IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 13, Issue 4 Ver. II (Jul. – Aug. 2018), PP 58-65
www.iosrjournals.org

Power Quality Investigate by Using the Varying of Voltage Parameter

Yen-Ming Tseng[1,*], Hsi-Shan Huang[1], Chen JiQuan[2], Chen Chuanzhou[2]
[1](*College of Robotics/ Fuzhou Polytechnic, China)*
[2](*Yalong Intelligent Equipment Group Co. LTD., China*)
Corresponding Author: Yen-Ming Tseng

Abstract : *To evaluate the power quality of a power system which is necessary to monitor the power quality of the power supply environment. The purpose of monitoring is mainly to determine power quality problems or to assess power consumption at a specific location. The ideal power supply quality should have the characteristics of such as no voltage variation, no power outage, and no frequency variation. In this research, use the low voltage event recorder to collect data, analyze data and to judge including five kinds of Irregular power quality voltage events such as voltage swell, voltage sag, power interruptions, frequency changing and voltage transients. By statistically and analyzing the above five abnormal voltage parameters or waveform changes that can infer the power quality of the power supplier with discriminated by quantization. There are selected two types of research objects connected and powered to the same main transformer, one is high voltage key-customer and another is low voltage power demand of underground feeder. The chosen user is installed and connected by parallel connection to the voltage event recorder Fluke VR101 through a communication network or channel with micro-processor and fed into database by mathematics method to calculate the events percentage or said reliability of power provider.*

Keywords *- Power quality, voltage parameters, voltage events, frequency changing, and power interruptio*ns.

Date of Submission: 09-08-2018 Date of acceptance: 23-08-2018

I. Introduction

Power quality [1, 2] issues are broadly divided into the following categories, including voltage swells [3], voltage dips [4~9], power harmonics [10], voltage pulses, and voltage flicker that is the flashing of voltage in the power system mainly reason and cause the luminance of lighting equipment such as fluorescent lamps to change rapidly, which makes the human eye feel uncomfortable and dizzy. And if apply to requires power quality higher of semiconductor factory that will cause damage to the finished product, precision equipment damage and loss of data. If in protective relaying of power systems will Power quality issues are broadly divided into the following categories, including voltage swells, voltage dips, power harmonics, voltage pulses, frequency variation[11~12] and voltage flicker. The flashing of voltage in the power system can cause the luminance of lighting equipment such as fluorescent lamps to change rapidly, which makes the human eye feel uncomfortable and dizzy. If the semiconductor factory that requires power quality will cause damage to the finished product, precision equipment damage and loss of data. If in protective relaying system of distribution system or power system will made the mistaken operation by relate protected device and caused the power system chain reaction and caused a large area of power outages. For industries with strict power quality requirements which investigate the power parameter varying of power supply system by measure for a period of time and to infer power quality with collected data for statistical and analysis to confirm that the power quality meets the demand. The abnormal events of measurement are completed by VR101 special software and hardware and the abnormality of each event is taken out through the statistical data of the database. Furthermore, to reach the effect of real-time power quality monitoring is achieved.

II. Power Quality Theory and Standards

2.1 Voltage dip (Voltage Sag)

The voltage sudden drop phenomenon refers to a period of several cycles and the root mean square value of voltage between from 0.1 P.U. to 0.9 P.U. and like as the equation (1). The voltage dip can be divided into instantaneous, short-lived and temporary voltage dips that is according to the voltage dip duration of its duration. The duration is subdivided into 0.5~30 cycles, 30 cycles~3 seconds and 3 seconds~1 minutes which abnormal voltage amplitude is reduced for a long time and is made under voltage of system. Among the power quality problems and the most frequently encountered in the industry is the sudden drop in voltage by loading increasing suddenly for the high-tech industry is not allowed. In the past historical, severe voltage dips caused some equipment to trip based on the protective relaying or protective coordination. For example, if the equipment of a foundry is tripped by voltage dip which will influences serious consequences of product damage. In addition, the voltage dip may also cause the computer equipment to be restarted due to not installation of the uninterruptible power supply system (UPS) to result in the loss of important data.

0.1 P.U.≦**v(t)** PU< 0.9 P.U. (1)

Where

P.U. : Per-Unit value is equal to actual value divide by base value.

v(t) PU: voltage per-unit value is equal to voltage actual value divide by base value.

Voltage dips are usually caused by large motor starts, system shorts and overloads nearby. Moreover, the distance between the measuring instrument and the fault point will influences the magnitude of the voltage dip and also closely related. In general, the system voltage level higher will extended the effect rang more when the fault occurs. And demand is closer the fault location will cause the voltage sag more serious. Otherwise, the demand farther from the fault location will cause smaller the voltage dip.

2.2 Voltage Swell

The phenomenon of voltage swell refers to the value of the voltage root mean square value at the range of 1.1~1.8 P. U. in the period of several cycles and the voltage value such as the equation (2). The voltage swell is divided into instantaneous, short-lived, temporary and long-term voltage swells according to the duration of its duration that are 0.5~30 cycles, 30 cycles~3 seconds, 3 seconds~1 minutes and 1 minute or more, correspondingly. But it is also called Over-voltage under abnormal high voltage for a long time.

1.1 P.U.≦v(t) PU< 1.8 P.U. (2)

A sudden voltage rise (Swell) may cause damage or burnout of the instrument or electronic equipment because the voltage value exceeds the rating of the electronic device or instrument. Short-term voltage surges are usually caused by system failures such as single-wire ground faults and non-faults also have a brief voltage rise. And voltage swell is also occur with untie of large loads or the switching into of capacitor banks. For long-term voltage swell situation is the detected voltage with root men square value more than 110% of the rate voltage which often occurs in insufficient installation by power controller unit and incorrect transformer tap switching in heavy loading. For long-term voltage swell situation is the detected voltage with root men square value more than 110% of the rate voltage which often occurs in insufficient installation by power controller unit and incorrect transformer tap switching in heavy loading. The improvement method is that the unloading of the large load equipment in the plan and should be matched with the relevant power factor to avoid the switching action on the device and over voltage phenomenon generated.

2.3 Transient phenomenon (Transient)

Transient in the varying analysis of power system is mean the events of unnatural transient not good waveform changing which can said unintended sine or cosine voltage waveform distortion in very short time interval. In wide area speaking, voltage transients can be divided into two types and one for impulsive transient, another is oscillatory transient. A pulse transient is a sudden and non-fundamental (for example fundamental frequency is 60 Hz or 50 Hz on the system of world) voltage changing that has a unipolar (just varying in area of positive or negative) direction of varying which aim at a single direction of voltage changing. Pulse transients can be described by their waveform of rising and decay times such as the lightning strike wave is also one of the pulse transients and which can used the Fourier analysis to transformation to frequency domain to analyze. Pulse transients can be described by their waveform of rising and decay in specific time interval such as the lightning strike wave is also one of the pulse transients which can used the Fourier analysis to transformation to frequency domain to analyze. If a frequency matches the system frequency while a resonance phenomenon will occur. The oscillating transient is also a sudden change in voltage or current at a non-supplies frequency, and the direction of changing is bipolar which its voltage or current waveform changing its positive and negative polarity momentarily.

In the transient phenomenon of power quality that point out the waveform distortion, voltage transient, power interruption, voltage dip and voltage swell are one of the all part of the power transient signal. By spectrum analysis that the oscillation transients can be divided parts into high frequency, intermediate frequency and low frequency oscillation transients by the main spectral components, duration and amplitude.

2.4 Power interruption (Interruption)

Power interruption means that the power is completely interrupted without a voltage value or a voltage value close to zero. Power interruptions can be divided into instantaneous, short-lived, and temporary voltage dips depending on the duration of their power-off for 0.5 to 30 cycles, 30 cycles to 3 seconds and 3 seconds to 1 minute correspondingly. In addition, a power outage of up to 1 minute or more is called a continuous power interruption and the voltage value such as the equation (3). Highly stable and reliable power supply is the goal of both power companies and users. However, due to either of improper matching of supply and demand of equipment, natural disasters and human error, etc. made the system equipment may also be tripped by chain reaction, such as the 921 earthquake in Taiwan will been affect power outages caused many factories and electricity users to lose power cause the economic losses significant. In general, power interruption is mainly caused by equipment failure which is maybe or usually caused by power system protective relaying systems mistake operation or power dispatching leading to long time power interruption. By the way, the failure of system components and regular maintenance of equipment that is one of reason for power interruption such as the relay, circuit breaker and so on. In addition, natural disasters such as lightning strikes, storms and traffic accidents are also one of the causes of power outages.

$$v(t)\ PU < 0.1\ P.U. \qquad (3)$$

2.5 Frequency Variation

In the power system which the system frequency often represents the balance between the supply-side and demand-side of real power. So the increase or decrease of the load often causes the system frequency to rise or fall that the system frequency also reflects the balance level between the power supply and the load. If the supply is greater than the demand of the power will made the frequency increases. Otherwise, the supply is less than the demand of the power will made the frequency decrease. The frequency must be within 5% variation that said the frequency is fitting the definition.

III. Actual Installation Of Instruments And Setting Parameters

There are selected two types of research objects, one is a high-voltage key-customer such as school and so on, and another is a low voltage power demand of underground feeder. The chosen user is installed and connected by parallel connection to the voltage event recorder Fluke VR101 through a communication network or channel with micro-processor.

Use the special program of the voltage accident recorder to enter the settings and modify the parameters to be determined. The parameter items set in this research are:

1. Location where data is stored.
2. The way to record data.
3. Maximum and minimum frequency.
4. Instant frequency voltage and ground voltage display.
5. Neutral and ground voltage swell, the root mean square of voltage sag and transient voltage.
6. The effective value and transient voltage of the live and neutral voltage swell and sag.

The above-mentioned data value is obtained by the voltage events recorder which record the data of the event type, effective value, end time, duration of each event that can be measured by the dedicated program of the voltage event recorder. Fig. 1 is the FLUCK VR101 voltage event record setting value of parameters which is based on the rated voltage for 110 V and base frequency for 60HZ that also can setting in rated voltage for 220V with another type and base frequency for 50HZ. Both of the high-voltage key-customer and power demand of underground feeder at the low-voltage side are set up the FLUCK VR101 voltage event recorder with the same setting value of parameters.

IV. Historical Power Data of Research Object

There are selected two types of research objects, one is a high-voltage key-customer such as school and so on, and another is a power demand of underground feeder. The both former user measured the historical voltage event data of three months and s separately. The chosen power system standard frequency is 60HZ and the low voltage side is 110V or 220V A.C. With the calculate skill to sort out the voltage surge (Swell), voltage dip (Sag), voltage transient phenomenon (Transient), power interruption (interruption) and frequency changing which monitoring items for analyze and judge. Tables 1 and 2 are the data tables of voltage events of Key-customers and a power demand of underground feeder in Kaohsiung City, Taiwan. There are numerous abnormal voltage records in three months and just only list ten of them are the most referenced.

V. Statistical and analysis of voltage events

Base on the users of a high-voltage key-customer and low voltage power demand of underground feeder which according to the data measure by the voltage events recorder can analyze for three related voltage events curves and abnormal phenomenon.

5-1 High-voltage key-customer

5-1-1. Statistical and drawing the Bar graph of voltage sags, voltage swells, voltage transients, power interruptions and frequency variations of high-voltage key-customer show at the figure 2. In this figure shows in the measurement period have voltage sags is 0 times, voltage swells is 444 times, power transients is 14 times , voltage interruptions (outage events) is 7 times and a frequency changing is 2 times.

5-1-2. Observe and draw the low voltage side of between the live-neutral (H-N) line and the neutral-ground (N-G) line of the high voltage key-customer to count the relative relationship of the excess voltage over setting value and classify in the duration. Figure 3 shows the H-N and N-G voltage events statistics for the low voltage side of high voltage key-customer. In this figure label X is denoted for H-N voltage events and label + is denoted for N-G voltage events. By the easily classify in figure 3can divided into three catalog, one for section I is the voltage swells phenomenon of high voltage key-customer, another for section II is the voltage sags phenomenon of high voltage key-customer and the other section III is the voltage interruption (power outage) phenomenon of high voltage key-customer.

5-1-3. (3) Observe the statistical diagram of the voltage transient event between the live-neutral (H-N) line or the neutral-ground (N-G) line such as the figure 4 is a diagram of the transient event between H-N and the N-G line for high-voltage key-customer. In the figure shows the #40 event extracted by the voltage event recorder which measures at 272° of cycle in a 60 Hz and the H-N transient voltage is as high as -560Vp.

5-1-4. Analysis of the percentage of each voltage event in all voltage events of high voltage key-customer. As the figure 5 which is the percentage chart of each voltage event in all voltage events of high voltage key-customer. It is shown the 95% of voltage event which is contributed by voltage swells, 0% for voltage sags, 3% for power transients, 0% for frequency vitiation and 2% for power interruption.

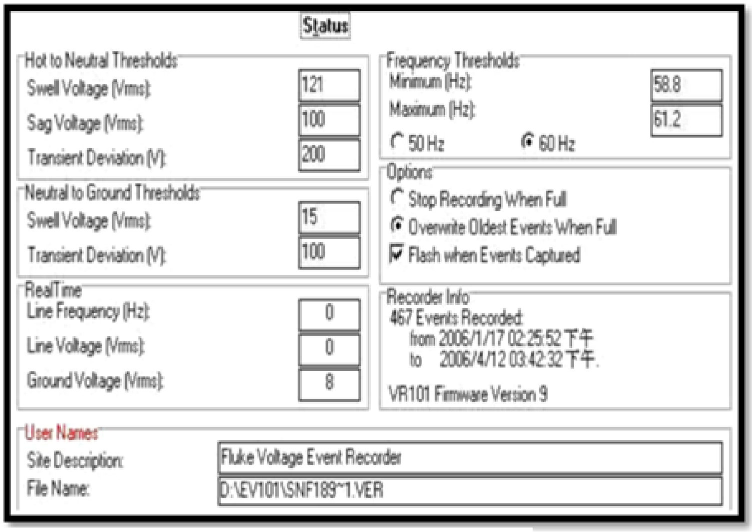

Fig. 1. Fluke VR101 voltage event record setting value of parameters

TABLE 1. Data table of voltage events of key-customer

order	event	extreme	End time/during/ degree
1	Low Frequency	58.8 Hz	0.5 cycles
2	N-G Swell	19 Vrms	54.1 seconds
3	Outage	0 Vrms	00:00:08
4	N-G Swell	19 Vrms	00:03:27
5	N-G Transient	+300 Vp	320°
6	H-N Transient	+350 Vp	320°
7	H-N Swell	123 Vrms	52.9 seconds
8	Outage	0 Vrms	10:38:48
9	N-G Swell	140 Vrms	80.9 seconds
10	H-N Swell	129 Vrms	0.5 cycles

TABLE 2. Data table of voltage events of low voltage of underground feeder

order	event	extreme	End time /during/ degree
1	H-N Swell	122 Vrms	00:02:05
2	Outage	0 Vrms	00:02:40
3	N-G Swell	17 Vrms	00:13:12
4	Outage	0 Vrms	00:03:12
5	H-N Sag	98 Vrms	0.5 cycles
6	N-G Swell	17 Vrms	00:21:20
7	H-N Swell	122 Vrms	00:03:00
8	H-N Swell	122 Vrms	00:05:00
9	N-G Transients	+110 Vp	305°
10	H-N Transients	+260 Vp	305°

5-2. Low voltage power demand of underground feeder

5-2-1. Statistical and drawing the Bar graph of voltage sags, voltage swells, voltage transients, power interruptions and frequency variations of low voltage demand of underground feeder show at the figure 6. In this figure shows in the measurement period have voltage sags is 2 times, voltage swells is 19 times, power transients is 2 times , voltage interruptions (outage events) is 5 times and a frequency changing is 0 times.

5-2-2. Observe and draw the low voltage side of between the live –neutral (H-N) line and the neutral-ground (N-G) line of the low voltage demand of underground feeder to count the relative relationship of the excess voltage over setting value and classify in the duration. Figure 7 shows the H-N and N-G voltage events statistics for the low voltage demand of underground feeder. In this figure label X is denoted for H-N voltage events and label + is denoted for N-G voltage events. By the easily classify in figure 6 can divided into three catalog, one for section I is the voltage swells phenomenon of low voltage demand of underground feeder, another for section II is the voltage sags phenomenon of low voltage demand of underground feeder and the other section III is the voltage interruption (power outage) phenomenon of low voltage demand of underground feeder.

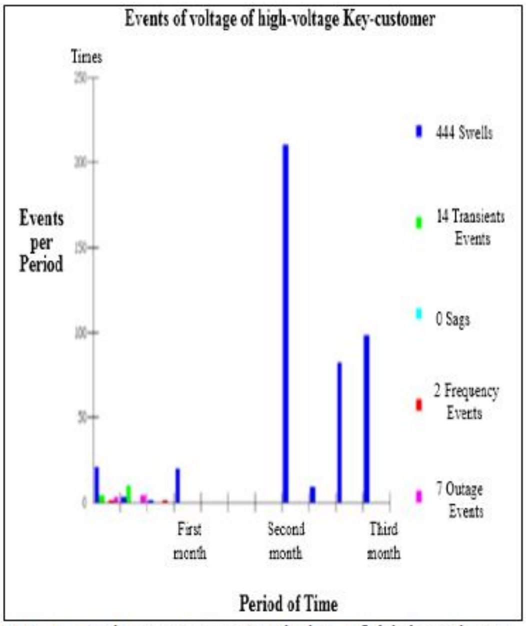

Fig. 2. Voltage events statistics of high voltage key-customer

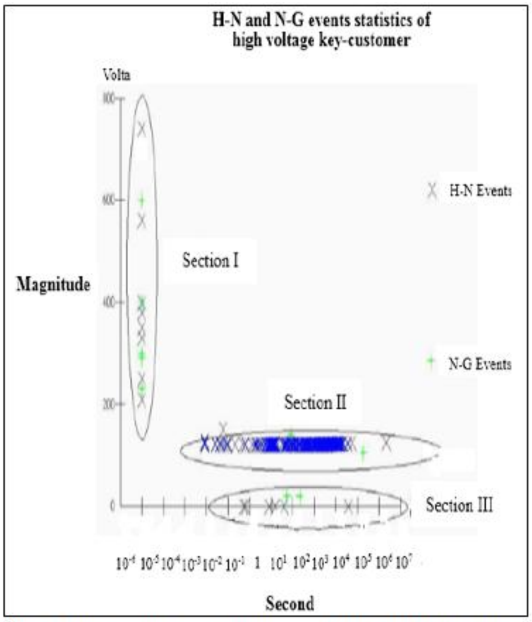

Fig. 3. H-N and N-G events statistics of high voltage key-customer

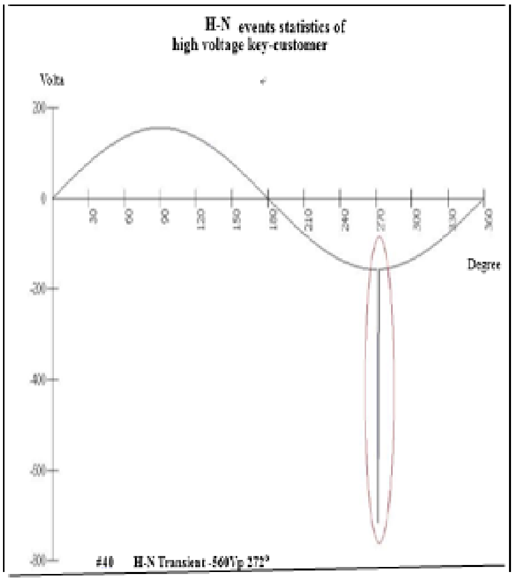

Fig. 4. H-N voltage transient diagram of high voltage key-customer

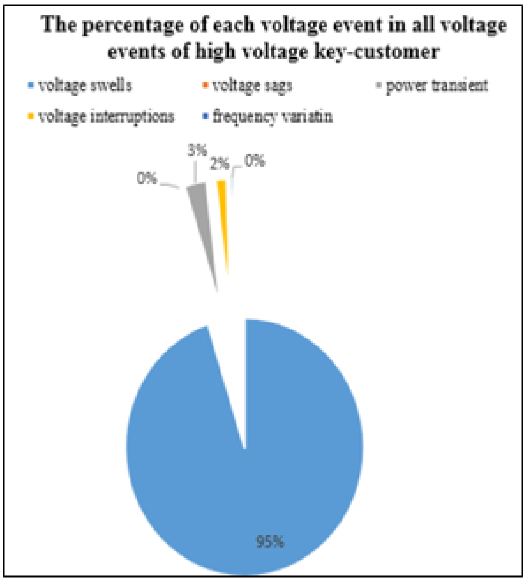

Fig. 5. The percentage chart of each voltage event in all voltage events of high voltage key-customer

5-2-3. Observe the statistical diagram of the voltage transient event between the live-neutral (H-N) line or the neutral-ground (N-G) line such as the figure 8 is a diagram of the transient event between H-N and the N-G line for low voltage demand of underground feeder. In the figure shows the #31 event extracted by the voltage event recorder which measures at 45° of cycle in a 60 Hz and the H-N transient voltage is as high as -700Vp.

5-2-4. Analysis of the percentage of each voltage event in all voltage events of low voltage demand of underground feeder. As the figure 9 which is the percentage chart of each voltage event in all voltage events of high voltage key-customer. It is shown the 68% of voltage event which is contributed by voltage swells , 0% for frequency variations, 7% voltage sags, 7% for power transients and 18% for power interruption.

5-3. Comparison the different type voltage events of both type users

It is use the simple add and divide mathematics method to calculate the following result.

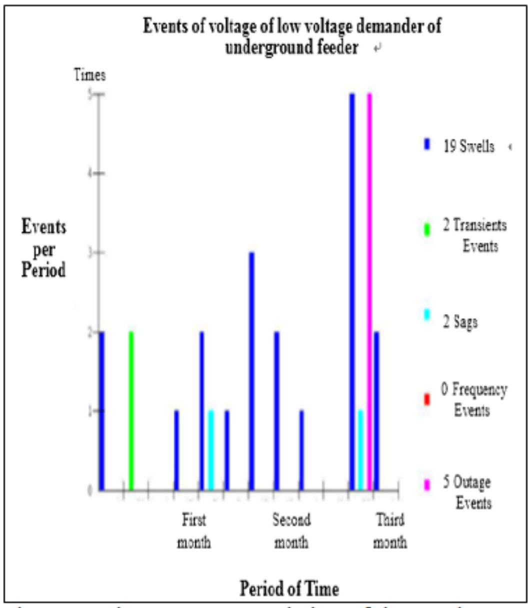

Fig. 6. Voltage events statistics of low voltage demand of underground feeder

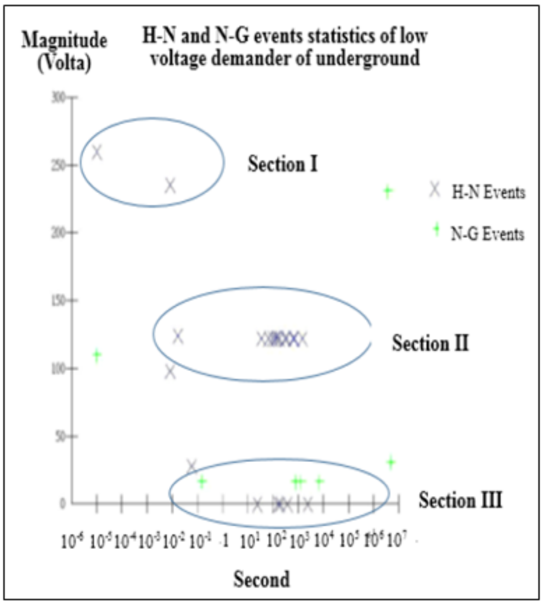

Fig. 7. H-N and N-G events statistics of low voltage demand of underground feeder

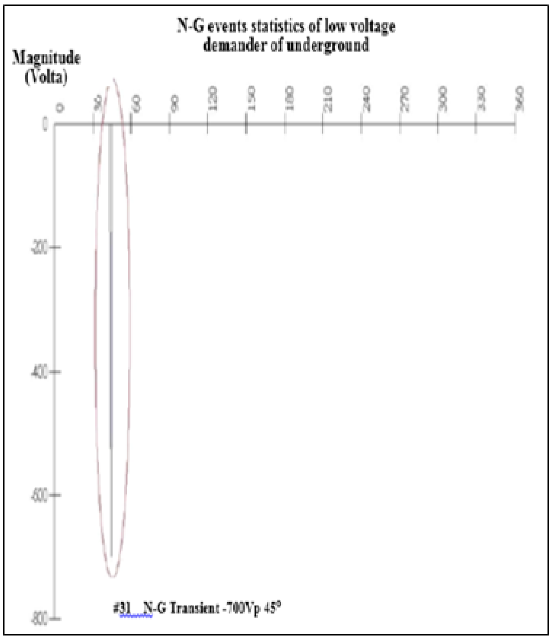

Fig. 8 N-G voltage transient diagram of low voltage demand of underground feeder

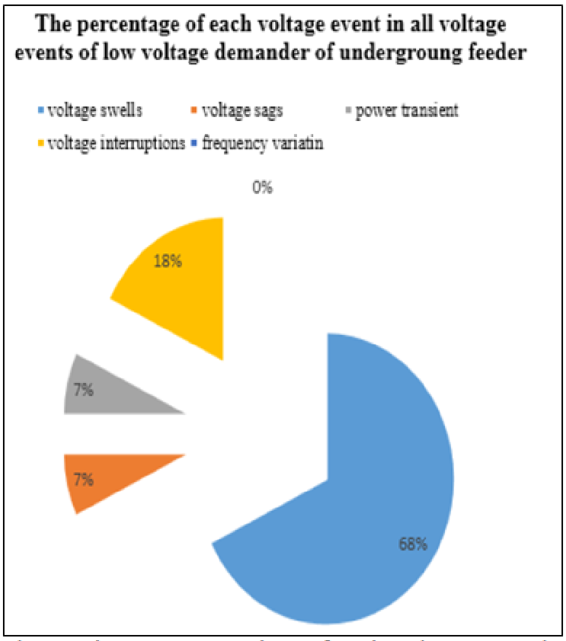

Fig. 9. The percentage chart of each voltage event in all voltage events of low voltage of underground feeder

5-3-1. Statistical by summation of voltage events on both of high voltage key-customer and low voltage demand of underground feeder is 495 times. Both of voltage events times of high voltage key-customer and low voltage demand of underground feeder are 467 times and 28 times, individually. The voltage swells events of high voltage key-customer is 444 times and 89.7% of the total voltage events of the two users, especially. It is sown in bar chart of figure 10.

5-3-2. Comparison the voltage events the both of high voltage key-customer and low voltage demand of underground feeder which can discuss by five type voltage events such as the table3. In first phase of voltage swell events and both type user total events is 463 times and the high voltage key-customer and low voltage demand of underground feeder with events accounted for 95.9% and 4.1%, individually. In second phase of voltage swell events and both type user total events is 2 times and the events is all contributed by low voltage demand of underground feeder. In third phase of power transient and both type user total events is 16 times and the high voltage key-customer and low voltage demand of underground feeder with events accounted for 87.5% and 12.5% , separately. In fourth phase of Frequency variation events is 2 times and the events is all contributed by high voltage key-customer. And final in fifth phase voltage (power) interruptions and both type user total events is 12 times and the high voltage key-customer and low voltage demand of underground feeder with events accounted for 58.3% and 41.7%, individually.

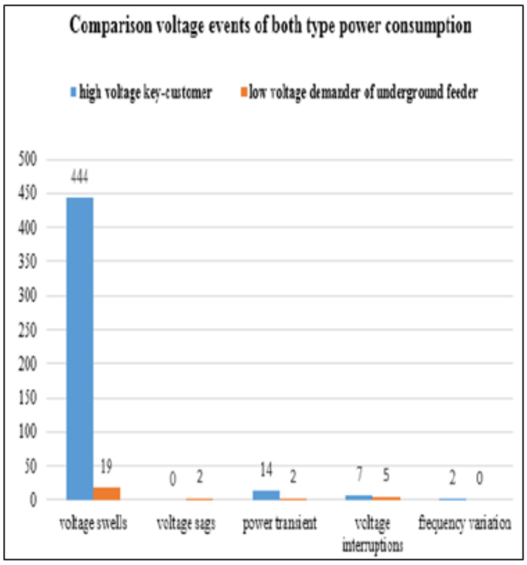

Fig. 10. Comparison the different type times of voltage events bar chart.

TABLE 3. Comparison the different type voltage events percentage of both type users

Type of events	High voltage key-customer		Low voltage demand of underground feeder		Subtotal
	times	percentage	times	percentage	
Voltage swells	444	95.9%	19	4.1%	463
Voltage sags	0	0.0%	2	100. 0%	2
Power transient	14	87.5%	2	12.5%	16
Voltage interruptions	7	58.3%	5	41.7%	12
Frequency variation	2	100.0%	0	0.0%	2
Subtotal	467	94.3%	28	5.7%	495

VI. Conclusion

There are selected two types of research objects which are connected and powered to the same main transformer, one is high-voltage key-customer and another is low voltage power demand of underground feeder. An ideal power supply quality should have the characteristics of such as no voltage variation, no power outage, and no frequency variation. In the view opinion of connective phase and powered to low voltage side which the low voltage demand can seem direct connected to the distribution system but high voltage key-customer similar to indirect connected with the distribution system because power delivery must be through its own voltage conversion device and protective relaying system that is belong and controlled by high voltage key-customer. Furthermore, it is to find the number of voltage event by user itself factors which can use the existing user voltage events minus the number of system voltage events. So it can find the voltage swells is 425 times, power transients is 12 times, power interruptions is 2 times and frequency variations is 2 times.

Due to the high voltage key-customer has self-contained substation equipment and not under the jurisdiction of the power provider that itself power quality get worse rely its own bad control strategies, not appropriate setting or other factors. According to the form and times of voltage events that the solution improve and evaluate the power quality in two aspects. First, for high-voltage key-customer which the turn ratio of the high and low voltage sides of step-down transformer must be resetting and preferably with install the On-Load Tap-Changer (OLTC). Second, for the distribution systems need to install a surge absorber and the strategy of optimizing the reactive power compensation. At this way that will reduce the occurrence of voltage events in the distribution system and high-voltage key-customer. Furthermore, it is can improve power supply stability and reliability to prompt the power delivery quality.

Acknowledgements

Thanks to Fuzhou Polytecnics for finance support and the project code is RCQD201702.

References

[1]. Pradeep Kumar, "A Review of Power Quality Problems, Standards and Solutions", International Research Journal of Engineering and Technology (IRJET), 4(1), pp. 1765~1775.

[2]. Miska Prasad, A.K. Akella," Mitigation of Power Quality Problems Using Custom Power Devices: A Review", Indonesian Journal of Electrical Engineering and Informatics (IJEEI), 5(3), September 2017, pp. 207~235.

[3]. Mustafa Inci, Mehmet Buyuk, Adnan Tan, Kamil Cagatay Bayindir, Mehmet Tumay, "Multipurpose Compensation Scheme for Voltage Sag/Swell and Selective Harmonics Elimination in Distribution Systems", Advances Electrical and Electronic Engineering, DOI: 10.15598/aeee. 16(1), 2018

[4]. Syed Suraya, P. Sujatha, P. Bharat Kumar," Contemporary Control of DG Integrated DVR for Sag, Swell and Harmonic Mitigation", international Journal of Electrical and Computer Engineering (IJECE), 8(5) , 2018, **DOI:** 10.1109 /ISS1.2017.8389274.

[5]. Mohammad Imran ; S.M. Kulkarni ; S.V. Murkute, "Dynamic voltage restorer for mitigation of voltage sag and swell", 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), 1~2 Aug. 2017, 10.1109/ICECDS.2017.8390077.

[6]. Pawel Szczesniak," The compensator of voltage sage/swell installed in connection terminals of small industrial plant or selected loads", 2017 19th European Conference on Power Electronics and Applications (EPE'17 ECCE Europe), 11~14 Sept. 2017, 10.23919 /EPE17ECCEEurope .2017.8099029.

[7]. Z.H.Rather, D.Flynn, "Impact of voltage dip induced delayed active power recovery on wind integrated power systems", Control Engineering Practice, 61, April 2017, Pages 124~133.

[8]. Gu Ye, Yu Xiang, Michiel Nijhuis, Vladimir Cuk, J. F. G. Cobben, "Bayesian-Inference-Based Voltage Dip State Estimation", IEEE Transactions on Instrumentation and Measurement , 66(11), Nov. 2017, pp. 2977~ 2987

[9]. Ebrahim Balouji ; Irene Y.H. Gu ; Math H.J. Bollen ; Azam Bagheri ; Mahmood Nazari, "A LSTM-based deep learning method with application to voltage dip classification", 2018 18th International Conference on Harmonics and Quality of Power (ICHQP), 13~16 May 2018, 10.1109/ICHQP.2018.8378893.

[10]. Li Ma , Qian Zhou, "Voltage Dip Evaluation Index Based on Voltage Dip Matrix", 2017 4th International Conference on Information Science and Control Engineering (ICISCE), 21~23 July 2017, 10.1109/ICISCE.2017.276

[11]. MohammadDreidyH.MokhlisSaadMekhilef, "Inertia response and frequency control techniques for renewable energy sources: A review ", Renewable and Sustainable Energy Reviews, 69, March 2017, Pages 144~155.

[12]. Jianqiang Hu, Jinde Cao, Josep M. Guerrero, Taiyou Yong, Jie Yu, "Improving Frequency Stability Based on Distributed Control of Multiple Load Aggregators", IEEE Transactions on Smart Grid , 8(4), July 2017 , pp. 1553~ 1567.

IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) is UGC approved Journal with Sl. No. 4198, Journal no. 45125.

Yen-Ming Tseng "I. Power Quality Investigate by Using the Varying of Voltage Parameter". IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) 13.4 (2018): 58-65.