42 Aero Camino, Goleta, CA 93117
Tel (805) 685-0066 | Fax (805) 685-0067
info@biopac.com | **www.biopac.com**

11.07.16

Application Note 195: MP100 and MP160/150 System Data Sampling Reference

NOTE: The MP100 System was discontinued in 2004, and the MP150 (32-bit) was discontinued in 2016. The MP160 (64-bit) is the current MP1xx System offering. This application note is intended as a reference to note the differences between the older and the newer systems.

The MP100 and MP160/150 Systems employ separate methods to acquire data, in order to accommodate the differences in sampling speeds and aggregate rates between the two systems. Both systems are microprocessor based data acquisition systems, but the MP160/150 uses dedicated, conformable hardware for the data acquisition engine. In addition, while the MP100 includes a single A/D converter, the MP160/150 incorporates dual A/D converters.

The dual A/D converters in the MP160/150 System sample any chosen two channels simultaneously, so there is significantly reduced channel-to-channel timing latency when comparing the MP160/150 to the MP100. The MP160/150 System's unique data acquisition engine will support the sampling of two channels at 200 kHz for each channel with no (measurable) timing latency.

The following table illustrates the basic timing differences between the two systems:

System	Maximum Sampling Rates	Channel- to-Channel Latency	Multiplexer Switching Speed	A/D Conversion Time	Channel Sampling Order
MP100	One Channel Rate: 70 kHz Aggregate Rate 70 kHz	10 µsec per channel up to channel 16 (150 µsec max)	10 µsec	10 µsec	1,2,3……16
MP160/150	One Channel Rate: 200 kHz Max Aggregate Rate: 400kHz	5 µsec per every two channels up to channel 16 (35 µsec max)	5 µsec	5 µsec	AD1 and AD2 Alternate Channels

The older MP100 System is suitable for long-term, aggregate data acquisition rates with a nominal upper limit of 16 kHz. However, this limit may vary, depending on certain other data acquisition parameter settings. The MP100 System is generally very suitable for most any cardio-pulmonary or hemodynamic oriented recording scenario. Almost all signals of this type can be fully characterized at sampling rates of 1000 Hz or less. The MP100 System is also suitable for higher speed (burst) recordings up to 70 kHz. However, in these situations, data collection must be limited to 16,000 samples or less.

The MP160 (64-bit) or MP150 (32-bit) Systems are suitable for long-term, aggregate data acquisition rates up to a highest possible setting of 400 kHz. However, this limit may vary, depending on certain other data acquisition parameter settings. The MP160/150 Systems are very suitable for almost any cardio-pulmonary and neurophysiology oriented recording scenario. The maximum meaningful frequency obtained from any surface potential measurement is on the order of 10 kHz or less. The MP160/150 Systems will support acquisition rates of 25 kHz on as many as 16 channels simultaneously, thus satisfying the Nyquist criteria for 10 kHz source data. Also, due to the MP160/150 System's unique architecture, two channels of data can be acquired at a 200 kHz rate with zero channel-to-channel latency. This particular characteristic makes the MP160/150 Systems especially suitable for high-speed, neurophysiological recording.

The following table illustrates the differences in maximum sampling rates for the two MP Systems when used with different data storage methods and with different functional options.

System	Channels	Disk Rate per CH	Memory Rate per CH	MP Memory Rate per CH	MP Memory Averaging	Short or Repetitive Simultaneous Stimulation	Arbitrarily Long Simultaneous Stimulation
MP100	1	11,000	11,000	70,000	48,000	30,000	4,750
	2	7,000	7,000	33,000	26,000	22,000	3,500
	3	5,000	5,000	24,000	20,000	17,500	3,000
	4	4,000	4,000	19,000	17,000	14,700	2,500
	5	3,250	3,250	15,000	14,000	12,500	2,200
	6	2,750	2,750	13,000	12,500	11,000	2,000
	7	2,400	2,400	11,000	11,000	9,900	1,800
	8	2,000	2,000	10,000	10,000	8,900	1,600
	9	1,800	1,800	9,000	9,000	8,000	1,500
	10	1,750	1,750	8,200	8,200	7,400	1,400
	11	1,600	1,600	7,500	7,500	6,750	1,300
	12	1,500	1,500	7,000	7,000	6,300	1,200
	13	1,400	1,400	6,500	6,500	5,900	1,100
	14	1,300	1,300	6,000	6,000	5,500	1,000
	15	1,200	1,200	5,600	5,600	5,200	900
	16	1,100	1,100	5,300	5,300	4,900	800
MP160/150	1	200,000	200,000	200,000	200,000	200,000	200,000
	2	200,000	200,000	200,000	200,000	200,000	100,000
	3	100,000	100,000	100,000	100,000	100,000	100,000
	4	100,000	100,000	100,000	100,000	100,000	50,000
	5	50,000	50,000	50,000	50,000	50,000	50,000
	6	50,000	50,000	50,000	50,000	50,000	50,000
	7	50,000	50,000	50,000	50,000	50,000	50,000
	8	50,000	50,000	50,000	50,000	50,000	40,000
	9	40,000	40,000	40,000	40,000	40,000	40,000
	10	40,000	40,000	40,000	40,000	40,000	25,000
	11	25,000	25,000	25,000	25,000	25,000	25,000
	12	25,000	25,000	25,000	25,000	25,000	25,000
	13	25,000	25,000	25,000	25,000	25,000	25,000
	14	25,000	25,000	25,000	25,000	25,000	20,000
	15	25,000	25,000	25,000	25,000	25,000	20,000
	16	25,000	25,000	25,000	25,000	25,000	20,000

Notes

The MP100 stimulator output rate is identical to the sampling rate except in Averaging mode. In this mode, Stimulator output occurs PRIOR to recording, so the stimulator rate is limited to 45 kHz maximum.

The MP160/150 stimulator rate is independent of the sampling rate in all modes. Stimulator sampling rate is limited to 100 kHz maximum.

Other system characteristics are not so easily tabulated. These characteristics concern the following issues:

1) System Timing Stability

There are two issues to consider for this parameter. The first concern is sample-to-sample timing variability. The second issue is mean timing accuracy.

MP100 System: System timing is determined via a crystal oscillator and mediated via microprocessor interrupts. The interrupt time delta variability is on the order of 0.25 µsec. Accordingly, at a sample rate of 1 kHz, sample-to-sample timing variability is on the order of 0.25/1000 or 0.025%. At a rate of 10 kHz, timing variability is on the order of 0.25%. The mean timing accuracy is subject to variations in the crystal timing circuitry, which can contribute an error up to 50 ppm or 0.005%.

MP160/150 System: System timing is determined via a crystal oscillator applied directly to a hardware-based data acquisition engine. Since no interrupts are necessary to mediate the acquisition rate, the sample-to-sample timing variability is not easily measured, due to its extremely low value. Given this situation, mean timing accuracy becomes the dominant source of error. The mean timing accuracy is subject to variations in the crystal timing circuitry, which can contribute an error up to 50 ppm or 0.005%.

2) External Trigger Latency

MP100 System: External trigger latency is less than 10 µsec.

MP160/150 System: External trigger latency is less than 5 µsec.

3) Time Required to Display Data

This parameter is subject to a wide range of values, due to the influences of the following elements:

- Data transfer rate
- USB or ETHERNET traffic
- Acquisition rate
- Computer type and speed
- Video refresh rate

In most instances, the sample-to-display latency is subject to the computer's video screen refresh rate. This is the rate at which the computer screen redraws information. Typically, the video refresh interval is on the order of 16 ms (60 Hz rate). In any event, the specification may be somewhat irrelevant due to latencies in the visual centers of any particular individual who may be looking at the computer screen.

Timing accuracy is preserved, despite any latency encountered when transferring data from the MP System to the computer. The data, as it's viewed and stored, is accompanied by timing information also sent by the MP System. Under no conditions is the personal computer clock used as a timing reference when recording data. In this fashion, no factors associated with computer type, processing speed, video refresh rate, etc. can have any influence on the timing accuracy of the data collected by the MP Systems.

4) Data Storage and Reproduction Integrity

Both MP Systems employ a double-buffered data transmission scheme when transferring data from the MP unit to the computer. The MP System digitizes data in the respective MP unit and loads the data in an internal buffer prior to transmission to the computer. During transmission, data is sent in packets. Each packet is checked for data integrity via checksum. If any errors are noted, the packet is retransmitted. Upon data packet receipt, the computer stores incoming data in another buffer and proceeds to send data to the computer screen and memory or disk as the acquisition storage parameters specify.

Each MP System acts to constantly preserve data acquisition and storage integrity while optimizing system resources for maximum performance. For example, if the computer draws information too slowly, the MP System will buffer transmitted data differently, and potentially (momentarily) stop drawing data to the computer screen in order to achieve the best possible acquisition and storage performance. In this fashion, the MP Systems can work successfully with a wide range of computer types.

Under no conditions will the MP Systems permit gaps (missing data) in the stored data stream as a result of inadequate computer performance. Due to the double-buffered data transmission scheme, the MP Systems will shut down data collection via a “Buffer Overflow” message when the computer is unable to store data at the speed requested by the MP System in use.

Due to the significantly larger local buffer in the MP160/150 System (6,000,000 samples), versus the local buffer in the MP100 System (16,000 samples), the MP160/150 System is often used for acquisition applications falling within the sampling range of the MP100 System. The advantage supplied by the MP160/150 System is that the local buffer is large enough to readily tolerate interruptions in the computer’s ability to accept data from the MP160/150 unit. These interruptions can occur if the user is performing extensive interactive data analysis (other than real-time calculations), such as scrolling through data as it’s being collected or performing spot measurements on that data. In these cases, the MP160/150 internal buffer is large enough to tolerate long delays in computer readiness. Accordingly, from the user’s perspective, the acquisition will appear to proceed normally, without providing a “Buffer Overflow” message, which may occur more readily in the MP100 System.