Cascade Stimulus Trigger Table Description

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The Cascade surgical monitoring system uses a stimulus trigger table to control the timing of stimuli. An algorithm running on the host computer is used to generate the table and download it to the DSP controller in the Cascade base unit. The table is recomputed any time the run status of a mode changes.

Version 1.2.32 of the Cascade software now supports two methods for generating the stimulus trigger table. The method is selected on the "General" tab of the system setup dialog. The two choices are "Optimize Random Noise Reduction" and "Optimize Synchronous Noise Reduction". The "Optimize Random Noise Reduction" choice is the same method that was used in previous versions of the Cascade software. The new selection, "Optimize Synchronous Noise Reduction" was added to help reduce the amplitude of steady state sine wave noise which is common in operating rooms.

When the stimulator is triggered at a constant frequency very good cancellation of steady state sine wave noise can be achieved provided the noise frequency is close to an exact harmonic of the repetition rate. The old method of generating multi-modal trigger tables allows the instantaneous repetition rate to vary to prevent collisions between modes while attempting to maintain an average repetition rate which is as close as possible to the requested rate. The new method requires the repetition rates be adjusted so that the instantaneous repetition rate for each mode can remain constant. This can only be achieved by synchronizing the repetition rates for all of the running modes.

The following rules are used in generating the table:

Rules 1 – 5 apply to both methods.

1. Only one EMG mode may run its stimulator at any given time. When the stimulator is started in an EMG mode, an automatic shut down will be performed if a stimulator is running in any other EMG mode.

2. An EMG stimulator always runs at the requested repetition rate.

3. If the sweep length for an EP mode is longer than the interstimulus interval for a running EMG mode, the EP mode will be inhibited and will not run at all until the EMG mode stimulator is turned off.

4. EP mode may be run concurrently. Sweeps are always triggered sequentially and the sweep must be complete before the next mode can be triggered. A fixed interval of 5 milliseconds is added to the sweep interval to allow time for stimulus setup. If a positive sweep delay is in effect, this is also added to the sweep interval.

5. Retriggering the stimulator during a sweep is not allowed when multiple modes are running. This may be done, however; when only one mode is running.

Rules 6 – 8 Apply to the "Optimize Random Noise Reduction" Method

6. To avoid sweep collisions when multiple EP modes are running, the repetition rate will be slowed when necessary. The repetition rate is never increased. This is true for the instantaneous peak rate as well as the average repetition rate.

7. When repetition rates must be slowed an attempt is made to maintain equal repetition rate ratios for all modes (except EMG modes). Deviations from precise values occur for two reasons. a) The length trigger table is 128 entries. This sets a limit on the accuracy of repetition rate ratios for any two modes specified in the table. b) The algorithm stops at the end of the table without attempting any adjustments. Two modes having identical repetition rates may not receive exactly the same number of stimuli in the table.

8. The actual repetition rate displayed by the program is an average repetition rate. It is computed by counting the number of stimuli in the table for a mode and dividing by the time required to cycle through the complete table.

Rules 9-10 Apply to the "Optimize Synchronous Noise Reduction" Method

9. Repetition Rates are adjusted as follows:

$$r'_m = r'_{max} \div n$$

r'_m is the actual repetition rate for mode m.
r'_{max} is the maximum actual repetition rate.

n is a whole number in the range 1 to 16. The value is chosen to minimize the absolute value of the difference $r'_m - r_m$

r_m is the requested repetition rate for mode m.
r_{max} is the maximum repetition rate for all r_m
r_{min} is the minimum repetition rate for all r_m
r_{emg} is the requested repetition rate for the EMG mode.

In certain cases it may be necessary to adjust r'_{max} to a value other than r_{max}. If an EMG mode is running with a stimulator on, the EMG repetition rate r_{emg} remains fixed and other repetition rates are adjusted as follows:

$$r'_{max} = r_{emg} \times n$$

n is a whole number in the range 1 to 16 and is chosen to minimize the absolute value of the difference $r'_{max} - r_{max}$.

If $r'_{max} \div r_m > 16$ for any mode the mode will be shut off.

In the case where an EMG mode is not running with a stimulator on, r'_{max} is set as follows:

$$r'_{max} = \text{Minimum}(r_{max}, r_{min} \times 16)$$

If either case, if the sweeps for the modes are too long to fit, r'_{max} is reduced as much as necessary to allow time for the sweeps without any overlap between modes.

10. In complex setups with many modes at different repetition rates, it may not be possible to fit the required trigger table into the maximum length allowed. If this occurs, the system will first attempt to resolve this by reducing the number of choices for the value of the repetition rate divisor "n". If this strategy fails to produce a useable trigger table, modes will be shut off starting with the slowest repetition rate until a usable trigger table is obtained.