Technical science and innovation

Volume 2021 | Issue 3 Article 8

9-27-2021

COMBINED DEVICES OF FACTS TECHNOLOGY

Bahrom Ravshanovich Normuratov Associate lecturer
Tashkent State Technical University named after Islam Karimov, normuratov.bahrom@mail.ru

Misrikhan Misrikhanov
Ivanovo State Energy University, Russia.

Shukhrat Khamidov
Tashkent State Technical University named after Islam Karimov, khamidov_sh@mail.ru

Recommended Citation
Normuratov, Bahrom Ravshanovich Associate lecturer; Misrikhanov, Misrikhan; and Khamidov, Shukhrat (2021) "COMBINED DEVICES OF FACTS TECHNOLOGY," *Technical science and innovation*: Vol. 2021: Iss. 3, Article 8.
DOI: https://doi.org/10.51346/tstu-01.21.3-77-0136
Available at: https://btstu.researchcommons.org/journal/vol2021/iss3/8

UDC 621.311

COMBINED DEVICES OF FACTS TECHNOLOGY

Misrikhan Misrikhanov[1], Shukhrat Khamidov[2], Bahrom Normuratov[2]

[1]*Ivanovo State Energy University, Russia.*

[2]*Tashkent State Technical University named after Islam Karimov, Department of Power Plants, Netwoks and Systems, Universitet street – 2, Tashkent, 100095, Uzbekistan.*

Email:**khamidov_sh@mail.ru and normuratov.bahrom@mail.ru**

Abstract. *FACTS - Flexible Alternative Current Transmission System technology is a family of devices, each of which can be used individually and in concert with other devices to control the interrelated parameters of the electrical power system. The mission of FACTS technology is to improve the control of power flows in both steady-state and transient modes of EPS. Flexibility of Electric Power Transmission, applied as "The ability to adapt to changes in transmission system or operating conditions while maintaining sufficient operating limits in steady-state and transient modes". Controlled Flexible AC Transmission Lines - Flexibility from Electric Power Transmission means "AC Power transmission systems that incorporate power electronic devices and other static controllers to improve controllability and increase throughput". Device (regulator, controller) FACTS - FACTS regulator, which means "A system based on power electronics and other static devices that provides control of one or more parameters of the AC power transfer system". FACTS Devices are conventionally divided into three types: parallel devices (lateral compensation devices); serial devices (longitudinal compensation devices); combined devices.*

Key words. *FACTS, electric power systems, Unified Power Flow Controller, Interline Power Flow Controller, thyristor control, transmitted power, STATCOM, Pulsed Power.*

I INTRODUCTION

The Technology FACTS technology is a family of devices that can be used individually or in conjunction with other devices to control the interrelated parameters of the electrical power system. The goal of the FACTS technology is to improve the control of power flows in both steady-state and transient modes of EPS. One of the key elements of FACTS is the RPS reactive power source (Fig. 1), which is capable of both generating and consuming reactive power depending on the desired mode of operation and the specified characteristics of the EPS [1].

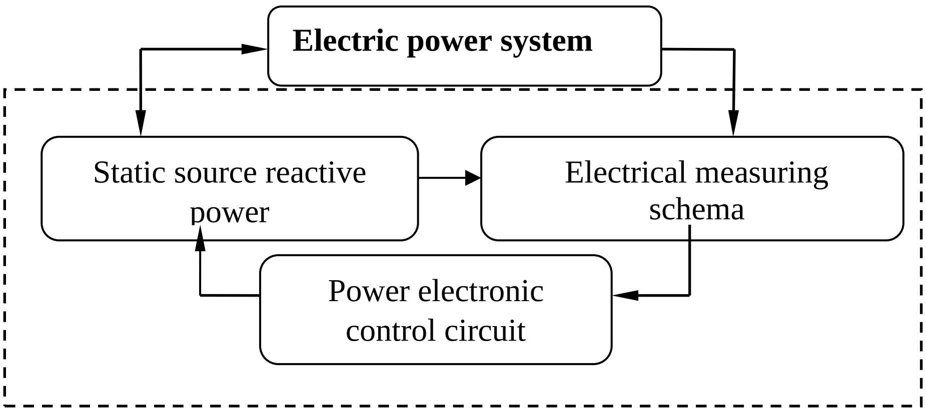

Fig. 1. General diagram of the FACTS device.

II MAIN PART

Combined FACTS devices include the combined UPFC (Unified Power Flow Controller) and the Interline Power Flow Controller (IPFC) [2].

UPFC -UNIFIED POWER FLOW CONTROLLER.

The UPFC combined power flow controller is designed for operational control and dynamic balancing in AC power plants. It can be used to control all important parameters affecting the power flow. In addition, the UPFC is capable of controlling both active and reactive power independently.

The UPFC consists of two voltage transformers - a STATCOM and a Static Synchronous Series Compensator SSSC connected in antiparallel and operating through a common DC link or DC capacitor (Figure 2.). Active power can flow freely in either direction between the AC terminals of the voltage converters, with each converter capable of independently generating or consuming reactive power. Thus, converter 2 in Fig. 2 feeds the voltage Upq into the line with controlled amplitude and phase angle ρ, thus working as a current source [2].

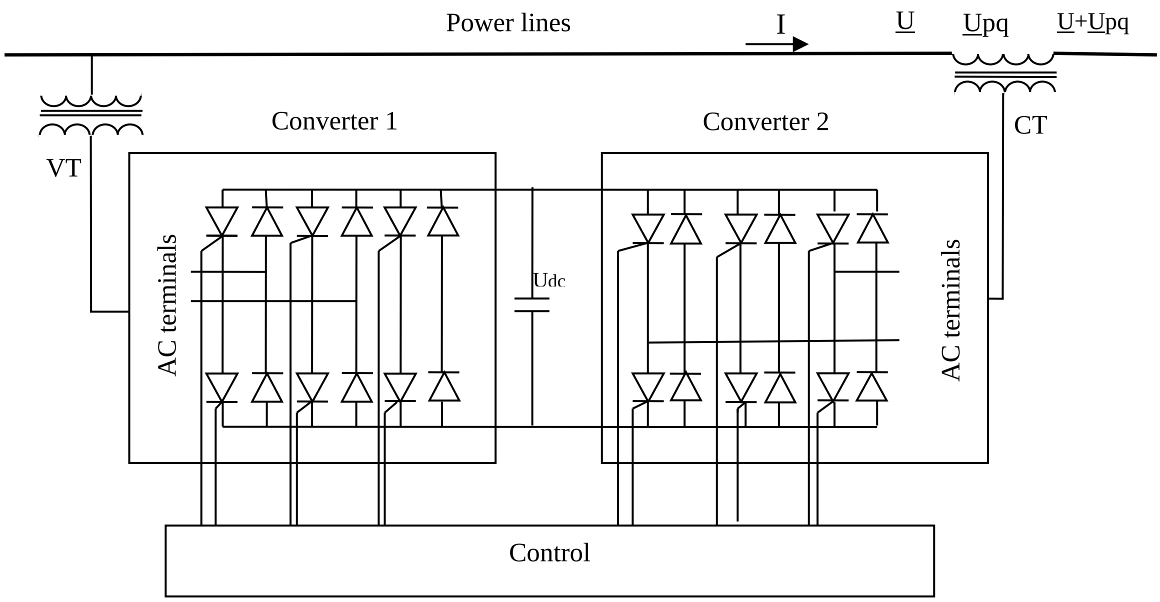

Fig. 2. Combined power flow regulator UPFC.

The excess reactive power generated by the voltage AC occurs at the terminals AC. The active power is converted to DC and injected into the DC link in the form of negative or positive active power injection, which is converted back to AC power in the converter 1 and enters the line through the VT voltage transformer [2].

In addition, the inverter 1 can control the reactive power flow to compensate the reactive power component when needed. The active power for the SSSC comes from the transmission line through the STATCOM, which is also used to control the voltage with its own reactive power.

Thus, the UPFC is a FACTS device for regulating active and reactive power in transmission lines, for changing the line capacitance, and also for regulating the line voltage. The use of an additional energy storage device, such as a superconducting inductive energy storage device (SCIES), through DC coupling can significantly increase the efficiency of the UPFC application. The unique characteristics of SCIES are the ability to transition from energy storage mode to energy release mode almost instantaneously and the high speed of power decay. This property of SCIES is particularly sought after in high energy physics and pulsed power applications. Inductive energy storage is most effective in superconducting magnets, where energy storage and release are virtually lossless. The fundamental advantage of inductive storage is that the energy in them is stored in the same form in which it is used - electromagnetically. The absence of the need to convert one form of energy into another provides high efficiency (97-98%) and high speed of the device.

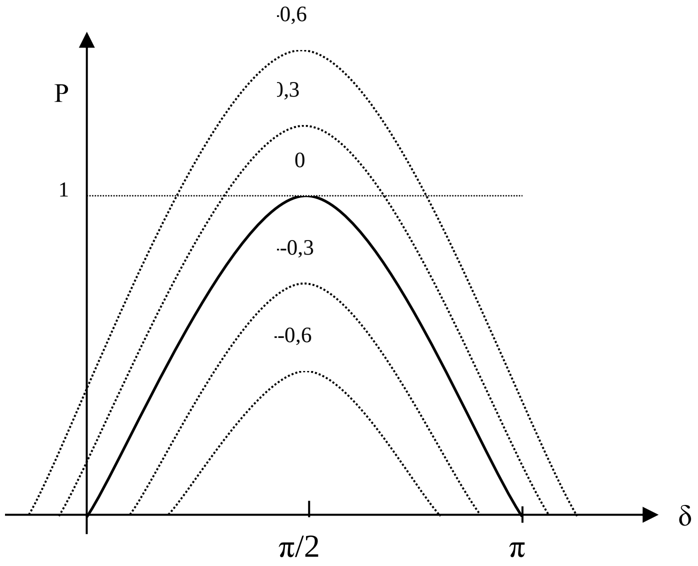

Fig. 3. Dependence of the transmitted power on the phase shift angle for UPFS at δ = 90º.

Fig. 3. shows the corresponding graph of the dependence of the transmitted power on the phase angle of the voltage at the ends of the line. Depending on the amplitude of the UPFC voltage, the characteristic curve shifts up or down [2].

IPFC -INTERLINE POWER FLOW CONTROLLER.

The IPFC controller is used to solve control problems that arise when the reactive component in several adjacent lines must be compensated.

Capacitive longitudinal compensators are commonly used to increase the transmission power of a line. However, they are not capable of regulating the reactive power flow, which can lead to load imbalance.

Using IPFC, it is possible to control the active power flow between multiple lines simultaneously [2].

IFPCs thus provide a solution to the following tasks:

-Balancing (equalizing) active and reactive power between transmission lines;

-Reduction of secondary loads overloaded by power lines;

-Compensation of voltage drops in power lines and the corresponding cost of reactive power;

-Increasing the efficiency of overall compensation under the influence of dynamic disturbances.

The general IFPC diagram is shown in Figure 4.

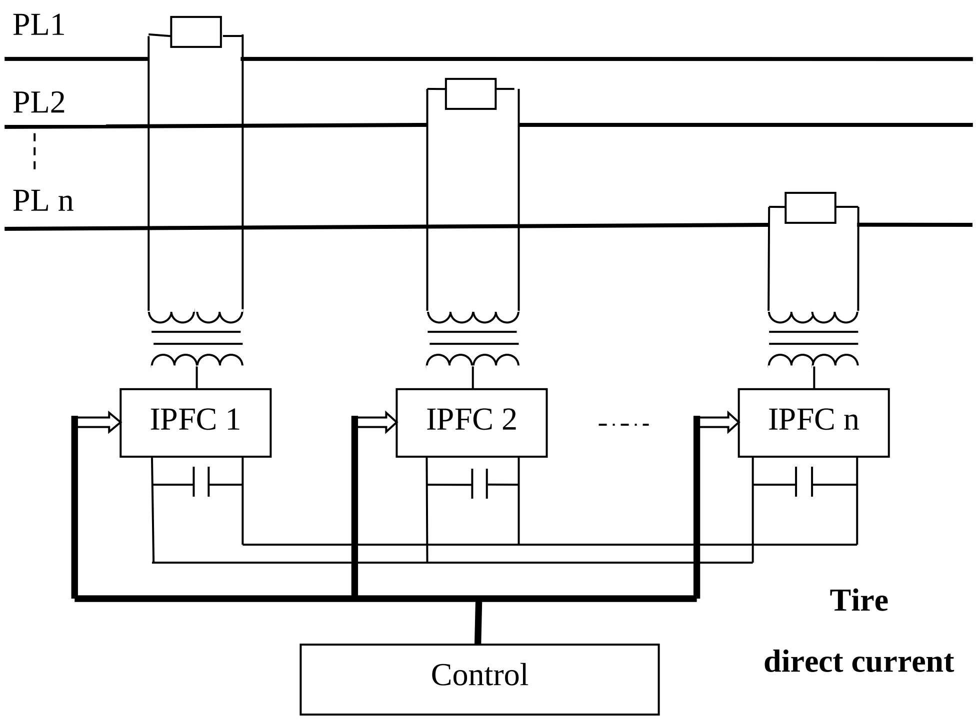

Fig. 4. Diagram of the power flow regulator between the IPFC lines

The IFPC controller contains several inverters (SSSC Static Synchronous Series Compensators), each of which performs line compensation for its own line. According to the diagram in Fig. 4, IFPC not only provides longitudinal blindness compensation, but is also capable of transferring the active power of the corresponding line to the common DC link [3-6].

Thus, it is possible to draw active power from overloaded transmission lines to balance the active component in other lines. This system requires strict adherence to the energy balance, since active power is transmitted over underloaded lines instead of overloaded transmission lines.

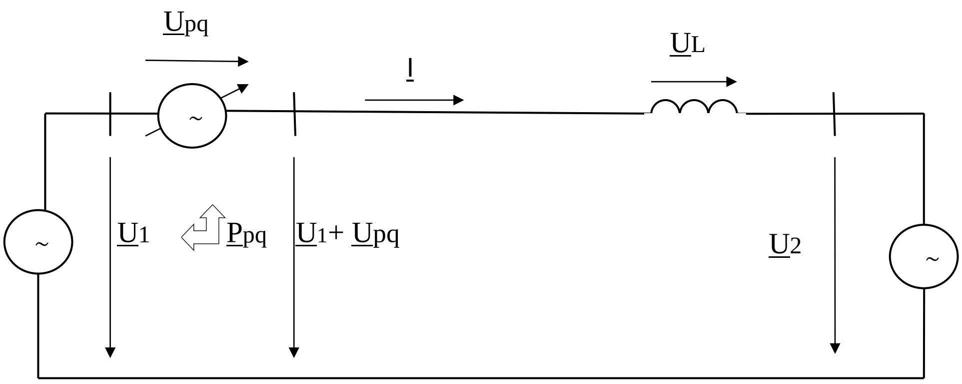

Fig. 5. The principle of UPFC operation on the example of a two-machine EPS.

Note that the UPFC can be considered as a synchronous voltage source with adjustable amplitude Upq and angle β, connected in series in the transmission line, as shown in Fig. 5.

The voltage source distributes both active and reactive power, but it can only produce reactive power. The active power must be provided by a power source in one of the termination buses.

III CONCLUSION

The devices of FACTS open up new possibilities for controlling power flows, both in existing and in new or upgraded power lines. These arise from the ability of FACTS technology to control interconnected parameters that govern power line operation, including resistance, current, and phase angle. Shifts between voltages at network nodes, damping of oscillations at different frequencies, etc. FACTS devices can increase the capacity of transmission lines to the allowable limit of line thermal resistance.

As a holistic approach, FACTS technology represents a new concept for the construction and development of power transmission networks with fast electronic control of their operating modes.

REFERENCES

1. Texnologiya i ustroystva FACTS: Ucheb. Posobie / M.SH.Misrikhanov, V.N.Ryabchenko / FBGOVO «Ivanovskiy gosudarstvenniy energeticheskiy universitet imeni V.I.Lenina. -Ivanovo, 112 - 217 s.
2. Misrikhanov M.Sh., Khamidov Sh.V. Kombinirovannie ustroystva texnologii upravlyaemix gibkix elektroperedach peremennogo toka FACTS. // Nauchno-texnicheskiy jurnal “Problemi energo i resursosberejeniya”. Tashkent, 2019, №2.
3. Misrikhanov M.SH., Khamidov Sh.V. Matematicheskaya model potoka moshnosti v elektricheskoy sisteme, soderjashey shuntiruyushiy reaktor i kondensatornuyu batareyu s tiristornim upravleniem dlya kompensatsii reaktivnoy moshnosti. // Vestnik TashGTU.Texnicheskie nauki i innovatsiya. 2019. №1. S.90-97.
4. Misrikhanov M.Sh., Khamidov Sh.V. Matematicheskaya model potoka moshnosti v elektricheskoy sisteme, soderjashey posledovatelniy kompensator reaktivnoy moshnosti s tiristornim upravleniem. // Vestnik TashGTU. Texnicheskie nauki i innovatsiya. 2019. №2.
5. Misrikhanov M.Sh,Khamidov Sh.V. Raschet potokov moshnosti v odnofaznoy seti s staticheskim sinxronnim kompensatorom i obedinennim regulyatorom. //Nauchno-texnicheskiy jurnal «Problemi informatiki i energetiki». - Tashkent, 2019, № 3.
6. Misrikhanov M.Sh., Khamidov Sh.V. Raschet potoka moshnosti v trexfaznoy seti, soderjashey ustroystva upravlyaemix gibkix elektroperedach peremennogo toka.// Nauchno texnicheskiy jurnal Problemi informatiki i energetiki.-Tashkent, 2019, - № 3.
7. Hingorani, N.G. Flexible AC Transmission Systems (FACTS) - Owerview / N.G. Hungorani // Paper presented at the Panel Session of FACTS. IEEE PES 1990 Winter Meeting. Atlanta, 1990.
8. Hingorani, N.G. Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems / IEEE Press, 2000.
9. Song, Y.H. Flexible AC Transmission Systems (FACTS) / Y.H. Song, A.T. Johns. – London: IEEE Press, 1999.
10. Pospelova T.G. Effekti primeneniya FACTS i ASM v povishenii effektivnosti regionalnix i natsionalnix energosistem// International Conference “Energy of

Moldova.Regional aspects of development”. October 4-6, 2012. - Chisinau, Republic of Moldova.Pgs.83-90.
11. Khamidov Sh.V. Sostoyanie i perspektivnoe razvitie OES Sentralnoy Azii.// Metodicheskie voprosi issledovaniya nadejnosti bolshix sistem energetiki: Sbornik nauchnix trudov 89 zasedaniya Mejdunarodnogo nauchnogo seminara imeni U.A.Rudenko. – Izdatelstvo:Fede-ralnoe gosudarstvennoe byudjetnoe uchrejdenie nauki Institut sistem energetiki im.L.A. Melent`eva Sibirskogo otdeleniya Rossiyskoy akademii nauk, 2017.- S.
12. Shukhrat Khamidov, Sunnatilla Tillaev, Bahrom Normuratov. “Improving the reliability of UPS Central Asia implementation of FACTS devices”- Rudenko International Conference “Methodological problems in reliability study of large energy systems” (RSES 2020).
13. Khamidov Sh.V,Normuratov B.R.,Pulatov B.M,Kilichov O.G. “Optimization of power flow through FACTS in electrical networks”- “Construction Mechanics,Hydraulics and Water Resources Engineering”(CONMECHHYDRO-2020)

СВЕДЕНИЕ ОБ АВТОРАХ:

- фамилия, имя, отчество: Мисриханов Мисрихан Шапиевич
- место и адрес работы: Ивановский государственный энергетический университет.
Адрес: 153003, г. Иваново, ул. Рабфаковская, д. 34.
- должность: заведуюшая кафедрой
- рабочий телефон: (495) 963-47-17
- образование: высшее
- ученая степень: доктор технических наук
- научное звание: профессор
- e-mail: mmsh@mes-centra.ru

- фамилия, имя, отчество: Хамидов Шухрат Вахидович
- место и адрес работы: Ташкентский государственный технический университет.
Адрес: 100095, Республика Узбекистан, г. Ташкент, ул. Университетская, 2.
- должность: -
- рабочий телефон: +99890 808-48-61
- образование: высшее
- ученая степень: доктор технических наук
- научное звание: профессор
- e-mail: khamidov_sh@mail.ru

- фамилия, имя, отчество: Нормуратов Бахром Равшанович
- место и адрес работы: Ташкентский государственный технический университет.
Адрес: 100095, Республика Узбекистан, г. Ташкент, ул. Университетская, 2.
- должность: ассистент
- рабочий телефон: +99899 871-91-88
- образование: высшее
- ученая степень: -
- научное звание: -
- e-mail: normuratov.bahrom@mail.ru