Testing of the Keysight Extension Cables for the Hall C Neutral Particle Spectrometer

Aaron Brown, Mary Ann Antonioli, Peter Bonneau, Pablo Campero, Brian Eng, George Jacobs, Mindy Leffel, Tyler Lemon, Marc McMullen, and Amrit Yegneswaran
Physics Division, Thomas Jefferson National Accelerator Facility, Newport News, VA 23606
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The Hall C Neutral Particle Spectrometer (NPS) will use an Agilent Keysight measurement unit with seven multiplexers and seven terminal blocks to monitor the lead tungstate crystals' temperature and their relative humidities [1]. This note details the testing procedure for the extension cables.

The thermal readback system [2] requires ten 60-ft extension cables. The cables are 54-conductor, terminated at one end with a male, 50-pin D-sub connector and at the other with a female, 50-pin D-sub connector. Four conductors are not used.

Each multiplexer and terminal block has 40 channels for two-wire sensors divided over two banks, Fig. 1. Bank 1 has channels 1–20 for two-wire sensors (channels 1–10 for four-wire sensors). Bank 2 has channels 21–40 for two-wire sensors (channels 11–20 for four-wire sensors).

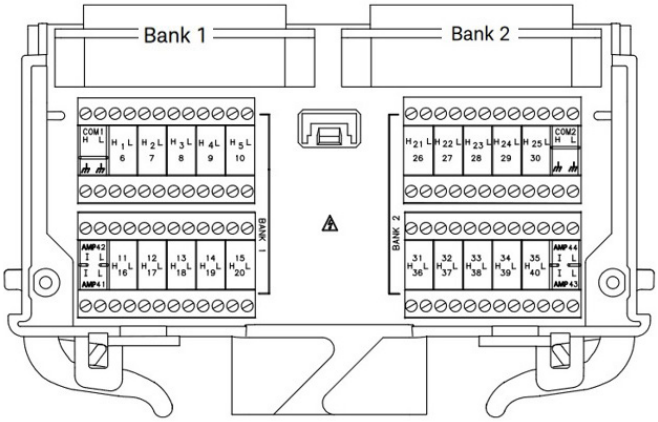

FIG. 1. Keysight drawing of terminal block, detailing two-wire sensor channel connections.

To monitor the temperatures of the lead tungstate crystals, 112 K-type thermocouples have been placed in the crystal array [3]. The Keysight mainframe reads voltage signals from the thermocouples and converts them to temperatures that are used in the thermal readback program. Per specification, a thermocouple voltage signal of 40 µV is equal to 1°C. The test developed is to determine whether it is possible to read this small signal over a distance of ~70 ft.

A Python program using the VXI-11 Python package was developed to send to the Keysight mainframe Standard Commands for Programmable Instruments (SCPI) commands to measure the temperature and voltage for each of the 40 channels, Fig. 2. Each of the 500 temperature and voltage measurements per channel is appended to an array, which is written to a comma-separated values (.CSV) file. At the end of each test, this .CSV file contains all measurements for all 40 channels (40 K measurements).

```
import vxi11
import numpy as np
import pandas as pd

instr = vxi11.Instrument("nps-mux.jlab.org")

print(instr.ask("*IDN?"))
print()

testNum = input("Enter cable number (like 1,2,3...10): ")
EC = input("Is the extension cable connected (Y/y or N/n)? ")
if EC == "Y" or EC == "y":
    EC = "-EC"
if EC == "N" or EC == "n":
    EC = "-KC"

print("Getting thermocouple temps and voltages")
fname = "cableTest-"
fout = open(fname + testNum + EC + ".txt","a")
#fout = open('cable1Test.txt',"a")

i = 0
j = 0
T = []
V = []
TV = []
C = []
c = 1001
q = "MEAS:TEMP? TC,K,DEF,"
vq = "MEAS:VOLT:DC? AUTO,DEF,"
```

FIG. 2. Screenshot of portion of cable testing Python script with SCPI commands outlined in red.

A plot of a single channel, Fig. 3, shows black points for a Keysight 10-ft cable and red points for a 70-ft cable (10-ft Keysight plus 60-ft extension). The plot indicates that there is no significant difference between the red and the black dotted lines. The slope is ~35 µV/°C, close to the specification.

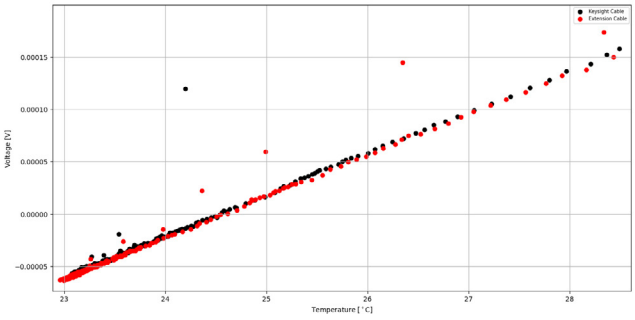

FIG. 3. Single channel data shows no significant difference between the 10-ft cable, black dots, and the 70-ft cable (10-ft Keysight cable + 60-ft extension cable), red dots. The slope is ~35 µV/°C. Outliers are possibly due to cycling of the rooms's air conditioning.

In conclusion, a test for the 60-ft. extension cables has been developed. A Python program reads temperature and voltage measurements for all multiplexer channels to determine whether the voltage and the temperature measurements can be transmitted over a 70-ft. distance without significant attenuation. Initial analysis indicates that the measurements can be transmitted.

[1] A. Brown, et al, *LabVIEW Program for the Keysight Switch/Measure Unit of the Hall C Neutral Particle Spectrometer*, DSG Note 2021-35, 2021.

[2] A. Brown, et al, *Error Handling for the Keysight Thermal Readback System of the Hall C Neutral Particle Spectrometer*, DSG Note 2023-05, 2023.

[3] P. Rossi and A. Brown, DSG Hall C Projects, DSG Talk 2022-07, 2022.