0.1 Slow Monitoring and Recording System

A slow monitoring and control system is required to control systematic effects that could impact the experiment, to allow automated scans of parameters such as thresholds and high voltages, and to provide alarms, warnings, and diagnostic information to the experiment operators. The quantities to be monitored and controlled include temperatures and voltages in electronics, experimental hall environmental conditions, line voltages, liquid levels and temperatures, gas system pressures, radon concentrations, photo-tube high voltages, and discriminator settings and rates. Most of these functions can be accomplished using “1-Wire®” devices from Dallas Semiconductor [1]. The high voltage and discriminator sub-systems will have their own control and readback hardware. All slow monitoring and control systems will use the same database and history log software. A computer in each experimental hall will monitor the local 1-wire bus and a local radon monitor, acquire any data provided by other subsystems, record the data, and make the data available via the local internet connection.

0.1.1 Monitoring via 1-Wire interface

The “1-Wire®” line of semiconductors from Maxim IC / Dallas Semiconductor use a simple interface bus that supplies control, readback, and power to an arbitrary number of devices over a single twisted-pair connection [1]. (Fig. 1.) A variety of sensor and control functions are available in traditional IC packages and stainless-steel-clad “iButton®s”. (Fig. 2.) Each device has a unique, factory-lasered and tested 64-bit registration number used to provide device identification on the bus and to assure device traceability. Some devices are available in individually calibrated NIST-traceable packages. The features of low cost, multidrop capability, unmistakable device ID, and versatility make this an attractive choice for implementing the slow instrumentation and control system.

Implementation details and expected performance for several subsystems are given here.

Crate and card temperatures and voltages: Temperature and voltage monitoring can be included in any custom-built electronics at a component cost of only a few dollars per device using DS18S20 and DS2450 chips and low-cost modular connectors to connect to the 1-Wire® bus. Note in addition to the temperature and voltage functions, the unique ID on each chip provides automatic tracking of any card swaps. Trivial custom boards containing only these components can be used to monitor temperature and bus voltages on crates which otherwise contain no custom-built electronics.

In these chips, digitization of temperature and voltage is initiated by an explicit “convert” command from the bus master. Temperature conversion takes 900 ms, and digitization of the four 12-bit channels of the DS2450 takes less than 4 ms total. During conversion, the bus master may communicate with other devices if the chips have an external source of power; if a chip is powered parasitically from the bus, then the master must maintain the bus level high throughout the conversion. Testing of samples provided by Maxim IC / Dallas...
Figure 1: The 1-Wire® bus: (a) control, readback, and power provided to multiple devices over a “single” wire; (b) parasite power circuit captures power during high period of 1-Wire® waveform. (Adapted from figures by Maxim IC / Dallas Semiconductor.)

Figure 2: Examples of 1-Wire® devices. From left to right: digital thermometer in TO-92 package; 4-channel ADC on prototype board, mounted in RJ-11 modular phone jack box; USB to 1-Wire interface.
Figure 3: Data from three day test of several 1-Wire® samples: (a) temperature in an office at Kansas State University vs. time as read by two adjacent DS18S20 thermometer chips; (b) difference in reading of the two chips.

Semiconductor confirm that multiple devices can maintain their internal state while all are powered parasitically from the same bus. Figure 3 shows data from a three day period during which two DS18S20 thermometers were sampled once a second by a program written in Java. The two thermometer chips were mounted in direct contact with each other, and recorded the same temperature to within a small fraction of a degree. In this test, the thermometers were located about two meters from the bus master, and another 1-Wire® device was connected on the same bus about three meters further downstream. No failures or interruptions occurred during this period.

**Experimental hall environment:** The DS1923 “Hygrochron” iButton® looks ideal for monitoring temperature and humidity. In addition to the humidity and temperature functions, this device features on-board battery backup and automatic logging to internal memory independent of external control. Power or computer failures will not interrupt the temperature and humidity record. This iButton® is designed for tracking sensitive products during shipment or other handling. Each DS1923 is individually calibrated and NIST traceable. Another iButton®, the DS1922, provides similar functionality without the humidity function.

Monitoring of barometric pressure and other environmental factors is easily achieved using the DS2450 ADC and one or more external transducers. (Note: A complete 1-Wire® weather station is even available [2].) Another interesting “environmental” condition to monitor is ambient light level in the experimental area: many systematic effects in past and present
neutrino experiments have been attributed, correctly or incorrectly, to electrical or optical noise introduced by lighting, and a simple phototransistor addresses the issue handily. The phototransistor technique also can be used to monitor status LEDs on devices which lack electrical status outputs. AC line voltage is also easily monitored using a 1-Wire® ADC and a trivial circuit.

**Liquid levels and temperatures, and gas pressures:** Transducers should be provided for monitoring important aspects of the detector such as scintillator and buffer oil levels, temperatures, and pressures in any gas systems used. Transducers should produce voltages in the 0 to 5 V range for maximum compatibility with the DS2450 ADC. The further specification, purchase, and installation of such transducers are naturally the responsibility of those responsible for the systems to be monitored.

**Simple controls:** The DS2890 is a 1-Wire® digitally controlled potentiometer. It can be used to provide slow control for simple servos, power supplies, or other devices controllable by an external analog signal. At present, there is no definite plan to use this capability, although the discriminator levels could possibly be controlled in this way. Support for slow control as well as monitoring should be provided in the software for maximum flexibility.

### 0.1.2 Radon monitoring

Professional continuous radon monitors have become readily available and relatively inexpensive. An example is Sun Nuclear’s Model 1027 [3]. Each experimental hall will have at least one radon monitor read out by the slow control PC. The data will be stored and made available via the same interface used for all slow monitor data.

### 0.1.3 Interface to other subsystems

Some hardware subsystems may have important slow monitor that cannot be made available on the 1-Wire® interface or the serial ports of the slow monitor computers. Examples may include the clean room particle counters, the high voltage power supplies, and the discriminator circuitry in the trigger system. In such a case, either the hardware itself or a computer which monitors and controls it should make the data available via network TCP connection. “Virtual” monitor data, such as capture time, event rates, or other quantities determined by online analysis, could also be recorded by this mechanism. The software on the master slow monitor computers will poll these external servers and make all slow monitor data available in a common framework. This is preferable to each subsystem providing a separate data interface. In the common framework, systematic correlations may be studied among any variables. Support for control functions and synchronization with externally controlled devices should be provided in the software to allow for scans of controlled parameters such as high voltages and threshold levels. The common framework will allow dependent variables observed in one subsystem, *e.g.*, discriminator rates, to be easily correlated with parameters monitored or controlled by some other subsystem, *e.g.*, high voltage.
References

