

## 3.2 - Stream Mode [U6 Datasheet]

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### Stream Mode Overview

The fastest data rates on the U6 occur when operating in stream mode. Much of the command response overhead is eliminated in stream mode because the U6 is responsible for initiating IO operations. Collected data is stored in the U6's stream buffer it is retrieved by the host application. The end result is a continuous data stream, sampled at regular intervals, collected with a minimum number of command response data sets [1].

As samples are collected, they are placed in a small FIFO buffer on the U6, 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.

The U6 uses a feature called auto-recovery. If the buffer overflows, the U6 will continue streaming but discard data until the buffer is emptied, and then data will be stored in the buffer again. The U6 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.

Table 3.2.1 and 3.2.2 provide typical stream-related performance results[2]. The tabulated data is useful for determining what types of signals can be analyzed using a U6. The U6 is capable of streaming analog data at regular discrete intervals. As a result, various discrete time signal analysis tools can be utilized to interpret data.

**Table 3.2.1.** Stream scan rates for stream mode over various gain, resolution index, channel count combinations.

	Gain : Range	Maximum Scan Rate			
		1 Channel	2 Channels	4 Channels	8 Channels
		[Hz]	[Hz]	[Hz]	[Hz]

	1 : ±10V	50k	25.0k	12.5K	6.3K
<b>Resolution Index = 1</b>	10 : ±1V	50k	2.2k	1.1k	540
	100 : ±0.1V	50k	444	222	110
	1000 : ±0.01V	50k	178	88	44
	1 : ±10V	30k	14.5k	7.3k	3.6k
<b>Resolution Index = 2</b>	10 : ±1V	30k	2.0k	1.0k	500
	100 : ±0.1V	30k	220	110	54
	1000 : ±0.01V	30k	178	88	44
	1 : ±10V	16k	7.8k	3.9k	2.0k
<b>Resolution Index = 3</b>	10 : ±1V	16k	817	408	204
	100 : ±0.1V	16k	175	87	43
	1000 : ±0.01V	16k	175	86	43
	1 : ±10V	8.4k	4.2k	2.0k	990
<b>Resolution Index = 4</b>	10 : ±1V	8.4k	742	371	185
	100 : ±0.1V	8.4k	165	85	41
	1000 : ±0.01V	8.4k	172	84	42
	1 : ±10V	4.0k	2.0k	1.0k	500
<b>Resolution Index = 5</b>	10 : ±1V	4.0k	370	185	92
	100 : ±0.1V	4.0k	163	82	40
	1000 : ±0.01V	4.0k	165	82	40
	1 : ±10V	2.0k	1.0k	500	250
<b>Resolution Index = 6</b>	10 : ±1V	2.0k	184	92	46
	100 : ±0.1V	2.0k	153	77	38
	1000 : ±0.01V	2.0k	153	76	38
	1 : ±10V	1.0k	500	250	130
<b>Resolution Index = 7</b>	10 : ±1V	1.0k	156	78	39
	100 : ±0.1V	1.0k	133	66	33
	1000 : ±0.01V	1.0k	133	66	33
	1 : ±10V	500	250	130	62
<b>Resolution Index = 8</b>	10 : ±1V	500	120	62	33
	100 : ±0.1V	500	105	52	26
	1000 : ±0.01V	500	106	53	26

A distinction between the terms scan and sample must be drawn to better interpret the data from Table 3.2.1. A sample and a scan represent two separate parameters which make up a U6 data stream. The definitions for each parameter are as follows:

**Sample** - A reading from one channel/address.

**Scan** - One reading from a list of channels/addresses (scan list).

The scan rate, by definition, is a fraction of the sample rate where the fraction is the inverse of the number of channels being read in a single scan. The scan rate is defined as:

$$\text{ScanRate} = \text{SampleRate} / \text{NumChannels}$$

The U6 has a **maximum sample rate** of 50 ksamples/second. The stated maximum sample rate is achievable when a stream is configured with Range = +/-10V and ResolutionIndex = 0 or 1 [3]. This is reflected in the first row of data in table 3.2.1 (highlighted). The reported scan rate is simply the maximum sample rate divided by the number of channels in the scan list (within ~10%). Note that the

sample rate and scan rate for a single-channel stream are equal since the NumAddresses = 1.

The maximum scan rate will decrease at higher resolution index and range settings simply because analog conversions take longer to complete. Table 3.2.2 illustrates how analog conversion times increase at higher resolution index and range settings.

**Table 3.2.2.** Stream performance characteristics for single-channel stream over various gain and resolution index combinations.

<b>Resolution Index</b>	<b>Peak-to-Peak Noise</b> [16-bit counts]	<b>Interchannel Delay</b> [ $\mu$ s]
<b>Gain/Range: 1/<math>\pm</math>10V</b>		
1	$\pm$ 3.0	15
2	$\pm$ 2.5	30
3	$\pm$ 1.5	40
4	$\pm$ 1.0	110
5	$\pm$ 1.0	220
6	$\pm$ 0.5	440
7	$\pm$ 0.5	875
8	$\pm$ 0.5	1,740
<b>Gain/Range: 10/<math>\pm</math>1V</b>		
1	$\pm$ 4.5	205
2	$\pm$ 3.5	220
3	$\pm$ 2.5	545
4	$\pm$ 1.5	600
5	$\pm$ 1.0	1,210
6	$\pm$ 1.0	2,430
7	$\pm$ 0.5	2,880
8	$\pm$ 0.5	3,740
<b>Gain/Range: 100/<math>\pm</math>0.1V</b>		
1	$\pm$ 16.0	1,010
2	$\pm$ 11.0	2,030
3	$\pm$ 8.0	2,560
4	$\pm$ 5.0	2,630
5	$\pm$ 3.0	2,730
6	$\pm$ 2.5	2,940
7	$\pm$ 1.5	3,380
8	$\pm$ 1.0	4,240
<b>Gain/Range: 1000/<math>\pm</math>0.01V</b>		
1	$\pm$ 67.0	2,500
2	$\pm$ 42.5	2,535
3	$\pm$ 21.5	2,560
4	$\pm$ 16.5	2,630
5	$\pm$ 11.5	2,730
6	$\pm$ 11.0	2,940
7	$\pm$ 6.0	3,380
8	$\pm$ 4.5	4,240

**Notes:**

1. The number of command response data sets used to retrieve stream data from the U6 depends on the number of data points allowed to accumulate in the in the U6's stream buffer.
2. Some systems might require a "USB high-high" configuration to obtain the maximum speeds listed. A "USB high-high" configuration means the U6 is connected to a high-speed USB2 hub which is then connected to a high-speed USB2 host. Even though the U6 is not a high-speed USB device, such a configuration does often provide improved performance.
3. Stream mode only supports resolution index values 0-8 (24-bit ADC not supported). Therefore, setting the resolution index to 0 is equivalent to resolution index = 1.

## 3.2.1 - Streaming Digital Inputs, Timers, and Counters [U6 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. Note that you must always have at least 1 AIN channel in the stream list for the U6.

**Table 3.2.1-1. Special Stream Channels**

<u>Channel #</u>	
193	EIO_FIO
194	MIO_CIO
200	Timer0
201	Timer1
202	Timer2
203	Timer3
210	Counter0
211	Counter1
224	TC_Capture
230	Timer0 with reset
231	Timer1 with reset
232	Timer2 with reset
233	Timer3 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 and MIO is the upper 8 bits.

**200-203 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).

**230-233 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. There must always be at least 1 analog input in the stream scan list.

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 U6, the timing is known anyway (elapsed time = scan rate \* scan number) and it does not make sense to stream the system timer modes 10 or 11.

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