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DESIGN OF CONTROL SYSTEM OF AIR DECONTAMINATION MACHINE IN TEXTILE ENTERPRISES USING IOT

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Abstract: *In this paper, a control system for an IoT air disinfection machine is designed based on the ESP32 microcontroller. The system utilizes the ESP32 as the main control chip and adopts a control scheme based on IoT technology. Remote control and monitoring of the air disinfection machine are achieved through a cloud server. The sensor module detects parameters such as particles, carbon dioxide, temperature, and humidity in the air to realize real-time monitoring of air quality. The control module programs the opening and closing of actuators such as relays and motors to achieve the automatic control of the air disinfection machine. The communication module is connected to the cloud server to realize remote control and monitor of the air disinfection machine. The power management module monitors and controls parameters such as current and voltage to achieve energy consumption monitoring and control of the air disinfection machine.*

Annotasiya: *Ushbu maqolada IoT havo dezinfeksiya mashinasini boshqarish tizimi ESP32 mikrokontrolleri asosida ishlab chiqilgan. Tizim asosiy boshqaruv chipi sifatida ESP32 dan foydalanadi va IoT texnologiyasiga asoslangan boshqaruv sxemasini keltirilgan. Havoni dezinfektsiyalash mashinasini masofadan boshqarish va nazorat qilish bulutli server orqali amalga oshiriladi. Sensor moduli havo sifatini real vaqtda monitoringini amalga oshirish uchun havodagi zarralar, karbonat angidrid, harorat va namlik kabi parametrlarni aniqlaydi. Boshqaruv moduli havoni dezinfektsiyalash mashinasini avtomatik boshqarishga erishish uchun motorlar kabi aktuatorlarning ochilishi va yopilishini dasturlaydi. Aloqa moduli havoni dezinfektsiyalash mashinasini masofadan boshqarish va monitoringini amalga oshirish uchun bulutli serverga ulangan. Quvvatni boshqarish moduli energiya sarfini kuzatish va havo dezinfektsiyalash mashinasini nazorat qilish uchun oqim va kuchlanish kabi parametrlarni nazorat qiladi.*

Аннотация: *В данной работе спроектирована система управления IoT-аппаратом для дезинфекции воздуха на базе микроконтроллера ESP32. Система использует ESP32 в качестве основного чипа управления и использует схему управления, основанную на технологии IoT. Дистанционное управление и мониторинг установки для обеззараживания воздуха осуществляется через облачный сервер. Сенсорный модуль обнаруживает такие параметры, как частицы, углекислый газ, температура и влажность в воздухе, для осуществления мониторинга качества воздуха в режиме реального времени. Модуль управления программирует открытие и закрытие исполнительных механизмов, таких как реле и двигатели, для достижения автоматического управления машиной для дезинфекции воздуха. Модуль связи подключен к облачному серверу для осуществления удаленного управления и мониторинга установки обеззараживания воздуха. Модуль управления питанием контролирует и контролирует такие параметры, как ток и напряжение, для обеспечения мониторинга энергопотребления и управления машиной для дезинфекции воздуха.*

Introduction. *With the development of the social economy and the improvement of people's health awareness, disinfection, and hygiene have become a highly concerned topic [1][2]. Traditional disinfection methods are usually labor-intensive and time-consuming, with low efficiency.*

The disinfection process is prone to secondary pollution, which fails to meet people's needs for disinfection. Smart air disinfection machines, on the other hand, can automatically complete the disinfection process, improve disinfection efficiency, and reduce the risk of disease transmission. Therefore, it has a wide range of applications [3]. The goal of this paper is to design an intelligent air disinfection machine control system, aiming to effectively solve the problem of harmful microorganisms and viruses in indoor air pollution [4], and achieve intelligent data processing.

Overall design of the scheme. This system is based on the ESP32 microcontroller as the main control chip, with a high-efficiency main motor, combined with advanced technologies such as sensor technology, ultraviolet irradiation, and ozone generation devices. It is also equipped with human-computer interaction displays, buttons, and APP operations. It innovatively improves the control principle of traditional disinfection machines, solves indoor air pollution problems, and provides a good solution for humans to have a safe, comfortable, and healthy living environment. Through the built-in WiFi and Bluetooth modules of ESP32, data exchange with external sensors, including temperature, humidity, and air quality data, can be achieved. Through the built-in WiFi module of ESP32, it can be connected to the Internet and communicate with external servers to achieve remote control and data transmission. By outputting PWM signals from the IO port of the ESP32 control board and amplifying them through the driving circuit, the motor in the air disinfection machine can be controlled, including adjusting the fan speed and controlling the UV lamp switch. The overall system framework design is shown in Fig. 1.

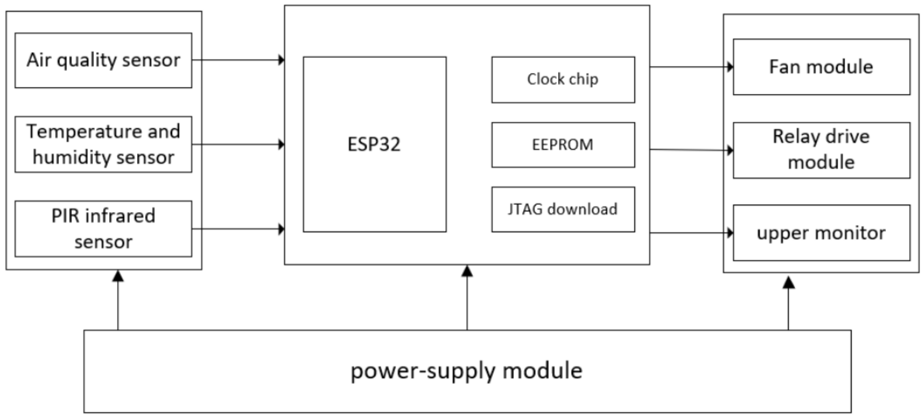

Fig. 1. Overall system framework design.

System hardware design. Master control module design. The ESP32-S3 is a chip designed specifically for the Internet of Things by Espressif Systems. It can meet different power consumption requirements and has high stability and versatility. The main control module of the air disinfection machine control system consists of the ESP32 microprocessor, clock circuit, flash circuit, download interface, and crystal circuit, which form the minimum system circuit. When the ESP32-S3 series chip is operating in TX mode, the instantaneous current will increase, which often causes the power supply to collapse. Therefore, when designing the circuit, a 10 μF capacitor should be added to the power supply line, which can be used in combination with a 0.1 μF capacitor. In addition, an LC filtering circuit needs to be added near the two VDD3P3 pins to suppress high-frequency harmonics, and the rated current of the inductor should be 500 mA or higher. 3.2. Air quality sensor acquisition module This system uses the SDS011 air quality sensor [5], which can detect both PM2.5 and PM10 particles simultaneously. The sensitivity range is 0-1000 μg/m³, and the measurement range is 0.3-1000 μg/m³. It can also automatically adjust the data update function. The SDS011 has two communication modes: UART serial communication and pulse width modulation analog signal output. This module uses UART serial communication, and the microcontroller can send commands to the sensor through serial communication to obtain data such as the particle concentration detected by the sensor. The

SDS011 communication hardware circuit diagram is relatively simple, but the transmitted data needs to be amplified. Fig. 2 shows the SDS011 signal op-amp circuit.

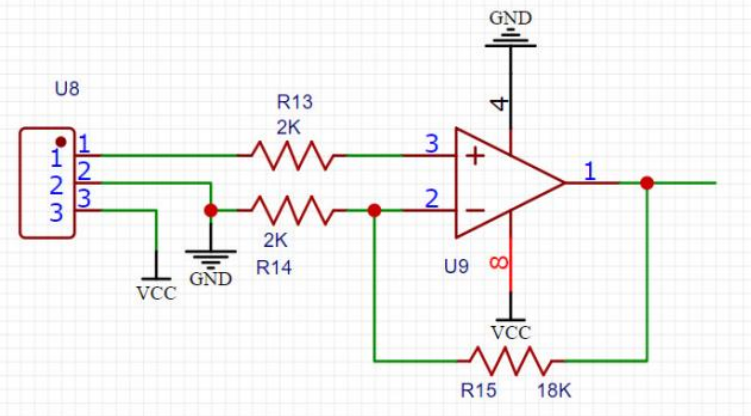

Fig. 2. Air quality sensor transport discharge module.

Power module design. According to the design requirements of each module of the air disinfection machine, the main voltage nodes are supplied by 24 V, 5 V and 3.3 V by distributed power supply [6]. The input voltage of the system is 220 V and converted to 24 V through the voltage circuit as shown in Fig. 3

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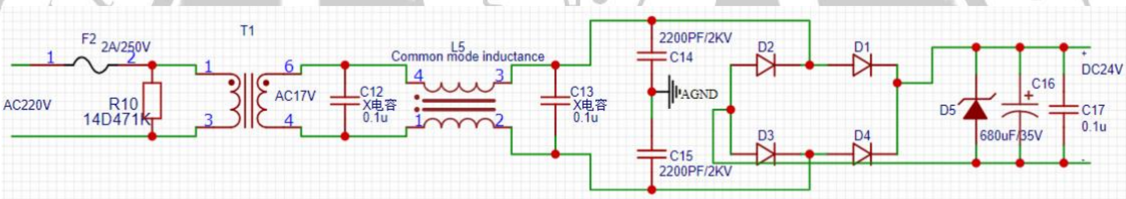

Fig. 3. Transfer from AC220V to DC24V

This voltage regulation circuit converts the AC 220 V mains voltage on the primary side to AC 17 V voltage through an AC 220 V/AC 17 V transformer, rectifies and filters it, and then converts it to DC 24 V voltage through a rectifier bridge, and outputs it to the secondary circuit through a voltage stabilization circuit. F1 is a fuse that quickly melts and cuts off the current when the system malfunctions or abnormalities occur and the current rises to a certain range, protecting the secondary circuit. R10 is a 470 V varistor that is equivalent to an insulator when the overvoltage occurs, and can short-circuit the secondary circuit to prevent damage to the secondary circuit. The sensor module of this system requires a 5 V power supply, while the main control chip and its peripheral circuits, as well as the acquisition circuit, require a 3.3 V power supply. The 24 V to 5 V and 3.3 V circuit uses the AMS1117 series of LDO voltage regulator chips, which are low dropout high-efficiency regulators that adjust the output by comparing the output voltage with an internal reference voltage. To ensure the stability of the output terminal, the AMS1117 requires a tantalum capacitor from VOUT to GND to provide compensation feedback for the internal gain stage. 3.4. The PWM drive fan The fan selected in this system is a G1G133-DE 19-15 centrifugal fan with a working voltage of DC24 V. It is low cost and easy to install.

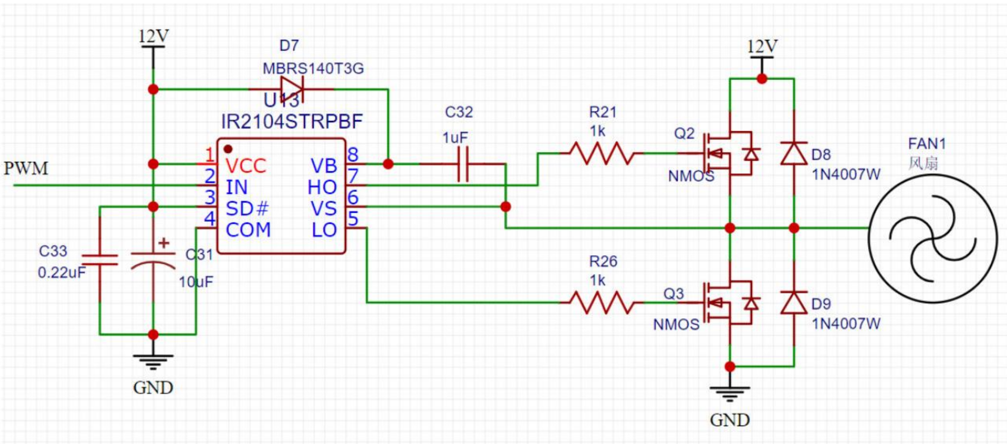

Fig. 4. The PWM controls the fan motor speed.

The output driving capability of the ESP32 microcontroller is limited, so its signal cannot be used directly as a driving signal and needs to be amplified through a driving circuit. As shown in Figure 4, the IR2104 chip is used to drive MOS tubes to generate large currents for motor driving. When the PWM duty cycle changes, the desired speed modulation can be achieved by controlling the even voltage applied to the motor through the driving chip. For this module, two half-bridge driving chips IR2104 are selected to form a fan H-bridge driving circuit. IR2104 is low-cost, fully functional, has low output power, and has a hardware dead zone function, which can meet the requirements of driving amplification very well.

System Test. The air disinfection machine is placed in a smoky environment, and initially, the touchscreen display showed a reading of “43” and “Excellent” quality, and the actuator was in sleep mode. After being placed in the smoky environment for 10 seconds, the touchscreen display showed a reading of “355” and “Poor” quality. At this point, the fan successfully started, and it was clearly seen that air was being drawn in from the air inlet. The touch screen displayed a fan speed of 4 levels and the UV-C sterilization lamp successfully started working. After the machine had been running for about 5 minutes, the amount of smoke in the air greatly decreased, and the air quality index on the touch screen changed to “77” and “Good”. The fan speed changed to level 2, and at this point, the machine was running almost silently, with the UV-C lamp still on, working in conjunction with the negative ion generator to achieve the sterilization and disinfection effect. After 20 minutes, the touch screen displayed “Excellent”, the UV-C lamp turned off, and the fan speed changed to level 1, at which point the air was primarily purified by the HEPA filter.

Table 1.

Purification effect

T (min)	0	1	2	3	4	5	6	7	8	9	10
Air index	355	296	243	202	174	147	123	101	92	84	77

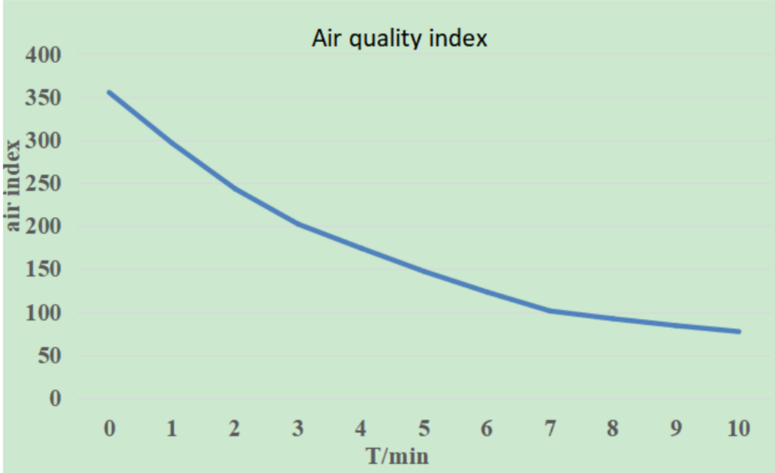

Fig. 5. Air purification performance test.

Conclusion. This article presents a novel control system for an air disinfection machine using ESP32 and IoT technology. Sensors detect the air quality, temperature, and humidity, then send the data to the microcontroller, which determines whether to activate passive disinfection. Users can also control the air disinfection machine through a mobile app, which allows them to turn it on or off, switch modes, and query data. The air disinfection machine was placed in a smoky environment to observe and record its purification time and effect. Experimental results showed that this system achieved the air quality monitoring perfectly. Besides, the air disinfection machine can automatically detect, process, purify, and disinfect when the air quality index is below excellent.

References:

1. Mirzaxmatova S.S. (2025). O'QUVCHILAR KAYFIYATINI BOSHQARISHNING O'ZIGA XOSLIGI. Fan, Jamiyat Va Innovatsiyalar, 3(21), 37-39. https://uzresearch1.uz/index.php/FJI/article/view/481

2. Mirzaxmatova S.S. (2025). TALABALARDA KASBIY MOTIVATSIYANI SHAKLLANTIRISHNING PSIXOLOGIK ASOSLARI. Fan, Jamiyat Va Innovatsiyalar, 3(21), 75-76. https://uzresearch1.uz/index.php/FJI/article/view/482

1. Analysis of multi cloud storage applications for resource constrained mobile devices. Bedi R K, Singh J, Gupta S K. Perspectives in Science, 2016：22-34.

2. Rashmi Thakur, Dipayan Das, Apurba Das. Electret Air Filters[J]. Separation & Purification Reviews, 2013, 42(2):89-90.

3. Hemanth Kapu, Kavisha Saraswat, Yusuf Ozturk, et al Resting heart rate estimation using PIR sensors[J]. Infrared Physics and Technology, 2017, 85：120-130.

4. Jo W K, Park J H, Chun H D. Photocatalytic destruction of VOCs for in-vehicle air cleaning[J]. Journal of Photochemistry & Photobiology A Chemistry, 2002, 148(1): 109-119.

5. Etkin D S. Biocontaminants in indoor environments[M]. Cutter Information Corp. 1994.

6. Yusupov, A. A., Sabirov, U. K., Begijonov, M. S., & Valiyev, D. H. (2023). Analysis of common errors and methods of calibration of ultrasonic level meter. In E3S Web of Conferences (Vol. 402, p. 03051). EDP Sciences.

7. Yusupov Azamat, & Dadajanov Muzaffar. (2023). Uz-meter tech co korxonasida avtomobil ehtiyot qismlarini quyish jarayonida suv bilan sovutish tizimini avtomatlashtirish. Innovations in Technology and Science Education, 2(9), 1999–2012. Retrieved from https://humoscience.com/index.php/itse/article/view/946

8. Юсупов, А. А., & Акрамова, Г. А. (2024). МЕТОД И ПРАКТИКА ТЕХНОЛОГИИ ХОЛОДНОГО КОНДИЦИОНИРОВАНИЯ ЗЕРНОВЫХ. JOURNAL OF INNOVATIONS IN

SCIENTIFIC AND EDUCATIONAL RESEARCH, 7(10), 117-123. https://bestpublication.net/index.php/jiser/article/view/538
9. Muhitdinov, D., Yusupov, A., Safarov, E., Igamberdiyev, A., & Sultanov, I. (2024, July). An improved device for automated control of mass transfer processes used in distillation units. In Third International Conference on Digital Technologies, Optics, and Materials Science (DTIEE 2024) (Vol. 13217, pp. 174-181). SPIE. https://www.spiedigitallibrary.org/conference-proceedings-of-spie/13217/132170T/An-improved-device-for-automated-control-of-mass-transfer-processes/10.1117/12.3035642.full
10. Qo'ldashev, E., Yusupov, A., & Akramova, G. (2024). DONNI SOVUQ KONDITSIONERLASHNI NAZORAT QILISH VA ADAPTIV BOSHQARISH JARAYONINI MATEMATIK MODELINI ISHLAB CHIQISH. Новости образования: исследование в XXI веке, 2(22), 475-478. https://nauchniyimpuls.ru/index.php/noiv/article/view/16515
11. Alijonovich, Y. A. (2024). MODELING OF OIL AND OIL PRODUCTS PROCESSING AND STORAGE SYSTEM IN OIL BASES. European Journal of Emerging Technology and Discoveries, 2(4), 193-198. https://europeanscience.org/index.php/1/article/view/566
12. Юсупов, А. А., & Алибекова, М. (2024). ХАРАКТЕРИСТИКИ И МЕТОДЫ ОЧИСТКИ СТОЧНЫХ ВОД ТЕКСТИЛЬНОЙ ПОЛИГРАФИЧЕСКОЙ И КРАСИЛЬНОЙ ПРОМЫШЛЕННОСТИ В ГОРОДЕ АНДИЖАН. Universum: технические науки, 1(6 (123)), 38-43. https://cyberleninka.ru/article/n/harakteristiki-i-metody-ochistki-stochnyh-vod-tekstilnoy-poligraficheskoy-i-krasilnoy-promyshlennosti-v-gorode-andizhan