



# Current Waves

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## EDITOR'S NOTE

The two important parameters that govern the supply of electricity are quality and reliability. By quality, I mean maintenance of declared voltages, frequency and harmonic contents by the supply authorities and by reliability I mean availability of electricity at all time to the consumers.

Shortage and reliability of electric power are two independent aspects and shortage cannot be used as an excuse for frequent interruptions in power supply except for planned load shedding. Process industries and computer installations are sensitive to power interruptions. While the cure for power shortage is a long drawn, high end budget, mammoth programme, improvement in reliability of power supply is achievable in a relatively shorter period and with lesser financial burden.

Perhaps with this concept in mind and with an intention to provide consumers of Bangalore with cent per cent reliable power, Bangalore Electricity Supply Company Limited, (BESCOM) whose responsibility is to distribute power at 11kV and lower voltages to Bangalore, has embarked on a project on Distribution Automation System (DAS), and Distribution Management System (DMS) in Bangalore. The project, estimated at about 5.6 billion rupees will take about four years to complete.

Presently BESCOM is operating the distribution system manually and therefore a lot of time is lost in fault location and restoration of power supply. While the factual interruption per consumer in cities like New York, London, Tokyo, Paris etc. is in the order of minutes per annum, the same figure for Bangalore is about 86 hours.

The scheme briefly is, control and monitoring of Ring Main Units (RMUs), monitoring centre at substation level to supervise distribution network under the control of the substation and Master Control Centre for overall monitoring and controlling of the distribution network using DMS.

The decision of BESCOM to take up DAS/DMS project is a step in the right direction to provide relief to the industrial, residential and commercial consumers. These projects assume importance because, with the deficit of power in Bangalore especially during summer season, the available power should be most reliable for efficient performance of industries and business houses. On completion of the above project, Bangalore will be the first city in the country to adopt DAS/DMS and among a few cities in the world.

Of course, once the 100% reliability is achieved by BESCOM, there will be some collateral benefits like improved productivity in industries, reduced public panic in market places, hospitals, etc. and reduction of pollution caused by diesel generator sets run in the industries, commercial complexes, residences etc. during power outages.

My very best wishes to BESCOM for the success of the project.

Thank you,

Engr. J. D. Krupakar





## LOW VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

by C.S.Nambisan  
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### INTRODUCTION

L.V. Switchgear is the backbone in electrical power systems, as it is a key component used as Power Distribution Panels, Motor Control Centres or a combination of both. As majority of the loads in industrial plants and buildings are supplied with low voltage-for motors, lighting, small power, air conditioning, heating etc., L.V. switchgear has special significance. The term 'LV Assembly' related to L.V. Switchgear and Controlgear assemblies refers to one or more low voltage switching devices together with associated equipment for switching, protecting, converting, controlling, measuring, signaling etc., completely assembled under the responsibility of the manufacturer with all the internal electrical and mechanical interconnections and structural parts. L.V. Switchgear covers all configurations with rated voltages up to 1000V A.C. At frequencies up to 1000 Hz or 1500 V D.C. except for small distribution boards. It can be combinations of Electro Mechanical and Electronic equipment or only Electronic equipment e.g. Variable Speed Drives, Programmable Logic Controllers/other automation panels, Soft Starters etc. L.V. Switchgear shall provide reliable power supply by ensuring good availability, flexibility for process related modifications and high operating safety. Long term reliability and safety with least stand-still time are the key features.

There are widely varied applications and requirements in the construction of the switchgear, as well as considerations with regard to various operating conditions and safety aspects from operation/access by unskilled people, to access limited to skilled maintenance staff to the electrical equipment located in locked electrical rooms. Accordingly, different constructions and combinations are used to match the application.

### IEC STANDARD

The relevant IEC Standard is:

#### **IEC 60439-Low Voltage Switchgear and Controlgear Assemblies**

#### **Part 1:-Type Tested and Partially Type Tested Assemblies.**

Current edition is the year 2004, Edition 4.1

CEI/IEC 60439-1:1999+A1:2004

Equivalent British Standard is also in conformity with IEC i.e. BSEN 60439-1

The standard applies to assemblies intended for use in connection with generation, distribution and conversion of electrical energy and for the control of electrical energy consuming equipment. It also applies to assemblies designed for use under special service conditions, for example in ships, in rail vehicles, for hoisting equipment or in explosive atmosphere, and for domestic (operated by unskilled persons) applications, provided that the relevant specific requirements are complied with. This standard also applies to assemblies designed for electrical equipment of machines along with additional requirements of IEC 60204-1.

The standard is not applicable to individual devices and self-contained components such as starters, fuse switches, electronic equipment etc.

These are also several other related standards indispensable for the application of IEC 60439 which shall also be considered.

### PRINCIPLES OF FORM OF SEPARATION

L.V. assembly employs many variations in designs to meet the market and application requirements. This includes floor standing or wall mounted distribution boards, panel boards, MCCs etc., but excludes individual devices /components for only one circuit like a starter/fuse switch. Typically, major panels in industrial plants are in the form of floor standing cubicles in modular incoming and outgoing units. The modules can be combined as necessary. Wall mounted type MCCB boards and starter panels are also widely used, mostly in buildings and light industries.

Separate compartments are provided for:

- ▶ Functional units,
- ▶ Busbars - main horizontal and vertical
- ▶ Cable connections

The Functional Unit is defined as 'A part of an LV assembly comprising all the electrical and mechanical elements that contribute to the fulfillment of the same function for each incoming or outgoing circuits'. It includes all the main current carrying equipment including control devices and cable terminals within

**The Functional Unit is defined as 'A part of an LV assembly comprising all the electrical and mechanical elements that contribute to the fulfillment of the same function for each incoming or outgoing circuits'.**



the assembly, but excludes connections from unit to vertical busbars (busbar connections) and any insulation or shrouding.

Dividing the switchgear into busbar compartment, equipment compartment and cable compartment provides many operational and safety advantages while doing maintenance work and making alterations to switch boards.

By dividing the switchgear assembly by means of partition or barriers metallic or non-metallic - into separate compartments or barriered sub sections, following key objectives are achieved:-

□ Personnel protection against contact with live parts belonging to adjacent functional units.

□ Prevention of probability of initiating a short circuit and arc faults by unintentional means like dropping of tools etc. Protection against spreading of an arc fault in which it started to any other compartment.

□ Partition between busbar compartment and equipment compartment provides arc resistance. Switchgear functional units are made arc proof even in their basic form in that the effects of arc is restricted to that unit only.

□ Opening between the compartments should be such that the gases produced by the short circuit devices do not affect the operation of adjacent functional units/compartments. The effects of arc can be reduced by monitoring devices to limit the magnitude and duration of the short circuit current.

Depending on nature of application - industrial, buildings etc. and the requirements with respect to ensuring availability of power and critical nature of any processes, the L.V. assembly construction can be classified in to various 'Forms of Separation'. This refers to division of LV assembly by means of partitions or barriers into separate compartments or barriered sub-sections i.e., functional units or functional groups.

The three fundamental criteria to be considered for the Form of Separation are:

- Protection against contact with live parts
- Limitation of the probability of initiating arc faults and
- Protection against passage of solid foreign bodies from one unit of assembly to an adjacent unit.

These three criteria are inter-related.

1. Protection against contact with live parts belonging to adjacent function units, degree of protection shall be IP2X or IPXXB.

As a minimum, finger contact with live parts in adjacent functional units is prevented and also they can include protection against finger contact between functional units, adjacent busbars and connections, and terminals as required for the particular form of separation used. Requirement is tested with standard test finger.

2. Limitation of the probability of initiating arc faults which is ensured by good design practices and ensuring by type test, that the operation of switching and short circuit devices does not adversely affect adjacent function units or busbars.

3. Protection against the passage of solid foreign bodies from one unit of an Assembly to an adjacent unit with at least IP2X protection. Minimum requirement is proven by standard test finger not being able to touch live parts and a 12mm ball not being able to pass between units. A higher degree of protection may be required in critical usage for horizontal partitions to prevent small objects from falling between compartments. This shall be agreed with manufacturer.

The following are the main 'Forms of Separation' by partitions or barriers:

**Form 1-** No separation. Form 1 may be used where the LV assembly can be totally isolated elsewhere for all activities involving access of any kind.

**Form 2-** Busbars are separated from functional units. Functional units are not separated from other functional units. There are two sub-

divisions: **Form 2a and Form 2b.** In Form 2a, the terminals are not separated from the busbars, or each other. In Form 2b, the terminals are separated from the busbars, but not from functional units.

**Form 2** is used where separation of the functional unit from the busbar is required, e.g. wall mounted Sub Main DBs (MCCB DBs) which are typically Form 2b Type 2. Main LV panels in relatively unimportant use of buildings and non-critical industrial plants may also employ Form 2 type of construction as it will cost less. Form 2 provides protection against contact with live parts of the bus bars. This eliminates the risk of initiating a short circuit arc unintentionally like by slipping of the tool or an assembly while working. In Form 2, in principle, it is only possible to switch OFF the switchboard (to work etc) by disconnecting the whole switchboard. If an arc occurs due to short circuit etc. after the protective device (MCCB/fuse etc.) in a functional outgoing unit or functional group after the protection device, it will be unable to spread and create

**Dividing the switchgear into busbar compartment, equipment compartment and cable compartment provides many operational and safety advantages while doing maintenance work and making alterations to switch boards.**



a primary arc; however, there is nothing to prevent arc spreading among each device.

**Form 3-** Assemblies provide protection against contact with internal live parts and components and there is internal separation of the busbars from functional units and separation of all functional units from each other. But incoming and outgoing terminals are not separated from each other.

- Bus bars are separated from functional units
- Functional units are separated from each other
- Functional units are separated from incoming and outgoing terminals
- Incoming and outgoing terminals are not separated from each other

In Form 3, terminals are placed in the cable compartment or in terminal compartments. Each functional unit is in own compartment, separated from each other. Form 3a and Form 3b are its variations.

**Form 3a** -Separation of bus bar from the functional units and separation of all functional units, but not of their terminals, from one another. The terminals for external conductors need not be separated from the bus bar or from each other.

**Form 3b** -As basic Form 3. Bus bars are separated; the terminals are therefore separated from the bus bar, but not from each other.

Form 3 may be used where access is required to functional units for limited maintenance work with adjacent live circuits- terminals are in the cable compartment or in terminal compartment. Form 3b is used extensively in building projects and general industrial plants. This can provide cost effective solution for many of the applications

**Form 4-** In Form 4 assemblies, there is internal separation of the busbar system from functional units and separation of all functional units from each other. Incoming and outgoing terminals are also required to be separated from the bus bars and from each other.

Following apply:

- Bus bars are separated from functional units
- Functional units are separated from each other
- Terminations to functional units (incoming/ outgoing) are separated from each other

There are two subdivisions- Form 4a and Form 4b.

**Form 4a-** As basic Form 4, Cables are terminated within the same compartments as the associated functional units ; cables may be glanded elsewhere e.g. in a common cabling chamber or each unit can have own integral glanding facility.

**Form 4b-** As basic Form 4, the difference with Form

4a is in that, in Form 4b, terminals are external to the functional units and separated from each other. The terminals can be separated by various means depending on the manufacturer/specification - by insulated coverings like PVC boots, or terminals in own compartment of rigid barriers or partitions. The cable to each unit can be glanded in common cabling chamber or can be integral glanding separately for each unit.

Form 4 is an improvement on Form 3 in that it ensures complete separation of all units including the incoming and outgoing termination from one another thus achieving highest operational and functional safety. Separation must be at least IP2X. If an arc occurs due to short circuit etc., in a functional unit after the protection device (MCCB or Fuse etc) it must not be able to reignite and create a primary arc or to move into other functional units. If an arc occurs on the busbars, it must not be able to move in to or reignite the secondary side of the functional units. Thus the effect of an arc is contained with in the

compartment where it started until the short circuit protection of the section itself switches off the current before serious damages can occur, such that the switchboard can function without affecting any other units.

Form 4 affords facility to work in a live switchboard in critical conditions e.g., new cabling without switching off complete board.

#### Live working

Users of Electricity need an uninterrupted and reliable power supply. Process industry and computer installations are sensitive to power interruption. Service, repair or upgrading of L.V. switchgear may sometimes need to be performed on "live conditions", though it is recognized that it is dangerous and not permitted in many cases. If however, there may be circumstances that it is not possible to switch off the board and work need to be done without personal risk and danger of initiating arc fault.

In general, following can be a guide for live working:

Form 1 and Form 2: Live working is not possible on a switchboard in Form 1 and Form 2 as risk of contact with live parts is high due to lack of separation.

Form 3-A: Skilled and trained person can work with in a functional unit ( e.g., changing a fuse) in a relative safety as an inadvertent slip would not put person in immediate danger.

Form 4a: Cabling up outgoing ways is possible with Form 4a type switchboard, but it may not be good idea

**Form 4 is an improvement on Form 3 in that it ensures complete separation of all units including the incoming and outgoing termination from one another thus achieving highest operational and functional safety.**



to work on functional units as the person can be exposed to the terminals which could have a back feed or other voltage on that.

Form 4b: Form 4b switchboard offers the highest level of protection. It is possible to work on functional units and cable outgoing ways in relative safety while the board is live as the busbars, functional units and terminals are all separated. In many process industries, power stations etc., Form 4 is an automatic choice. Form 4 may be used where access is required to the cable terminals of a functional unit with adjacent live functional units. This gives more safety for personnel and prevent inadvertent initiation of short circuits. This is typically used for critical applications in continuous process plants, metal processing plants, power plants/substations, oil/gas/ petrochemical plants, data processing centres, key buildings etc. Form 4b additionally provides a clear boundary between functional units and cabling contractor.

Form 4 may be required even in major buildings, because power requirements for the lighting and other essentials are usually decided and switched on first, before the requirements of the different sections of building are finalized. In a large building project, common areas like basement, circulation areas and common services may be made ON/functional initially, while the major portion of building may be 'fitted out' later, e.g. for offices by tenants as per their varying plans to suit individual requirements. This may lead to making changes and / or additional cabling requirements to a live switchboard to suit the tenant 'fit out'. In such cases Form 4 switchboard may be specified as power for essential services cannot be interrupted.

Authorized and trained and skilled personnel only shall carry out work on live boards, after taking due safety precautions in all respects.

Form 1 and Form 2 can be used where complete switch OFF of board is permissible e.g. during holidays, so the work can be performed with full isolation of board.

Form 3 may be used where there may not be need for live cabling work, but may be in replacing functional units (replacing fuses or a plug-in withdrawable unit only, or maintenance / fault checking etc.)

Above are typical applications only. There is no rule to be followed. Consultant / User shall specify the requirements. Forms of separation shall be the subject of agreement between the manufacturer and the user so as to establish the best suitable solution considering

all aspects of the intended application.

BS EN 60439-1 is in line with IEC standard. However, it recognizes some more sub-divisions (e.g. Type 1 to 7 for Form 4) to the basic Forms of Separation than IEC standard. Form of Separation can be achieved in several ways - covering busbars with PVC or similar sleeving, wrapping or plastic coating, using insulated terminal shields, rigid insulated barriers or partitions, earthed metal compartments, a device's integral housing etc. Where a specifier has any preference, this should be specified clearly in the enquiry.

Form 4 type 7 gives maximum separation as terminals are external to functional unit compartment and enclosed in their own compartment by means of rigid barriers/partitions, complete with integral glanding facility.

In general, cost of LV Switchgear goes up with increased levels of separation / types of construction. Choice of the most expensive arrangement need not be the best solution. Hence the Consultant shall specify

cost effective and appropriate 'Form of Separation' depending on the application and critical nature of any processes involved.

Following may be considered while selecting the suitable form of separation.

- Location of switchboard, e.g. locked rooms provides more safety.
- Skill levels and training of maintenance personnel e.g. in industrial plants, mostly skilled / trained personnel are available. In

buildings this may or may not be the case.

- Maintenance requirements for the application.
- Difficulty and / or inconvenience in isolating the complete switchgear, e.g. key data processing centres, continuous process plants etc., where loss of power supply can not be tolerated.
- Probability of requiring access to the terminals of a particular circuit with those adjacent line in services, e.g. in Form 3, terminals are in common area, whereas in Form 4, terminals are also separated from each other to provide complete separation and more safety to personnel / avoid accidental short circuits.
- Price and benefits for various Forms for intended application.

(To be continued in the next issue)

\* \* \*

**Form 4 type 7 gives maximum separation as terminals are external to functional unit compartment and enclosed in their own compartment by means of rigid barriers/partitions, complete with integral glanding facility.**



# Management antra

Never become irreplaceable.  
If you do,  
you become unpromotable.

If you and I always agree,  
one of us is unnecessary.

When you criticize subordinates,  
they may do better because  
they "have to".  
When you praise,  
they do better because  
they "want to".

One of the biggest complaint employees  
have about their managers is  
lack of appreciation for what they do.

Never discuss one employee's shortcoming  
with other staffers.  
Once you get the reputation as a "Loose Lip",  
you have lost all trust and confidence.

The ultimate diplomacy is  
the ability to tell the boss  
that he or she is mistaken.

Practising things does not make you perfect,  
if you are practising the wrong things.

The best way to receive loyalty  
is to give it.

The people who report to you  
are far more important to future  
than the people you report to.  
Those reporting to will push you up  
with their outstanding performance.  
Those above you will not pull you up  
if the performance is substandard.

Courtesy:  
Rajiv Khurana, Management Consultant

## MOVING ?

IN CASE YOU ARE PLANNING TO MOVE PLEASE SEND US YOUR  
NEW ADDRESS AS SOON AS YOU MOVE TO THE  
NEW LOCATION, SO THAT OUR 'CURRENT WAVES' FOLLOWS YOU.

PLEASE INTIMATE THE EDITOR  
THANK YOU!

## AN INTERVIEW WITH GOD

"Come in," God said, "So you would like to interview Me?"

"If you have the time" the interviewer says.

God smiled and said, "My time is eternity and is enough to do everything. What questions do you have in mind to ask me?"

"What surprises you most about the mankind?"

God answered:

"That they get bored with being children, are in a rush to grow up, and then long to be children again. That they lose their health to make money and then lose their money to restore their health. That by thinking anxiously about their future, they forget the present, such that they live neither for the present nor for the future. That they live as if they will never die, and they die as if they never lived.

The interviewer then asked, "As a parent, what are some of life's lessons you want your children to learn?"

God replied with a smile:

"To learn that they cannot make anyone love them, what they can do is to let themselves be loved.

To learn that what is most valuable is not what they have in their lives, but who they have in their lives.

To learn that it is not good to compare themselves with others.

To learn that a rich person is not the one who has the most but is one who needs the least.

To learn that it only takes a few seconds to open profound wounds in persons we love, and that it takes many years to heal them.

To learn that there are persons who love them dearly, but simply do not know how to express or show their feelings.

To learn that money can buy everything but happiness.

To learn that two people can look at the same thing and see it totally differently.

To learn that it is not always enough that they be forgiven by others, but that they have to forgive themselves.

To learn that a true friend is someone who knows everything about them and likes them anyway.

The interviewer sat there for a while enjoying the moment. He thanked Him for His time and for all that He has done for him and his family.

God replied, "I am here twenty four hours a day. All you have to do is to ask for me and I will answer".

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# POTPOURRI PAGE

There was a farmer who raised watermelons. He was disturbed by some local kids who would sneak into his watermelon patch at night and eat watermelons. After some careful thought he came up with a clever idea that he thought would scare the kids away for sure. So he made up the sign and posted it in the field. The next day the kids show up and they see this sign, it says "Warning!! One of the watermelons in this field has been injected with cyanide."

So the kids run off, make up their own sign and post it next to the sign that the farmer made. The farmer shows up the next week and when he looks over the field he notices that no watermelons are missing but he notices a new sign next to his. He drives up to the sign which read: "Now there are two".

\*

Three guys are fishing in the Caribbean. One guy says, "I had a terrible fire; lost everything. Now the insurance company is paying for everything and that's why I'm here."

The second guy says, "I had a terrible explosion; lost everything. Now the insurance company is paying for everything and that's why I'm here."

The third guy says, "What a coincidence. I had a terrible flood; lost everything. Now the insurance company is paying for everything and that's why I'm here."

The other two guys turned to him with confusion and asked, "Flood? How do you start a flood?"

\*

Donald MacDonald from the Isle of Skye was admitted to Oxford University, and was now living in his first year of residence there. His clan was very excited that one of their own had made it into the upper class of education, but were concerned how he'd do in "that strange land." After the first month, his mother came to visit, with reinforcements of whiskey and oatmeal.

"And how do you find the English students, Donald?" she asked.

"Oh, Mother," he replied, shaking his head sadly, "they're such terrible, noisy people: The one on that side keeps banging his head against the wall, and won't stop; and the one on the other side screams and screams and screams away into the night."

"But Donald! How do you manage with those dreadful noisy English neighbours?"

"Well, mother, I just ignore them. I just stay here quietly, playing my bagpipes..."

\*

The doorbell rang and the lady of the house discovered a workman, complete with tool chest, on the front porch.

"Madam," he announced, "I'm the piano tuner."

The lady exclaimed, "Why, I didn't send for a piano tuner."

The man replied, "I know you didn't, but your neighbors did."

\*

An artist asked the gallery owner if there had been any interest in his paintings on display at that time.

"I have good news and bad news," the owner replied.

"The good news is that a gentleman enquired about your work and wondered if it would appreciate in value after your death. When I told him it would, he bought all 15 of your paintings."

"That's wonderful," the artist exclaimed. "What's the bad news?"

"The guy was your doctor..."

\*

Mr Goldberg, from Pinsk, coming to America, shared a table in the ship's dining room with a Frenchman. Mr Goldberg could speak neither French nor English; the Frenchman could speak neither Russian nor Yiddish.

The first day out, the Frenchman approached the table, bowed and said, "Bon appétit!"

Goldberg, puzzled for a moment, bowed back and replied "Goldberg."

Every day, at every meal, the same routine occurred.

On the fifth day, another passenger took Goldberg aside.

"Listen, the Frenchman isn't telling you his name. He's saying 'Good Appetite,' that's what 'Bon appétit!' Means."

At the next meal, Mr Goldberg, beaming, bowed to the Frenchman and said, "Bon appétit!".

And the Frenchman, beaming, replied: "Goldberg!"

\*

NASA was interviewing professionals to be sent to Mars. Only one could go and couldn't return to Earth.

The first applicant, an engineer, was asked how much he wanted to be paid for going. "A million dollars," he answered, "because I want to donate it to M.I.T."

The next applicant, a doctor, was asked the same question. He asked for \$2 million. "I want to give a million to my family," he explained, "and leave the other million for the advancement of medical research."

The last applicant was a lawyer. When asked how much money he wanted, he whispered in the interviewer's ear, "Three million dollars."

"Why so much more than the others?" asked the interviewer.

The lawyer replied, "If you give me \$3 million, I'll give you \$1 million, I'll keep \$1 million, and we'll send the engineer to Mars."

\*



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