CAENels CT-BOX Current Measurement System for HDice

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The HDice experiment in Hall B uses a nuclear magnetic resonance (NMR) system to measure frozen-spin polarization of the targets. To measure the NMR magnet's current, required to determine the polarization, the CAENels CT-BOX current measuring system is used.

A stand-alone, CAENels, digital current measurement system consisting of a CT-BOX (Fig. 1) and a CT-150 direct current to current transformer (DCCT) (Fig. 2) was selected to measure the NMR magnet's current.

FIG. 1. CT-BOX.

FIG. 2. CT-150 DCCT.

The CT-BOX and the CT-150 DCCT were factory calibrated together, as a set, to provide a full-scale (±150 A) accuracy (<0.005%), surpassing the required accuracy of 0.1%.

To ensure temperature-stabilized current measurements lower than 1 ppm/°K, the system integrates temperature-stabilized circuitry, including a burden resistor, signal conditioning networks, and a precision 24-bit ADC. The CT-BOX continuously monitors the internal temperature stabilization circuitry and reports the status in the device status code.

Multiple communication interfaces, external temperature monitoring, and external triggering are standard features of the CT-BOX. Table I summarizes the main technical specifications.

Specification	Value
Current accuracy	<0.005%
Current resolution	24 bit
Sampling frequency	data-logger mode: 0.1–10 Hz (in 0.1 Hz steps); oscilloscope mode: 1.0–100 KHz (in 10 µs steps)
Thermal coefficient	<1 ppm/°K
Local current display	7½ digits
Digital interfaces	Ethernet 10/100 TCP/IP, USB 2.0, RS-232
Output analog monitor	±10 V (LEMO coaxial)
Triggering modes	digital interface (soft-trigger), TTL 5 V on I/O connector
Alarm output	TTL -5 V, magnetic relay
Data storage	SD card (oscilloscope mode data acquisition only)
External temperature sensor	range: -40–125°C, temperature readings resolution: 12 bit

TABLE I. CT-BOX specifications.

The CT-BOX's ADC sampling can be configured either in the data-logger or in the oscilloscope mode. Different features are available for each mode.

In data-logger mode, the sampling range is 0.1–10 Hz in 0.1 Hz steps, and the output data format is in ASCII, in a variable length depending on the options chosen. Data acquired while in data-logger mode can be saved to the SD drive in the CT-BOX and/or to the output communication interface. Optionally, it is possible to read and/or store the temperature of the DCCT and/or the external temperature sensor.

In the oscilloscope mode, the CT-BOX sampling range is 1.0–100 KHz. The stepsize is in the time domain; it is 10 µS. Data can be read using the communication interface, but saving data to the SD card is not possible. Output data format is binary and has a fixed length of 64 bits.

Since the CT-BOX does not have internal storage memory, the computer reading out the CT-BOX must be able to accept

Parameter	Oscilloscope mode	Data-logging mode
Sampling frequency	1–100 kHz	0.1–10 Hz
Data representation	binary	ASCII (text)
Data representation length	fixed – 64 bits	variable
Acquisition data values	status, index, current	status, index, current, 2 optional temperatures
Saving data to SD card	not allowed	allowed

TABLE II. CT-BOX sampling mode comparison.

the data at the sampling rate. Table II summarizes the capabilities of the data-logging and oscilloscope modes.

For each acquisition in oscilloscope mode, the CT-BOX transmits a sequence number, device status code, and the measured current value, Fig. 3.
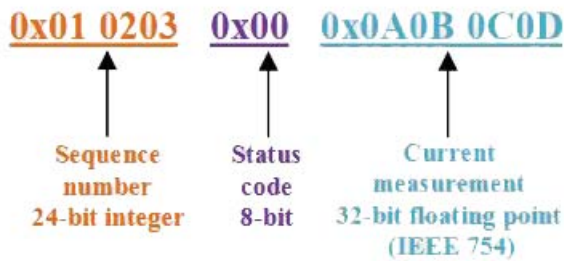

FIG. 3. Data representation in the oscilloscope mode.

The 24-bit sequence number starts at one at the first acquisition, is incremented at each ADC acquisition up to a maximum of 16,777,216. The sequence number is reset at the start of each acquisition cycle.

The 8-bit status code reports the condition of the CT-BOX during each acquisition cycle, Table III.

Status code bit #	Bit name	Description
1	no error	CT-BOX acquiring correctly
2	DCCT head fault	DCCT head experienced fault
3	buffer over-run	CT-BOX cannot send data to computer
4	SD card full	SD card is full; no data can be saved
5	SD error	error writing file to SD card
6	ADC temp OK	CT-BOX temperature OK
7	alarm	current outside limits
8	alarm direction	when high, current over limit; when low, current under limit

TABLE III. CT-BOX status codes.

The current measurement is a 32-bit number in amps and is represented as a single-precision, floating-point number in IEEE-754 format.

To conclude, the CAENels digital current measurement system is a high accuracy, temperature-stabilized, stand-alone system, which surpasses specified requirements.