Minutes – Second Meeting: WG PC57.133

"Guide for Evaluating Transformer Performance under Reverse Power Flow"

11:00 AM to 12:00 PM EST | February 24, 2025
Virtual only – Google Meet

Chair:	Ryan Hogg	Bureau of Reclamation	rhogg@ieee.org
Vice Chair:	Bruce Webb	Knoxville Utilities Board	bruce.webb@kub.org
Secretary:	Drew Welton	Intellirent	dwelton@intellirentco.com

Minutes – items in green = discussion during meeting

1. Behavior, Copyright, and Patent – reviewed all slides
2. Quick review – PAR (expires 12/31/2028) – reviewed
3. Attendance form and quorum check (89 members; 45 required for quorum)
    a. Only 36 members were present, quorum was not achieved
    b. No official business performed
4. Agenda approval
    a. No quorum, agenda unable to be approved
5. Minutes approval – October 29, 2024 meeting
    a. No quorum, minutes unable to be approved
6. Discuss document outline:
    a. Too many items?
    b. Missing items?
    c. Slide displayed with the proposed document outline (see next page)

Working Outline

1. **Historical context**
    1. Watts and VARs chart
    2. Typical causes of reverse power flow
    3. How to assess which transformers are/may be subject to reverse power flow *(possible informative annex; system condition not a transformer issue)*
2. **Step-down vs step-up vs bi-directional vs same voltage both sides**
    1. C57.12.00, C57.12.01… other standards and how they discuss power flow direction
3. **Potential effects**
    1. Voltage regulation
    2. Core saturation (LV taps, variable flux)
    3. Winding heating (common windings of autos)
    4. …
    5. Include different transformer designs and potential concerns:
        1. Simple two winding
        2. Two winding w/ LV taps
        3. Two winding w/ LV taps, variable flux
        4. Auto transformers
        5. Multi winding transformers…
4. **Recommended actions for operation of existing transformers**
5. **Recommended guidance for new transformers (e.g., specification type language)**

d. Group discussion was held around "working outline" slide:
    i. J. Bradshaw
        1. As an end user, how do we tell a manufacturer how we are going to operate this transformer
        2. Do we see any restrictions, for criteria for "4. Recommended actions for operation of existing transformers"? Example of a GSU that will now provide reverse power to motor a generator. How will the reverse power affect the transformer and what do we do about it?
    ii. S. Shull
        1. Need to ensure we define reverse power flow first
    iii. R. Hogg
        1. Agree with need to define reverse power flow, new "definition of reverse power" task force meeting is scheduled for Thursday following this working group meeting
    iv. R. Girgis

1. Impact of reverse power flow on transformers, Ed tyNyenhuis presentation had good information, Ramsis plans to present to our working group in the Denver meeting

v. J. Wright
    1. Will the guide provide guidance to manufacturers on how to design a transformer for reverse power?

vi. R. Hogg
    1. Responding to J. Wright's question, title, scope and purpose do not seem to include guidance for design to manufacturers

vii. J. Wright
    1. Clarify that desire is to know what reverse power flow affects in what transformer design, which 3.5. seems to cover in outline (as well as 5.)

viii. J. Bradshaw
    1. **Add to outline**: Propose an informative annex on "how to determine what you would put into a specification"
    2. E.g., specifying values in Watts/VARs to the manufacturer, example of how to determine what your require of the transformer in "reverse"

ix. JC Hernandez
    1. Amorphous cores – should consider the effects between grain oriented and amorphous cores
    2. **Add to outline**: Amorphous core considerations – is there an impact?

x. R. Girgis
    1. Some of these discussions seem pre-mature, need to ensure we have enough knowledge of the impacts of reverse power flow
    2. Need to hear more from the users, what are the different ways of reverse power flow that users have/experience
    3. Does reverse power flow really apply to dry type and distribution transformers?
    4. Power versus dry type versus distribution – impact could be different for each different type of transformer

xi. R. Hogg – taking off hat as the WG chair, speaking as an end user
    1. Dry type and reverse power flow – have a dry type outdoor GSU that operates in reverse power flow to provide station service power when all generation is offline

xii. J. White
    1. Hawaii voltage regulators installed on distribution transformers due to large roof top solar reverse power into distribution system

2. California gas fired “peaker” plants, parking lots have now been filled up with battery storage, tapping the low side of the GSU, the GSU is being use as a traditional load serving transformer while charging the batteries (reverse power)

xiii. D. Welton – taking off hat as secretary of the working group
   1. DER penetration and reverse power flow throughout the distribution system
   2. OLTC controls auto-determine true-reverse power flow condition
      a. Voltage regulators run in a reverse power mode, one manufacturer of controls has implemented “smart” controls into their systems, to account for reverse power and make different voltage regulation decisions
      b. "true-reverse power flow conditions" – considering Watts in reverse and voltage influence of the reverse Watts
      c. Measuring voltage on original source side, and then see influence when the tap changer moves
      d. Makes smarter decisions if in reverse power flow

xiv. D. Blaydon
   1. Net metering for 10 to 15 years, roof top solar, battery systems, large commercial solar farms on buildings of end users, selling power back to the grids
   2. Traditional radial substation power
   3. Seems that distribution transformers should have been dealing with this for decades, seems this should have been part of discussion for a longer time in the distribution transformer world

xv. B. Staley
   1. Solar, wind, battery storage (direct coupled or not) coming into the grid; certain scenarios will have reverse power issues

xvi. H. (Alan) Zhang
   1. Potential effects - voltage imbalance issues, e.g., with battery system
   2. Delta connection load side, depending on grounding, back feed from battery side, voltage imbalance
   3. 3-phase voltage back to the transformer no longer all positive sequence
   4. **Add to outline**: voltage imbalance during reverse power (considering grounding, low side connection, grounding, e.g., back feeding from battery systems).

xvii. J. White
   1. In addition to historical content, "how we got here" as an industry (propose to add to "1. Historical context")

2. Provide background for why we are talking about reverse power, education to why this is an issue

xviii. S. Shull
1. The "how we got here" fits into the foreword of a standard
2. **Add to outline**: "how we got here" included in the foreword

xix. J. Izquierdo
1. Seems important to include how to proceed with transformer design, distribution/dry type transformers

xx. R. Hogg
1. Seems that we have a good outline, will update outline (updated outline per this meeting is after all agenda items/discussion, prior to attendee list)
2. Plan to ask for task forces to begin drafting the report sections in Denver (form those task forces in Denver)

7. Call for volunteers to present at future in-person meetings:
   a. E.g., how have you/your organization been approaching reverse power and transformers, what impacts are you/your organization seeing…
   b. In the works
      i. Spring 2025 – Ramsis Girgis
      ii. Fall 2025 – Joe White
   c. Volunteers to present at Denver meeting:
      i. R. Hogg – Bureau of Reclamation – plans to present on GSUs and dry type
      ii. V. Patel – Con Edison of New York – plans to work with coworkers about transformers they have been monitoring, etc., develop slide(s)
      iii. D. Blaydon – Baltimore Gas and Electric – present briefly on substation power transformer, power flow direction changes with cloud cover…
8. Old Business – none – none
9. New Business – any? – none
10. Next meetings – reviewed
    a. Virtual:
       i. TF to define "reverse power flow"
    b. In person: Denver, CO in Spring 2025
       i. Plan to delegate drafting of report sections to new task forces
11. Adjourn – meeting adjourned as completed the agenda items

Updated outline per this meeting:

1. **Foreword**
    a. "How we got here" as an industry
2. **Historical context**
    a. Watts and VARs chart
    b. Typical causes of reverse power flow
    c. How to assess which transformers are/may be subject to reverse power flow (possible informative annex; system condition not a transformer issue)
3. **Step-down vs step-up vs bi-directional vs same voltage both sides**
    a. C57.12.00, C57.12.01… other standards and how they discuss power flow direction
4. **Potential effects**
    a. Voltage regulation
    b. Core saturation (LV taps, variable flux)
    c. Winding heating (common windings of autos)
    d. Voltage imbalance (battery back feeding, delta connections and grounding)
    e. …
    f. Include different transformer designs and potential concerns:
        i. Simple two winding
        ii. Two winding w/ LV taps
        iii. Two winding w/ LV taps, variable flux
        iv. Auto transformers
        v. Multi winding transformers
        vi. Amorphous vs grain-oriented cores
5. **Recommended actions for operation of existing transformers**
6. **Recommended guidance for new transformers (e.g., specification type language)**
7. **Informative Annex A: "how to determine what Watt/VAR values to put into specification"**
    a. E.g., GSU reverse power, other examples

Working Group Force Membership/Guests:

	First Name	Last Name	Affiliation	Membership	Attended Feb 24, 2025 Meeting?
1	Kayland	Adams	Prolec-GE Waukesha	Member	Yes
2	Gilles	Bargone	FISO	Member	Yes
3	Mats	Bernesjo	Hitachi Energy	Member	Yes
4	Daniel	Blaydon	Baltimore Gas and Electric	Member	Yes
5	William	Boettger	Boettger Transformer Consulting LLC	Member	
6	Garrett	Bradshaw	Howard Industries	Member	
7	Jeffrey	Brooks	Asplundh Engineering Services	Member	Yes
8	Alfredo	Carrizales	PROLEC	Member	Yes
9	Thomas	Dauzat	AEP-SWEPCO	Member	
10	Nikolaus	Dillon	Dominion Energy	Member	Yes
11	Fernando	Duarte	EPRI	Member	
12	Roger	Dugan	(Retired) Self	Member	Yes
13	Eric	Elson	San Diego Gas & Electric	Member	
14	Miguel	Garcia	Hitachi Energy	Member	
15	Eduardo	Garcia	Siemens Energy	Member	
16	David	Garcia-Paredes	Virginia Transformers Corp	Member	
17	James	Gardner	Prolec-GE Waukesha	Member	
18	Jose Antonio	Gonzalez Ceballos	Virginia/Georgia Transformers	Member	
19	William	Griesacker	WGA	Member	
20	Jesse	Hall	Virginia Transformer Corp.	Member	
21	Corey	Hanson	Flex-Core	Member	
22	U	Hernandez Decanini	Virginia Transformers Corp	Member	
23	Saramma	Hoffman	PPL	Member	
24	Ryan	Hogg	Bureau of Reclamation	Member	Yes
25	Derek	Hollrah	Burns & McDonnell	Member	Yes
26	Saif	Hossain	Trench Group	Member	Yes
27	Miljenko	Hrkac	Hitachi Energy	Member	
28	Jose	Izquierdo	Siemens energy	Member	Yes
29	Nick	Jensen	Delta Star	Member	Yes
30	John	John	Virginia Transformer Corp	Member	Yes
31	Christopher	Johnson	Oncor	Member	Yes
32	Akash	Joshi	Kimley-Horn	Member	
33	Thrinadha	Katapalli	Virginia Transformer Corp	Member	
34	Anton	Koshel	Delta Star, Inc.	Member	
35	Mark	Lachman	Doble	Member	
36	Jihun	Lee	HD HYUNDAI ELECTRIC	Member	
37	Junho	Lee	HD Hyundai Electric	Member	

	First Name	Last Name	Affiliation	Membership	Attended Feb 24, 2025 Meeting?
38	Kushal	Mahajan	Sungrow	Member	
39	Swapnil	Marathe	Megger	Member	
40	Daniel	Martinez	Jfe guest	Member	
41	Katherine	Marulanda	Magnetron	Member	
42	Brian	McCarrick	Virginia Transformer Corp	Member	Yes
43	Omar	Mendez	Prolec	Member	Yes
44	Emilio	Morales-Cruz	QUALITROL	Member	Yes
45	Tyler	Morgan	Duke Energy	Member	
46	Dan	Mulkey	Mulkey Engineering Inc	Member	
47	Ali	Naderian	EnerPars	Member	
48	Shankar	Nambi	Bechtel Energy, Inc.	Member	
49	Eduardo	Orozco	GE Grid Solutions	Member	
50	Sanjay	Patel	SGB-Smit USA	Member	Yes
51	Vinay	Patel	Con Edison	Member	Yes
52	Gustavo	Prado	Siemens Energy	Member	Yes
53	Tim	Raymond	Inductive Reasoning	Member	Yes
54	Yuri	Rossini	Siemens Energy	Member	Yes
55	Marnie	Roussell	Entergy	Member	
56	Paul	Salvato	Intellirent	Member	
57	Amitabh	Sarkar	Virginia Transformer Corporation	Member	
58	Markus	Schiessl	SGB	Member	
59	Eric	Schleismann	Southern Company	Member	
60	Leena	Shimpi	Mgm transformer	Member	
61	Stephen	Shull	BBC Electrical Services Inv	Member	Yes
62	Igor	Simonov	Toronto Hydro	Member	
63	James	Spaulding	City of Fort Collins Utilities	Member	
64	Andy	Speegle	Entergy	Member	Yes
65	Brad	Staley	Leeward Renewable Energy	Member	Yes
66	Sunny	Swarna	Virginia Transformer Corp	Member	
67	Marc	Taylor	JFE Shoji Canada	Member	
68	Joseph	Tedesco	Hitachi Energy	Member	
69	Ed	teNyenhuis	Hitachi Energy	Member	Yes
70	Mark	Tostrud	Dynamic Ratings	Member	
71	Kannan	Veeran	Virginia/Georgia Transformer Corp	Member	Yes
72	Juan	Velasquez	Magnetrón SAS	Member	
73	Karsten	Viereck	Reinhausen Germany	Member	
74	Krishnamurthy	Vijayan	Pennsylvania transformers	Member	
75	Dharam	Vir	Prolec GE	Member	Yes
76	Pragnesh	Vyas	Sunbelt Solomon	Member	

	First Name	Last Name	Affiliation	Membership	Attended Feb 24, 2025 Meeting?
77	David	Walker	MGM Transformers	Member	
78	Joe	Watson	JD Watson and Associates	Member	
79	Bruce	Webb	Knoxville Utilities Board	Member	Yes
80	Drew	Welton	Intellirent	Member	Yes
81	Joe	White	POWER Engineers	Member	Yes
82	Jeffrey	Wright	Duquesne Light	Member	Yes
83	Fei	Yang	Hitachi Energy	Member	
84	Tim	Young	Hitachi Energy	Member	
85	Guang	Yuan	Hitachi Energy	Member	Yes
86	Michael	Zarnowski	Carte International	Member	Yes
87	Hongzhi	Zhang	Hitachi Energy	Member	Yes
88	Shibao	Zhang	PCORE Electric	Member	
89	Waldemar	Ziomek	PTI Transformers LP	Member	
90	Stefan	Abelen	Maschinenfabrik Reinhausen Germany	Guest	Yes
91	Edwin	Betancourt	Siemens Energy	Guest	
92	Naveen	Bhardwaj	Trench Group	Guest	
93	Kevin	Biggie	Weidmann	Guest	
94	Bhaumik	Choksi	Hitachi Energy	Guest	Yes
95	Rhett	Chrysler	ERMCO	Guest	
96	Adriana	Cisco Sullberg	Salt River Project	Guest	
97	Luiz	de Oliveira	Hitachi Energy	Guest	
98	Paul	Dolloff	EKPC and University of Kentucky	Guest	
99	Janko	Dzodan	Koncar D&ST	Guest	
100	Sanford	Fong	Georgia Power	Guest	
101	Raymond	Frazier	Ameren	Guest	
102	Jose	Gamboa	The H-J Family of Companies	Guest	Yes
103	Dragana	Gasic	Koncar D&ST	Guest	
104	Kevin	Hampton	Siemens Energy	Guest	
105	Jean Carlos (JC)	Hernandez-Mejia	Georgia Tech NEETRAC	Guest	Yes
106	Kenneth	Klein	Johnson	Guest	Yes
107	Nihat	Kosedagi	Hitachi Energy	Guest	
108	Angela	Leigl	Eaton	Guest	
109	Xose	Lopez-Fernandez	Universidade de Vigo	Guest	
110	Charles	Morgan	Eversource Energy	Guest	
111	Fredy	Murcia	Siemens Energy	Guest	
112	Hugo	Murillo	Guest	Guest	Yes
113	Adnan	Rashid	Measurement Canada	Guest	Yes
114	Robert	Reepe	Georgia Power Co	Guest	Yes

	First Name	Last Name	Affiliation	Membership	Attended Feb 24, 2025 Meeting?
115	Masoud	Sharifi	Siemens Gamesa Renewable Energy	Guest	
116	Hemchandra	Shertukde	University of Hartford	Guest	Yes, Requesting Membership, Granted for Denver Meeting
117	Andrew	Steineman	Delta Star, Inc.	Guest	Yes
118	Michael	Thompson	SEL Engineering Services	Guest	
119	Timothy	Tillery	Howard Industries	Guest	
120	Reinaldo	Valentin	Duke Energy	Guest	
121	Terry	Wong	Trench Limited	Guest	
122	Koray	Yavuz	Noark Electric US	Guest	
123	Jeremiah	Bradshaw	Bureau of Reclamation	Guest	Yes
124	Ramsis	Girgis	Hitachi Energy	Guest	Yes, Requesting Membership, Granted for Denver Meeting
125	Christine	Grunbaum	Ameren	Guest	Yes
126	Daniel	Sauer	Eaton	Guest	Yes
127	Jason	Snyder	First Energy Corp	Guest	Yes
128	Patrycja	Jarosz	IEEE SA	IEEE SA	Yes