Pre – Standardisation Report of
Solid – State Transformers (SSTs)

1. Scope

This document specifies the information about the solid-state transformers (SSTs) including their principle, types, specifications and other terminologies. It is a literature review of the research papers and journals available online since it is a developing concept and hence there are no manufactures of SSTs available in India and hence no industrial visit can be done for the same.

2. Principle

The solid-state transformer (SST) is offered as a tool to meet the requirements of the smart grid. Solid state transformers are comprised of three primary parts: converter to produce high-frequency AC from input line frequency AC, isolation by a high-frequency transformer (HFT), and at last, converter to produce AC with line frequency from AC high frequency. Additionally, the isolation barrier partitions the transformer into two sections: high voltage and low voltage. In addition to being able to perform the same functions as a conventional transformer, SST provides a range of services to the grid, including reactive power compensation, power quality improvement, current limiting and voltage regulation power factor correction, etc., which can lead to improvements and establishing a connection between direct current (DC) and alternating current (AC) equipment. The basic concept of SSTs is shown in figure. The main problems of current power transformers nowadays are as follows :

6.1 They are bulky and voluminous, being inconvenient in applications such as high density urban areas, onboard and special application.

6.2 They are not able to control the power flow.

6.3 Traditional power transformers are not able to regulate the output voltage, etc.

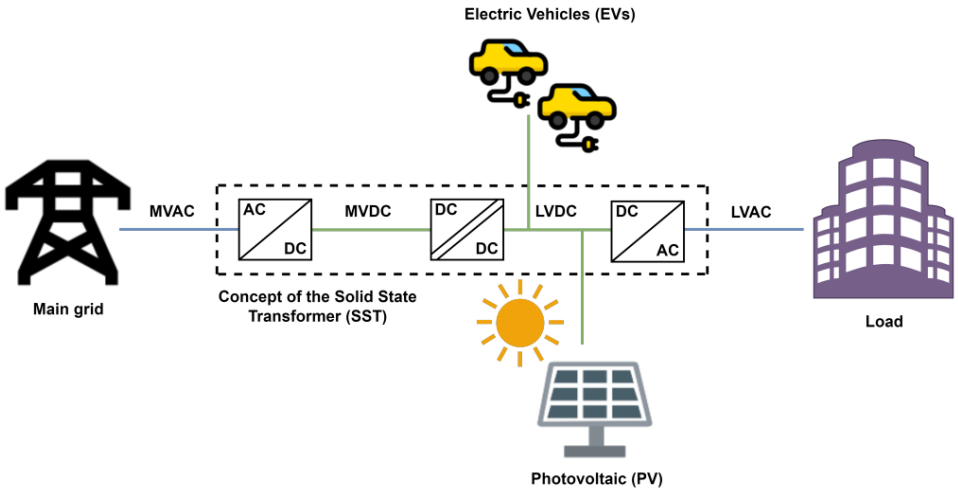

Figure 1. Basic concept of the SST.

3. Types of SSTs proposed

3.1. One Stage : This structure comprises of converting high voltage AC to low voltage AC with an isolation stage.

3.2. Two Stage : In this structure, two models are proposed. In the first model, at first the AC voltage is converted to low voltage DC and then the low voltage DC is converted to low voltage AC. But in the second structure, first the AC voltage is converted to high voltage DC and then to low voltage AC.

3.2.1 AC-DC isolated boost + PWM inverter
3.2.2 AC-DC DAB + PWM inverter

3.3. Three Stage : This structure has a triple conversion in which high frequency isolation is performed in DC-DC stage. In this model, both HVDC and LVDC links are available.

3.3.1 PWM rectifier + DC–DC DAB + PWM inverter
3.3.2 Multilevel rectifier + DC-DC full-bridge converter + PWM inverter

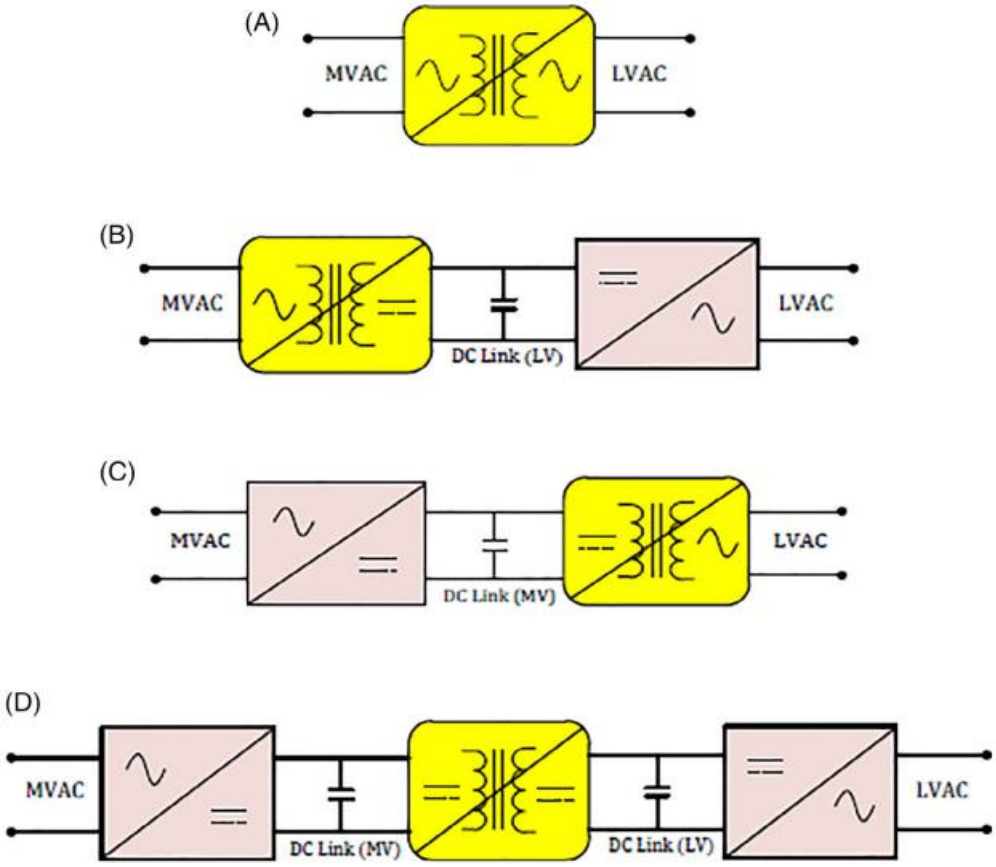

Figure 2. Types of SSTs

4. References

4.1. United Nations Framework Convention on Climate Change, Paris Agreement, 2015.

4.2. European Commission. The European Green Deal; European Commission: Brussels, Belgium, 2019.

4.3. Kartalidis, A.; Atsonios, K.; Nikolopoulos, N. Enhancing the self-resilience of high renewable energy sources, interconnected islanding areas through innovative energy production, storage, and management technologies: Grid simulations and energy assessment. Int. J. Energy Res.

4.4. Apostolopoulos, V.; Giourka, P.; Martinopoulos, G.; Angelakoglou, K.; Kourtzanidis, K.; Nikolopoulos, N. Smart readiness indicator evaluation and cost estimation of smart retrofitting scenarios—A comparative case-study in European residential buildings. Sustain. Cities Soc.

5. Projects started on developing SSTs

Project Name/Year	Stakeholder	Application	Voltage	Power	Switching Freq.	Country
M2LC [56]/2004	Siemens	Railway, Distribution power grid	15 kV	2 MW	≤2.5 kHz	Germany
UNIFLEX-PM [66]/2009	ABB (Hitachi Energy now), Univ. of Nottingham	Distribution power grid	3.3 kV	300 kVA	Not mentioned	Japan
Fast charger for EVs [62]/2016	Delta Electronics	Charger for electric vehicles	4.8 kV or 13.2 kV AC to 1 kV DC	400 kW	Not mentioned	Taiwan
FUNDRES [75]/2021	LAPLACE	Railway	1.8 kV DC	300 kW	15 kHz	United Kingdom
TIGON [81]/2024	CIRCE, PREMO	Hybrid grids AC/DC DC grid integration	3 kV DC/0.4 kV AC	300 kW	83 kHz	Spain

6. Conclusion

This document is a literature review of the research papers and journals available online since it is a developing concept and hence there are no manufactures of SSTs available in India and hence no industrial visit can be done for the same. It is a growing concept and soon it will be implemented worldwide and India is also going to work further in this field. Apart from India, other countries in Europe and Asia are moving towards SSTs rapidly and also started some projects regarding this concept.

SST technology is attracting worldwide attention. If we consider of present scenario, SSTs are not going to substitute 50/60 Hz power transformers. Traditional power transformers are a cheap, mature and very reliable technology, and SSTs will not overpass them completely, at least for the next few decades. Indeed, several studies have assessed SST technology from an economic point of view.