Power Factor Control in the Building by the Air Conditioning built-in Active Filter

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Abstract- The authors, reviewed the recent situation, and think that the compensation capability allowance of active filters incorporated in air-conditioners could be brought into play in order to further utilize the active filters because air-conditioners are scarcely operated in the off-season or in the light load period. That is, the authors investigated the possibility of an air-conditioner built-in type automatic power factor regulator that uses the excess compensation capability of air-conditioner built-in active filter in order to improve the leading power factor during a light load period such as in the off-season, etc. We would like to report our investigation result as follows. The authors investigated and evaluated the possibility of an air- conditioner built-in type automatic power factor regulator utilizing the excess compensation capabilities of the air- conditioner built-in active filter in order to improve the leading power factor during a light load period such as the off-season, etc. of electrical system. As a result, the desired control performance of improving the power factor was obtained.

Keywords Air Conditioning, Active Filter, Automatic Power Factor Controller, Static Capacitor(SC).

1. Introduction

Recently, prompted by the global environmental issues, photovoltaic generation, wind-power generation, and other dispersed power sources are increasing rapidly. Meanwhile, in office buildings and factories, static capacitors (SC) are installed for the purpose of phase modifications and power factor improvement of the electric power system. The static capacitor with capacity about 1/3 that of a three-phase transformer has been installed customarily. In recent years, the average power factor of loads has been improved by an increase of inverter equipment, etc., giving rise to an issue of a leading power factor, in particular, during the intermediate period when the air-conditioner load is small. Reference [1] reports that at a high-voltage customer where no automatic power factor regulator is installed, it is frequently observed that the power factor at the power receiving point tends to lead irrespective of the type of business or time of year, and it also reports that the installation ratio of automatic power factor regulators, etc. is 9%, suggesting that the automatic power factor regulators have not yet gained popularity. This causes the rise of voltage of the power distribution system due to the Ferranti effect, and recently, it is not infrequent that the Ferranti effect presents a problem. Meanwhile, survey results of Agency for Natural Resources and Energy of Japan, etc. reported that in an office building, commercial-use air conditioners are installed and the electricity consumed by the commercial-use air conditioners accounts for about 40% on average of the total power consumption of the whole building. In addition, specific customers install air-conditioners with active filters incorporated to reduce power line harmonics. The active filter shipment volume is increasing yearly. As shown in Fig. 1, the ratio of active-filter shipment volume to the domestic shipment volume of commercial-use air-conditioners of our Company reaches nearly 30%. Speaking of the active filter, a large number of people have engaged in research since long before [2]-[6]. The authors, therefore, reviewed the recent situation, and think that the compensation capability allowance of active filters incorporated in air-conditioners could be brought into play in order to further utilize the active filters because air-conditioners are scarcely operated in the off-season or in the light load period. That is, the authors investigated the possibility of an air-conditioner built-in type automatic power factor regulator that uses the excess compensation capability of air-conditioner built-in active filter in order to improve the leading power factor during a light load period

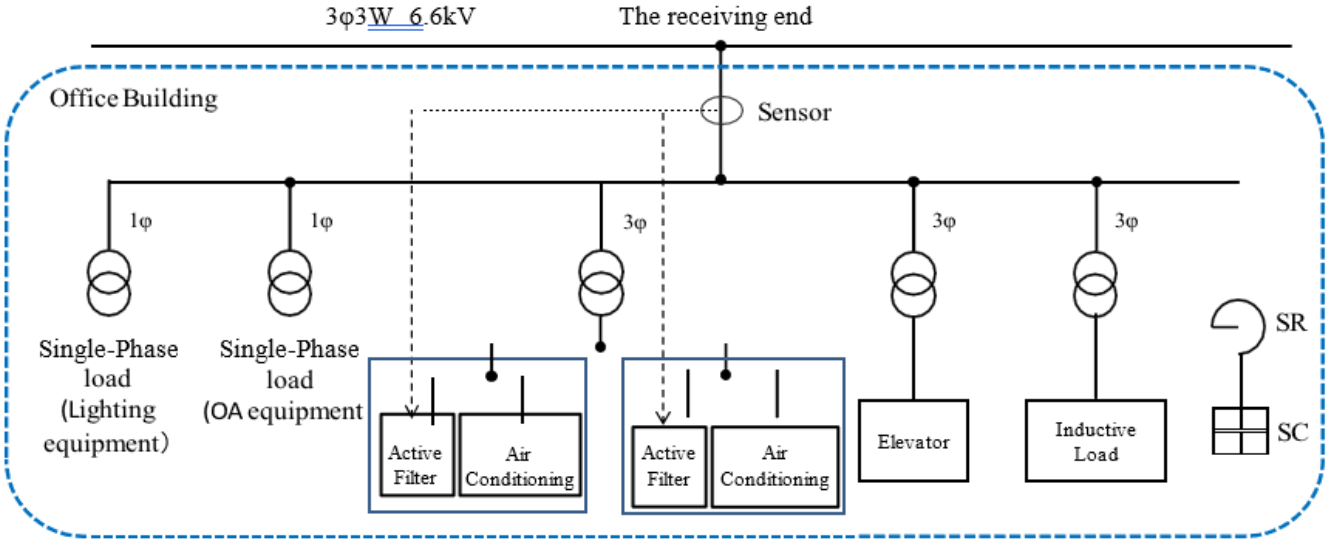

Fig. 2. Proposed system configuration

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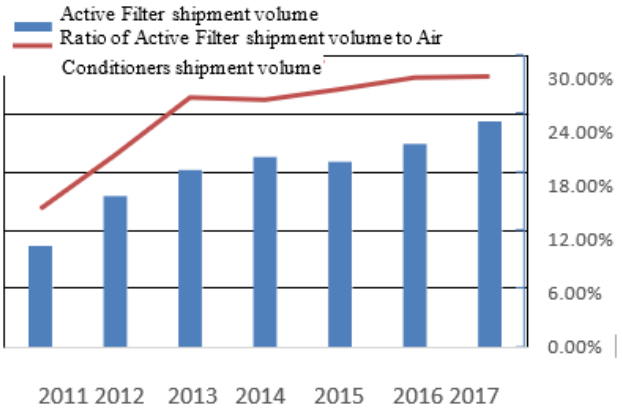


Fig. 1. The percentage of Active Filter shipment volume

2. Automatic Power Factor Regulator By The Air-Conditioner Built-in Active Filter

The present chapter describes the result of our evaluations on the system configuration of automatic power factor regulator by the proposed air-conditioner built-in active filter as well as on the proposed method using evaluation equipment.

2.1. Proposed System Configuration

Fig. 2 shows the proposed system configuration. It indicates a configuration for a general office building. In a large-volume building, several tens of air-conditioners are installed and in each of the air-conditioners, an active filter is incorporated. In order to correct the lead of power factor at the power-receiving point of the building during the light load period, etc. of air-conditioners, the information of the sensor installed to the power-receiving point is sent to each air-conditioner, and based on the sensor information, the active filter incorporated in the air-conditioner makes up for the lead.

2.2.2. Evaluation Equipment

Fig. 3 shows evaluation equipment which was used for evaluation of the proposed system configuration. Table 1 shows conditions of each load for the evaluation equipment. The load was set in such a manner that the ratio of the air-conditioner load to other three-phase loads becomes 4 to 1 at the maximum, assuming the electric power usage of a general office building. OA equipment, lighting equipment, and other single-phase devices are not taken into account for the present evaluation equipment, because they include many high-power factor products.

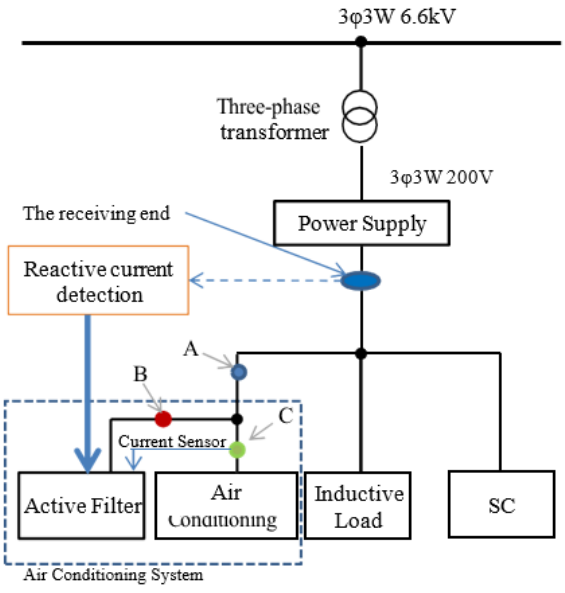


Fig. 3. Evaluation equipment of the proposed system

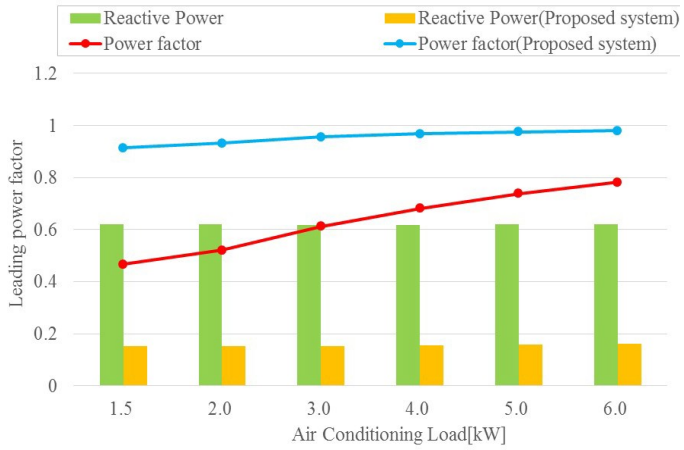
Table 1. Condition of the evaluation equipment.	
Air Conditioning	1.5kW～6.0kW
Active Filter	5.3kVA
Inductive Load	2.47kVA
Static Capacitor (SC)	8.3kvar

3. Results

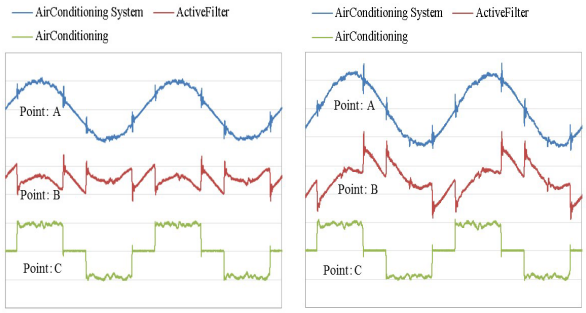
Fig. 4 shows the test result. When the proposed system configuration is not available, the reactive power of air-conditioner is compensated by the active filter, and therefore, the reactive power of the power receiving point depends on sizes of inductive load and static capacitor. Consequently, when a light load is applied to the air- conditioner, based on Fig. 4 (a), the leading reactive power supplied from the static capacitor becomes excessive, and about 0.47 leading power factor is generated at the power receiving point.

Meanwhile, Fig. 4(a) also shows that the power factor at the power receiving point has been able to be greatly improved to 0.9 or higher by operating the air-conditioner built-in type automatic power factor regulator that makes the best of excess compensation capabilities of air-conditioner built-in active filter.

According to the current waveform of Fig. 4 (b), in a conventional system, the active filter operates for controlling harmonics as well as improving the power factor of air-conditioner only, but in the proposed system configuration, it can be confirmed that the compensating current of active filter is lagged in order to make up for the leading power factor of overall load.



(a) Power Factor and Reactive power



Conventional system Proposed system

(b) Current wave

Fig. 4. Evaluation result

4. Conclusion

The authors investigated and evaluated the possibility of an air- conditioner built-in type automatic power factor regulator utilizing the excess compensation capabilities of the air-conditioner built-in active filter in order to improve the leading power factor during a light load period such as the off-season, etc. of electrical system. As a result, the desired control performance of improving the power factor was obtained. From now on, the authors plan to carry out evaluations by field tests throughout one year and hope to report any successful result when obtained.

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