

Application of Electrical Automation in Smart City

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Abstract: With the acceleration of urbanization, the concept of smart city came into being, aiming to improve the efficiency of urban management and the quality of life of residents through advanced information technology and integrated innovative technologies. Electrical automation is the foundation and support of smart city construction, and its intelligent and automated application is crucial to realize the functions of smart city. This article explores several key application areas of electrical automation in smart cities, including smart grids, smart buildings, smart transportation, smart security, etc., and analyzes how these technologies contribute to the development of smart cities, as well as the benefits they bring, and looks at future trends.

Keywords: Electrical Automation; Smart City; Smart Grid; Intelligent Building; Intelligent Transportation; Intelligent Security.

1. Brief Introduction of Electrical Automation

1.1. Definition of Electrical Automation

Electrical automation technology, as the cornerstone and core of modern science and technology, is developing rapidly with its deep integration with daily life and industrial production. This technology field has reached a relatively mature stage and has become a key force driving the development of high-tech industries. It plays a decisive role in industry, agriculture, national defense and other fields, and has an increasingly far-reaching impact on social economy.

The widespread application of electrical automation technology, from the subtle, such as the manufacture of a simple switch, to the grand project, such as the design of spacecraft, all reflect its ubiquitous influence. The great leap in electronic technology has not only made great contributions to the arrival of the information age supported by computer networks, but also profoundly changed the mode of human work and life.

Professor of Stanford University once pointed out: "At present, electrical engineering has expanded to almost all the fields related to electrons and photons." This statement highlights the widespread and far-reaching impact of electrical automation technology in modern technology. As technology continues to advance and innovate, electrical automation will undoubtedly continue to be a powerful engine driving society forward.

1.2. Development Prospects

Electricity is not only a key material basis for promoting production development and improving people's living standards, but also an important symbol of the modernization of the national economy and people's lives. With the continuous deepening and expansion of electric power application, its importance in modern society is becoming increasingly prominent. The current international situation predicts that the global demand for electricity will continue to grow in the coming years, and this trend also applies to the urgent need for electrical technology and automation professionals.

On the one hand, when modern enterprises set up factories, they increasingly rely on electrical equipment, with a wide

variety of equipment and different functions, which directly leads to a huge demand for skilled and experienced technicians and maintenance personnel. As the demand for these professionals continues to rise, so do their pay packages.

On the other hand, scientific research personnel in the field of electrical automation also need a large number of training. Many electrical products, especially those at the forefront of high-tech products, their research and development process requires a large number of scientific research talents with professional skills and innovative thinking. Therefore, the extensive establishment of scientific research institutions throughout the country is gradually strengthening the strength of professional scientific research personnel. The market of electrical automation is developing rapidly, and it occupies a pivotal position in the entire social and economic development, and the market development prospects are broad and full of unlimited potential.

2. Concept and Development of Smart City

2.1. Definition of Smart City

Although the concept of smart city has been in existence for more than a decade, its definition is still not settled. Next, we will explore the interpretation and understanding of this concept by different companies and scholars.

Smart city is a city built with the support of digital technology, which integrates AI technology, VR technology, spatial and geographic information integration technology, decision-making technology and other information technologies. The application of these technologies in urban construction and planning not only realizes the sharing and interaction of resources within the city, but also completely breaks the status quo of information island inside the city[1].

The concept of smart city can be summarized into three levels: first, modern information technology as the basic support, supplemented by policies and other supporting conditions; Secondly, it is the object of smart city service, that is, urban governance and all aspects of residents' lives; Finally, it is the ultimate goal of improving the quality of life and health of urban residents, covering specific small goals in different fields.

2.2. Characteristics of Smart Cities

After in-depth study of the existing research results of smart city construction in various regions, it can be found that the construction of smart cities mainly focuses on the following typical characteristics:

1. People-oriented concept: Many smart cities emphasize the principle of "people-oriented" in the planning and construction. They believe that the needs of the public must be put first to ensure that the design and implementation of smart cities can effectively solve the real problems of residents in order to enhance public satisfaction.

2. Shared linkage: Shared linkage is one of the core features of smart city construction. Through the sharing and linkage of information resources, different departments and agencies can collaborate efficiently, make full use of urban resources, and significantly improve the efficiency of government services and residents' lives. However, while promoting the sharing linkage, the importance of information security cannot be ignored.

3. Innovation-driven: Innovation is the driving force for the construction of smart cities. Smart city itself is an innovative practice, and urban development needs to rely on continuous innovation to promote. Through the innovation of information technology, the innovation of system and management mode, the city will become more efficient and healthy, and realize the coordinated development of government, enterprises and individuals.

4. Sustainability: The construction of smart cities aims to achieve long-term sustainable development of cities. This requires attention to green construction in the construction process, such as energy-saving facilities, public service platforms and project self-sufficiency, are the embodiment of green development concept. Smart city projects may be pure investments in the initial stage, but after entering the middle and later stages, they must have profitability to ensure sustainable viability.

To sum up, the construction of smart cities is a comprehensive and multi-dimensional process, which requires us to take into account the people-oriented concept, shared linkage, innovation-driven and sustainability in planning and implementation, so as to build a more intelligent, efficient and green future city.

3. Smart Grid

3.1. Concept of Smart Grid

In recent years, with the successive introduction of national policies, the development of smart grid has been strongly supported. China's definition of smart grid can be understood as "strong grid frame" and "information platform"[2]. Since 2011, China's smart grid construction has entered a new stage of comprehensive promotion. This process has not only promoted the bidding and procurement activities of smart meters, but also accelerated the vigorous development of the smart meter market. In the context of global smart grid development, the demand for new meters has brought unprecedented opportunities for Chinese enterprises. Thanks to the incentives of national policies and the pull of the international market, it is expected that in the next few years, China's smart meter market will continue to maintain a steady growth momentum.

Smart grid, known as "grid 2.0", is based on a highly integrated, high-speed two-way communication network, integrating advanced sensing and measurement technology,

equipment technology, control methods and decision support system technology to implement real-time monitoring and management of the production, transmission, distribution and consumption of the power system. Its goal is to ensure the reliability, security, economy, efficiency, environmental friendliness and safety of the power grid. Key features of smart grids include self-healing capabilities, user incentives and protection, attack resistance, power quality to meet user needs, acceptance of diverse forms of generation, activation of power markets, and optimal and efficient operation of assets. Smart grid solutions include increasing the digitization of assets and equipment, establishing data integration and collection systems, and the ability to optimize operation and management based on data analysis.

The intelligence of smart grid covers six aspects: intelligent substation, power generation, transmission, distribution network, power consumption and dispatch. Here, we pay special attention to intelligent substation systems. The smart substation adopts advanced, reliable, integrated and environmentally friendly intelligent equipment, and automatically completes basic functions such as information collection, measurement, control, protection, measurement and detection based on the digitization of the whole station information, the networking of the communication platform and the standardization of information sharing, and supports advanced functions such as real-time automatic control, intelligent regulation, online analysis and decision making and collaborative interaction of the power grid.

The smart grid is the core of smart city energy management, which not only greatly improves the efficiency and reliability of the grid, but also promotes the integration of renewable energy sources and the development of demand side management. In a broad sense, smart grid includes intelligent scheduling systems that prioritize the use of clean energy, intelligent metering systems with dynamic pricing, and intelligent technology systems that optimize load balance by adjusting power generation and electrical equipment. The basic structure of the future smart grid will show that electricity flows from centralized power plants to users, while the grid will be filled with a variety of new and clean energy sources, such as solar, wind, fuel cells, electric vehicles, and so on. High-speed, two-way communication systems will enable information exchange between the control center and the grid equipment, while advanced analytical tools and decision-making systems will ensure the safe, stable and optimized operation of the smart grid.

3.2. Renewable Energy Integration

The renewable energy integration of smart grid is a complex process that requires concerted efforts from many aspects, such as technological innovation, policy support, market mechanism and public participation. With the advancement of technology and the promotion of policies, this field is expected to achieve faster development and wider application.

The renewable energy integration of smart grid is an advanced process that efficiently integrates clean energy sources such as wind, solar, and water into the grid, aiming to diversify and clean energy supply. Although this process is full of challenges, it is also pregnant with unlimited opportunities.

At the technical level, we can significantly improve energy conversion efficiency through the deployment of efficient wind turbines, solar photovoltaic panels and hydroelectric

power facilities. At the same time, integrated battery energy storage systems, pumped storage and compressed air energy storage technologies help balance supply and demand fluctuations and cope with the intermittent nature of renewable energy. The use of automation and artificial intelligence technologies further optimizes the generation, transmission and distribution of electricity. The establishment of real-time monitoring and demand response mechanism, the use of electricity demand can flexibly adapt to changes in the supply of renewable energy. The establishment of microgrid enhances the utilization efficiency of renewable energy and the anti-disturbance ability of power grid. The deployment of smart meters realizes the real-time collection of electricity consumption data, which provides strong data support for energy management and demand response.

At the regulatory level, it is crucial to develop policies that support the development of renewable energy, including subsidies, tax incentives and quotas. Create a green electricity market to incentivize consumers to choose renewable electricity. The formulation of unified technical standards and communication protocols ensures the compatibility and interoperability between different systems. The strengthening of public education and training has increased the understanding and acceptance of renewable energy and smart grid in society. Encouraging public participation, such as community solar projects, not only increases social acceptance, but also promotes cross-sectoral collaboration, forming a synergistic effect.

From a benefit perspective, smart grid renewable energy integration helps reduce greenhouse gas emissions and reduce dependence on fossil fuels, while creating jobs and boosting local economies. It promotes diversification of energy supplies and reduces dependence on a single source of energy. In addition, it increases public awareness and acceptance of clean energy, promotes sustainable lifestyles, and drives research and development and innovation in related technologies, ensuring the maintenance of technological leadership.

In conclusion, the renewable energy integration of smart grids is a complex process that requires multi-party collaboration including technological innovation, policy support, market incentives, and public participation. With the continuous advancement of technology and the continuous promotion of policies, we have reason to believe that this field will usher in faster development and wider application, laying a solid foundation for building a clean, efficient and sustainable energy future.

3.3. Requirement Response Management

Smart grid can accurately implement demand response strategies through real-time monitoring and in-depth analysis of users' electricity consumption data. This strategy encourages users to increase electricity consumption during low peak hours of power demand, effectively balance the load of the grid, and promote the stable operation of the power system.

Demand response management of smart grid is a core technology in power system management. It sets up a bridge between grid operators and consumers, and uses price signals or incentive mechanisms to guide users to adjust their power consumption habits to achieve economic and dynamic balance of grid loads. The five core elements of demand response management include:

1. Real-time monitoring: The use of intelligent metering

equipment to collect electricity consumption data, real-time monitoring of power grid status and user consumption behavior, to provide accurate data support for demand response.

2. Price signal: Through the dynamic pricing mechanism, such as the implementation of peak and valley electricity prices, the user's power decision is affected, and the user is guided to use more electricity during the period of low electricity prices.

3. Incentive mechanism: Provide economic incentives for users participating in demand response, such as subsidies or rewards, to increase the enthusiasm of users to participate.

4. User participation: Households, commercial and industrial users are encouraged to participate in demand response through direct or indirect means to jointly maintain the stability of the grid.

5. Load control: During the peak or low load period of the power grid, the power load can be adjusted automatically or manually to achieve reasonable load distribution.

To realize the demand response management of smart grid, it is necessary to comprehensively evaluate the load characteristics of grid and the consumption patterns of users, and determine the potential capacity and demand of demand response. Develop and implement demand response strategies based on grid operation and user characteristics. Communicate with users through various channels to ensure that users understand the relevant information and operation methods of demand response. When the power grid needs, timely start the demand response measures, such as adjusting the temperature of the air conditioner and suspending non-critical electrical equipment. At the same time, the implementation effect of demand response is monitored, and its impact on the power grid load and the consumption behavior of users is evaluated.

The implementation of demand response management not only reduces the load peak of the power grid, improves the stability of the power grid operation, but also promotes the optimal distribution of power resources and improves the efficiency of energy use. It reduces investment in grid infrastructure and reduces the cost of electricity supply. By encouraging the use of clean energy, demand response management helps to reduce greenhouse gas emissions and drive the energy transition and sustainable development. By participating in demand response, users can not only gain economic benefits, but also improve their power management capabilities.

Demand response management of smart grid is an important means to realize intelligent and efficient power system, which is of great significance to promote energy transformation and sustainable development. With the continuous progress of technology and the improvement of market mechanism, demand response management will certainly play a more critical role in the future power system, and make important contributions to the construction of a clean, efficient and sustainable energy future.

4. Smart Building

4.1. Definition and Characteristics of Intelligent Buildings

Since the concept of smart buildings was first unveiled in 1984, the field has undergone tremendous changes. That year, United Technologies Building Systems, a subsidiary of United Technologies, successfully remodeled a building in

Hartford, Connecticut, called Town Square, and used the term "smart building" for the first time.

Intelligent building is a model of interdisciplinary integration, which not only relies on basic discipline principles to promote the development of planning, design, construction and operation management and other technologies, but also has clearly defined scientific problems and characteristics, showing significant comprehensive characteristics. However, these characteristics also bring challenges to system integration, and a standardized information exchange technology is urgently needed. XML/WebServices technology stands out for its openness, standard and ease of use, becoming an ideal choice for intelligent building automation system integration. The use of XML/WebServices technology for intelligent building automation system integration is the embodiment of the development of the industry, leading the future direction of intelligent building automation technology.

Intelligent building has distinct features in function, the core of which is that it must be centered on the service object. All intelligent designs should focus on their functions and service objects, and are committed to providing more humanized services. Intelligent buildings should not only provide intimate humanized services for customers, but also provide efficient services for managers. For example, it provides intelligent decision support for the system, intuitive visual management interface for technical personnel, and energy saving and consumption reduction strategies for management personnel.

The level of intelligence of a building is often measured by its degree of automation, with common classifications being 3A buildings and 5A buildings. 5A building represents a highly intelligent building, on the basis of 5A, by expanding the functions and services of the subsystem, the formation of a more advanced intelligent building.

The development of intelligent buildings not only improves the operating efficiency and living comfort of the building itself, but also brings unprecedented convenience and value to the building managers and service objects, marking the construction industry's firm progress towards a smarter, greener and more humanized direction.

4.2. Application of Electrical Automation in Intelligent Buildings

4.2.1. Energy Management System

The energy management system in the intelligent building ensures the optimal distribution of energy consumption through accurate real-time monitoring and adjustment. This system is a key component of the Smart energy network, which aims to improve energy efficiency and reduce energy costs while mitigating environmental impact by monitoring, controlling and optimizing energy use.

Electrical automation technology plays a central role in energy management systems. It can monitor the use of electricity, gas, water and other energy sources in real time, collect data using sensors and smart meters, and transmit it to a central control system for in-depth analysis. In the power system, electrical automation technology can automatically adjust power demand according to the real-time load condition of the power grid, such as adjusting the operation plan of equipment or reducing the energy consumption of non-critical equipment to adapt to changes in power grid demand.

Electrical automation systems can also automatically

dispatch energy resources, such as intelligent control of generator start and stop, adjust the load distribution, to achieve efficient use of energy. In a smart building environment, the technology can control the operation of lighting, air conditioning, heating and other systems, and automatically adjust energy consumption according to actual demand, greatly improving energy efficiency. In the field of industrial production, electrical automation technology can also optimize the use of energy in the production line, for example, by controlling the motor speed through the variable frequency governor, effectively reducing energy waste.

In addition, electrical automation technology can also manage and optimize distributed energy resources, such as solar, wind, energy storage systems, etc., to ensure the rational distribution and efficient use of energy. By analyzing the operational data of energy equipment, electrical automation systems can predict and prevent potential equipment failures, perform maintenance ahead of time, and avoid energy waste. The system can also automatically generate energy audit reports to help enterprises and institutions deeply understand energy use, tap energy saving potential, and formulate effective energy saving measures.

The integration of electrical automation technology and smart grid further realizes the automatic monitoring, protection, recovery and optimization of the power grid, and enhances the stability and reliability of the power grid. The user-friendly interface design enables users to monitor their energy usage in real time and perform necessary control actions through a mobile app, web page or central console.

In summary, the application of electrical automation technology in energy management systems is crucial, which not only improves energy efficiency and reduces energy costs, but also promotes sustainable development and reduces environmental impact. With the continuous progress of technology, the application of electrical automation in energy management systems will become more extensive and in-depth, opening a new chapter in smart energy management.

4.2.2. Environmental Control System

The smart building creates a comfortable and healthy living and working space for its occupants through carefully designed automated control. Environmental control systems, as one of the core technologies in smart buildings, cover a range of methods for monitoring and regulating indoor and outdoor environmental parameters (such as temperature, humidity, air quality, etc.).

The application of electrical automation technology in environmental control system greatly improves the efficiency and reliability of the system. Here are some practical examples:

1. Temperature and humidity control:

The automatic temperature and humidity control system can automatically adjust the working status of air conditioners, humidifiers, dehumidifiers and other equipment according to preset standards or real-time monitoring data to maintain the comfort of the indoor environment and meet the strict requirements of temperature and humidity in specific places (such as laboratories, museums, etc.).

2. Air quality monitoring and control:

With the help of electrical automation technology, the system can monitor air quality indicators inside and outside the room in real time, including PM2.5, CO2 concentration, etc., and automatically manage the ventilation system or air purification equipment to ensure continuous improvement of air quality.

3. Lighting control:

The intelligent lighting system can automatically adjust the brightness and color temperature of the lighting according to the natural light intensity, indoor and outdoor environmental conditions and people's activity patterns, which not only saves energy, but also improves the comfort of the light environment.

Through these intelligent applications, electrical automation technology plays a crucial role in environmental control systems. It not only improves the intelligent level of environmental management, but also effectively reduces energy consumption, while enhancing user comfort and safety. With the continuous progress of technology, the application of electrical automation in environmental control systems will be more extensive, providing strong support for creating green, energy-saving and efficient intelligent buildings.

5. Intelligent Transportation

5.1. Overview of Intelligent Transportation Systems

The construction of urban intelligent transportation system aims to integrate advanced technology and management strategies to achieve efficient management and optimization of urban traffic flow. Through a unified control platform and a powerful data computing center, as well as a series of application subsystems, the system significantly enhances the traffic control and emergency command and dispatch capabilities of expressways, urban core areas and key development areas. Intelligent transportation system realizes intelligent, efficient and streamlined traffic management through advanced computer technology, diversified data detection technology, network technology, communication technology and advanced traffic model[3].

5.2. Traffic Signal Control

One of the core links of intelligent transportation systems (ITS) is traffic signal control, which uses advanced electrical automation technology to significantly improve the efficiency of traffic flow, effectively alleviate traffic congestion, and enhance road safety. Through the deployment of sensors, cameras and other equipment, the system can collect real-time traffic data, including vehicle flow, speed and workshop distance and other key information, providing a solid data foundation for signal control.

The electrical automation system can automatically adjust the timing and timing of traffic lights according to the real-time monitoring of the traffic flow, optimize the traffic flow and reduce the waiting time of vehicles. Through in-depth analysis of historical and real-time data, the system intelligently adjusts the duration of the green, red and yellow lights to adapt to the traffic needs of different periods and sections.

In emergency situations, such as fire trucks, ambulances and other emergency vehicles need to pass quickly, the electrical automation system can respond quickly, prioritize the adjustment of the signal light, and ensure the rapid passage of emergency vehicles. When the system detects a traffic jam, it can implement traffic control measures, such as adjusting the timing of the lights to guide the vehicles to a reasonable diversion.

In addition, electrical automation technology also plays an important role in the control of pedestrian crossing signals, which automatically adjust the signal light according to the

flow of pedestrians and vehicles to ensure the safety of pedestrians and vehicles. In the event of a traffic accident or abnormal situation, the automated system can react quickly and adjust the timing of the lights to reduce the impact of the accident and prevent the occurrence of secondary accidents.

In complex urban traffic environments, electrical automation systems can simultaneously manage multiple traffic modes, including cars, bicycles and pedestrians, ensuring smooth and safe traffic. The traffic signal control center can remotely monitor and control the signal lights at each intersection, respond to traffic changes in time, and make remote adjustments and troubleshooting.

The large amount of traffic data collected by the electrical automation system not only provides support for daily traffic management, but also can be used for in-depth analysis of traffic trends, and provides powerful decision support for the formulation of traffic planning and signal control strategies.

To sum up, the application of electrical automation technology makes traffic signal control more intelligent and efficient, which is of great significance for alleviating urban traffic pressure, improving road use efficiency and improving traffic safety.

5.3. Intelligent Parking

Intelligent parking system, with the wings of modern information technology, such as the Internet of Things, big data, cloud computing, etc., to achieve efficient management and optimization of parking resources. This system not only improves parking efficiency and user experience, but also effectively reduces traffic congestion and enhances the operational efficiency of the parking lot.

By deploying advanced equipment such as sensors and cameras, smart parking technology can collect and display critical data about parking lots in real time, such as the number of vacant Spaces and vehicle access. The system can intelligently recommend the best parking route and location according to the driver's real-time location and parking needs, which greatly reduces the time to find a parking space.

The application of license plate recognition technology makes the entry and exit procedures of vehicles automated, both fast and accurate. Users can now easily pay for parking through mobile apps or online payment platforms, eliminating the hassle of cash transactions and significantly improving payment efficiency. In addition, users can book parking Spaces in advance through the mobile app to ensure a guaranteed parking space when they arrive.

The application of big data analysis provides the possibility of deep optimization for the operation and management of parking lots, including adjusting charging strategies, predicting parking demand, etc., and further improving operational efficiency. The intelligent parking system can also be integrated with the traffic signal control system to intelligently adjust the timing of the traffic lights on the surrounding roads according to the busy level of the parking lot to relieve traffic pressure.

The implementation of the intelligent parking system not only reduces the time of looking for parking Spaces, improves the operational efficiency of the parking lot, but also reduces the traffic congestion caused by looking for parking Spaces through intelligent guidance and traffic signal control. It provides users with convenient and efficient parking services, which greatly improves the user experience. At the same time, by optimizing management and operation, the operation cost of the parking lot is effectively reduced.

Intelligent parking systems also make a positive contribution to environmental protection by reducing vehicle idling time and reducing emissions. With the continuous progress of technology and the acceleration of urbanization process, intelligent parking system will become an indispensable part of urban traffic management, and has far-reaching significance for promoting the intelligent development of urban traffic.

6. Conclusion and Prospect

6.1. Suggestions for Future Smart Cities

With the continuous progress of technology, smart cities are ushering in wave after wave of innovation. The application of cutting-edge technologies such as artificial intelligence, cloud computing and big data will be more in-depth, paving the way for efficient resource management and personalized service delivery.

Environmental protection has become a global consensus, and the construction of smart cities has also integrated the concept of green and sustainable into its blood. Through the application of smart technology, energy conservation, pollution monitoring and treatment can be achieved, and together create a more livable and harmonious urban environment.

The construction of smart cities always focuses on serving citizens. Looking forward to the future, smart cities will continue to optimize the public service system, use smart technology to provide residents with more convenient transportation, medical care, education resources, and comprehensively improve the quality of life of residents.

Big data is playing an increasingly important role in the construction of smart cities. Through the collection and in-depth analysis of massive data, smart cities can provide a solid scientific basis for government decision-making and achieve scientific and refined urban management.

In the blueprint of smart cities, the integration of technology and humanity will be closer, which will not only improve the efficiency of urban operation, but also enrich the life experience of citizens, making cities smarter, friendlier and more vibrant. The future of smart cities will be a perfect integration of technology and life, opening up new possibilities for the development of human society.

6.2. Development Trend of Electrical Automation

Electrical engineering plays a diversified key role in the construction of smart cities, and its influence runs through various fields from energy management to intelligent upgrading of infrastructure. The continuous innovation of technology has injected new vitality into electrical engineering, indicating that its core position in the development of smart cities will become increasingly prominent.

With the rapid development of technology, electrical engineering is gradually becoming the driving force for the development of smart cities. It not only improves the efficiency of energy use and ensures the security of energy supply, but also promotes the transformation and upgrading of urban infrastructure to a smarter and more environmentally friendly direction. The intelligence of electrical engineering makes urban energy management more refined, optimizes energy distribution, and reduces waste.

In addition, electrical engineering also plays a vital role in improving the intelligent level of urban infrastructure. Smart grid, intelligent transportation system, intelligent buildings, etc., are the concrete embodiment of the wisdom of electrical engineering, and together they build a solid foundation for smart cities.

In the future, electrical engineering will continue to provide strong support for the efficient operation, safety, reliability and sustainable development of smart cities with its innovative capabilities. It will become an indispensable technological pillar of smart cities, promoting urban life to a more convenient, comfortable and environmentally friendly direction.

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