NIM Crate Monitoring Card

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The HMS Monitoring System (HMS) checks a variety of electronic instrumentation of the Continuous Electron Beam Accelerator Facility's Large Acceptance Spectrometer at the Thomas Jefferson National Accelerator Facility in Newport News, Virginia, USA. This paper describes the design of the Nuclear Instrumentation Module (NIM) crate's monitoring card (NIM-CMC)

NIM-CMC is one of the HMS read-out cards developed for NIM crates that do not have the built-in capability to monitor voltage and temperature. NIM-CMC monitors ±6 VDC, ±12 VDC, ±24 VDC, VAC, and temperature and determines whether the values are within the predefined limits shown in Table I.

Parameter	Low Limit	High Limit
+6 VDC	+5.8	+6.2
+12 VDC	+11.8	+12.2
+24 VDC	+23.8	+24.2
-6 VDC	-5.8	-6.2
-12 VDC	-11.8	-12.2
-24 VDC	-23.8	-24.2
120 VAC	110	130
Temperature	20ºC	40ºC

TABLE I. Limits on monitored signals.

Figure 1 shows the dataflow. The ADC uses five volts as the reference voltage which gives the ADC a range of zero to five volts. Since the absolute value of all the voltages being monitored is greater than five volts all voltages must be stepped down to a voltage less than five volts. The DC voltages are divided by six and the AC voltage is divided by 100.

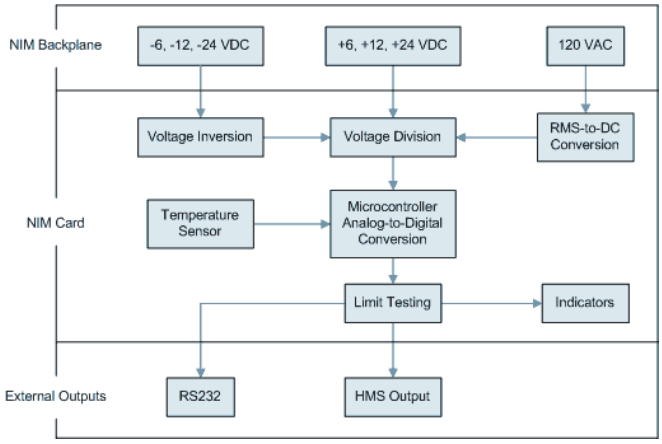

FIG. 1. Dataflow of NIM-CMC.

The processing of the inputs and outputs is handled by Microchip Technology Inc.'s programmable microcontroller, PICmicro 16F877 (PIC), which has an internal eight-channel ten-bit ADC. The PIC has outputs for LEDs, status output to HMS and an RS232 output, for debugging. The pin-out for the PIC is shown in Fig. 2.

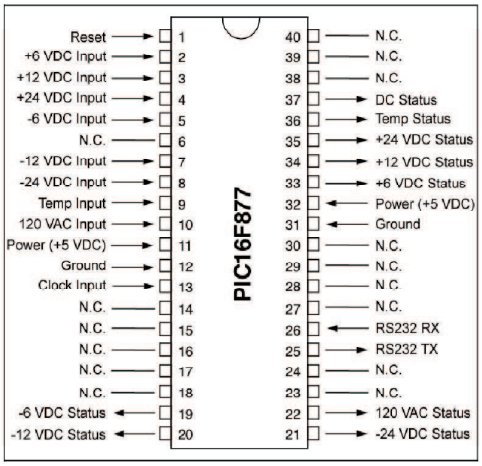

FIG. 2. PIC pin out.

NIM-CMC has a National Semiconductor precision integrated temperature sensor. The output voltage of this sensor is linearly proportional to the temperature in the vicinity of the sensor.

The AC voltage is converted to DC voltage via a Maxim 536A RMS-to-DC Converter.

The prototype PCB, Fig. 3, monitors only positive voltage and performs the AC voltage conversion using a full-wave bridge rectifier using a smaller 16F876 PIC. The new version, Fig. 4, monitors both positive and negative voltage and performs AC voltage conversion using the 536A.

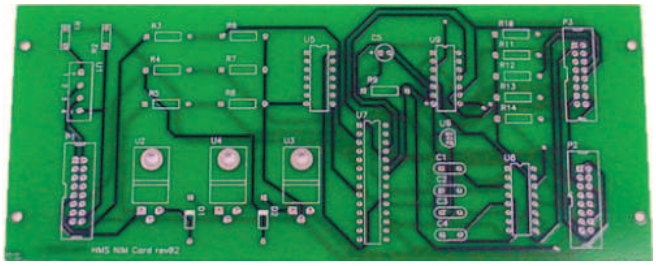

FIG. 3. Prototype PCB.

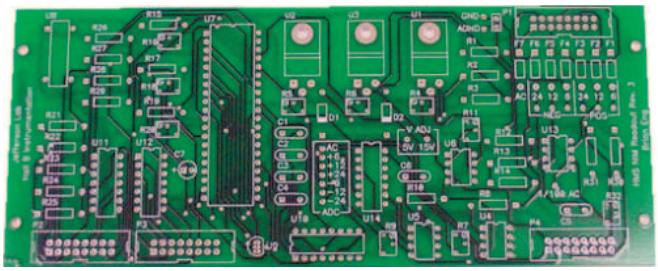

FIG. 4. New version PCB.

A problem encountered in the early versions of the software was the unstable voltage readings. The findings over a one minute period are presented in Table II. Large fluctuations (standard deviations) caused HMS to constantly alarm. To correct the problem, 250 samples were taken by the PIC before it output the voltage. This has the effect of reducing the voltage fluctuations while still allowing a true voltage rise or drop to be detected. Table III summarizes the results averaged over one minute – the standard deviations have dropped by an order of magnitude.

Voltage	Low	High	Std Dev	Average	DMM Value
+6 VDC	5.54	6.36	0.16	5.96	6.00
+12 VDC	11.55	12.34	0.158	11.91	11.96
+24 VDC	23.57	24.39	0.168	23.98	23.99
-6 VDC	-5.54	-6.33	0.16	-5.92	-5.99
-12 VDC	-11.61	-12.46	0.164	-12.02	-11.99
-24 VDC	-23.57	-24.45	0.166	-24.03	-24.00
120 VAC	110.4	123.1	3.103	116.1	114.5

TABLE II. Voltage fluctuations (948 readings/1 minute).

Voltage	Low	High	Std Dev	Average	DMM Value
+6 VDC	5.92	6.01	0.02	5.96	6.00
+12 VDC	11.99	12.05	0.020	12.01	11.95
+24 VDC	23.98	24.07	0.026	24.02	23.95
-6 VDC	-5.92	-5.98	0.03	-5.95	-5.99
-12 VDC	-11.99	-12.08	0.027	-12.02	-11.99
-24 VDC	-24.01	-24.10	0.023	-24.06	-23.98
120 VAC	115.3	116.8	0.263	116.1	114.9

TABLE III. Correct voltage measurements (221 readings/1 minute).

Voltages sampled by the ADC are compared with the predetermined limits listed in Table 1, which generates a digital TTL status signal (1 = good, 0 = bad). The temperature, DC voltage, and AC voltage status signals are used for the card's front panel indicators and also are sent to HMS. The DC voltage status is generated by performing a boolean AND on all the measured DC voltages, so if one voltage is out of specifications, the DC status returns a fault.

NIM-CMC is performing to expectations and allows HMS to monitor the NIM crates in the end station providing increased safety and a decreased downtime because of its ability to quickly diagnose faulty NIM crates.