 | 549 | 0.8 | 0.8 | 0.87 | 50.02 |
| 11AM | 15.0 | 14.98 | 15.0 | 78 | 77 | 77 | 539 | 531 | 578 | 0.8 | 0.8 | 0.87 | 50.03 |
| 12AM | 15.0 | 14.98 | 15.0 | 79 | 81 | 81 | 547 | 560 | 606 | 0.8 | 0.8 | 0.87 | 50 |
| 1PM | 15.0 | 14.98 | 15.0 | 85 | 84 | 85 | 585 | 584 | 639 | 0.8 | 0.8 | 0.87 | 49.99 |
| 2PM | 15.0 | 14.98 | 15.0 | 84 | 85 | 85 | 581 | 591 | 642 | 0.8 | 0.8 | 0.87 | 50.03 |
| 3PM | 15.0 | 14.98 | 15.0 | 84 | 85 | 85 | 584 | 590 | 642 | 0.8 | 0.8 | 0.87 | 50.0 2 |
| 4PM | 15.0 | 14.98 | 15.0 | 81 | 82 | 82 | 562 | 565 | 615 | 0.8 | 0.8 | 0.87 | 50.02 |
| 5PM | 15.0 | 14.98 | 15.0 | 92 | 93 | 92 | 634 | 643 | 691 | 0.8 | 0.8 | 0.87 | 50.02 |
| 6PM | 15.0 | 14.98 | 15.0 | 87 | 89 | 89 | 600 | 614 | 669 | 0.8 | 0.8 | 0.87 | 50.03 |
| 7PM | 15.0 | 14.98 | 15.0 | 86 | 85 | 88 | 594 | 589 | 661 | 0.8 | 0.8 | 0.87 | 50 |
| 8PM | 15.0 | 14.98 | 15.0 | 79 | 79 | 80 | 549 | 550 | 602 | 0.8 | 0.8 | 0.87 | 50.01 |
| 9PM | 15.0 | 14.98 | 15.0 | 83 | 84 | 84 | 576 | 581 | 632 | 0.8 | 0.8 | 0.87 | 50.01 |
| 10PM | 15.0 | 14.98 | 15.0 | 80 | 81 | 77 | 555 | 560 | 581 | 0.8 | 0.8 | 0.87 | 50 |
| 11PM | 15.0 | 14.98 | 15.0 | 83 | 84 | 84 | 578 | 581 | 635 | 0.8 | 0.8 | 0.87 | 50.01 |
| 12PM | 15.0 | 14.98 | 15.0 | 83 | 89 | 89 | 575 | 614 | 666 | 0.8 | 0.8 | 0.87 | 50 |
| 1AM | 15.0 | 14.98 | 15.0 | 99 | 98 | 97 | 688 | 676 | 733 | 0.8 | 0.8 | 0.87 | 50.01 |
| 2AM | 15.0 | 14.98 | 15.0 | 106 | 106 | 105 | 734 | 734 | 791 | 0.8 | 0.8 | 0.87 | 50.01 |
| 3AM | 15.0 | 14.98 | 15.0 | 102 | 103 | 102 | 706 | 713 | 768 | 0.8 | 0.8 | 0.87 | 49.99 |
| 4AM | 15.0 | 14.98 | 15.0 | 94 | 92 | 92 | 654 | 638 | 693 | 0.8 | 0.8 | 0.87 | 50.01 |
| 5AM | 15.0 | 14.98 | 15.0 | 91 | 90 | 91 | 632 | 626 | 682 | 0.8 | 0.8 | 0.87 | 50 |
| 6AM | 15.0 | 14.98 | 15.0 | 87 | 86 | 87 | 602 | 596 | 652 | 0.8 | 0.8 | 0.87 | 49.99 |
| **Average** | **15.0** | **14.98** | **15.0** | **84** | **85** | **85** | **583** | **589** | **640** | **0.8** | **0.8** | **0.87** | **50.008** |

## III. SYSTEM MODEL

### 3.1. Google Earth Model of the Distribution Network

Google Earth is a virtual globe, map, and geographical information program. It maps the Earth by the superimposition of images obtained from satellite imagery and aerial photography. Google Earth user can explore layers created by other Google Earth users or create their own layers to display data and other information on the Google Earth map. The routes of the distribution networks, the network components and basic solution of the reliability and power quality problems exist in the distribution network of Debre Markos city is modeled and mapped using Google Earth.


**Figure 3.1:** Existing Distribution Network Routes of Debre Markos Town

Google Earth help us to model the routes, to measure main and branch distribution line length, to locate the location of transformer and bending point of the distribution network. In this study the distribution system of Debre Markos town contains two outgoing feeders (feeder-3 and feeder-4) and hundreds of transformers to supply power for thousands of customers found in the town are properly mapped by taking the exact location of the distribution system components. The map of the distribution network is prepared based on the location assigned by GPS measurement. The map contains full information about the location of the transformers, the rating of the transformer and its local place.

### 3.2. ETAP Model of the Distribution Network

ETAP is the most comprehensive analysis tool for the design and testing of power systems available. Using its standard offline simulation modules, ETAP can utilize real-time operating data for advanced monitoring, real-time simulation, optimization, energy management systems, and high-speed intelligent load shedding. ETAP combines the electrical, logical, mechanical, and physical attributes of system elements in the same database. For example, a cable not only contains data representing its electrical properties and physical dimensions, but also information indicating the raceways through which it is routed. Thus, the data for a single cable can be used for load flow or short-circuit analyses (which require electrical parameters and connections) as well as cable ampacity derating calculations (which require physical routing data). This integration of the data provides consistency throughout the system and eliminates the need for multiple data entry for the same element, which can be a considerable time savings.

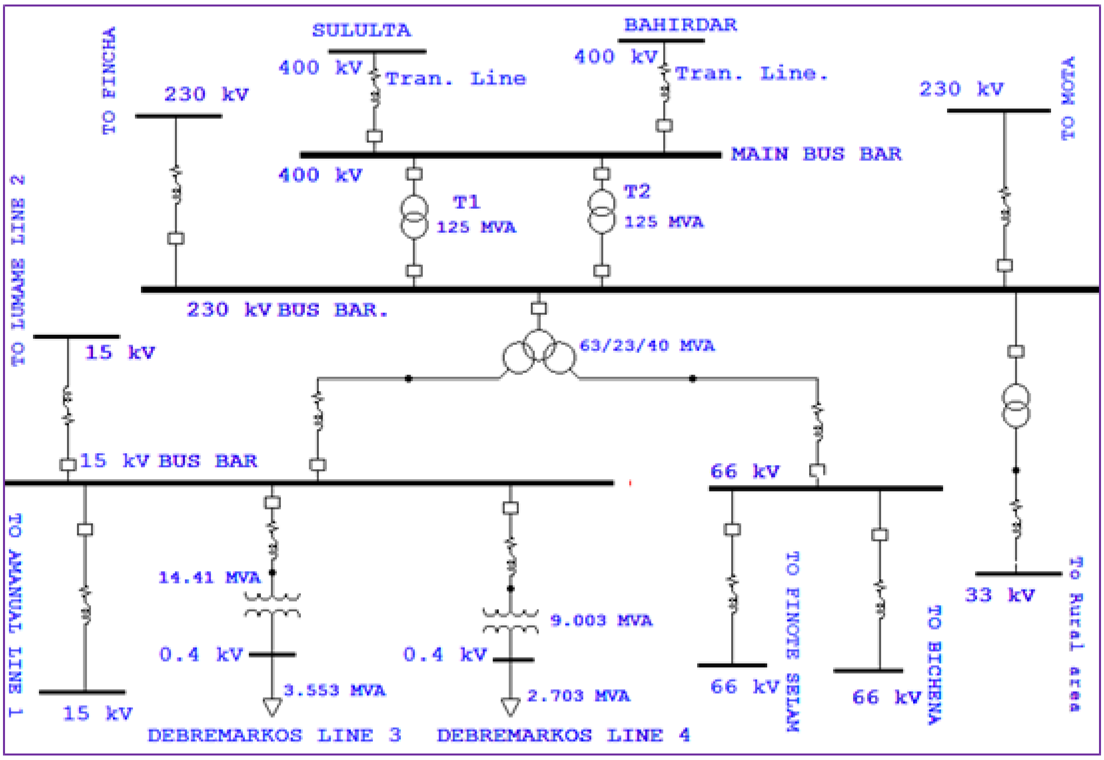


**Figure 3.2:** ETAP-Model Single line diagram of Debre Markos Substation

## IV. DATA ANALYSIS AND RESULT DISCUSSION

### 4.1. Power Quality Analysis of Feeder-3

#### a). Current and Voltage Unbalance

ANSI C84.1-1989 standard recommends that the maximum voltage and current unbalance measured at the customer end under no load conditions should be 3%. Unbalance greater than this value may result in significant motor heating and failure if there are not unbalance protection circuits to protect the loads [3-6]. The average rms current value of feeder-3 is 84.77A and the minimum current measurement is 84.2A through phase R in Table 2.3.

$$\text{Current unbalance} = \frac{(\text{Average current} - \text{Minimum value current})}{\text{Average current value}} * 100\% \quad (1)$$

$$I_{unbalance} = \frac{(84.77-84.2)}{84.2} * 100\% = 0.669\%$$

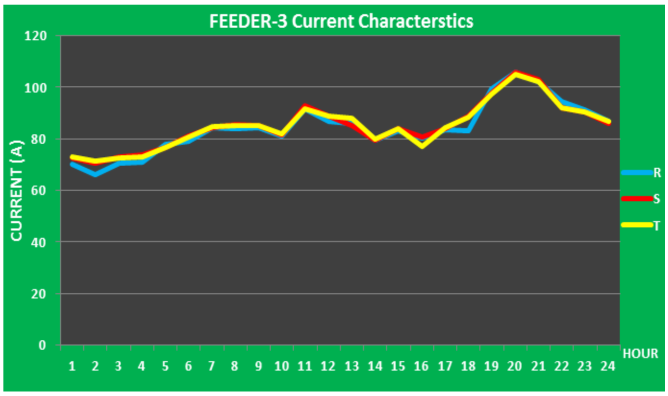


**Figure 4.1:** Current Characteristics of Feeder-3 at Sending end Terminal.

The standard for current unbalance is less than 3% and the value 0.669% is less than the maximum allowable current unbalance standard value. Using a similar formula for voltage unbalance, the value of voltage unbalance for voltage by referring Table 2.3 is 0.089% which is within the permitted of voltage unbalance standard value so there is no voltage and current unbalance problem at feeder-3.

### b). Voltage Fluctuation

Voltage fluctuations are systematic variations of the voltage envelope or a series of random voltage changes, the magnitude of which does not normally exceed the voltage ranges specified by ANSI C84.1, the voltage variation is within ±5% the nominal voltage value. These fluctuations are often referred to as flicker [4].

The Line voltages of feeder- #3 are, R-S=15kV, R-T=14.98kV, S-T=15kV and the nominal voltage is 15V shown in Table 2.3.

$$\text{Voltage deviation} = \frac{(\text{Nominal Voltage} - \text{Actual voltage})}{\text{Nominal voltage value}} \quad (2)$$

$$\text{Voltage deviation } (R-S) = \frac{(15kV-15kV)}{15kV} = 0.0\%$$

$$\text{Voltage deviation } (R-T) = \frac{(15kV-14.98kV)}{15kV} = 0.1333\%$$

$$\text{Voltage deviation } (S-T) = \frac{(15kV-15kV)}{15kV} = 0.0\%$$

The calculated voltage deviation value of all the three lines are within the limit of 5% deviation range. Therefore there is a voltage fluctuation across R-T of the feeder.

### c). Power Frequency Variation

The actual line frequency of feeder-3 is 50.08Hz and the nominal system frequency is 50Hz shown in Table 2.3.

$$\text{Frequency deviation} = \frac{(\text{Nominal frequency} - \text{Actual frequency})}{\text{Nominal frequency value}} \quad (3)$$

$$\Delta f_R = \Delta f_S = \Delta f_T = \frac{(50Hz-50.08Hz)}{50Hz} * 100\% = 0.16\%$$

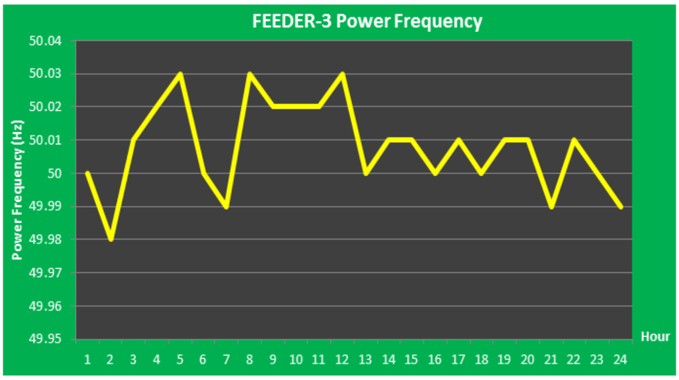


**Figure 4.2 :** Power Frequency Characteristics of Feeder-3.

Since the allowable frequency deviation is maximum of 1% the nominal value. So, there is no power frequency variation problem exist in feeder-3.

### 4.2. Power Quality Analysis of Booster-1

#### a). Current Unbalance

The average rms current value is 266.1A and the minimum current measurement is 263A through phase R as shown in Table 2.1.

Using equation 1 the current unbalance value is 1.153% which is less than the standard for current unbalance 3%. In booster-1 there is no zero sequence current that causes thermal heating and the transformer operates below nominal temperature.

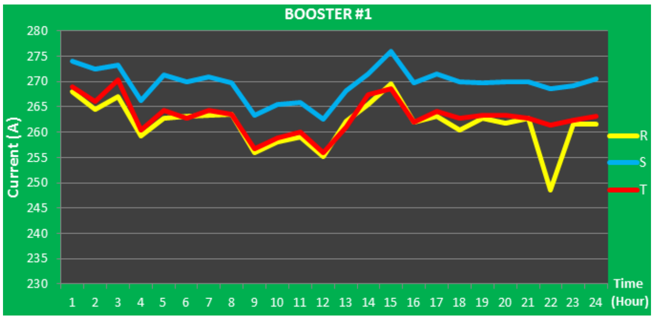


**Figure 4.3 :** Current Characteristics of Booster #1.

#### b). Voltage unbalance

The average rms voltage reading is 394.27V. The minimum voltage measurement is 391.7V across S-T as shown in Table 2.1. Since the deviation of the minimum voltage reading from the average value 0.651% is less than 3% so at booster-1 there is no voltage unbalance problem.

#### c). Under/Over Voltage

The Line voltages of Booster #1 are, R-S=377.143V, R-T=376.714V, S-T=379V and the nominal voltage is 400V.

$$\text{Voltage deviation} = \frac{(\text{Nominal Voltage} - \text{Actual voltage})}{\text{Nominal voltage value}} \quad (4)$$

$$\text{Voltage deviation (R} - \text{S)} = \frac{(400\text{V} - 377.143\text{V})}{400\text{V}} * 100\% = 1.075\%$$

$$\text{Voltage deviation (R} - \text{T)} = \frac{(400\text{V} - 376.714\text{V})}{400\text{V}} * 100\% = 1.15\%$$

$$\text{Voltage deviation (S} - \text{T)} = \frac{(400\text{V} - 379\text{V})}{400\text{V}} * 100\% = 2.075\%$$

The calculated voltage deviation value of all the three lines are within the limit of 10% deviation range. Booster #1 transformer is faced neither under voltage nor over voltage power quality problems.

#### d). Voltage Fluctuation

From the calculated result of voltage variation in equation-4, the deviations of the actual measurement from the nominal voltage value of the three lines are within the range of ±5 % of the nominal value. Therefore there is a voltage fluctuation problem in this transformer.

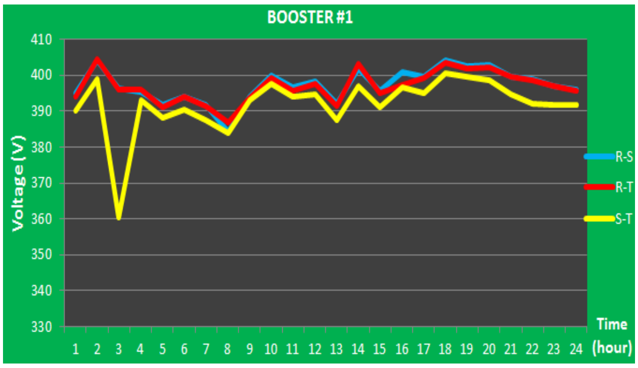


**Figure 4.4 :** Voltage Characteristics of Booster-1.

#### e). Power Frequency Variation

The Line frequency of Booster-1 are, R=50Hz, S=50Hz, T=50Hz and the nominal system frequency is 50Hz as shown in Table 2.1. Therefore, frequency deviation is 0.0%. Since the allowable frequency deviation is maximum of 1% so there is no power frequency variation in booster #1.

### 4.3. Power Quality Analysis of Booster #2

#### a). Current Unbalance

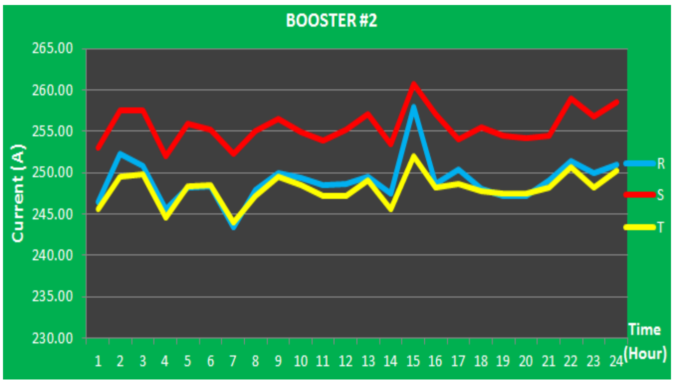


**Figure 4.5 :** Current Characteristics of Booster #2.

The average rms current value is 249.73A and the minimum current measurement is 246.9A through phase T as shown in Table 2.2. Therefore, the current unbalance value is 1.135% which is less than the standard current unbalance of 3%. In booster #2 transformer there is no zero sequence current that causes thermal heating and the transformer operates below nominal temperature.

### b). Voltage unbalance

The average rms voltage reading is 392.07V. The minimum voltage measurement is 387.9V across S-T as shown in Table 2.2 and the resulting voltage unbalance value is 1.063% computed by using equation-1. Since the deviation of the minimum voltage reading from the average value is less than 3% so voltage unbalance is not exist.

### c). Under/Over Voltage

The Line voltages of booster #2 are, R-S=394.2V, R-T=394.1V, S-T=387.9V and the nominal voltage is 400V as shown in Table 2.2 and the deviation of each line voltages are computed by using equation-4 .

$$\text{Voltage deviation } (R-S) = \frac{(400V-394.2V)}{400V} * 100\% = 1.45\%$$

$$\text{Voltage deviation } (R-T) = \frac{(400V-394.1V)}{400V} * 100\% = 1.475\%$$

$$\text{Voltage deviation } (S-T) = \frac{(400V-387.9V)}{400V} * 100\% = 3.025\%$$

The calculated voltage deviation value of all the three lines are within the limit of 10% deviation range. Booster #2 transformer is faced neither under voltage nor over voltage power quality problems.

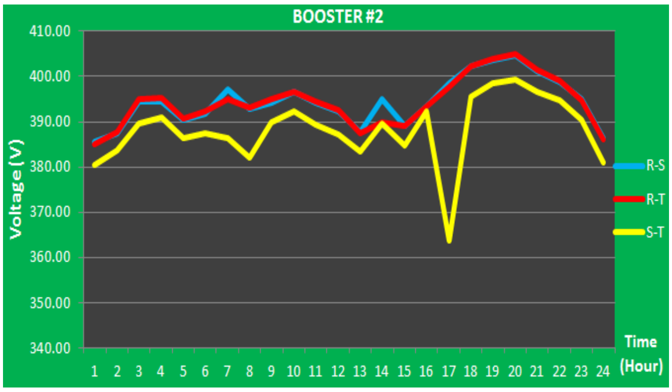


**Figure 4.6** : Voltage Characteristics of Booster #2.

### d). Voltage Fluctuation

From the calculated result of part-c of this section, the deviation of the actual measurement from the nominal of the three lines is within the range of ±5%. Therefore, there is a voltage fluctuation problem in Booster-2.

### e). Power Frequency Variation

The Line frequency of booster #2 are, R=50Hz, S=50Hz, T=50Hz and the nominal system frequency is 50Hz. Since the allowable frequency deviation is maximum of 1% but the actual frequency deviation is 0.0% therefore no frequency issue in booster-2.

## V. CONCLUSION

This research focuses on the water pump station at booster-1 and booster-2 of feeder-3 supplied from Debre Markos distribution system. In feeder-3 there are a total of 99 distribution transformers having rating ranges from 25kVA to 800kVA. Studying the power quality status of the whole loads (99 transformers) is tedious and time taking. Due to a frequently power problem on the pump station, two transformer of 800KVA transformers at booster-1 and booster-2 is selected to investigate whether the problem is power quality problem or not. But the study result shows that most of the distribution system problems are related with power system reliability rather than power quality. The only power quality problems exist in the system are high current unbalance and a frequent voltage fluctuation.

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