Variable Frequency Transformer For Power Transfer Between Two Network

Pushpendra kumar singh
M.tech Student, Department of Electrical Engineering
Rama University, Kanpur, Uttar Pradesh, India

Amit singh
Assistant Professor
Rama University,Kanpur

Abstract

This paper represent a new model of the variable frequency transformer (VFT). It is basically bidirectional, controllable transmission device. It transfer power between two network. The construction of VFT is similar to conventional asynchronous machines, where the two separate electrical networks are connected to the stator winding and the rotor winding, respectively. The core technology of the VFT is a rotary transformer with three-phase windings on both stator and rotor. A drive motor system are used to adjust the rotational position of the rotor relative to the stator, thereby magnitude controlling and direction of the power flow through the VFT.

This paper gives an overview about core components, mechanical design, commissioning, model, operation, analysis and applications of VFT.

INTRODUCTION

A variable-frequency transformer (VFT) is used to transmit electricity between two (asynchronous or synchronous) alternating current frequency domains. The VFT is a relatively recent development. Most asynchronous grid inter-ties use high-voltage direct current converters, while synchronous grid inter-ties are connected by lines and "ordinary" transformers, but without the ability to control power flow between the systems.

It can be thought of as a very high power synchro, or a rotary converter acting as a frequency changer, which is more efficient than a motor–generator of the same rating.

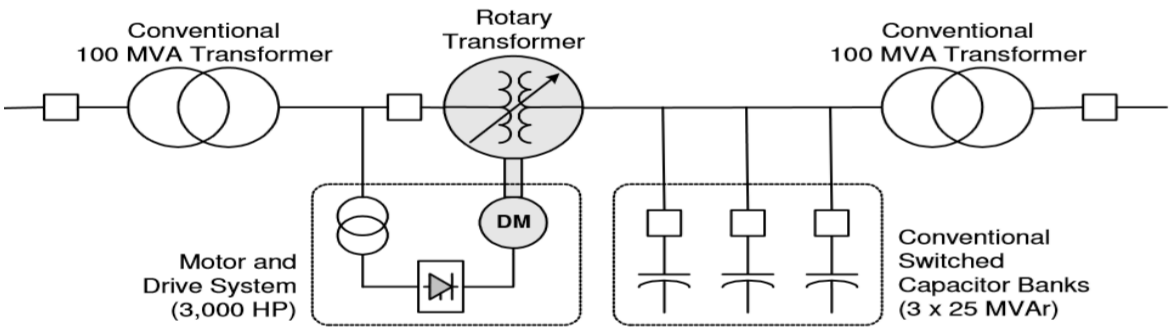


FIG -One line diagram of VFT

VARIABLE FREQUENCY TRANSFORMER OVERVIEW

The basic phenomenon of the vft is that the three phase windings are connected in both side of the transformer that is stator and the rotor side. there is a three phase collector which conducts current between the three phase rotor windings side and its stationary part is duct. The rotor as well as the stator part of electrical network separated respectively in two parts. Due to magnetic coupling presence in network the electrical power is transformed between in the two network through air gap.for apply torque to the rotor of the transformer we used a drive motor and variable speed drive system and to adjusting the rotational position of the rotor which is relative to the stator, thereby controlling

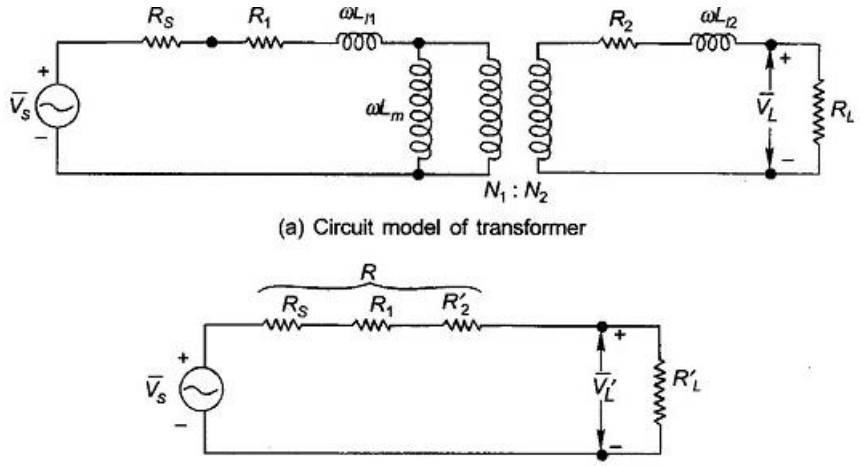
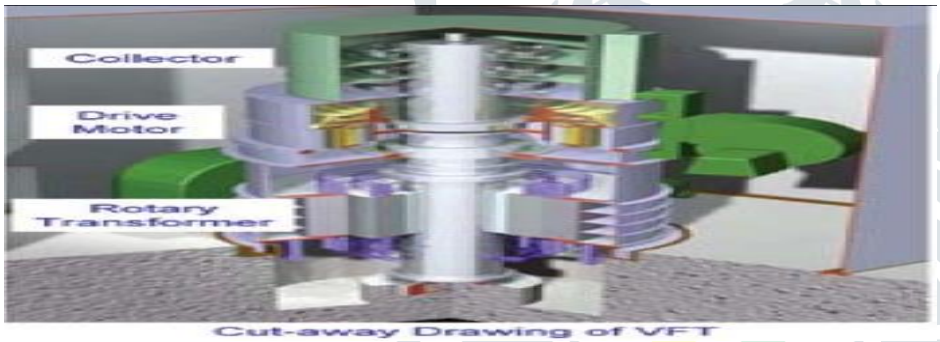


Fig: Equivalent model of transformer

The direction and magnitude of the power flow through the VFT. Equivalent model of transformer figure the core components of the VFT. Cut away drawing of vft figure illustrates a conceptual system diagram of the VFT. For balance the transmission voltage with respect to machine voltage a conventional transformer is used. In this circuit the shunt capacitor are used to compensate the reactive magnetizing current. In AC power circuit, the real power flow through the rotary transformer is proportional to the phase angle difference between the stator and the rotor. The magnitude if the phase shift require for a given power transfer is determine by the impedance of rotary transformer and AC grid of the network. Reactive power flow through the VFT is determined by the difference in magnitude of voltages on the two sides and series impedance of the rotary transformer.



Cut-away Drawing of VFT

If torque is applied in the opposite direction, then power flows from the rotor winding to the stator winding. Power flow is proportional to the magnitude and direction of the torque applied. The motor and drive system are designed to continuously produce torque while at zero speed (standstill). If torque is not applied, then not any power flows through the rotary transformer. When the two systems are no longer in synchronism, the rotor of the VFT will rotate continuously and the rotational speed will be proportional to the difference in frequency between the two power grids. During this operation the load flow is maintained. The VFT is designed power flow to continuously regulate with drifting frequencies on both grids. Regardless of power flow, the rotor built in orients itself to follow the phase angle difference apply by the two asynchronous systems.

VFT Control & Protection System –

VFT control system comprises of unit VFT control (UVC), which includes automatic switching function (start/stop/synchronization), governor, power regulator, power run back, reactive power control and other monitoring function. The UVC also contains a local manual operator panel, which serves as a back-up for higher level operator interface system.

VFT unit is protected by a protection system which comprises ten standard protective relays. Protective system are ac substation, generating station/plant including over current ,over voltage, over excitation, failure of breaker, protection of capacitor, ground fault, negative sequence etc.

An VFT installation the redundant bus & line protection specific for VFT. An VFT substation the protection given to the inter connection between local grid & VFT equipment.

The main VFT control is monitor by the remote operator HMS through the SCADA. An entire VFT station, SCADA interface for unmanned operation and substation Automation, UVC processor and other electronics device. The main VFT control support the operator interface on the primary purpose.

In substation human-machine interface (HMI)uses a GE D200 data concentrator coupled with GE power link, It's advantage for graphical operator interface[1].On the monitor screen included one line diagram ,Show the several level details like Control unit, Temperature, Alarm, communication, ventilation etc.

In the VFT sub-station overall controlling system design by priority with the overall control hierarchy. Thus, It is also support expandability to several VFT unit sharing the same operator interface.

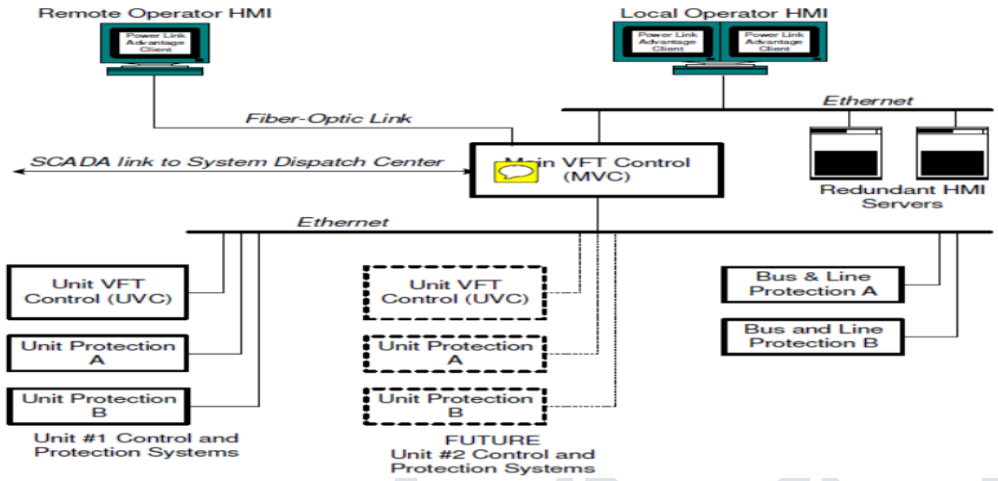
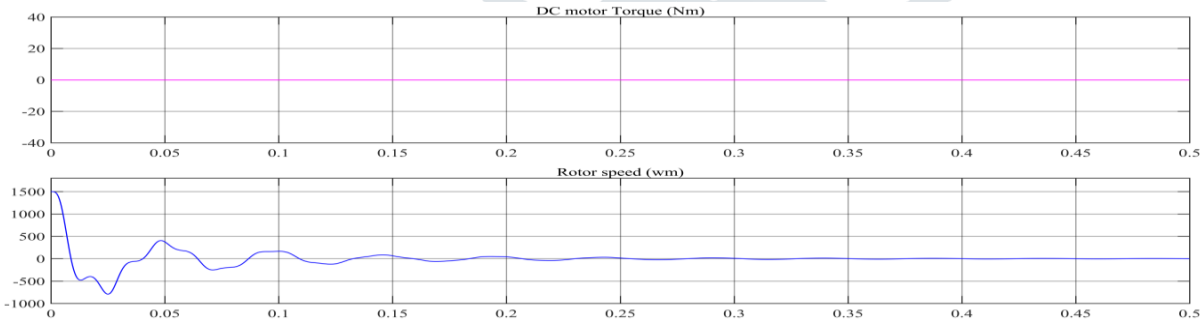


Figure : Protection and Control of VFT

Result

The analysis of power flow control with in synchronous power system network (both1&2) kept as a same line voltage and frequency i.e. 420V, 59Hz supply. So that the model, represented fig .It is used to transfer and control to the flow both network, on the varying the torque value in positive and negative cycle the current, voltage, active and reactive power in network #1 and #2.The simulation waveform of torque, rotor speed, stator speed, stator current, stator active power, stator reactive power, rotor voltage, rotor current, rotor active power, rotor reactive power are shown in fig

For **Td= 0 Nm**, below Fig. shows the simulated result waveforms



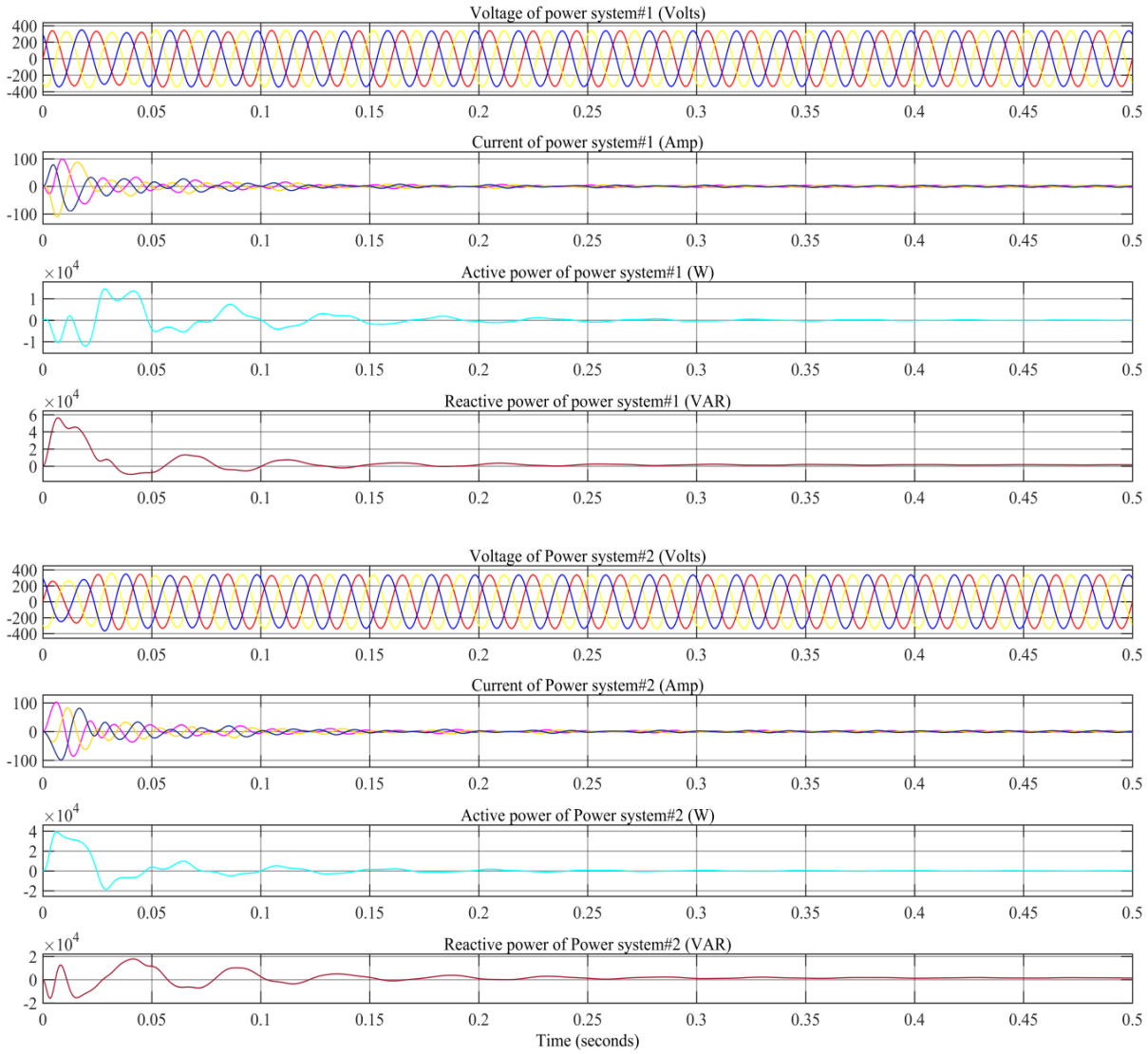


Fig. Waveforms showing torque, rotor speed, current, voltage, reactive power and active power transfer with Td= 0 Nm.

For **Td= 10 Nm**, below Fig. shows the simulated result waveforms

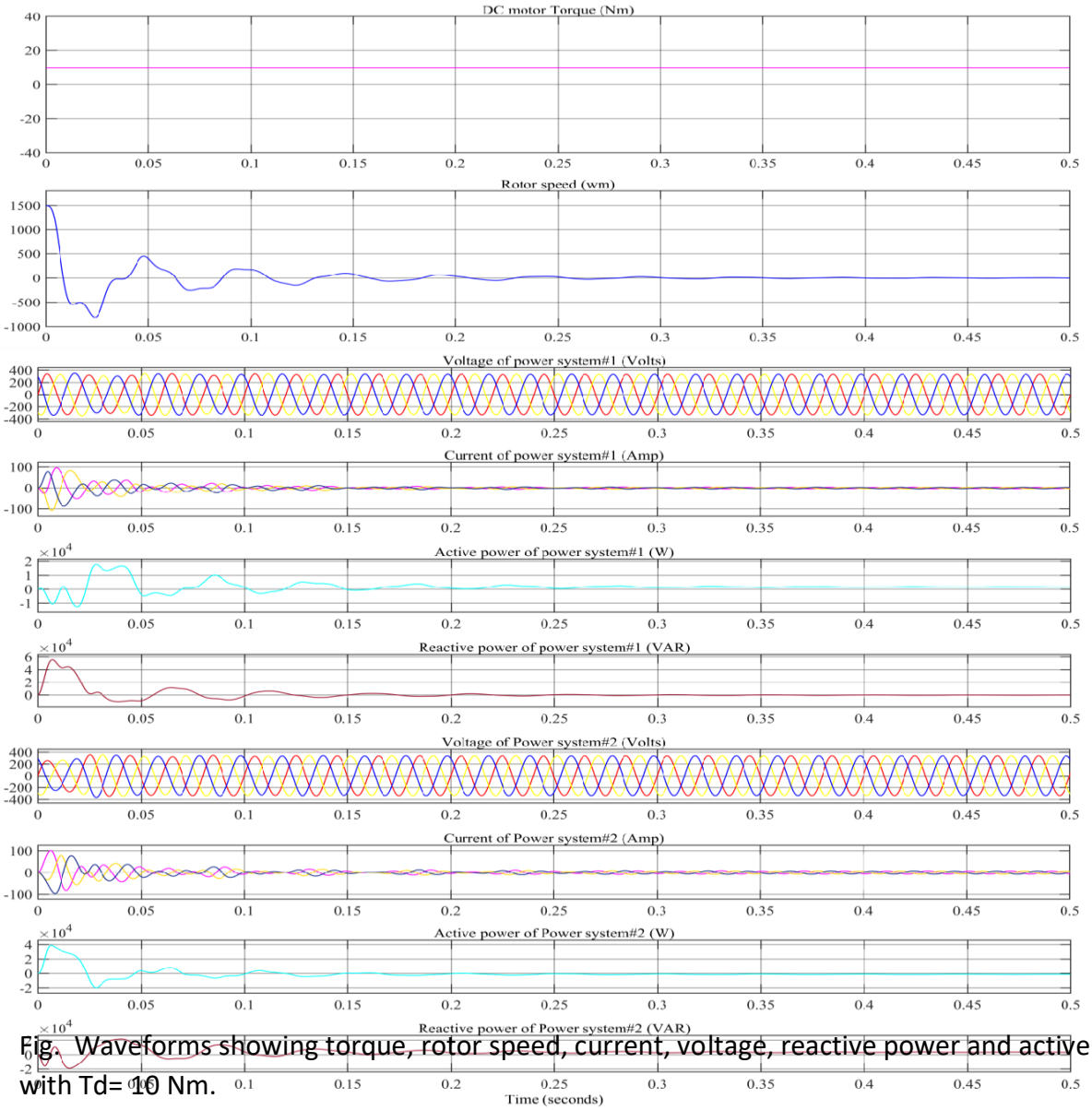


Fig. Waveforms showing torque, rotor speed, current, voltage, reactive power and active power transfer with Td= 10 Nm.

CONCLUSION

VFT technology is a viable technology for achieving real power transfer control between two or more asynchronous power system networks. Moreover, the direction and the magnitude of power transfer can also be controlled.

For Future application of the VFT would be to utilize the dual ability to control the phase as well as to compensate for the frequency variation. This could be used to operate pumps or hydro turbines closer to their maximum efficiency conditions. It could also be used to stabilize or absorb load swings in a power system, which would permit operation with a lower spinning reserve.

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