

## Web-based Electronic Load To Test DC Power Supply

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**Abstract:** This paper focuses on the integrated application of embedded technology and computer network technology in the electronic load monitor controlling system and designs a networked electronic load monitor controlling system based on ARM. This electronic load is one kind of instrument, which allow user to examine – or visualize -- the voltage (V) and current (I) delivery ability of an energy source. Using pulsatile loads test the voltage regulation accuracy of a conventional power supply. By including the signal generation, testing algorithms, and data capture/storage functions in a single instrument and making connectivity to web browser forms complete data analysis system. This network monitoring electronic load offers an advantage over lash-ups using several pieces of commercially available gear to achieve the same results.

**Keywords:** ARM, Electronic Load, power electronics, power resistor, network communication, network monitor controlling.

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### I. Introduction

As the common testing equipment, load plays a very important role in many kinds of power tests, which performance has a direct effect on the test results. The traditional resistance load refers to the slide rheostat and the resistance box, which has a bad accuracy because of the thermal noise while going through the high current [1]. Meanwhile, the resistance load has to be fitted with a set of large cooling equipments to bring down the temperature which rises because of the thermal energy transformed.

The electronic load is a new kind of load consists of electronic components, which usually refer to the Power MOS or IGBT, and power resistance [2]. It can not only works as a fixed impedance, but also simulate some special load waveform to test the dynamic and transient characteristics of the power equipment [3], which is impossible for the resistance load. Besides, it has numerous advantages for its simple structure, high precision, adjustable range and high reliability [4].

The literature on Programmable DC Electronic loads is limited to what is available from the manufacturers' websites and product manuals. Different manufacturers [4]-[8] offer programmable dc load modules for different ranges of power, voltage, current and resistance. The products on the market are quite expensive, costing as high as a few thousand dollars per kilowatt. Programmable dc loads are usually designed to operate in constant-current, constant-voltage, constant-resistance and constant-power modes of operation. Transient and pulse modes may also be provided. These modes enable the power source developers and customers to test and evaluate the steady-state and transient response characteristics of power sources. Programmable loads are normally made in the form of load modules that can be paralleled to increase power handling capability [9].

In this paper, ARM7 based network monitoring electronic load is proposed. In section 2, basic electronic load circuit of proposed system will be introduced. In section 3, total system overview is described.

### II. Proposed Basic Dc Electronic Load

Fig. 1 shows schematic of DC Electronic Load. This is a simple constant current sink. Essentially, an electronic load functions as a constant-current power resistor, with an adjustable range of current controlled by some external control signal, such as an analog voltage. The main component of circuit is potentiometer, MOSFET, op-amp and current sense resistor. The potentiometer controls the amount of current being sunk into the electronic load. The opamp drives the MOSFETs. The N-Type MOSFET serves as a variable resistor and is the main component making up the load that the device under test (DUT) is connected to it. The MOSFET will be dissipating the majority of the DUT's output power so power handling is a critical spec when choosing a MOSFET. You also want to ensure the MOSFET has proper heat sinking. R1 serves as a sense resistor. The voltage drop across R1 is used by the opamp to control the current output of the DUT. R1 is also used to measure the output current from the DUT. The opamp works by taking a control voltage level into its non-inverting input. It will then drive the gate of the MOSFET so that the same voltage value is at its inverting input,

which is connected to the R1 node. This means the opamp allows us to control the voltage drop across R1 regardless if there is a change in the DUT's output.

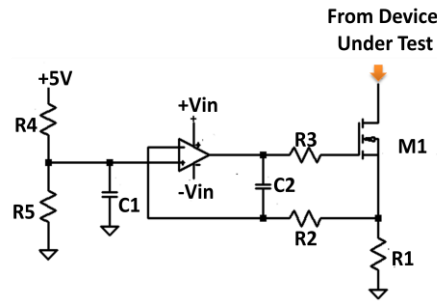


Fig. 1 Basic electronic load (current sink ckt.)

R2, R3, and C2 were chosen for compensation to keep the circuit from oscillating and to provide the right amount of feedback for the op-amp.

### III. System Design

The heart of the system is ARM7 cortex M3 mbed LPC 1768 processor module. Here all the peripheral devices are connected to the processor and the whole device is connected to remote PC through internet. Fig 2 shows main components of ARM7 based network monitoring, electronic load.

It is DC electronic load instrument with fast response to test DC power supplies with following features:

- 1) Max. Input power: 100 watts.
- 2) Max. Current rating: up to 20 Amps.
- 3) Max. Voltage rating: 100V.
- 4) Over temperature protection.
- 5) Over current protection.
- 6) External pulse generation.
- 7) Remote user interfacing through web.

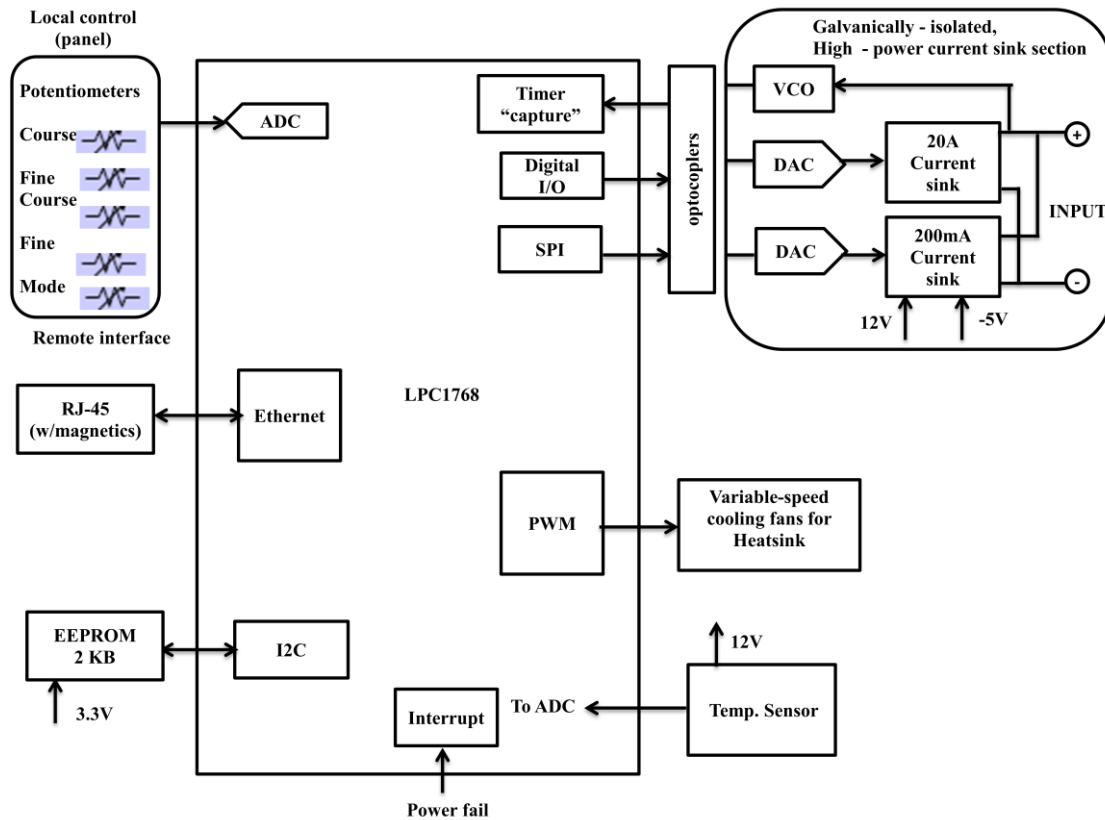


Fig. 2 Block diagram of system structure

### 3.1 HARDWARE DESIGN

Hardware design is divided into four parts: Input section, analog module, digital module and power supply module.

#### 3.1.1 Input section

The layout of the front panel is shown in Figure 3.

##### 3.1.1.1 Load Type

The Load Type switch selects the two of operating modes of the electronic load. They are as follows:

- **Safe** – Input current is set to zero, so the load is effectively disconnected.
- **Current** – The load draws steady or pulsed current. This mode is used to test power supplies.

##### 3.1.1.2 Load Value

The Load Value control determines the current drawn from the input in **Current** mode. It is set by means of concentric potentiometers: the outer knob controlling the coarse value and the inner knob the fine value.

##### 3.1.1.3 Pulse coarse/fine

The value of current drawn by the Electronic load during a pulse is set using the coarse/fine concentric controls in exactly the same manner as the Load Value controls.

##### 3.1.1.4 Sync Out

A TTL-level synchronizing signal is provided at the front panel Sync out jack, so that an oscilloscope can be triggered when the Electronic load is about to apply a pulse. This is useful for watching the transient response of the device under test (DUT).

#### 3.1.2 Analog module

Main part of analog module is designed using five electronic loads shown in fig. 1. Each comprises a power MOSFET and a fan-cooled heat sink that can support 25 watts of dissipation. One of these current sinks operates in the range of 0 – 200 mA. Other four current sinks can each handle up to 5A. They are ganged, so the total range is up to 20A. The load current is controlled by a bank of power MOSFETs mounted on fan-cooled heat sinks, controlled by a DAC/op-amp drive circuit that is used to set the target current. For isolation between the DAC output and the digital logic board, an outboard DAC MCP4812 is used. The DACs are driven through an optical isolation interface, MCT6 is used for it. A voltage-controller oscillator LM331 is used to sense the applied voltage. The oscillator's output is also optically isolated.

#### 3.1.3 Digital module

Heart of digital module is mbed LPC 1768 processor.

##### Mbed LPC1768

The module, 44 mm × 26 mm, contains an LPC1768 ARM7 microcontroller and a USB port. It can also include an Ethernet connection, the flexibility of lots of peripheral interfaces and FLASH memory. It is packaged as a dual in-line package for prototyping with through-hole PCBs and includes a built-in USB FLASH programmer. This last characteristic is one of the most important because it means neither an external programmer nor removal of the mbed is necessary to program or update an application, it can be done through the USB port. The NXP LPC1768 includes an ARM Cortex-M3 core running at 96 MHz. It includes 512 KB FLASH, 32 KB RAM and lots of interfaces: built-in Ethernet, USB Host, USB Device, CAN, SPI, I2C, ADC, DAC, PWM among others.

## IV. Software Design

The mbed module comes with online development tools. The programming philosophy of mbed is based on the cloud computing concept. The mbed microcontroller's programs are hosted by the *mbed.org* developer website, including a lightweight online compiler for instant access to your working environment through a web browser and therefore possible on any OS. One can move between home and office and resume editing code on any system. There is no need to check for software updates, as the server will always be current. Mbed programs are written in C++ and the environment includes a C/C++ SDK for productive high-level programming of peripherals. Combined with a complete set of libraries and code examples published by the mbed community, the platform provides a productive environment for achieving results.

## V. Test Result

A web page provided so the user can monitor the status of the electronic load remotely. Figure 4 shows the page:

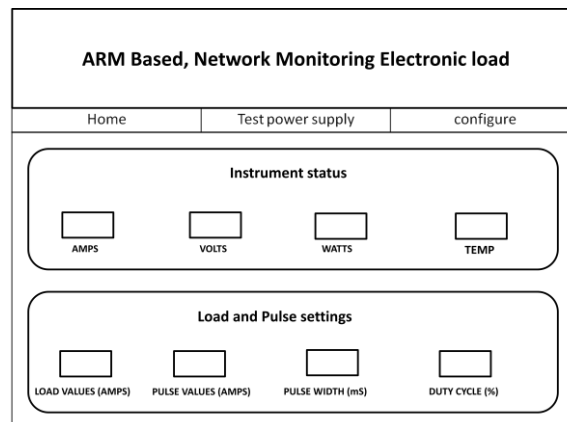


Fig. 4 Test power supply web page

In the upper box are four real-time status windows, displaying effective load current in Amps, load voltage, watts dissipated by the electronic load, and the temperature of the internal heat sink.

The lower box reports the front panel control settings: load value and pulse values in Amps, pulse width in milliseconds, and duty cycle percentage. When the pulse mode is active, the effective current displayed in the top window reflects the duty cycle applied to both load and pulse values.

Also transient response of device under test can see through Sync out jack, which triggered oscilloscope when the Electronic load is about to apply a pulse.

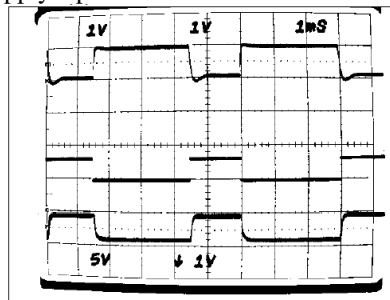


Fig. 5 Scope photo of power supply being tested

The photo in figure 5 shows a scope trace of pulse operation. For this test, a small power supply was set to about 9 volts, and then hooked to the Electronic Load through 1ohm current sampling resistor. The instrument was set up to generate pulses starting at about 200mA and rising about 1 Amp, with pulse width about 1.6 mS and duty cycle around 36%.

The top trace shows the voltage at the instrument input (1 V/div), the second trace shows sync out (5 V/div), and the third trace shows the differential voltage (1V/div with two channel in "ADD" mode) across the 1 ohm current sampling resistor.

## VI. Conclusion

A high performance ARM based, network monitoring electronic load is introduced. DC electronic load module is successfully interfaced to ARM7 embedded system. Because of this it is possible to add features to DC electronic load like excess power or temperature protection, control the speed of fan used for cooling of heatsink, converting analog voltage to digital using ADC. Also when the firmware detects an error condition, it signals the user by lighting the **Protect** LED. Pulse control section is added to control the total power dissipation. **Sync out** jack is provided on front panel to see the transient response of the DUT.

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