Meeting Minutes
Task Force to Study Shunt Reactor Switching Endurance for HVCB
October 17, 2018, Kansas City, MO

Revision: 1 (11/9/2018)

Chair – Sushil Shinde
Secretary – Roy Alexander

Introduction of members and guests

40 attendees present
14 members
26 guests

Discussion

1. Victor Hermosillo – Chopping number is based on the arcing window of the breaker and will be specified in range rather one single number. Which chopping number (corresponding to minimum arcing or maximum arcing time) is being requested in the survey?
2. Sushil Shinde – We would typically look for worst case so corresponding to the minimum arcing time would be ideal but we can even request the range for detail analysis of the chopping number relation to other parameters.
3. Arben Bufi – requested to add snubber circuit as a mitigation method.
4. Sushil Shinde – Yes, it will be added as a separate entry in the mitigation tab.
5. Carl Schuetz – Can we request users to include synchronous controller settings of their application?
6. Rich York – The controller setting is based on a particular breaker type and controller and this data would not be helpful in this survey. The settings are manufacturer design specific and are changed often based on the additional type testing and field feedback.
7. Sushil Shinde – Agree with both Carl & Rich. The controller setting field will be included in the survey. It won't hurt to collect this data, if users can provide such data and utility of this data will be decided after the survey analysis.
8. John Hall – Can we include type of operating mechanisms being used on a switching device in the application for this survey?
9. Sushil Shinde – the operating mechanisms do not contribute to the electrical endurance of the switching device as we are talking of failures primarily originating due to current chopping, re-ignitions or over voltages. There is no value of including additional field requesting this data in the survey.
10. Dave Caverly – Tertiary reactor details are missing from the survey.
11. Sushil Shinde – Will share the template with Dave for his inputs.
12. The introduction for the survey was shared for additional inputs from WG members.
13. The next steps were discussed.
14. Lucas Collette – volunteered to help with a chapter on system study guidelines.
15. Xi Zhu – will help with the survey data analysis

Attendance:

Sr. No	First Name	Last Name	Company	Role	10/17/20
1	Mauricio	Aristizabal	ABB Inc.	Guest	X
2	Harm	Bannink	KEMA Netherlands	Guest	X
3	Michael	Boulus	PSE&G	Guest	X
4	Arben	Bufi	HITACHI HVB, INC.	Member	X
5	Mohit	Chhabra	S&C Electric Company	Guest	X
6	Andrew	Chovanec	GE	Member	X
7	Chih	Chow	PEPCO	Member	X
8	Lucas	Collette	Duquesne Light	Guest	X
9	Mike	Crawford	MEPPI	Guest	X
10	Patrick	DiLillo	Consolidated Edison, NY	Guest	X
11	Kirk	Dlalan	HITACHI HVB, INC.	Guest	X
12	Bernie	Dwyer		Guest	X
13	Karl	Fender	Southern States LLC	Guest	X
14	Raymond	Frazier	Ameren	Guest	X
15	John	Hall	TVA	Member	X
16	Jeremy	Hensberger	MEPPI	Guest	X
17	Victor	Hermosillo	Alstom Grid	Member	X
18	Jennifer	Hunter	MEPPI	Guest	X
19	Todd	Irvin	GE Grid Solutions	Guest	X
20	Bharat	Jagadeesan	Southern States LLC	Guest	X
21	Cory	Johnson	BPA	Guest	X
22	David	Lemmerman	PECO/Exelon	Member	X
23	Vincent	Marshall	Southern Company	Guest	X
24	Stephanie	Montoya	SCE	Guest	X
25	Tom	Pellento	DTE Energy	Guest	X
26	Brian	Roberts	Southern States LLC	Member	X
27	Dan	Schiffbauer	Toshiba	Guest	X
28	Carl	Schuetz	ATC	Member	X
29	Sushil	Shinde	ABB Inc.	Chair	X
30	Erin	Spiewak	IEEE	Guest	X
31	Dragan	Tabakovic	Hubbel Power Systems	Guest	X
32	Vernon	Toups	Siemens	Guest	X
33	Richard	York	MEPPI	Member	X
34	Marcus	Young	MEPPI	Guest	X
35	Will	Zhang	HITACHI HVB, INC.	Member	X
36	Xi	Zhu	GE	Guest	X
37	David	Caverly	Trench Limited	Member	X
38	John	Hall	TVA	Guest	X
39	Michael	Skidmore	AEP	Member	X
40	Vernon	Toups	Siemens	Guest	X

Task Force
To Study Shunt Reactor Switching Endurance

Sushil Shinde

October 17, 2018 / Kansas City, MO

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Agenda

- Welcome and Introductions
- Objective of TF
- Survey Template
- Next steps

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Objective of TF

- Document submitted by Roy (see attachment).
- Roy discussed some concerns in existing standards where testing practices for shunt reactor switching may be lacking.
- A motion was passed to create a TF to study electrical endurance of shunt reactor switching.

Objective of TF

Explained by Roy Alexander at HVCB meeting (4-26-17):

Roy Discussion

There are 2 flaws in IEC 62271-110

1) There is nothing to determine switching endurance. 40 or 80 shots do not ensure endurance. Many are failing or failing the reactors after say 500 operations.

2) The reignition requirements are hokey at best. Presently, one is allowed any number and magnitude of reignitions in one half cycle but none in subsequent half cycles. This is crazy. There should be limits on the number of big reignitions. What difference does it make if small reignitions occur on subsequent half cycles?

TF could possibly review and study a new standard or modifications to parts of existing documents (such as IEC) with a new number to be determined.

Motion: Form a TF to study shunt reactor switching endurance.

Moved: Mike Skidmore

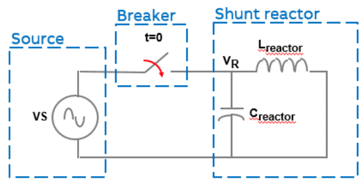
Second: John Webb

Vote (only members)

Unanimous approval

Shunt Reactor Switching

- The phenomena likely to generate overvoltages upon low inductive current breaking are well known.
- There are two types as follows:
  - premature current interruption, commonly termed "current chopping";
  - successive re-ignitions.
- These two phenomena can in fact take place successively during the same operation



Shunt Reactor Switching

- The overvoltage level depends on numerous parameters such as:
  - the natural frequency of the load-side circuit;
  - the point on current wave of contact separation;
  - the rate of rise of dielectric strength across contacts;
  - the characteristics of the high-frequency current oscillation

Survey Template

Input items			Example
Shunt Reactor	Rated	Voltage [kV]	
		Capacity [MVA]	
		Current [A]	
		Power Frequency [Hz]	
	Winding constraction	3-leg or 4-leg	
	Core type	Oil-immersed, Dry type or Air-core	
	Reactor location	Tertiary or direct connected	
	Type of grounding	Solidly ground/ Neutral reactor /Non-grounded	
	Type of neutral reactor if used	Oil filled or Air core	
	Equivalent lumped constants (Refer below sketch)	Lm [H]	
		Rm [ohm]	
		Ln [H] (only 4-leg)	
		Rn [ohm] (only 4-leg)	
		Cm [pF]	
		Cn [pF] (only 4-leg)	
		Natural frequency [kHz]	
Line/bus between CB and reactor	Line parameters	OHL or Cable	
		Length [m]	
		Line capacitance [pF]	
		Reactor stray capacitance [pF]	
Surge protction	MOSA	Varistor voltage (X kV at Y kA)	
Maintenance	Mitigation added to the reactor if any	Parallel capacitance/ Snubber/ Bushing arrestor/ None	

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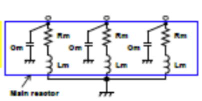
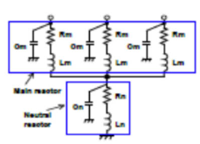
Survey Template

	Failure if any	Reactor/ Bushing/ Both	
	No of switching operations on reactor prior to failure		

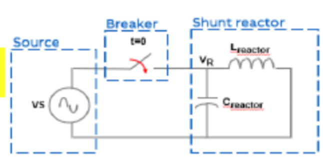
3- Leg type reactor



4- Leg type reactor



Shunt reactor switching equivalent circuit



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Survey Template

Switching Device	Type of switching device	MV/DTB/LTB/Circuit Switcher		
	Interrupting medium	Gas, vacuum, oil		
	Rated voltage	kV		
	Operating voltage	kV		
	Short circuit current	kA		
	No of breaking units	1/2/3/3		
	Interrupter type	Self-blast/Arc assist/ Puffer		
	Circuit breaker testing per relevant IEC Std 62271-110; IEC 61233	Y / N		
	Width of the re-ignition free arcing window	ms		
	Rate of rise of the dielectric strength			
	Current chopping number	$A\ F^{-0.5}$		
	Location of CB relative to reactor	Before HV terminal or After neutral terminal		
Mitigation	Controlled switching used?	Y / N		
	Type of controlled switching	OPEN / CLOSE / Both		
	Open/Close resistors used?	Y / N		
	MOSA across interrupter used?	Y / N		
Maintenance	Number of operations until interrupter maintenance is required			
	Number of operations until interrupter replacement was required			
	Average no of operations per year			
	Number of Ops currently on device			
	CB Failed	Y / N		
	If failed, did it fail during opening/closing	Opening / Closing		
	Major components failed	Nozzle/ main contacts/ arcing contacts/ interrupter tube/ grading capacitor / mechanism		
	Insulation component condition after failure	puncture/ internal surface ablation		

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Concerns Related to Survey

- Will the data for the reactors that we collect help define endurance requirements for reactor switching?
- What is needed is further research / understanding into erosion severity (of the arcing contacts and nozzle) as a function of cumulative operation.

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Introduction to Survey

Shunt reactor switching has been recognized as a particularly challenging switching duty for HV circuit breakers. Over voltages generated by shunt reactor de-energization may cause harm to the shunt reactor and in many cases the circuit-breaker itself. The over voltages are mainly generated by re-ignitions and current chopping phenomenon. These two phenomena can in fact take place successively during the same operation. Currently, IEC Std 62271-110 is being used for type testing. The purpose of the testing is not so much to demonstrate interrupting capability but rather to establish that the circuit-breaker meets certain performance criteria and to derive its chopping current and chopping number characteristics. As per the testing protocol outlined in IEC standard 40 to 80 test shots are performed. There are some concerns in existing standards where testing practices for shunt reactor switching may be lacking. A motion was passed during a HVCB subcommittee Spring 2017 meeting to create a task force to study electrical endurance of shunt reactor switching. A further research is needed to understand into erosion severity (of the arcing contacts and nozzle) as a function of cumulative operation. The reactor switching stress is a dielectric stress for the circuit breaker and is therefore related to a certain statistical behavior. The idea of a type test is to provide a test procedure, which gives high confidence with a low/reasonable number of tests. For example this has been done when creating the cap switching test duties. In order to judge about the possible test procedures for reactor switching it would therefore be interesting to know the overall number of operations the breaker will be subjected to during its life time. This task force is conducting a survey of all shunt reactor switching applications to collect all application related data to analyze this in more detail.

Next Steps

- Finalize the online survey template
- Prepare a list of users/mfgs who can complete the survey
- Follow up with target respondents
- Data collection & analysis
- Volunteers for Task Force Report
- List of deliverables from this TF
  - Survey Results & short TF report
  - System simulation study guide

Questions?