SMBNC/13/DV

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2020-08-28

INTERNATIONAL ELECTROTECHNICAL COMMISSION

STANDARDIZATION MANAGEMENT BOARD

SUBJECT

Proposal for a new TC on *Robotics for electricity generation, transmission and distribution systems*

BACKGROUND

The attached proposal from the Chinese NC for a new Technical Committee on *Robotics for electricity generation, transmission and distribution systems* is submitted to all IEC National Committees in accordance with the process described in the ISO/IEC Directives, Part 1, §1.5.6 and with the IEC Rules of Procedure § 11.2, for reply within 12 weeks.

11.2 Setting up of a technical committee

The Standardization Management Board shall create a technical committee if the following conditions are fulfilled:

a) it is proposed in accordance with the Directives;
b) all Full Member National Committees have been consulted by the Central Office;
c) a two-third majority of Full Member National Committees having voted approves the proposal;
d) at least five Full Member National Committees have expressed their intention to participate actively;
e) the scope has been clearly defined.

ACTION

IEC National Committees are invited to vote on the establishment of the proposed new TC using the IEC voting/commenting system **by 2020-11-20**.

Annex 1: Chinese NC proposal
Annex 2: Chinese presentation

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PROPOSAL FOR A NEW FIELD OF TECHNICAL ACTIVITY

PROPOSER:	DATE OF CIRCULATION:
Chinese NC	**2020-08-28**

A proposal for a new field of technical activity shall be submitted to the Central Office, which will assign it a reference number and process the proposal in accordance with ISO/IEC Directives, Part 1, 1.5. Guidelines for proposing and justifying a new field of activity are given in the ISO/IEC Directives, Part1, Annex C.

THE PROPOSAL (to be completed by the proposer):

TITLE (the title shall be described unambiguously and as concisely as possible)

Robotics for electricity generation, transmission and distribution systems

SCOPE (the scope shall define precisely the limits of the proposed new field of activity and shall begin with "Standardization of ..." or "Standardization in the field of ...")

Standardization of robotics applied in power systems, i.e. power plants, substations, transmission and distribution lines, etc., mainly includes terminology, design, functions and performance, test methods, interfaces between robots and information systems, operation methods, and safety and security requirements.
Robot systems used in power systems shall include those travelling on rails, on ground (via unmanned ground vehicles), in the air (just like unmanned aerial vehicles based inspection robots), under water/liquid (via unmanned underwater vehicles), and on or inside equipment, etc.
Standardization of edge computing as well as diagnosis and analysis of information acquired by robot systems also falls in the scope of the TC.
This TC will coordinate with other relevant standardization organizations in the related fields, such as ISO/TC 299, and other IEC TCs which relate to industry specific applications, such as TC 82, TC 88, and TC 114. Robotics for nuclear power applications is excluded from the scope of this TC.
* Robotics applied in the electric power system means robotics which is featured with a degree of autonomy that allows for assisting or even replacing human workers to complete certain tasks, such as construction, patrol, inspection, operation and maintenance of electrical equipment.

PURPOSE AND JUSTIFICATION (the justification shall endeavour to assess the economic and social advantages which would result from the adoption of International Standards in the proposed new field)

Traditional life-cycle management of the electric power system requires significant manpower and have issues with efficiency, consistency, quality, and especially safety in high voltage environments, severe climatic conditions, and hardly accessible locations. Power utilities, asset managers and engineers are always looking for ways to achieve highest levels of safety and technical excellence, while keeping costs of construction, operations and maintenance down. Application of robotics in the electric power system is one of the promising ways to achieve these goals. Based on the rapid development of sensors and artificial intelligence, many different robots have been developed in different countries, which could assist or replace people for different work in construction, patrol, inspection, operation, and maintenance of power facilities, either in power generation, transmission, or distribution. Currently, many types of robot systems have already been in full operation in some countries.
(1) Robotics used in power generation
For robotic inspection in power generation, CIGRE Technical Brochure (TB) 503 collected data by means of a survey made through a questionnaire. Power utilities and consultants from Israel, Spain, Canada, and South Africa answered they had business with the robotic inspection in turbo generators, and in-situ inspections with the aid of robots had provided assessment capability of some generator components without rotor removal. For thermal power generation, robots are developed in China to inspect defects on outer surface of finned heat exchange tubes of boilers. In hydropower stations, underwater robotic vehicles are used to detect dam cracks and damages as well as debris blocking in countries like Canada, China, France, Italy, Venezuela, and Thailand. On wind farms, robots are used to inspect wind turbine blades in the USA and Germany, and they can autonomously move along a blade to reach each part of it and detect cracks or scuffs on the surface, while ultrasonic enable them to detect damage to interior layers. For photovoltaic power generation, robots are used to clean solar panels in China, Switzerland, and Japan. For nuclear power generation, robots are developed and used for emergency response in countries like Japan and China.
(2) Robotics used in power transmission
In power transmission inspection and maintenance, based on CIGRE TB 731, many robotic technologies have already proven to be a new and valuable means of inspecting overhead transmission lines. A few major utilities have already introduced robotics into their maintenance practices, and several are funding projects to do so. Line suspended robots have been developed in Canada, China, Japan, the USA, South Africa, and New Zealand. Among them, inspection robots can obtain clear visible light images and infrared images of lines, metal fittings, and towers, as well as detect the exact fault location; de-icing robots can remove the ice on overhead lines. Unmanned Aerial Vehicles (UAV)-based inspection robots have been developed in several countries such as China, the USA and Spain, and are mainly used for automatic photographing of transmission lines, towers and equipment thereon, defect identification and location, as well as early alarming. Ground-based robots in the USA and South Africa represent a mature technology to remotely capture and control energized conductors and execute tasks, just like transmission structure repair and replacement. The insulator string detection robots have been

developed in China, South Korea and the USA, and can examine the details of defects in the insulators with a resistance tester or a crack detecting device. Other types of robots have been developed for less conventional works, such as tower/pole climbing, insulator cleaning.
(3) Robotics used in substations
For application of robotics in substations, the studies carried out by the CIGRE B3.47 working group show that thousands of unmanned ground vehicle (UGV)-based patrol robots have been in full operation in 110 kV to 1000 kV substations in China. Carrying HD cameras, infrared imagers, optional ultraviolet imagers and ultrasonic sensors, these robots can perform equipment status recognition, thermal defect detection, audible sound/noise measurement, and detection of partial discharge. In addition, robots packed with high-resolution cameras have been used for fault response and scheduled patrol in New Zealand, while for partial discharge detection and infrared temperature measurements in the USA. And new inspection robots are in the research or trial operation stage in Canada and Japan. In addition, transformer internal inspection robots have been developed and used to do inspection in several countries, without the need to drain the oil. For equipment maintenance, live washing robots and live brushing robots have been put into trial operation in China. Other types of robots, such as operation robots and fire-fighting robots, are still under development and testing in China, Japan, and the USA.
(4) Robotics used in power distribution
In power distribution, CIGRE TB 561 shows that several types of live working robots are used to carry out the insulation stripping, bolts tightening, falling arrest device replacement, live disconnection, live wiring and other tasks, so that workers can be completely isolated with the high voltage electric field to ensure the maximum safety. To complete complex operation and fulfil safety requirements in live work, several types of live working robots are under development, such as those designed with master-slave arm control, insulated rod, or teleoperation on ground. Currently, robots have been used for live maintenance in the USA, Japan, Spain, China, South Korea, and Ukraine.
At present, a variety of robots have been successfully developed and put into operation in different power utilities in the world. Due to the lack of standards and not clear technical demands, the functions and performance of robots vary in different countries, while showing low compatibility. International Standards need to be established to reach consensus on functions and performance, safety and security, availability, and efficiency, to improve the service quality of robots and reduce repeated research cost.
Currently, there is no specific TC in IEC dealing with robotics applied to electric power systems, neither have other international organizations started standardization activities in such field. There are some organizations that have started the standardization for general robotics and some other specific robots. For example, ISO/TC 299 works on standardization of robotics and robotic devices, with a focus on industrial robots, service robots and medical devices using robotic technology. There are no directly related International Standards being developed or published to provide support or guidance for application of robotics in electric power systems, while existing standards cannot fulfil this goal.
For the harmonization on a global scale, it is necessary to establish a new TC in IEC for standardization of robotics applied to electric power systems, to accelerate the development of relevant standards. The proposed TC will work out a standard system framework to ensure clear and comprehensive standards development, such as in terms of robot system definition, function and performance, testing and application, and then develop relevant standards to meet the application requirements on safety and functionality.
The proposed TC will carry out the technical analysis and application requirements research via such means as questionnaire-based survey and discussion at meetings and seminars, and will develop standards with priority given to the most urgent global market needs.

PROGRAMME OF WORK (list of principal questions which the proposer wishes to be included within the limits given in the proposed scope, indicating what aspects of the subject should be dealt with, e.g. terminology, test methods, dimensions and tolerances, performance requirements, technical specifications, etc.)

The standardization work of the proposed TC will focus on the development of standards on: terms and definitions; safety and security requirements; typical design for robots systems with different functions; performance requirements and test methods for robot systems that are already used; interfaces between robot systems and information systems of power utilities; and use cases, which are all focused on typical robot systems applied to electric power systems with certain functions and other features.

- Terms and definitions of electric power robots
- General requirements of safety and security for electric power robots
- Design
  - Typical design of the inspection robot systems

…

- Functions and performance
  - Functions and performance of inspection robot systems for substations
  - Functions and performance of inspection robot systems for overhead transmission lines

  …
- Test methods
  - Test methods of inspection robot systems for substations
  - Test methods of inspection robot systems for overhead transmission lines

  …
- Communication interface between robot systems and information systems of power utilities
  - Data model, interface definition, and information security between patrol robot systems and information systems in substations

  …
- Use cases

  …
- ……

PREFERRED TYPE OF DELIVERABLES

IS, TS, TR, PAS

RELEVANT EXISTING DOCUMENTS AT THE INTERNATIONAL, REGIONAL AND NATIONAL LEVELS (relevant documents to be considered: national standards or other normative documents)

(1) CIGRE TB 503 “State of the Art and Capacity for Robotic Inspection of Turbo-generators”. Conclusions are presented based on the experience acquired with robotic inspection by manufacturers and users. A robotic inspection allows detecting any foreign objects in the air gap, hot spots, scratches and flaking paint in the stator or rotor active part surface, etc.
(2) CIGRE TB 731 "The use of robotics in assessment and maintenance of overhead lines" (prepared by CIGRE B2.52 Working Group) presents a review of robotic technologies for the effective implementation, assessment, and maintenance of overhead transmission lines. Maintenance tasks, including inspection and repairs, are identified as high-value applications in transmission live-line work. The ability to perform maintenance and inspection services and upgrading transmission lines without de-energizing the transmission lines has many economic, social, and environmental benefits to the network owner.
(3) CIGRE TOR WG B2.74 “Use of unmanned aerial vehicles (UAVs) for assistance with inspection of overhead power lines”.
(4) CIGRE WG B3.47’s TB “Application of Robotics in Substations” has been established to collect worldwide needs for the application of robotic technology in substations, define main application scenarios, identify key technical requirements and challenges, prepare case studies describing best practices, identify standardization needs and provide suggestions for the follow-up work. The TB will be published in May.

RELATION TO AND IMPACT ON EXISTING WORK

The proposed TC, if established, will set up liaisons with relevant IEC and ISO committees, such as IEC TC 8, TC 57, TC 65, TC 78, TC 82, TC 88, TC 114, PC 128, and ISO/TC 299.

OTHER ORGANIZATIONS RELATED TO THE PROPOSED TC INCLUDE CIGRE, IEEE, ETC.

RELEVANT COUNTRY PARTICIPATION

National members of CIGRE B3.47 and CIGRE B2.52, such as China (Convener of B3.47), Canada (Convener of B2.52), the USA, Japan, New Zealand, and Portugal, will be invited to participate in the proposed TC, if the TC is established. Other NCs are also welcomed to join the work.

LIAISON ORGANIZATIONS (list of organizations or external or internal bodies with which co-operation and liaison should be established)

Internal IEC liaisons:
IEC TC 78 Live working

External liaisons:
ISO/TC 299 Robotics
CIGRE A1 Rotating electrical machines
CIGRE B2 Overhead lines
CIGRE B3 Substations and electrical installations

STAKEHOLDERS

Power utilities, electric power research institutes, robot manufacturers, universities

LEADERSHIP COMMITMENT

If the proposal is approved, the Chinese NC would like to undertake the work of secretariat of the new TC.

The Chinese NC confirms to accept the responsibilities of the secretariat of the proposed new TC and will ensures that adequate resources are available for this task.

OTHER COMMENTS (if any)

COMMENTS OF THE GENERAL SECRETARY (to be completed by the Central Office):

This proposal was initially reviewed by the SMB at its remote meeting on 2020-06-09. The SMB recommended to first gather inputs and feedback from NCs, TCs, as well as ISO/TC 299, in a web conference that was held on 2020-07-17. A report from this web conference was circulated to the SMB on 2020-07-24 (document SMB/7093/R), based on which the SMB approved on 2020-08-25 (document SMB/7093A/RV) to recommend circulating the proposal for a new TC on Robotics for electricity generation, transmission, and distribution systems, to NCs for formal ballot.

A New TC on Robotics for Electricity Generation, Transmission and Distribution Systems



IEC National Committee of China

July 17, 2020

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1. Market needs

Application of robotics in power systems is becoming a trend.

Safety, efficiency, reliability, and **workforce shortage** are the typical concerns of power utilities, stressing urgent need for robotics.

Due to the **rapid development** of sensors, computing, and artificial intelligence (AI), the robotic technologies are becoming **more and more mature.**

Now, different robots have been **massively deployed** in power utilities and become **part of daily operation and maintenance scheme.**

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1. Market needs

Generation

Dam inspection robot (UK)

Transmission

UAV-based inspection robot system (China)

Substation

Inspection robot (New Zealand)

Distribution

Maintenance robot (Japan)

Robots have been applied in power generation, transmission, transformation and distribution systems across the countries such as **Brazil, Canada, China, France, Germany, Israel, Japan, New Zealand, South Africa, South Korea, Spain, United Kingdom and United States.**

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1. Market needs

Construction

Wall treatment

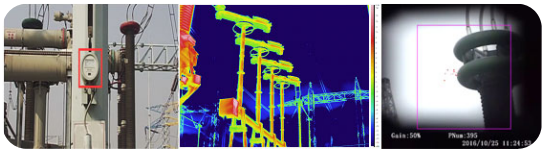
Operation

Disconnecting switch

Maintenance

Live working

Inspection



Visual, IR & UV inspection

Emergency response

Fire-fighting

The future market of robots in power systems is **very promising.**

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1. Market needs

Example video of substation patrol robot

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2. Technical Challenges

Challenges in robotics application

- Safety and security
- Interchangeability for key parts
- Interoperability
- Standardized interfaces
- Common testing methods
- Typical operation procedures

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3. Relevant Research

- **Final report of IEC/SMB/SG7 Electrotechnical Applications of Robot Technologies (SMB/5582/R) in 2015**
  - provided an overview of collaboration between former ISO/TC299 (ISO/TC184/SC2) and IEC/TCs.
  - foresee that there will be an increasing robotic application work in IEC.

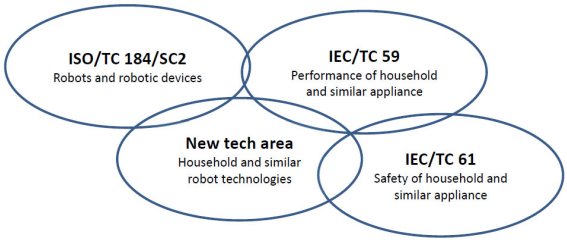

Figure 1: Current and possible future work items in the field robotic standardization

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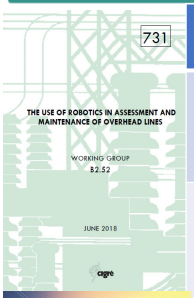
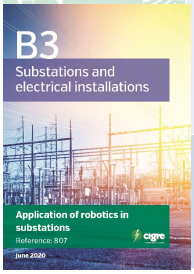
3. Relevant Research





Category	CIGRE	Title	Members
Generation	WG A1.23	State of the Art and Capacity for Robotic Inspection of Turbo-generators	Convenor: S. Marcio BR Member: CA, ES, IL, ZA, …
Transmission	WG B2.52	Use of robotics in assessment and maintenance of overhead lines	Convenor: A. Lwblond CA Secretary: C. Pon CA Member: AT, AU, DE, ES, FR, GB, IE, JP, KR, US, …
	WG B2.74	Use of UAVs for assistance with inspection of overhead power lines	Convenor: M. Nishal ZA
Substation	WG B3.47	Application of robotics in substations	Convenor: J. Fan CN Secretary: S. Sagareli US Member: CA, JP, NZ, …

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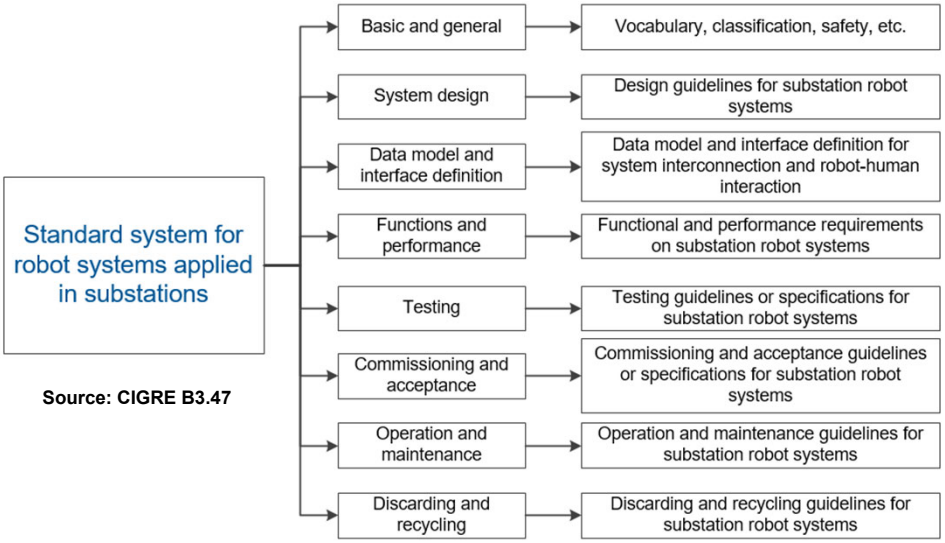
3. Relevant Research



Source: CIGRE B3.47

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4. Necessity of a New IEC TC

Necessity

- No TC in IEC specifically deals with this new field of electric power robots
- No relevant standards development has been carried out in IEC

Targets

- To develop a systematic standardization framework
- To specify horizontal requirements of electric power robots
- To standardize the design, functionality, performance evaluation, testing methods, common interface and etc.
- To provide application guidance for typical scenarios.

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5. Scope of the New IEC TC

The standardization of robotics applied in power systems, i.e., power plants, substations, transmission/distribution lines, etc., mainly includes terminology, design, functions and performance, test methods, interfaces between robots and information systems, operation methods, and the safety and security requirements.

- Robot systems used in the power system shall include those travel on rails, on ground (via unmanned ground vehicles), in the air (e.g. unmanned aerial vehicles-based inspection robots), under water/liquid (via unmanned underwater vehicles), on or inside equipment, etc.
- Standardization of edge computing as well as diagnosis and analysis of information acquired by robot systems also falls in the scope of the TC.
- The new TC will coordinate with other relevant standardization organizations in the related fields, such as ISO.

Note: Robotics applied in the electric power system means robotics which is featured with a degree of autonomy that allows for assisting or even replacing human workers to complete certain tasks, such as construction, patrol, inspection, operation and maintenance of electrical equipment.

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6. Program of work

Electric power robots

Terms and definitions	System composition, application scene, work zone, …
Safety & Security	Operation safety requirements, information security, …
Design	Specialized parts, communication mode, interaction items, …
Functions and performance	Mobility, equipment status recognition, inspection accuracy, …
Test method	Test methods for mobility, inspection accuracy, …
Communication interface	Data model, interface definition between robot systems and utility information systems
Use cases	Operation method of inspection robot systems in substations, …

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7. New TC and existing ISO TCs

ISO/TC 299 Robotics:

Scope

"Standardization in the field of robotics, excluding toys and military applications."

Working groups under TC 299:
ISO/TC 299/WG 1 Vocabulary and characteristics
ISO/TC 299/WG 2 Service robot safety
ISO/TC 299/WG 3 Industrial safety
ISO/TC 299/WG 4 Service robot performance
ISO/TC 299/JWG 5 Joint ISO/TC 299 - IEC/SC 62A - IEC/SC 62D WG: Medical robot safety
ISO/TC 299/WG 6 Modularity for service robots

Distinctions and relevance

- Electric power robot systems are designed to work on power facilities with specific functions in high-voltage environment. Obviously, IEC is the best place to have the most relevant expertise.
- General standards developed by ISO/TC 299 will be followed.

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8. New TC and existing IEC TCs

IEC TC 78 Live working:

Scope

"To prepare international standards for tools, equipment and devices for utilization in Live Working, including their performance requirements, care and maintenance. Excluded: Work practices and methods for Live Working.
To prepare technical publications related to the utilization of tools, equipment and devices on, and in the vicinity of, live parts of electrical installations and systems."

Working groups under TC 78:
WG 1 Terminology and symbols
WG 11 Technical support
WG 12 Tools and equipment
WG 13 Protective equipment
WG 14 Diagnostic equipment
WG 15 Arc Flash protection

Distinctions and relevance

The proposal requires independent design and guidance on work practices and methods depending on different application scenarios such as patrol robots and also includes sensing, drive, mechanical, battery, control and HMI systems.

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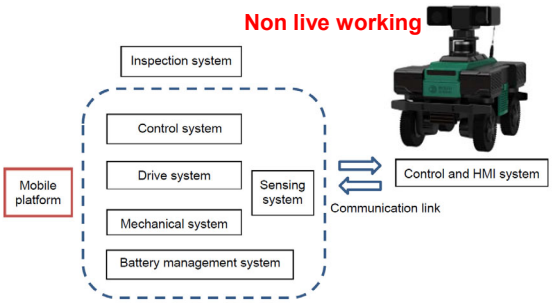
8. New TC and existing IEC TCs

Difference between IEC TC 78 Live working and new proposal

Non live working



1. Tools: insulating sticks, gloves, rods, matting, blankets, sleeves, ladder, ropes, conductive clothing and voltage detector
2. Minimum approach distances

TC 78

A typical electric power robot system consists of a mobile platform, inspection or operation equipment and an AI based decision-making control system. It is a multifunction system to aid or replace people.

New proposal

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8. New TC and existing IEC TCs

Example video of insulator string inspection robot

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8. New TC and existing IEC TCs

- **Other TCs claimed to be relevant to the proposed TC in IEC**
  - IEC TC 8 System aspects of electrical energy supply
  - IEC TC 65 Industrial-process measurement, control and automation

  TC8 is about system aspects of power grids. TC 65 is about the automation system for industrial manufacturing. And the proposed is about robot system applied in power system. They are in completely different domain.
  - IEC/TC123 power asset management

  TC123 develops common methods and guidelines for lifetime management of network assets. Although the inspection of the power robots might provide a solution to achieve more efficient lifetime assets, the proposed TC will focus on the power robots system itself and will not cover asset management aspects.

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8. New TC and existing IEC TCs

- **Other TCs claimed to be relevant to the proposed TC in IEC**
  - IEC TC18 Electrical installations of ships and of mobile and fixed offshore units
  - IEC TC 82 Solar photovoltaic energy systems
  - IEC TC 88 Wind energy generation systems
  - IEC TC 114 Marine energy - Wave, tidal and other water current converters
  - IEC/PC128 Operation of electrical installation

  The above TCs focus on standardization of electrical equipment and key components rather than robotics and the applications.

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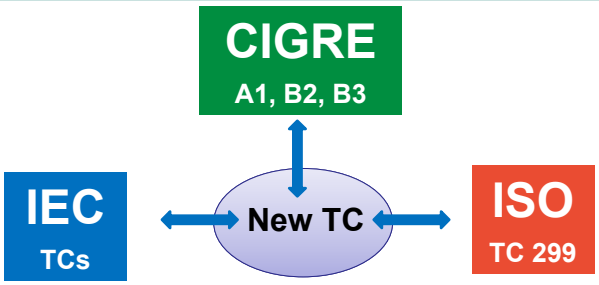
9. Liaisons



- Relevant IEC TCs
- ISO TC 299 Robotics
- CIGRE A1 Rotating electrical machines
- CIGRE B2 Overhead lines
- CIGRE B3 Substations and electrical installations

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10. Conclusions

1. No overlap with ISO and IEC TCs

Through comparison and analysis mentioned above, one can see there is no overlapping issue identified.

2. Strong Market Needs

Rapid development of relevant technologies leads to more mature robotic application. In-depth analysis from worldwide survey shows an increasing need for standardization.

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11. Remarks

1. **IEC lost many opportunities to make the first move in …**

   Electrical Vehicle, electrification of aircrafts…

   Many NCs have expressed their concern that IEC should be more agile and proactive and should not be left behind other SDOs such as ISO and IEEE in these fields.

2. **We should not lose this one again**

   Power generation, transmission and distribution is the core domain of IEC. We should move quickly and start the standardization work in this area to meet the fast-growing market needs.

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Thanks for your attention !

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