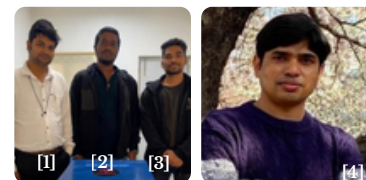


Design and Fabrication of a 3-Channel DC Laboratory Bench Power Supply

KID: 20260205



A reliable power source is essential for modern electronics laboratories, research and prototyping. This project presents a versatile 3-channel regulated DC power supply combining two high-power adjustable SMPS channels (1.3 V – 35 V, up to 10A) with an ATX-based channel providing fixed 3.3 V, 5 V, 12V, and -12V. The outputs can operate independently in series for high voltage or in parallel for high current. Built without a microcontroller, the system relies on discrete control, switching regulator, feedback and hardware protection. Integrated current limiting, short-circuit protection, thermal protection, and real-time monitoring ensure safe, reliable, and efficient operation, making the power supply well-suited for both educational and professional applications.

The design of the 3-channel lab bench power supply (PARAMSAKTHI) was based on the requirement for a compact yet powerful laboratory instrument capable of handling a wide range of experimental conditions. The system combines commercially available switching power modules with custom-designed protection circuits. The first two channels use 36V/10A, 300 W SMPS units as their primary power sources. These modules convert the AC mains supply into a regulated 36V DC. Unlike conventional transformer-based linear supplies, SMPS technology uses high-frequency switches and pulse width modulation (PWM), allowing efficient power conversion with reduced size, weight and heat generation.

The 36 V output is supplied to XL4016 buck converter modules, which step the voltage down to the required output level. The XL4016 regulates the output through high-frequency PWM and provides adjustable voltage and current control. The outputs can range from approximately 1.3 to 35 V, with a current capability of up to 10A. Multiturn potentiometers are used to precisely adjust voltage and current. This arrangement provides fine control and is particularly useful in experiments where a small change in supply can influence device behaviour.

The channels 1 and 2 provide independently adjustable voltage and current outputs. Their independent operation allows two different circuits or experimental loads to be powered simultaneously. When correctly configured, the channels can also be combined in series or parallel to extend the available voltage or current range.

Channel 3 uses an 800W ATX SMPS, a power module commonly used in computer systems. The ATX supply provides several regulated voltage rails, including approximately 3.4V/20A, 5V/30A, 12V/25A and -12V/0.5A. These fixed outputs are useful for digital circuits, motors, actuators and electronic components.

The rotary switch and relay selection circuit for channel 3 was designed to enable selection between multiple fixed-voltage rails and the precision-voltage output. This circuit ensures that only the desired voltage output is connected to the load while keeping other outputs isolated, providing both safety and operational flexibility.

System design

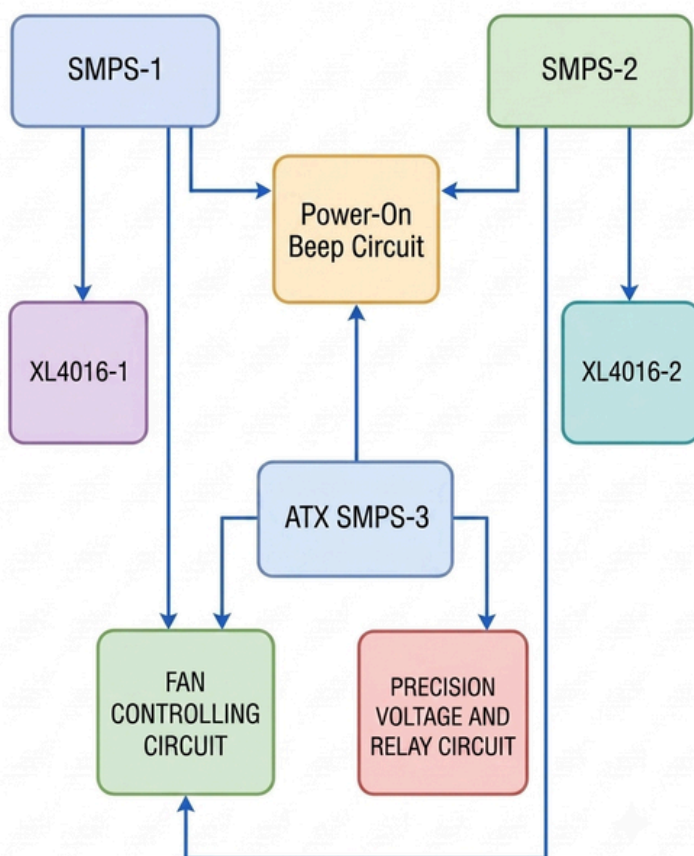


Figure 1. Block diagram of a 3-channel lab bench power supply

Precision voltage control and monitoring

To extend the power supply's functionality, a precision voltage-generator circuit was developed for low-voltage applications. The circuit provides an adjustable output of approximately 0.1- 2.5V, making it suitable for sensitive load testing.

The circuit uses an operational amplifier as the voltage controller and an IRF540N N-channel MOSFET as the pass element to supply higher currents while maintaining precise regulation. A feedback network regulates the output voltage, while resistive and capacitive components contribute to gain control and circuit stability. This design allows incremental voltage steps of 0.1 V, providing fine-tuned control over the output, even under varying load conditions.

It also incorporates dedicated digital voltage and current displays for real-time monitoring. These displays allow users to verify the selected voltage, observe load current variation and identify abnormal operating conditions during experiments. Thermal management is handled by an automatic fan control module, which employs a relay driver circuit and a 7805-voltage regulator. This system activates the cooling fans only when any output channel is switched on, optimizing energy efficiency and prolonging fan lifespan. Furthermore, a power-on beep indicator circuit utilizing a BC547 transistor was included to provide an audible confirmation of system startup, improving operational feedback for the user.



Figure 2. A 3-channel DC power supply built by MSc (Physics, 2024-26) students (Mr. Soham Sahu, Mr. Krushna Chandra Mahali, and Mr. Kruttibasa Danduasi)

To deliver a professional and user-friendly interface, the system incorporates digital display modules that continuously show real-time voltage and current readings for each channel. In addition, LED indicators indicate power status, channel activation, and fault conditions, providing clear and immediate visual feedback.

Development Challenges:

The development involved several practical challenges related to voltage regulation, thermal management, PCB modification, component failure, and circuit integration, which were eventually resolved.

Outcome and Future Scope

The completed 3-channel DC lab bench power system successfully integrates two adjustable high-current channels and a multi-rail fixed-voltage channel into a single laboratory instrument. The combination of adjustable outputs, high current capability, precision voltage generation, real-time monitoring, protection circuits, and thermal management provides considerable flexibility for lab applications.

The project also provided practical experience in power electronics, switching regulation, feedback control, circuit integration, testing and troubleshooting. Importantly, the system achieved its core functionality without a microcontroller or sophisticated digital control system, relying primarily on switching converters, feedback circuits and relays. Future versions could incorporate microcontroller-based control, programmable voltage and current settings, digital data logging, USB communication, and wireless monitoring. Temperature sensors could enable intelligent fan-speed control and automatic thermal shutdown. Programmable voltage profiles could also allow voltage ramps or pulses for automated testing.

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