Digital Tube Base

TB-5

Includes

- Digital pulse processor with charge sensitive preamplifier, and MCA
- All power supplies (low voltage and high voltage)
- Interface hardware and PC software
- 14 pin photomultiplier tube base

Features

- Compatible with standard scintillation spectrometers
- USB or Ethernet (10T-PoE) for control and power
- Flexible architecture for tailoring interfaces
- For OEMs and custom users
- Includes pulse height acquisition, MCS, SCA, and List Modes. Supports pulse shape discrimination.
- Optional gamma-ray spectrum analysis software and software development kit with examples

Typical Performance with NaI(Tl)

- Dynamic range: 10 to 3000 keV
- Resolution: <7% FWHM @ 662 keV, <5% @ 1.33 MeV
- Count rates: to 200,000 cps
- Power: 750 mW typical

Applications

- **Homeland Security**: portal monitors, shipping containers, handheld monitors
- First responders and emergency workers
- Nuclear safeguards verification
- Toxic dump site monitor
- In situ processing
- Environmental or industrial monitoring
- Teaching and research
- For OEMs and custom users
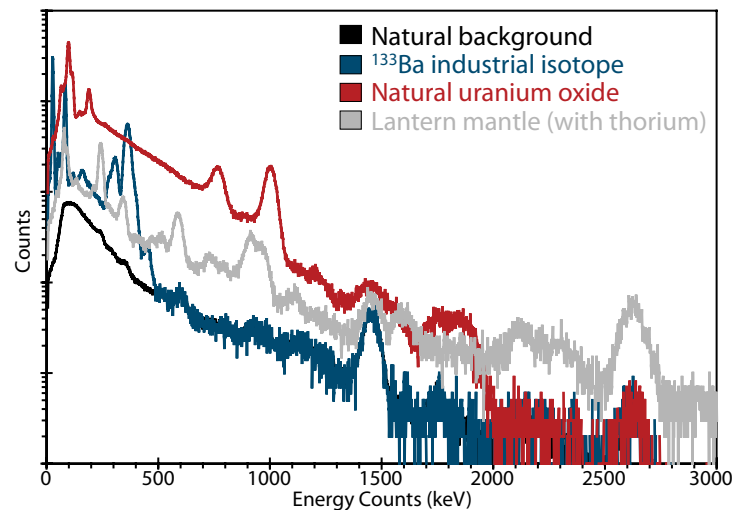
Measured γ-ray spectra of naturally occurring radioactive materials (NORM), an industrial ^{133}Ba isotope, compared to natural background with no sources present.

Overview

The TB-5 Digital Tube Base contains all the electronics needed for high performance spectroscopy with your scintillator and photomultiplier tube (PMT). It contains a preamplifier, a full-featured digital pulse processor with MCA, a high-voltage power supply, and all low voltage power supplies. It can be controlled and powered over USB or Ethernet (PoE). The TB-5's auxiliary interfaces and flexible architecture can be easily tailored for specific applications and advanced data acquisition options. It is all packaged in a low power, compact tube base.

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TB-5 Specifications

Detector

Compatible with standard 14 pin scintillation detectors using 10 stage PMTs. This includes NaI(Tl), CsI(Na), BGO, LaBr and many others. The resolution, efficiency, and maximum count rate are primarily determined by the scintillation crystal. The TB-5 digital tube base is for users providing their own scintillator and PMT. For an integrated product, including the scintillator, PMT, and tube base, please refer to Amptek's Gamma-Rad5.

Pulse Processing Performance

Gain Settings	Four software selectable coarse gain settings (1.5 to 7). Fine gain is adjustable between 0.75 & 1.25.
Pulse Shape	Trapezoidal, typically set to 2.4 µs peaking time (1 µs shaping time constant), software selectable from 0.8 to 102.4 µs. The flat top has 63 software selectable values for each peaking time. The fast channel, used for pile-up rejection and pulse shape discrimination, has a pulse pair resolving time of 0.25 µs.
Gain Stabilization	The gain from stintillators and PMTs is well known to vary with temperature. A software gain stabilization algorithm is available.
Maximum Count Rate, Dead Time, and Throughput	With the typical configuration, T_{peak}=2.4 µs, the maximum input count rate is 150 kcps with a throughput of >50% and good baseline stability and pile-up rejection. At T_{peak}=0.8 µs, the maximum input count rate is 200 kcps.
Custom Configuration	The DP5G is set at the factory for either a 20 MHz or 80 MHz clock. For NaI(Tl), 20 MHz is standard. The 80 MHz setting is recommended for custom scintillation materials with faster decay times, fast pulse shape discrimination, or other unique requirements. It draws about 50% more power.

MCA Performance

Number of Channels	Commandable to 8k , 4k, 2k, 1k, 0.5k, or 0.25k channels.
Presets	Time, total counts, counts in an ROI, counts in a single channel. Minimum acquisition time is <10 ms.

External Connections

USB	Standard 2.0 full-speed (12 Mbps). Provides both serial data and power.
Ethernet	10Base-T or UDP, DHCP or fixed IP. (PoE)
RS232	Standard serial interface 115 Kbaud.
DAC Output	Single pin LEMO connector.
Aux I/O	Gate, 8 SCAs

Power

+5 V	Average current 150 mA. Can be powered from USB, PoE or external. No external PoE injector required.
Range	3.0 to 6.4V.
High Voltage	A stabilized, high efficiency Cockroft-Walton power supply provides PMT bias. HV is software controlled. 0 to +1,200 V

Physical

Size	Ø2.44 in x 4.02 in; Ø62mm x 102 mm
Mass	8.4 oz; 238.14 g

Interface Software

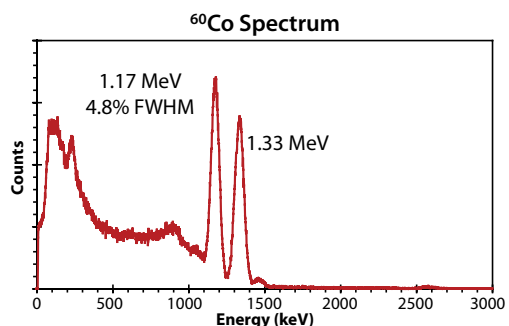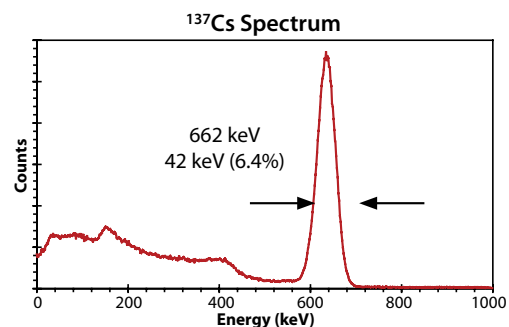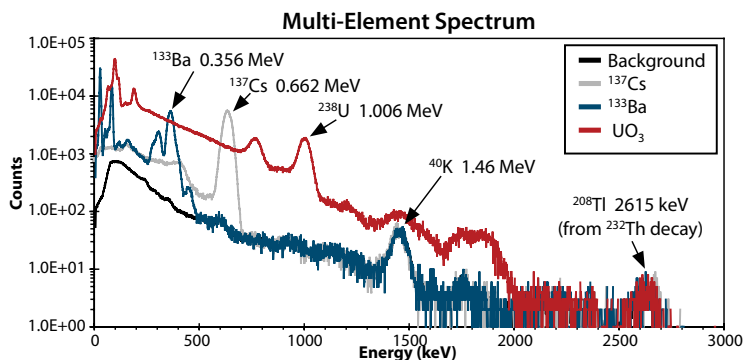|	
DPPMCA	The Amptek DPPMCA display and acquisition software controls the TB-5 and downloads and displays the data. It supports regions of interest (ROI), calibrations, peak searching, and more. Runs under Windows XP PRO SP3 or later.
Analysis Software (Optional)	The TB-5 includes an interface to analysis software, which processes the raw spectrum to identify radioisotopes and to quantify the intensities.
SDK	Free Software Developer's Kit (SDK) is included. Easily write custom code to control your system for custom applications or to interface it to a larger system. Examples are provided in VB, VC++, etc. Also included are examples of low level communication protocols, which can be used for applications running under Linux or other operating systems.

TB-5 Photos

TB-5 External Connections

TB-5 14 Pin Connector

# TB-5 Architecture
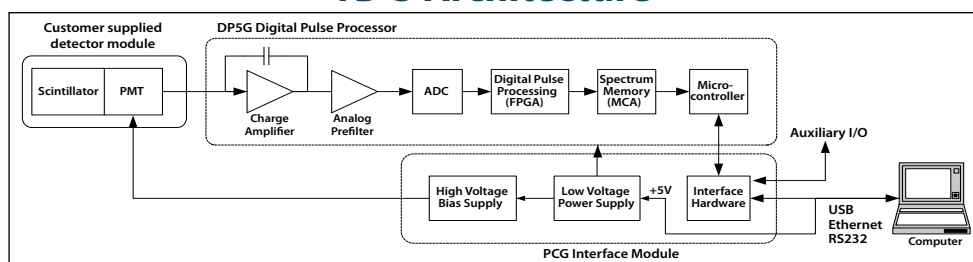
Typical NaI(Tl) Spectra

The spectra in this section were obtained with a 76 x 76 mm (3 x 3 in) NaI(Tl) scintillator. This is the most common scintillation crystal used for gamma-ray spectroscopy.

Multi-Element Spectrum

^{133}Ba 0.356 MeV
^{137}Cs 0.662 MeV
^{238}U 1.006 MeV
^{40}K 1.46 MeV
^{208}Tl 2615 keV
(from ^{232}Th decay)

Background
^{137}Cs
^{133}Ba
UO_3

^{137}Cs Spectrum

662 keV
42 keV (6.4%)

^{60}Co Spectrum


1.17 MeV
4.8% FWHM
1.33 MeV

Typical Applications

Nuclear Safeguard or Environmental Monitor

An example program is provided to aid in long term monitoring where weak sources are present. This program automatically saves a spectrum at user defined intervals, it provides gain stabilization using the ^{40}K background peak, and it provides a simple ROI analysis capability to verify if suspect counts are present above preset thresholds. This software can run on a laptop, connected to the system by a USB cable. It can also run over an Ethernet link and the Internet, and be monitored on the other side of the world. The plot on the right shows a background spectrum and measurements from natural UO_3 and a lantern mantle containing natural thorium.

Natural UO_3 Spectrum

Natural uranium oxide
Lantern mantle (with natural thorium)
Natural background (in laboratory)
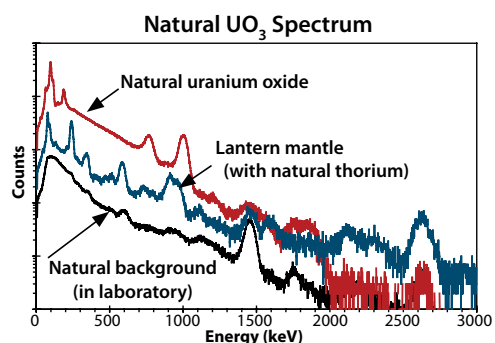
Simultaneous Neutron Detection with Gamma-Ray Spectrum

The pulse shape discrimination capability of the Digital Tube Base enables one to detect thermal neutrons and measure a gamma-ray spectrum, simultaneously, with a single module. The key is the use of a "Phoswich" detector, a sandwich of two scintillators (with different time constants) mated to a single photomultiplier tube. At Amptek, we used a unit containing a LiI(Eu) crystal coupled to a NaI(Tl) crystal. The lithium is enriched in 6Li, providing efficienct detection of thermal neutrons via the 6Li(n,a) reaction. The two scintillators produce different pulse shapes so the pulse shape discrimination logic distinguished between them, counting the neutron events while measuring the gamma-ray spectrum.
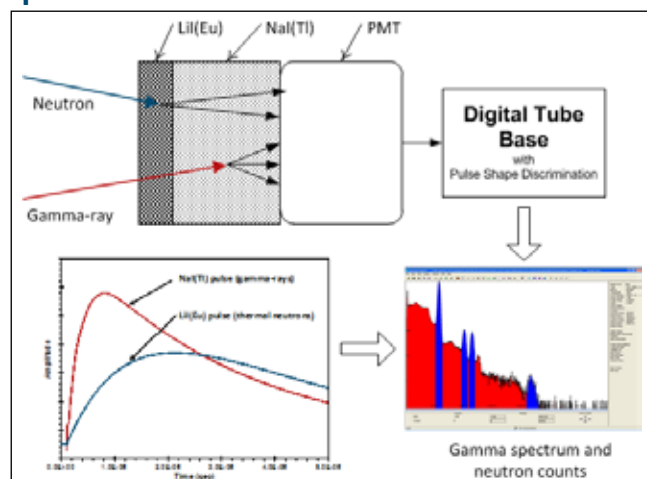
Fast Neutron Detection

A fast neutron detector was fabricated, using an EJ-410 phosphor (zinc sulfide phosphor embedded in a plastic matrix) coupled to a 5" PMT. Fast neutrons undergo proton recoil interactions in the strongly hydrogenous polymer, producing a large optical signal. Gamma-ray interactions are eliminated by setting an appropriate threshold. This is a counting system, rather than a spectroscopy system, but uses pulse height analysis to discriminate between the species. The compact digital tube base with its PoE interface and software environment make implementation of a complete system straightforward.

Networking and Interoperability

Networking and interconnection of radiation detectors frequent poses problems for system integrators. Amptek's TB-5 digital tube base makes it easy to interface with custom scintillators and also makes it easy to connect large and complicated systems, spread over a large geographic area and involving many different types of radiation detectors.

The TB-5 can easily interface with many scintillators: conventional gamma-ray spectrometers such as NaI(Tl), CsI(Na), BGO, lanthanum halides, and others are straightforward to use. A user can obtain the scintillator and PMT in whatever geometry is best for the specific application. With the TB-5, a single interface to the computer (USB or Ethernet) provides control, data acquisition, and all power supplies. But the TB-5 can be used with other materials. Thermal neutron and fast neutron detectors utilizing scintillators or phosphors and PMTs can be connected to the TB-5. Although these are counting systems and do not necessarily need the high performance signal processing electronics required for spectroscopy, the standard power supplies, communications interfaces, and application software of the TB-5 make operation straightforward. Most systems requiring a 14 pin PMT base can use the TB-5.

The TB-5 uses the same communications protocols and interface software as Amptek's other digital pulse processors. This includes the PX5-HPGe (for use with high purity germanium detectors in high resolution gamma-ray spectroscopy), the GammaRad-5 (for ruggedized scintillation applications), the PX5 (a general purpose processor which can be used with CdTe or coplanar grid semiconductors), and the DP5 (a board designed for embedded applications). A single computer can easily interface to a network of dissimilar radiation detectors. The drawing below illustrates just a few concepts for interconnecting radiation detectors using Amptek's digital processing technology

Using Ethernet, a very large area detector network can easily be established. A single computer can interface to dozens of radiation detectors, spread throughout a building, over many buildings, or across the globe. In a large facility, one can network gamma-ray spectrometers, neutron counters, and even high purity germanium detectors to a central location. Using PoE, a single connection is needed, allowing fast and easy reconfiguration of detector networks. One can locate monitors in many different cities even and, using the globally available Internet, read them from one office.

The USB interface is ideal for smaller networks, with the 3 meter maximum cable. This works very well in research or operational laboratories. A single laptop can interface with multiple radiation detectors, for example high purity germanium detectors in a counting lab combined with gamma-ray and neutron scintillators used for radiation safety. The auxiliary connectors on all of the processors permit easy integration with external electronics, e.g. using gate signals to do coincidence measurements, to do beam—on versus beam-off measurements, and so on.
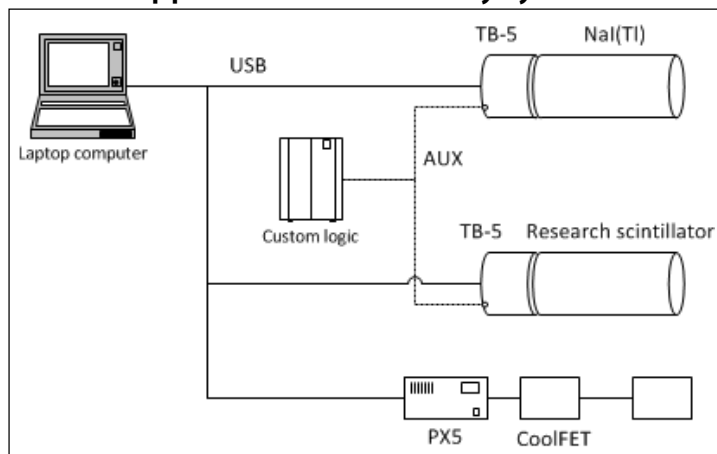
The RS232 interface is well suited to embedded systems, avoiding the overhead of USB and Ethernet. In a handheld radioisotope identifier, the RS232 interface to the TB-5 is straightforward to implement. One can even use multiple sensors, e.g. combining a DP5 processor to read out a semiconductor detector with the TB-5 mated to a scintillator. In addition, one can use commercially available RS232 adapter modules for other communication protocols: RS232 to Bluetooth, RS232 to WiFi, and others are available.

In short, the TB-5 is a powerful tool, providing a standard and flexible tool for connecting scintillation based radiation detector systems.
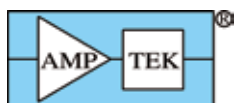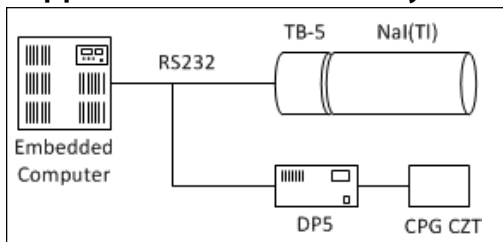
Application 1: Distributed system using Ethernet
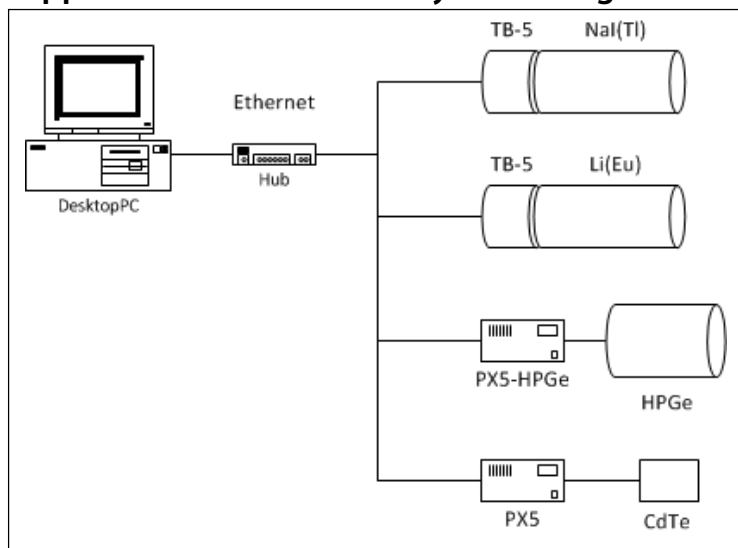
Application 2: Laboratory system

Application 3: Embedded system