

## 8000 Series Performance

### Foreword

The application of a safety PLC often requires that the performance be estimated. In this case performance is a function of how fast the PLC can perform a given task, usually a combination or subset of reading input variables, processing application logic and commanding outputs to a required state. For safety applications this time is used as a component of the overall loop performance that is required to be within a period considerably less than the Process Safety Time (PST). The required PST is established from the characteristics of the process being controlled and the mechanical limitations of the process plant itself.

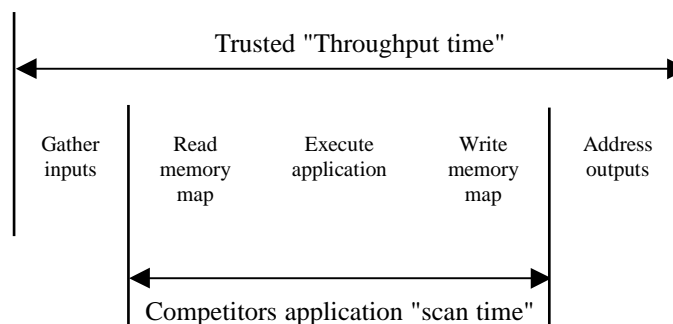
In addition to the safety aspects, performance is sometimes specified where continuous control is required of a process with fast dynamics. In this case the ability of the system to regulate an output based on the measured value within the given time is crucial to maintaining a stable process.

### Confused terminology or untruths?

The method of calculation and the terminology used is the subject of much deliberate misinterpretation. The generally accepted terms are defined as follows:

- Scan time: The time taken for the PLC to read latest variable states from memory, execute the entire application logic and write correct output values to memory. This also should include any effect of background tasks required to maintain the required level of diagnostics in the system.
- Throughput time: The time taken from reading of the input values from the input module and addressing memory, scan time and changing state of the output based on the latest written value. A complete cycle of the PLC.

As you can see from the diagram below, scan time appears to include reading inputs and writing outputs but in fact may not include the process of addressing the module via the bus or the module reaction time. The misuse of scan time instead of throughput by some vendors is common.



Remember, Trusted is the only safety system to time stamp inputs at the input conditioning of the input module and outputs at the output switches of the output module. For this reason only Trusted can show the true throughput time via the engineers workstation.

To compare any other system to Trusted you must connect a timing device from input to output as suggested in the summary example below.

## System Operation

The 8000 series is designed to operate continuously. Each completed cycle is followed immediately by another. As well as the components of a cycle mentioned above the system is also required to perform many other tasks such as I/O tests, voter tests, memory tests and communications tasks. These are scheduled by the multitasking operating system and performed as background tasks. Coincident tasks within a cycle can sometimes occur and will have a marginal affect on throughput time. All configuration factors will have some effect on throughput time. The major contributors to throughput time are the module type and quantity, their operational configuration (software settings) and the application program.

The normal system operation can be characterised by "as fast as possible". In addition the engineer, given the appropriate permission, is able to increase the scan time to a defined time, by using the 1131 Toolset Debugger.

## Predictions - Safety Manual

The Safety Manual is a document that details key requirements to be considered when designing and configuring a system. It only considers those requirements, which could directly affect the functional safety of the system. Aspects of system performance such as throughput and availability (fault tolerance) are only viewed with their regard to safety.

The Safety Manual provides a method of estimating throughput time. Due to this being a safety calculation, there is a degree of pessimism applied to the calculation that will help to ensure the normal performance achieved falls within the calculated value. The basic number given reflects the default module configuration with an estimate of the application program complexity. The calculation does have the ability to improve the calculated value by adjusting some of the parameters of software configuration. These include communications scan factor and exception output update. Adjusting these parameters will give a result closer to that achieved with a real system but still include a margin of safety to accommodate the variations found between different applications.

## Verification

To verify the throughput time of any system the 1131 Toolset provides a monitoring facility within the online Debugger. This shows the throughput time sampled approximately every second. Accuracy of this value may vary a little with configuration. A more accurate method is to monitor an output, which is programmed to change state every cycle and monitor this with an appropriate instrument.

## Reality check

To confirm the predictions of the safety manual are correct and estimate the safety margin included, tests were conducted on a real system using an actual application program developed by a customer. Results are shown below.

## Trusted System Performance Summary

Tests were performed to replicate the expected performance of a given system and show that the factors affecting throughput time shown in the safety manual are indeed reflected in the results. The tests are also expected to show what degree of offset and variation can be expected when comparing a calculated value with typical value in a real system. The system used for reference during the tests has the following configuration.

- Dual communications
- 14 I/O modules
- 2 Expanders
- Application code size of 114K

## Conclusions

The results of the testing allow the following conclusions. These conclusions are particularly useful when trying to assess the likely performance of a system compared to the Safety Manual predictions. None of these conclusions obviate the need for the user to ensure that all appropriate actions defined within the safety manual and by good engineering practice are included within the design, configuration and use of the system, or that the throughput time is used appropriately within a proper assessment of PST.

- \* A typical system with default settings would be expected to fall within the Safety Manual calculated value
- \* The Safety Manual calculated value has a margin of between 20-30% over the normal scan time of a typical system
- \* Coincident background tasks rarely increase scan time by a measurable amount. This peak increase (<once per 5 seconds) is 10-15% above the normal scan time.
- \* The scan time of a typical system can be improved by 25% from the default settings by use of the configurable tuning parameters.

## The Results are as Follows

The system was tested with an output looped back to an input and inverted in the logic to enable accurate measurement of the throughput time by Oscilloscope. This also ensures that whatever the configuration settings at least one output module was being written to every cycle

No	Configuration - change	Measured scan time	Displayed scan time range	Freq of max per minute	Safety Man equivalent	Variation (calc'd to actual)	Comments
1	Default	140	138 -155	6	183	30%	
2	Default plus peer to peer	145	138-163		N/A		Limited peer to peer adds approx 5ms to typical scan time
3	Default but 1 Comms interface removed	124	121-131	3	150	21%	
4	Default plus standby processor	152	-	-	208	37%	
5	Default plus outputs on exception	121	117-136	1	147	22%	
6	<i>Test above but outputs toggled on all modules</i>	142	136-151				<i>Should be same as test No 1</i>
7	Default plus outputs on exception and tuned communications	106	102-110	-	136	28%	Preferred configuration. No effect on communications notices