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IDENTIFICATION OF HARMONIC PROBLEMS USING POWER QUALITY ANALYZER-A CASE STUDY

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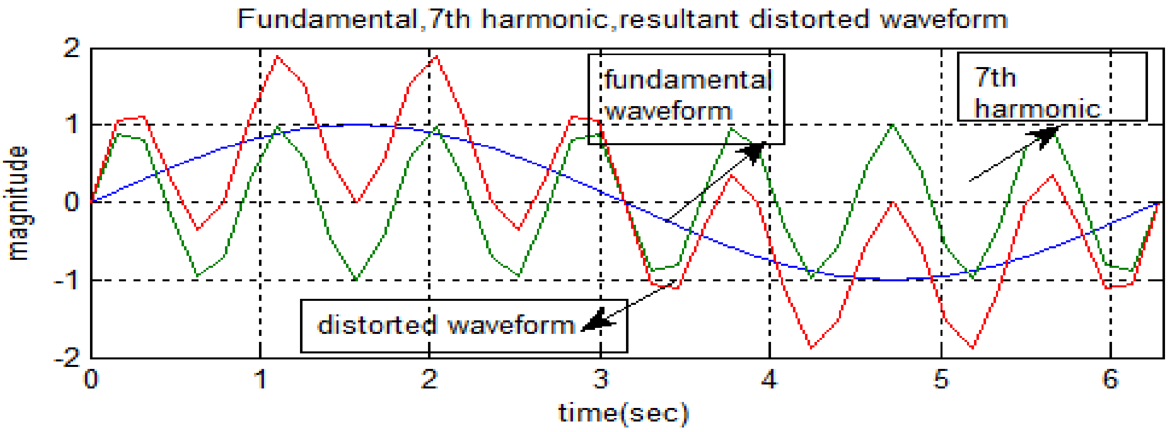
ABSTARCT:
With the increasing of use of power electronic devices in industries, harmonic distortion in electric power system has become a serious issue in recent years. In this paper, the impacts of harmonic distortions due to pulse rectifier in JOCIL , pericharla, Guntur (Dist), A.P, India is investigated. Harmonic measurements are taken with the help of ALM power quality analyzer .From these measurements the impact of harmonics is analyzed

Keywords: *nonlinearloads,harmonics,THD,waveform distortion , rectifier*

1. INTRODUCTION

Before twentieth century, linear loads are the predominant in electrical power system. These loads have little effect on the fundamental frequency because the current rises and falls in proportion to the voltage wave. In recent years, industries use devices such as rectifiers or converters, power supplies and other power electronics devices. These nonlinear devices distorted sinusoidal waveform because the current flow was not directly proportional to the voltage. Non-linear loads cause waveforms that are multiples of the fundamental frequency sine wave to be superimposed on the base waveform. These multiples are called harmonics, like the frequency of the second harmonic is two times the fundamental; the third harmonic is three times the fundamental. The combination of the sine wave with all the harmonics creates a new non sinusoidal wave of entirely different shape is called harmonic distortion. Fig1 shows the typical distorted wave form . The nonlinear load can be modelled as load for fundamental current and as a current source for the harmonic current.The main source of the harmonics is any non-linear loads that produce the voltage harmonics and current harmonics. This occurs because the resistance of the device is not a constant. The resistance in fact, changes during each sine wave. So, non linear device is one in which the current is not proportional to the applied voltage. Harmonic currents and voltage distortion are becoming the most severe and complex electrical challenge for the electrical industry[1]
This paper is organized as follows: Section II describes effects of harmonics. Test system underconsideration is described in Section III and In section IV experimental results are presented.



Fig(1) Resultant distorted waveform of fundamental and 7th harmonic

2. EFFECTS OF HARMONICS

The presence of harmonics on the system can cause a lot of practical problems to various users. The presence of harmonic currents on the system interferes with the normal operation of communication circuits, appearing as unwanted noise on the communication channel. One of the major problem encountered by customers and utilities; alike is the cause of compensation capacitor bank failure due to harmonic resonance **[2].** Capacitor banks which offer a low impedance path to higher harmonics may overload and fail due to increased dielectric loss. This resonance may also occur with reactive components of the network, creating sustained overvoltages. It has been bserved that when two or three capacitor banks are in service there is a significant fifth harmonic current present **[2].**Depending on the phase angle relation between the fundamental and fifth harmonic the peak voltage on the capacitor could exceed that normally permitted, thus causing the capacitor to fail on occasion.The presence of harmonic current causes increased eddy current and hysteresis losses in the iron cores of transformers, motors, fluorescent light ballast, etc. The total harmonic distortion of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency . THD is used to characterize the linearity of audio systems and the power quality of electric power systems. Total harmonic distortion, or THD, is the summation of all harmonic components of the voltage or current waveform compared against the fundamental component of the voltage or current wave. The formula above shows the calculation for THD on a voltage and current signals. The end result is a percentage comparing the harmonic components to the fundamental component of a signal. The higher the percentage, the more distortion that is present on the mains signal.The RMS voltage or current “total harmonic distortion”, *Vthd* and *Ithd*, respectively can be expressed as:

$$THD_V = \frac{\sqrt{\sum_{h=2}^{\infty} V_h^2}}{V_1} \times 100 \quad \% \quad (1)$$

$$THD_i = \frac{\sqrt{\sum_{h=2}^{\infty} i_h^2}}{i_1} \times 100 \quad \% \quad (2)$$

3. DESCRIPTION OF TEST SYSTEM

JOCIL uses couple of rectifiers for its electrolysis process. One is diode based and other is thyristor based twelve pulse rectifiers unit. The thyristor based controlled rectifier unit provides variable DC output for electrochemical application. Whether it is the production of the gas in electrolytic cells, electrolysis of salt or plating bath, the output is to the desired level regardless of fluctuations in AC mains or changes in the regulatory controller, does is less and down time reduced. Apart from these, it has the added features of accurate control and fast response. 12 pulse rectifiers consist of two six-pulse rectifiers, displaced by 30^0 electrical degrees, operating in parallel. The 30-degreesss phase shift is obtained by using a phase shifting transformer. This also uses an isolation transformer with a delta primary, a delta connected secondary, and a second wye connected secondary to obtain the necessary phase shift. The rectifier equipment basically comprises of the oil cooled rectifier transformer, thyristor converter and electronic control with annunciation. The rectifier transformer is connected to the thyristor cubicle housing the silicon controlled rectifiers which converts the AC to DC. The SCRs are mounted on cooling fins which are placed in such a way as to provide good cooling. The cubicle houses the associated components of SCR like semiconductor fuse, trigger modules, surge suppressors etc.This system converting the AC to there DC consists of the following units 1. Rectifier transformer2. Three phase fully controlled thyristor bridge.3. Control cubicle.Rectifier tranformer:The three phase AC supply is fed to the primary of main transformer input bushings. The rectifier transformer is provided with off line tap changing switch in the primary for voltage variation. The transformer secondary connections are brought out at the top in the form of bushings for connections to the rectifier cubicle. A set of interconnecting bus bars are supplied provided the equipment. The transformer is provided with the standard fittings and protections like gas oil relay, oil temperature indicator, magnetic oil gauge and explosion vent etc. Three phase fully controlled thyristor bridge:The three phase Ac output from the rectifier transformer is fed to two three phase fully controlled thyristor bridges in parallel and having inter phase transformer connected between the negative at the two bridges. This ensures current sharing between the two bridges.The thyristor bridge consists of high power silicon controlled rectifiers. Each bridge consists of eighteen SCRs. Each SCR is protected by a fast acting series fuse and dv/dt circuit. Trip fuse across the device series fuse provides alarm/indication in the control panel for blown fuses. The SCR Bridge is protected against input voltage transients by a suppression network comprising of rectifier bridge MR, RS and CS. The complete SCR assembly is cooled by 2nos of heavy duty axial blowers. Bleeder Resistor RB is connected across the DC output terminals. SCR trigger pulses are provided by its respective pulse amplifier cards which are mounted on the SCR modules. The negative bus of the SCR cubicle houses the DC current transformer for measurement of DC current and feedback to control cubicle to control the current output. Control cubicle:This houses the controller rack for thyristor controlled rectifier with annunciation and indication. Blower supply for the rectifier cubicle is provided by contactor CON1-CON2.Protection of blower is provided by fuse and bimetal overload O/L1-L2 relays. Push button PB1 and PB2 are for PROSESS ON/OFF push buttons. Push button PB3, PB4 and PB5 are for ALARM ACCEPT, RESET and LED TEST. PR6, PB7 are for BLOWER-1, BLOWER-2 ON/OFF Contractor CON4 and CON5

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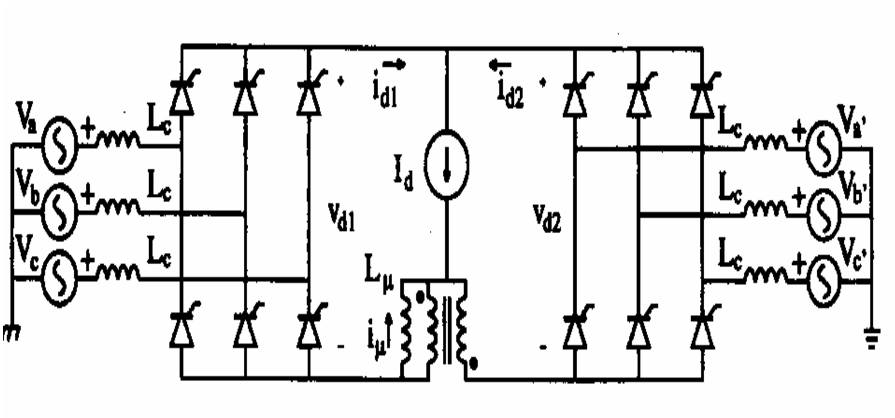

Fig(2) rectifier unit

provides supply to the pulse amplifier cards and controller. Phase fail/reversal circuit monitors the input transformer secondary supply as well as its sequence. TR1 to TR6 are auxiliary transformers used for synchronizing the AC supply to the SCR firing circuit. TR7 provides the necessary AC voltage for the +/-15 volts regulated supplies for control cards and 24 volts for relays and annunciation card. TR8 provides excitation for DC current transformer. DCCT signal proportional to the DC current is fed to the ACCT and the proportionate mean signal is used for current feedback and current output indication (Am2). The output current can be adjusted by potentiometer RV1 a special designed process timer circuit is provided to ensure ramp time of 12 minutes in both dummy switching ON and switching OFF the rectifier.

4. EXPERIMENTAL RESULTS

Measurements are taken by using the the ALM power quality analyzer. The harmonic analyzer is a sophisticated instrument from we can get the harmonic distortion in the current waveform.

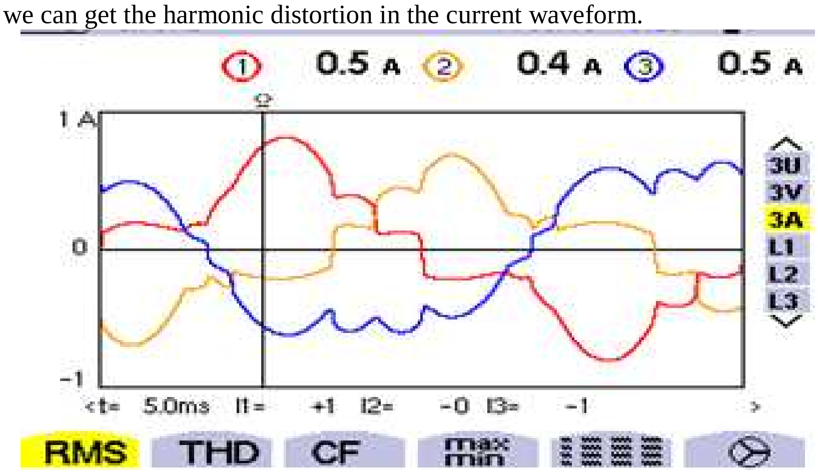

Fig (3) The current waveforms at primaryside of tranformer

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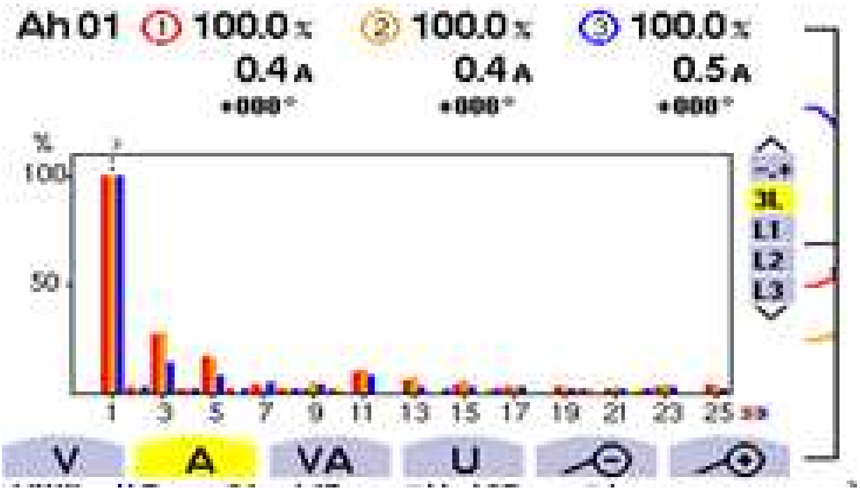
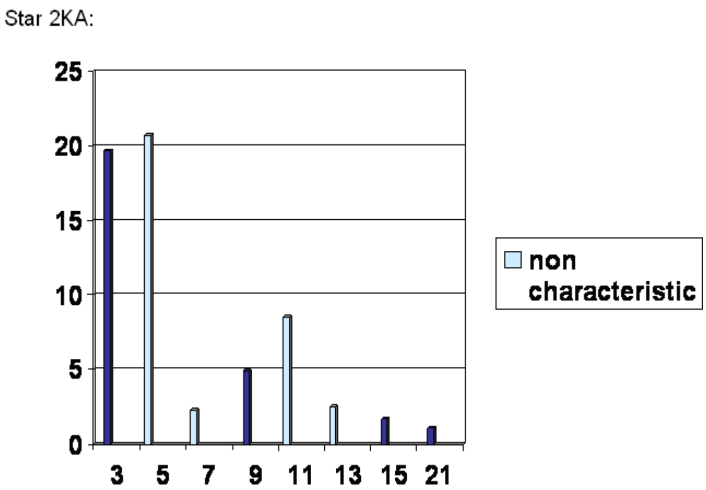


fig(4) harmonic spectrum of all phases(primary side)



Fig(5) harmonic spectrum 2KA side

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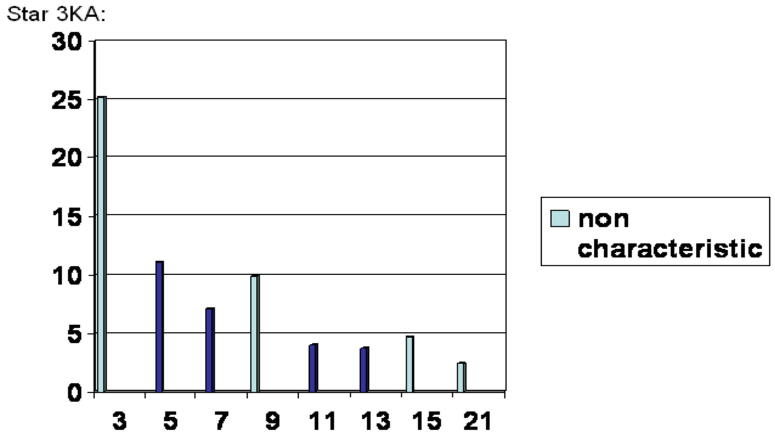
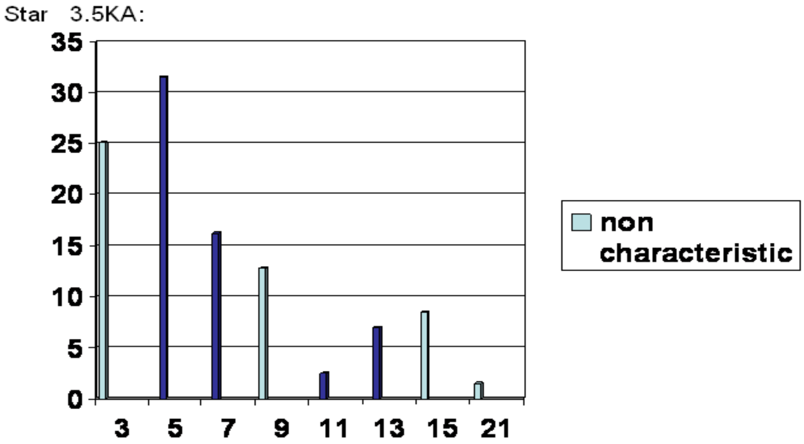
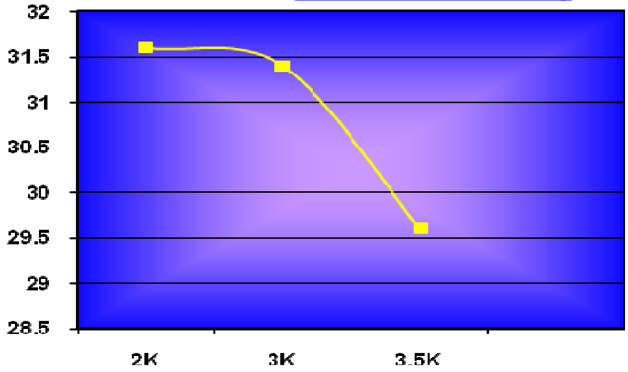


Fig (6) harmonic spectrum 3KA side

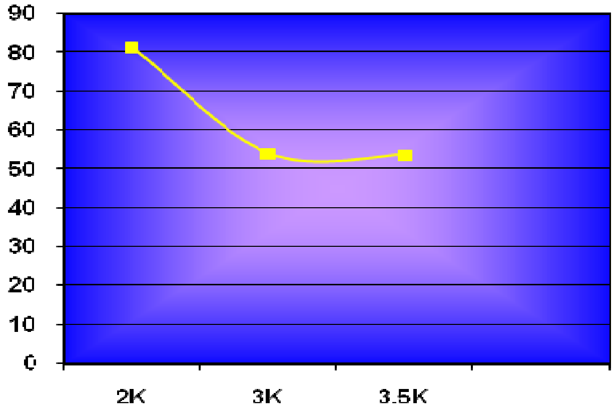


Fig(7) harmonic spectrum 3KA side

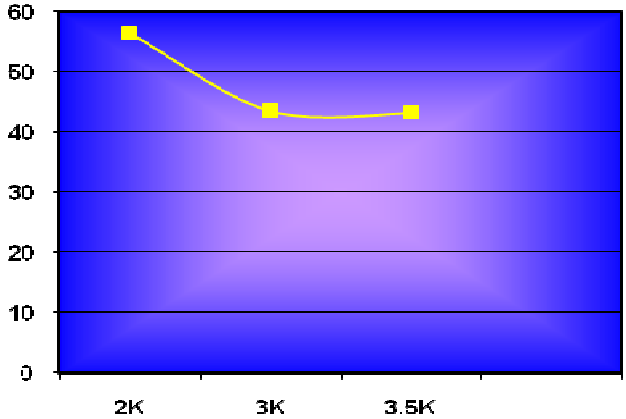
From fig(5) we can see that triplet harmonics are dominating .Here only the 3rd harmonic is and the other triplet harmonics are negligible. This effect shows that there is a small firing imbalance.From fig(6) we can see that the entire graph is dominated by the Triplet harmonics so we can conclude that there is a large commutation problem. We can say that this type of graph is undesirable.From fig(7) characteristics harmonics are dominating .but there is a considerable non characteristic harmonics i.e. triplet harmonics. But the 3rd harmonic is comparable to the dominant harmonic. The graph for the load and the THD is given below for star side.



Fig(8) %THD vs load in R phase



Fig(9) %THD vs load in Y phase



Fig(10) %THD vs load in B phase

From graphs we can conclude that with increase in the output load from 2k to 3.5k the distortion is decreasing. At the 2k load the distortion is 82% which is not desirable. So operating at the lighter loads will increase the harmonic distortion which is not healthy for the system and the surrounding environment. But there is a less difference between 3k and 3.5k. The THD is decreasing and reaching an almost constant value in each phase.

5. Conclusion

It is found that Due to the unbalance loading of arms and non characteristic harmonics are predominant .the loading is one of the important factors which cause low pf and high harmonics as the chopping of input wave form is much at lighter loads to reduce current. It is suggested that filters should be placed to reduce that harmonic distortion

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