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Research paper

Railway Traction System Based on Power Electronic Transformer

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Abstract

In this work design and development of Power Electronics transformer (PET) – based railroad traction system presented. Conventional system is more weight, less efficient and more size. To overcome problems in conventional system PET based system is proposed. The simulation results are carried out by MATLAB/SIMULINK software for, 25kV, 50Hz Supply, which is given to the Locomotive which draws the Power (P) of 400kW.

Keywords: *Power Electronics Converter, Front End Converter, Back End Conveter, Medium Frequency Transformer, IGBT .*

1. Introduction

These days, ordinary conventional transformers (CTs) are broadly spread in electrical frameworks giving fundamental functionalities, for example, voltage segregation and voltage adjustment. Be that as it may, to manage control quality issues at medium level voltage (MLV) range, there is a requirement for the establishment of extra hardware .This prompts a further increment of establishment volume, so some specific applications may not be practical. Later patterns in MLV applications are replicating something that has just been accomplished and set in motion in the lower level voltage applications. There, CTs have generally been supplanted by medium Frequency transformers (MFTs) where high frequency waveforms are input to the transformer, there by reduction of volume.

Traction system is perceived as one of the probable early adopters of this developing innovation. A customary (best in class) way to deal with give DC voltage to the variable speed drive on the train is delineated in a rearranged way in Fig.1. The essential twisting of the CTs is associated straightforwardly to the AC catenaries and dynamic rectifier(s) are associated with the auxiliary winding(s) of the transformer where the voltage is ventured down and managed. At least one inverter and engine units are additionally associated with the given DC connect. Since Traction CTTs are typically streamlined for least weight (2-4kg/kVA) and are vigorously stacked, the subsequent proficiency is fairly poor and it is around 90%. Because of using oil as cooling and protection, which further increasing weight and potential natural issues (i.e. on account of spillage)?

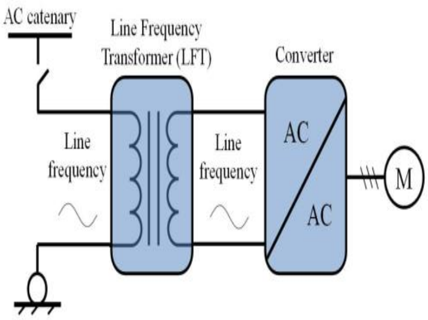

Fig 1: Conventional transformer

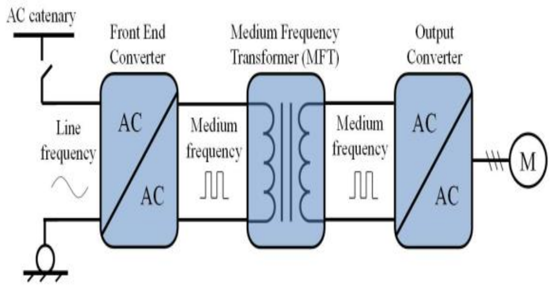

Fig2: medium frequency transformer (MFT)

In a traditional prepare course of action, where the drive framework is gathered in the train, the heaviness of a CTs isn't important an issue, since a specific weight is required so as to give adequate traction. In the instance of electric multiple units (EMU), where the drive framework is appropriated all through the train, weight turns into an issue and lessening would be invaluable.

A contrasting option to the cutting edge arrangement is the utilization of a supposed power electronic transformer (PET), comprising of a electronic converter in combination of transformers, as delineated in Fig2. Here, some kind of energy is associated straightforwardly to catenaries, while the MFT is giving voltage protection and voltage adjustment.

Single power device can't work specifically with these medium voltages and in this way generally some of sort of arrangement association of various combinations (cells or modules) are required so as to meet the mega level of supply, bringing about a multilevel structure. At long last, correction is required on the auxiliary side of the MFT keeping in mind the end goal to give a DC to the inverter(s).

2. PET Topologies

Different topologies were presented in literature for the acknowledgment of PETs for traction purpose. In literature utilized the thyristor based arrangements [1,2], as in Fig3. The MFTs consists of two H-bridges associated in against parallel while the auxiliary side has a single phase constrained commutated H-connect.
In this execution, the MFT is energized from the auxiliary side by the VSI and the MFT voltage is utilized to commutate the cyclo converter on the essential side. Couple of several Hz is the limitation with thyristor based and produces genuinely high line harmonics at lower frequencies.
To relieve a portion of the issues, the utilization of completely controllable gadgets, for example, IGBTs has been proposed. A particular structure comprising of various cascaded cells acknowledged with IGBTs has risen. At exhibit, the most noteworthy blocking voltage of financially accessible IGBTs is just 6.5kV.

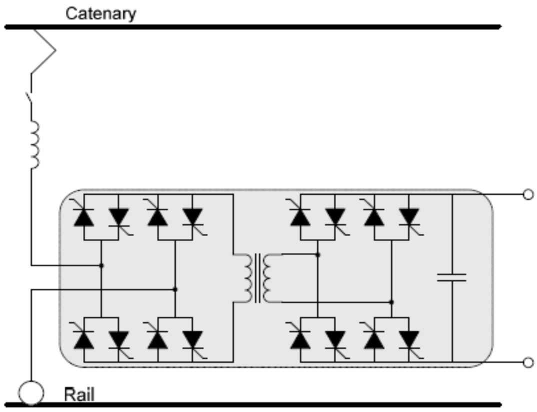

Fig. 3. Primary converter (Thyristor Based)

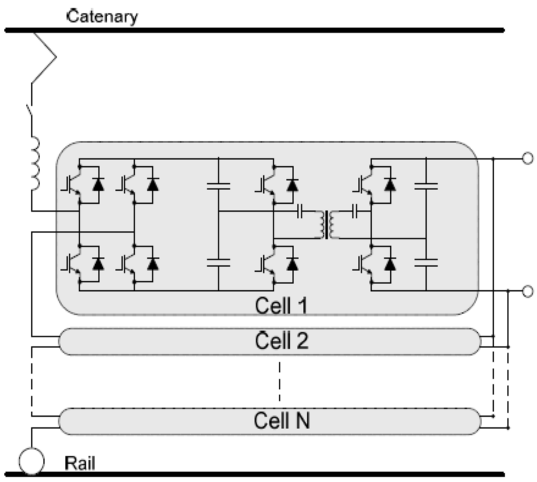

Fig. 4: Cascaded Half Bridge Configuration

A multilevel waveform at the contribution of the PET diminishes the line harmonics and the subsequent channel prerequisites. There is a requirement for various MFTs, each being basic piece of a related cell and evaluated for a small amount of the full power. Be that as it may, protection necessities are not casual and each MFT must be intended for a similar dielectric worry as previously.

The latest topology is appeared in Fig.4 what's more, comparably to the past case it comprises of H-bridges in cascaded at the input and resonating half bridge DC/DC converters at output. Additionally a LLC full tank is utilized. In this manner, both the leakage inductance and the polarizing inductance of the transformer are taking an interest in the reverberation.

3. Reliability of MFT system

The amount of IGBTs and Gate Drive Units (GDUs) is fundamentally expanded contrasted with a traditional framework. Because of expanded number of segments the dependability is relied upon to diminish. A traditional framework is normally set up redundant. The transformer is more solid as the converter with its hardware. Consequently the conventional system has a 50% redundancy, which implies that in most disappointment cases 1 from 2 converter is as yet working and the prepare can keep running by claim control, might be with decreased execution.
To guarantee high accessibility of one MFT framework if there should arise an occurrence of failures, redundancy is built in. Hanging in the balance side one subsystem can be bypassed when the DC/DC converter is blocked, permitting activity with N-1 subsystems in a disappointment cases. Notwithstanding when the dependability is diminished, because of higher amount of segments, the accessibility could be even expanded because of good repetition. Yet in addition the MFT framework may need to develop with excess converter, to expand the "fifty percent redundancy". At any rate in the presentation period of the new innovation the segments prompting a ceasing disappointment should be limited.

4. The Proposed System

Proposed Model with cascaded connection of two cells at line side and parallel at the load side is shown in fig. 5. Both the FEC (Front End Converter) and BEC (Back End Converter) are using 6.5kV IGBTs and instead like in previous models two of the FECs are connected to single MFT (Medium Frequency Transformer), thus making the combination a single module. All the modules are connected to the single BEC having 6.5kV.

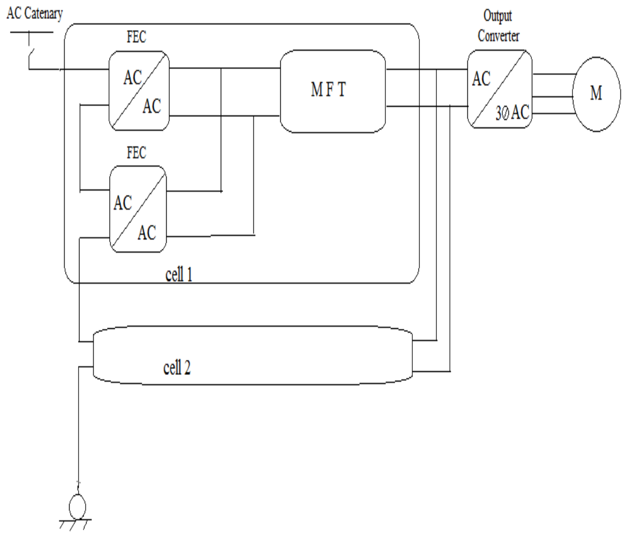

Fig .5. Proposed Model.

5. Matlab/Simulink Results

Proposed model has been realized in MATLAB (Simulink) as shown in fig.6.

Table1: Specifications of proposed model of PET

Input Voltage	25 kV
IGBT Module 5SN 0750G650300	V_{CE}=6500V, I_c= 750 A
Transformer Frequency	1kHz
Power Rating of MFT	250 MVA
Required Output Voltage	415V
Load	400 kW

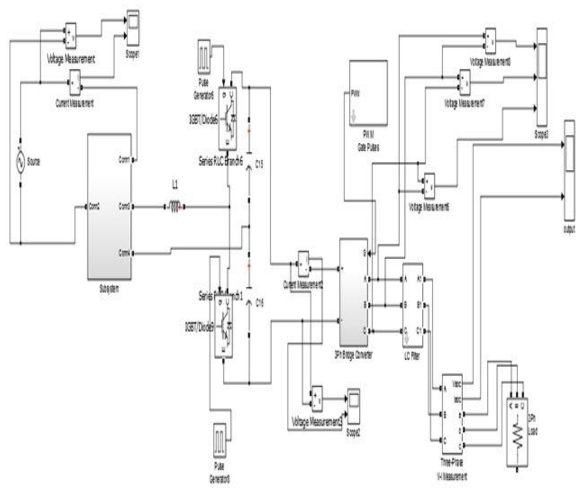

Fig.6. proposed system (MATLAB/Simulink)

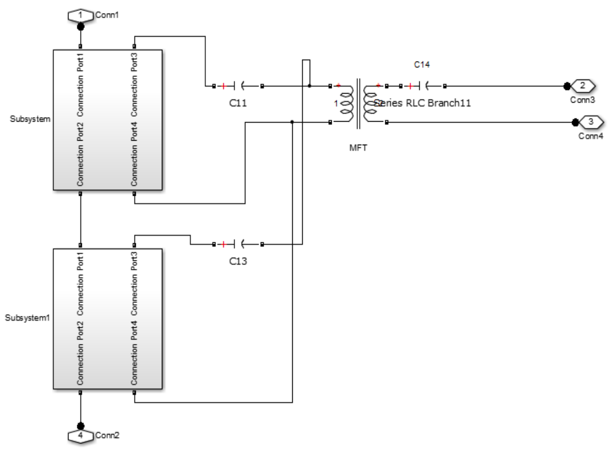

Fig .7. Simulink Model of Single Module of FECs

Line voltage and current, gate pulses to the cascaded converter, load voltage and current waves are shown in fig.(8) to fig.(12).

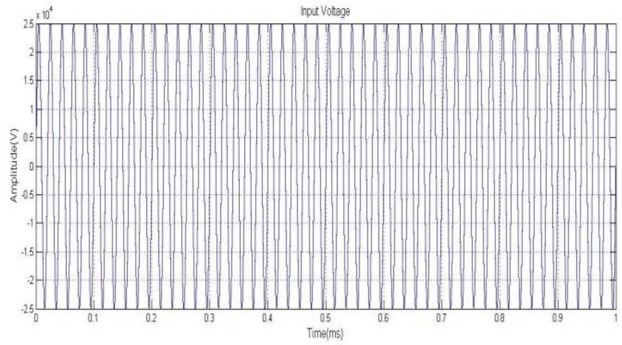

Fig.8 Line voltage waveform

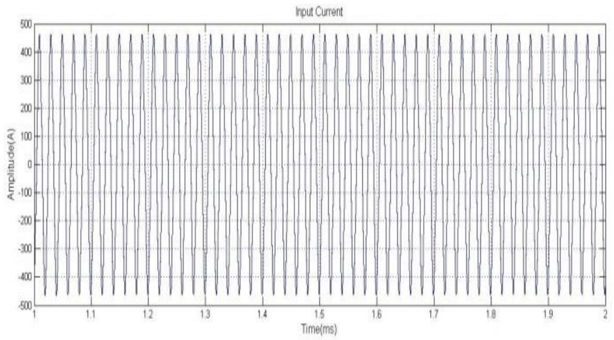

Fig.9 Line current waveform

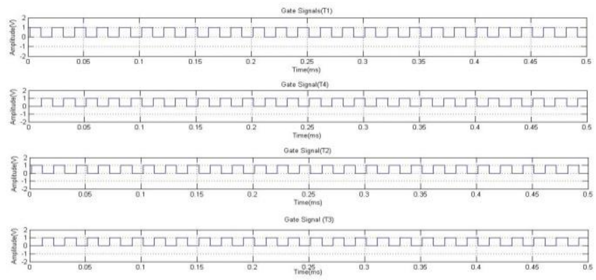

Fig 10. Gate pulses given through PWM to the Full Bridge Rectifier of Front End Converter(FEC)

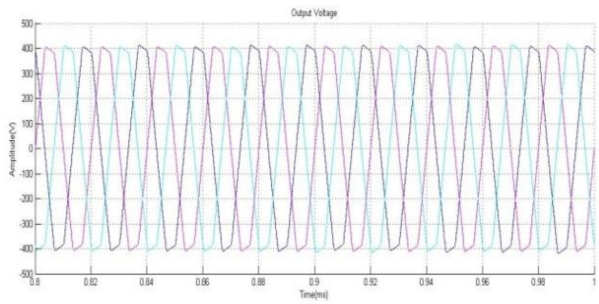

Fig 11. Load Voltage Waveform

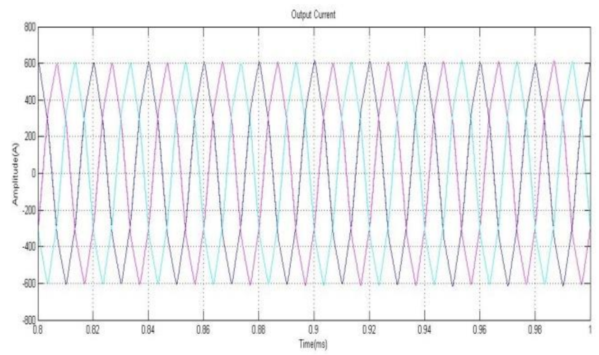

Fig 12. Load Current Waveform

6. Conclusion

From the results, PET-based systems are more superior than CTs systems. PETs are lighter weight, reduced volume and smaller in size. Table (2) Shows results of proposed topology of PET.

Table 2: Results

Input Voltage	25 kV
Input current	463 A
Switching Losses	P_{sw}=11700 W
Output Voltage	415 V
Output Current	615 A
Load	400 kW
Power Factor	0.9
Efficiency of MFT	94%

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