Design of an FPGA-based Radar Controller

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The radar controller is a crucial, often over-looked, component of a radar system; allowing the transmitter to operate within a safe range and providing the flexibility to generate a variety of complex pulse schemes. Additionally, the radar controller provides precision timing to gate the radar system's receiver(s) at regions of interest. Specifications for the design were chosen to match or exceed requirements for the 430MHz transmitter at the Arecibo Observatory. Robustness, flexibility, and ease of use were the primary factors concerning software design, and open-source tools were used to promote re-use, sharing, and cost minimization within the community. We report an overview of system development, capabilities, and future plans and uses for the instrument.

FPGA-based instrumentation, unlike its hard-wired predecessors, are capable of adapting, within limits of surrounding hardware, to ever-changing requirements. For example, a system utilizing this technology can be fully simulated using software, deployed in the field for real-time testing, and then be reprogrammed to accommodate unforeseen obstacles. This particular design was based on a low-cost FPGA module combined with a Linux-based mini-ITX computer to program the system, report status, and provide an ethernet interface to control the system remotely. An LCD display, mounted on the front panel of the instrument, reports system system status and timing information for on-site users. Two custom pcb boards were developed to: 1) buffer the FPGA module's input/output signals and 2) drive the signals on a 50-ohm coaxial transmission line. Additionally, these boards modularized the system, thus minimizing down-time for repairs during a system failure. FPGA development tools consisted of the Xilinx webpack platform and the Verilog HDL language; providing an array of open-source tools for code verification and simulation. Schematic capture, circuit simulation, and board design used the gEDA development tools, an open-source EDA development suite widely used in open-hardware development. Core software follows a modular design so that the radar controller can adapt to numerous applications (i.e. a general purpose digital waveform generator) and the FPGA module supports a variety of languages including: C, C++, C#, Python, Ruby, and Matlab; allowing users to develop applications in their language of choice. The FPGA's bit image can also be modified making hardware changes fast and flexible.