Fast Digitizers in IRMs

Available support

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The following digitizers are currently supported by IRM-based hardware and software.

KHz digitizer

This digitizer is used to digitize 64 A/D channels at 1 KHz and store the readings in a circular buffer memory that has room for 512 sets of such data; hence, the circular buffer wraps every 512 ms. The most recent set is copied into the data pool at 15 Hz, synchronous with the accelerator clock. Values from the 15 Hz data pool are sampled to fulfill ordinary Acnet user `RETDAT` requests, selectively averaged for beam pulses for reply rates of less than 15 Hz.

For `FTPMAN` requests, this data is supported both by the continuous protocol as well as the snapshot protocol. For the continuous case, any rate may be specified up to 1 KHz, and the reply buffer will be filled to bring the requester up-to-date from the previous reply. (Note that for this to work, the replies must be delivered at 2 Hz or faster, since the circular buffer wraps at that rate.) For snapshot requests, the data is accumulated every cycle, sampled at a rate of 1 KHz or any submultiple thereof. All rates from 1 KHz down to 1 Hz are supported in this way.

All of these uses of the KHz digitizer are supported for multiple user requests without interference. The hardware updates the circular buffer memory in the same way all the time; all channels get equal treatment.

For special system needs, the 1 KHz rate can be driven at a slower rate externally. In the case of the PET IRMs, the rate was driven externally at 360 Hz, because that was the maximum cycle rate of that accelerator.

Data from this digitizer may also be supported continuously via `RETDAT` requests. In this case, the offset can be used to specify the clock event desired. The sample rate is implied by the number of words requested and the reply rate. It does not change the digitize rate, of course, but merely alters the sampling that is done from the KHz circular memory buffer to fulfill the user request.

Time stamps are provided for the continuous support, both for `FTPMAN` and for `RETDAT`. The time stamps are referenced to the selected clock event. This is accomplished by maintaining a time stamp for each clock event and also a time stamp for each of the 512 sets of data in the circular buffer. Time stamps for `FTPMAN` have resolutions of 100 μs. Those for `RETDAT` have resolutions of 10 μs.

Swift digitizer

The Swift digitizer supports rates of up to 800 KHz. It can also operate at slower rates by factors of two all the way down to 6.25 KHz. The hardware packages eight digitizers on one board, each with 4K words of waveform memory. Hardware registers must be set up to specify the rate, the clock event, and the delay. The original use for this digitizer was in Booster HLRF. The maximum rate of 800 KHz was chosen to permit operation with an externally-driven input to match the beam circulation rate of the Booster. (Circulation time in the Booster at the speed of light is about 1.5 μs.)

The Swift digitizer is supported via snapshot protocol. With a maximum number of points in the buffer for each channel of 4K words, the periods of time covered by the possible digitize rates span a range of about 5–650 ms.

In order to support requests that specify different settings (rate, delay, event), requests are handled by a queuing scheme. (One may think of this as requests for using a single camera to take a picture; each photographer must stand in line to have his turn at using the camera.) If two requests are waiting to use different settings, only one can be handled at a time; however, if multiple users happen to request the same settings, then they can be serviced simultaneously, and the waveform data they receive will be the same. Such snapshots cannot be satisfied at 15 Hz.

In the case that only a single set of fixed settings is to be used, the waveform data can be collected regularly, even at rates up to 15 Hz. In that case, the queuing scheme is not used, and the hardware operates continuously, awaiting the next clock event, waiting out the delay, then digitizing the waveform. (Such requests would be fulfilled by `RETDAT` rather than `FTPMAN`.) Whether the key assumption can be made, that of using only a fixed set of settings, is a configuration matter. The fixed set can be altered, but doing so necessarily affects all requesters.

Quick digitizer

This is a commercial VME board that supports 4 channels at various maximum rates, depending on the specific model ordered. The boards have maximum digitization rates of 1, 2, 5, or 10 MHz. The boards with maximum rates of 1, 2, or 5 MHz allow 16 possible rates; the 10 MHz board allows 8 rates. The memory is large enough to hold 64K points for each channel. This digitizer is supported via the snapshot protocol. The support assumes that the settings used are fixed, established at system configuration time. If the settings are changed, they affect all users. There is no built-in clock event support, so external hardware must be used to provide the proper external trigger. Support for a related V177 board is included to do this.

Quicker digitizer

The most recent fast digitizer can operate at rates from 156 KHz to 20 MHz. Again, the rates are spread as factors of two below 20 MHz. It includes memory for 8 channels at 16K points per channel, so that the time base ranges from 0.8–105 ms, depending on the digitize rate. During digitization, the data words are written into a FIFO that is emptied automatically into memory. About 100 ms is required to store 8 complete waveforms, which is too slow for 15 Hz. But if one needs a smaller number of points to make up the waveforms, it can operate faster. If 4K words of data are enough, then it can easily keep up with 15 Hz.

This digitizer may be operated via the snapshot protocol with the queuing scheme described above, or it can be operated using fixed settings via the `RETDAT` protocol. The snapshot protocol does not support 15Hz, but one could attain 15Hz using `RETDAT`. With the needs of 15 Hz operation of the Linac and Booster, it is likely that it will be used with fixed settings.

Hardware

The kHz digitizer is included with every IRM. The Swift and Quicker digitizers require an additional IP board plus its associated interface board to be installed inside the IRM box. The Quick digitizer is a separate VME board that can also be installed in the IRM box.