OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

High Performance Digital Electronics

EESG: Bridging Technology for World-Class Science

Purpose: Our Group develops high performance digital electronics to meet the needs of world-class researchers at ORNL.

Sponsors: Department of Energy and other government agencies.

Capabilities:
- Field-programmable gate arrays.
- Embedded microprocessors and microcontrollers.
- Programmable/ reconfigurable system-on-a-chip.
- Hybrid design.
- Low-power systems.
- Graphical user interfaces.
- High-speed printed circuit board design.
- Surface-mount, ball-grid array, and chip-scale package fabrication capability.

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MSSE

OAK RIDGE National Laboratory

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The Electronic and Embedded Systems Group (EESG) uses modern electronic methods to bridge the gap between research scientists and solutions to nationally and internationally significant problems. One of the key strengths of this group is the development of high performance digital electronics to support world-class research at the Oak Ridge National Laboratory (ORNL).

Technologies include field-programmable gate arrays (FPGAs), embedded microprocessors, microcontrollers, programmable system on a chip (PSoC), and a hybrid combination of these. The group also has strong a capability in analog and mixed-signal systems, especially low-noise systems. Our Group thrives on providing innovative electronic solutions to challenging real-world problems.

High-Speed Digital Design

As clock speeds rise into the gigahertz range, special care must be taken in designing electronic systems for reliable operation. Printed circuit board traces must be treated as transmission lines and carefully routed to minimize reflections. We have proven success in high-speed digital design techniques as well as the use of alternative printed circuit board materials for improved performance. Hybrid designs use an embedded microprocessor for supervisory control and FPGAs for speed and precise timing.

Firmware Development and Testing

High performance digital systems require precise timing for effective data transfer. EESG uses state-of-the-art design tools in the design and simulation of firmware. Field upgrades enable adding new functions to equipment already in the field, as well as the ability to make design changes. The group also makes use of hardware-in-the-loop simulation to test electronic systems by applying precisely timed stimuli and recording the response.

Supporting Capabilities

- High-speed printed circuit board layout to take advantage of state-of-the-art hardware.
- Fabrication facilities for surface mount, ball-grid array, and chip-scale packages.
- Analog and mixed-signal design to interface to real-world sensors and actuators.
- User interface systems for experiment monitoring.
- Low-power design for remote monitoring and extended operation.
- Hardware-in-the-loop simulation and testing.
- Access to classified fabrication facilities.
- Analog, digital, and mixed-signal circuit modeling.
- Power electronic development.
- Web-enabled wired or wireless embedded system with encryption.
- Radiation-hardened design.

Success Story: Nuclear Material Identification System

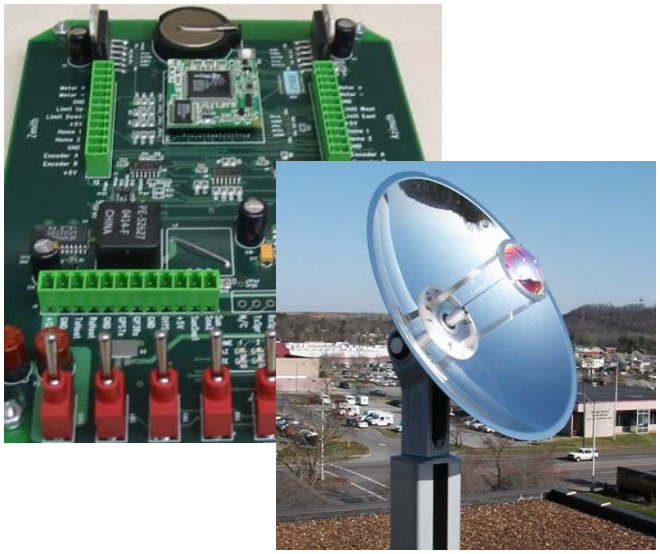
The Nuclear Material Identification System (NMIS) was pioneered by ORNL and the Oak Ridge Y-12 Plant to sense the presence of fissile materials inside closed containers. Applications include nuclear materials control and accountability, process plant monitoring and control, nuclear criticality safety applications, nuclear warhead dismantlement, and nuclear arms control treaty verification. EESG recently developed data acquisition electronics for the NMIS system. This system required the use of high-speed digital design and layout. Circuit board impedance was carefully controlled, and trace lengths were matched for precise timing. For verification testing, a special low-cost 5-channel pulse generator was developed with less than 50 picosecond channel-to-channel skew.

Some features of this system include the following:

- 5 analog input channels.
- Sustained 1.0 GHz sampling.
- Real-time data compression and formatting.
- Innovated use of commercial off-the-shelf parts to reduce cost.
- Powered by PCI bus to improve portability.
- Field-upgradeable firmware for flexibility.
- PCI Interface with high-speed DMA transfers.

Success Story: Single-Board Solar Tracker

The single-board solar tracker was developed to enable ORNL research into new techniques in hybrid solar lighting. Approximately the size of a textbook, this unit computes the tracking coordinates every second and generates motor drive signals to position the solar collector. This unit was designed with low power consumption to facilitate the use of a solar cell power source. Our group also developed graphical user interface software for remote monitoring, calibration, and diagnostics.



Features of this system include the following:

- Developed for ORNL Hybrid Solar Lighting tracker/concentrator.
- Implements Flandern and Pulkkinen azimuth/zenith planetary tracking formulae.
- Open architecture C-Language programmable.
- Automatic homing at night and initialization in the morning.
- 0.1° tracking accuracy.
- GPS interface to maintain clock accuracy.
- Less than 150 mA steady state current draw from 12 V supply.
- Onboard variable speed motor drive up to 3 A.
- Analog, digital, and serial expansion interfaces onboard.
- –40°C to +70°C operating range.

Contact Information

Our group looks forward to new challenges in adapting the latest in high performance digital electronic technology to complex scientific measurement and control.

For more information about the EESG's expertise in high performance digital electronics, please contact R. Wes Wysor (wysorrw@ornl.gov) at 865-576-2283 or Dwight Clayton (claytonda@ornl.gov) at 865-576-8134.