25th August, 2016 – Tech Day, Nairobi, Kenya

ABB
High Voltage Product Portfolio
CONTENTS

- ABB’s Divisions and PGHV
- Key Facts – BU PGHV
- High Voltage Products offering – Broadest range in the industry
- PGHV in India
- Technology Innovation and design features – CB / IT and DS.
- Manufacturing with special facilities & Quality.
# ABB - Divisions

PGHV – Part of Power Grids Division of ABB

<table>
<thead>
<tr>
<th>Power &amp; Automation</th>
<th>Utilities</th>
<th>Industry</th>
<th>Transport &amp; Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power Grids (new)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#1 T&amp;D offering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market and technology leader</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global reach</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Largest installed base</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Power & Automation “for the grid”**

**Electrification Products (new)**
A leading player for LV and MV electrification

**Discrete Automation and Motion**
#1 in industrial motion, a leading robotics player

**Process Automation**
#1 in DCS, leading in process industries, marine

**Power & Automation “for the site”**

---

August 26, 2016
Key facts
High Voltage Products (BU PGHV)

- Leading global player in high-voltage products – applications from 66 kV to 1200 kV, AC and DC
- 35 manufacturing locations worldwide
- About 8000 employees
- Sales support in over 100 countries
- Installations across the world including in extreme and harsh environments –
  - Temperature range from -60 °C to +55 °C
- Product certifications as per a wide range of international standards like IEC, ANSI/IEEE, GB or GOST
At the forefront of technology leadership
High Voltage Products

World Firsts

- Gas-insulated switchgear - 1967
- Disconnecting circuit-breaker (DCB) in 2000; DCB with Fiber-optic-current-sensor - 2013
- Generator circuit breakers with highest short circuit breaking capacity of 300 kA – 2012
- Cryogenic SF₆ gas recycling technology SF₆ gas purified up to 99.9% -2012
- Enhancing eco-efficiency with alternatives to SF₆ gas, developed in-
  - High- voltage circuit breaker on CO₂ platform - 2012
  - GIS with new eco-efficient gas mixture - 2014
UHV AC & DC transmission – Technology edge
High Voltage Products

- **1200 kV Hybrid GIS**
  - **India**

- **1100 kV AC GIS**
  - **China**

- **1100 kV DC**
  - **Bypass breaker**

- **1100 kV DC Coupling Capacitor & Surge Arrester**
Enabling digital grids
High Voltage Products

- Integrated primary equipment
  - Compact, modular with integrated functionality-making, measuring, disconnecting, earthing switches

- Advanced Sensors
  - Non-conventional transducers e.g. for Current, Partial Discharge (PD), SF6 with digital substation compatibility

- Integrated control cubicles and equipment monitoring
  - Control and monitoring with seamless integration in digital automation systems

Integrated Solutions – digital grid enabled
Life cycle approach to eco-efficiency
High Voltage Products

High Voltage Products from ABB – Designed to enhance eco-efficiency over the life cycle

Research and development
Alternatives to switching and insulation medium SF6 and oil e.g. new gas mixture for GIS, dry capacitors and cable terminations

Product design and manufacturing
Reduced space, material, and SF6 gas
Energy efficient manufacturing

Product operations and disposal
Reduced thermal and resistive losses
Eco-efficient disposal processes

SF6 gas management
On-line monitoring, reduced leakages, end-of-life recycling
Solutions for wide range of power quality issues
High and low voltage products and solutions

Benefits of having good Power Quality

- Reduction of system losses
- Enhanced equipment life
- Compliance with utility regulations
- Increased production efficiency
- Enhancing eco-efficiency

Resulting in lower running costs and down-time
Well positioned across the value chain
High Voltage Products

Enhancing power reliability, efficiency and quality
ABB’s high voltage products – global footprint
Factories and service centers

- Factories - 44
- Service Centers - 26
Local Business Unit – High Voltage Product

- Footprint

- HV breakers,
- HV Instrument Transformers
- HV Disconnector
- HV Services
- PASS/GIS

- Capacitor

Source: Internal
ABB in India
1.3+ BUSD in revenues, 9000+ employees

ABB in India is the 7th largest contributor to the group business volumes

Note: the revenue figures are that of 2016
1USD=64.14 Indian rupees
Strong local presence across the subcontinent
12 manufacturing locations, 22 sales and branch offices
ABB’s High Voltage Products
Innovation is key differentiator

Examples

- Cost optimization
- Smaller product footprint
- Green portfolio
- Intelligent products
- Higher voltages

- 1200 kV hybrid GIS
- DCB for Smart Grid application
- Dry Capacitor technology
CIRCUIT BREAKERS

CONTENT OVERVIEW

- Circuit Breaker Evolution & Portfolio
- Circuit Breaker Reliability- CIGRE Report
- Technology Evolution- Interrupter & operating mechanism
- Design Features, Innovations and advantages
History
Circuit breaker development

Example: 420 kV

Air Blast  ...around 1960
Oil Minimum  ...around 1980
SF6 Gas  ...today’s technology
Product Portfolio
Circuit breakers for all applications

Standard applications
- Overhead lines
- Transformers
- Capacitor banks
- Harmonic filters
- Shunt reactors
- HVDC Systems

Special applications
- "Tailor made" solutions

ABB Breakers can meet all Customer Needs
Live Tank Breaker Portfolio - ABB

* Ratings valid at -30°C and 50Hz.

- ED
- LTB D1
- LTB D1
- LTB E1
- LTB E1
- LTB E2
- HPL B1
- HPL B2
- HPL B2 w/o CAP
- HPL B4
- LTB E4 (BLG)
- Test CB

[kA] vs [kV]
CIGRÉ: Surveys of circuit breaker reliability

- First survey
  - Service data collected 1974—77
  - 79000 breaker years of service
  - All types of breakers

- Second survey
  - Service data collected 1988—91
  - About 75000 breaker years
  - Single pressure type of SF6-breakers
  - Also GIS surveys took place

- Third survey
  - Service data collected 2004—07
  - 281090 SF6-breaker years and around 15000 failures recorded
  - Most comprehensive reliability data
Cigre : Reference documents

International Enquiry on Reliability of High
Voltage Equipment

Part 1 - Summary and General Matters

Working Group
A3.06

International Enquiry on Reliability of High
Voltage Equipment

Part 2 - Reliability of High Voltage
SF6 Circuit Breakers

Working Group
A3.06
Cigre: Main sources for major & minor failure rate

Figure 2-47: Distribution of CB MiF per component responsible

Figure 2-48: Distribution of CB MaF per component responsible
Cigre: Reasons for major & minor failure rates

Figure 2-43: Distribution of CB MIF per failure mode

- No answer: 35.6%
- Air or oil leakage in operating mechanism: 20.3%
- Small SF6 leakage: 14.2%
- Oil leakage of grading capacitors: 18.3%
- Change in mechanical functional character: 3.3%
- Change in electrical functional character: 6.8%
- Change in character of control or auxiliary systems: 1.0%
- Other: 0.4%

Figure 2-44: Distribution of CB MaF per failure mode

- Does not close on command: 25.1%
- Does not open on command: 28.2%
- Opens without command: 16.4%
- Locking in open or close position: 5.4%
- Loss of mechanical integrity: 8.1%
- Others (including Breakdowns): 16.8%

© ABB Group
August 26, 2016 | Slide 23
Conclusion of Survey

FACTS

- Operating mechanisms are responsible for almost all major and minor failure
- SF6 gas leakage is the second problem after operating mechanism.
- Major or minor failure because of interrupter is negligible.

Direction of CB development

- Interrupter chamber should be very energy efficient
  - Use of simpler and less mechanically stressed operating mechanism
- SF6 gas leakage should be minimized by inherent strong design.
ABB : CB Interrupter & Operating Mechanisms. Technology Evolution
Operating Mech:
Energy Level Evolution

- BLG for 420kV: 6000J
- FSA for 72.5kV: 780J
- FSA for 145kV: 800J
- MSD1 for 245kV: 1200J

STORED ENERGY 50%
Technology Evolution - Interrupter (Self Blast)

- Single Motion Self Blast
- Double Motion Self Blast
  - 50-60% reduction in operating energy
  - Simpler, reliable drive
- Full Double Motion Self Blast
  - 50% reduction in operating energy
  - Significant reduction in break time
Interrupters
Interrupter design – LTB and HPL

For all interrupters we use a well proven and simple design:

- Unique patented copper tube design
- Integrated contact fingers
- Low resistance in main contacts
- Extremely few parts
- Gives high reliability and switching capability
Interruptors

Why we chose it?

- Simplicity of design creates robust long term performance and strong switching capability
- Supports productivity and fast manufacturing & high quality control
- Stronger design remove need for much monitoring of chamber parts during electrical life of equipment
IN - Interrupters factory
Quality Process: Flow Chart

1. Supplier Selection and audit
   - OK?
     - Y: Comp. Development
     - N: Search for another supplier

2. Comp. Development
3. Approval from TLC (OTS)

4. Globally approved comp. and supplier

5. Component Development
6. Regular Production
7. Sustainable Quality

8. Quality Process: Flow Chart
   - In process Quality Check
   - 4-Q/8-D analysis
   - Customer Complaint through CCRP
   - Installation of equipment

9. Final Inspection
10. Routine testing
11. Routine Testing
12. In process Quality Check

13. Incoming Inspection
14. Production
15. M2+ testing
16. Failure

17. Analyze failure
18. Conclude
19. Product Revision
20. M2 test
21. Change Design/Improve Quality

22. Sustainable Quality
IN - Interrupters factory

View from Mezzanine floor

Factory Gallery

145kV Cut-out Model
IN - Interrupter factory

Ultrasonic M/c

Roller Conveyor

CMM
Interrupter Factory
Gas system
Optimized sealing systems

The optimized and well proven design provides

- Minimized leakage: Less than 0.5% per year. Suits latest env. regulations
- Efficient sealing even under extreme conditions: -50 up to +55 °C

Benefits

- Long Service Life of Many years before any filling may be required. Depending upon operations normally no filling needed during the service life
- Environmental friendly
New Reliable Gas Distribution System
72.5kV & 145kV Breakers

- 2 joints eliminated
- 1 Gas pipe eliminated
- Distribution block eliminated
Operational Performance
ABB Circuit breakers – Performance in Varied climate conditions

- ABB Live tank circuit breakers are operating in installations with
  - Extreme temperatures (-50 to + 55° C)
  - High seismic withstand (≤0.5g) horizontal & vertical accelerations
  - High pollution levels
  - Extended tested for High altitude Operations – Creating Value
  - Operation in 100% humid environments
  - In High Temperature Desert Areas

EDF breaker at s/s in Switzerland with polymeric insulators

EDF breaker at s/s in Alberta, Canada in extreme low temperature conditions
Technology Innovation
Composite insulators (Silicone rubber)

ABB live tank circuit breakers can be delivered with composite insulators

- Flashover resistant
  - Hydrophobic insulator surface; water stays as droplets and suppresses leakage currents
- Ageing withstand
  - Unaffected by natural UV-light
  - Reduces the risk for breakdown as compared to EP rubber and epoxy material
  - Proven withstand from field test installations
- Low mass

Benefits
- Increased personnel safety
- Improved insulating properties
Technology Innovation - Controlled switching
Switchsync™

Switchsync™

 Eliminates transients

Reduces switching transients in the sub-station and the system
Controlled switching is a method for eliminating harmful transients via time controlled switching operations. Closing or opening commands to the circuit breaker are delayed in such a way that making or contact separation will occur at the optimum time instant related to the phase angle.

All applications
- Capacitor banks, filter banks
- Shunt reactors
- No-load transformers
- No-load transmission lines

Benefits
- Longer life of the equipment
- Improves power quality
Instrument Transformers

Application

Fault in the Power System

Sensed by Instrument Transformers & communicated to Relay

Relay Issues Trip Command To Breaker

Breaker Trips & Clears Fault

Brain - Relay

Eyes, Ears, Nose & Skin - CTs, CVTs, VTs

Hands & Legs - Circuit Breakers
Instrument Transformers
Application
Instrument Transformers

Application

The main Tasks of Instrument Transformer are:

- To transform current and voltages from usually high to a value easy to handle for relays and meters.
- To insulate metering circuit from primary high voltage system.
- To provide possibilities of standardizing the meters and relays to few rated currents and voltages.

Instrument Transformers are a special type of transformers.
Instrument Transformers
Reliable Instrument Transformers up to 800 kV

- Current Transformers, Type IMB up to 800 kV
- Capacitor Voltage Transformers, mixed dielectric type CPB up to 800 kV
- Coupling Capacitors up to 245 kV
- Grading capacitors

Long experience and reliable products
Reliable products reduce the lifetime costs

Used by Circuit Breaker manufacturers
ABB IT Manufacturing facilities

ABB Ludvika
Sweden
Product Range
72-800 kV oil CT
72-800 kV oil CVT
72-170 kV oil IVT

ABB Przasnysz
Poland
Product Range
123 kV oil CT top-core
123 kV oil IVT
123-145 kV combined CT/VT

ABB Ekaterinenburg
Russia
Product Range
72-145 kV SF6 CT

ABB Baroda
India
Product Range
72-800 kV oil CT
72-800 kV oil CVT

ABB Kuhlman, Crystal Springs
US
Product Range
72-170 kV oil CT top core
72-123 kV oil IVT
34.5-345 kV oil SSVT

ABB Lodi
Italy
Product Range
72-800 kV SF6 CT
72-420 kV SF6 IVT
72-245 kV SF6 CT/VT
72-420 SF6 SSVT

ABB Przasnysz
Poland
Product Range
123 kV oil CT top-core
123 kV oil IVT
123-145 kV combined CT/VT

ABB Ludvika
Sweden
Product Range
72-800 kV oil CT
72-800 kV oil CVT
72-170 kV oil IVT

ABB Przasnysz
Poland
Product Range
123 kV oil CT top-core
123 kV oil IVT
123-145 kV combined CT/VT

ABB Ekaterinenburg
Russia
Product Range
72-145 kV SF6 CT

ABB Baroda
India
Product Range
72-800 kV oil CT
72-800 kV oil CVT

ABB Kuhlman, Crystal Springs
US
Product Range
72-170 kV oil CT top core
72-123 kV oil IVT
34.5-345 kV oil SSVT

ABB Lodi
Italy
Product Range
72-800 kV SF6 CT
72-420 kV SF6 IVT
72-245 kV SF6 CT/VT
72-420 SF6 SSVT

ABB

Oil-insulated Instrument Transformers:
3 CT designs, 72-800 kV
2 CVT designs, 72-800 kV
3 IVT designs, 72-170 kV
1 Combined CT/VT design 123-145 kV
1 SSVT design 34.5 kV-345kV

SF6 Instrument Transformers
1 CT design 72-800 kV
1 IVT design 72-245kV
1 Combined CT/VT design 72-245
1 SSVT design 72-420 kV
Current Transformers

Product Range

Insulator - Porcelain/Polymer – 31mm/kV creepage max

- 66kV/132kV
- 220kV
- 400kV
- 765kV

- 63kA/1s
- 50kA/3s
- 40kA/3s

Up to 4000A x 100%
Up to 3000A x 100%
Up to 3000A x 100%

© ABB Group
August 26, 2016 | Slide 45
Current Transformers
IMB – Refined for decades

- The most sold current transformer in the world, more than 170,000 units are installed all over the world, from desert to arctic climates
- Improved in several generations during more than 65 years
- A reliable product with no need for regular maintenance

Long experience, rich inheritance and reliable products

Reliable products reduce the lifetime costs

© ABB Group
August 26, 2016 | Slide 46
Current Transformers
Constructional features

1. Expansion Tank
2. Nitrogen gas cushion
3. Oil
4. Primary Terminal
5. Primary Flange
6. Insulator
7. Insulated primary conductor
8. Secondary cores with winding
9. Secondary terminal box
10. Bottom Tank

Hair pin type Dead Tank CT
Robust and proven design
Current Transformers
Design Advantages

Quartz Filling
- Embedding active parts in quartz gives advantage to CT for withstanding strong vibrations during transportation and earthquake and provide excellent dynamic strength during short circuit fault.
- Being a bad conductor of heat, rapid heating and cooling is avoided, hence eliminates possibility of gas bubble formation.
- Quartz being hygroscopic in nature absorbs the remenant moisture from oil thus improves the quality of oil.

Reliable Expansion system
- Dry N2 gas without moving parts, No maintenance.
- Minimum 15% gas compared to oil.
- All O rings and gaskets under oil which ensures better gasket life and leak detection.
- SS Bellows with top sealing for higher currents.

Optimized primary design
- Primary conductor is hollow Aluminium tube and facilitates heat dissipation by oil circulation through tube by thermocyclic effect.
- Above design avoids thermal ageing of main insulation and thus CT has very good thermal stability.
- Graded and automated insulation improves quality and minimises variations.

Seismic Aspects
- Low Centre of gravity.
- Heavy cores in bottom tank and will not stress insulators.
- Quartz embedded active part.
- Bottom tank acts as a part of support.

We have flexible solutions and offer custom made products by optimizing best technology and economy.
Current Transformers
Comparison between Dead Tank and Live tank CT
Current Transformers
Comparison between Dead Tank and Live tank CT
Seismic aspects-IMB

Center of gravity

Ease of handling

Reduce the costs for supports

Excellent seismic performance due to lower CG
Current Transformers
Comparison between Dead Tank and Live tank CT

**Insulation**

**Dead Tank Type CT**
- Simple and controlled wrapping of primary winding
- Automated insulation technique
- Improves quality and minimizes variations

**Live Tank Type CT**
- Manual or semi-automated insulation
- Complex and demanding wrapping
- Manual works----May cause variations in insulation
  Implies quality risks

**Stress distribution**

**Stress distribution**

**High Voltage**

**Earth**

**Capacitive grading (semiconductor)**

**Steep wave**

[Image of Dead Tank Type CT]

[Image of Live Tank Type CT]
Current Transformers
Comparison between Dead Tank and Live tank CT

Dead Tank Type CT
Heat from secondary is dissipated in surrounding oil.
Heavy weight cores are free resting on support

Live Tank Type CT
Heat from secondary windings is dissipated through main insulation causing faster thermal ageing.
Heavy core weight is borne by main insulation
Current Transformers
High quality production process

- Pressurized air system has been established that leads to a dust free environment in the shop floor.
- The insulation is dried in ovens at high temperature and vacuum to remove moisture. A SCADA system has been set up for precise control and monitoring of the oven. Efficient drying ensures reduced tan delta and enhances life of product.
- After drying CTs are connected to Oil Filling system, where the CTs go through evacuation by applying vacuum to ensure that there is no moisture or trapped gases in CT. The vacuum level of 0.15 pascal is checked on individual CTs.
- After oil filling (at 65°C and vacuum) the CTs are subjected pressurized impregnation at 1.6-1.8 kg/cm². Thus ABB CTs experience high vacuum and positive pressure during process which proves leak free CTs and suitability of components and robust sealing design.
Current Transformers
Automated Winding Machines

- Unique automated insulation technique improves quality and minimizes variations, reduces dimensions and increases voltage withstand.
- Primary insulation room is dust free (to ensure PD free insulation) and has temperature controlled environment (to get required quality of winding)
- The supplier for critical raw material such as crepe paper and aluminium foil are single source for all ABB factories globally
- Proven insulation design over years throughout all ABB factories with skilled and certified workmen and stringent quality norms.
Current Transformers
Success stories

- Recently ABB has supplied 400kV_4000A CTs to KETRACO, Kenya in 2015.
- ABB has supplied 400kV_4000A CTs with TPY core for HVDC project NE Agra.
- ABB has supplied > 200 nos of 800kV_4000A CTs various sites of Power grid and others.
- IMB type transformers are most sold and more that 170000 units are delivered all over world.
- ABB Sweden is certified supplier to Russia with ambient of – 60°C
- ABB Sweden have supplied huge number of 800kV_4000A CTs with TPY cores to Hydro quebec Canada.
- ABB Sweden have supplied and installed huge number of IMB CTs in South America with very high altitude.
- ABB is homologated supplier to Power grid, NTPC, GETCO in India and ABB Sweden to many big utilities like Russian national grid, National grid in UK, ENEL, TRENNA in Italy and TENNET in Germany.
Capacitor Voltage Transformer

Long experience

- Produced in different generations since the early 50’s
- Mixed dielectric, since more than 25 years. Possible to use our CVTs for high accuracy metering

1955 2005 2014

Long experience and reliable products
Capacitor Voltage Transformer - Construction

Primary terminal

CVD with Synthetic oil

EMU

Terminal Box

H F Bushing
Capacitor Voltage Transformer
Design features

Voltage Range: 72 - 800 kV
High voltage capacitor
- High or extra high capacitance
- Metal Bellow used for oil volume compensation
- ABB type mixed dielectric:
  - 1 paper & 2 poly-propylene-film
  - Synthetic oil in CVD and mineral oil in EMU

Advantages
- Better PLCC performance
  - Wider bandwidth
- Insensitive to temperature variations
  - High accuracy stability
  - Accuracy maintained for all service conditions
- Solder free design

High accuracy at all service conditions
Reduce the risk to lose money at revenue metering
Capacitor Voltage Transformer
Advantages of synthetic oil over mineral oil

- Very low viscosity for better impregnation
- Very high breakdown voltage sustained for life time
- Very low pour point, hence suitable for low temperature
- Low loss angle
- High volume resistivity
Capacitor Voltage Transformer
EMU

Electro Magnetic Unit (EMU)

- High intermediate voltage - 20/√3 kV or 24/√3 kV
  - Better transient response
- Active Ferro-resonance damping circuit
  - L-C-R circuit
- Accuracy
  - Quality winding and proper tuning facilitates maintaining accuracy
Capacitor Voltage Transformers
Automated Winding Machine

- We know that, to be able to produce world class products, personnel and machinery of production have to be world class.
- Our workshop has the most modern machinery and process equipment. These are often tailor made in order to satisfy the high demands of our customers.
- Coil winding room is class 10000 with automatic dry coil testing facility.

Modern factory
High quality
Capacitor Voltage Transformers
Comparison between EMVT and CVT

1. Modular construction
   Easy to transport, handle and erect

2. Can be used as coupling capacitor for PLCC

3. All CVTs are provided with FR damping circuit

4. Uniform electrical stress distribution thus more reliable design

1. Single & bulky unit

2. Communication application is not available

3. EMVTs experience resonance with grading capacitors provided with CB which create permanent resonance and this can lead to failure.

4. Non uniform electrical stress distribution due to inter turn & interlayer capacitance
Non conventional Instrument Transformer
SSVT- Oil Filled Station Service Voltage Transformer

Combines oil-filled dielectric structure of HV Inductive VT with distribution transformer power ratings
Can supply 600 volt class output with up to 333kVA power rating for electrical panel within control room
Conveniently sited within substation to provide substation control power directly from the HV transmission bus
Used in North America since late 1980s with ratings up to 245kV
Confirming to IEC & IEEE
Non conventional Instrument Transformer
SSVT- Oil Filled Station Service Voltage Transformer

Reasons to use SSVT

- Auxiliary power for substation - Used in lieu of main transformer MV tertiary - lower energy losses and power quality control
- In switching stations where MV not available
- Eliminates need to buy control power from outside
- Cost effective, reliable source of power
- Community Electrification - areas with no distribution infrastructure
- Remote Sites - cell towers, pumping stations, mining & Construction
Non conventional Instrument Transformer
FOCS- Fiber Optic Current sensor

- Optical fiber replaces tons of conventional equipment
- Zero footprint capability
- True image of primary current (no magnetic saturation, large bandwidth)
- Inherent galvanic isolation of electronics from high-voltage
- Intrinsically safe
- Digital communication
- ABB’s FOCS achieves 0.2% accuracy in outdoor temperature range (appropriate sensing fiber packaging, intrinsic temperature compensation of Faraday effect)
- Field data over 3 years show stable performance within metering accuracy
- Superior behavior at faults with DC components
Instrument Transformers
Focus on Environmental Aspects

- All metal parts recyclable and re-usable
- Biodegradable mineral oil and minimized oil content
- Strict adherence to non use of restricted/banned material from environment, health and safety concern
- Certified according to
  - ISO 9001
  - ISO 14001
  - OHSAS 18001
Disconnectors – Critical Component of S/S Availability
Disconnectors in a Substation

IEV 441-14-05: A mechanical switching device which provides, in the open position, an isolating distance in accordance with specified requirements
Why are disconnectors required?

Historically, bays were designed to make it possible to isolate the circuit breaker for maintenance

- The basis was that circuit breakers demanded more maintenance than disconnectors
- Typical maintenance intervals for old circuit breakers 1-2 years and for disconnectors 4-5 years
- To avoid total outage of the busbar during disconnector maintenance a second busbar was used

The above assumptions are no longer valid

Modern circuit breakers require less maintenance than disconnectors with open contacts
DS – User’s Expectation: Reliability with Min. Maintenance

- Operates smoothly & consistently when command is given
- Consistent Main Circuit Resistance (mV drop) over life. Less losses.
- Short time current withstand capacity with some min. current carrying capability
- Minimum maintenance during Lifetime
  - Good lubricating system
  - Synthetic and dry lubrication
- Retains isolating properties
  - Links do not get disturbed
  - Permanent adjustments
- Good seismic withstand capability
- Constructional flexibility to suit various layouts & spaces in the s/s
Reality & Consequences

- Unable to carry rated current due to deterioration of current carrying path
- Unable to close or open (correctly) due to deterioration of linkages etc.
- Failure of interlocks due to auxiliary switch malfunction
- Failure of electrical circuits due to poor enclosure.
- Failure to withstand seismic forces.
- Mechanical failures when installed in special layouts

Grid collapse
- Unable to (close) energize circuit.
- More downtime for maintenance
- Spare inventory
- Unsafe operation
- Unable to isolate (open) the circuit.

Severe threat to safety
Loss of revenue
WHY DOES IT HAPPEN?

- Jamming of rotary pedestal/linkages
- Change/shift in the setting of disconnector.
- Mechanical breakage/damage of contacts and mating parts
- Hot spots are formed on contact and terminal pads
- Rusting of cabinets. Jamming of door hinges.
- Malfunctioning of Aux. Switches
- All linkages/ bearing assembly require frequent/periodic greasing
- Setting of limit switches change after some operation and require re-adjustment to have proper operation of disconnector.
**PGHV B&M – Disconnectors**

**Product Portfolio**

<table>
<thead>
<tr>
<th></th>
<th>SDF</th>
<th>eDB</th>
<th>GW54</th>
<th>GW57</th>
<th>DSSP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>72-550kV</td>
<td>72-420kV</td>
<td>123-550kV</td>
<td>245-550kV</td>
<td>123-245kV</td>
</tr>
<tr>
<td></td>
<td>4000A, 50kA</td>
<td>3150A, 50kA</td>
<td>5000A, 63kA</td>
<td>4000A, 63kA</td>
<td>4000A, 50kA</td>
</tr>
<tr>
<td></td>
<td>Center Break</td>
<td>Double Break</td>
<td>Pantograph</td>
<td>Horizontal Knee</td>
<td>Semi-Pantograph</td>
</tr>
</tbody>
</table>

**Remarks:** Higher ratings on request

DISC with / without earthing switch
Motor or manual drive mechanism
Stand-alone earthing switch

(*) CN local portfolio, center break (GW55) and double break (GW56)
(**) BG Local portfolio – centre break (NSA) and Double Break (NRB)
PGHV B&M – Disconnectors
Footprint

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB</td>
<td>Center Break</td>
</tr>
<tr>
<td>DB</td>
<td>Double Break</td>
</tr>
<tr>
<td>PA</td>
<td>Pantograph</td>
</tr>
<tr>
<td>HK</td>
<td>Horizontal Knee</td>
</tr>
<tr>
<td>SP</td>
<td>Semi-Pantograph</td>
</tr>
<tr>
<td>VB</td>
<td>Vertical Break</td>
</tr>
</tbody>
</table>

ABB China
Beijing
Product Range
123-550kV CB-DISC
245-550kV HK-DISC
123-245kV SP-DISC

ABB Egypt
Cairo
Product Range
72-245kV CB-DISC

ABB India
Vadodara
Product Range
72-550kV CB-DISC
72-420kV DB-DISC

ABB Bulgaria
Sevlievo
Product Range
72-550kV CB-DISC
≤ 52 kV DB-DISC **

ABB Russia,
Ekaterinberg
Product Range
123-245kV CB-DISC

ABB Russia,
Ekaterinberg
Product Range
123-550kV PA-DISC
245-550kV HK-DISC
123-245kV SP-DISC
Contact alignment is essential to avoid undue mechanical & thermal stress & create long term reliability.

Only Cylindrical form can give

**Absolute Rotational Alignment**
Special Features
Spring Less Main Contacts - High contact reliability

- No Separate springs
  - No rusting/corrosion
  - No loose positions. Min. components & maint.
  - Consistent Contact resistance over long periods.

[Diagram showing springless contacts vs. traditional contacts with springs]
Special Features
Terminal Head – Weather proof & Robust

- Tulip contacts protected from outdoor conditions
- Graphite and synthetic material bearings used for lifelong performance
- Synthetic contact grease used for enduring lubrication
Special Features
Turn Tables – Maintenance Free Design

- Turn table bearings protected from environment
- Two stainless steel bearings for reliable rotary movement and reduced friction
- High temperature stable grease used for lubrication. Lifetime lubrication. Virtually no maintenance
Special Features
Links & End Fittings

- Several Conventional designs use bushes or no bushes at all. This leads to metal to metal contacts that need regular maintenance.
- During the operation, three dimensional freedom not achieved and could lead to additional friction and deformation of parts.
- This could also lead to galvanic corrosion.
Special Features - Solution
Links – Frictionless joints , Maintenance free

- Use of insulated rod end spherical stainless steel bearings give
  - Protection to galvanic corrosion
  - Three dimensional flexibility in movement
  - Giving reduced friction through the life

Bearing after 10 years in field
Special Features
Drive Type MD80 – Common to SDF & eDB

- All mounting nuts & bolts are of non corrosive material
- Aux. Switches are suitable for SCADA applications and can be changed from NO to NC and vice-versa even at site.
- AL. cabinet and powder coated with Polyurethane paints -gives lasting protection to corrosion.
- Stainless steel door hinges does not allow door jamming even after many years.
- In built safety mech. safety release as standard feature – main arms cannot rotate more than 90 degrees in manual or motorized mode
Special Features
Dead Center Locking – High Seismic withstand

Disconnected -- Close
Dead center position -- 1

Disconnected -- Open
Dead center position -- 2
Special Features

Constructional Flexibility - Any side mounting of drives and ES
Special Features
Constructional Flexibility – Tandem Arrangements for Center Break to 245kV
Special Features
Constructional Flexibility – Vertical Mounting arrangements
Special Features
Constructional Flexibility - Integrated or Stand Alone Earth switches
Special Features
Constructional Flexibility – Modular Transport Assemblies
Special Installations
Proven quality & flexibility in Worldwide Installations

Isolator


245kV - Colombia

145KV - Bangladesh
Special Installations
Proven quality & flexibility in Worldwide Installations – Guatemala
Special Installations
Proven quality & flexibility in Extreme Environments

Disconnector with 3 drives on one phase – Reliable operation in minimum ambient temperatures upto – 40 C

SGF123n100+2E (TANDEM)
AT AL-ARCHA, Kyrgyzstan
ABB’s DS – Robust and Reliable Offerings
Strong solution to system availability

- Operates correctly consistently when command is given
- Gives consistent & less Main Circuit Resistance (mV drop) over lifetime
- Has good short time current withstand capacity
- Needs no Lubrication with permanent adjustments
- Strong seismic capability
- Provides adequate isolation during maintenance

ABB DS
RELIABLE solution
Saves Energy Time & Money!
The ABB Breakers & Module Evolution

- LTB
  - Circuit Breaker
  - Current Transformer
  - Disconnector
  - Earthing Switch
  - Voltage Transformer
- PASS
  - Circuit Breaker
  - Current Transformer
  - Disconnector
  - Earthing Switch
  - Voltage Transformer
- DCB
  - Circuit Breaker
  - Disconnector
  - Earthing Switch
- DTB
  - Circuit Breaker
  - Current Transformer
- GIS
  - Circuit Breaker
  - Current Transformer
  - Disconnector
  - Earthing Switch
  - Busbar / Bus ducts

Value

Functional Integration

GLOBAL 2014
3000 MUSD

LTB
- 39 000

DTB
- 8 000

PASS
- 2 500

DCB
- 500

GIS
- 1 500

- 850

- 550

- 100

3000 MUSD
Hybrid Switchgear PASS – ABB India Portfolio

<table>
<thead>
<tr>
<th>PASS M00</th>
<th>PASS M0</th>
<th>PASS M0S</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Voltage Voltage Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>72.5 kV 145 kV 245 kV</td>
</tr>
<tr>
<td>50 / 60 Hz 50 / 60 Hz 50 / 60 Hz</td>
</tr>
<tr>
<td>2500 A 3150 A 4000 A</td>
</tr>
<tr>
<td>31.5 KA 40 kA 50 kA</td>
</tr>
</tbody>
</table>
GIS - ABB India Portfolio

<table>
<thead>
<tr>
<th>Voltage (kV)</th>
<th>ELK-04 / 145S</th>
<th>ELK-14 / 245S</th>
<th>ELK-3 / 420C</th>
</tr>
</thead>
<tbody>
<tr>
<td>145 kV</td>
<td>3150 A</td>
<td>3150 A</td>
<td>5000 A</td>
</tr>
<tr>
<td>245 kV</td>
<td>40 kA</td>
<td>50 kA</td>
<td>63 kA</td>
</tr>
<tr>
<td>420 kV</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Surge Arresters

Available up to 800 kV for surge protection in LV, MV and HV networks
All voltage classes and surge ratings

Applications
- Indoor and outdoor substations and transmission lines
- High energy applications

Special features
- Polymeric housing for improved performance
High voltage capacitors and filters

Capacitor and harmonic filtering solutions up to 800 kV to improve the efficiency and reliability of utility and industrial networks.

Applications
- Reactive power compensation
- Improvement of asset utilization
- Reduction of network losses
- Compliance with grid regulations
- FACTS/HVDC

Special features
- Quality and technology leadership
- Products supported by application know-how
- Extensive portfolio coverage
Low voltage capacitors and filters

Capacitor units, banks and harmonic filters up to 1000 V to improve the efficiency and reliability of industrial and commercial networks.

Applications
- Automatic Power factor correction
- Harmonic filtering
- Load balancing
- Reactive power compensation
- Dynamic voltage support

Special features
- ‘Best in class’ functionality
- High level of reliability and safety
- Compliance with Power Quality regulations
Our Service Centers Network
26 Service Centers, 1000 Service Experts

Moorebank, Australia
Guarulhos, Brazil
Montreal, Canada
Santiago, Chile
Beijing, China
Bogota, Colombia
Helsinki, Finland
Paris, France
Mannheim, Germany
Vadodara, India
Lodi, Italy
Kuala Lumpur, Malaysia
San Luis Potosi, Mexico
Bergen, Norway
Lima, Peru
Cheboksary, Russia
Al-Khobar, Saudi Arabia
Gauteng, South Africa
Madrid, Spain
Ludvika, Sweden
Zurich, Switzerland
Kaohsiung, Taiwan
Bangkok, Thailand
Abu Dhabi, UAE
Stone, UK
Mount Pleasant, USA
HV Service facility
Vadodara

• **Installation and commissioning**
  Certified staff and on-site testing

• **Spare Parts**
  Current and legacy products

• **Maintenance and field services**
  Asset updates and remote service

• **Extension, Upgrades & Retrofit**
  Extension of legacy assets with state-of-the-art components,
  Upgrade of switchgear components with cutting-edge technology

• **Repair and refurbishment**
  On-site or factory repair

• **Power quality services**

• **Training and certification**
  In factories, on-site, on-line
Manufacturing with Special Facilities & Quality
We know that to be able to produce world class products, the personnel and machinery of production have to be the same.

Our workshop has the most modern processes and machinery. These are often tailor made in order to satisfy the high demands of our customers.
Local Business Unit – High Voltage Products
Manufacturing facilities in India

**Maneja, Vadodara**  
100 acres  
- HV Circuit Breakers  
- HV Inst. Transformers  
- HV Disconnectors  
- HV Services  
- Technology Centre  
- Training Centre

**Savli, Vadodara**  
30 acres  
- Gas Insulated Switchgear (GIS)  
- Plug and switch system (PASS)

**Peenya, Bangalore**  
18 acres  
- HV & LV Capacitors
Special Facilities : Mech. Test Lab. : Sustainable Quality
Testing for Reliability

- Mechanical Type Tests on the circuit breakers are performed
  - As a requirement of the standards for certification.
  - They are to be regularly performed on the equipments to improve the reliability.
- Such testing helps in improving quality of the product by identifying the deficiencies in the materials or the manufacturing processes.
Special Test Facilities - EHV Test laboratory
State-of-the-art equipment

Accredited by NABL

Laboratory equipped with
- Series Resonant Test System
- Impulse Voltage Test Set-up
- Facilities for wet tests

Tests that can be performed
- Power Frequency Voltage tests up to 700 kV
- Lightening Impulse Voltage tests up to 1600 kvp
- Switching Impulse voltage test
- Partial Discharge measurement
- Radio interference voltage (RIV) test
- Visible Corona test
- Capacitance measurement
- Dielectric dissipation factor ($\tan \delta$)
Technology Center, India
For High Voltage Products

Established in Dec’2010
- No of Resources – approx. 40
- R&D Spend ~ 4 MUSD
- 3~4 patents / year

Vision
- To be recognized as the model products development center which will help local and global business units in terms of creating value through technology and in full alignment with ABB Global culture

Strategy
- Development related to local mkt needs. Act as Technical lead center for such product/s.
- Increase contribution in international/global R&D projects
  - Serve other global PPHV TCs with key area (Simulation and design)
- Develop new Mechanical Lab
  - Enhance R&D activity
  - Product quality improvement
Training Centre
Maneja, Vadodara

- Hands on training for a wide range of Power products
- Customer training
- Internal / Employee training.
- Equipped with a live demo room and outdoor switchyard with equipment in operating condition
Quality and operational excellence
We share our global experience with you

We prove our reliability

- With successful product installations in all kind of harsh environments from -55 °C to +55 °C
- With product certifications according to a wide range of international standards like IEC, ANSI/IEEE, GOST, DL or GB
- With experience showing that many of our installations exceed the designed service life of 30 years
- For any issues claim through Customer Complaint Resolution Process (CCRP) available on www.abb.com
Local Business Unit – High Voltage Products

- Certifications – ISO 9001, 14001, OHSAS 18001
Well positioned across the value chain
High Voltage Products

Range of offerings across value chain

1. Gas- insulated switchgear
2. Air-insulated switchgear
3. Hybrid switchgear
4. Multifunction modules
5. Generator circuit breakers
6. Instrument transformers
7. Disconnectors
8. Surge arresters
9. Capacitors and filters
10. Power quality solutions
11. Water cooling systems
12. Cable accessories
13. Components e.g. operating mechanisms, insulators
14. Service across value chain

Enhancing power reliability, efficiency and quality
High Voltage Products

Why ABB

- ABB cares and strives to satisfy customer requirements.
- Long experience > 50 years, ABB HV equipment are installed in all climates all over world
- Safe and reliable products with complete range from 66kV to 765kV/1200kV class
- Optimum and well engineered Product customized to requirement
- Strong technical support from Global Technology Lead Centre (TLC) and local Technology Centre (TC). ABB can offer custom made solutions.
- Stringent quality control and NABL accredited laboratory for type and routine tests
- Modern manufacturing facility with trained, experience and skilled work force.
- Prompt after sales service
Power and productivity for a better world™