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Trends in mobile radiological instrument system design for gamma-ray spectroscopy

Modern radiological sensing applications such as dispersible sensors and unmanned sensing platforms are increasing the priority of reduced size weight and power (SWAP). The complexity of spectroscopic detection instrumentation is great and the design challenge is vastly multidisciplinary. Here, several techniques will be reviewed that have enabled smaller and lower-power gamma-ray spectrometry systems and overall the trends will be evident when compared to classical or traditional methods. Photon sensing – The most common spectroscopic sensors are scintillators read-out by photomultiplier (PMT). With developments in the last several years, solid-state photon sensing devices are gaining a great deal of attention and certainly provide a reduction in size. However, the argument of power savings is not completely won over PMT solutions. PMT biasing techniques along with careful high-voltage supply design enables PMT function with several milliwatts. Digital signal processing – The traditional pre-amplifier and shaper are giving way to digitization and oversampling of analog signals. Many embeddable commercial products exist to digitize pre-amplifier signals and use digital filtering to replace the analog shaping amplifier. Furthermore, some techniques involve the digitization of the raw photon sensor; eliminating the charge sensitive pre-amplifier. Depending on the sampling rate of the digitizing process, power reduction is achieved over analog circuitry. Lastly, a trend is currently being set with fast-sleeping digital circuitry that can literally sleep in a very low-power state in between signal pulses or "counts". Embedded computation – Computational hardware such as single-board computers are now ubiquitous and in a general sense allow one to integrate software and programming capabilities once reserved only for desktop PCs and laptops. Thus spectroscopic analysis including template matching and energy filtering can be executed in real-time and on battery-power. Cryogenics – HPGe sensors provide the utmost in spectroscopic performance and have not traditionally been very portable. Mechanical cooling has resulted in "luggable" hand-held systems to be common, but also the improvements in cryo-cooler efficiency and ultra-high vacuum technology has recently enabled smaller HPGe systems to be achievable, including hand-held imaging systems.

Biography

Walter McNeil began his research in the design and fabrication of numerous sensor technologies including charge-particle and neutron counters as well as room-temperature spectroscopic gamma-ray sensors such as CdZnTe. Walter has been awarded 2 patents and 3 R&D 100 awards from R&D magazine for top 100 technologically significant inventions. Since then, Walter has spent several years in system integration and detection system design and fabrication within the U.S. Department of Defense. Over the years, he has designed several portable instruments and address challenges in signal processing, sensor performance, and power reduction with scintillator based spectroscopy systems as well as cryogenically cooled semiconductor systems.

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