

Investigating R&D Committee on Present State of Insulation in Increasingly Widespread Converter-fed Rotating Machines

Technical Committee on Electrical Discharges,
Plasma, and Pulsed Power Technologies

1. Purpose

Advances are being made in converter-fed industrial machines for energy-saving and high-efficiency operations. In the automotive industry, the demand for environmentally friendly hybrid cars (HVs) and electric vehicles (EVs) is increasing, and high-output and high-efficiency motors are being installed. Degradation in electrical insulation owing to repetitive steep pulse waveform (inverter surge) caused by impedance mismatch among motors, inverter power supply, and cables connecting them became apparent in industrial motors in the 1990s; since then, various researches have been conducted worldwide.

These technical problems and research trends have been the subject of IEEJ investigations through the Technical Committee on Electrical Discharge and the Technical Committee on Dielectric and Insulation Materials. The Technical Committee on Dielectric and Insulation Materials established the "Investigation Committee on Inverter Surge Insulation" in 1997, which issued the IEEJ Technical Report No. 739, comprehensively summarizing power electric technology in Japan and abroad prior to 1998, the impact of surges on insulation, and trends in researching various devices. In 2007, the Technical Committee on Electrical Discharge established the "Investigation Committee on Measuring Partial Electrical Discharge under Repetitive Surges," which issued IEEJ Technical Report No. 1218, summarizing the last 10 years of research into partial discharge measurement techniques. In 2013, the Technical Committee on Dielectric and Insulation Materials established the "Investigation Committee on Inverter Surge Insulation," which surveyed related literature in Japan and abroad prior to 2015, conducted a joint study using real inverters, and issued IEEJ Technical Report No. 1407.

Through these joint study, various findings were obtained on partial discharge, generating conditions in actual motors. Nevertheless, some problems remained unexplained, such as the effect of environmental conditions and clarification of degradation factors in insulating materials. In addition, the insulation system standard (IEC 60034-18-42), allowing for partial discharge after inspection, was established, and deliberations over the standard (IEC 60034-27-5) on partial discharge measurement methods for repetitive surges in converter-fed rotating machines have started. Furthermore, remarkable progress has been observed in the aforementioned power devices at the time of the initial (prior to 1998) survey.

The proposed investigation committee aims to continue investigation activities on the present general state of insulation technology for increasingly widespread converter-fed rotating machines, in view of the above-mentioned history and necessity. The committee will comprise specialists in discharge physics, in addition to engineers on the manufacturing and user sides. The committee will investigate academic journals and related standards in Japan and abroad, focusing on the present state of voltage-upgrading power modules, the situation in industries experiencing marked introduction of EVs and other devices in recent years, the development of partial discharge test equipment based on the understanding of discharge phenomena, and the status of explaining the mechanisms of partial discharge and material degradation.

2. Background and internal and external research activities

The effects of repetitive surge on insulation have been studied in detail at universities, research institutes, and industries. Insulation design for rotating machines accounting for partial discharge characteristics in time domains with scales of nanosecond and the development of various measuring devices have urgently pressing issues. Further, developments have been made, including the superior use of enameled wire in surge resistance, electric wire-using resin films for automobiles, and motors with flat wire structures; their reliable evaluation is an important topic.

Although the standard (IEC 60034-18-41) for insulation systems that do not allow the generation of partial discharges was issued in March 2014 during the term of the previous investigation committee, test data from the evaluation of the insulation of actual motors based on the standard was hardly reported. Therefore, the joint testing of repetitive partial discharge inception voltage (RPDIV) measurement under repetitive impulse voltage in an actual motor was conducted by some committee members rather than a literature investigation by the previous committee, and the data were closely scrutinized. These results have been widely introduced at domestic and international conferences as the world's first measured test data of RPDIV in practical equipment test, and have been fed back to the deliberation of IEC standards. However, there remained several points that could not be explained, such as variations in the test data, and as a result, the problem of partial discharge phenomena was expressed in the ns-based time domain.

3. Investigative matters

- ① Latest technologies and application trends in power electronics
- ② Trends and explanations of IEC standards (18-41, 18-42, 27-5)
- ③ Status of efforts by each company to comply with IEC standards
- ④ Partial discharge characteristics and degradation mechanism (theoretical study)
- ⑤ Development trends and issues in motors for automobiles

4. Expected effects

By examining these items, we obtain a comprehensive understanding of trends in the latest standards and developments in industrial technology related to power electronics technology and rotating machine insulation, and deepen our understanding of insulation phenomena based on the physical mechanisms of discharge. These understandings are expected to be useful to researchers at universities, manufacturers, and users. These technologies and findings are directly related to the acquisition of insulation design policies for converter-fed motors and the advancement of insulation diagnosis technology, and are expected to make a significant contribution to raising the level of Japan's technological competitiveness.

5. Investigation period

December 2018 to November 2021 (3 years)

6. Committee members

Position	Name	Affiliation	Member/Non-member category of IEEEJ
Chairperson	Akiko Kumada	The University of Tokyo	Member
Member	Yasuyuki Akashi	Meidensha Corporation	Non-member
"	Hiromitsu Asai	DENSO Corporation	Member
"	Hiroki Igarashi	Oriental Motor Co., Ltd.	Non-member
"	Takahiro Ishida	Shizuoka Institute of Science and Technology	Member
"	Yugo Imai	Adphox Corporation	Member
"	Takahisa Ueno	National Institute of Technology, Oita College	Member
"	Satoshi Uchida	Tokyo Metropolitan University	Member
"	Kiyoshi Umezu	ECG-Kokusai Co., Ltd.	Member
"	Shinya Urata	Toyota Central R&D Labs., Inc.	Member
"	Hiroshi Eto	Kuwahara Electric Corporation	Non-member
"	Hideyuki Kikuchi	Hide Technology LLC.	Member
"	Ken Kimura	He used to be a professor at National Institute of Technology (Kosen), Nara College.	Member
"	Hiroaki Kojima	Hitachi, Ltd.	Member

Position	Name	Affiliation	Member/Non-member category of IEEJ
Member	Atsushi Komuro	The University of Tokyo	Member
"	Hisato Sato	Nissin Pulse Electronics Co., Ltd.	Member
"	Kosuke Shibata	Teikoku Electric MFG. Co., Ltd.	Member
"	Takumi Shibata	Honda Motor Co., Ltd.	Member
"	Masaru Setomoto	Nishishiba Electric Co., Ltd.	Non-member
"	Masahiro Takeno	Toshiba Mitsubishi-Electric Industrial Systems Corporation	Non-member
"	Fumio Tokutake	Hioki E.E. Corporation	Non-member
"	Keiichi Tomizawa	Furukawa Electric Co., Ltd.	Member
"	Akihito Toyota	Yasukawa Electric Corporation	Member
"	Masayoshi Nagata	University of Hyogo	Member
"	Koichi Nishiwaki	Fuji Electric Co., Ltd.	Member
"	Naoki Hayakawa	Nagoya University	Member
"	Takeshi Hara	Yanmar Holdings Co., Ltd.	Member
"	Masayuki Hikita	Kyushu Institute of Technology	Member
"	Tatsuya Hirose	Toshiba Infrastructure Systems & Solutions Corporation	Member
"	Satoshi Matsumoto	Shibaura Institute of Technology	Member
"	Yoshinobu Murakami	Toyohashi University of Technology	Member
Secretary	Yusuke Kikuchi	University of Hyogo	Member
"	Toru Wakimoto	SOKEN, Inc.	Member
Assistant secretary	Takahiro Umemoto	Mitsubishi Electric Corporation	Member

7. Activity schedule

Committee meetings: 4 times/year; Secretariat: 2 times/year; Planning of technical meetings and others

8. Reporting format

A technical report shall be prepared to present the results.