POWER QUALITY AND NEUTRAL CURRENT PROBLEMS FROM UNBALANCED AND NON-LINEAR LOADS IN THREE-PHASE POWER SYSTEMS

Omer GUL
Faculty of Electrical and Electronic Engineering
Istanbul Technical University, Maslak, Istanbul, 80626,
Turkey ,Tel:+90 212 2856709, Fax:+90 212 2856700,
E-mail:gul@elk.itu.edu.tr

Mehmet BAYRAK
Instute of Science and Technology
Istanbul Technical University, Maslak, Istanbul, Turkey
80626Tel:+90 212 2856709, Fax:+90 212 2856700

ABSTRACT

An increasing percentage of building load consists of electronic equipment supplied by switched-mode power supplies, electronic and magnetic ballasts, on line UPS systems, adjustable-speed drives, harmonic distortion problems in commercial building distribution system is becoming increasingly. Whenever three-phase, four-wire power systems are used to supply power to computer systems, office equipment and other similar sensitive electronic loads, the power system design should allow for the possibility of high harmonic neutral current to avoid potential problems. This paper discuss power quality problems associated with high harmonic neutral currents including overloaded transformers, overloaded neutral conductor, voltage distortion, and common mode noise.

INTRODUCTION

In recent years, concern over the quality of electric power has been increasing rapidly since poor electric power quality causes many problems for the affected loads, such as malfunctions, short life time and so on. Today, load equipment is more sensitive to power quality variations than equipment applied in the past. Many new load devices contain microprocessor-based controls and power electronic devices that are sensitive to many types of disturbances[1].

The term ***"power quality***" has been used to describe the variation of the voltage, current and frequency on the power system. Most power system equipment has been able to operate successfully with relatively wide variations of these three parameters. However, within the last five to ten years a large amount of sensitive electronic equipment(Answering machines, Electronic cash registers, Electronic Clocks, Hospital equipment, Personal and Mainframe computers, Process control, Robotics and automation, Security Systems, Telecommunications) has been added to the power system which is not so tolerant of these variations [2] .

Power quality problem refers to "any power problem manifested in voltage, current or frequency deviation that results in the failure(equipment failure, power supply problems, etc.), or misoperation (Automatic resets, data errors, loss of memory, system lockout)of customer equipment."

Commercial and residential building applications, the harmonic producing loads(adjustable-speed motor drives, switched-mode power supplies, refrigerator, clothes dryer, color television, laser printer, electronic and magnetic ballasts, on line UPS systems, and shunt capacitors for power factor correction to reduce losses) are used single-phase which typically results in high current distortion and a significant third-harmonic component commonly[1,2].

There are many variation on the types of power quality problems that can occur, and the most significant power quality issues are transients, long-duration voltage variations (overvoltage, undervoltage, sustained interruptions), short-duration Voltage Variations (Interruption, Sags, Surge), voltage imbalance, power frequency variations: Waveform distortion, noise[2].

NEUTRAL CURRENT PROBLEMS IN THREE-PHASE POWER SYSTEMS

On three-phase power systems, neutral current is the vector sum of three line-to-neutral currents. With balanced, three-phase, linear currents, which consist of sine waves spaced 120 electrical degrees apart, the sum at any instant in time is zero, and so there is no neutral current. In most three-phase power systems supplying single-phase loads, there will be some phase current imbalance and some neutral current. Small neutral current resulting from slightly unbalanced loads do not cause problems for typical building power distribution systems. There are conditions where even perfectly balanced single-phase loads can result in significant neutral currents. Nonlinear loads, such as rectifiers and power supplies, have phase currents which are not sinusoidal. The vector sum of balanced, nonsinusoidal, three-phase currents does not necessarily equal to zero[3-7] .

In three-phase circuits, the triple harmonic neutral currents(third, sixth, ninth, etc.) add instead of cancel. Being three times the fundamental power frequency and spaced in time by 120 electrical degrees based on the fundamental power frequency, the triple harmonic currents are in phase with each other, and so add in the neutral circuit. High level of third order, zero sequence harmonics are principally the by-product of switch mode power supply technology which is used in modern office equipment and lighting systems, and in virtually all other low power electronic devices. High neutral currents in power systems can cause overloaded power feeders, overloaded transformers, voltage distortion, and common mode noise[8-10].

Three-phase, four-wire building power feeders are often sized based on three current-carrying conductors in a conduit. When the neutral conductor carries harmonic currents, additional heat is generated and the capacity of the power feeder is reduced. With four current-carrying conductors, the capacity of the power feeder must be dreaded to 80% of the three-current-carrying-conductor. Neutral conductors, can still be overloaded since the neutral current can exceed the rated phase current.

Because of the power supplies which produce the harmonic neutral currents have high peak-to-rms. current waveforms, the voltage waveform can become distorted. “Flat-tapping” of the waveform can result due to the impedance of the power system at the harmonic current frequencies. Since the power supplies use the peak voltage of the sine wave to keep the capacitors at full charge, reduction in the peak voltage appear as low voltage to the power supply, even though the rms. of the voltage may be normal. The wave form distortion can also cause additional heating in motors and other magnetic devices which are operated from the same(distorted) voltage source[4,6,7].

One form of common mode noise in three-phase power systems is the voltage difference between neutral and ground. With high harmonic neutral currents, the impedance of the neutral conductors at the harmonic frequencies can cause significant neutral conductor voltage drops. The neutral conductor voltage drop appears as common mode noise to the computer system. The effect of these relatively low-frequency common-mode noise voltages on the computer system is some What debatable, yet computer vendor specifications typically call for loss than 0.5-3V rms., neutral to ground, regardless of frequency.

In order to develop an engineered solution to this power quality problem, it is usually necessary to measure the harmonics using a harmonics analyzer. These measurements will provide detailed information on the full spectrum of harmonic currents and voltages. It is best to start monitoring as close as possible to the sensitive equipment being affected by power quality variation. In order to analyze power quality problems using measurements, it is important to be able to correlate the characteristics of a distortion with possible cause of distortion[11].

ON-SITE MEASUREMENTS OF VOLTAGE, CURRENT, POWER COMPONENTS IN INSTALLATIONS

This paper deals with the neutral harmonic currents based problems in an electrical distribution system of a 6 floored building. There are a lot of offices in this building one of which is a bank office. For this reason almost all the loads in this building are harmonic sources. Buildings' power demand is supplied by a 34.5/0.4 kV 630 kVA Delta/Star (grounded) connected power transformer. Central compensation is valid but no measures are taken for harmonics.

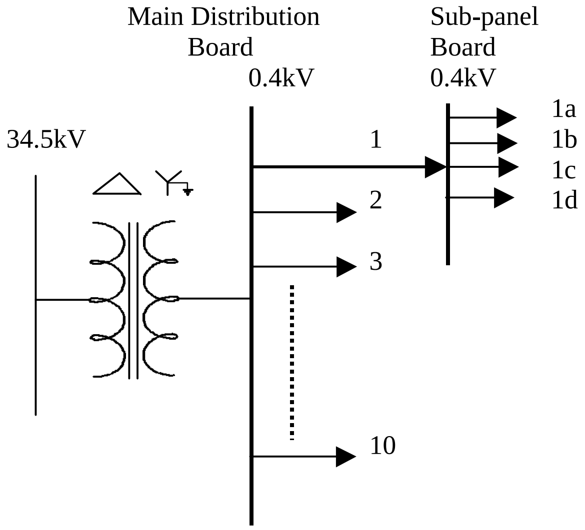

Figure 1 Installation of building
1)Bank Office
2)on-line UPS
3) Other loads
4)1.office
5)2.office
6)3.office
7)4.office
8)5.office
9)6.office
10)7.office

Three different measurements were done in buildings' electrical distribution system. First one is main distribution board, second one is all sub-panels and the third one is the first sub-panels' 1b feeder (bank office entrance floor).

First measurement(Table 1), all phase and neutral current harmonics of 1b feeder of first sub-panel supplying the bank offices' entrance floor was measured. Some important data are obtained for the analysis on harmonic based power loses, overloading and power quality by determining the bank offices' phase and neutral current harmonics.

Table 1,Magnitute and %THD of Phase, Neutral currents, 1th. floor bank offýce (1a. feeder).

	A,B,C phases and neutral currents							
	Phase A		Phase B		Phase C		Neutral	
	Mag	THD	Mag	THD	Mag	THD	Mag	THD
dc	0,17	0,30	0,34	0,53	0,29	0,59	0,28	1,36
1	55,5	99,2	63,5	99,6	48,0	98,5	20,4	96,5
3	3,31	5,92	3,65	5,73	4,40	9,03	4,33	20,5
5	3,85	6,88	2,58	4,05	5,15	10,5	0,74	3,5
7	2,46	4,39	1,28	2,01	3,32	6,81	0,46	2,16
9	2,01	3,6	0,98	1,53	2,59	5,31	2,85	13,5
11	1,76	3,15	0,91	1,42	1,93	3,96	0,38	1,77
13	1,50	2,68	0,72	1,13	1,38	2,82	0,19	0,92
15	1,19	2,13	0,61	0,95	0,92	1,89	1,39	6,66
17	0,84	1,51	0,43	0,67	0,49	1,0	0,08	0,38
19	0,49	0,87	0,24	0,38	0,12	0,24	0,17	0,83
21	0,24	0,44	0,13	0,21	0,06	0,13	0,31	1,45

Second measurement(Table 2) is to determine the neutral-ground voltages which is problem for sensitive electronic devices. And it is also to determine the neutral currents, which causes neutral-ground voltages and overload conditions of neutral line

Table 2 Magnitute and%THD of Neutral currents and Neutr-ground voltages in sub-panels

Sub-panel			
	Neutral Currents		Neutral-Ground Voltages
No	Magnitute Ampers	%THD	Magnitute(volts)
1	63,13	27,90	8,7
2	-	-	-
3	18,2	23	2,9
4	19,8	61,5	3,1
6	12,9	49,6	1,82
7	23,1	40,7	3,6
8	36,2	64,3	5,4
9	16,5	51	2,4
10	24,2	43,5	3,63

Table 3 Measurements of main Distribution panel.

630kVA, 36/0,4kV,Delta/star(g) Transformer				
	Currents			
	A	B	C	N
RMS	765,6	654,8	853,4	210,7
Peak	1316,8	995,3	1424	363,2
DC Offset	-0,3	-0,28	-0,31	-0,27
Crest	1,64	1,52	1,67	1,72
THD Rms	33,7	28,2	36,9	66,99
THD Fund	42,5	34,7	46,2	90,23
K Factor	3,25	2,92	3,49	5,39
Active Power	347kW			
Appearen Powert	526kVA			
Nonactive Power	395kVAR			
Total PF	0,66			
DPF	0,92			

Third measurement(Table 3) is aimed to determine the correctness of measurements of various current, voltage, power factor, active and reactive power measurement devices. Also transformers' and other devices overload conditions are searched.

CONCLUSIONS

There-phase four-wire power systems are used to supply power to computer systems, modern office equipment, other similar electronic loads in commercial building, the power system design should allow for the possibility of high harmonic neutral current to avoid potential problems.
solution to the overloaded neutral current conductor problem include the following

It is seen that harmonics must be taken into consideration in planning of a building electrical installation. Measurements in every sub-panel show that in spite of its expense, compensation systems designed as a filter in every sub-panel is the best solution for energy loses, overloading and power quality. At least a filter can be used for the triplen harmonics on the neutral line to reduce the neutral-ground voltage, overloading of neutral line and power loses on neutral line. If there is no compensation system in every sub-panel, central compensation system must be designed as a filter. So that, transformer and other devices should not be overloaded and measurement faults can be reduced. Also buildings' 34.5 KV distribution systems' adverse effects to power quality should be eliminated to satisfy the standards[12].

One proposed method of dealing with the potentially high neutral currents involves using full-sized neutral wiring and monitoring the neutral current. All neutral components, including neutral terminals, and neutral busburs, should be sized for the additional neutral current. The loading on the three phases should be kept as balanced as possible. In this way, neutral current in excess of the triple harmonic current is minimized. A separate neutral conductor for each phase in the three-phase circuit that serves single-phase nonlinear loads should be run, increasing neutral conductor rating, double neutral conductor,

The loading of the transformer with nonlinear loads requires additional considerations. Most transformers are designed for linear loads with a peak current of 1.414 times rms. current. With nonlinear loads, the maximum loading of transformer should be reduced to less than nameplate capacity tip to avoid overheating the transformer and avoid causing excessive output voltage distortion. It should be noted that K-factor transformers are now available, with winding and a magnetic structure which is specifically designed to reduce the heating effects of harmonic load current distortion. zig zag transformer on the load side of the affected neutral conductor.

Parallel connected third harmonic filter on the load side of the affected neutral conductor. Series filter to block third harmonic current in the

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