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3.2 - Stream Mode [U3 Datasheet]

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Stream Mode Overview

The highest input data rates are obtained in stream mode, which is supported with U3 hardware version 1.21 or higher. Hardware version 1.21 started shipping in late August of 2006. Contact LabJack for information about upgrading older U3s. Stream is a continuous hardware timed input mode where a list of channels is scanned at a specified scan rate. The scan rate specifies the interval between the beginning of each scan. The samples within each scan are acquired as fast as possible.

As samples are collected, they are placed in a smallFIFO buffer on the U3, until retrieved by the host. The buffer typically holds 984 samples, but the size ranges from 512 to 984 depending on the number of samples per packet. Each data packet has various measures to ensure the integrity and completeness of the data received by the host.

Since the data buffer on the U3 is very small it uses a feature called auto-recovery. If the buffer overflows, the U3 will continue streaming but discard data until the buffer is emptied, and then data will be stored in the buffer again. The U3 keeps track of how many packets are discarded and reports that value. Based on the number of packets discarded, the UD driver adds the proper number of dummy samples (-9999.0) such that the correct timing is maintained.

The table below shows various stream performance parameters. Some systems might require a USB high-high configuration to obtain the maximum speed in the last row of the table. A "USB high-high" configuration means the U3 is connected to a high-speed USB2 hub which is then connected to a high-speed USB2 host. Even though the U3 is not a high-speed USB device, such a configuration does often provide improved performance.

Stream data rates over USB can also be limited by other factors such as speed of the PC and program design. One general technique for robust continuous streaming would be increasing the priority of the stream process.

The max sample rate of the U3 is 50 ksamples/second. The max scan rate depends on how many channels you are sampling per scan:

Sample => A reading from one channel.

Scan => One reading from all channels in the scan list.
SampleRate = NumChannels * ScanRate

ScanRate = SampleRate / NumChannels

For example, if streaming 5 channels at ResolutionIndex=0 and all at Range=+/-10V, the max scan rate is 10 kscans/second (calculated from 50 ksamples/second divided by 5).

Table 3.2-1. Streaming at Various Resolutions

Low-Level Res Index	UD Res Index	Max Stream (Samples/s)	ENOB (RMS)	ENOB (Noise-Free)	Noise (Counts)	Interchannel Delay (µs)
0	100	2500	12.8	10	±2	320
1	101	10000	11.9	9	±4	82
2	102	20000	11.3	8.4	±6	42
3	103	50000	10.5	7.5	±11	12.5

Full resolution streaming is limited to 2500 samples/s, but higher speeds are possible at the expense of reduced effective resolution (increased noise). The first column above is the index passed in the Resolution parameter to the low-level StreamConfig function, while the second column is the corresponding index for the Resolution parameter in the UD driver. In the UD driver, the default Resolution index is 0, which corresponds to automatic selection. In this case, the driver will use the highest resolution for the specified sample rate.

ENOB stands for effective number of bits. The first ENOB column is the commonly used "effective" resolution, and can be thought of as the resolution obtained by most readings. This data is calculated by collecting 128 samples and evaluating the standard deviation (RMS noise). The second ENOB column is the noise-free resolution, and is the resolution obtained by all readings. This data is calculated by collecting 128 samples and evaluating the maximum value minus the minimum value (peak-to-peak noise). Similarly, the Noise Counts column is the peak-to-peak noise based on counts from a 12-bit reading.

Interchannel delay is the time between successive channels within a stream scan.

3.2.1 - Streaming Digital Inputs, Timers, and Counters [U3 Datasheet]

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There are special channel numbers that allow digital inputs, timers, and counters, to be streamed in with analog input data.

Table 3.2.1-1. Special Stream Channels

Channel #	
193	EIO_FIO
194	CIO
200	Timer0
201	Timer1
210	Counter0
211	Counter1
224	TC_Capture
230	Timer0 with reset
231	Timer1 with reset
240	Counter0 with reset
241	Counter1 with reset

Special Channels:

193: Returns the input states of 16 bits of digital I/O. FIO is the lower 8 bits and EIO is the upper 8 bits.

194: Returns the input states of 16 bits of digital I/O. CIO is the lower 8 bits.

200-201 and 210-211: Retrieves the least significant word (LSW, lower 2 bytes) of the specified timer/counter. At the same time that any one of these is sampled, the most significant word (MSW, upper 2 bytes) of that particular timer/counter is stored in an internal capture register (TC_Capture), so that the proper value can be sampled later in the scan. For any timer/counter where the MSW is wanted, channel number 224 must be sampled after that channel and before any other timer/counter channel. For example, a scan list of {200,224,201,224} would get the LSW of Timer0, the MSW of Timer0, the LSW of Timer1, and the MSW of Timer1. A scan list of {200,201,224} would get the LSW of Timer0, the LSW of Timer1, and the MSW of Timer1 (MSW of Timer0 is lost).

230-231 and 240-241: These channels perform the same operation as their 200-211 counterpart above, then reset the timer or counter.

Adding these special channels to the stream scan list does not configure those inputs. If any of the FIO or EIO lines have been configured as outputs, timers, counter, or analog inputs, a channel 193 read will still be performed without error but the values from those bits should be ignored. The timers/counters (200-224) must be configured before streaming using normal timer/counter configuration commands.

The timing for these special channels is the same as for normal analog channels. For instance, a stream of the scan list {0,1,200,224,201,224} counts as 6 channels, and the maximum scan rate is determined by taking the maximum sample rate at the specified resolution and dividing by 6.

It is not recommended to stream timers configured in mode 2 or 3 (32-bit period measurement). It is possible for the LSW to roll, but the MSW be captured before it is incremented. That means that only the LSW is reliable, and thus you might as well just use the 16-bit modes.

Mode 11, the upper 32 bits of the system timer, is not available for stream reads. Note that when streaming on the U3, the timing is known anyway (elapsed time = ScanNumber / ScanRate) and it does not make sense to stream the system timer modes 10 or 11.