PC37.016 WG, Standard for AC High Voltage Circuit Switchers Rated 15.5 kV (HVCB)

October 14, 2024 – Oklahoma City, Oklahoma

Chair: Neil McCord (Consultant)
Vice Chair: Sudarshan Byreddy (Consultant)
Secretary: Luke Collette (Utility)

Meeting Minutes

1. **Call to order and introduction:**

   The PC37.016 WG IEEE Standard for AC High Voltage Circuit Switchers Rated 15.5 kV met on Monday, October 14, 2024, at 3:45 P.M. Neil McCord, Working Group Chair, presided over the meeting.

2. **Introduction of Members and Guests**

   Roster distributed and attendance recorded (attendance sheet attached to MOM).
   52 in attendance with 18 of 25 members (72%) present. Quorum met.

3. **Review of Copyright, Patent, and Behavior/Ethics Slides & Call for Patents**

   Chair called for any potential Patent claims. No Patent claims identified.

4. **Approval of Previous Meeting Minutes:**

   Chair presented MOM from Spring 2024 meeting:

   - Motion to Approve MOM: Pete Marzec
   - 2nd to Motion: Jan Weisker
   - Approved by unanimous consent

5. **Review PAR and Deadline for Project**

   There was a discussion on extending the PAR, but it was suggested to wait until at least a first draft of the document is completed

6. **Proposed Revisions to C37.016**

   Contents – Chair briefly went through the scope of the document and definitions section.
   Discussion on terminal fault and transformer-limited fault:

   - Terminal fault – Fault between circuit switcher and Transformer
   - Transformer limited fault – Fault current is limited by Transformer impedance. (Chair discussed calculations on TRV based on transformer size)

Remove the section 5.12.2 and add the reference IEEE C37.04
The chair discussed whether initial TRV (iTRV) should be included in the standard and any specifics regarding that.

The working group decided to form a task force to define applications for circuit switchers so that the TRV requirements can be defined. The following volunteered for the task force:

- Mark Peterson Xcel Energy
- Ben Sax – NES
- Dave Mitchell – Southern States
- Pete Marzec – S&C

7. Future Meetings

Plan for next meeting is a virtual meeting on November 14th

8. Meeting Adjourned at 5:30 PM

Submitted by:

Lucas Collette
WG Secretary, C37.016
Standard for AC High Voltage Circuit Switchers Rated 15.5 kV

and

Neil A. McCord
WG Chair, C37.016
Standard for AC High Voltage Circuit Switchers Rated 15.5 kV

C37.016

IEEE Standard for AC High Voltage Circuit Switchers Rated 15.5 kV through 245 kV

Chair: Neil McCord; Vice Chair: Sudarshan Byreddy; Secretary: Lucas Collette

October 14, 2024

Agenda

- Call to Order
- Introduction of attendees
- Review of Patent and copyright slides
  - Call for patents
- Membership List
- Approval of Previous MOM
- Review PAR and deadline for project
- Proposed revisions to C37.016
- Schedule virtual meetings
- Adjournment

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  - http://standards.ieee.org/develop/policies/best_practices_for_ieee_standards_development_051215.pdf
- Distribution of Draft Standards (see 6.1.3 of the SASB Operations Manual)
  - https://standards.ieee.org/about/policies/opman/sect6.html

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- The IEEE SA Copyright Policy is described in the IEEE SA Standards Board Bylaws and IEEE SA Standards Board Operations Manual
  - IEEE SA Copyright Policy, see
    Clause 7 of the IEEE SA Standards Board Bylaws
    https://standards.ieee.org/about/policies/bylaws/sect6-7.html#7
    Clause 6.1 of the IEEE SA Standards Board Operations Manual
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- IEEE SA Best Practices for IEEE Standards Development
  - http://standards.ieee.org/develop/policies/best_practices_for_ieee_standards_development_051215.pdf
- Distribution of Draft Standards (see 6.1.3 of the SASB Operations Manual)
  - https://standards.ieee.org/about/policies/opman/sect6.html

IEEE SA Patent Slides

PARTICIPANTS HAVE A DUTY TO INFORM THE IEEE

- Participants shall inform the IEEE (or cause the IEEE to be informed) of the identity of each holder of any potential Essential Patent Claims of which they are personally aware if the claims are owned or controlled by the participant or the entity the participant is from, employed by, or otherwise represents

- Participants should inform the IEEE (or cause the IEEE to be informed) of the identity of any other holders of potential Essential Patent Claims

Early identification of holders of potential Essential Patent Claims is encouraged

IEEE SA Patent Slides

WAYS TO INFORM IEEE

- **Cause an LOA to be submitted to the IEEE SA (patcom@ieee.org); or**
- **Provide the chair of this group with the identity of the holder(s) of any and all such claims as soon as possible; or**
- **Speak up now and respond to this Call for Potentially Essential Patents**

If anyone in this meeting is personally aware of the holder of any patent claims that are potentially essential to implementation of the proposed standard(s) under consideration by this group and that are not already the subject of an Accepted Letter of Assurance, please respond at this time by providing relevant information to the WG Chair

IEEE SA Patent Slides

OTHER GUIDELINES FOR IEEE WORKING GROUP MEETINGS

- **All IEEE SA standards meetings shall be conducted in compliance with all applicable laws, including antitrust and competition laws.**
  - **Don't discuss the interpretation, validity, or essentiality of patents/patent claims.**
  - **Don't discuss specific license rates, terms, or conditions.**
    - Relative costs of different technical approaches that include relative costs of patent licensing terms may be discussed in standards development meetings.
      - **Technical considerations remain the primary focus.**
  - **Don't discuss or engage in the fixing of product prices, allocation of customers, or division of sales markets.**
  - **Don't discuss the status or substance of ongoing or threatened litigation.**
  - **Don't be silent if inappropriate topics are discussed. Formally object to the discussion immediately.**

For more details, see *IEEE SA Standards Board Operations Manual*, clause 5.3.10 and *Antitrust and Competition Policy: What You Need to Know* at http://standards.ieee.org/develop/policies/antitrust.pdf

IEEE SA Patent Slides

PATENT-RELATED INFORMATION

The patent policy and the procedures used to execute that policy are documented in the:

- *IEEE SA Standards Board Bylaws*
  (http://standards.ieee.org/develop/policies/bylaws/sect6-7.html#6)
- *IEEE SA Standards Board Operations Manual*
  (http://standards.ieee.org/develop/policies/opman/sect6.html#6.3)

Material about the patent policy is available at
http://standards.ieee.org/about/sasb/patcom/materials.html

If you have questions, contact the IEEE SA Standards Board Patent Committee Administrator at patcom@ieee.org

Voting Members (25)

- Andy Beckel
- Sanket Bolar
- Sudarshan Byreddy
- Andrew Chovanec
- Lucas Collette
- Pat Dilillo
- Todd Irwin
- Chris Jarnigan
- Andy Keels
- Vincent Marshall
- Pete Marzec
- Steve May
- Neil McCord
- David Mitchell
- Fernando Ordein
- Mark Peterson
- Brian Roberts
- Victor Savulyak
- Dan Schiffbauer
- Carl Schuetz
- Vernon Toups
- Francois Trichon
- Adam Voyles
- Casey Weeks
- Jan Weisker

Approval of Previous MOM

Spring 2024 MOM

Review PAR

Type of Project: Revision to IEEE Standard C37.016-2018
Project Request Type: Initiation / Revision
PAR Request Date: 15 Oct 2021
PAR Approval Date: 08 Dec 2021
PAR Expiration Date: 31 Dec 2025
PAR Status: Active
Root Project: C37.016-2018

5.2 Scope of proposed standard: This standard specifies the basis of rating, preferred ratings, and test procedures for ac circuit switchers, which are designed for outdoor installation and for rated power frequencies of 50 Hz and 60 Hz and rated maximum voltages of 15.5 kV through 245 kV. The standard applies only to three pole circuit switchers for use in three-phase systems. This standard also applies to the operating devices of circuit switchers and to their auxiliary equipment.

Change to scope of proposed standard: This standard ~~is~~ specifies the basis of rating, preferred ratings, ~~applicable~~ and test ~~to~~ procedures for ac circuit switchers, which are designed for outdoor installation and for rated power frequencies of 50 Hz and 60 Hz and rated maximum voltages of 15.5 kV through 245 kV. ~~It~~ The ~~is~~ standard ~~applicable~~ applies only to three-pole circuit switchers for use in three-phase systems. This standard ~~is~~ also ~~applicable~~ applies to the operating devices of circuit switchers and to their auxiliary equipment. ~~It includes the basis of rating, preferred ratings and test procedures for circuit switchers.~~

Proposed Revisions:

- Review of proposed revisions

➢ Contents – Chair briefly went through the scope of the document and definitions section.
➢ Discussion on terminal fault:
➢ Terminal fault – Fault between circuit switcher and Transformer
➢ Transformer limited fault – Fault current is limited by Transformer impedance. (Discuss calculations on TRV based on transformer size.)
➢ Remove the section 5.12.2 and add the reference IEEE C37.04
➢ The chair discussed whether inherent TRV included in the standard and any specifics regarding that.

Applications for circuit switchers

The working group decided to form a task force to define applications for circuit switchers so that
the TRV requirements can be defined. The following volunteered for the task force:
Volunteers

- Mark Peterson Xcel Energy
- Ben Sax – NES
- Dave Mitchell – Southern States
- Pete Marzec – S&C

Schedule a virtual meeting for early November 2024.

Adjourn

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A circuit switcher developed to C37.016-2018 is normally connected to the high side of a transformer to protect against faults inside the transformer and secondary faults through the transformer, see Figure 1.

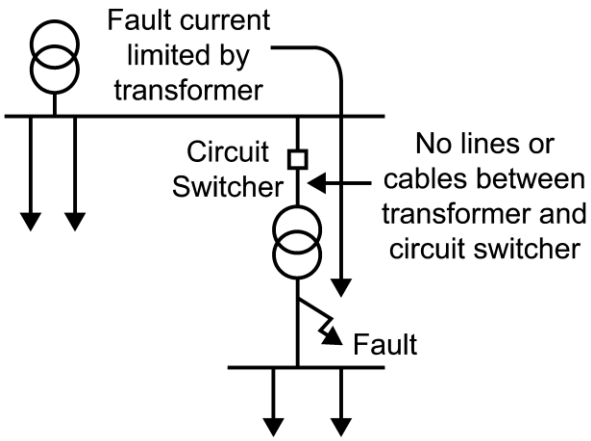


Figure 1: Diagram of a transformer-limited fault from C37-016-2018

The transformer limited fault (TLF) rating represents the primary side fault current that is limited by a transformer with a fault on the secondary side. This rating is unique to IEEE/ANSI C37.016-2018.

To determine the fault current through the transformer we need to know the size of the transformer. Let's start with a 145 kV 50 MVA transformer. The first step in determining the necessary test values is to calculate the current value of the through fault. The basic equation for this is:

$$I = \frac{P}{E}$$

Where P is the power of the transformer, E is the system phase to phase voltage of the high side of the transformer and I is the fault value through the transformer.

In the case of an actual three phase transformer the transformer impedance and the effect of the 3 phase system must be considered changing the equation to

$$I = \frac{P}{\sqrt{3} * E * \%Z}$$

Taking a unit analysis into account where P is in kVA and E is in kA the equation becomes:

$$I_{tf} = \frac{100P}{\sqrt{3} * E * \%Z} = 57.8\frac{P}{E\%Z}$$

I_{tf} = Transformer limited fault in A
P = Transformer self-cooled three-phase base rating, kVA
E = System phase-to-phase voltage, kV
%Z = Percent transformer primary-to-secondary impedance

For transformers on 145 kV systems with a 10% percent transformer primary-to-secondary impedance, the through fault is 2 kA. For transformers on 72.5 kV systems, the transformer through fault is 4 kA.

Knowing the transformer limited fault currents the TRV can be calculated for each current using the equations in C37.016-2018 section 5.14.

U_r = rated maximum voltage (kV)
k_{pp} = first pole to clear factor, 1.3 for effectively grounded systems, 1.5 for ungrounded systems.
k_{af} = amplitude factor

u_c = reference voltage (TRV peak value) (kV) $u_c = 0.9 * k_{pp} * k_{af} * U_r * \sqrt{(2/3)}$

t_3 = time to reach uc (μs) $t3 = 0.106\sqrt{(\frac{UrC}{Itf})}$

For 123 kV and above $C = 1650 + 180 * I_{tf}(pF)$

For < 123 kV $C = 1480 + 89 * I_{tf}(pF)$

RRRV, Rate of Rise of Recovery Voltage RRRV=Uc/t3

Table 1:TLF values based on test results per C37.016-2018, 5.15.3 (-35 C)

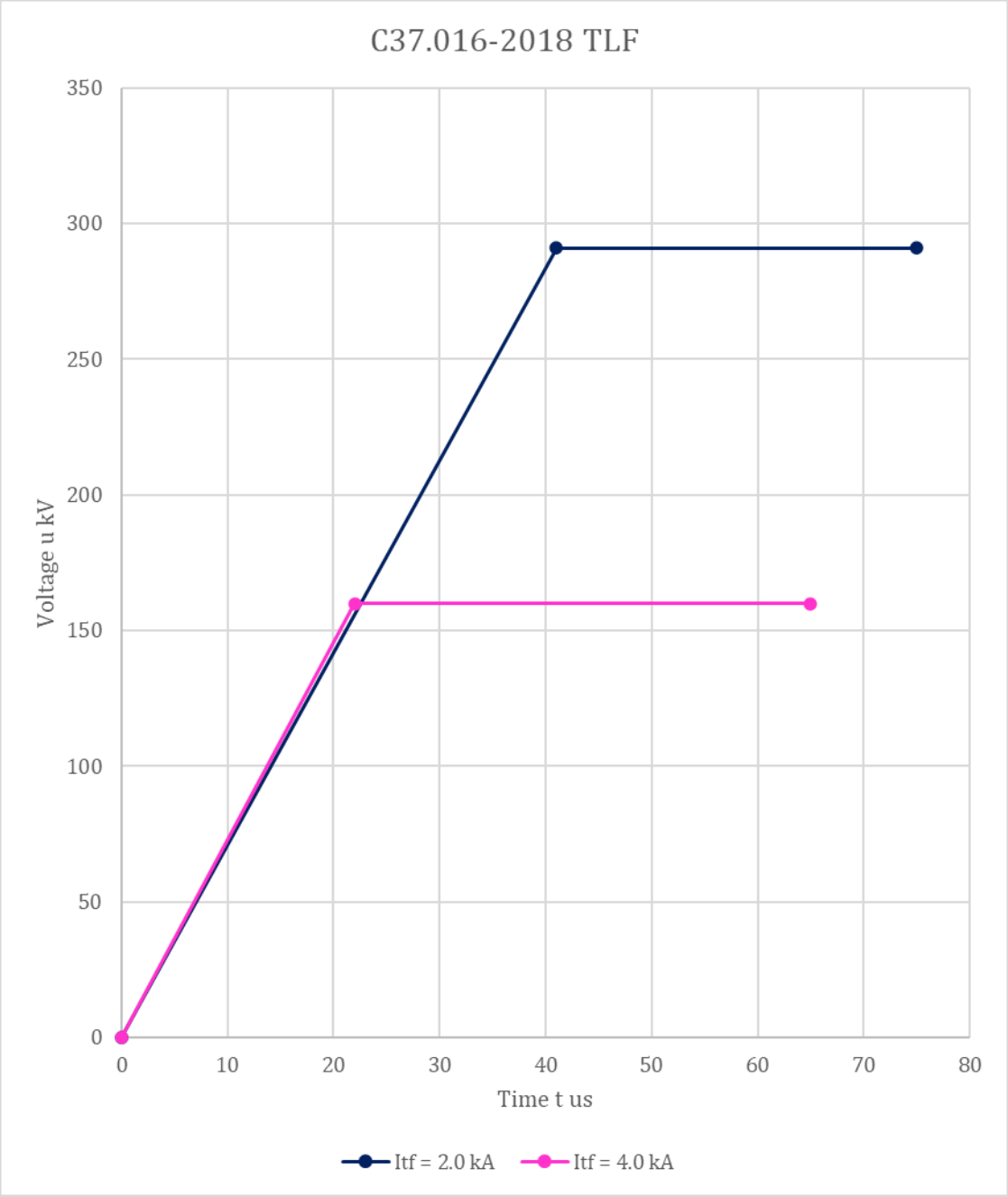
Rated Maximum Voltage (U_r)	First pole-to clear factor (k_{pp})	MVA	%Z	TRV Peak Value U_c (kV)	Transformer Secondary Fault [2, 3] (I_{tf})	Transformer Limited Fault (I_{tlf})	Rate of Rise du/dt (kV/µs)
170 kV	1.3	50	10	292	2.0	1.7	6.8
145 kV	**1.5**	**50**	**10.0**	**288**	2.0	**2.0**	**7.2**
145 kV	1.3	60	10.0	249	2.0	2.4	7.3
123 kV	1.5	50	11.5	244	2.0	2.0	6.6
123 kV	1.3	60	10.0	212	2.0	2.8	7.3
72.5 kV	**1.5**	**50**	**10.0**	**160**	4.1	**4.1**	**7.3**
38 kV	1.5	40	15.0	75	4.1	4.0	5.4

Notes:

1. Assume the 145 kV values, shown in BOLD type, reflect the actual, successful, test values.
2. The TLF Values shown are the calculated maximum TLF current, per the C37.016-2018 standard, based on the tested rate of rise.

Table 2: TRV values beyond the scope of the most circuit switchers

MVA	E U_r kV	%Z	U_c kV	I_{tf} kA	t_3 µs	RRRV
100	145	10	288	**4.0**	44.0	9.3
200	145	20	288	**4.0**	44.0	9.3


C37.016-2018 TLF
350
300
250
200
150
100
50
0
Voltage u kV
0
10
20
30
40
50
60
70
80
Time t us
Itf = 2.0 kA
Itf = 4.0 kA

IEEE PES Switchgear Committee
HVCB C37.016 - Meeting Roster

Place / Date of meeting: Omni Oklahoma City, Oklahoma City, Oklahoma

Initial to denote attendance	Last name	First name	Company name	Role	Request Membership
	Allinghan	Edward	Hydro One	Guest	
	Andreyo	Joe	Southern States	Guest	
	Antantis	Michelle	Duquesne Light Co.	Guest	
	Ashtekar	Koustubh	JST Power Eq	Guest	
	Balasubramanian	Ganesh	Eaton Corp	Guest	
	Beckel	Andy	Xcel Energy	Voting Member	
	Beecher	Zachary	~~Southern States~~ Power Grid Components	Guest	✓ ZB
DB	Benedict	Dan	PPL	Guest	✓
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BJB	Berner	Brian	Power Grid Comp.	Guest	BJB
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	Cary	Stephen	2 Phase Solutions	Guest	
	Castillo	Pedro	ABB	Guest	
	Chovanec	Andrew	Power Grid Comp.	Voting Member	ALC
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	Pellerito	Tom	DTE Energy	Guest	

IEEE PES Switchgear Committee
HVCB C37.016 - Meeting Roster

Place / Date of meeting: Omni Oklahoma City, Oklahoma City, Oklahoma

Initial to denote attendance	Last name	First name	Company name	Role	Request Membership
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	Pounders	Isaac	Meiden	Guest	
	Rexroad	Aaron	Meiden	Guest	
	Richter	Frank	50 Hz Transmission	Guest	
BAR	Roberts	Brian	Southern States	Voting Member	
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	Rowell	Amy	Schneider Electric	Guest	
	Santulli	Jen	IEEE SA	Guest	
Victor	Savulyak	Victor	KEMA	~~Guest~~ VOTING MEMBER	
BS	Sax	Benjamin	Nashville Electric Services	Guest	BS
DS	Schiffbauer	Dan	Toshiba International	Voting Member	
	Schuetz	Carl	ATC	Voting Member	
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	Sharma	Devki	Retired	Guest	
MJS	Skidmore	Mike	AEP	Guest	MJS
	Smith	Kirk	Retired	Guest	RKS
DGS	Steigerwalt	Don	Duke Energy	Guest	DGS
JT	Tarleton	John	Southern States	Guest	JT
	Toups	Vernon	Siemens Energy	Voting Member	
ET	Trichon	Francois	Schneider Electric	Voting Member	ET
	Usner	Joe	AEP	Guest	
	Voyles	Adam	Ameren	Voting Member	
	Ward	Jeff	Doble Engineering	Guest	
	Webb	John	ABB	Guest	
CW	Weeks	Casey	Siemens Energy	Voting Member	
JW	Weisker	Jan	Siemens Energy	Voting Member	~
	Westerdale	Matt	Bureau of Reclamation	Guest	
	Young	Marcus	MEPPI	Guest	
	Yunseorg	Kim	KERI	Guest	
	Zhang	Wei	Southern Company	Guest	~~[illegible]~~
	Zia	Danish	UI Solutions	Guest	
NDB	Bouchez	Nick	Switchgear Power Systems	Guest	
SLZ	ZAHARKO	SAM	MEPPI	GUEST	
BA	Alexander	Brian	S&C Electric Canada Ltd.	Guest	
JR	RATNIKOFF	JAVIER	GE VERNOVA	GUEST	JR
JLD	Beck	Jason	Dominion Energy	Guest (second meeting)	JLB
AL	LIVSHITZ	Albert	Quality Services	Guest	AL
CD	Dunn	Chris	Dominion Energy	Guest	
S	SAKARAPANEE	KATHRYN	SCHNEIDER ELECTRIC	GUEST	
	Beauchemin	Francis	Hydro-Quebec	Guest	
	MARKHAM	JESSE	ECI	Guest	
	Schwartz	Skyler	American Transmission Co.	Guest	
	~~ARAGAV~~	~~TABAKOV~~	~~HUBBELL POWER SYSTEMS~~	~~GUEST~~	
	Hartmann	Gleber	Siemens Industry	Guest	
EH	HENRIET	Eduardo	SIEMENS ENERGY	Voting Member	
EB	Banda	Eloy	SIEMENS ENERGY	Guest	EB