**Application Note 162   Using the Stimulation Features of the MP160/MP150 System – Wave Output**

The MP160/150 System stimulation features provide a powerful vehicle for outputting a variety of wave shapes of varying duration, coincident with the data acquisition process. This application note will focus on the following output requirements:

- Short term wave output once during an acquisition
- Short term wave output repeatedly during an acquisition
- Long term wave output during an acquisition

The difference between a short and long term wave output is related to the number of points describing the wave in question. A short term wave has less than or equal to 4096 points, a long term wave has more than 4096 to 512,000 points.

To launch the Acq*Knowledge* Stimulator setup, go to **MP160/150 > Set Up Data Acquisition and** choose **Stimulator**.
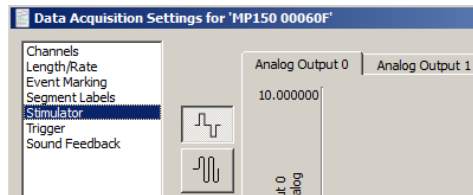
There are four basic signal types in the Acq*Knowledge* Stimulator: **Square**, **Sine**, **Ramp**, and **Arbitrary** waves. The various signal types are selected via the respective buttons in the Stimulator setup window. For specific information about these available signals, see the Stimulator chapter of the Acq*Knowledge* Software Guide.

Square, **Sine**, and **Ramp** waves are limited to 4096 samples. These are õcannedö waveforms which may be outputted once or continuously. 4096 samples also define the upper limit of a short term wave. **Arbitrary** waves, like the other types, can be outputted once or continuously, but are not subject to the 4096 sample upper limit.

The short / long distinction exists because the MP160/150 hardware unit has a specific amount of built-in memory available for waveform output, as dictated by the Acq*Knowledge* software.

MP160/150 analog output buffer:

- Up to 512 K sample points per analog output channel in Acq*Knowledge* 3.9 or above
- Software-limited to 4096 sample points in Acq*Knowledge* 3.8 or below

Stimulator Output Sample Rate

The Stimulator output sample rate is configured in the Acq*Knowledge* Stimulator setup dialog under the Stimulator sample rate option.

The stimulator sample rate setting is independent of the acquisition sample rate setting, and ranges from 10 s/s to 100k s/s can be selected. The stimulator output signal can be redirected to an analog input channel. In this case, the number of samples displayed in the graph is determined by the acquisition sample rate. If the source wave can be uploaded entirely to **MP160/150 memory** (Ö512K samples), then the number of samples displayed in a reference analog input channel may be estimated with this formula:

$$Displayed\ Samples = AcqRate/StimRate*\#Sample_{(source\ wave)}$$

If the waveform to be outputted exceeds the output data buffer length, the MP160/150 unit requests that the balance of the data be sent as soon as space becomes available in the output data buffer. Naturally, if the output waveform fits completely inside the data buffer, the outputting process is more efficient (and thus faster) as compared to cases when the output wave is larger than the data buffer size.

For a full comparison of acquisition sample rates vs. stimulator sample rates, see the **Appendix**:

An additional factor affecting waveform outputting concerns the storage mode selected for the input data. The MP System has two basic data acquisition modes:

- **Memory mode** (includes acquisitions to Disk)*
- **MP160 or MP150 mode** (includes Averaging acquisitions)*

Usually, the MP160/150 System is operated in Memory mode. In this case, input data is collected by the MP unit and sent to the computer, **during** the acquisition.

In MP160/150 mode, input data is stored in the MP System's internal input data buffer and then downloaded to the computer only **after** the signal is completely outputted. Up to 512,000 samples can be uploaded into the MP160/150 memory and then outputted as a stimulator signal. Longer source waves will upload the first 512,000 samples, and the remaining waveform as memory becomes available.

If the MP160/150 mode is chosen, waveform output, simultaneous with the acquisition, is generally limited to short files. However, it is possible to õwrap aroundö a short output data file such that the waveform is output repeatedly and continuously during the acquisition. This mode is selectable by setting the duration to ÷Output continuouslyø in the Stimulator Setup dialog box. The following dialog boxes illustrate how to set up the stimulator for both õOutput Continuouslyö and õOutput Once.ö

MP160/150 mode is used when data needs to be input and output at high speed, and for relatively short duration acquisitions. These requirements are typically manifested when performing general stimulus/response tests.
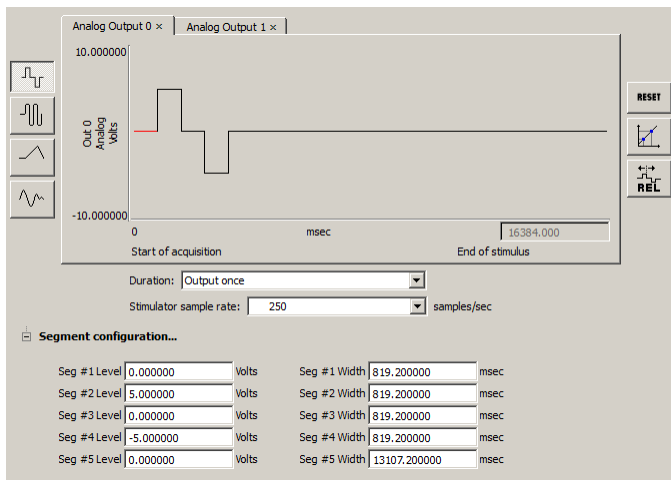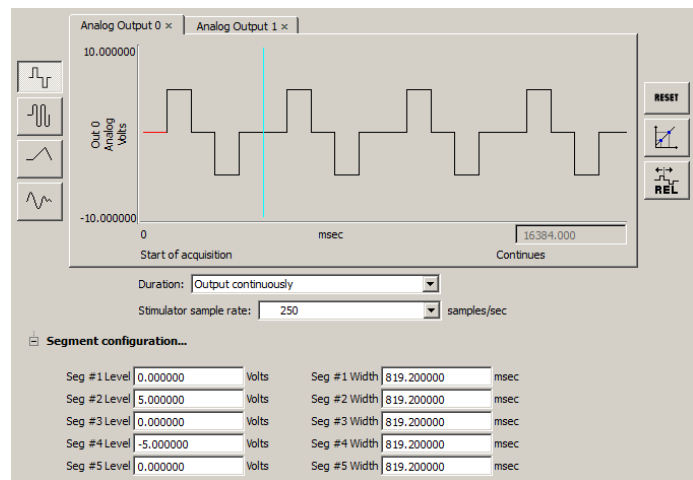
Output Once   **Output Continuously**

If Memory mode is chosen for the MP160/150 System, then waveform output simultaneous with the acquisition is possible for either short or long files. In Memory mode it's possible to perform all functions that are permitted in MP160/150 mode. If the stimulator dialog setup is used to create your output waveform, the waveform will always be a short term wave. Namely, the õcannedö waveform constructed by the dialog will always fit into the 4096 point limit for short term waves. Whether õOutput Onceö or õOutput Continuouslyö is chosen makes no difference as to the type of wave. In both cases, the wave output will be a short term wave.

When long arbitrary waves are outputted, then the MP160/150 System should be run in Memory (or Disk) mode. In this case, the MP160/150 will send acquired data to the computer and the computer will simultaneously send the data to be output to the MP160/150 unit. In these cases, the limiting output rate is roughly 20 kHz.

For higher outputting rates in Memory (or Disk) mode, limit the length of the output file so the entire output waveform can be loaded into the MP160/150 output data buffer. Thus, the effective output rate will be significantly increased.

*For more information on setting up acquisition modes, see Chapter 7 of the Acq*Knowledge* Software Guide.

The following table illustrates the various output options and limitations for the MP System:

Output Mode	MP160 or MP150 System	
	Memory Mode	MP160/150 Mode
Once	Yes (up to 100 kHz)	Yes (up to 100 kHz)
Continuously	Yes (up to 100 kHz)	Yes (up to 100 kHz)
Arbitrary (≤512K points)	Yes (up to 100 kHz)	Yes (up to 100 kHz)
Arbitrary (>512K points)	Yes (up to 100 kHz)	Yes (up to 20 kHz)*

* IMPORTANT NOTE

Arbitrary waveform output for long data files, during acquisition, is a complex process. This complexity results from the contribution and interaction of many factors. In these types of acquisitions the speed and OS type of the computing platform is quite relevant to overall performance. A relatively slow computer may perform to a different level than indicated in the above tables.

Generally considered, if the above limits are exceeded, then the Acq*Knowledge* software will generate the following error message:

<p style="text-align:center">Communications Error: Acquisition Terminated</p>

A buffer overflow message may also be displayed. The computer may become sluggish and any task may unduly burden the system.

The following dialog illustrates the arbitrary file outputting process. In this case, an ECG recording is being output simultaneously with a data acquisition.

- For **MP160/150** mode outputting: The arbitrary output file will be truncated to 512K samples prior to being transferred to the MP hardware unit.

- For **Memory (or Disk)** mode outputting: The arbitrary output file will be outputted for as long as the acquisition permits.
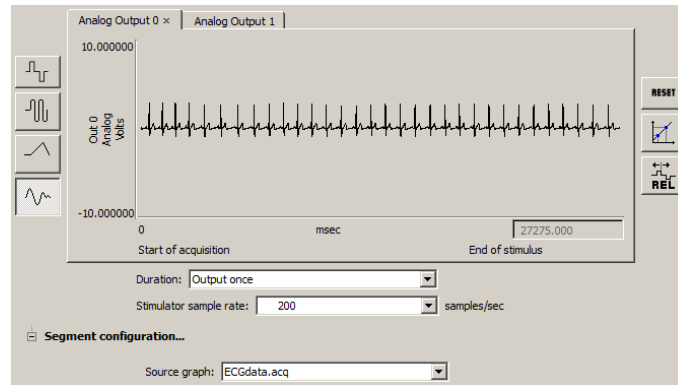
Arbitrary Wave Outputting

In the course of outputting data using the MP160/150 System, some additional factors require consideration:

- **Memory mode outputting**:
  In this case, the MP160/150 System will output additional data points beyond the length of the output data. This behavior is due to the MP160/150 System outputting process being halted by the computer during Memory mode. To obtain a precise number of cycles in the output data (and end the output with a known data value), simply increase the acquisition length by anywhere from 5 to 50 ms longer than the output file length.

- **MP160/150 mode outputting**:
  The MP160/150 may output the last data point in the output file after the acquisition is completed. This behavior results from the input and output data becoming interleaved, with the input data going first. This occurs if the source data is larger than the internal memory of the MP160/150 (512K)

Analog Output Upper Limits Summary

The upper limits for short burst, long and longer waves are detailed below. At high or aggregate acquisition sample rates, the data display may become sluggish. Additional user actions may overwhelm the system.
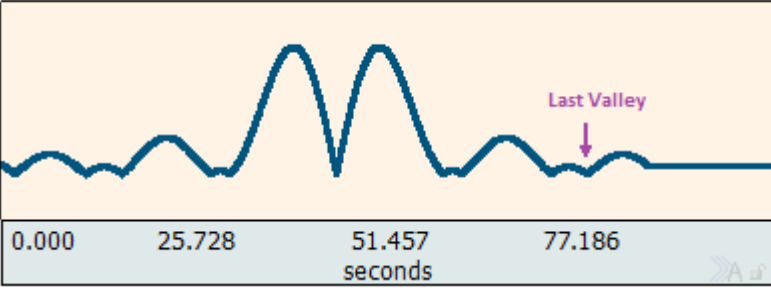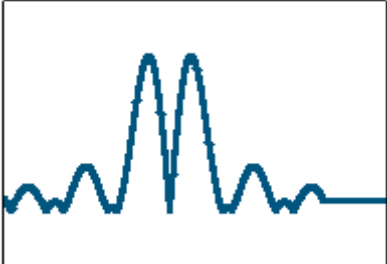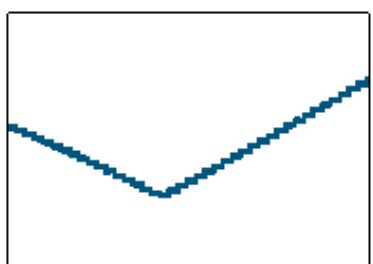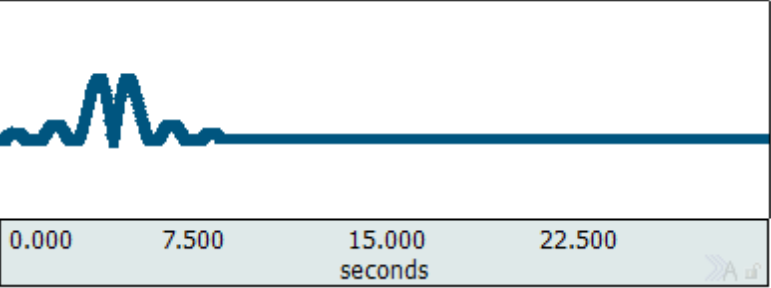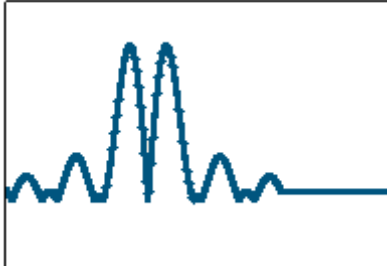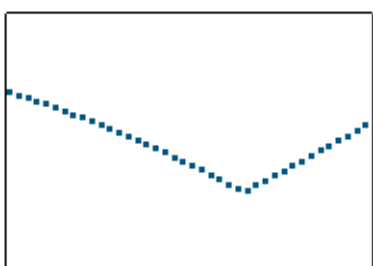
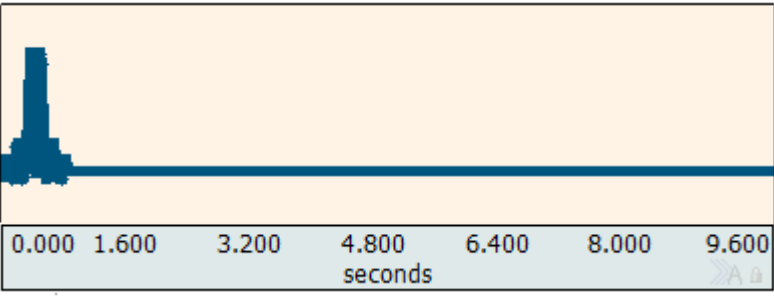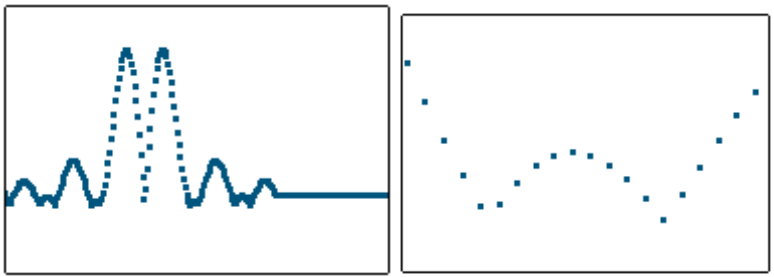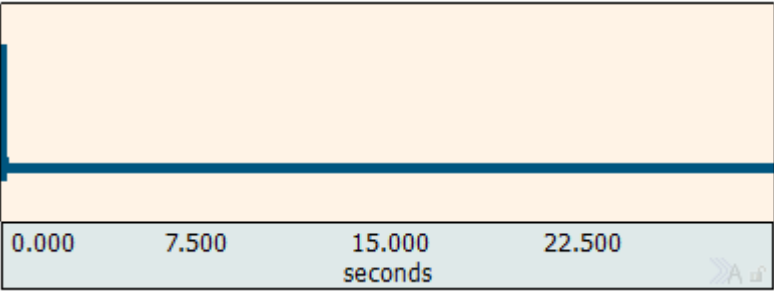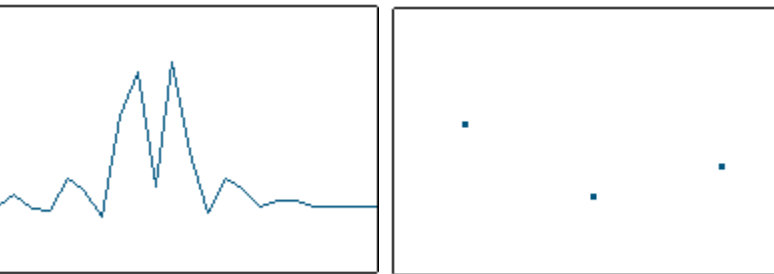|	Short Burst Wave (≤ 4096 samples)	Long Wave (> 4096 samples but ≤ 512 K samples)	Longer Waves (≤ 512 K samples)
Stimulator Sample Rate:	100 K max (sample rate not adjustable for averaging)	100 K max	20 K max
Acquisition Modes:	Save to MP160/150 Memory Save to Averaging	Save to MP160/150 Memory Save to Memory or Disk	
Source Output Maximum per Analog Output:	4096 samples	512 K samples (256 K if dual stimulators are used via outputs A0 and A1)	
Maximum Aggregate Acquisition Sample Rate:	400 K		

Appendix:

Acquisition Sample Rate versus Stimulator Sample Rate

The relationship between the Acquisition and Stimulator Sample Rate not only affects the number of samples displayed in a reference channel (Analog Out # → Analog Channel), but also the length of the stimulated signal. The same source signal graph was used for each of the example screenshots below. All graphs were acquired at 200 samples/seconds and the stimulator sample rate varied for each example: 20, 200, 2000 and 20,000. Part of the resulting waveforms are shown in dot plot.

Output source: 1726 samples

Stimulator Sample Rate (s/s)	Screen Shots—Entire Outputted Signal	Comment
20		Stim Rate < Acquisition Rate (Stimulator is 10% 0f Acquisition rate) 1 stimulator sample/10 acquisition samples
	  a. Close up b. Last Valley	
200		Stim Rate = Acquisition Rate 1 stimulator sample/1 acquisition sample
	  a. Close up b. Last Valley	

Stimulator Sample Rate (s/s)	Screen Shots—Entire Outputted Signal	Comment
2000		Stim Rate < Acquisition Rate; (Stimulator is 10 times greater) 1 acquisition sample/10 stimulator samples
	 a. Close up b. Last Valley	
20,000		Stim Rate > Acquisition Rate; (Stimulator is 100 times greater) 1 acquisition sample/100 stimulator samples
	 b. Close up b. Last Valley	

For additional information about using the Acq*Knowledge* Stimulator, see the [Acq*Knowledge* 4 Software Guide](#).
For additional information about setting up arbitrary waveforms, see [Application Note 200](#).