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Multi-Objective Optimal DG Sitting and Sizing by MBAT Algorith

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ABSTRACT

The interline power flow controller (IPFC & UPFC) is one of the latest generation flexible AC transmission systems (FACTS) controller used to control power flows of multiple transmission lines. The main objective of this paper is detailed study about a new real and reactive power coordination controller for a interline power flow controller (IPFC & UPFC).

The basic control for the IPFC is such that the series converter of the UPFC controls the transmission line real/reactive power flow and the shunt converter of the (IPFC & UPFC) controls the bus voltage/shunt reactive power and the DC link capacitor voltage. Because of the common link, any inverter within the (IPFC & UPFC) is able to transfer real power to any other and thereby facilitate real power transfer among the lines of the transmission system. Since each inverter is able to provide reactive compensation, the (IPFC & UPFC) is able to carry out an overall real and reactive power compensation of the total transmission system. This capability makes it possible to equalize both real and reactive power flow between the lines, transfer power from overloaded to under loaded lines, compensate against reactive voltage drops and corresponding reactive line power and to increase the effectiveness of the compensating system against dynamic disturbances. A simulation in MATLAB has been done in order to extend conventional algorithm based on this model.

Keywords: IPFC & UPFC

INTRODUCTION

The electrical power system serves to deliver electrical energy to consumers. An electrical power system deals with electrical generation, transmission, distribution and consumption. In a traditional power system, the electrical energy is generated by centralized power plants and flows to customers via the transmission and distribution network. The rate of the transported electrical energy within the lines of the power system is referred to as ‘Power Flow’ to be more specific, it is the active and reactive power that flows in the transmission lines.

During the last twenty years, the operation of power systems has changed due to growing consumption, the development of new technology, the behavior of the electricity market and the development of renewable energies. In addition to existing changes, in the future, new devices, such as electrical vehicles, distributed generation and smart grid concepts, will be employed in the power system, making the system extremely complex. Figure 1.1 shows the representation of a future power system, where the clouds in the figure indicate the mentioned developments. According to the time line, these developments are happening in the sequence from bottom to top of Figure 1.1

The above-mentioned developments and growth will have a great impact on the power system, especially on power flow. Conventionally, the power flow in power systems has a fixed direction; it always flows from the point of generation through the transmission network to the distribution network. In these systems, changes in power flow are scheduled based on hours, not more frequently. However, due to the trends listed above, newer systems with greater capabilities are already being put to use; power flow can be bidirectional and variations can occur in minutes or even seconds. Figure 1.2 illustrates the impact of these new trends on the power flow.

Distributed Generation (DG) takes place at small and medium power generators that are connected to the distribution side of the power system. Many DG units are based on renewable energy sources such as solar and wind. Driven by government policies aimed at reducing greenhouse gas emissions and conserving fossil fuels, as agreed by the Kyoto protocol, the number of grid-connected DG units is increasing. Introducing a number of generators on the distribution side leads to big changes of the power flow in networks. First, the direction of the power flow is different from the traditional direction.

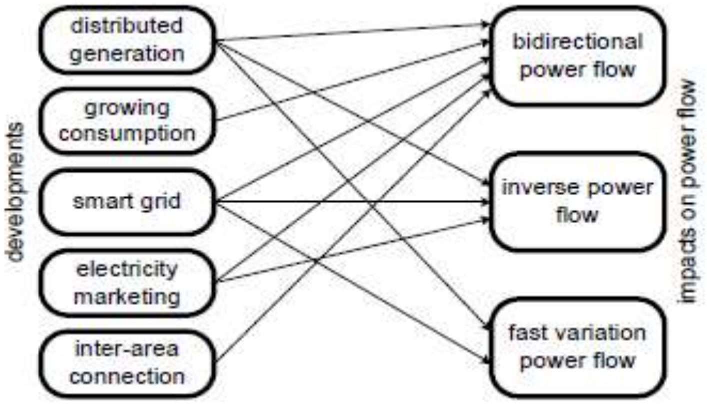


Figure 1.2: Relation chart of the trends and their impact on the power flow

When DG units in one area feed loads in other areas, there will be reverse power flow from the distribution to the transmission side. Second, the output energy of renewable sources depends on weather conditions.

With the increasing percentage of renewable energy sources in use, a large amount of power has to be controlled to enable the power system to quickly switch between the renewable sources and stand-by power generation.

1.2 CLASSIFICATIONS OF ACTIVE POWER FILTERS

1.2.1 Converter based classification

Current Source Inverter (CSI) Active Power Filter (Fig 1.3) and Voltage Source Inverter Active Power Filter (VSI) (Fig 1.4) are two classifications in this category. Current Source Inverter behaves as a non sinusoidal current source to meet the harmonic current requirement of the nonlinear loads. A diode is used in series with the self-commutating device (IGBT) for reverse voltage blocking. However, GTO-based configurations do not need the series diode, but they have restricted frequency of switching. They are considered sufficiently reliable, but have higher losses and require higher values of parallel ac power capacitors. Moreover, they cannot be used in multilevel or multistep modes to improve performance in higher ratings. transformer, to eliminate voltage harmonics, and to balance and regulate the terminal voltage of the load or line. It has been used to reduce negative-sequence voltage and regulate the voltage on three-phase systems. It can be installed by electric utilities to compensate voltage harmonics and to damp out harmonic propagation caused by resonance with line impedances and passive shunt compensators.

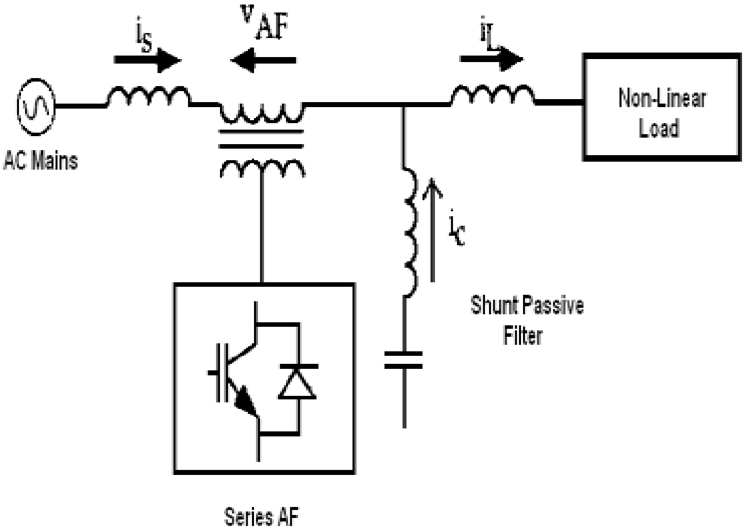


Fig 1.7 Hybrid filter

Fig 1.7 shows the hybrid filter, which is a combination of an active series filter and passive shunt filter. It is quite popular because the solid-state devices used in the active series part can be of reduced size and cost (about 5% of the load size) and a major part of the hybrid filter is made of the passive shunt L–C filter used to eliminate lower order harmonics. It has the capability of reducing voltage and current harmonics at a reasonable cost.

1.3 SUPPLY-SYSTEM-BASED CLASSIFICATION

This classification of AF’s is based on the supply and/or the load system having single-phase (two wire) and three-phase (three wire or four wire) systems. There are many nonlinear loads, such as domestic appliances, connected to single-phase supply systems. Some three-phase nonlinear loads are without neutral, such as ASD’s, fed from three-wire supply systems. There are many nonlinear single-phase loads distributed on four-wire three-phase supply systems, such as computers, commercial lighting, etc. Hence, AF’s may also be classified accordingly as two-wire, three-wire, and four-wire types.

1.3.1 Two-wire AF’s:

Two-wire (single phase) AF’s are used in all three modes as active series, active shunt, and a combination of both as unified line conditioners. Both converter configurations, current-source PWM bridge with inductive energy storage element and voltage-source PWM bridge with capacitive dc-bus energy storage elements, are used to form two-wire AF circuits. In some cases, active filtering is included in the power conversion stage to improve input characteristics at the supply end.

3.1 UPFC CONTROL SCHEME

3.1.1 Introduction:

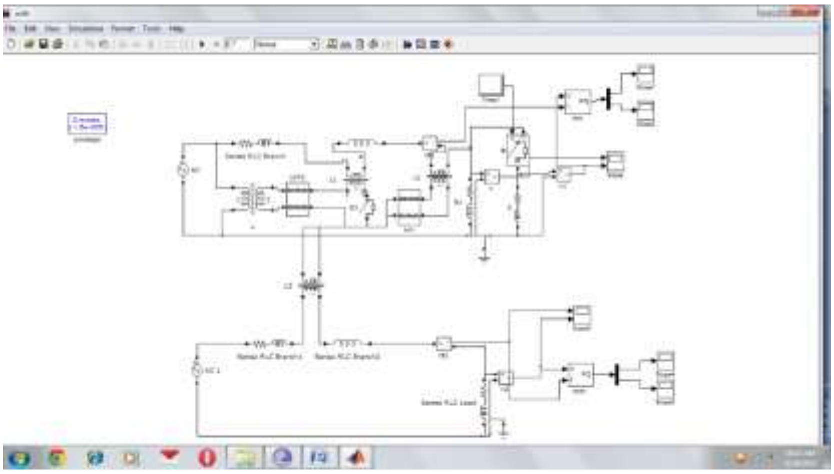
In the previous chapter, an overview was given of PE-based PFCDs i.e. FACTS controllers. Because of high control capability, the PE-based combined PFCs; specifically UPFC is suitable for the future power system. However, the UPFC is not widely applied in practice, due to their high cost and the susceptibility to failures. Generally, the reliability can be improved by reducing the number of components; however, this is not possible due to the complex topology of the UPFC. To reduce the failure rate of the components by selecting components with higher ratings than necessary or employing redundancy at the component or system levels are also options. Unfortunately, these solutions increase the initial investment necessary, negating any cost-related advantages. Accordingly, new approaches are needed in order to increase reliability and reduce cost of the UPFC at the same time.

After studying the failure mode of the combined FACTS devices, it is found that a common DC link between converters reduces the reliability of a device, because a failure in one converter will pervade the whole device though the DC link. By eliminating this DC link, the converters within the FACTS devices are operated independently, thereby increasing their reliability.

The Unified Power Flow Controller (UPFC) concept was proposed by Gyugyi in 1991.The UPFC was devised for the real-time control and dynamic compensation of ac transmission systems, providing multifunctional flexibility required to solve many of the problems facing the power delivery industry. Within the framework of traditional power transmission concepts, the UPFC is able to control, simultaneously or selectively, all the parameters affecting power flow in the transmission line (i.e., voltage, impedance, and phase angle), and this unique capability is signified by the adjective "unified" in its name. Alternatively, it can independently control both the real and reactive power flow in the line. The reader should recall that, for all the Controllers discussed in the previous chapters, the control of real power is associated with similar change in reactive power, i.e., increased real power flow also resulted in increased reactive line power.

From the conceptual viewpoint, the UPFC is a generalized synchronous voltage source(SVS) represented at the fundamental (power system) frequency by voltage phasor $\mathbf{V}_{pq}$ with controllable magnitude $\mathbf{V}_{pq}(0 \le Vpq \le Vpqmax)$ and angle $\rho(0 \le \rho \le 2\pi)$, in series with the transmission line, as illustrated for the usual elementary two machine system(or for two independent

SIMULATION MODEL, RESULTS AND DISCUSSION



VOLTAGE WAVEFORMS:

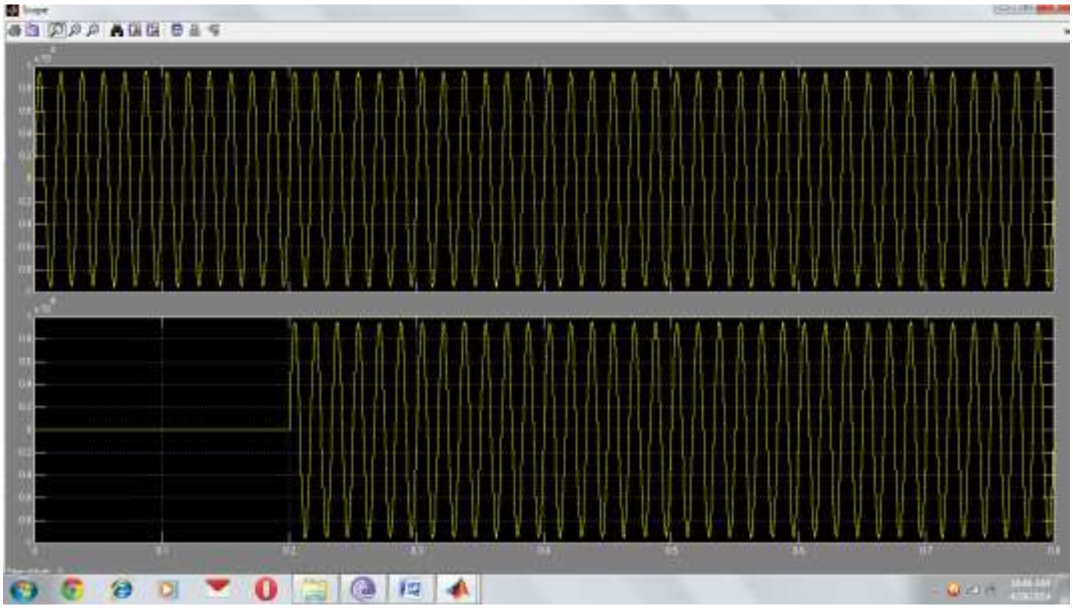


FIG 5.5: WAVEFORMS OF OUTPUT VOLTAGE

If we observe the output waveforms, the current is zero at starting. This is because the circuit breaker is opened for a short period of time. After that whenever the circuit breaker is closed, the current will now pass through the circuit, So,now the magnitude of the voltage waveforms will increase.

VOLTAGE AND CURRENT WAVEFORMS:

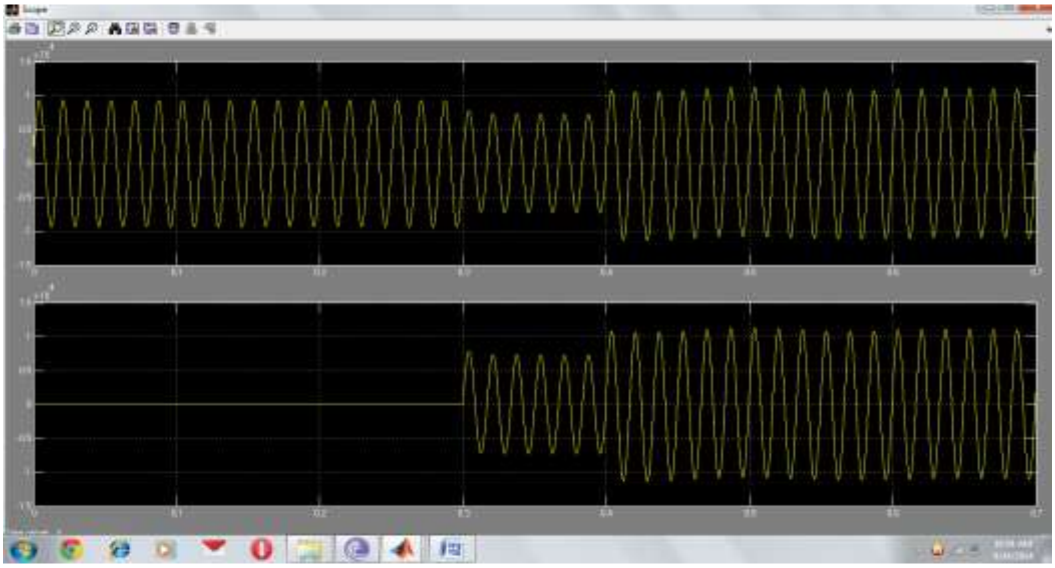


FIG 5.10: OUTPUT WAVEFORMS OF VOLTAGE AND CURRENT

If we observe the voltage waveforms and current waveforms, the current is zero at starting. This is due to the reason that the circuit breaker 2 is opened for a short period of time.

FIG 5.11: VOLTAGE AND CURRENT WAVEFORMS OF IPFC

In fig.5.12 at initial stage the circuit breaker 1 is closed and the UPFC is also in operating mode. So the voltage waveform will be as shown in above figure. After sometime the cirucit breaker 2 will also be closed. So due to this reason, the IPFC as well as UPFC will operate.So the magnitude of voltage and current will be as shown in figure.

The real power and reactive power after compensation is 40 KW and 14 KVAR. So by this we know that after the implementation of UPFC and IPFC there is an increase in the real power and reactive power is compensated.

REAL POWER:

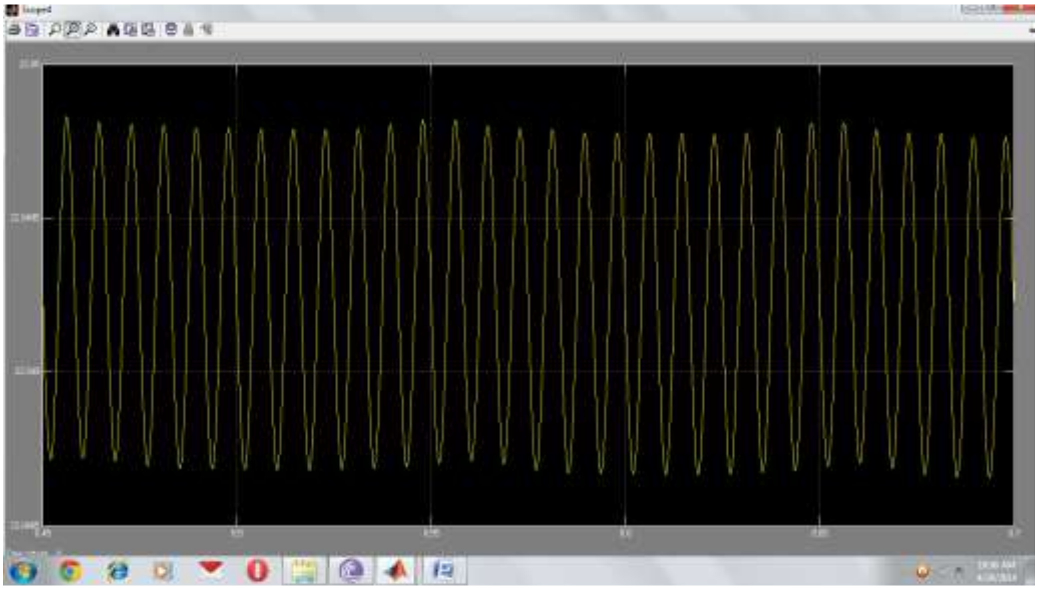


FIG.5.12. REAL POWER WAVE FORMS OF IPFC

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