A PQ CASE STUDY

POWER QUALITY AT A LARGE INDUCTION FURNACE INDUSTRY - ISSUES ON CURRENT HARMONICS AND REGULATIONS
Abstract:

A large industry involved in the melting of iron for making castings and machining them uses the induction furnaces as well as other equipment. The industry desired the Institute to undertake power and energy audit studies of their plant during 2010-11 period. The 110kV grid power supply to this industry is through 2 numbers of 12.5 MVA transformers feeding nearly 10MVA loading of induction furnaces with medium frequency inverter, a non-linear load producing high level of harmonic currents. This PQ study report highlights, as part of power and energy audit report, the major findings, interpretations as well as comparison of the IEEE 519-1992 standard with the CEA regulations (adopted by power utility for such type of industry loads) for limiting the harmonic distortions introduced.

Preamble:

The incoming power supply for the industry is at 110 kV and the maximum demand is 25 MVA. The incoming feeder feeds two 12.5 MVA transformers. One of these transformers is feeding 3 x 3600 kW induction furnaces controlled by large capacity medium frequency inverters which produces high levels of input current harmonics due to their incoming rectifiers. The load variation is also substantial due to the operating cycle of the melting and also due to production levels of the plant. The other transformer is feeding the other steady conventional motor loads for the other operations. The Power and energy audit report was submitted in May 2011. The report included, among others, measurements and findings regarding the input power quality to the two incoming transformers with respect to the IEEE 519-1992 regulations.

In May 2012 the customer received a communication from the distribution company to ensure compliance to the CEA regulations -2007 to avoid getting penalized. Hence the company...
Case Study 33
Power Quality at a Large Induction Furnace based Industry – Issues on Current Harmonics and Regulations

approached the institute again to clarify the situation and highlight the difference, if any between these regulations. The CEA regulation stipulates the limiting total harmonic distortion for the voltage and current at the point of common coupling as 3% and 8% respectively without any qualifications i.e. for all the voltage and load current levels. As against this IEEE 519-1992 is a comprehensive document providing the Voltage Distortion limits as total voltage distortion, THD, for different input voltage levels and Current Distortion limits as Total Demand Distortion, TDD (not THD) again for different input voltage levels and for different $I_{SC} / I_L$ (the ratio of short circuit current to the maximum load demand) levels at the point of common coupling.

On the face of it CEA regulations provide a very liberal voltage and current distortion limits. However, the non-specification of TDD for the current harmonic limits might create a problem of ambiguity and can result into subjective interpretation of the regulation and may result into unfair penalizing of such industries with large fluctuating loads. This is because any random measurement of current harmonics with a standard power analyzer instrument at the point of common coupling of such an industry can exhibit seemingly higher levels of instantaneous current harmonic ratios especially at low load conditions. The difference between $I_{THD}$ and TDD and the reason as to why for the current harmonic limits TDD is considered by IEEE 519-1992 and not $I_{THD}$ - like $V_{THD}$ - is significant. This study throws light into this aspect.

Demonstration Site

A Southern India based industry has a large Iron melting facility for die-casting type foundry and machining facility for producing critical cast moulded components. The overall process mainly involves melting of iron in Electric Induction furnaces, casting of the liquid metal into appropriate parts in the moulds and then machining/finishing them.

Electrical Power system

The incoming electrical grid power of 25 MVA is received at 110 kV and this is stepped down to 11kV through two numbers of 12.5 MVA Main incoming transformers named as I & II.

The single line diagram of Transformer# I is shown below:
As seen from the above, the major load for transformer #1 is that of three numbers of 3 MW Induction furnaces at Foundry section. They are fed by medium frequency Inverters. One of the outgoing feeders of the transformer has a harmonic filter to deal with predominant current harmonics. The load on Transformer #1 can be classified as non-linear and also of fluctuating type, due to variable load cycle of furnace requirements.

Other Main incoming transformer #2 feeds six (6) feeders connecting to various plant loads. Four of these feeders, a comparatively steady linear loads of the plant, like major motor loads, DISA casting machines, the machine shop floor and also other auxiliary loads. The other 2 feeders through additional sub feeders feed one number smaller capacity medium frequency furnace (0.55 MW), two numbers smaller capacity main frequency furnaces (0.75 MW each) and two numbers of holding furnaces (0.8 MW).

The single load diagram of Transformer # II is shown below:
Thus the plant has segregated linear/non-linear loads by separate transformers of each 12.5MVA, 110kV/11kV. Both these transformers are fed by a common input feeder mentioned above from the utility.

**PQ Audit approach and analysis of the findings:**

Considering the nature of load and requirement of PQ issues the company initiated the comprehensive instrumented PQ Audit at their facility during 2010-2011. This was done by the Institute and the level of compliance to the international IEEE 519-1992 standard was presented to the company.

The methodology of PQ audit basically involved physical inspection in detail, Identification of PCC and other relevant locations, Conducting PQ survey/ measurements (using power/PQ measuring instruments), Reviewing Power/PQ measurements and analyzing for evaluation/ recommendations. The locations for longer duration recordings for power/PQ were identified for better understanding of system.
Case Study 33
Power Quality at a Large Induction Furnace based Industry – Issues on Current Harmonics and Regulations

In the recent past (during May 2012) the company received communication from the distribution company to comply with the national CEA regulations-2007 for the voltage and current distortion limits. Hence they contacted the Institute to clarify the implications of the CEA regulation vis-a-vis IEEE regulation.

It was decided to carry out further long time measurements at PCC and also at the input of the two input transformers immediately after the PCC, mainly from the point of clarifying the above requirement.

Hence measurements were done at:

i) Input of 12.5 MVA transformer#1, feeding the furnace (non-linear) loads for two hours

ii) Input of 12.5 MVA transformer#2, feeding the linear loads (mainly consisting of induction motor loads) for two hours.

iii) The common input which is the PCC for more than 40 hours.

The data recorded were analyzed. As regards compliance to the CEA regulations, the voltage THD requirement of CEA is no problem; but meeting the current THD limits specified by CEA ( @ 8% ) is an issue since CEA has mentioned of the total harmonic distortion of the current (which is normally defined as ratio of the RMS value of the harmonic currents to the instantaneous value of fundamental current). CEA has not taken any cognizance of the parameter TDD (total demand distortion) as defined by IEEE 519-1992 for normalizing the instantaneous I THD with a common base value corresponding to the maximum demand of the plant monitored over a long period. The purpose of this study is to highlight the need for the same.

The important recordings for the above 3 cases include RMS voltages and currents, voltage THD and individual voltage harmonics, current THD and individual current harmonics, active, reactive and apparent power, power factor, frequency and unbalances. These were submitted to the customer and are available. Only the relevant recording showing the effect of loading on the current THD is included under and the salient points are discussed as follows:

i) Main transformer # I 12.5 MVA:

The load varies between 6574.5 kW to kW 450 kW with occasional peaks of 7800 kW (7900 kVA). Due to such wide fluctuation of non-linear medium frequency inverter loads, the maximum instantaneous current harmonics measured by the instrument are quite high with maximum value of 20.0%. However the calculated maximum normalized current harmonic distortion as defined by IEEE standard 519-1992, i.e. I TDD, is at 7% only and hence is in the manageable levels. But under CEA
Case Study 33
Power Quality at a Large Induction Furnace based Industry – Issues on Current Harmonics and Regulations

regulations this may be interpreted as well beyond the compliance level specified. It may be noted that there is major difference between I TDD and I THD values, especially when there is large load variation.

ii) Main transformer # II 12.5 MVA:

In the main transformer #2 feeding the induction motor loads the load fluctuations are within limited range (7500 kW maximum 4800 kW minimum). Being linear load of induction motors the harmonic levels are also less. The measured I THD and the I TDD exhibit low values in the range of 3.6% and 2.24% respectively. It may again be noted that since the fluctuations are less, the I THD and I TDD are in the same levels.

iii) At the PCC (point of common coupling) incoming 110 kV feeder feeding the two transformers’ inputs at 25 MVA maximum demand:

Here the load fluctuation was recorded between 15135 kW and 4860 kW. The maximum instantaneous value of current THD was 8.15% (much less than when considering transformer #1 only) and current TDD is also lower at 5.43% as compared to Transformer # 1. This is because the measurements at the common input feeder exhibits the combined effects of the transformer #1 and #2 measurements (hence exhibits in-between values compared to the two individual transformer related figures mentioned above).

At this common input feeder which is also the PCC (point of common coupling) the overall voltage distortion is well within limits of both CEA regulations and IEEE standards. The current demand distortion (TDD) is higher at 5.43% as compared to 4% (allowed for the 110 kV system and for the generally assumed value, in Indian conditions, of less than 50 for I_{SC}/I_L). Industry is presently banking on the fact that in their case the actual I_{SC}/I_L is greater than 50; In which case the entitlement would be up to 6% for current harmonics. Otherwise industry will have to further restrict the current harmonics (they already have some harmonic filters) injected into the power system with the help of appropriate filters.

The percentage I TDD will be further less if the plant maximum demand considered is more than 15 MVA on a long time basis (IEEE recommends calculation of maximum demand over the preceding 12 months’ period) or as per the contracted maximum demand (the contracted maximum demand being 25 MVA).

The following table provides the maximum and minimum values of the various important parameters recorded during the last measurements on 27th to 29th July 2012 for the total input feeder, Transformer #1 input feeder and the transformer #2 input feeder.
## Case Study 33
### Power Quality at a Large Induction Furnace based Industry – Issues on Current Harmonics and Regulations

The Graphical PQ recordings for the transformer #1 are shown below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Voltage in kV</th>
<th>Current in A</th>
<th>Active Power in MW</th>
<th>Power Factor</th>
<th>THD&lt;sub&gt;v&lt;/sub&gt; in %</th>
<th>THD&lt;sub&gt;i&lt;/sub&gt; in %</th>
<th>TDD* in %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total input Line Feeder</strong></td>
<td>Max 110830</td>
<td>Min 96040</td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Max 15.135</td>
<td>Min 4.86</td>
<td>Max 0.93</td>
</tr>
<tr>
<td></td>
<td>Min 90.00</td>
<td>Max 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
<tr>
<td></td>
<td>Max 90.00</td>
<td>Min 34.50</td>
<td>Min 15.135</td>
<td>Max 4.86</td>
<td>Min 0.93</td>
<td>Max 1.46</td>
<td>Min 0.73</td>
</tr>
</tbody>
</table>

* TDD is calculated (as per the recommendations of IEEE 519-1992) from the THD, maximum and minimum by multiplying these values by the corresponding instantaneous values of fundamental currents and then dividing the same by the maximum value of average demand recorded over a 15 minutes period. As mentioned above, IEEE recommends the maximum demand (averaged over 15 minutes period) over the last one year.
Case Study 33
Power Quality at a Large Induction Furnace based Industry – Issues on Current Harmonics and Regulations

Figure 3: Current Trend Curves

Actual Current = Measured current x 75A

Figure 4: Current THD Trend Curves

9/17
It can be clearly seen from the above graphs that the I THD-s exhibit higher values at low load conditions and vice versa. This is specifically seen for transformer # I which is predominantly feeds non-linear loads of furnaces and exhibits large load variation.

IEEE standards and set limits for current & voltage Harmonics:

IEEE 519-1992 is a comprehensive document dealing only with the issue of the harmonics and its recommendations on limits/conditions of voltage levels and connectivity are accepted as standard all over the world for governing the power quality.

The level of voltage or current harmonic distortion existing at any one point on a power system is usually measured individually as well as collectively as total harmonic distortion (THD) of the current or voltage waveform.
Case Study 33
Power Quality at a Large Induction Furnace based Industry – Issues on Current Harmonics and Regulations

The THD (for a voltage waveform) is given by the following formula:

\[ V_{\text{THD}} = \sqrt{\left(\frac{V_2^2 + V_3^2 + \ldots + V_n^2}{V_1}\right)} \]

Where:
- \( V_1 \) = Fundamental voltage value
- \( V_n \) = \((n = 2, 3, 4, \text{etc.})\) = harmonic voltage values.

Similarly, THD (for a current waveform) is given by the formula:

\[ I_{\text{THD}} = \sqrt{\left(\frac{I_2^2 + I_3^2 + \ldots + I_n^2}{I_1}\right)} \]

Where:
- \( I_1 \) = Fundamental current value
- \( I_n \) = \((n = 2, 3, 4, \text{etc.})\) = harmonic current values.

The extracts of Voltage distortion limits or defined as voltage THD in IEEE-519 for different grid voltage levels are indicated in the following table:

<table>
<thead>
<tr>
<th>Bus Voltage at PCC</th>
<th>Individual voltage distortion, (%)</th>
<th>Total voltage distortion THD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>69KV and below</td>
<td>3.0</td>
<td>5.0</td>
</tr>
<tr>
<td>69.001 KV through 161KV</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>161KV and above</td>
<td>1.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Table 2: Voltage distortion limits

As seen from the above, the applicable limits for 110KV voltage grid for this specific case would be 2.5% only (for the voltage range of 69KV to 161 kV). Against this CEA regulation specifies 5% across the complete spectrum and hence is very liberal.

Similarly, extracts of the IEEE 519-1992 for the requirements of Current distortion limits is given below and the same is specified under two combination conditions as follows:
Case Study 33
Power Quality at a Large Induction Furnace based Industry – Issues on Current Harmonics and Regulations

i) for the different grid voltage levels

ii) for the different ISC / IL ratio - i.e. the ratio of the short circuit current to the maximum demand load current at the point of common coupling - this would mean the maximum current averaged over a demand interval of 15 or 30 minutes for a given customer over a long period.

Also in this standard the harmonic current limits are defined as current TDD-s and not Current THD-s.

Current distortion limits for General Sub transmission Systems

(69 001 V through 161 000 V)

<table>
<thead>
<tr>
<th>Isc/IL</th>
<th>&lt;11</th>
<th>11&lt;=h&lt;17</th>
<th>17&lt;=h&lt;23</th>
<th>23&lt;=h&lt;35</th>
<th>35&lt;=h</th>
<th>TDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20*</td>
<td>2.0</td>
<td>1.0</td>
<td>0.75</td>
<td>0.3</td>
<td>0.15</td>
<td>2.5</td>
</tr>
<tr>
<td>20&lt;50</td>
<td>3.5</td>
<td>1.75</td>
<td>1.25</td>
<td>0.5</td>
<td>0.25</td>
<td>4.0</td>
</tr>
<tr>
<td>50&lt;100</td>
<td>5.0</td>
<td>2.25</td>
<td>2.0</td>
<td>0.75</td>
<td>0.35</td>
<td>6.0</td>
</tr>
<tr>
<td>100&lt;1000</td>
<td>6.0</td>
<td>2.75</td>
<td>2.5</td>
<td>1.0</td>
<td>0.5</td>
<td>7.5</td>
</tr>
<tr>
<td>&gt;1000</td>
<td>7.5</td>
<td>3.5</td>
<td>3.0</td>
<td>1.25</td>
<td>0.7</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Note: Even harmonics are limited to 25% of the odd harmonic limits above

Table 3: Current Distortion Limits

Two very important points must be made in reference to the above limitations:

i. The customer is responsible for maintaining current distortion to within acceptable levels, while the utility is responsible for limiting voltage distortion. However the Voltage distortion typically results due to the distorted currents (demanded by the consumers) flowing through the system impedance.

ii. The limits by these regulations are applicable at the Point of Common Coupling (PPC) between the utility and the customer. The PCC is usually regarded as the point at which the utility equipment ownership meet the customers or the metering point. However, the above limits can be meaningfully applied to the other distribution panels or individual equipment within the plant. In that case the entire plant can be considered to be complying with these limits.
It is very much necessary to note that the current distortion limits are dependent upon the magnitude of the customer’s non-linear currents (i.e. the harmonic currents) and their ratio to the plant maximum demand.

It is also, as mentioned above, based on the available short circuit capacity of the utility (stiffness). The other way of putting this would be, the current harmonic limits vary based on the short circuit strength of the system they are being injected into. Essentially, the less the system short circuit strength, the less the customer is allowed to inject. In this way, customers whose loads potentially have more effect on the utility system and neighboring customers are held to tighter limits.

**More on interpretation of TDD and THD for the harmonic Current limits as defined by IEEE:**

- In case of Voltage harmonic THD ratio, the denominator is usually constant being the fundamental of the nominal voltage of the system, the system voltage is normally constant within a band of plus or minus 5 or 10%.

- However in case of the current harmonic THD ratio, the denominator which is the fundamental of the actual current recorded at any instant, varies over a wide range - no load to full load. Due to this reason, the ratio of THD will be projected very high when the load current at any instant is low, say only 10%, and hence in fact will not contribute significantly to the distortion of the system. This obvious discrepancy is being addressed by the parameter TDD defined by IEEE.

- TDD is defined as the RMS harmonic current divided by the maximum demand current rather than the instantaneous value measured. The difference between the I THD and I TDD values become significant when the load current varies over a wide range. For steady loads these (I THD and I TDD) are of similar or comparable figures.

- TDD is actually a calculated figure (and is calculated from the measured I THD which considers the instantaneous fundamental current) and is the ratio of the RMS values of the harmonics to the fundamental RMS maximum demand of the plant averaged over about 15 minutes when the plant is fully loaded.

- The definition of TDD is necessary especially when the load is varying over a wide range.

- Voltage categories for the current distortion limits: As per this standard, I TDD are defined for two voltage category ranges and also for different fault levels as per the above table.

- Hence as per the IEEE 512-992 regulations the maximum I TDD allowed is 4% for the 110 kV system for the above assumed fault level ratio of 20 to 50. Higher TDD percentage can be allowed if the ratio is more than 50.
National CEA regulations:

The central Electric authority (CEA) have defined the limits for voltage and current distortions as 3% for voltage harmonics and total harmonic distortions for current as 8% (well above the international standard IEEE 519-992).

The CEA regulations is not presently considering different voltage levels as well as the system fault levels for defining the above limits. Also CEA regulations also do not define the I TDD (which is important due to reasons mentioned in the previous pages).

Hence the implementation of the CEA regulations (as it is, with out any qualifying conditions as indicated above) might result into disadvantageous situation for some of the industries which have varying power electronic controlled loads while for other loads the figures mentioned can be very generous.

Until a more comprehensive Indian power quality regulations for harmonic limits are arrived at, it is felt that CEA regulations may also co-opt for IEEE 519-1992 limits to avoid problems to some of the customers due to interpretations of the regulations. It has already co-opted IEEE 519-1992 for the generating installations.

Conclusion:

The industry with wide fluctuating loads, as in the present case, desires full adaptation of the proper definitions/limits/interpretations as stipulated in IEEE-519 for the current distortion measurements so that there will be in a level playing ground (it may be noted that they have already co-opted IEEE 519-1992 for the generating sectors). This is required so that they will not be in a disadvantageous situation (due to different interpretations) requiring to pay compensation as part of the tariff on this account. Present example highlights how electric utilities have already initiated claiming financial compensation and may be even considering service interruption for customers injecting excessive harmonics into the utility system. However these needs to be undertaken carefully as in the present case, customer is drawing power at the 110kV bus and hence expects a stiffer system.

The goal of applying the harmonic limits at the PCC specified is to prevent one customer from causing harmonic problems for another customer or for the utility. Moreover it will be a good idea for the consumers to voluntarily limit harmonics within one’s own industrial power distribution system in order to avoid avoidable losses as well as the operational problems.
About the Authors & the Institution

Authors: 
1) Prof. K. Narayanan (e-mail: knarayanan@kongu.ac.in) 
2) Mr. V. Pushparajesh (e-mail: rajesh@kongu.ac.in) 
3) Mr. A. Sivaprakasam (e-mail: sivaa_prakasam@kongu.ac.in)

1. **Professor, EEE department**: Chief coordinator, Industry Institute Partnership Cell Kongu Engineering College, Perundurai Erode-638052, Tamilnadu, India.

2. **Assistant Professor (Senior Grade) EEE department**, Kongu Engineering College Perundurai, Erode-638052, Tamilnadu, India.

3. **Assistant Professor (Senior Grade) EEE department**, Kongu Engineering College, Perundurai, Erode-638052, Tamilnadu, India.

**Institution:**

M/s Kongu Engineering College (KEC) is a leading Institution, offering technical education and research with state of the art facilities. It is an autonomous institution affiliated to Anna University, Coimbatore and has completed 27 years of dedicated service to the students of India and also from abroad. The Industry Institute Partnership Cell (IIPC) of Kongu Engineering College is in existence from 2002 started with the grant in aid funding from All India Council of Technical Education (AICTE), New Delhi and it is undertaking various consultancies for the nearby industries with the involvement of the expertise of the appropriate departments of the college.
ANNEXURE

SUMMARY OF THE MEASUREMENTS AT INDUSTRY BY KEC EEE DEPT POWER QUALITY AUDIT TEAM

The following details and data are available with the authors of the case study, for further reference:

1. Three set of word documents (each having 10 curves) giving the trend curves for
   a) Measurement at Transformer – I for 2 hours,
   b) Measurement at Transformer – II for 2 hours,
   c) Total input line feeder for 42 hours.

2. The trend curves given for the above three situations are:
   a. Line voltages and line currents for 3 phases (2 nos)
   b. THDV and individual voltage harmonics for 3 phases (2 nos)
   c. THDI and individual current harmonics for 3 phases (2 nos)
   d. Total powers- active power, reactive power and apparent power (2 nos) recorded.
   e. Total Pf, displacement pf (1 no.)
   f. Frequency and Voltage and Current unbalance recorded (1 no.)

2. Considering the CT and PT ratios,
   a. The line voltages measured are to be multiplied by 1000 to get the actual value.
   b. The line currents measured are to be multiplied by 75 to get actual value for transformer I & II and by 150 for the total input feeder.
   c. The power recorded has to be multiplied by 75,000 to get the various power values recorded at transformer I & II and by 150,000 to get the various total power values at the plant input.
Case Study 33
Power Quality at a Large Induction Furnace based Industry – Issues on Current Harmonics and Regulations

The sole responsibility for the content of this document lies with the authors. It does not represent the opinion of the Asia Power Quality Initiative and/or ICPCI/ICA network. APQI and ICA network are not responsible for any use that may be made of the information contained therein.

APQI was initiated with support of Asia Invest Europe Aid Co-operation office. It is nurtured by ICA network and supported by Leonardo Power Quality Initiative as knowledge partner.