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Realities in Harmonics Mitigation as per IEEE-519-2014 Way Forward. Series - 1

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ABSTRACT

People are aware of pollution in the known and visible areas such as air, water, and so on, However, there is pollution in electric power supply as well. Though such pollutions in the power supply are invisible, the effects are being realised nowadays. Electricity being a basic need like water and air, ensuring its quality is also essential to safeguard the equipment and people from any safety and operational issues. In the worst case, it could put people's lives at risk in mission-critical applications and sensitive protection environment like hospitals.

The series of articles on “Realities in Harmonics Mitigation as per IEEE-519-2014-Way Forward-Series 1” is focused on the practical approach towards the mitigation of harmonies, based on IEEE 519-2014, the IEC 61000-4-30 and the Central Electricity Authority of India (CEA) Regulations. The harmonic dumping into the Grid has become a concern in the recent past. To preserve the grid stability from the injurious harmonics injection, the international Standards making bodies and the Regulatory authorities are striving to implement a judicious way of protecting the interests of the stakeholders. The implementation is now gaining attention after the notification of “Central Electricity Authority Technical standard for connectivity to the Grid (Amendment) Regulation, 2019”.

Electricity being a basic need like water and air, ensuring its quality by mitigation of harmonics is essential to safeguard the equipment and people from any safety and operational issues.

However, some of the practical situations make this exercise challenging to the consumer as well as utility. Since some bottlenecks could always crop up during the initial phase of any implementation, it is essential to overcome such bottlenecks for a confident and reliable harmonic compliance/implementation, thereby minimizing harmonic dumping into the grid to establishing a win-win situation.

We came to know from a few consumers that even though one of the major factors, say, methodology of one week and daily measurement duration prescribed in the IEEE 519-2014 is observed, some simple factor, namely, average maximum demand current (IL), can impose as substantial impact on the measurement results of harmonics emission, namely, Total Demand Distortion (TDD). However, a basic understanding of various other factors that influence the values of Total Demand Distortion (TDD) which represents the harmonics emission for mitigation is necessary.

Hence, we have conducted field tests and studies at various facilities to illustrate how various factors could contribute to the harmonics emission measurement so that the remedial measure is properly applied to contain the harmonics within the prescribed limits.

To start with, we are dealing with the application of the factor IL only and we have recommended measures to manage this factor for avoiding disputes during implementation in this paper.

1. INTRODUCTION

Mitigation of harmonics injection has become a challenge between the facilities/consumers/users and system owners/operators/distribution companies (DISCOM). Understanding the compliance of harmonics emission as per Standards and Regulations should not become a tough task; it should be made as easy as a piece of cake. Electrical engineers are now recognizing the need for harmonic control in their power distribution since harmonics always overheat the electrical equipment and affect the operational performance of the equipment and controls. It is a known fact that harmonics generation is inevitable in the modern era of power electronics. Though it cannot be curbed totally, a tolerable limit of harmonics generation must be allowed.

The objective of IEEE 519 is to provide a judicial framework between the consumer and the utility and ensure implementation to minimize the harmful effects of harmonics without affecting either party as well as the other parties who do not attract the compliance with regulations but are becoming victims of the uncontained polluted power from the grid. Day by day, the grid impedance gets increased due to ever-increasing non-linear loads.

IEEE 519-2014 recommends a rational approach between system owners and users by sharing equal responsibility in order to control and maintain the electricity grid in a healthy state.

- All users limit their harmonic current emissions to reasonable values determined in an equitable manner based on the inherent ownership stake each user has in the supply system and
- Each system owner or operator takes action to decrease voltage distortion levels by modifying the supply system impedance characteristics as necessary.

This article is written to assist in the implementation based on the following Regulation and Standards

- Central Electricity Authority (Technical Standards for Connectivity to the grid) (Amendment) Regulations, 2019.
- IEEE Std 519-2014 "Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems” and
- IEC 61000-4-30 – Ed-3– Redline Version of 2015, IEC 61000-3-6 and IEC 61000-4-7

Despite the provisions of the above Regulations and Standards, there exist some ambiguities and misconceptions in understanding the effects of various parameters, especially, IL, Operating current iTHD, TDD, Isc, PCC, operating current during the time of measurement, and the measurement methodology that are influencing the applicable limits of harmonics injection. It is therefore essential to analyse these factors for arriving at a correct interpretation in practical situations.

We feel that real-life case studies might help raise awareness among all consumers, including those who implement the regulation. Our primary objective is to make this document address the actual challenges that customers and utilities face while implementing the standard in the real world. To achieve this objective, a series of write-ups along with case-studies are proposed and this paper forms the first one of such a series. In this write-up, the factors influencing the limits of harmonics, especially, the average demand current (IL) is analyzed.

2. DEFINITIONS OF VARIOUS PARAMETERS

2.1 - PCC - (Point of Common Coupling)

The harmonic limitations are applied to a location that is defined by PCC. Electricity consumers are connected to a power system at Point-of-Common Coupling (PCC), which is the interface point between the utility company and the consumer.

Hence it is a point on a public power supply system, electrically nearest to a particular load, at which other loads are, or could be, connected. Electricity consumers are connected to a power system at Point-of-Common Coupling (PCC), which is the interface point between the utility company and the consumer.

The standard recognizes that an electrical user must ensure that heavy non-linear or distorted currents do not compromise the voltage quality of the utility. It also recognizes the utility's responsibility to offer customers a voltage that is close to a sine wave.

Hence the PCC is generally a point located upstream of the considered installation and it lies on the HV side of the transformer. Since such a point cannot be practically feasible, it is considered at the DISCOM substation which feeds either a group of consumers or an individual consumer.

However, for smaller or Low voltage installations without involving a consumer's transformer, and that are supplied through a common service/distribution transformer, the PCC is commonly on the LV side of the distribution transformer. Harmonics from different consumers can be considered as converging at the PCC.

To avoid adverse effects, understand the impedance characteristics of source and load before placing line chokes anywhere in the AC network.

2.2 - Total Harmonic Current Distortion - (iTHD)

It is the ratio of the root mean square of the harmonic current, considering harmonic components up to the 50th order and specifically excluding interharmonics,) expressed as a percentage of the fundamental current. It is important to understand that THD can refer to both voltage and current harmonic distortion. In this paper, we are concerned with the current harmonics (iTHD) only.

The harmonic generated in a facility is expressed as Total Harmonic Current Distortion (iTHD) as follows:

$$iTHD = \sqrt{\sum_{h=2}^{50} \left[I_h^2 / I_1^2 \right]} \times 100\% \quad \text{.........1}$$

Where I_1 represents the fundamental component of current and I_h represents the harmonic component of current up to the 50^{th} order. Hence it is vital to remember that each harmonic contributes to the total harmonic distortion.

The harmonic generation depends upon the power electronic devices deployed in a facility for various purposes like VFD drives, UPS, power conversion devices, etc. It can be seen from the above expression that the iTHD will get reduced for a higher fundamental current drawn by a consumer. But there is a likelihood of harmonic generation also getting increased at higher loads. However, the variation will not be proportional as it is characterized by the nature of switching and power electronics involved in a facility.

As a result, the measurement methodology prescribed in the Standards alone could assess the actual value of harmonic generation in a facility. The measurement methodology and voltage harmonic distortions will be discussed in the next series of write-ups.

2.3 - Maximum demand current (IL)

The current drawn by the consumer every day or season throughout a year is always variable in nature due to different factors like modernisation or expansion of the plant, commercial or business trends, labour and energy issues, and other unforeseen circumstances, etc.

Hence, treating iTHD alone during the period of measurement will not be practical to quantify harmonics emission for compliance and implementation. Some consideration for the size of the facility is required. It is reasonable to consider that the higher the load consumed by a facility, the higher the harmonics that can be absorbed and hence permissible. Further, harmonics emission must be related to the entire period of a year instead of the measurement duration alone. To address these points an average maximum current is to be considered for a period of one year preceding the month of measurement. Such a consideration becomes either helpful or challenging to the user as well as to the DISCOM in harmonics mitigation.

As per standards, the Maximum Demand Current (IL) is taken as the sum of the currents corresponding to the maximum demand during each of the twelve previous months divided by 12.

2.4 - Operating Current (I-RMS)

The Operating Current in a facility is a time-varying quantity depending upon the operation. Accordingly, the harmonics generation will also vary during the period of testing. This current has a major role in determining the iTHD and TDD for compliance and mitigation. Hence the current that prevails during the period of testing can be considered as the operating current (I-RMS).

The recommended limits in IEEE 519-2014 apply only at the (PCC) point of common coupling and should not be applied to either individual pieces of equipment or at locations within a user's facility.

2.5 - Total Demand Distortion - (TDD)

Depending upon the consumer's demand, the IEEE 519-2014 Standards specify the limits for the injection of harmonic content into the Distribution Company's (DISCOM) Grid in the form of a permissible Total Demand Distortion (TDD).

The TDD provides the fact regarding the linearity of the load associated with an electrical system. The current distortion is less when more loads are linear compared to the non-linear loads and hence the TDD value will also be less in the facility. When more loads are non-linear, the TDD value will increase.

The ratio of the root mean square of the harmonic content, considering harmonic components up to the 50th order and specifically excluding interharmonics, is expressed as a percent of the average maximum demand current. The standards states that harmonic component of order greater than 50 could be included, when necessary. The present Regulation does not insist on it at present.

The TDD is expressed mathematically as

$$\sqrt{\sum_{h=2}^{50} \left[I_h^2/I_L^2\right]} \times 100\% \quad \text{......... (2)}$$

Where I_L represents the load current arrived from the average of Maximum Demand Current for the previous 12 months and I_h represents the harmonic component of current up to the 50^{th} order.

The TDD is influenced by the average load current I_L while the iTHD is influenced by the operating current that prevailed during the period of measurement.

The relationship between iTHD and TDD can be expressed as

$$TDD = THD \times \frac{I_1}{I_L} \quad \text{......... (3)}$$

2.6- Short Circuit Ratio (SCR)

The voltage harmonics on DISCOM/system result from the current harmonics produced by the consumers and it affects the power quality. The grid strength is indicated by the short circuit current/fault level which implies that a strong grid with a higher fault level can afford to bear a higher harmonic injection than a weak grid with a lower fault level. Hence the Standards prescribe the permissible limits of harmonics by a consumer based on the short circuit level of the grid at the PCC by a factor Short Circuit Ratio (SCR).
The SCR at the PCC is expressed as

$$SCR = I_{sc}/IL \ldots(4)$$

Where Isc is the short-circuit current and IL is the average maximum demand current. (12M)

3. RELATIONSHIP BETWEEN ITHD, IL,TDD, AND IRMS ON HARMONIC LIMITS

It can be seen from the expressions 1 to 2 above, that a relationship exists between the operating current (that prevails during the period of testing) and iTHD as well as TDD. But TDD is dependent on IL also unlike iTHD which is dependent on the operating current only and not on the IL. Here, the expression 3 becomes useful to relate TDD in terms of iTHD.
From the above relationships between the harmonics generation, operating current during testing (Irms), average demand current (IL), iTHD, and TDD, it can be deduced that various scenarios are possible.

3.1 - Effect of operating current on iTHD

The operating current, harmonic current, and hence the corresponding fundamental current are dynamic depending upon the type of consumer. For a spinning mill, it may exhibit an average value, unlike a foundry unit where the change in the operating current varies widely due to the nature of the manufacturing process. The harmonic current normally increases with the increase in the operating current. **But the corresponding increase in iTHD is not appreciable due to the denominator effect in the expression (1) defining iTHD**. It is seen from the testing conducted by us that iTHD gets reduced for a higher operating current drawn by the consumer due to the corresponding increase of fundamental current which forms the denominator of the expression.

This can be seen from the following charts obtained from the measurement taken in a textile mill and a foundry unit as shown in Fig 1 and Fig 2:

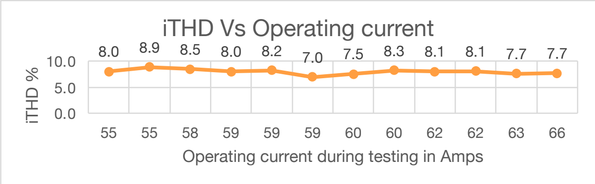


Fig.1: iTHD % for variation in operating current in a Textile Mill

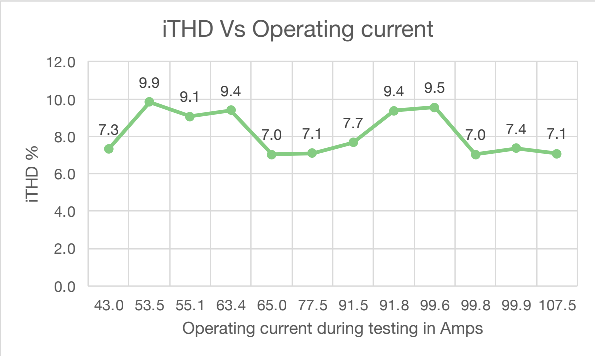


Fig.2: iTHD % for variation in operating current in a Foundry Unit

The operating current that prevails during the period of testing has a major role in determining the iTHD and TDD for compliance and mitigation.
Any implementation methodology should not drive a consumer to engage in manipulation that can affect the grid defeating the very purpose of implementation. The suffering of either the grid or the consumer is not permissible for any arbitrary reason.

3.2 - Effect of IL and operating current on TDD

TDD alone is considered for the compliance mechanism in the Regulations even though iTHD being the actual emission. This is to afford a due consideration that the larger loads have the capability to absorb emissions compared to smaller loads in a facility. It can be deduced from the expression 3 defining TDD, that the IL is expected to play a vital role for the same level of iTHD. IL value is an external factor required to be inserted into the iTHD measurements to arrive and declare the TDD for compliance/mitigation. Hence, the following three scenarios are possible in the IL consideration and the operating current prevailed during the measurement:

- When operating current is equal to the IL
- When IL is less than the operating current
- When IL exceeds the operating current

3.2.1 Scenario-1: When operating current is closer or equal to the IL

In this case, the TDD will not become an issue for harmonic mitigation since it will not exceed the iTHD at any point of time. The IL will match the operating current during the measurement period in a normal situation. In such a case, the variation in TDD will not be appreciable. This can be seen from the following chart obtained from the measurement taken in a textile mill, as shown in Fig 3 (The operating current is closer to the IL of 65 A):

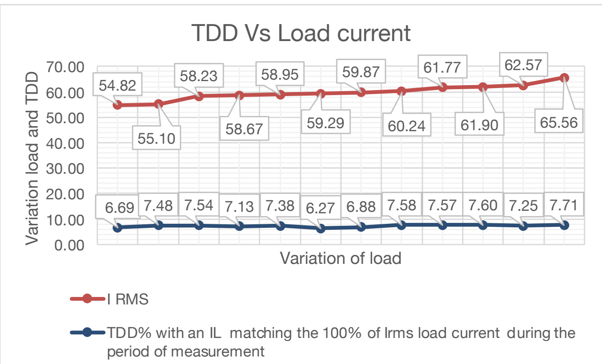


Fig.3: Variation of TDD when operating current matches the IL in a Textile mill

3.2.2 Scenario -2: When IL is less than the maximum operating current

However, in some facilities, the field conditions exhibit a major change in the connected load due to some genuine reasons like, full-fledged operation after a lock down, pandemic or some other unforeseen circumstances. Also, there are cases where a major expansion could take place for business improvement or modernization etc. In such cases, the average load current IL will be much lower than the operating current that prevails during the measurement period. It can also be seen from the relationship between the TDD and iTHD defined by the expression (3) that TDD gets drastically increased despite the iTHD being very low. This can be seen from the following chart shown in Fig 5 in an industry with an IL of 66A.

From the above relationships between the harmonics generation, operating current during testing (Irms), average demand current (IL), iTHD, and TDD, it can be deduced that various scenarios are possible.

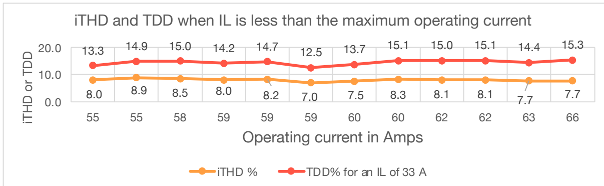


Fig.4: TDD variation when IL is less than the maximum operating current during the measurement period

This situation poses a challenge to the consumer in mitigating the harmonics. Providing harmonic filters would not be a remedy since the average maximum demand for the next 12 months (IL) would become higher, automatically avoiding the scope for the continuance of the already incorporated filter.

If the measurement is performed based on IEEE-519, need for insisting a minimum current requirement will not arise since TDD address the measure of harmonic component into the grid. Also there is no such requirement prescribed in the standards.

3.2.3 Scenario-3: When IL exceeds the Operating current

In case the IL exceeds by a larger proportion of the operating current, the iTHD is suppressed to a larger extent due to the denominator effect of expression 3. This is not a favourable situation to the Utility since the actual higher values of iTHD from various consumers at the PCC may affect the grid.

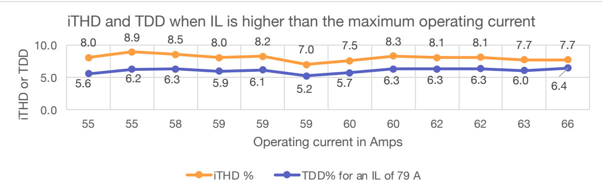


Fig.5: TDD variation when IL is higher than the maximum operating current during the measurement period

3.3 - Combined view on Different scenarios for the varying operating current

Varying scenarios can be seen from the following charts shown in Fig 6 (from the measurement taken in the foundry unit with an IL values of 50% to 120% of the maximum operating current).

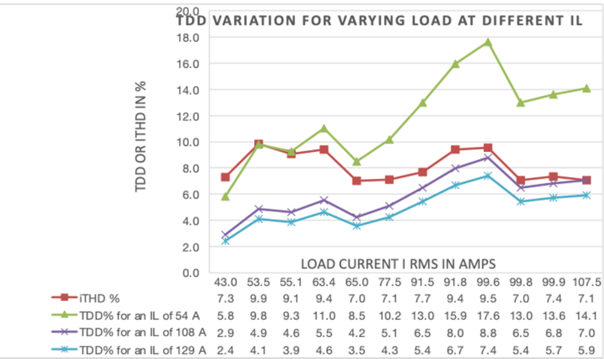


Fig.6: TDD variation for various IL values at the operating currents during the measurement period

It can be seen from the above graph that there always exists a possibility of iTHD being disproportionately represented by the % TDD values and it could affect either the consumer or the Utility.

4.0 CASE STUDY

A typical case to illustrate the scenario-1 is explained here:

An educational institution was getting gradual relief from the pandemic situation, and the facility was recovering from operating at a marginally higher load. The operation of the facility and the load pattern during the period of 12 months preceding the measurement are furnished below

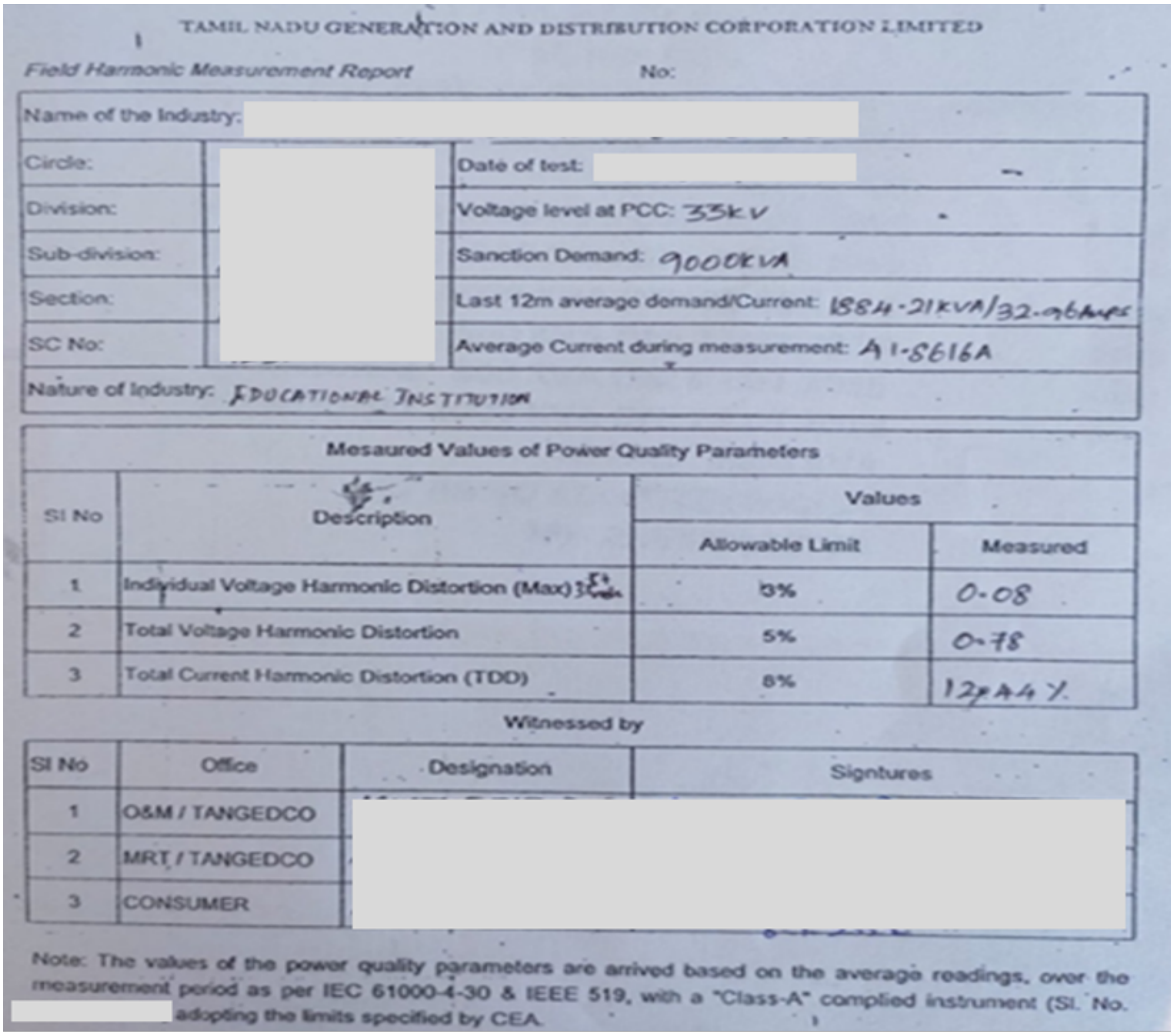
Table 1

System voltage in kV	33
SD in kVA	9000
MD reached in kVA for 12 Months	
MONTH	**MD**
January-2020	1500
February -2020	1555
March -2020	1520
April -2020	1600
May -2020	1881
June -2020	1885
July -2020	1890
August -2020	1880
September -2020	1900
October -2020	2350
November -2020	2300
December -2020	2350
Average Demand (1)	1885
Average current (2)	32

- (1) The average demand for the 12-month period preceding measurement by DISCOM
- (2) The average demand for the 12-month period preceding measurement by DISCOM

To perform a legally acceptable measurement based on IEEE 519-2014, a Class A Ed3 compliant instrument is necessary, as the third edition of IEC 61000-4-30 cancels and replaces the 2008 second edition.

The measurement was taken by the DISCOM on 06.01.2021 and the load was 2400kVA (Irms = 41.86A at 33kV) as depicted below:



TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

Field Harmonic Measurement Report No:

Name of the Industry:	
Circle:	Date of test:
Division:	Voltage level at PCC: 33kV
Sub-division:	Sanction Demand: 9000kVA
Section:	Last 12m average demand/Current: 1884-21kVA/32.96Amps
SC No:	Average Current during measurement: 41.8616A
Nature of Industry: EDUCATIONAL INSTITUTION	

Mesaured Values of Power Quality Parameters

Sl No	Description	Values	
		Allowable Limit	Measured
1	Individual Voltage Harmonic Distortion (Max)	3%	0.08
2	Total Voltage Harmonic Distortion	5%	0.78
3	Total Current Harmonic Distortion (TDD)	8%	12.44%

Witnessed by

Sl No	Office	Designation	Signtures
1	O&M / TANGEDCO		
2	MRT / TANGEDCO		
3	CONSUMER		

Note: The values of the power quality parameters are arrived based on the average readings, over the measurement period as per IEC 61000-4-30 & IEEE 519, with a "Class-A" complied instrument (Sl. No. adopting the limits specified by CEA.

The institution was operating at a low load due to pandemics and hence the average demand for the previous 12 months was 1885 kVA (IL=32.96A at 33kV). Incidentally, the measurement period happened during an increased loading condition of 2400kVA (Irms=41.86A at 33kV) due to an improved situation and a considerable relief from the pandemic. As a result, the iTHD of about 9.8 % got hiked to a TDD value of 12.44%. Had the facility operated at a slightly increased loading to hike the 12-month average demand to about 2975kVA (IL=52A at 33kV), the prescribed limit of 8%, in this case, would have not been exceeded. The following table illustrates this point:

iTHD %	IL	Irms	TDD %
9.8	32.96	41.86	12.44624
9.8	51.5	41.86	7.965592

Table:2- Effect of IL for a given load current in limiting the TDD for compliance

Such an act on the part of the consumer cannot be treated as a violation considering the enormous margin of Sanctioned Demand available for enjoyment by the consumer (Sanctioned demand of 9000kVA yields an IL of 157.464A at 33kV). But the consumer has been treated as a non-compliant of regulations in respect of harmonic mitigation.

It would be reasonable to consider such cases in a standard established manner which is mutually acceptable to the consumer as well as the DISCOM to avoid any arbitrary and discretionary approach during the measurement. Otherwise, a tendency could arise from the consumers to hike the average maximum demand load current during a shorter period of any few months and, such a tactful approach would be making a waste of energy and resorting to an unnatural way instead of proper mitigation.

Whenever a challenge arises, it becomes a necessity to overcome it by suitable means. But the challenge should not pave the way for adopting any activity, which is detrimental to the natural means. Various means of mitigating the challenge are always available to a consumer and divulging such possibilities will not be ethical. The intent of Regulation is to minimize the harmonic emission by providing the required filters for avoiding probable disturbance to the grid as well as to the consumers. Hence, a mitigation strategy should not become a tool to affect the grid and the consumers. The suffering of either the grid or the consumer is not permissible for any arbitrary reason.

IEEE 519-2014 prescribes performing all three measurements, which requires one full week given in the Table 2/3/4 in the guidelines

Daily 99th percentile very short time (3 s) harmonic currents should be less than 2.0 times

Weekly 99th percentile short time (10 min) harmonic currents should be less than 1.5 times

Weekly 95th percentile short time (10 min) harmonic currents should be less than the values

5.0 - CHALLENGES AND MITIGATION FOR THE ABOVE SCENARIOS

Since various scenarios are to be anticipated for mitigation, the following points would become useful for management and compliance.

5.1 - Impact of IL and operating current

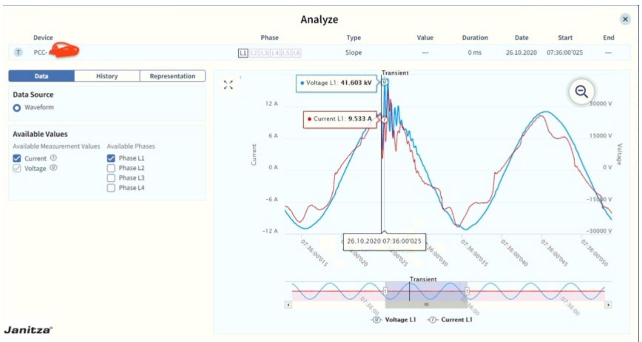
It can be seen that:

- Despite the absolute harmonic generation being high for the increase in operating current, the iTHD variation will not be abnormal and it gets even reduced due to increased value of operating current during the measurement period.

- iTHD and TDD are equal when the IL is equal or very closer to the operating current that prevails during the measurement period.

- The TDD gets decreased when the denominator of the expression increases, i.e. if the average maximum demand current IL is higher than the operating current that prevails during the measurement period.

- The TDD gets increased when the denominator of the expression decreases, i.e. if the average maximum demand current IL is less than the operating current that prevailed during the measurement period.



Transient captured during the time of measurement

5.2 - Possible challenge

In view of the foregoing reasons, we consider that IL plays a crucial role in implementation. The two possible challenges in the harmonics mitigation and implementation are:

- IL (12-months average maximum demand current) could be much lower than Irms, say less than 70% (operating current during measurement) that can inflate TDD and affect the consumer.
- IL (12-months average maximum demand current) could be much higher than Irms, say more than 120% (operating current during measurement) that can deflate TDD and affect the DISCOM.

It may be noted that iTHD (the actual harmonic generation) remains same in both the above scenarios.

5.3 - Reasons for the varying IL

The following situations are the main reasons for the above scenarios:

A. Unforeseen circumstances like pandemic during the immediate one-year period prior to the measurement.

B. Raw material or labour shortage, strikes or business disruptions leading to a minimal operation of the industry during the immediate one-year period prior to the measurement.

C. significant disruption in power supply by the utility during the immediate one-year period prior to the measurement.

D. Activities on energy efficiency, optimization, modernization undertaken at the plant during the immediate one-year period prior to the measurement that resulted in a reduced load current.

E. Consumers intentionally hold the highest level of demand in their possession without the need to use it”

F. Any other unforeseen reasons

While A to C and F of the above situations can affect the consumers, situation D, E and F can affect the Utility. Hence the IL far less than the operating current or IL very higher than the operating current poses major concerns.

But ‘E’ may have different view, since some consumers are intentionally availing maximum demand of about two times or more than their requirement due to a reasonable fear of power crisis or difficulties in surrendering the existing demand or obtaining an additional demand. As a result, such consumers keep the sanctioned demand as a reserve, and it remains unutilised. This surplus demand could become a tool for such consumers to artificially hike the IL for ensuring TDD limits. Both the scenarios are to be addressed without detrimental to the interest of the facility, grid, and the other consumers who do not attract the harmonic compliance regulation but are affected by the emission dumped into the grid and distributed thereof.

5.4 - Suggested mitigation and implementation measures

Since any significant variation in IL can impose repercussions on the part of the consumers as well as the DISCOM, a judicious way of mitigation/implementation must be ensured. Any short-term measurement or undefined discretionary measures may result in either penalizing many consumers or relieving all the consumers from mitigation ultimately affecting the grid. Hence, the consumers and DISCOM need to understand the following to achieve compliance and implementation:

It is the TDD that determines the limit of harmonic injection and not the iTHD as per standards and regulations.

- TDD variation is based on the IL and, the operating current during the measurement.
- The consumer should anticipate a scenario where the load current during the measurement period could be very low compared to the sanctioned demand and plan accordingly to avoid exceeding the limits of harmonics injection into the grid.

- Consumer should be aware that when the operating current during the measurement period exceeds the IL, no harmonic filter will support in limiting the TDD.

- Artificially increasing the IL to ensure that the operating current during the measurement period falls below the IL to fix the problem will be a temporary solution only.

- Installing filters without a proper design considering various technical and practical situations will not help and it will become oversized. Uncertainty in sizing the filters will increase the impedance of the grid which in turn could increase the voltage harmonic distortion.

- For a long-term solution, the continuous measurement for the entire whole month may be taken, and the IL needs to be considered as the maximum load current corresponding to the maximum recorded demand that prevailed at the time of measurement or one month prior to the month of measurement or any immediate months before the measurement month whichever is feasible depending upon the satisfactory operating period of the facility in a business-as-usual situation.

- Suitable amendments to the Standards and Regulations are also necessary to avoid conflict during implementation.

- For a facility operating in a business as usual scenario and a normal operation, the applicable measurement protocol and Regulations are to be strictly observed.

Disclaimer: The information contained in this white paper explains and addresses one of the issues that can emerge during harmonics mitigation based on the Standards and Regulations. It is not intended to be interpreted as a legal advice, and we are not responsible on the outcome of such an interpretation on the part of the reader.

6.0 - CONCLUSION

Hence, the natural possibility of an increased Average Maximum Demand current and reduced operating current during measurement or vice versa may arise in at least 20% of the consumers. Insisting operation of the industry with higher loading during the measurement period will become unnatural and hence a business-as-usual scenario must have arrived. Otherwise, there will be a tendency for the consumer to resort to an ingenious way to avoid mitigation instead of actual mitigation by deploying properly sized harmonic filters. Continuous measurement for the entire full month may be taken and an average current corresponding to one of the four weeks of measurement (where the maximum harmonics generation happened) can be treated as IL in respect of the consumers facing unavoidable and genuine circumstances of operating their facility. Such an approach could safeguard the grid as well.

Continuous measurement for the entire full month may be taken and the maximum current corresponding to one of the four weeks of measurement (where the maximum absolute harmonic current generation happened) can be treated as IL in respect of the consumers facing unavoidable and genuine circumstances of operating their facility.

<u>WHITE PAPER COURTESY</u>

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ABOUT PQ WELFARE CONSORTIUM

The PQ Welfare Consortium is a non-profit organization formed by experienced engineering professionals working in the fields for over 25 years on a national level with the objective of ensuring power quality and electrical safety for the public.

Some of the PQWC's contribution in power quality and electrical safety are:

- Provided technical inputs to the Maharashtra Electricity Regulatory Commission
- Impleaded in case No. MP 22 of 2020 in TNERC.
- Supported the TNERC by conducting PQ Measurements in various types of industries according to the measurement methodology prescribed by IEEE 519-2014 and submitted the reports.
- Offered stakeholder comments on the Draft Regulation on Power Quality released by TNERC.
- Conducted webinars on PQ and electrical safety as a service to society.

PQWC would like to thank Foretec Electric India Pvt Ltd for giving enough support in doing measurements in various industries and processing and providing data to compile this series of paper.

The following factors will be covered in the next series:

- Actual fault level and the role of Isc/IL in harmonics limits.
- Deviation from the Measurement methodology prescribed in the standards will make the implementation process futile.
- Shared responsibility for Voltage harmonics.
- Effects of an individual order, DC component, and higher-order harmonics.
- Harmonics filter design based on TDD.
- Any other issues.

Hope this paper covered the management and implementation of the single parameter of IL and the feedback will drive us to come out with solutions for the other parameters also to ensure an effective harmonics mitigation.

MANAGE PQ TODAY AND AVOID DARK DAYS