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Electronic Load Device for Testing DC Power Supply

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Abstract*: The project deals with a programmable electronic load device capable of dynamic variations of its load parameters to simulate a myriad of electrical conditions. Hence, one of the objectives of this paper is to implement, in a designed setup, variously heated loads, such as constant current, voltage, resistance, and power modes. That said, the designed system has hardware and software aspects that integrate advanced microcontroller capabilities so that high accuracy is assured through a series of test procedures on the system. The hardware design of the project encompasses choosing various resistors and relays modules (ESP32), selection of the proper power supplies, and microcontrollers. A program is being developed in the Arduino IDE that will program the microcontroller to do dynamic load control.It all began with the circuit design and resistor value choice, taking into consideration their power rating about effective heat dissipation. Dynamic loading control by the ESP32 microcontroller allows variable changes which are automatic in nature. On top of this, relay modules were used for effective switching of load and its adjustments, hence making the system flexible and responsive. The firmware developed in Arduino IDE automates control processes, which enables the smooth running of operations. In this regard, our experiments output results that show the device—a programmable electronic load mimicking load situations and providing performance information. Notably, the automated control system coupled with adjustable load capabilities increased the testing process efficiency and accuracy to a great deal. The overall effect of the programmable electronic load device is that it makes testing more professional by way of automation and provision of precise management for the test settings of the load. Its versatility also provides simulation of a wide scope of scenarios accommodating test conditions. It is designed to cater to heat regulation and power dispersion for the reliability of performance whiles in operation*

Keywords: DC electronic load, Switch Mode Power Supply, Heat dissipation, Load stability

I. INTRODUCTION

In the area of designing electronic circuits is a need to test their power supplies. Requirements are ever increasing, versatile and accurate electronic load devices in the world of designing electronic circuits. This paper works on developing a programmable electronic load device. The electronic load is a device designed for a one-test instrument designed for current sinking and absorbing of power out of a power source. It offers flexibility and accuracy in test cases relating to power. Different conditions can be emulated by changing the quantity of electric current and resistance. Any type of electronic device, during its testing and development processes, relies on an electronic load device as a very essential tool. It emulates those things that would happen to an electrical load through a device or power source in real-life situations. An electronic load device emulates the device under test to test the power supply powering it. The following report gives a brief overview of the electronic load device developed during the internship period. Again, this turns out to be inefficient, more precisely during dynamic testing when manual switching of the resistors to change the load and configuring the circuit is required. Testing is time-consuming, particularly since fixed resistors have to be used to adjust to changes and there is no automation in controlling the resistors. It emulates several situations and real devices that could be connected to your power source. The automation of electronic loads eases the testing process and enhances the development of complex test scenarios, able to lower the probable occurrences of errors and raise general testing effectiveness. The electronic load device is a versatile tool within industries testing and evaluating any electronic power sources. These devices differ from a simple passive resistor in that they emulate real-world conditions by actively drawing power from a source to achieve very fine control over voltage, current, resistance, and power parameters. This makes the electronic load a critical tool during design for testing and troubleshooting power supplies, batteries, and renewable energy systems. They are highly valued because of their accuracy, flexibility, and the capability to provide details related to performance data to ensure reliability and efficiency during the development and deployment of an electronic device. They imitate the real load behavior encountered by electrical sources in order to allow engineers to conduct rigorous tests on the performance characteristics of such an electrical source. They replicate a wide span of load conditions: from constant current and voltage to dynamic and transient loads. In general, electronic load devices become very critical during the development process in proving and validating electrical systems for reliability, efficiency, and conformance to design requirements before their launch into the market.

The embedded systems are really the invisible conductors of our technological orchestra today. Unlike your laptop or even your phone, this class of computing is not meant for general use. They really excel at performing particular tasks though—focused and precise in real time. They operate in the background, mostly unobtrusively and at times surprisingly, to assure smooth functioning and efficient operation across an enormous array of devices—from the humblest toaster to Mars rovers. The effect they have on the actual world of embedded systems is simply overwhelming. Therefore, basically embedded systems are unsung heroes that power the modern world today.

II. LITERATURE SURVEY

Design of a Programmable DC Electronic Load [1], J. Peng, Y. Chen, Y. Fang, and S. Jia. In this paper, a detailed design process for a regulated DC electronic load is proposed with various test modes. The designed electronic load can work either in constant current, constant voltage, constant resistance, and constant power mode. The proposed design was used to test a few DC sources. Difficulties were found in the portability of the proposed design.

Design and Developing of a DC electronic Load with Regulation for Testing Supplies and Batteries[2], S.R. Sadarjoshi and P. Usha describes the role of a DC electronic load in testing a power source at present as well as in the next years to come. Programmable E-loads are very important in analyzing the performance of a dynamic load. MOSFET used for Varying current and potentiometer to change the values of current Insert current at the right point. As variable Resistors, they dissipate much heat as in most cases, large heatsink are required.

Web-based Electronic Load to Test DC Power Supply [3], Mrs. Smita Vyavahare and Prof. B. T. Salokhe, the authors designed a more advanced electronic load system using the ARM7 Cortex M3 LPC 1768 processor module to monitor and test DC power supplies effectively. The programming and debugging were made easier by the online development tools provided by the mbed platform in software development. It has, however, been recognized that Bluetooth, applied for data transfer, was time-consuming and might have affected the performance or responsiveness of the system.

DC Variable Electronic Load for SMPS Testing [4], G A Rathy and Aravind Balaji explains a project which focuses on the implementation and use of a DC variable electronic load in testing SMPS. In this system, the MOSFET switching technique has been used to vary the load current and helps in effectively testing different configurations and functionalities of SMPS. This technology requires effective heat sinking and cooling of the large amount of heat generated by the MOSFETs. Additional space for heat dissipation components and protective casings is also desirable.

Programmable DC Electronic Load for Testing of On Board Voltage Regulators [5], Manjunath I, Dr. V Chayapathy deals with the design and development of a high slew rate programmable DC electronic load for testing on-board voltage regulators in Solid State Drives. Designed system has thermal limitations because of the large dissipation power across the MOSFET for a long time, which impacts the accuracy and reliability of the testing.

Design and Implementation of an Electronic Constant Current DC Load for Battery Discharge and Power Supply Test Systems [6], Murat Ceylan, Abdulkadir focuses on the design and implementation of an electronic constant current DC load device. The main topology used incorporates a voltage follower that drives the gate voltage of a linearly driven MOSFET. This design uses items of wide availability, including the IRFP2907 MOSFET and the LM358 operational amplifier. The MOSFETs operating in linear mode need to dissipate quite a significant amount of power, which complicates the thermal management. Even with a heatsink, this limits its applicability to higher order power systems.

Constant Current Control of DC Electronic Load based on Boost Topology [7], Guozhen Hu, Yan Wie, Huang Lei, Xuejun Ma, this device is a driven boost topology, and this will give a high-resolving rating in terms of control and scalability of power. The device is designed to test and characterize the steady-state and transient responses of the power source, such as batteries. Constant currents characteristics are achieved by using a Boost DC-DC converter in this proposed electronic load. These tests were conducted at low power levels. While the tests at low power level gave good accuracy and stability, these would probably differ under high-power condition. They therefore don't very satisfactorily represent the performance of electronic loads in high-power levels.

High Power DC Electronic Load [8], An ShiqiIt is based on an STM32F207VG microcontroller from STMicroelectronics, built around the ARM Cortex-M3 core. Describe the structure of the electronic load and the subsection load control idea, discuss the principle of IGBT PWM control, and design a control algorithm.

This may make the force-air cooling method utilized for heat dissipation at load less effective in high-power applications, much more so compared to liquid cooling. The duty cycles are fixed at intervals; therefore, this might reduce the fineness in tuning capability of the load.

III. EXISTING SYSTEM

The electronic load system has a major issue of fixed resistors hence labor-intensive, with very minimal automation. This results in inefficiency where much time is taken for tests and hence reduces the flexibility of the varied power sources and electronic devices under test. This, therefore, makes the testing rely on manual intervention in the control of the resistors; the procedure becomes quite time-consuming. This is usually associated with a number of problems that are prone to errors and time-consuming. The rigidity of the system is further impeded by the use of fixed resistors; anytime the test parameters require changing, a physical change must be effected on the resistors or they must be replaced, turning the system inefficient. Therefore, these fixed resistors can also dissipate a high amount of heat under varying loads, thus requiring a large cooling system or increased size and cost of the system.The next critical aspect is thermal management; heatsinks are attached to all components, like MOSFETs, that need heat dissipation so that the device does not overheat and has a very long life. Rathy and Balaji bring out the important part MOSFET switching plays in dynamic load current variation in their DC variable electronic loads used for SMPS testing. Dynamic variation in the load current allows the testing of Switch Mode Power Supplies for complete coverage of all configurations and operational functionalities. However, this is practically realizable only if proper heat sinking and cooling mechanisms are ensured against the high temperatures generated by the operating MOSFETs. It means more space is required for heat dissipation components and protective casings, including that needed for maintaining optimum performance and reliability of the electronic load system.Design and development of a programmable DC electronic load specifically for testing on-board voltage regulators in solid-state drives Their work highlights the fact that high slew rates are needed for properly judging voltage regulation under dynamic load conditions typical of SSD operation. Their design has some drawbacks concerning thermal management, too, as there will be considerable dissipation across the MOSFETs during long test sessions. The studies reflect the development in designs of electronic loads dedicated to special tests. Such electronic loads cope with special requirements, like high slew rates and techniques of dissipation, and therefore turn out to be useful means for the development and assurance of the quality of power electronics in telecommunication, computing, and automotive sectors.

IV. RESEARCH METHODOLOGY

The system proposed is to come up with a more advanced version of the electronic load device, enhancing the weaknesses of the existing systems and making additions of new features that shall upgrade functionality and efficiency. This section gives brief comparisons with previous works showing improvements and advancements. Resistors within the electronic load have values of 220 ohms, each designed to handle a power rating of 10W. This means that the design was mainly focused on spending a minimal amount of energy in order to make these resistors live longer and be more reliable. The way this was done was to ensure that each resistor in the circuit will dissipate power far below its rated maximum capacity—in this case, less than 5W.This ensured that there would not be overheating that might lead to the failure of the component, especially during a long time of running. Another design strategy input into the design was the improvement in self-life of the resistors while they are under continuous load over a long duration. One of the methods effectively used was the stacked load configuration using studs, which optimized the spatial arrangement for the resistors in the circuit. This configuration did not only ease the assembly but also improved

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convenience and reliability from its good heat management provisions that ensured efficient power dissipation in the resistive loads. With the new design came automated load parameter control, reducing the need for manual intervention in the testing process to a very minimal level, hence improving its efficiency. Inclusion of programmable elements allows dynamic changes in loads, making the system versatile and adaptive to various requirements at hand. Moreover, sophisticated microcontrollers—the ESP32—and software tools like Arduino IDE have improved the accuracy and reliability of the test under investigation. The project adopted both hardware and software development methodologies. In the circuit design, there were specified power requirements that had to be taken into consideration when choosing resistor values and, therefore, power dissipation. In the Arduino IDE environment, the ESP32 microcontroller was programmed to switch the electronic loads dynamically. All of the components—the relay board, the loads, and the microcontroller—were put together. This involved rigorous testing and debugging to ensure smooth operation.

In this respect, extensive test routines were developed to test the system's performance under different conditions and handling its reliability and accuracy. Utility Tools Used for Implementation The coding of the microcontroller along with the development of the firmware is done through Arduino IDE. Proteus 8 serves the utility of simulation and designing of circuits; through it, iterative development and testing can be performed. Integration of relay modules into the system for controlled switching and activation of various components has been done. Switched-Mode Power Supplies are applied for effective and reliable power distribution inside the system. The reliability is further enhanced through proper debouncing solutions for the push-button switches. The developed system of an electronic load significantly improves the existing manual process in terms of efficiency, scalability, and precision of electronic load testing with the new system through the addition of automation based on programmable elements and advanced microcontroller programming. In the process, this project met its initial objectives but delivered very valuable learning experiences on the need for innovation and adaptability in engineering solutions.

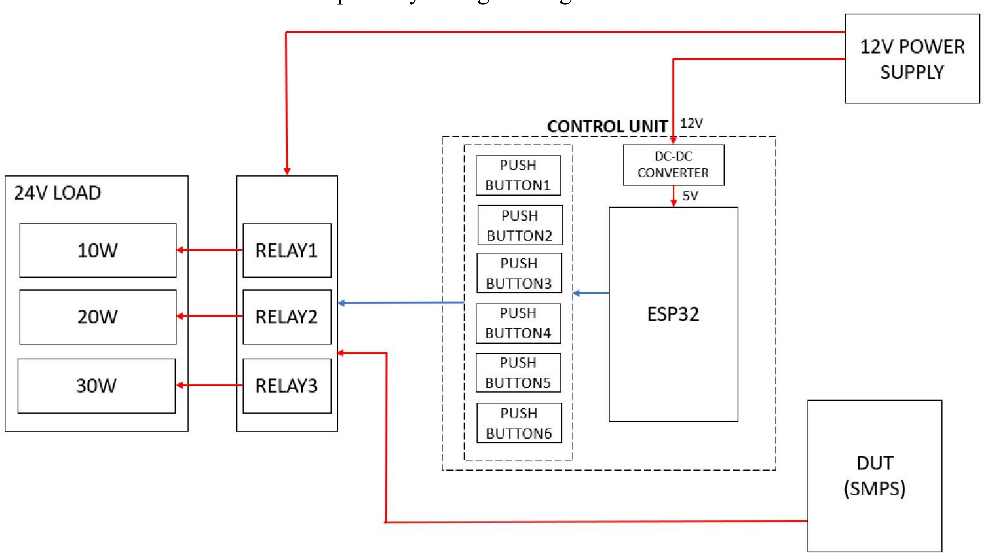

Figure 1 Block diagram of the System

V. RESULTS AND DISCUSSION

The developed electronic load device met the initial design objectives for providing a flexible and accurate solution for testing 24V power supplies and batteries. Compared with commercially available devices, it represents an inexpensive solution without really compromising performance or features. It becomes particularly suitable for use in laboratories and educational institutions because of the affordability coupled with robust functionality. The device also shows great potential for customer-specific electronic solutions to defined test requirements, observing the high standards of accuracy, reliability, and safety. In its capacity for adaptation and possible integration seamlessly into a number of test environments, it is a versatile and pragmatic tool to provide the alternative to off-the-shelf solutions with less flexibility or customizing to special test needs. Considering this factor, the electronic load device serves not only as a technological breakthrough but also by practical advancement in the area of electronic testing and measurement.

Figure 2 Prototype of the Device

VI. CONCLUSION

This project has successfully designed a modern electronic load testing system using the ESP32 microcontroller and Arduino IDE. It solves significantly important issues raised with previous systems in terms of efficiency, accuracy, and user-friendliness. The use of this system applies in very many spaces for power supply, battery, and component testing, making it versatile and adaptive. It is useful for any level of small- or large-scale testing environments as it can handle different types of load conditions with perfect control and real-time monitoring. The developed system behaved very well with the 24V load conditions and proved functionality and reliability. Robust software used with efficient components allowed for accurate measurement and fast data acquisition, hence it can be said to be a very reliable performance during extensive test scenarios. Added connectivity support for remote monitoring and control, along with the following key features: By the ESP32 microcontroller, the system was helped in throughput contents—proper processing and nudging of the load conditions. The data processing was fast enough, and loads on parameters can be adjusted in real time. General facility handling with a gamut of test scenarios, without any compromise on the accuracy and performance. Helps in increasing overall effectiveness because the time consumed in the testing and analysis phase is very less: Design Phase – Its process consisting of the selection of proper elements and design of the electronic load circuit. Development Phase process of actually writing and compilation of firmware in the Arduino IDE and integration with hardware elements in it Testing Phase Process of rigorous testing under different load conditions to ensure and validate how it performs and the reliability of the power supply.

REFERENCES

[1] J. Peng, Y. Chen, Y. Fang and S. Jia, *Design of Programmable DC Electronic Load,* 2016 International Conference on Industrial Informatics - Computing Technology, Intelligent Technology, Industrial Information Integration (ICIICII), Wuhan, China, 2016, pp. 351-355, doi: 10.1109/ICIICII.2016.0090.

[2] S. R. Sadarjoshi and P. Usha, *Design and fabrication of regulated DC electronic load for testing power supplies and batteries,"* 2016 IEEE 7th Power India International Conference (PIICON), Nov. 2016. doi:10.1109/poweri.2016.8077399

[3] Vyavahare, S., &Salokhe, B. T. (2014). *Web-based Electronic Load to Test DC Power Supply*. Proceedings of [Conference/Journal], February 2014.

[4] Rathy, G. A., & Balaji, A. (2018). *DC Variable Electronic Load for SMPS Testing*. [Conference/Journal], January 2018.

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[5] Manjunath, I., &Chayapathy, V. (2017). *Programmable DC Electronic Load for Testing On-Board Voltage Regulators*. [Conference/Journal], September 2017.
[6] Ceylan, M., & Abdulkadir, (2014). *Design and Implementation of an Electronic Constant Current DC Load for Battery Discharge and Power Supply Test Systems*. [Conference/Journal], September 2014.
[7] Hu, G., Wie, Y., Lei, H., & Ma, X. (2014). *Constant Current Control of DC Electronic Load based on Boost Topology*. [Conference/Journal], November 2014.
[8] Shiqi, A. (2018). *High Power DC Electronic Load*. [Conference/Journal], May 2018