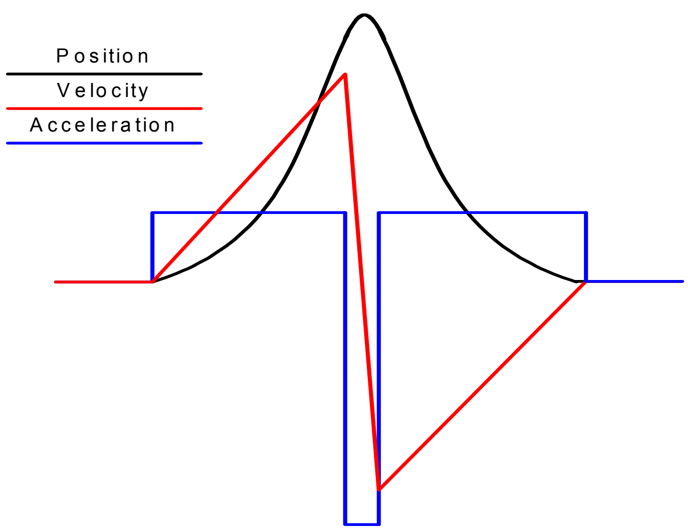
Custom Clearing Moves for CTI Scanners

Long durations of high frequency, small angle movement can cause the balls in the bearings of a galvanometer to wear notches in the bearing raceway. In small angle moves the balls do not move a complete revolution along the raceway. Instead they rock back and forth in place, pressing the bearing lubricant out from under the balls, and wearing narrow notches in the bearing raceway where each ball sits. When galvanometers are used in high frequency scanning applications deliberate moves can be executed which can greatly increase bearing life. The moves serve the following two functions:

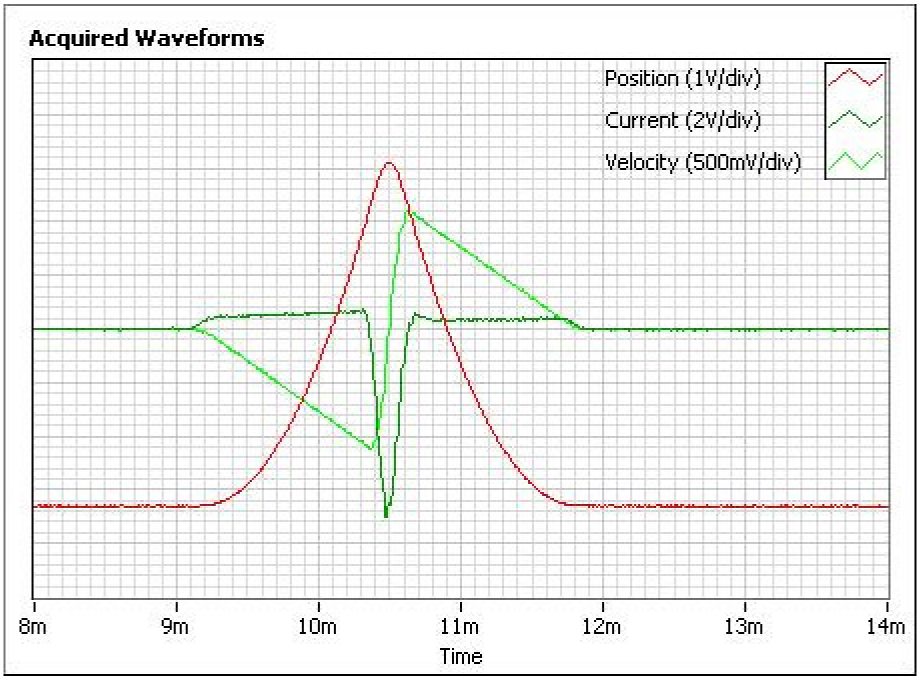
1. Redistribution of lubricant along the bearing raceway
2. Repositioning of bearing balls along the raceway to facilitate even raceway wear

Moves created and executed for the sole purpose of achieving these functions are called clearing moves. A clearing waveform has been designed by CTI to optimally suit both purposes. This clearing move is patent pending by Cambridge Technology, Inc., and should only be used by CTI customers on CTI galvos. Consider a waveform that starts a move at a constant acceleration from the edge of the field. Just as the rotor approaches the opposite edge of the field, the scanner accelerates in the opposite direction at a constant acceleration many times greater than the first to the point where the rotor is traveling in the opposite direction with equal velocity. Then with constant acceleration the scanner is slowed to a stop at the same point as it started.



The action of this asymmetric move will spread the lubricant full field during the constant acceleration portions that start and stop the move. The high acceleration portion where the rotor rapidly changes direction is intended to cause the balls in the bearings to slide to new points along the bearing raceway. By periodically executing this move with sufficient repetition even raceway wear and adequate lubrication can be achieved and bearing life can be greatly extended.

Below is an example of this type of clearing move executed on a 6200 scanner. The velocity is measured at a test point that causes it to appear inverted in relation to position.



Waveform Definition

This type of clearing waveform must be explicitly defined, or "customized", for each scanner and board combination, and to suit the tuning of each specific type of system. In other words, the curve cannot be stretched or condensed either in time or amplitude to suit a different system configuration. The waveform must be defined by the following parameters:

1. The acceleration constants in the clearing move definition must be chosen to suit the maximum current that can be put through the scanner without saturating the amplifiers driving the current. Consider that the scanner has a coil resistance, which will produce a voltage across the coil proportional to the current through it. This voltage (along with inductive and emf voltages) cannot exceed the power supply voltage or the output amplifiers on the servo board will saturate.
2. The waveform should be executed with an amplitude much larger than the typical exercise amplitude of the scanner's application. The peak-peak amplitude of the waveform defines the maximum velocity the rotor will reach with a given constant acceleration. This means that the turnaround acceleration (the large negative spike in acceleration) must be changed accordingly to reverse rotational velocity appropriately. Any change in acceleration should be re-optimized to provide maximum acceleration while not causing saturation of the driving output amplifiers. This means you cannot simply multiply or divide an existing waveform by two and use it effectively for a different the field size. The clearing move is best executed when the accelerations, particularly the turnaround acceleration, are maximized to produce the fastest possible move while not saturating the output amplifiers. Typically the maximum "turnaround" acceleration is about 20 times larger in magnitude than the initial and final constant acceleration portions of the waveform.
3. The clearing move waveform repeated at any given frequency should be checked to ensure it does not violate the maximum allowable RMS current through a scanner.

The efficiency of the clearing move is an expression of how much bearing ball slip distance can be accomplished each iteration of the move. Cambridge Technology will provide upon request a proprietary clearing move customized for a particular galvanometer application.

Clearing Move System Design and Repetition

The clearing waveform must be executed periodically during a high frequency exercise scan. This must occur frequently enough that the bearing balls do not have a chance to wear a large notch in the bearing raceway before they are slid to a new position. Once notches or bumps are worn in the raceway, the clearing move will not slide balls to new points on the raceway nearly as effectively as they will tend to fall back into existing worn areas during the following exercise. The key is to execute the clearing waveforms from the start of the life of the scanner, and achieve a continuous and evenly worn track on the raceway with no divots or bumps from individual ball wear. Cambridge Technology recommends execution of at least 25 cycles of the custom clearing waveform for every 15,000 cycles of high frequency small angle exercise. A greater number of clearing moves will be beneficial to extend bearing life. However, this number reflects an average efficiency clearing move. A system with a small field size, low torque, heavy load, or low power supply voltage will be limited in its ability to generate an efficient clearing move. A less effective clearing move will require more iterations to achieve adequate bearing ball migration. In addition, any system using a clearing move will require at least a 20 degree field size to allow the scanner to generate enough angular momentum to slip the bearing balls. Finally, a system with a higher power supply voltage will facilitate a more effective clearing move. With a higher power supply voltage the clearing move can incorporate higher accelerations and will therefore be more efficient in slipping the bearing balls. This would allow for fewer iterations of clearing moves to accumulate the same amount of bearing ball migration.