Motion and Safety with GuardLogix Controllers

There are few control systems that can effectively perform motion control and safety at the same time. This is because motion and safety may have very high performance requirements. It all depends on how high-performance is defined within the application and how the performance needs are addressed.

Ability to Prioritize Tasks for Maximum Performance

In Logix-based controllers, motion tasks have the highest priority over all other system tasks. This is necessary due to the time-critical nature of motion control. The high priority setting for motion is fixed in the Logix operating system and is not user-configurable. However, the safety task in the GuardLogix safety controller is just one of many control tasks you can prioritize, from 1 (highest priority) to 10 (lowest priority). This flexibility lets you maximize performance as needed to solve different types of standard and safety control problems.

Generally, safety can be split into two different application types.

- Applications that have controlled safety, such as doors or gates that are locked by the safety system
- Applications with reactive safety, where the safety system must react to a random event

Controlled safety typically has different performance requirements than reactive safety. In a controlled safety application, the safety controller allows access only when a hazardous condition is not present. In these applications, the need for high-speed safety response is reduced because the hazard is not accessible (at least within reason).

In reactive safety applications, where a safety event can occur at any moment, the safety control system needs to be designed for the fastest possible reaction time. This means determining the absolute worst-case system reaction time and then positioning safety-sensing devices, such as light curtains and laser scanners, an appropriate distance away from the hazard. The distance from the hazard provides sufficient time for the hazard to be brought to a safety state on demand and within a finite period.

Two methods are used to calculate safety distance.

- OSHA, specified in CFR Subpart o 1910.217 used to define the distance vs. time parameter: 63 in/s.
- EN 999, Formula for safety distance: 1600 mm/s.

Physical distance is an important issue because floor space and operator load times are key productivity issues. So, safety reaction time can be an important factor in determining control system performance.

What Kind of Motion Can GuardLogix Controllers Perform?

The kind of motion that GuardLogix controllers can perform depends on:

- the performance needed for motion (number of axis and update rates).
- the performance needed for safety (amount of safety and speed, based on whether the system is controlled or reactive).
- any other performance needed for standard control (number of I/O, amount of logic, and performance).

GuardLogix controllers do not have any imposed restrictions on the type or amount of control that can be attempted, but as with any computing device, there are limits in terms of processor capacity (memory) and performance (speed). Since virtually all applications are different, it is very difficult to provide hard data. The following is a typical example that can help explain how motion and safety perform together in a GuardLogix controller.

Example: The Impact of Motion on Safety Task Processing

This example includes a series of configurations to quantify the impact to the system. Since motion has the highest priority in a Logix-based system, motion performance will always be the same for any ControlLogix series processor, including GuardLogix controllers. The GuardLogix controller is designed to perform it's safety function safely within the performance envelope defined by the application configuration. So even if motion or standard control consume all processor resources and the safety task cannot be properly scanned, safety outputs will go to a safety state. Following IEC 61508 (SIL 3) standards, the GuardLogix controller will not allow an unsafe condition to occur.

This example system consists of:

- 8 safety nodes (1791DS-IB8XOB8), each with requested packet intervals (RPI) set at 6 ms.
- 1 DeviceNet network.
- logic in the safety task to simulate approximately 24 ms of safety logic.
- 16 axis of motion, where 8 axis were geared to a virtual axis, and 8 additional axis were cammed to a second virtual axis.

A larger than typical amount of safety logic was used to better gauge the true impact that motion would have on safety. This 16-axis system had a course update period of 16 ms, and a maximum motion group scan that was just under 2 ms.

In Logix-based systems, each axis used in an application consumes approximately 0.25 ms. In this application, the motion group scan is 2 ms. If the application had 8 axis, the motion group scan would be 1 ms. We changed the course update period for the motion engine to 8 ms, and then to 4 ms, and monitored safety task performance.

The priority you assign to tasks is important, because that priority defines the order in which tasks will be scanned after motion processing. For each configuration, the table shows how motion impacts the processing of the safety task and any scheduled task.

Impact of Motion Configuration on Task Processing

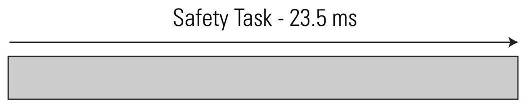
Configuration	Baseline	A	B	C
Course motion update period (ms)	none	16	8	4
Safety task scan, max. (ms)	23.5	27.9	31.1	40.2
Impact (% increase)	0%	18.7%	32.3%	71%
Safety task period (ms)	30	35	40	50
Safety task watchdog (ms)	25	30	35	45

IMPORTANT As processing horsepower is consumed by motion, the safety task, like any other task that is executing, will be affected. Motion always has the highest priority in a Logix-based system.

These graphics provide another view of the data in the table.

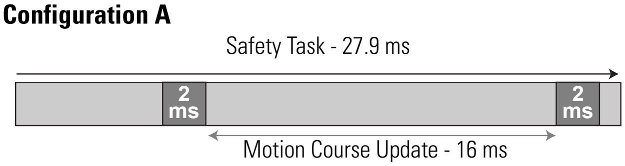
This is the safety task performance when the safety task has the highest priority, without any motion. This represents the baseline safety task performance for this application.

Baseline



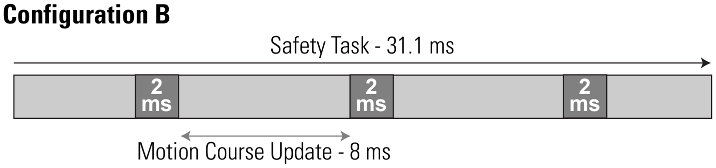
Configuration A shows 16 axis of motion running with a course update period of 16 ms. The safety task is configured exactly the same as the baseline configuration, but is now a lower priority. Timing dynamics result in the safety task being interrupted by motion either once or twice during any given scan of the safety task. This is because the motion course update period is 16 ms and the safety task scan time is 23.5 ms. If the motion interrupt occurred in the middle of the safety task scan, for example, at 12 ms, that specific safety task scan would see an impact of 2 ms, instead of the 4 ms show above. However, this example has 2 interrupts, which result in 4 ms being added to the safety task scan time. The baseline 23.5 ms + 4 ms = 27.5 ms. The additional 0.4 ms shown in the table is likely caused by the occurrence of other system processes, such as other tasks, interrupt switching, or communication processing.

Configuration A



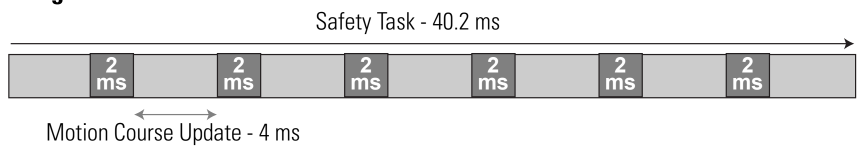
Configuration B shows 16 axis of motion running with a course update rate of 8 ms and the same safety task configuration. Timing dynamics result in either 2 or 3 interrupts in any given task scan.

Configuration B



Configuration C shows 16 axis of motion running with a course update period of 4 ms and the same safety task configuration. Timing dynamics result in either 5 or 6 interrupts in any given safety task scan.

Configuration C



Standard Control Impact

GuardLogix controllers are designed to perform SIL 3 safety and standard control. Standard control includes sequential, motion, process, and drive applications. The performance demands imposed by these control disciplines for a specific application determine if a GuardLogix controller by itself can handle the application. Today, many customers use multiple Logix processors due to the performance requirements of an application. One key feature of the Logix architecture is how easy it is to use multiple processors to meet the demands of large and complex control problems. Many applications also use GuardLogix controllers in conjunction with other Logix processors. In one application that has over 100 axis of motion, 4 ControlLogix processors and 1 GuardLogix processor are used to meet the performance demands. The GuardLogix processor handles a significant amount of standard control as well as all of the safety control, with the ControlLogix processors handling all of the high-performance motion control. With the V16 release of RSLogix 5000 software, GuardLogix can provide support for motion control in addition to standard and safety. The ease of integrating and synchronizing multiple processors with the Logix system makes these applications relatively simple to implement.

Conclusion

While this example may seem like a large application, as it uses 16 axis of motion and 25 ms of safety logic, the GuardLogix controller can effectively perform motion and safety control in even larger applications. By itself, or with other standard controllers to provide additional processing horsepower, or with other safety devices like the SmartGuard 600 (for high-speed safety loops), a GuardLogix controller handles motion and safety in a cost-effective, easy-to-implement solution that meets automation needs in high-performance applications.

Notes:

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Publication 1756-WP004A-EN-E - January 2007

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