Project Title: Preparation of a comprehensive guide for application of power electronic transformers in power grids

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Project Necessity:

With increasing global warming and declining prices for renewable energy technologies such as solar and wind, the importance of distributed energy generation is becoming more apparent than ever. distributed energy generation itself addresses the issue of smart grids and microgrids as well as the DC distribution network. Therefore, as the future of the power distribution network will move to smart grids, in order to lay the groundwork and prepare the distribution network for a fully controlled network, familiarity and research on electronic power transformer (PET) technology are essential**.**

In recent decades, the concept of smart grids has attracted the attention of researchers and craftsmen as an acceptable solution to the challenges of the power system. Due to the growth of load, increasing the penetration of new energies (renewable) and the various arrangements that exist from distributed generation sources, smart distribution networks have received more attention. Due to the existence of DC and AC production sources as well as AC and DC consumption in case of not using hybrid microgrids, there will be a need to use AC / DC converters frequently and vice versa, which will increase losses and costs in the system. It turns out. One solution for connecting distributed generation sources, loads, and energy storage sources to microgrids, as well as for connecting microgrids to the power grid, is to use multi-port converters and electronic power transformers or solid-state transformers. The need for accurate and fast control of smart grids and the creation of direct current lines, itself requires electronic power devices such as PET. Therefore, in the perspective of power networks, the use of power electronics, especially SST, will be inevitable. This technology can also replace converters that are connected to the network with a separate transformer. STATCOM, wind turbine and solar power plant converters, converters used in electric vehicle charging stations, high-power industrial motor drives, converters used in electric trains, etc. A few examples of The application of this

technology will be in the future of the electricity industry, which will reduce losses, reduce manufacturing costs, reduce weight and increase controllability.
With the development and increasing use of power electronic knowledge and high power converters in the world and the need to have a suitable platform for the development and use of this knowledge in Iran in line with other leading countries, the need for a comprehensive plan in this field is strongly felt. There is also a need for an organization in charge of technology development in this field in order to address the challenges facing the development of PET technology as well as the challenges of widespread use and application of the new generation of intelligent distribution systems. Proposed tasks for this organization include adapting international and valid international standards and guidelines, editing and amending existing standards and guidelines, providing a vision document for long-term time horizons in order to improve the existing distribution systems in the country, supporting producers and investors. Knowledge-based companies pointed to the advancement of this technology.

Project Goals:

The main purpose of this project is to properly identify and present the technology tree of power electronic transformers. Identifying areas of application, the impact of the application of this technology in increasing the flexibility of the power network and increasing productivity and controllability, how to achieve design knowledge, and also how to achieve manufacturing technology are other goals of this project.

Abstract:

In the first step, it has been shown that the use of PET technology is very increasing and it is very important to know the technology and acquire technical knowledge of its design, construction, and operation. Second, multi-level structures based on HB (CHB-based PET) modules are accessible and operational topologies for power electronics transformers. It seems necessary to use SiC semiconductors to build high-voltage, high-efficiency converters. The use of amorphous or nano-crystal nuclei is essential for the construction of the second floor (DC-DC). This is because other cores have the problem of high losses or low flux density, which would contradict the PET philosophy.
With the rapid development of power electronics technologies, the global PET market will be booming. In this project, it has been concluded that due to the high cost of manufacturing and production of high power semiconductors and high-frequency cores, in the short and medium-term, only the design, construction, and assembly of the converter have been localized. Key parts are supplied through imports. At the end of the standard draft, the use of PET in the distribution network is provided instead of traditional transformers.

Steps and Methodologies:

In this project, the concept of power electronics transformers was first explained. The history of technology introduction and the process of technology maturation were explained. Different types of power electronic transformers were introduced and the advantages and disadvantages of each were examined. The types of PET applications were examined. Application in electric trains, renewable power plants, electric car charging stations, distribution network FACTS devices, active filters, smart and micro-grids, distribution grid, etc are examples of the widespread use of PET. All information is encoded in one volume of the report and approved by the supervisor.

After the general introduction of the system, in the second step, the types of structures that can be used on different PET stages have been studied and the advantages and disadvantages of each have been collected. High-voltage and low-loss semiconductor technologies were studied and the future of their application in PET and other high-voltage converters was examined. The technology of high-frequency magnetic cores has also been studied and the importance of these cores in the overall structure of PET has been shown. The types of control methods for different stages have been studied. All information is encoded in one volume of the report and approved by the supervisor.

In the third step, the current and future markets of power electronics transformers are examined. At this stage, it has been tried to first evaluate the feasibility of using PET technology in various applications of energy and electricity distribution grid, and then to map the technological areas of PET, including topologies, filters, transducers, high-frequency transformers, control, and protection. The following is a comparison between PET and conventional magnetic transformers in terms of production cost and economic justification for their application in the distribution network. Authoritative external manufacturers as well as domestic capabilities for PET manufacturing and production have been identified, and laboratories and active domestic companies related to power electronics devices and converters that have the potential to produce PET have been investigated. All the information of this stage is written in one volume of the report and has been approved by the respected observer.

In our country, due to the advantages of power electronic transformers, localization, and access to technical knowledge of design and manufacturing are important. The prerequisite for this is the basic knowledge and development of this technology, and the first step in this direction is to fully identify and surround the practical, technical, and economic dimensions of this technology in the form of an executive document for the development of technology. The purpose of this step is to get a general understanding and process of accessing the technology of converters in the PET building and its development. In this regard, after conducting preliminary studies and identifying foreign manufacturers and examining internal capabilities, by determining the priority technologies and using the specified parameters and the opinions of experts, how to achieve the technology is determined. All the information of this stage is written in one volume of the report and has been approved by the respected observer.

For PET to replace traditional transformers in the distribution network, it must meet the standards and protection requirements of a typical transformer; For this purpose, first of all, the standards and functional-protective considerations of distribution transformers with a voltage of 20 kV / 400 V in the Iranian electricity distribution network were discussed and the requirements of each section for PET have been investigated. Then, to identify the domestic capability in the field of PET technology development, the areas of technology development required for designing, manufacturing and creating a production line have been studied and the capacities of each field in terms of domestic production or external supply of used parts have been identified; Also, the capacity of establishing a reputable laboratory for testing this equipment and issuing approval for the final product in the country was examined.

Main Results (technical outputs, patents, papers, books, reports, etc.):

Project documentation includes 5 step-by-step reports approved by the supervising supervisor.