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Design and implementation of a ground detection system for HERD-TRD front-end electronics

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The High Energy Cosmic-Radiation Detection (HERD) facility is a space astronomy payload under construction scheduled to be launched in 2027. It will be mounted on the cosmic lighthouse program onboard China's Space Station. The Transition Radiation Detector (TRD), one of the HERD subsystems, is mainly used to calibrate the Calorimeter (CALO) of the TeV energy spectrum and X-ray survey observations. It is installed on one side of the HERD. TRD has 6 front-end electronics (FEE), each completing a 128-channel detector signal readout. A comprehensive ground detection system has been designed to support the testing efforts of these FEEs. This system includes a data acquisition (DAQ) board and host computer software. The DAQ board mainly consists of Xilinx's Kintex-7 XC7325TFFG900-2I FPGA, some level shifters, quad serial peripheral interface (QSPI) Flash, oscillators, gigabit ethernet, serial port, and some peripheral interfaces. Peripheral interfaces are SFP+, Gigabit Ethernet, USB UART, J14A-26TK, LEMO standard connector etc. The DAQ uses an LVDS bus to receive scientific data from six FEEs, allowing data reading across 768 electronic channels. It also uses the RS422 protocol for command configuration of the six FEEs and receives control commands from the host computer software to distribute to each FEE. Additionally, it transmits telemetry data from the FEEs back to the DAQ. Real-time communication between the DAQ and the host computer is accomplished via gigabit ethernet and universal asynchronous receiver/transmitter (UART) protocols. The host computer software is developed on the cross-platform application and UI framework (QT) platform. It manages control of the FEEs, data acquisition, storage, and real-time display of operational status parameters of the FEEs. The ground detection system is characterized by its compact circuit design and comprehensive functionality, with the host computer software offering an excellent user interface for interaction. The ground detection system has been designed and used in TRD system testing. The ground detection system has been designed and successfully applied to the TRD system for testing, and the test results show that it meets the system testing requirements. The test results will be presented during the conference.

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