Advanced data acquisition modes for Amptek digital processors

Amptek's digital processors are usually operated in multichannel analyzer (MCA) mode: the output is a histogram of the pulse heights which were recorded during the acquisition interval. There are up to 8192 channels available. MCA mode produces energy spectra, which are the typical outputs of the digital processors. MCA mode operates at up to 4 Mcps. Its data transfer requirements are limited, since the histogram is a small data packet.

The digital processors can also be operated in multiscaling (MCS) mode: the output is still a histogram, but the histogram represents the number of counts in successive time intervals. These intervals can be as short as 10 ms. MCS mode is used to measure counts versus time, for example in measuring the half-life of a radioisotope or the time profile of the flux from an X-ray tube.

The minimum data acquisition interval in both MCA mode is 1 ms. The time to readout a spectrum depends on the communication interface but is typically 5 ms at 1k channels over USB (and much slower over Ethernet and RS232). MCA mode is adequate for data acquisition intervals and timing accuracies of tens of milliseconds or greater. This is suitable for the vast majority of application.

But there are situations in which MCA and MCS modes are not adequate. The DP5 family of digital processors supports several advanced data acquisition modes which address these needs. These modes are summarized here. Technical details can be found in the "DP5 Programmers Guide" and in the appropriate product manuals.

List Mode

In List Mode, for each radiation interaction, the processor records both the pulse height and the time of interaction. The processor generates a list of such data and then transfers this list, over the standard interfaces, to the computer. This can be useful in various applications. For example, one can synchronize the events with external hardware. One can implement a double buffer scheme, e.g. to separate fast and delayed neutrons in a pulse application. One can synchronize data from scanning systems where the position of the detector is known as a function of time. For example, X-ray detectors are often used to scan samples in an SEM. In an aerial surveys or a walk-through portal monitor, the position is known as a function of time. List Mode can be used in many such applications.

In List Mode, each event which passes all acceptance criteria (PUR, RTD, Gate, thresholds, etc) will be recorded. The pulse heights are recorded to 14 bits resolution (16k channels). The time of each event is recorded to a precision of either 100 or 1000 ns (software selectable). The time base can be synchronized using an external timing pulse (e.g. a 1 pulse per second pulse), which resets the List Mode timer. For each event, a "buffer select" logic bit is also stored, indicating the state of an external signal.

The maximum count rate that List Mode can support is limited by the interface. Theoretically, USB can sustain 150 kcps but this depends on software implementation. The demonstration software supplied by Amptek sustains 100 kcps over USB. Ethernet and RS232 are limited to 12 kcps and 2 kcps, respectively.

The digital processors provide a second version of List Mode, the 16-bit List Mode. In this mode, instead of associating a time tag with each event, a time tag is inserted in the data list at either a 1 kHz or 10 kHz rate. This mode allows a maximum count rate of about 240 kcps over USB. This mode is appropriate when the user does not need the time of each interaction but in the events recorded with a 0.1 to 1 ms window, e.g. in a scanning system with a suitable dwell time.

Amptek provides a demonstration program which reads the data in both List Modes. List Mode applications are inherently custom, so the user should expect to write his/her software based on this demonstration program to achieve the needed outputs.

Single Channel Analyzers

Amptek's digital processors also include eight hardware single channel analyzers (SCAs) for interfacing. Each SCA has a software commandable lower and upper level threshold. When an event has a pulse height in the SCA's window, a logic pulse is then generated on an auxiliary connector.

The SCA outputs are useful for synchronizing the digital processors to external hardware when all one needs is the counts in a region of interest, e.g. a photopeak or a background region. One can connect external counters to the different SCAs to count events at high time resolution. This can be combined with hardware tracking XY positions or other hardware synchronization circuits.

SCA Packets

The SCA packet mode essentially provides a reduced histogram, with the bins of commandable width, which can be transmitted rapidly to a computer. This is useful when one does not need the amplitude of each event, only counts in regions, but needs these more rapidly than is achievable in MCA mode.

Amptek's digital processors include eight software only SCAs, in addition to the eight hardware SCAs. In SCA packet mode, when an event has a pulse height in an SCA's window, a count is recorded the SCA histogram. A packet of histograms may be transmitted every 1 millisec. Amprek provides a demonstration program from which the user can develop custom software.

Streaming Mode

Streaming mode is essentially a hardware equivalent to List Mode. Every time a valid event is recorded, the complete pulse height is sent to a parallel output port (the SCA output lines are reconfigured into this parallel bus). User supplied external hardware can read the pulse height and then can combine this with timing and synchronization information.

In Streaming Mode, the pulse height resolution is 14 bits. The data are transmitted over two clock periods, with a 1 bit strobe to indicate a valid pulse was measured, 7 bits of pulse height, and a 1 bit LSB/MSB indicator. The values are written in the clock cycles immediately after the digital processor has detected a valid event so are delayed relative to the radiation interaction. This delay include the peaking time, the flat top, and certain pipeline delays. The delay depends on the configuration settings of the digital processor so should be measured by the user.