

How can I ...

Determine response time from a Com'X 510 with serial devices when used as a passthrough gateway?

System Technical Note
Gateway Performance

Design
Your architecture



Important Information

People responsible for the application, implementation and use of this document must make sure that all necessary design considerations have been taken into account and that all laws, safety and performance requirements, regulations, codes, and applicable standards have been obeyed to their full extent.

Schneider Electric provides the resources specified in this document. These resources can be used to minimize engineering efforts, but the use, integration, configuration, and validation of the system is the user's sole responsibility. Said user must ensure the safety of the system as a whole, including the resources provided by Schneider Electric through procedures that the user deems appropriate.

Notice

This document is not comprehensive for any systems using the given architecture and does not absolve users of their duty to uphold the safety requirements for the equipment used in their systems, or compliance with both national or international safety laws and regulations.

Readers are considered to already know how to use the products described in this document.

This document does not replace any specific product documentation.

The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.



The addition of either symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

DANGER

DANGER indicates a hazardous situation which, if not avoided, **will result in** death or serious injury.

WARNING

WARNING indicates a hazardous situation which, if not avoided, **could result in** death or serious injury.

CAUTION

CAUTION indicates a hazardous situation which, if not avoided, **could result in** minor or moderate injury.

NOTICE

NOTICE is used to address practices not related to physical injury.

Note: Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction, operation and installation of electrical equipment, and has received safety training to recognize and avoid the hazards involved.

Before You Begin

This automation equipment and related software is used to control a variety of industrial processes. The type or model of automation equipment suitable for each application will vary depending on factors such as the control function required, degree of protection required, production methods, unusual conditions and government regulations etc. In some applications more than one processor may be required when backup redundancy is needed.

Only the user can be aware of all the conditions and factors present during setup, operation and maintenance of the solution. Therefore only the user can determine the automation equipment and the related safeties and interlocks which can be properly used. When selecting automation and control equipment and related software for a particular application, the user should refer to the applicable local and national standards and regulations. The National Safety Council's Accident Prevention Manual also provides much useful information.

Ensure that appropriate safeties and mechanical/electrical interlocks protection have been installed and are operational before placing the equipment into service. All mechanical/electrical interlocks and safeties protection must be coordinated with the related automation equipment and software programming.

Note: Coordination of safeties and mechanical/electrical interlocks protection is outside the scope of this document.

START UP AND TEST

Following installation but before using electrical control and automation equipment for regular operation, the system should be given a start up test by qualified personnel to verify the correct operation of the equipment. It is important that arrangements for such a check be made and that enough time is allowed to perform complete and satisfactory testing.

WARNING

EQUIPMENT OPERATION HAZARD

- Follow all start up tests as recommended in the equipment documentation.
- Store all equipment documentation for future reference.
- Software testing must be done in both simulated and real environments.

Failure to follow these instructions can cause death, serious injury or equipment damage.

Verify that the completed system is free from all short circuits and grounds, except those grounds installed according to local regulations (according to the National Electrical Code in the USA, for example). If high-potential voltage testing is necessary, follow recommendations in the equipment documentation to prevent accidental equipment damage.

Before energizing equipment:

- Remove tools, meters, and debris from equipment
- Close the equipment enclosure door
- Remove ground from incoming power lines
- Perform all start-up tests recommended by the manufacturer

OPERATION AND ADJUSTMENTS

The following precautions are from NEMA Standards Publication ICS 7.1-1995 (English version prevails):

Regardless of the care exercised in the design and manufacture of equipment or in the selection and rating of components; there are hazards that can be encountered if such equipment is improperly operated.

It is sometimes possible to misadjust the equipment and thus produce unsatisfactory or unsafe operation. Always use the manufacturer's instructions as a guide for functional adjustments. Personnel who have access to these adjustments should be familiar with the equipment manufacturer's instructions and the machinery used with the electrical equipment.

Only those operational adjustments actually required by the operator should be accessible to the operator. Access to other controls should be restricted to prevent unauthorized changes in operating characteristics.

WARNING

UNEXPECTED EQUIPMENT OPERATION

- Only use software tools approved by Schneider Electric for use with this equipment.
- Update your application program every time you change the physical hardware configuration.

Failure to follow these instructions can cause death, serious injury or equipment damage.

INTENTION

This document is intended to provide a quick introduction to the described system. It is not intended to replace any specific product documentation, nor any of your own design documentation. On the contrary, it offers information additional to the product documentation on installation, configuration and implementing the system.

The architecture described in this document is not a specific product in the normal commercial sense. It describes an example of how Schneider Electric and third-party components may be integrated to fulfill an industrial application.

A detailed functional description or the specifications for a specific user application is not part of this document. Nevertheless, the document outlines some typical applications where the system might be implemented.

The architecture described in this document has been fully tested in our laboratories using all the specific references you will find in the component list near the end of this document. Of course, your specific application requirements may be different and will require additional and/or different components. In this case, you will have to adapt the information provided in this document to your particular needs. To do so, you will need to consult the specific product documentation of the components that you are substituting in this architecture. Pay particular attention in conforming to any safety information, different electrical requirements and normative standards that would apply to your adaptation.

It should be noted that there are some major components in the architecture described in this document that cannot be substituted without completely invalidating the architecture, descriptions, instructions, wiring diagrams and compatibility between the various software and hardware components specified herein. You must be aware of the consequences of component

substitution in the architecture described in this document as substitutions may impair the compatibility and interoperability of software and hardware.

⚠ CAUTION

EQUIPMENT INCOMPATIBILITY OR INOPERABLE EQUIPMENT

Read and thoroughly understand all hardware and software documentation before attempting any component substitutions.

Failure to follow these instructions can result in injury or equipment damage.

This document is intended to describe the relationship between Baud rate, the number of TCP connections, and gateway performance. The test scenario uses a Com'X 510 as a passthrough gateway; however, the algorithm developed to compare response times can be used with any Modbus gateway.

DANGER

HAZARD OF ELECTRIC SHOCK, BURN OR EXPLOSION

- Only qualified personnel familiar with low and medium voltage equipment are to perform work described in this set of instructions. Workers must understand the hazards involved in working with or near low and medium voltage circuits.
- Perform such work only after reading and understanding all of the instructions contained in this bulletin.
- Turn off all power before working on or inside equipment.
- Use a properly rated voltage sensing device to confirm that the power is off.
- Before performing visual inspections, tests, or maintenance on the equipment, disconnect all sources of electric power. Assume that all circuits are live until they have been completely de-energized, tested, grounded, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of back feeding.
- Handle this equipment carefully and install, operate, and maintain it correctly in order for it to function properly. Neglecting fundamental installation and maintenance requirements may lead to personal injury, as well as damage to electrical equipment or other property.
- Beware of potential hazards, wear personal protective equipment and take adequate safety precautions.
- Do not make any modifications to the equipment or operate the system with the interlocks removed. Contact your local field sales representative for additional instruction if the equipment does not function as described in this manual.
- Carefully inspect your work area and remove any tools and objects left inside the equipment.
- Replace all devices, doors and covers before turning on power to this equipment.
- All instructions in this manual are written with the assumption that the customer has taken these measures before performing maintenance or testing.

Failure to follow these instructions will result in death or serious injury.

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1 Introduction

1.1 Purpose

The purpose of this STN is to reliably predict how an Ethernet gateway will perform on a customer site and to allow system integrators to compare Com'X 510 performance with other gateways for optimal component selection in a solution. The Com'X 510 Response Time Tool described in this document can help determine if the selected gateway meets the end customer's requirements on performance and response time.

1.2 Customer Challenges

When system integrators or application engineers design custom solutions that include a gateway(s), the factors that contribute to gateway performance can vary. For example, a customer site requires a gateway with a connected serial bus operating at a low baud rate with a large number of connections. To save time and commissioning costs, the system designer for such a customer needs to know in advance how the gateway will perform in these conditions.

This document is intended to meet the following challenges:

- As a system integrator, I want a document that describes how to evaluate gateway performance under specific customer site conditions before commissioning an installation.
- As a sales representative or application engineer, I want to be confident that a Schneider Electric offer is going to meet the external customer's requirements.
- As a sales representative, I want to understand which Schneider Electric gateway to propose.
- As a developer, I want to understand how my product performs against other gateways.

1.3 Prerequisites

1.3.1 System Prerequisites

Software/Firmware Version Supported	Notes on version support
Com'X 510 firmware version 1.0.10	The Com'X 510 firmware version 1.0.10 was tested. Subsequent versions were not validated.
OS requirement: Java 7 or later	Java 7 must be installed on the PC running the Com'X 510 Response Time Tool.

1.3.2 Competencies and Training

In order to execute the Com'X 510 Response Time Tool as specified, you must be familiar with:

- Baud rates and TCP connections
- Java

1.4 About this Document

This document is structured as follows:

The **Introduction** gives an overview of the reason for the STN and the prerequisites necessary to achieve it.

The **Selection** section explains when you would choose this as a solution for a customer need.

The **Design** section explains the architecture and design of the deliverables.

The **Configuration and Implementation** section describes how to set up the architecture.

The **Validation** section describes how to verify proper function, and includes any information the lab has collected regarding the performance and limits of the architecture.

The **Conclusion** attempts to summarize the key aspects you should follow to achieve the architecture. Read this section if you want to quickly assess your capability to understand and follow the procedures in the document.

The **Appendix** provides reference materials and additional instructions for advanced configurations.

Target Audience	Document Section						
	Introduction	Selection	Design & Validation	Configuration & Implementation	Operation	Maintenance	Conclusion
Execution Center Designers	√	√	√				√
Sales/Bid Responders	√	√	√				√
Business Development	√						
Application Engineers, Project Staff				√	√	√	√
Technical Support			√	√	√	√	

2 Selection

Decision criteria for the using the document:

- Assumes the user is interested in Com'X 510 performance with a specific baud rate and number of TCP connections.
- Assumes connected devices are serial devices.

If you want to understand the performance of a gateway other than the Com'X 510, you should not use this document.

3 Design

The tested lab configuration included a Com'X 510 (functioning as a passthrough gateway) with an RS-485 serial bus containing 32 CM4000 meters. The CM4000 was chosen because of the large number of measurements it can report and for its reliable performance. Since the objective was to evaluate the gateway response time, the type of serial device was not otherwise a consideration.

Previous testing for the EGX300 Gateway Response Time STN proved that the number of connected devices and cable length had no significant affect on results.

Testing confirmed:

- The relationship between [Baud Rate and Response Time](#) (3.1) is a stretched exponential decay.
- The [TCP Connection Count and Response Time](#) (3.2) is a linear relationship.

From these results, the Com'X 510 Response Time Tool was developed to calculate the median response time for a Com'X 510 with a given baud rate and number of TCP connections. This tool is described in [Configuration and Implementation](#).

The graphic below illustrates the test configuration for the gateway performance STN:



3.1 Baud Rate and Response Time

The equation to describe how the Baud rate affects the response time is a stretched exponential decay, where x denotes the baud rate of the serial port in bits per second (bps), A is the amplitude of the exponential, λ is the decay constant, and β is the stretch constant:

$$f(x) = Ae^{-\lambda x^\beta}$$

Since there are three unknown constants, three points of data are required to determine their values. By taking the median values at three different baud rates (keeping the number of TCP connections constant), a system of equations is found such that:

$$f(\alpha) = Ae^{-\lambda\alpha^\beta} = \gamma$$

$$f(\psi) = Ae^{-\lambda\psi^\beta} = \Psi$$

$$f(\theta) = Ae^{-\lambda\theta^\beta} = \Theta$$

Where γ , ψ , and Θ the median response times in milliseconds (ms), over an appropriate sample size, for the baud rates given by α , ψ , and θ respectively. If the baud rates are chosen such that $\theta/\alpha = 16$ and $\psi/\alpha = 4$, the problem of finding the constants becomes much simpler to solve later on. For this reason, the suggested baud rates to sample data are:

$$\alpha = 2400$$

$$\psi = 9600$$

$$\theta = 38400$$

The constants are then found to be:

Table 1 Constants Values

Variable	Solution
A	$\gamma e^{\lambda\alpha^\beta}$
λ	$\frac{\ln(\frac{\Psi}{\gamma})}{\alpha^\beta - \psi^\beta}$
μ	$\frac{\ln(\frac{\Theta}{\gamma})}{\ln(\frac{\Psi}{\gamma})}$
β	$\log_4(\mu - 1)$

With values for all the constants found, the exponential function is now complete and can be used to accurately project how the device will perform at other baud rates.

3.2 TCP Connection Count and Response Time

As more TCP connections are simultaneously opened to the Com'X 510 and requesting data, the response time to a Modbus TCP request increases linearly. Consequently, only two points are needed to find an equation that describes an individual line. So, the initial linear equation is,

$$R = my + b$$

Where R is the response time in milliseconds, m is the slope of the line in question, y is the number of TCP connections requesting data, and b is the R -intercept. If there is a second point along the line at (R', y') , then we can solve for the slope as,

$$m = \frac{R' - R}{y' - y}$$

And the intercept,

$$b = R - my$$

3.3 Gateway Performance Index and Benchmark Testing

Because three points are needed to define the exponential curve for variable baud rates, and two points to describe the linear relationship of active TCP connections and response time at a given baud rate, the optimal algorithm will be one in which only six data points are needed. For example, the following points would allow us to model an entire gateway's performance:

Table 2: Example: Complete Data Input for Algorithm

TCP Connections	Baud Rate
1	2400
1	9600
1	38400
8	2400
8	9600
8	38400

For the remainder of this section, a data point will be described as: (Baud Rate, TCP Connections, Response Time). Below is the list of steps for the algorithm:

1. Use the three points at each TCP Connections value to find the complete exponential curve using the equations found in [Baud Rate and Response Time](#).
2. Find the response time values for baud rates of interest along each of these curves. An example of such baud rates could be: 1200, 4800, 19200, 115200, etc.
3. Using the equations from [TCP Connection Count and Response Time](#), find linear equations that connect points with the same baud rates, such as (2400, 1, R) and (2400, 8, R'). This should be done for all baud rates of interest.
4. Use the linear equations found in step 3 to project response time for TCP connection values of interest, for example 16, 32, 64, etc.

At the end of the algorithm a table of values is calculated, giving a clear picture as to the performance of the gateway in a variety of conditions.

In order to allow the comparison of different arbitrary gateway devices, a set of standard calculations should be done and compared. The following table is a list of the proposed data points that define a standard for gateway comparison.

Table 3 Proposed Standard Data Input for Algorithm

TCP Connections	Baud Rate	Poll Rate (ms)	Register Read Count
1	2400	250	120
1	9600	250	120
1	38400	250	120
8	2400	250	120
8	9600	250	120
8	38400	250	120

The final calculated score from these standard calculations is the Gateway Performance Index, or GPI. The GPI is a numerical value that describes the performance of the gateway. The GPI for the data points in Table 3 is calculated by adding together the median response time at each point. This means that the lower the GPI, the better performance a gateway has.

Note the GPI will change based on the Poll Rate (time between Modbus requests for each connection) of the incoming connections. It will also change based on the number of registers read in each poll. For this reason, a standard for both has been proposed below in *5 - Validation*. Gateways can then be compared by taking a simple ratio of the two gateways' GPIs.

The [Com'X 510 Response Time Tool](#) was developed to calculate a median response time with a specific baud rate and number of TCP connections.

4 Configuration and Implementation

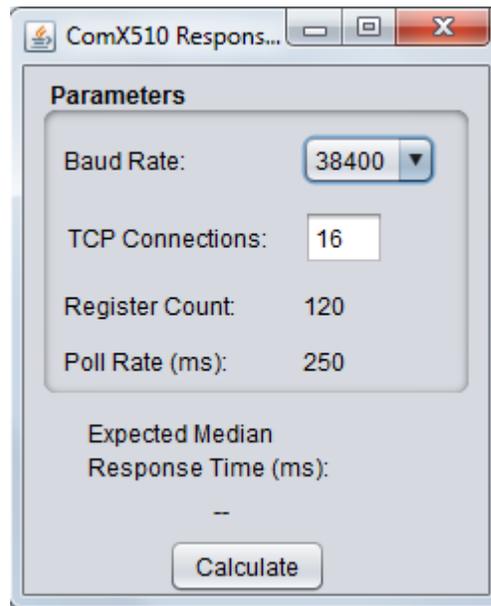
4.1 Com'X 510 Response Time Tool

The Com'X 510 Response Time Tool uses real data from testing and the algorithm described in 3.3 to calculate the predicted median response time of a Com'X 510 under the conditions specified.

Note that the tested configuration used CM4000 meters. If a customer is using a slower or faster slave device, their experience will deviate accordingly.

You can download the Com'X 510 Response Time Tool from the Schneider Electric Shopping Kiosk or the Solutions Expert Community.

Figure 1 Com'X 510 Response Time Tool



4.2 Using the Com'X 510 Response Time Tool

To use the Com'X 510 calculation tool:

1. Unzip the downloaded folder, then double-click the .jar file. The Com'X 510 Response Time Tool opens.
2. To calculate the median response time for the Com'X 510, choose the baud rate and enter the number of TCP connections you are interested in.
3. Click **Calculate**. The tool calculates the median response time you should expect with these conditions.

5 Validation

The algorithm for modeling a gateway was originally developed for the EGX300 Gateway Response Time STN. The table below shows the actual median response times of the Com'X 510 for the standard data points proposed in Table 3. From this data, we can determine that the Com'X 510 has a GPI of 14813 by adding the median response times.

Table 4: Com'X 510 Standard Input

TCP Connections	Baud Rate	Median Response Time (ms)
1	2400	1204
1	9600	315
1	38400	112
8	2400	9790
8	9600	2589
8	38400	803

Table 5 contains predicted values generated by the algorithm and the standard data input above. Table 6 contains the same data from the EGX300. Note that as a passthrough gateway, the Com'X 510 predicted response times are slightly faster.

Table 5: Com'X 510 Predicted Response Times

Baud rate for each data point	Response Time (ms) Per Number of active TCP connections*				
	1	8	16	32	64
2400	1204	9790	19603	39228	78478
4800	590	4929	9888	19806	39643
9600	315	2589	5188	10386	20781
19200	182	1415	2825	5644	11282
38400	112	803	1593	3172	6331
57600	87	586	1157	2299	4582
115200	59	351	687	1358	2700

Table 6: EGX300 Predicted Response Times

Baud rate for each data point	Response Time (ms) Per Number of active TCP connections*				
	1	8	16	32	64
2400	1231	9927	19865	39752	79495
4800	611	5101	10232	20524	41017
9600	309	2666	5360	10747	21522
19200	159	1417	2854	5729	11479
38400	83	765	1544	3103	6221
57600	57	537	1086	2184	4379
115200	31	297	602	1212	2432

* Polling 120 registers at a rate of 250 ms each

6 Conclusion

The algorithm behind the Com'X 510 Response Time Tool can be used to reliably predict Com'X 510 performance at a user-specified baud rate and number of TCP connections. This information allows the user (system integrator, application engineer, or sales representative) to make the appropriate gateway configuration selection for an external customer site, potentially reducing commissioning time and costs for an installation.

You can find the tool for running the test algorithm in the Schneider Electric Shopping Kiosk or the Solutions Expert Community. Search for "Com'X 510 Response Time Tool," download the files, and run the test according to [Using the Gateway Benchmark Tool](#).

7 Appendix

7.1 Glossary

The following table describes the acronyms and defines the specific terms used in this document.

Term	Description
Gateway Performance Index (GPI)	A numerical value that describe the performance of the gateway, calculated by adding the median response times for a set of data points standard to all gateways.
Com'X 510 Response Time Tool	Tool developed to calculate median response time for a given baud rate and number of TCP connections.
TCP connection	Modbus TCP/IP request
Passthrough gateway	Only tested as Modbus TCP/RTU gateway. Minimal configuration through the web UI (setting Baud rate and enabling the Modbus gateway on Eth1). Not tested with additional configuration.

7.2 Reference documents

The following table is a list of documents you might want to refer to when more details are needed.

Document title	Reference
Com'X 510 User Manual	DOCA0098EN
Com'X 200/210/510 Instruction Sheet (EN)	5406AD002
PowerLogic Circuit Monitor Series 4000 Installation Guide	63230-300-238

7.3 Document Version

Version	Changes	Author
1.0	Original version	Katie Cullen
1.1	Minor update in customer challenges	Katie Cullen

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Version 1.1 – 06/2015