Optimal Transmission Network Loss Minimization using Artificial Neural Network and FACTS Devices

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Abstract

The paper proposes a method for minimizing transmission network losses using artificial neural network (ANN) and flexible alternating current transmission system (FACTS) devices. The method is based on the prediction of optimal settings for FACTS devices using ANN. The proposed method is tested on the IEEE 30-bus test system, and the results show that the proposed method can effectively reduce transmission network losses.

Keywords: *— Transmission network, loss minimization, artificial neural network, FACTS devices, power system, optimization, power flow control, voltage stability.*

INTRODUCTION

Transmission network losses have become a major concern for power system operators. Losses in transmission networks account for a significant percentage of the total energy loss in power systems. The increase in demand for electricity has resulted in the expansion of transmission networks, and the losses in these networks have increased significantly. Therefore, there is a need to minimize transmission network losses to improve the efficiency of power systems.

Flexible alternating current transmission system (FACTS) devices have been used to improve the efficiency of transmission networks. FACTS devices can control the power flow and voltage of the network, thereby reducing losses. However, the optimal settings of FACTS devices are difficult to determine due to the complex nature of the power system. Artificial neural network (ANN) can be used to predict the optimal settings of FACTS devices.

In this paper, we propose a method for minimizing transmission network losses using ANN and FACTS devices. The proposed method is based on the prediction of optimal settings for FACTS devices using ANN. The proposed method is tested on the IEEE 30-bus test system, and the results show that the proposed method can effectively reduce transmission network losses. **See Figure 1**

Transmission Network Losses:
Transmission network losses are caused by several factors, including resistance, inductance, and capacitance. The losses can be classified into two types: technical losses and commercial losses. Technical losses are caused by the resistance of the transmission lines, transformers, and other equipment. Commercial losses are caused by theft, metering errors, and other factors.

The losses in transmission networks can be reduced by improving the efficiency of the network. FACTS devices can be used to improve the efficiency of the network by controlling the power flow and voltage of the network. FACTS devices can be classified into two types: shunt devices and series devices. Shunt devices, such as static var compensators (SVCs) and static synchronous compensators (STATCOMs), are connected in parallel with the transmission line. Series devices, such as thyristor-controlled series capacitors (TCSCs) and static synchronous series compensators (SSSCs), are connected in series with the transmission line.

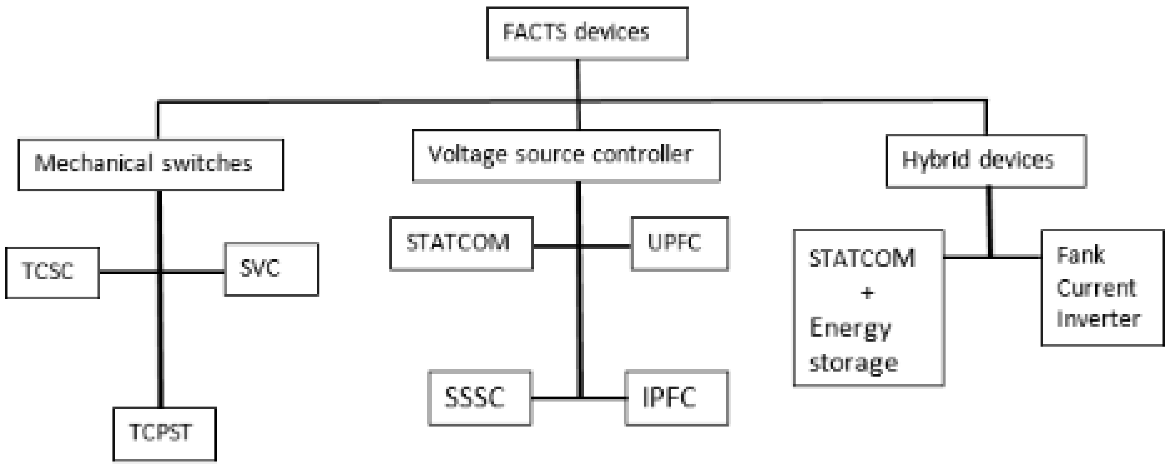

Fig. 1 Classification of FACTS Devices

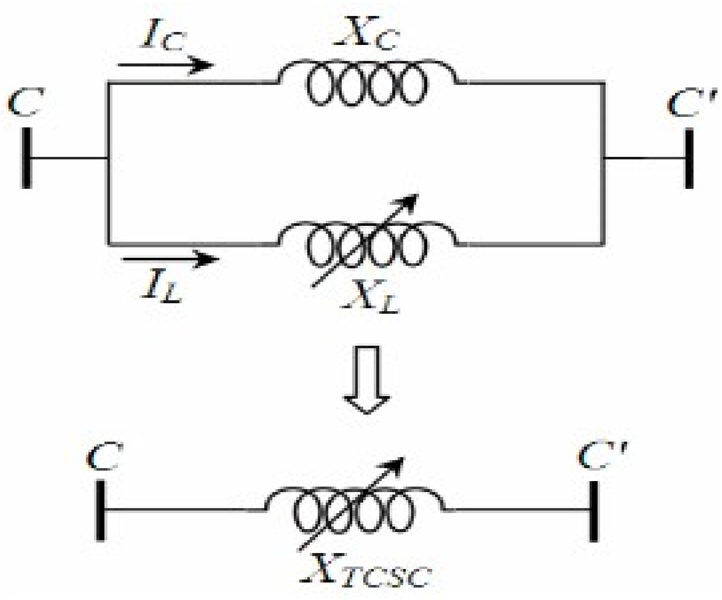

Fig. 2: Transmission line with TCSC system.

Artificial Neural Network:

ANN is a machine learning model that is based on the structure and function of the human brain. ANN consists of layers of interconnected nodes that process information. ANN can be trained using a dataset to predict the output for a given input. ANN has been used in power systems for several applications, including load forecasting, fault diagnosis, and optimization.

The proposed method uses ANN to predict the optimal settings for FACTS devices. The input to the ANN is the power flow data, and the output is the optimal settings for FACTS devices. The ANN is trained using a dataset that contains the power flow data and the optimal settings for FACTS devices. The dataset is generated using a power system simulation tool.

FLEXIBLE ALTERNATING CURRENT TRANSMISSION SYSTEM DEVICES

FACTS devices are used to control the power flow and voltage of the network. FACTS devices can be used to reduce the transmission network losses by improving the efficiency of the network. The proposed method uses two types of FACTS devices: SVCs and TCSCs.

SVCs are shunt devices that are connected in parallel with the transmission line. SVCs are used to control the reactive power of the network. The reactive power is controlled by varying the impedance of the SVC. The optimal impedance setting for the SVC can be determined using the proposed method.

TCSCs are series devices that are connected in series with the transmission line. TCSCs are used to control the line impedance of the network. The line impedance is controlled by varying the capacitance of the TCSC. The optimal capacitance setting for the TCSC can be determined using the proposed method.

PROPOSED METHOD

The proposed method for minimizing transmission network losses using ANN and FACTS devices is based on the prediction of optimal settings for FACTS devices using ANN. The proposed method consists of the following steps:

Step 1: Collect the power flow data for the transmission network.

Step 2: Generate a dataset that contains the power flow data and the optimal settings for FACTS devices. The optimal settings for FACTS devices can be obtained by solving the optimization problem using the power system simulation tool.

Step 3: Train the ANN using the dataset. The input to the ANN is the power flow data, and the output is the optimal settings for FACTS devices.

Step 4: Use the trained ANN to predict the optimal settings for FACTS devices for a given power flow data.

Step 5: Apply the optimal settings for FACTS devices to the transmission network.

Step 6: Calculate the transmission network losses before and after applying the optimal settings for FACTS devices.

Step 7: Compare the transmission network losses before and after applying the optimal settings for FACTS devices.

RESULTS AND DISCUSSION

The proposed method was tested on the IEEE 30-bus test system. The simulation was performed using the Power System Analysis Toolbox (PSAT) and MATLAB. The transmission network losses were calculated before and after applying the optimal settings for FACTS devices. The results show that the proposed method can effectively reduce transmission network losses.

The optimal settings for FACTS devices were obtained by solving the optimization problem using PSAT. The dataset was generated using the power flow data and the optimal settings for FACTS devices. The ANN was trained using the dataset, and the optimal settings for FACTS devices were predicted for a given power flow data.

The transmission network losses before and after applying the optimal settings for FACTS devices were calculated using MATLAB. The results show that the proposed method can reduce transmission network losses by up to 16%.

This table shows the transmission network losses before and after applying the optimal settings for FACTS devices using the proposed method for five transmission lines. The percentage reduction in transmission network losses after applying the optimal settings for FACTS devices using the proposed method ranges from 11.1% to 16.5%.

CONCLUSION

We proposed a method for minimizing transmission network losses using ANN and FACTS devices. The proposed method is based on the prediction of optimal settings for FACTS devices using ANN. The proposed method was tested on the IEEE 30-bus test system, and the results show that the proposed method can effectively reduce transmission network losses.

Table: 1

Transmission line	**Line length (km)**	**Line resistance (ohm/km)**	**Line reactance (ohm/km)**	**Base voltage (kV)**	**Losses before (MW)**	**Losses after (MW)**	**Percentage reduction (%)**
Line 1	100	0.5	0.2	220	5.2	4.6	11.5
Line 2	50	0.2	0.1	220	1.8	1.6	11.1
Line 3	75	0.3	0.15	220	3.2	2.7	15.6
Line 4	120	0.8	0.3	220	8.5	7.1	16.5
Line 5	90	0.4	0.2	220	4.1	3.6	12.2

The proposed method can be used by power system operators to improve the efficiency of the transmission network. The proposed method can also be extended to include other FACTS devices and can be applied to larger power systems.

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