SAND2014-1924P

Battery Operation of MINER (Mobile Imager of Neutrons for Emergency Responders)

John Goldsmith, Mark Gerling, Jim Van de Vreugde, and Jim Brennan
Sandia National Laboratories

February 15, 2014

This work is supported by the NNSA Office of Defense Nuclear Nonproliferation Research and Development. Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Sandia
National
Laboratories

Our reports titled “Design and Laboratory Characterization of the Mobile Imager of Neutrons for Emergency Responders (MINER) System” and “Field Measurements with MINER (Mobile Imager of Neutrons for Emergency Responders)” described operation of the system with a relatively power-hungry VME-based data acquisition system. Since that time, the company that manufactures the 16-channel digitizer has come out with a DC-powered “desktop” version of the digitizer that can be operated using Ethernet, eliminating the need for any VME-based electronics. This new product has made it straightforward to modify MINER so that it can be powered from either a wallplug or a battery, as described below.

The new desktop digitizer operates with 19-36 VDC power. The PMT circuitry in MINER operates on 12 VDC power (upconverted to high voltage using custom circuitry mounted behind each PMT base, as described in the first report referenced above). To provide these two voltages, we have built a power conditioning module that can in turn be powered by wallplug or battery power. For wallplug operation, the AC power is converted to 24 VDC, which directly powers the digitizer, and also powers a DC to 12 VDC converter which in turn powers the PMTs. For battery operation, the battery power (10-36 VDC) directly powers the same DC to 12 VDC converter to power the PMTs, and a separate DC to 24 VDC converter to power the digitizer. The circuit diagram of this module is shown in Fig. 1. As long as the battery voltage remains above 10 V, the performance of the system is identical under wallplug and battery operation.

To simplify transport and handling of the MINER system, we chose to mount the electronics on the side of the cylindrical detector head (see Fig. 2). The top box is the power conditioning module described above, and the bottom module is the desktop digitizer. With this configuration, only the three external cables visible in the figure are connected to the MINER assembly: power (either wallplug or battery), a USB cable to control the PMT high voltage, and an Ethernet cable to communicate with the digitizer. The latter two cables are connected to a Windows-based laptop computer (the only other component of the entire system) that runs the LabVIEW-based data acquisition and real-time display software. For transport, it is only necessary to disconnect the three cables before the assembly is placed in the 43”x27”x20” Pelican transport case. The system can then be set up at a new location and be acquiring data in less than five minutes. If desired, the electronics can be removed from the side of the detector head simply by pulling the two pins visible at the top of the module mounting rails, freeing the rails so that the modules can be relocated as a unit.

One disadvantage of this mounting scheme is that it introduces additional material on one side of the detector head, leading to a small asymmetry in the response of the system in the horizontal plane. We evaluated this effect by measuring the response to a ^{252}Cf source located 2 m from the system located directly in-line with the side-mounted modules, recording measurements both with the modules in place and with them removed. We found that the presence of the electronics reduced the neutron and gamma count rates by ~5% and ~10%, respectively. We did not observe any significant discrepancies between the resulting “images” or neutron spectra, however, and for most applications we believe that the asymmetry introduced by the presence of the electronics will not be significant.

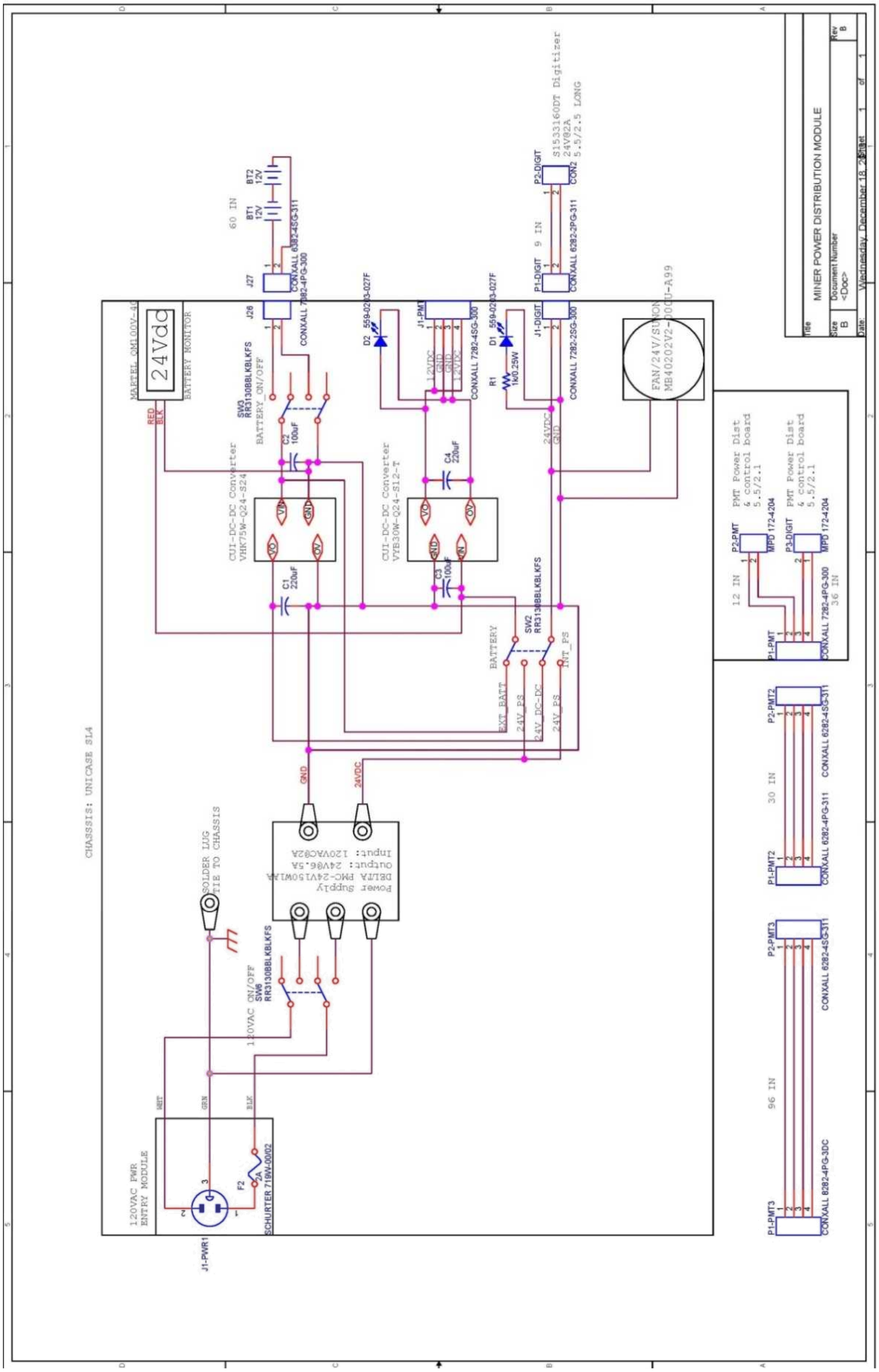

Figure 1. Circuit diagram of the power conditioning module.

Figure 2. Power conditioning module (top) and sixteen-channel digitizer (bottom) mounted on the side of MINER. Power can be supplied from a wallplug outlet or a battery (110 W at 10-36 VDC). The only other component of the system is the laptop computer connected by the USB and Ethernet cables visible at the bottom-right of the photograph.

During battery operation, the power draw of MINER (excluding the separately powered laptop computer) is shown in Fig. 3. The efficiency of one or more of the DC-DC converters evidently drops when operated at less than 12 VDC (and one or more cease operating properly below 10 V), but the overall power draw is fairly flat value of ~110 W from 12-32 VDC (the DC power supply we had available did not operate up to 36 V). At 12 V, the system draws slightly under 10 A. We operated the system for five hours using a nominally 92 amp-hour deep-cycle battery (Interstate Batteries SRM-27), observing a 1 V drop in battery voltage after that period (from 12.88 V to 11.89 V), which corresponds to roughly half the nominal capacity of the battery. The50-pound weight of such a battery is admittedly not trivial, and thus further power reduction is desirable. The digitizer draws ~90 W, and the PMTs draw ~20 W. The latter could be reduced substantially by replacing the standard resistor-based dynode chain with a transistorized circuit, but significant reductions in power can only be achieved by reducing the power required by the digitizer. The digitizer we are using was originally designed for use in a VME crate, and thus low power consumption was likely not an overriding concern. With careful attention to the power consumption of all components, we believe that the power requirements of MINER could be reduced to ~10-20 W.

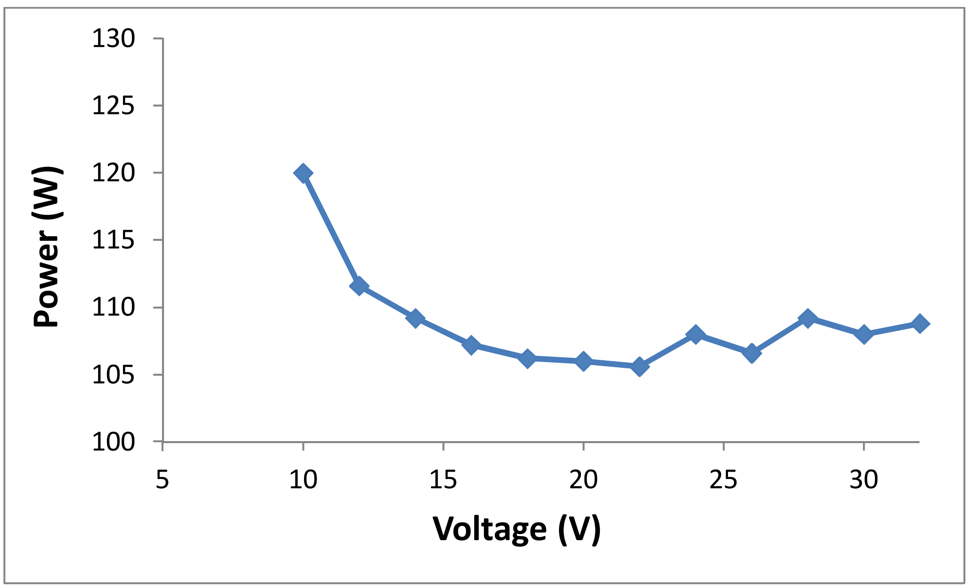

Figure 3. Power draw as a function of supplied DC voltage