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© EPESOL,
Hydran Commissioning at a K-Electric site

Just a fold away...!

Alstoms's portfolio added in **EPESOL's**

Panels by EPESOL **rocking** Systems

CEO visits Spain & **Dubai**

Islamabad **Seminar** yields **tech learning**

Field **Services** traverses **extra miles**

From the Desk of **CEO**

Akhlaq Ahmad

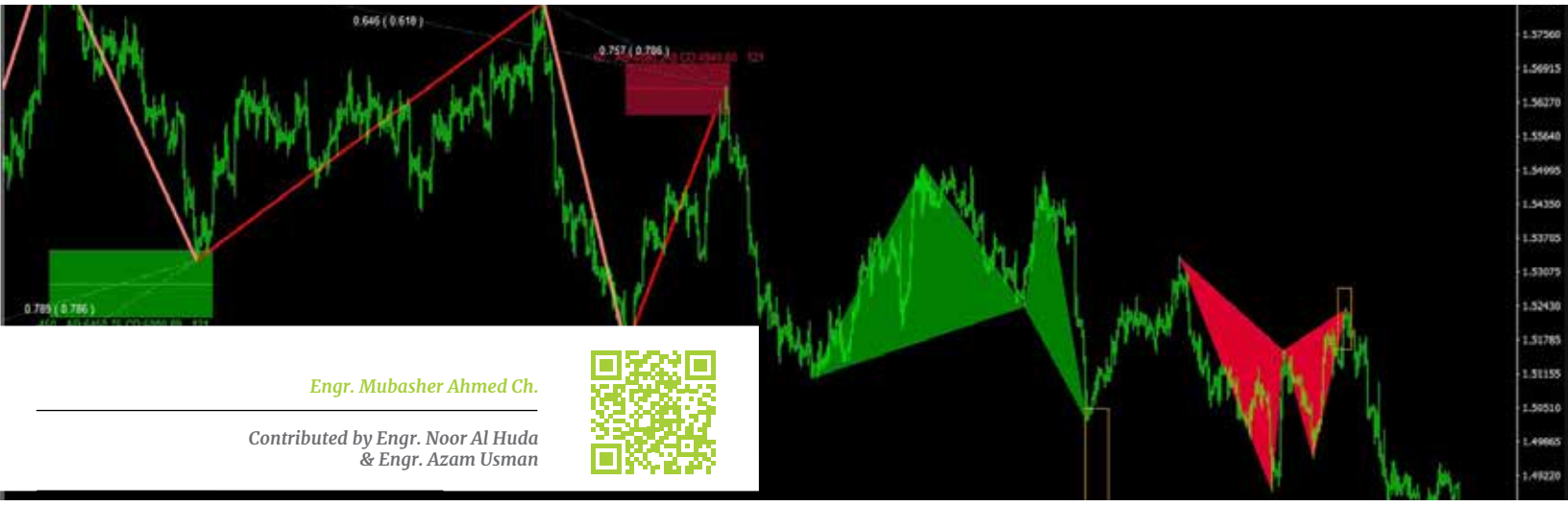
AlhamdoliAllah we have entered in 2016 with high expectations. Happy New Year to you all ! May Allah SWT help us in planning our year and to ponder the year gone. Last year was indeed full of blessings from Allah SWT for EPESOL. Our Field Services penetrated in KSA and secured various projects from Iraq. We started few new businesses and succeeded in adding value to the power sector of Pakistan. After GE acquiring Alstom the market was waiting for the realignment and finally product portfolio of Alstom is now added with EPESOL, another achievement on our part and acknowledgment of EPESOL team efforts from the two big multinationals. EPESOL Team, which we often term as EPESOL family, remained an integral part of our growth with tireless efforts and dedicated professional attitude. We are highly thankful to YOU, our customer and well wisher, being the prime pillar of this achievement. All of this was not possible without your trust and guidance and you becoming our ambassador. With best wishes for the year 2016, I would like to remind you the message of Allah Almighty in Sura Asar where He declared that man is in loss at all times except those who have four traits, believe in Allah, perform good deeds, urge one another to the Truth and Patience. This is the real path of growth that we must not forget in this new year too. I have one request to you that please pray for us so that we keep our best services to the nation and keep growing in the best interests of our beloved Pakistan.

A Scribe by the **Editor**

Noor Al Huda

Another new year has dawned accompanying with it more opportunities and more challenges. To cope with all the challenges we are facing on national and international hemisphere, our highest priority for the next decade from now onwards ought to be continuous improvement of internal security, elimination of religious extremism and terrorism, economic renewal and especially addressing the shortages of electricity and gas. Things have been moving in a positive direction in the recent past owing to LEA operations and the implementation of NAP, China Pakistan Economic Corridor, energy and infrastructure development projects and many other such undertakings. So, will 2016 be a happy new year for Pakistan? I'm not sure what lies ahead but some of these positive indicators should most definitely allow me to project the image of Pakistan as a safer, more prosperous, more peaceful and more inhabitable country in present turbulent times than many other countries of the world. I would conclude this note with the golden words of the father of nation, *"Finally, let me tell you, fellow citizens, Pakistan is a land of great potential resources. But to build it up into a country worthy of the Muslim nation, we shall require every ounce of energy that we possess and I am confident that it will come from all wholeheartedly."* Happy New Year, fellow Pakistanis! You can always drop your feedback and suggestions regarding this newsletter at *epetribune@epesol.com*.

Understanding Power System *Harmonics*



Engr. Mubasher Ahmed Ch.

Contributed by Engr. Noor Al Huda & Engr. Azam Usman

1. WHAT ARE HARMONICS?

Harmonics are a distortion of the normal sinusoidal electrical current waveform caused by nonlinear loads. A load is said to be nonlinear when the current it draws does not have the same waveform as the supply voltage. Examples are personal computer, fluorescent lamps, static converters, variable speed drives, welders, etc. In general, waveform distortion is due to the presence of bridge rectifiers (inside of these nonlinear devices), whose semiconductor devices carry the current only for a fraction of the whole period, thus originating discontinuous curves with the consequent introduction of numerous harmonics. Also transformers can be the cause of harmonic pollution, due to the phenomenon of the magnetic saturation of iron, whose magnetizing current is not sinusoidal. In harmonic distortion, each cycle of the waveform is effected independently and distorted equally. If one or two cycles are distorted we cannot say that it is harmonic distortion. In figure 1.2, the distortions are equal in each cycle and in repetition, so these are a true example of harmonic distortion.

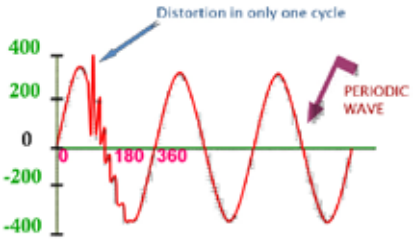


Fig 1.1 Non harmonic distorted voltage waveform

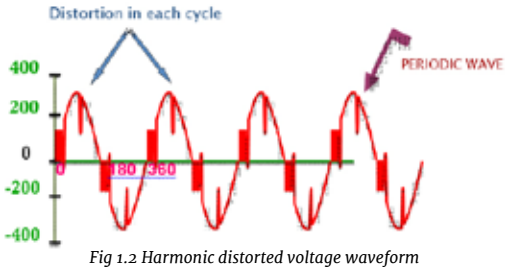


Fig 1.2 Harmonic distorted voltage waveform

1.1 DIFFERENT HARMONIC TYPES & THEIR DEFINITIONS

Harmonics can be either inter-harmonics or sub-harmonics.

1.1.1. Inter-Harmonics:

IEC 61000-2-1 standard defines inter-harmonics as follows:
"Between the harmonics of the power frequency voltage and current, further frequencies can be observed which are not an integer of the fundamental. They can appear as discrete frequencies or as a wide-band spectrum."

1.1.2. Sub -Harmonics:

The sub harmonics does not have itself any particular definition. It is basically a form of harmonics having frequency less than fundamental frequency. However, the term has been used by professionals very commonly. The table 1.1 describes the definitions of different terms used against harmonics.

Harmonic	$f = nf_1$	where n is an integer greater than zero
DC Component	$f = nf_1$	for n = 0
Interharmonic	$f \neq nf_1$	where n is an integer greater than zero
Subharmonic	$f > 0$ Hz and $f < f_1$	
f_1 = voltage fundamental frequency		

Table 1.1 Definition of harmonics and relevant terms

1.1.3. Harmonic Presentation – Fourier Series

According to the Fourier series, any periodic wave form can be determined mathematically in the form of a series of sinusoidal waves summed together.
The harmonic with frequency corresponding to the period of the original waveform is called fundamental and the harmonic with frequency equal to "n" times that of the fundamental is called harmonic component of order "n".
Mathematically,
Periodic function= $g(t)$
Fundamental frequency = ω

$$g(t) = B_o + \sum_{n=1}^{\infty} B_n \cos(n\omega t + \theta_n),$$

where, $T = 2\pi/\omega$, is denoted as time period.
and, B_o is described as DC component.

So,

$$B_n = \sqrt{X^2_n + Y^2_n}$$

and, $\theta_n = \tan^{-1}(-Y_n/X_n)$.

where,

$$X_n = 2/T \int_0^T g(t)\cos(n\omega t)\,dt$$

$$Y_n = 2/T \int_0^T g(t)\sin(n\omega t)\,dt$$

and,

$$B_0 = 1/T \int_0^T g(t)\,dt$$

The major difference between harmonics and transients can be described as under:

Harmonics	Transients
It is a steady state phenomenon	It is a signal like an impulse
It keeps its magnitude continuously	It will damp out in a few cycles
It lasts for long time	It lasts for few seconds
It is a result of distortion produced by nonlinear devices	It introduces non-power frequency signals in the waveform

Table1.2: Comparison between harmonics and transients

2. CHARACTERISTICS OF HARMONICS

Let's consider we have a three phase balance system in which all three phases are 120 degree apart from each other. It means phase B would lag phase A by 120 degree and leads phase C by 120 degree. Third harmonic signal components are present in all three phases. The third harmonic components of all three phases are in-phase and behave like zero sequence components. It is the property of zero sequence components that harmonics can only flow in the lines and neutral/ground through grounded system where in delta connection and ungrounded systems zero sequence does not survive in line currents at all. In a three-phase balanced power, harmonics falls into the phase sequence pattern shown in below table 2.1.

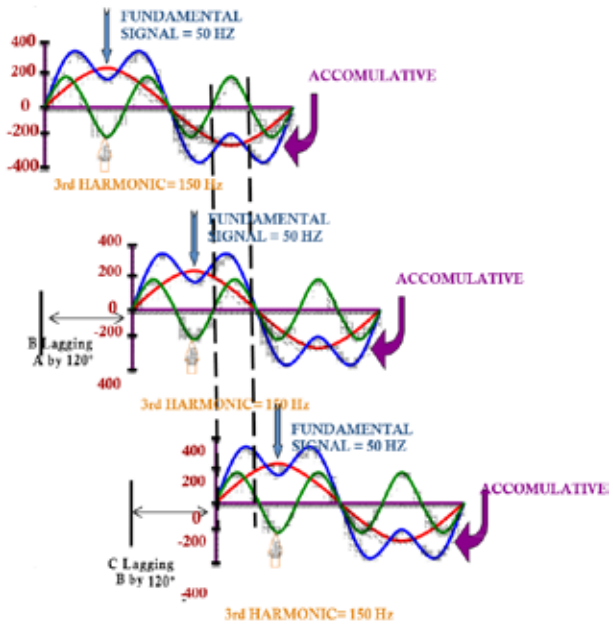


Fig 2.1 Vector sum of third harmonics in three phase power system

Harmonic	Phase Sequence
1	+
2	-
3	0
4	+
5	-
6	0

Table 2.1: Comparison between harmonics and transients

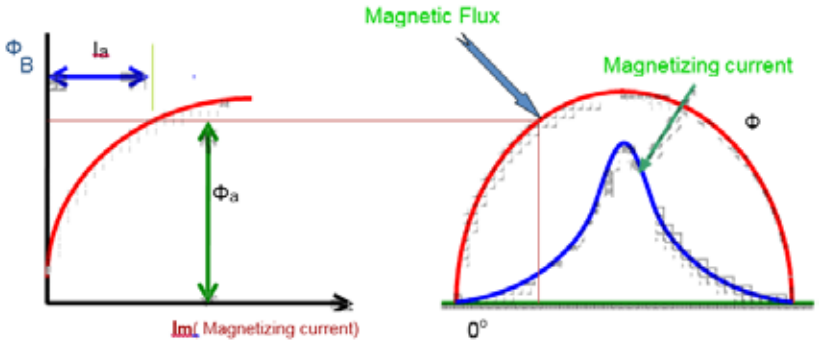
3. HARMONIC SOURCES

Harmonic sources in a power system can be classified in two types of devices described as follows:

a. Saturable Devices
b. Power Electronic Devices

3.1. SATURABLE DEVICES:

Saturable devices generate harmonics mostly because of saturation of iron used in the devices, the most famous practical example is transformers (where the transformer core can be saturated), and electrical machines (where stator core can be saturated).
Almost all the manufactured transformers and motors are designed to operate a little above the knee point of the saturation curve. It can be possible that the applied voltage to the transformer is sinusoidal but the harmonics built up in the transformer is non sinusoidal. The reason is that during the magnetization, current generated by flux through the magnetizing curve is non-sinusoidal due to saturation of the laminated core.



(a). Magnetization Curve (b). Magnetic Flux and Magnetization Current

Fig 3.1 Magnetization of a transformer

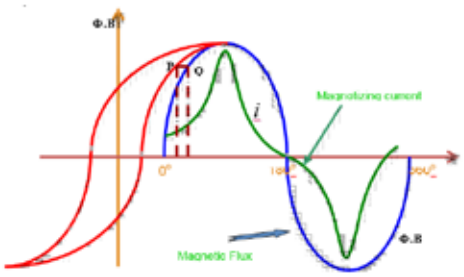


Fig 3.2 Magnetization of a transformer with Hysteresis

3.2. POWER ELECTRONIC DEVICES:

Power electronic devices such as fluorescent lights are extremely nonlinear in nature and draw nonlinear currents and hence produce significant levels of harmonic currents, to be precise odd harmonic currents. Hence in the distribution network where we have three-phase four-wire system, these odd harmonics add up at the neutral and because of the significant level of the 3rd harmonic a large zero sequence current can be experienced. The figure 3.3 explains harmonic current of a fluorescent lamp.

4. SYSTEM RESONANCE BEHAVIOUR

Capacitors and inductors are those equipment that are used in AC circuit very frequently. The circuit that is equipped with these two components has some resonant frequencies. When this frequency reacts with the frequency generated by nonlinear equipment, harmonic resonance is produced. Because of the high distortion effects, resonance can cause false tripping of sensitive electronic loads and can create high harmonic currents in feeder capacitor banks.

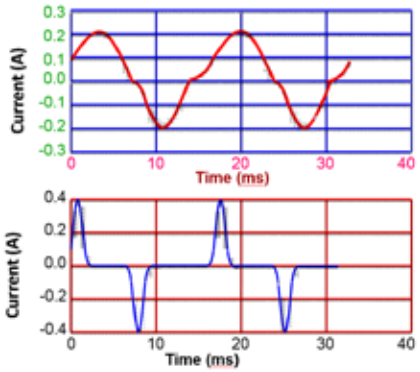


Fig. 3.3 Harmonic current of a fluorescent lamp

Modes of resonance are:

4.1. SERIES RESONANCE:

Series resonance is produced when the system sees a series relation between the inductance and capacitance of a circuit. For series resonance, the highest voltage distortion is at a remote point that is far away or on a neighbouring feeder, energized by the same substation transformer.

4.2. PARALLEL RESONANCE:

Parallel resonance only develops when the system sees a parallel relation between the system inductance and capacitors for power factor correction at the nonlinear loads mainly responsible for the production of harmonics in the power system.

5. MEASUREMENT OF HARMONICS

Harmonics are generally measured in the form of Total Harmonic Distortion or THD. The value of THD, described usually in percentage, is mostly recognized as measure of distortion. THD is valid on both currents and voltages and mathematically we can define it as the *rms* value of harmonics divided by the rms value of the fundamental, multiplied by 100 to get its percentage value.
In mathematical terms, the total harmonic distortion (THD) of a signal (current or voltage) is expressed as the ratio of the sum of the powers of all harmonic frequencies to the power of the fundamental frequency.
THD can also be defined simply a measurement of the percentage deviation from the fundamental voltage wave due to harmonic distortion and can be equated by

$$THD = \frac{\sum_{n-2}^{N} V_n^2}{V_1}$$

where, Vn is the *rms* voltage at harmonic "n", N is the maximum harmonic under consideration & V1 is the fundamental single phase *rms* voltage.

Example:

Consider a voltage waveform having rms value V and the fundamental and harmonic components are V1 and VH. These three values can be related mathematically by the following equation:

$$V^2 = V_1^2 + VH^2$$

For example consider a harmonic voltage of 17 V and the a sine wave of 230 V, the rms value of the these two added together will be

$$V^2 = 230^2 + 17^2$$

$$V = 230.62 \text{ V}$$

THD is measured by the ratio of harmonic voltage to fundamental expressed as a percentage as follows
%THD= (VH/V1) x100
For above case,
THD = (17/230) x100 = 7.4%

6. IMPACTS OF HARMONICS

A lot of unwanted effects can be observed by the harmonics on sensitive power system components and loads. These effects can be:

6.1. SHORT-TERM EFFECTS:

These are generally the most commonly occurrences and are covered under the excessive voltage distortion. False tripping of sensitive loads can be observed with short-term effects. There are a few nonlinear loads particularly computerized controlled loads are voltage distortion responsive. It is also a fact that the voltage distortions value on lower side is not usually a problem, however voltage distortions exceeding more than ten percent always cause considerable false tripping of nonlinear loads which are enough sensitive for their power supplies. It can also produce the overheating in the transformers.

6.2. LONG-TERM EFFECTS:

Long-term effects most of the time go undetected and are usually related to increased resistive losses or voltage stresses.

6.3 METERING ACCURACY:

For measuring the values of power system parameters, there are a number of measuring devices installed throughout the power network. The harmonics can also affect the metering equipment accuracy. This phenomenon is more problematic in case of electromechanical based single-phase induction disk type meters. It is closely noticed that movement of the disk becomes faster on nonlinear loads.

6.4 CAPACITOR FAILURE:

Capacitor fuses can also be blown in the presence of harmonics. The reason behind the fact is the inverse relationship between impedance and frequency of the capacitor, unnecessary harmonic currents are produced in capacitors due to distorted voltage that can damage the capacitors.

6.5 OVERHEATING OF TRANSFORMERS AND ROTATING MACHINES:

Transformers and rotating machines can go towards overheating in the presence of harmonics.

Brand Pakistan now evolves further

EPESOL Portfolio covers Alstom's portfolio amid GE-Alstom merger

This will bring quality products with EPESOL's commitment to Pakistani market, Akhlaq Ahmad CEO EPESOL says

Since its inception in 2009, EPESOL is in a continuous process of evolution and advancements. With a recent manoeuvre in international domain by our principal General Electric Digital Energy EPESOL was also effected. GE Digital Energy acquired whole of Alstom except its locomotive arm with a land mark joint venture deal. This brings 90% of world power engineering sector under one leadership that embodies same values of quality, commitment, innovation and imagination as EPESOL does in its domains. Therefore, EPESOL proudly announces a huge addition in its portfolio that now covers whole of GE Digital Energy and Alstom relay portfolio. Alstom is long known for its amazing products and services in engineering field. Their portfolio includes highly famed 'Agile protection relays' which cover feeder protection, motor protection and management, self/dual powered over current, generator protection, differential, phase comparison, pilot differential, bus bar differential, transformer protection, bus-wire supervision, circuit supervision, auxiliary, tripping, time delay and many more relays. On the occasion CEO EPESOL Engr. Akhlaq Ahmad congratulated Pakistani consumers that such a huge portfolio is now at their disposal along with EPESOL's legacy. 'This deal will enhance the capabilities and efficiency of Pakistan's power sector. EPESOL is committed to make available fast and cheap solutions for Pakistani customers and this deal will bring quality products with EPESOL's commitment to Pakistani market. EPESOL will always be there for testing and commissioning facilities along with strong after-sales services', said CEO, Akhlaq Ahmad after the merger and his Dubai business trip that shaped the EPESOL-GE Grid Solutions agreement for Pakistani market.

EPESOL Panels, rocking the Power Systems!

Purely ingenious, customized and beautifully designed

EPESOL Panel Manufacturing team with close tabs on Design and Consultancy department completed a huge order from IESCO for their continuously expanding needs. This is indeed a good news for both Pakistan and EPESOL that new power projects are being developed and thus this infrastructure need rises. Islamabad Electric Supply Company a.k.a IESCO recently hired EPESOL for panel manufacturing. Panels included were Relay Panels of type RP3 and RP4 which are the major panel on grids and incorporate 'D60', 'MIFII' and '345' relays. They also include BJ8R and RJ8R auxiliary relays which were also supplied by EPESOL. Other panels were Control Panels equipped with EPESOL's home production Annunciators and Supervision Relays few AC/DC panels equipped with EPESOL own relays and GE state-of-the-art breakers along with Metering panels fitted with G60, FGN, FD, EP100 and Elster meters and GE test blocks were also included in the customer need. There were total 42 panels in the order of which 18 were Relay panels, 19 were Control panels, 4 were AC/DC panels and a Metering Panel was also included. It is worth mentioning that EPESOL's technology has recently bagged GE partnership and authorization in Relay and Control panels manufacturing.

Design & Consultancy protecting national green energy initiatives!

Design & Consultancy arm of EPESOL has always been regarded as leader of the market. Recently, it has completed protection system studies of 3x wind farms, namely, 50 MW Yunus Wind Power Project, 50 MW Metro Wind Power Project, 50 MW Gul Ahmed Wind Power Project. The scope included relay configuration, parameter settings and coordination of relays at 22 kV and 132 kV systems and the protection systems included line protection system, transformer protection system, low impedance busbar protection system, and over current & earth fault protection system.

FICO Engineering ready to secure national assets with large relay order

Large MIF-II, TS-101 and MIV-II provided

FICO engineering is in the field of power engineering since 1958 and serving a large clientele since its inception. Recently with its growing needs FICO contacted EPESOL for a large order of MIF-II Feeder protection digital relay that can be used for backup protection of transformers and other assets. A part from that MIV-II digital relays were also ordered that offer voltage and frequency protection. It is worth mentioning that GE offers 10 years world-wide warranty on these relays.

LV Business yields positive figures this quarter amid new contracts

Mega supply to new vendors in Pakistan

With EPESOL's LV agreements with GE, we have embarked footings in LV Solutions too. This quarter proved really affluent in domain of low voltage stream as we secured orders of supply of low voltage components to Green T&D, Siddique Sons and Dost Steel Mills. MCBs, MCCBs, AC/DC Contactors, thermal overload relays, breaker and motor protection components and other auxiliary components were supplied to these customers.

Insulation coordination study for FPCL

60 MW Energy projects is now more secure

When it comes to studies and consultancy the obvious name pops in mind is EPESOL's Design & Consultancy. EPESOL has recently conducted insulation coordination study at FPCL 60 MW coal based power plant being constructed in Karachi. The scope included insulation coordination study of 132 kV GIS substation to ascertain ratings of surge arresters installed at incoming transmission lines and GIS. The project was of crucial importance for the national power crisis. EPESOL was given a short time to perform the studies which were done on time thus making the overall project progress more fast.

ACPL assets get secured by EPESOL's Design & Consultancy

6.3 kV electrical systems protection studies

EPESOL has successfully conducted protection system study at Attock Cement Pakistan Limited (ACPL) in Tehsil Hub, District Lasbela, Baluchistan. The scope of work included protection relay setting calculations and coordination study of complete 6.3 kV electrical system of waste heat recovery plant (WHRS) and included feeder and generator protection systems.

International Field Services

EPESOL around the globe, pinning brand Pakistan with its quality commitment

Generator Panel Commissioning at Samur Project, Sipitang, Malaysia

» EPESOL has continued its Excellency in international platform with one more service project in Malaysia. Scope included QC of panel, Wiring and Scheme verification of the system, complete interface checks with control and excitation panels and then synchronization of the panel with grid.

Commissioning of Online DGA analysers in Saudi Arabia

» EPESOL has continued its commissioning services for Monitoring & Diagnostics products of transformer in Kingdom of Saudi Arabia. In this quarter our team has commissioned 05 units at following sites:
  » 02 Units of Online DGA Analysers type Transfix make GE at 380 kV Al-Jouf BSP, Saudi Arabia.
  » 03 Units of Online DGA Analysers type Transfix make GE at 380 kV HAIL BSP 9030, Saudi Arabia.

Field Services, Serving at home!

Happiness is to traverse the whole country with top quality

Engro Polymer Karachi

» EPESOL welcomes Engro Polymer in its broad clental club. Recently Engro Polymer hired epesol for conducting the testing of ABB relays and Nexus energy meters on their plant. Team EPESOL did the job in timely manner with utmost customer satisfaction.

Fauji Fert. Bin Qasim secures its generators through EPESOL.

G-30 gen. protection relay supplied to FFBL

Fauji Fertilizer Bin Qasim Limited is a Public Limited Company with a modern Granular Urea and Di-Ammonium Phosphate (DAP) fertilizers manufacturing complex. FFBL is one of the largest fertilizer producer in Pakistan and hence of a crucial importance. Recently they switched to modern generator protection relays for their generating units that power the whole complex. G-30 relays were delivered timely by EPESOL thus securing the whole complex.

DHA staff room & parking are safe for operation by EPESOL intervention

LV Dist. Boards shipped through SolarTech

DHA Karachi is a unique project in a perspective that it harnesses green energy on massive scale. Apart from consultancy for that project EPESOL also manufactured Low Voltage distribution boards for DHA parking lots and staff rooms as a SolarTech order. The DBs at EPESOL are engineered to detail accommodating more than 20 years needs. They incorporate GE's state-of-the-art circuit breakers which can be bought separately as we are the official LV partner of GE.

Hyosung CT/VT boxes are shipped, manufactured by Panels Team

Junction boxes are the heart of protection

CT and VT boxes are of crucial importance at substations. They provide an interface for measurement and troubleshooting purposes as you cannot directly tap on to CTs and VTs out in switchyard. Recently Hyosung, a Korean multinational, ordered CT/VT boxes for its ongoing substation project in Pakistan. EPESOL on its manufacturing facility for panels manufactured junction boxes. Schematics and drawings were done by EPESOL's highly famed Design and Consultancy arm.




Islamabad region gears up to implement better substation management

A mega technical seminar on substations concludes in Islamabad Club

A technical seminar was organised by EPESOL in Islamabad Club, Islamabad on Dec 15 as "Substation Monitoring Techniques and Solutions". It was first of its kind seminar in whole Islamabad region, a continuation of EPESOL's vision of enhancing technical knowledge of Pakistani engineers and exposing them to latest advancements currently undergoing around the world. EPESOL with this vision has already organised two seminars in Lahore and Karachi, each. The seminar was focused on Utility sector (IESCO), Mangla, Tarbella, Ghazi Barotha, concerned Government organizations, Industry and IPPs surrounding Islamabad. A remarkable participation of Engineers from every quarter of IESCO and GENCOs was observed. The agenda of the seminar covered transformer diagnostics and substation automation domains. CEO EPESOL Pvt. Ltd. Engr. Akhlaq Ahmed in his keynote address asserted EPESOL's resolution of value addition especially to the deteriorating government sector. "The key to current power crisis lies in an engineering approach and this can not be achieved without educating our engineering sector", said Engr. Akhlaq.

CEO EPESOL visits Spain and Dubai amid latest deals undergoing

Internationalising will empower our national power sector , Engr. Akhlaq Ahmed

EPEOL is always the heart of latest technological import in Pakistan's power sector. Internationalising is the key to the entrepreneurship EPESOL does. Recently CEO EPESOL Pvt. Ltd. Engr. Akhlaq Ahmed visited Spain and Dubai for the same purpose. He met top leadership of both GE Grid Solutions and Arteche, major principals of EPESOL. On his Spain tour he visited GE's Zamudio, Balbao factory, laboratory and testing facility and met with Luis Maria Pérez, Global Sales Leader - GE grid solutions. He also met with Patxi Infante, Isabel Liquin, Iñigo Escalante Moreno, Iñigo Mendezona, Carlos Aguilar and Oscar Casanova regarding technical aspects. A meeting also took place with ZIV Dimat regarding substation automation and attended by its top leadership. CEO also visited Arteche, Spain - another EPESOL principal - and met with Jon Rotaetxe, Iratxe Muga, Ager Larrabeiti and Gonzales Sonia, Sales Director Europe, Middle East & Africa. In his Dubai visit, CEO EPESOL met with newly formed regional leadership of GE-Grid Solutions after GE-Alstom merger. There he met with Ali Hamze, Regional Sales Leader for GE Grid Solutions. He also met with other regional executives to discuss matters of concern.