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Title: Unattended Single Channel Analyzer (USCA) FY20 Summary Report

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FY20 Summary Report

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Matthew R Newell, 10/1/2020

Summary

In FY20 LANL was funded to design, fabricate, test and document an instrument that can be used by the IAEA for gamma ray measurements in scintillator applications. This instrument, the Unattended Single Channel Analyzer (USCA), will be part of the family of IAEA unattended instruments and completes the suite of most used data acquisition needs provided by the previously designed UNAP instrument. The USCA is designed to meet all the same IAEA requirements designed into the UMSR and UDCM. The new instrument has the same look and feel making it simple for agency staff to move between instruments. This project taps into all the design functions developed during the UMSR and UDCM development. Along with the design and fabrication of a USCA, this project included production of a prototype for IAEA testing and a complete set of documentation.

Description

Design, Fabricate and Test

The USCA design combines the UNAP front end electronics analog circuitry with the UMSR/UDCM processor, enclosure and board design. Combining these two already complete designs simplified the design process and allowed the implementation of many of the IAEA comments from the UMSR/UDCM. Much of the design work had already been completed and vetted through the IAEA testing on the UMSR/UDCM instruments.

The USCA development was straight forward and started with the design of the main USCA circuit board. This board encompassed the front-end electronics from the UNAP, the HV power supply from the UMSR and the processor interface circuitry for the MicroZed processor. Software and firmware development included code to write to Digital to Analog Converter (DAC) chips on the main board to allow the user to set the range of interest on each of the input channels.

Much of the development work focused on the firmware used to set the threshold levels for both the upper level threshold and the lower level threshold. The USCA design used the comparators and the DACs from the UNAP design. Thresholds for each comparator were set via the four-channel DAC using firmware loaded into the Microzed processor. Most of the firmware modules used in the USCA are copies of the UMSR modules. The USCS_daq module was modified to control the analyzer thresholds and perform single channel analyzer specific functions.

Prototype Fabrication

This project included building a prototype for the IAEA to test. Serial Number (SN) 001 USCA was fabricated and programmed for delivery to the IAEA. The unit was completely tested per the USCA test plan and results of these tests were documented in the USCA test results document. Testing of the USCA involved the following tests:

1. testing the on-board power supplies,
2. testing the threshold settings,
3. testing the front-end electronics with a pulse generator,
4. testing miscellaneous functionalities such as data storage and
5. testing with a Cs137 source and a NaI detector.

USCA SN001 was shipped to the IAEA on September 24th and received on the 28th.

Documentation

To successfully commercialize an instrument for the IAEA, a complete drawing package must be produced. As part of this project we generated a drawing package that can be used by any vendor to reproduce the USCA design. The drawing package includes the following sections:

1. Bill of Materials
2. Assembly drawing
3. Wiring diagram
4. Machining drawings
5. Label drawings
6. Schematics
7. Printed Circuit Board (PCB) drawings.

The USCA complete documentation package includes a user manual and both the test results and the test plan. These documents will be provided with the USCA for use in evaluating the USCA.

Conclusion

The design plan for the USCA continues the implementation of the UNAP capabilities in simple, inexpensive devices such as the UDCM and UMSR. This project successfully executed this plan and the new USCA implements the single channel analyzer from the UNAP design. The design was fabricated in a prototype and completely tested. A prototype instrument, SN001, was shipped and received by the IAEA. A complete documentation package including drawings, test documents, and a user manual have been produced.

Findings during testing suggest that modifications to the front end electronics would significantly improve the usability of the USCA. The current implementation accepts strictly a positive unipolar shaped analog pulse. Thus requiring a preamplifier and a unipolar shaper to be connected to the scintillation detector before the signal can be presented to the USCA. Most detectors don't include preamplifiers, and almost none have shapers. We recommend modifying the front end to include a preamplifier and bipolar shaper,

Future Work

Future work for the USCA should include fabrication of multiple USCA devices and functional demonstrations as described in the original project work plan. Redesigning the analog front end electronics would improve the function of the USCA and make the USCA a valuable device for scintillation detectors. An upgrade to the GUI to improve security and software sustainability could also be performed. Software sustainability as well as a third party audit of the software have also been proposed for future work.