Improving Time Accuracy on Field Mapping Units

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This note presents additional analysis on the data from the field mapping units, as well as improvements implemented.

Refer to [1] for details on the hardware and software setup of the field mapping units and [2] for the analysis of the data from the CLEO magnet during the initial low power test.

The timestamp for the field mapping units' data, an integer data type, is recorded as UNIX time, which is the number of seconds since 00:00:00 UTC on 1 January 1970. While correlating data between sensor units, by performing an inner join—a form intersection on each unit's timestamp index—there were what appeared to be gaps in time.

Since the precision of the UNIX time is only one second, an additional field that listed the number of milliseconds since the program was first started was added to the data file. This additional field has a data type of unsigned long and wraps back to zero after ~50 days.

Figure 1 shows a histogram of the number of milliseconds between each measurement in the data file. The peak with entries at ~1028 corresponds to the normal program sequence of sampling data 10 times a second and writing the data to the SD card every second, while the peak with entries at ~1060 corresponds to the exact same sequence plus the additional time of updating the display every five seconds.

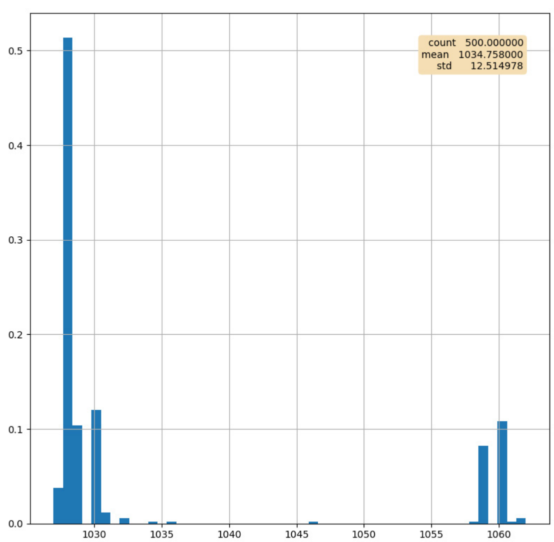

FIG. 1. Time in milliseconds between loops with fixed delay.

This analysis shows that it takes ~30 ms for both the sensor acquisition and writing data to the SD card (1000 ms expected delay + 30 ms acquire and write time = 1030 ms) and an additional 30 milliseconds to update the display with the latest sensor values (1030 ms to acquire and write data + 30 ms to update the display =1060 ms). The effect of these additional times is that around every 30 data entries the integer timestamp is rounded and appears as a two second gap rather than the expected one second gap.

To remove this gap, rather than the fixed 100-ms delay between each loop execution, a variable delay was used. The number of milliseconds between the start and just prior to finishing the loop is calculated and subtracted from the desired delay of 100 ms. This attempts to reduce time spent in the loop writing to the SD card or updating the display.

Figure 2 shows a histogram of the number of milliseconds between each measurement in the data file with the variable delay.

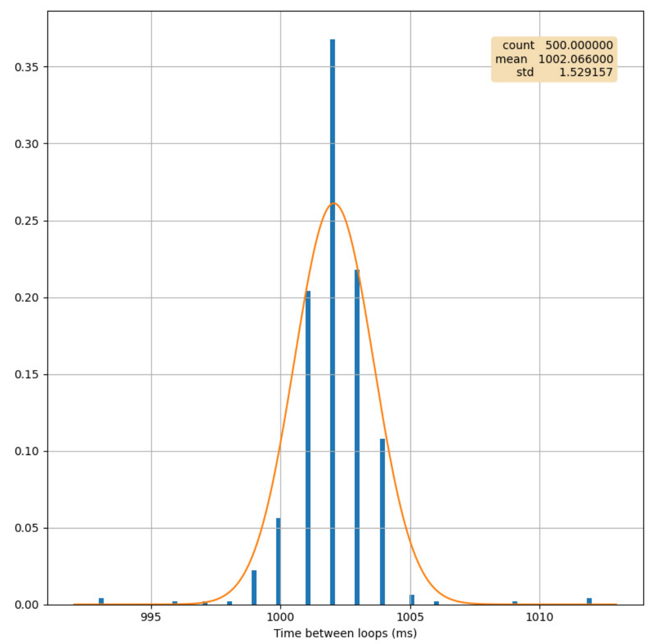

FIG. 2. Time in milliseconds between loops with variable delay.

With the variable delay code, the distribution of the time is much improved compared to the fixed delay, as the distribution is a gaussian.

To conclude, despite the variable delay, there is still an offset of ~2 ms (less than 60 ms previously), which appears as a one second gap every 500 entries. While it is unclear if the timing can be improved further, additional research is ongoing.

[1] B. Eng, et al., *Standalone Stray Field Mapping Units for Hall A's CLEO Solenoid*, DSG Note 2023-07, 2023.
[2] B. Eng, et al., *Analysis of the Field Mapping Data of the CLEO Magnet*, DSG Note 2023-19, 2023.