Integrated Architecture and CIP Sync Configuration

Application Technique

Allen-Bradley • Rockwell Software

Rockwell Automation

Important User Information

Solid-state equipment has operational characteristics differing from those of electromechanical equipment. Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls (publication SGI-1.1 available from your local Rockwell Automation sales office or online at http://www.rockwellautomation.com/literature/) describes some important differences between solid-state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid-state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

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The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

	WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
	ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence
	SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.
	BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.

Summary of Changes

This manual contains new and updated information. Changes throughout this revision are marked by change bars, as shown to the right of this paragraph.

New and Updated Information

This table contains the major changes made to this revision.

Topic	Page
Optional Hardware	12
Where to Find Sample Projects	14
Overview of the Precision Time Protocol (PTP)	19
High Speed Applications	22
Axis Position Registration	23
First Fault Detection	25
High Speed Product Reject	28
Integrated Motion on the EtherNet/IP network using CIP Sync over the EtherNet/IP Network	28
CIP Sync System Concepts	29
Boundary Clocks	33
Transparent Clocks	37
Selecting Priorities	40
Sequence of Events Modules Set Up	68
ArmorBlock 2-Port Ethernet Module Set Up	69
Selecting a Switch for CIP Sync	83
Control System Architecture Scenarios	86
Network Segmentation using 1756-EN2T modules in Boundary Clock Mode	122
Network Segmentation using VLANS and a Stratix 8300 Switch in Boundary Clock Mode	123
System Specifications	139
Time Sync Object Attributes	141

Notes:

Chapter 2

CIP Sync System Concepts

Chapter 3

External Time Sources

Chapter 4

Setting Up Synchronized Clocks in the Logix System

Chapter 5

CIP Sync Architecture

Chapter 6

Visualizing Sequence of Events on HMI using FactoryTalk Alarms and Events Instructions

Appendix A
System Specifications

Appendix B
Time Sync Object Attributes

Appendix C
Interoperability with CIP Sync IEEE 1588-2008

Appendix D
Frequently Asked Questions

Glossary
Index

Notes:

Introduction

This document explains CIP Sync technology and how you can synchronize clocks within the Rockwell Automation Integrated Architecture.
This manual does the following:

- Explains CIP Sync technology
- Defines the system Grandmaster clock
- Describes synchronizing clocks within a Logix system
- Defines external time sources
- Describes the visualizing Sequence of Events
- Illustrates CIP Sync architectures
- Lists system specifications
- Describes the CIP Time Sync object

CIP Sync Configuration

CIP Sync lets you synchronize the clocks within the following applications:

- Multiple Logix controllers
- Integrated Motion on the EtherNet/IP network
- ControlLogix redundancy system
- Personal computer based events

IMPORTANT	If you have RSLogix 5000 software version 17 or earlier, you must upgrade to version 18 or later to have complete compatibility with CIP Sync technology.

What You Need

You will need the following hardware and software for implementation of the CIP Sync IEEE 1588-2008 protocol:

- 1756-L6*x* or 1756-L7*x* ControlLogix controller, firmware revision 18 or later
- 1756-EN2T, 1756-EN2TR, 1756-EN3TR, and 1756-EN2F Ethernet communication modules, firmware revision 3 or later
- RSLogix 5000 programming software, version 18 or later
- RSLinx Classic software, version 2.53 or later

For example hardware architectures, see CIP Sync Architecture on page 79.

Optional Hardware

- 1756-IB16ISOE or the 1756-IH16ISOE Sequence of Events modules, firmware revision 2 or later.
- Managed Ethernet Switch that is fully capable of CIP Sync IEEE 1588-2008 protocol, for example, the 1783-MS10T Stratix 8000 switch, revision 12.255SE2. This switch is not needed for most CIP Sync applications.
- 1756HP-TIME GPS module, firmware revision 3.0 or later, with CIP Sync protocol. The Symmetricom XL-GPS module has the same basic functionality, but cannot reside in a ControlLogix backplane.
- 1732E-IB16M12SOEDR EtherNet/IP ArmorBlock module supporting Sequence of Events.
- 1756-IF4FXOF2F High Speed Analog I/O Module.
- 1756-OB16IS Scheduled Output Module
- 1756-CN2 ControlNet communication modules can be used to establish a connection between the ControlLogix controller and its I/O modules.

  The ControlLogix controller revision 18 or later, support both ControlNet and EtherNet/IP I/O communication.

TIP	The ControlNet Network does not participate in CIP Sync time synchronization.

- 2094-EN02D-M01-SO Kinetix 6500 Drive and Power Modules (various catalog numbers).
- 20G PowerFlex 755 Embedded EtherNet/IP Adapter.

General Clock Terms

These are a subset of terms used throughout this publication. This list provides an overview to help you understand the basics of time synchronization.

See the Glossary on page 171 for a complete list of terms.

Table 1 - General Clock Term Descriptions

Term	Description
1756-EN*x*T*x* 1756-EN*x*T	1756-EN2T, 1756-EN2TR, 1756-EN3TR, and 1756-EN2F firmware revision 3.0 or later. Redundancy Systems - The 1756-EN2T and 1756-EN2TR are compatible with redundancy systems and must be at firmware revision 4.0 or later.
Boundary Clock	A clock that has multiple PTP ports in a domain and maintains the time scale used in the domain. It may serve as the source of time, for example, a Master clock, and may synchronize to another clock, thus being a Slave clock.
Coordinated System Time (CST)	A backplane clock propagated between all modules on the ControlLogix backplane.
Coordinated Universal Time (UTC)	The time standard for `civil time', representing time at the Prime Meridian. The time does not include time zone or daylight savings time offsets. System Time is based on UTC.

Table 1 - General Clock Term Descriptions

Term	Description
Device Level Ring (DLR)	A DLR network is a single-fault tolerant ring network intended for the interconnection of automation devices.
Grandmaster Clock (GM)	Within a domain, a clock that is the ultimate source of time for clock synchronization by using the CIP Sync protocol.
Greenwich Mean Time, (GMT)	Greenwich Mean Time is the mean solar time of the longitude (0°) of the former Royal Observatory at Greenwich, England, or Greenwich meridian. UTC replaced GMT as the basis for the main reference time scale or civil time in various regions on January 1, 1970.
GPS	Global Positioning System, a time source reference.
Hand Set	A clock that has been set manually is considered 'Hand Set'.
Master (M)	A clock that is the source of time to which all other clocks on that path synchronize on a local subnet.
Master Clock (M)	In the context of a single CIP Sync communication path, a clock that is the source of time to which all other clocks on that path synchronize. The Master clock may not be the Grandmaster. The Master clock is the reference clock for the local subnet.
NTP	A protocol for synchronizing the clocks of computer systems over packet-switched, variable-latency data networks.
Ordinary Clock	A clock that has a single PTP port in a domain and maintains the time scale used in the domain. It may serve as the source of time, for example, a Master clock, and may synchronize to another clock, thus being a Slave clock.
Priorities (P1 and P2)	Parameters that can override the Best Master Clock Algorithm to choose a different Grandmaster.
Precision Time Protocol (PTP)	A high-precision time synchronization protocol for networked measurement and control systems.
Quality of Service (QoS)	A function that guarantees a bandwidth relationship between individual applications or protocols.
Redundant Chassis Pair (RCP)	The ControlLogix redundancy system uses an identical pair of ControlLogix chassis to keep a machine or process running if a problem occurs with any hardware in one of the chassis.
Slave (S)	Synchronizes the local clock to the Master time. Syntonizes the local clock frequency to match the Master reference.
SOE	Sequence of Events are any events that need to be compared against a second event.
System Time	The absolute time value as defined by CIP Sync in the context of a distributed time system where all devices have a local clock that is synchronized with a common Master clock. System Time is a 64-bit integer value in units of nanoseconds or microseconds with a value of 0 corresponding to an epoch of January 1, 1970.
Transparent Clock	A Transparent Clock improves the accuracy of time synchronization by compensating for the effect of port to port PTP packet propagation delays.
Coordinated Universal Time (UTC)	The time standard for \`civil time', which represents time at the Prime Meridian (0° longitude). The time does not include time zone or daylight savings time offsets. System Time is the same as UTC.
Wall Clock Time (WCT)	The controllers' real-world time is represented as Wall Clock Time, which is the time the controller gets from the Grandmaster. For example, the controller WCT is used as the time source for the Alarm and Events instruction, better know as System Time.

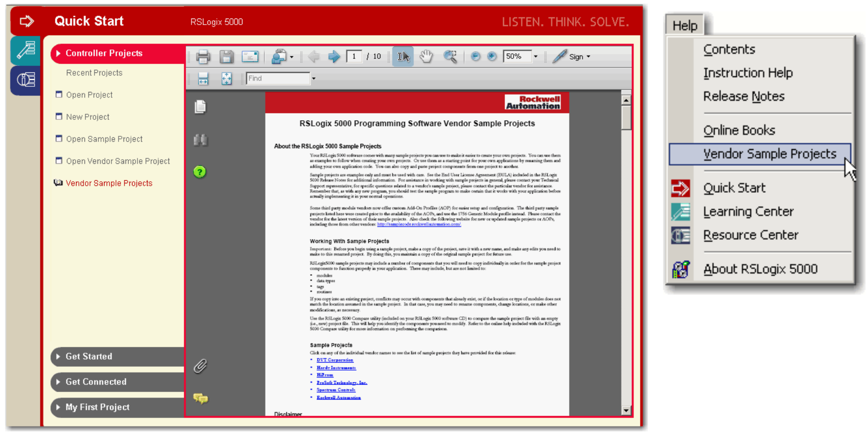
Where to Find Sample Projects

Use the RSLogix 5000 Start Page (ALT+F9) to find the sample projects.

These are the Rockwell Automation sample project's default locations:

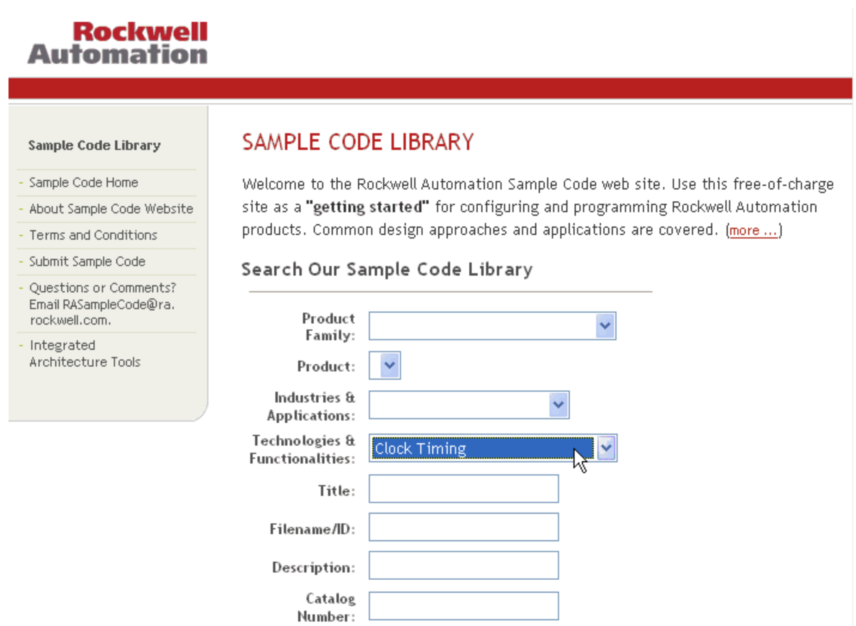
C:\RSLogix 5000\Projects\Samples\ENU\v18\Rockwell Automation
C:\RSLogix 5000\Projects\Samples\ENU\v19\Rockwell Automation

The Vendor Sample Projects PDF file on the Start page explains how to work with the sample projects.



You can access free sample code also at: http://samplecode.rockwellautomation.com.

For CIP Sync sample code, type 'Clock Timing' in the Technologies and Functionalities Search Box.



Additional Resources

These documents contain additional information concerning related Rockwell Automation products. You can view or download publications at http://www.rockwellautomation.com/literature. To order paper copies of technical documentation, contact your local Rockwell Automation distributor or sales representative.

Resource	Description
1732E ArmorBlock 2-Port Ethernet Module Installation Instructions, publication 1732E-IN004.	Describes how to install, configure, and troubleshoot the ArmorBlock module.
1732E EtherNet/IP ArmorBlock Supporting Sequence of Events User Manual, publication 1732E-UM002.	Describes the procedures you use to install, wire, and troubleshoot the module.
Add-On Instructions Programming Manual, publication 1756-PM010.	Provides a programmer with details on how to design, configure, and program Add-On Instructions.
ControlLogix Enhanced Redundancy System User Manual, publication 1756-UM535.	Provides the design, installation, and troubleshooting information specific to the enhanced redundancy system.
ControlLogix Sequence of Events Module User Manual, publication 1756-UM528.	Describes how to use, install, configure and troubleshoot the module the ControlLogix Sequence of Events module.
ControlLogix System User Manual, publication 1756-UM001.	Describes the necessary tasks to install, configure, program, and operate a ControlLogix system.
EtherNet/IP Embedded Switch Technology Application Guide, publication ENET-AP005.	Provides detailed information on how to install, configure, and maintain linear and Device-level Ring (DLR) networks by using Rockwell Automation EtherNet/IP devices with embedded switch technology.
EtherNet/IP Modules in Logix5000 Control Systems User Manual, publication ENET-UM001.	Describes how you can use the EtherNet/IP network modules with your Logix5000 controller and communicate with various devices on the Ethernet network
IEEE 1588-2008 Standard. http://ieee1588.nist.gov/	Describes the precision clock synchronization protocol for networked measurement and control systems.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1.	Provides general guidelines for installing a Rockwell Automation industrial system.
Integrated Architecture Recommended Literature Reference Manual, publication IASIMP-RM001.	Provides lists of technical publications for Integrated Architecture products.
Integrated Motion on EtherNet/IP Configuration and Startup User Manual, publication MOTION-RM003.	Provides details about creating a Integrated Motion on the EtherNet/IP network application solution with ControlLogix controllers and the EtherNet/IP network communication modules and drives.
Logix5000 Controller Motion Instructions Reference Manual, publication MOTION-RM002.	Provides details about motion instructions for a Logix-based controller.
Logix5000 Controllers Common Procedures, publication 1756-PM001.	Provides detailed information about how to program a Logix5000 controller.
Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.	Provides a programmer with details about general instructions for a Logix-based controller.
Logix5000 Controllers Process and Drives Instructions Reference Manual, publication 1756-RM006.	Provides a programmer with details about process and drives instructions for a Logix-based controller.
Logix5000 Controllers Quick Start, publication 1756-QS001.	Describes how to get started programming and maintaining Logix5000 controllers.

Resource	Description
PhaseManager User Manual, publication LOGIX-UM001.	Describes how to set up and program a Logix5000 controller to use equipment phases.
Product Certifications website, http://www.ab.com.	Provides declarations of conformity, certificates, and other certification details.
Stratix 8000 and Stratix 8300 Ethernet Managed Switches User Manual, publication 1783-UM003.	Describes the embedded software features and tools for configuring, managing, and troubleshooting the Stratix 8000 and Stratix 8300 Ethernet Managed Switch.

CIP Sync Overview

Introduction

CIP Sync provides a mechanism to synchronize clocks between controllers, I/O devices, and other automation products in your architecture with minimal user intervention. The Ethernet I/P network is the only network that supports CIP Sync time synchronization.

What is CIP Sync?

CIP Sync brings together CIP (Common Industrial Protocol) with the CIP Sync IEEE 1588-2008 standard for time synchronization. Because CIP Sync is an ODVA standard, other industrial product manufacturers have developed products that participate in this protocol. The Time Sync object provides an interface to CIP Sync that lets you access the synchronization attributes.

CIP Sync provides accurate real-time (Real-World Time) or Coordinated Universal Time (UTC) synchronization of controllers and devices connected over CIP networks and the ControlLogix backplane. This technology supports highly distributed applications that require time stamping, Sequence of Events recording, distributed motion control, and increased control coordination.

CIP Sync provides the capabilities to perform the following functions:

- Create sequence of events applications
- System-wide synchronization of time for CIP-based networks
- Integrated Motion on the EtherNet/IP network applications

What is CIP Sync IEEE 1588-2008 PTP (Precision Time Protocol)?

The CIP Sync IEEE 1588-2008 standard specifies a protocol to synchronize independent clocks running on separate nodes of a distributed measurement and control system to a high degree of accuracy and precision. The clocks communicate with each other over a communication network. In its basic form, the protocol is intended to be administration free. The protocol generates a Master/Slave relationship among the clocks in the system.

Within a given subnet of a network, there will be a single Master Clock. This Master Clock is known as the Grandmaster of time and all clocks in the system will derive their time from the Grandmaster clock.

The PTP protocol is a time-transfer protocol defined in the IEEE 1588-2008 standard that allows precise synchronization of networks, for example, the Ethernet network. Accuracy within the nanosecond range can be achieved with this protocol when using hardware assisted synchronization.

CIP Sync IEEE 1588-2008 is designed for local systems requiring very high accuracies beyond those attainable with Network Time Protocol (NTP). NTP is used to synchronize the time of a computer client or server to another server or reference time source, such as a GPS.

It is also designed for applications that cannot bear the cost of a GPS receiver at each node, or for which GPS signals are inaccessible.

In the CIP Sync architecture, the Grandmaster clock provides the Master time reference. All other nodes participating in CIP Sync use this time to synchronize.

The Grandmaster could be one of the following components:

- 1756-EN*x*T*x* communication module, firmware revision 3.0 or later
- Ethernet switch that supports IEEE 1588-2008 PTP
- 1756-L6*x* or 1756-L7*x* controller, revision 18 or later
- 1756HP-TIME module from Hiprom Technologies
- Any other CIP Sync compliant Master-capable device

CIP Sync Relationship to Precision Time Protocol (PTP)

CIP Sync is the ODVA Standards Organization's name given to the CIP (Common Industrial Protocol) implementation of time synchronization using the IEEE 1588-2008 Precision Time Protocol.

TIP The Ethernet I/P network is the only network that supports CIP Sync time synchronization.

A CIP Sync system is likely to have many devices containing master-capable clocks. All of the master-capable clocks in the system automatically negotiate among themselves, comparing clock quality attributes, to select the best Grandmaster clock. This clock selection, called the Best Master Clock Algorithm, runs continuously.

Your choice of a Grandmaster depends on your system requirements. For example, if you require synchronization between remote locations, one of the GPS options might be appropriate. If local synchronization is enough, a 1756-L6*x* controller may be a suitable Grandmaster.

A 1756-EN*x*T module has a good quality clock, but does not preserve time through a power cycle. It may work well as an alternate Grandmaster if a battery-backed Grandmaster fails, or you may choose to include user application code to set the clock after each power cycle.

Overview of the Precision Time Protocol (PTP)

This statement is a direct quote from the IEEE 1588 specification:

> 'The IEEE 1588 standard specifies a protocol to synchronize independent clocks running on separate nodes of a distributed measurement and control system to a high degree of accuracy and precision. The clocks communicate with each other over a communication network. In its basic form, the protocol is intended to be administration free. The protocol generates a master slave relationship among the clocks in the system. Within a given subnet of a network there will be a single master clock. All clocks ultimately derive their time from a clock known as the grandmaster clock. The communication path between any clock and its grandmaster clock is part of a minimum spanning tree.'

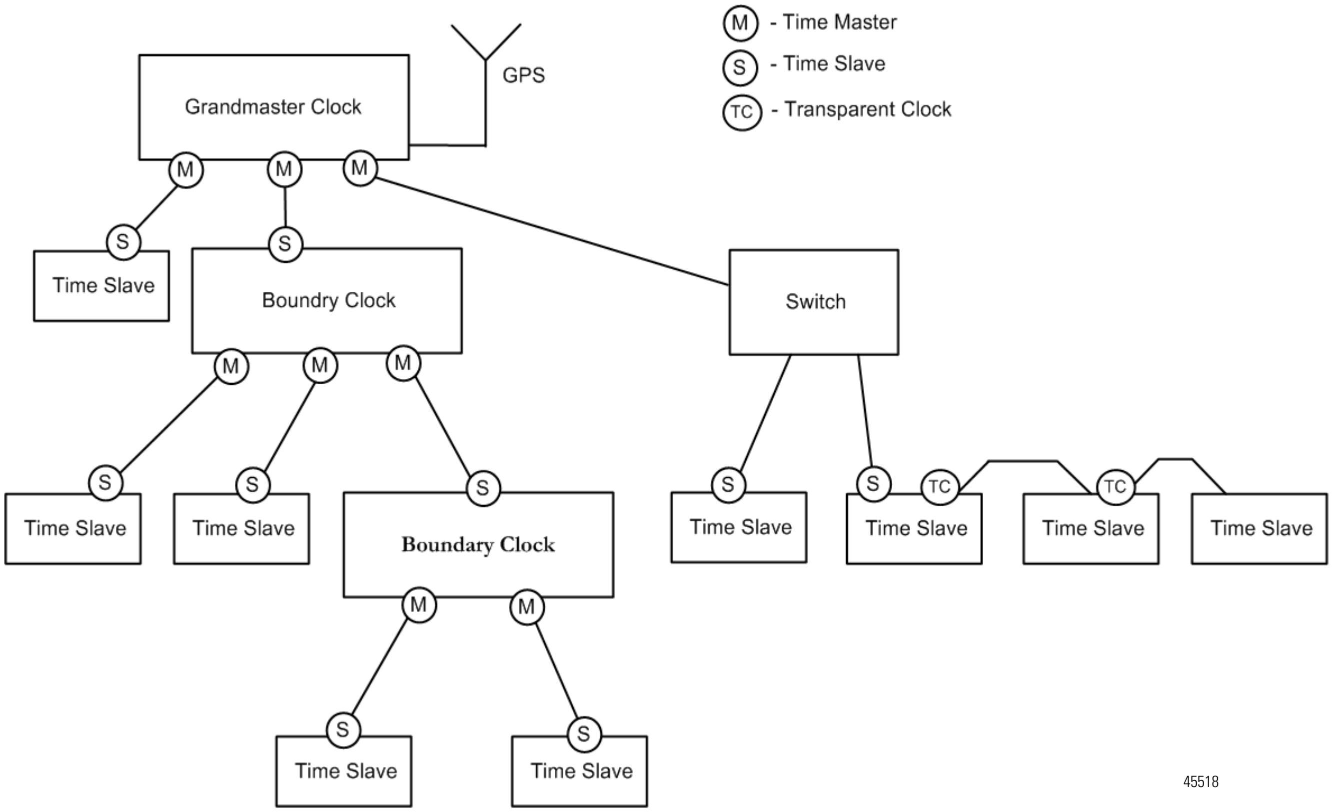
For more information about the IEEE 1588-2008 Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems see http://ieee1588.nist.gov/.

A PTP system of distributed clocks consists primarily of ordinary clocks, boundary clocks, and transparent clocks. One clock in the system is selected as the Grandmaster clock. This selection is made by each of the other clocks by examining information contained in special messages termed Announce messages. An Announce message is sent periodically by any port associated with a clock claiming to be the Grandmaster.

All ports use the same algorithm, termed the Best Master Clock Algorithm. If a port of a Grandmaster clock receives a Announce message from a better clock then that clock will cease to claim to be the Grandmaster and the receiving port will assume the status of a slave.

Likewise if a clock with a port acting as a slave determines that it would make a better master than it's current master, it assumes the status of master and begins to send Announce messages. Some nodes may be implemented as slave only and will never assume mastership, for example, an I/O device.

Figure 1 - Example Time Synchronization Topology



Using CIP Sync

There are several reasons why you would want to use CIP Sync in your automaton architecture. If you are using the following, use CIP Sync in your automation architecture:

- Multiple controllers
- Sequence of events and first fault systems
- High speed applications
- Motion control

Multiple Controllers

Controller clocks are used for a multitude of automation operations: everything from Alarms and Events logging into an IT database, to signaling shift change or lunch breaks. CIP Sync provides a simple mechanism to assure that all clocks in the system are reporting and acting from the same time reference.

Sequence of Events (SOE) and First Fault Systems

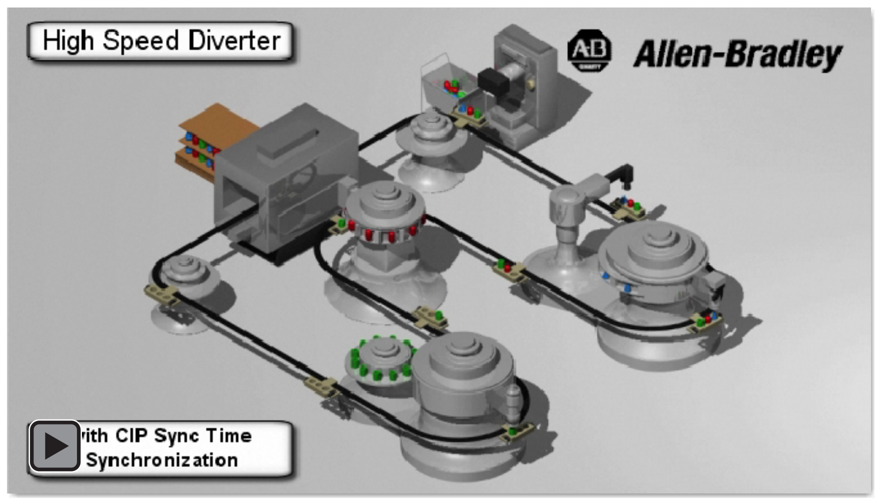
Many systems require high accuracy time stamps for faults and events that occur. Often times, these timestamps need to be evaluated against other controllers or automation equipment. Identifying which event occurred first in a system can help maintenance personnel figure out the root cause of machine faults or substation breaker faults. A cascade of alarms or faults needs to have accurate time stamps to have meaning, even if they cross large geographic boundaries or are local to one machine.

High Speed Applications

Packaging machines or sorters that have fast part cycles are often bottle-necked by controller scan times. By switching to a time based solution, you can remove many scan time critical components of the system. This programming technique lets you do predictive events and schedule outputs to run things like diverters without having a scan time to match the part cycle time.

Click on the graphic below to view a diverter animation with explanation.

Figure 2 - High Speed Diverter Example



Motion Control

CIP Sync also provides a common time reference for distributed VFD drives, servos, and controllers throughout the system. This allows controllers to request axes to reach a pre-defined position at a known time reference or run at a set jog speed per second by using the same reference. Because all drives and controllers in the system have the same reference to time, the controller can issue requests for axes to reach synchronized target positions.

Axis Position Registration

Registration is achieved by using photoeye sensor triggers on a conveyor system. With a valid time stamp, controllers can identify what the axis position was when a photo eye sensor was triggered.

Registration refers to a function usually performed by the drive where a physical input is triggered causing the drive to precisely capture the actual axis position when the input event occurred. Rather than wiring up inputs to the registration input on all of the drives, you only have to wire up one time-based SOE input module. The time stamp returned for that input can be used by the motion planner to calculate the actual axis position at the time the input triggered. This simplifies system installation, reduces wiring costs, and provides a global machine registration for all the axes in the system through one SOE input.

This technique provides for the following:

- One input can provide system wide registration
- Intelligent decision making when sorting based upon product
- Saves expensive drive-based registration inputs

Often the hardware registration found on the drive is in the 1…2 μs range. With the SOE module, within 50 μs is sufficient for most applications.

TIP In some cases, the accuracy of a distributed I/O card will not be high enough; some applications require 1 μs capture.

Enable Time Synchronization

In RSLogix 5000 software, version 18 or later, you can enable time synchronization. The software performs two functions:

- Enables the controller for CIP Sync operation. If the controller is the best clock in the system, it will become the system Grandmaster clock.
- Enables the controller for CST operation. If there is no other CST Master in the chassis, the controller will become the CST Master.

ControlLogix 1756-L6*x* and 1756-L7*x* controllers, revision 18 or later, can become a System Time Master. As a System Time Master (or Grandmaster) the controller provides a common time reference that is distributed throughout the control system over the Ethernet network. The controller decides, based on an algorithm called the Best Master Clock Algorithm, if it should become a System Time Master.

See CIP Sync System Concepts on page 21 and Best Master Clock Algorithm on page 25 for more information about time synchronization.

Correlation between CIP Sync and the Controller Wallclock

The System Time transported between controllers, across backplanes, across the the EtherNet/IP network, and between other devices, is a UTC value. That implies it has no local time offsets that are normal components of a wallclock, so it does not contain DST (daylight savings time) and local time zone offsets.

UTC time is a good mechanism for most controller functions. Times with offsets can be problematic for true SOE evaluations as DST transitions in and out. Systems that may cross time zones could be confusing as geographical data is not usually included in the data base storing the time stamps.

HMIs are typically capable of taking UTC time stamps and displaying them as local wallclock time based on the HMIs server. For example, FactoryTalk View SE software does this for time stamps by default.

There are several ways to manage DST and time zone data in the controllers. The easiest would be to set the time zone manually (necessary only once at system commissioning) and then by using an Add-On Instruction to manage the DST in your location.

You can find Add-On Instructions at http://samplecode.rockwellautomation.com/ and also see the Add-On Instructions Programming Manual, publication 1756-PM010.

Once the controller has proper DST and timezone configuration, the controller applies the DST and timezone configuration to the UTC value for display purposes for the controller's wallclock time.

Real Time Sampling

Time configuration capabilities are built into a ControlLogix system as an integral part of its operation. The CST clock in its simplest form is a backplane clock propagated between all modules on the ControlLogix backplane. This clock is an integral part of coordination between different modules. For example, coordination of multiple motion cards, as well as time stamping and scheduling of events on I/O cards.

The challenges for time synchronization can be summed up in two key points:

- Making the system, or UTC time, relevant to the real world time
- Synchronizing the System Time between different controllers, or points of I/O, that may be distributed throughout the machine, the plant, or the world

Relevance to real world time is basically the difference between the Logix backplane time standard, which starts counting when power is applied to the CST Master in microseconds from January 1st, 1970, and time in the real world. The time relevant to the real-world time means building a correlation between the Logix backplane CST (which cannot be programmatically or externally influenced in anyway) and the real world clock (UTC).

First Fault Detection

First Fault measures the time between events with no correlation to events outside of that system. The time between events happens in relation to another event, not in terms of 'real world time'.

For example, intermittent failure from a sensor on a safety system can fault a machine and halt production, cascading a flood of other interrelated machine faults. Traditional fault detection or alarms may not appear in the correct timed order of actual failure, making root cause of the down time difficult or impossible.

IMPORTANT	All first fault detection alarms must be on the same CIP Sync network.

Event Captures

Event captures happen at the time of an event occurrence by using UTC as it relates to an external clock. Typically, this is a GPS, NTP server, or some other very accurate clock source. This method allows distributed systems to capture events and build a history of these events. These events are almost always digital, however, some are analog thus having lower performance requirements.

Applications that Require Accurate Data Logging

CIP Sync provides the System Time reference that can be used to generate time stamps. The following are the types of applications that require accurate time stamp data:

- Time-stamped data logging
- Sequence of events measurements
- Scheduled outputs
- Synchronized actuation

Time Stamped I/O

High precision time stamps on I/O creates accurate first fault detection. This accuracy makes identifying initial faults that cause machine down time efficient:

- Common time base for the Alarming System logs user interaction as well as alarm events by using common time reference.
- Power industry requires sub 1 ms accuracy on first fault across geographically dispersed architecture.

High Performance Sequence of Events in the Logix Architecture

Sequence of Events applications span a wide range of industry applications. Typically, any event that needs compared against a second event can be classified as SOE:

- Used on discrete machines to identify failure points
- Used in power substations or power plants to indicate first fault conditions
- Used in SCADA applications to indicate pump failures or other discrete events

In today's environment, specifications for Sequence of Events (SOE) applications typically require 1 ms or better resolution on time stamps. There are two types of SOE applications, position registration and motion application registration.

In a position registration application using a conveyer, a photo eye device would trigger and a time stamp would be sent to a controller that would identify an axis position at the triggered time stamp. With this type of time stamping, the application can make an intelligent sorting decision.

In a complete motion registration application, one input can provide system wide registration. Often the registration on/off time is in the 1 or 2 ms range. Most networked distributed I/O cards cannot get this information on the wire fast enough for a controller to access.

By using time stamps, the actual length and position of the marks can be established. This would be used in a specialty application and in some cases the actual scan time of a distributed I/O card will not be fast enough, as some require 1µs capture. An application example would be a printing line with colored registration marks used for print and head alignment.

Power Substations

In the power industry, where there is a need to understand what event happened first and when, sub 1 ms time stamps are the standard. These event and time stamps can be captured by the following:

- 1756-IB16ISOE Sequence of Events module
- 1732E-IB16M12SOEDR EtherNet/IP ArmorBlock module
- Time stamping relays, or many other accurate time based devices

This device based time stamping can provide extremely accurate SOE data. These SOE modules are usually connected to electrical breakers that help produce and distribute power to the grid. Because of the extremely fast response time of these breakers, higher accuracy on the time stamp of the event is necessary to recreate the cause of a system failure.

Pharmaceutical Industries

Many regulated industries require a precise audit trail. Part of this trail requires an ability to accurately identify when operators performed actions, when control systems responded, and provide a very accurate picture of what occurred first.

SCADA Applications

Distributed control systems require accurate time stamps that may cross many different time zones. For example, a pipeline with multiple pumping stations may require time stamps from multiple time zones get consolidated into a common time reference. In these applications, it is often required to bring in a Grandmaster time source, for example, a GPS, to coordinate clocks for time stamping.

High Speed Product Reject

In a control system you can program a scheduled output module, for example, a 1756-OB16IS module. A scheduled output module can trigger multiple outputs simultaneously or trigger a reject at the precise point a product is at the reject station.

Because of latency in networks and controller code scan rates, firing multiple outputs simultaneously is extremely difficult and very controller intensive. Hitting the exact point when a part is in front of a reject station can be impossible on a high speed packaging machine. However, it can be accomplished by identifying when the product will be at a known position, by using time to schedule the output in advance.

See High Speed Applications on page 22 for an example.

You can find free sample code for a single product reject application at: http://samplecode.rockwellautomation.com/.

Integrated Motion on the EtherNet/IP network using CIP Sync over the EtherNet/IP Network

Integrated Motion on the EtherNet/IP network provides a flexible, common application-level interface to a wide variety of motion control devices that are common to industrial automation. It provides motion control on the unmodified standard Ethernet network. There are no proprietary switches or hardware required for real time control and the time synchronization mechanism is highly accurate.

CIP Sync is an enabling technology for Integrated Motion on the EtherNet/IP network. CIP Sync provides a single time reference for drives, network cards, and controllers. Once all the devices have a common concept of time, it is a simple matter for the Motion Planner to distribute target positions for motion devices based on time.

Because all devices have a common time reference, when the Motion Planner targets drive 1 to be at position 1 at time Y, drive 2 to be at position 2 at time Y, and drive 3 to be at position 3 at time Y, all three drives having a common time reference will reach position at the same time.

See the Integrated Motion on the EtherNet/IP Network Configuration and Startup User Manual, publication MOTION-RM003, for more information.

Motion control is based on a time event; precise packet delivery is not required. Data packets include a precise time stamp by using CIP Sync. With each new cycle, a data packet is sent that includes new position values based on actual position values sampled at the beginning of the cycle. Data packets are delivered by the EtherNet/IP network. If a packet is late for the next cycle, the time stamp of the packet is used to compensate for the delay.

Chapter 2

CIP Sync System Concepts

Introduction

This chapter provides a detailed explanation of CIP Sync concepts, requirements, and terminology.

Control systems have different requirements for clock synchronization. In many cases, simply enabling CIP Sync and using default configuration values will provide acceptable performance. If your application requires tighter synchronization, you can accomplish a higher level of performance with your up-front design and configuration.

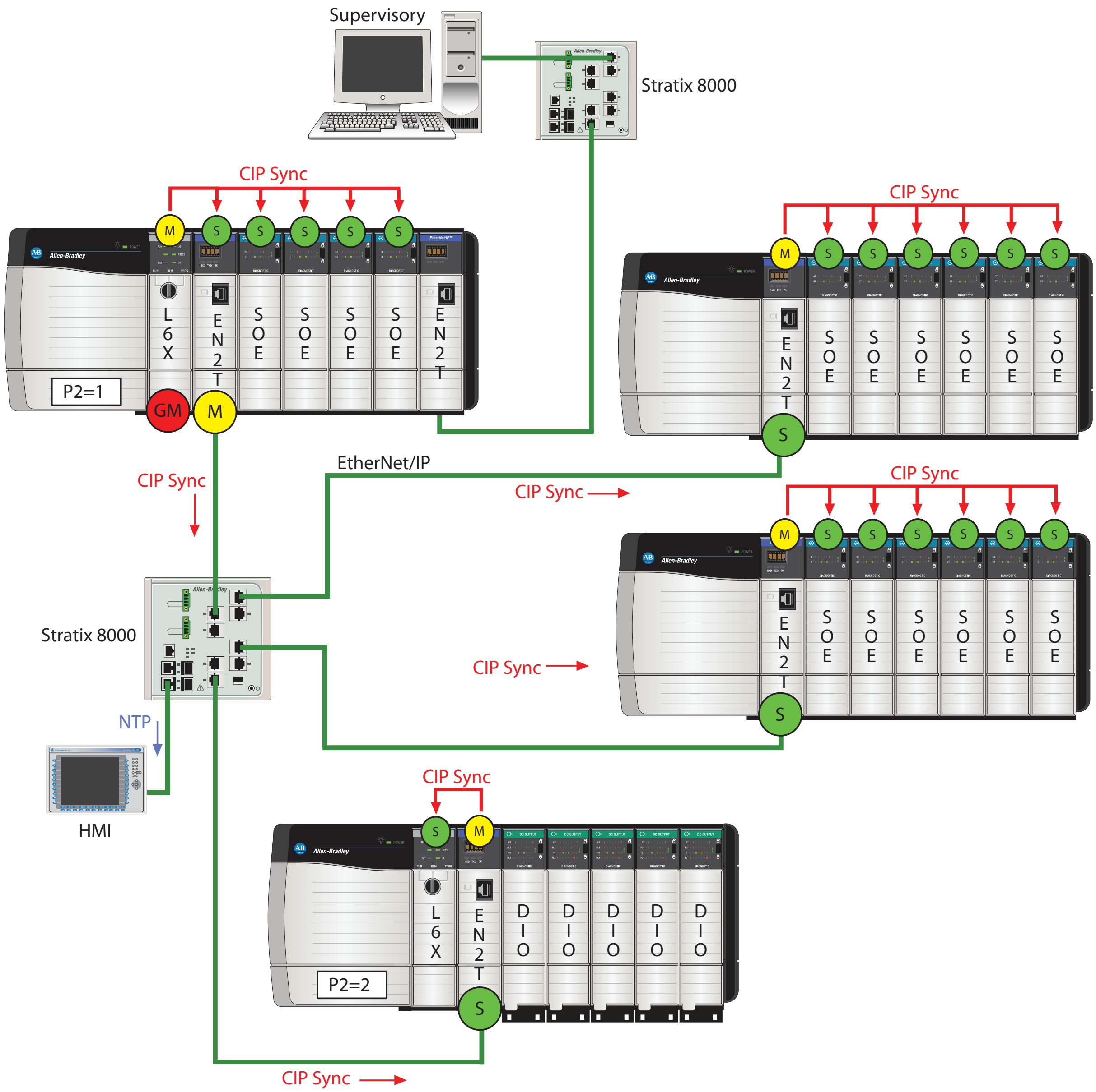
CIP Sync enables an entire system of clocks to synchronize to a single Master clock. The Master clock in a CIP Sync system is referred to as the Grandmaster. Because the Grandmaster clock provides the master time reference for the entire system, it is important that it be a good quality, maintainable clock.

A CIP Sync system is likely to have a number of devices containing master-capable clocks. All of the master-capable clocks in the system will automatically negotiate among themselves, comparing clock quality attributes to select the best Grandmaster clock. This clock selection process, called the Best Master Clock Algorithm, runs continuously.

Your choice of a Grandmaster depends on your system requirements. For example, if you require synchronization between remote locations, one of the GPS options might be appropriate. If local synchronization is enough, a 1756-L6*x* controller may be a suitable Grandmaster.

A 1756-EN*x*T module has a good quality clock, but does not preserve time through a power cycle. It may work well as an alternate Grandmaster if a battery-backed Grandmaster fails, or you may choose to include user application code to set the clock after each power cycle.

Figure 3 - CIP Sync Example Architecture



This is an example of multiple remote racks using CIP Sync protocol in a network configured for a Star topology. The time source for the Grandmaster clock is the ControlLogix controller.

For more information about CIP Sync application scenarios, see Types of Control System Architectures on page 80.

Designing Your System

Your control system is likely to include several types of CIP Sync clocks, including but not limited to the following devices.

Table 2 - CIP Sync Devices, Clock Type, and Capabilities

Device	Clock Type	Capability
1756-L6*x* or 1756-L7*x* controller	Ordinary	Master/Slave
1756-EN2Tcommunication modules	Boundary	Master/Slave
1756-EN*x*TR communication module	Boundary or Transparent	Master/Slave
1756-EN2F communication module	Boundary or Transparent	Master/Slave
1756HP-TIME module (Hiprom Technologies)	Ordinary	Master only
1732E-IB16M12SOEDR, EtherNet/IP ArmorBlock module	Ordinary	Slave
1756-IB16ISOE or the 1756-IH16ISOE I/O module	Ordinary	Slave
1783-MS10T Stratix 8000, Ethernet switch	Boundary or Transparent	Master/Slave or Pass thru
1783-ETAP, 1783-ETAP1F, 1783-ETAP2F, embedded switches	Transparent	Pass thru
2094-EN02D-M01-S0, 2094-EN02D-M01-S1, Kinetix 6500 drive	Transparent	Pass thru
20G PowerFlex 755 drive	Transparent	Pass thru
1756-IF4FXOF2F, high speed analog I/O module	CST	Slave
1756-OB16IS, scheduled output module	CST	Slave

Clock Types

The different clock types support different Master and Slave capabilities. The types of clocks include the following:

- Grandmaster
- Slave
- Boundary
- Transparent
- Hybrid

Grandmaster Clock

The responsibility of a Master clock participating in CIP Sync is to do the following:

- Provide a Master time reference for the Slave clocks in the region.
- Respond to requests from Slave clocks to measure network latency.
- Provide information describing the clock quality of the Grandmaster.
- Provide additional management and identification data to Slave clocks.
- Release Mastership when a better quality clock comes into the system.

Slave Clock

The responsibility of a Slave clock is to do the following:

- Synchronize the local clock to the Master time reference.
- Syntonize the local clock frequency to match the Master reference frequency.
- Occasionally generate requests to measure network latency.
- Monitor information describing the clock quality of new Master clocks that may appear.
- Switch to the new Master when a Master clock appears that is better than the current Master.

Boundary Clocks

A boundary clock uses its own separate but synchronized clock. These devices synchronize their internal clock to a higher quality Grandmaster clock. Time synchronization packets sent are timestamped by using their own internal time reference.

Boundary clocks function as a 'boundary' or interface between PTP synchronization segments, intercepting upstream PTP messages and then generating new PTP messages. Standard or non-PTP messages are allowed to pass uninterrupted through the switch.

Boundary clocks are multi-port clocks where one port is typically a slave to an upstream master, while the remaining ports become masters to the downstream devices.

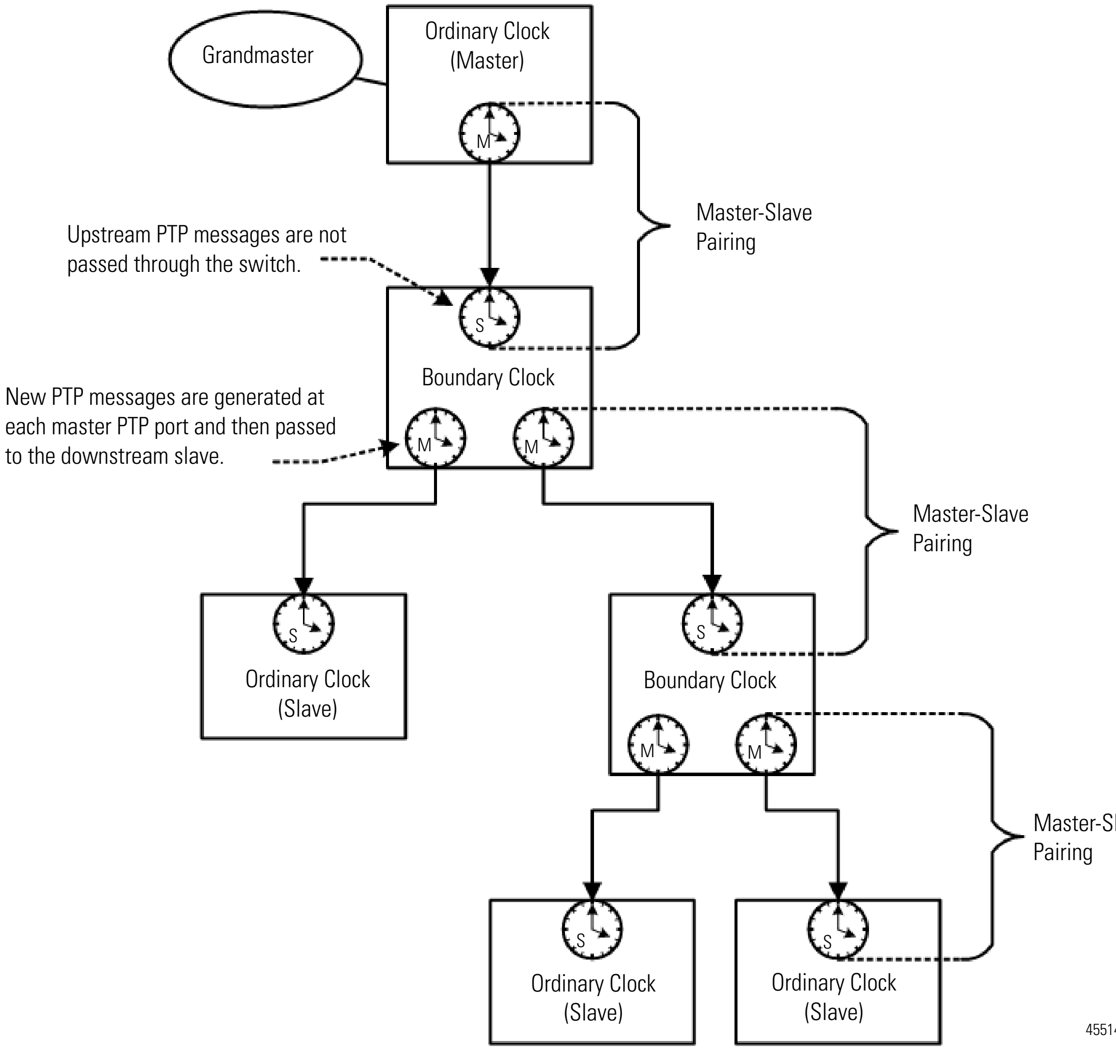
A boundary clock does the following:

- Reduces the load on your Grandmaster clock that is caused by path measurement messages.
- Mitigates the effect of highly-variable network loading on CIP Sync time accuracy.
- Propagates a high-quality Grandmaster clock to multiple subnets in your plant.
- Translates CIP Sync packets between network communication paths, for example, between the EtherNet/IP network and the ControlLogix chassis backplane.

Integrated Motion on the EtherNet/IP Network

For applications that contain Integrated Motion on the EtherNet/IP network, we recommend that you don't apply a boundary clock to more than one hop or two because multiple hops can reduce the accuracy of the clocks needed for a motion control system. If more than one hop is needed, use a transparent clock for downstream devices.

Figure 4 - Boundary Clock with Multiple Switches



A switch may be a boundary clock when it implements the IEEE-1588 protocol. It is also possible for the switch to become the Grandmaster clock in a system, in that case all ports are master ports to the connected devices.

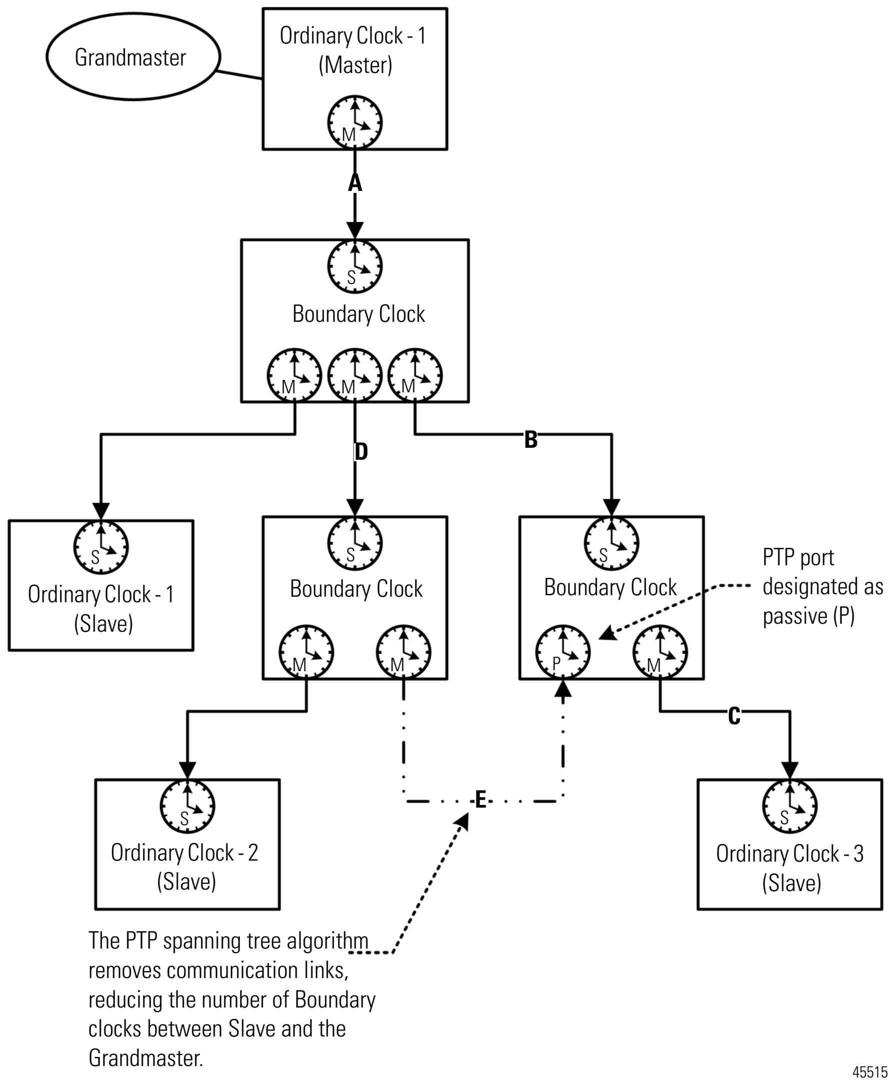
The master-slave PTP port assignment is determined by the Best Master Clock algorithm, as each of the ports interrogates adjacent clocks to compare credentials. The port that is connected to the 'best' clock becomes the slave PTP port.

This process is repeated through each cascaded Boundary clock out toward each of the end nodes, thus constructing a tree like hierarchy of master-slave clocks with the Grandmaster clock located at its root.

The slave PTP port will be a slave to its upstream master, typically an ordinary clock or another boundary clock. Similarly, the master PTP ports will serve as master to their downstream slaves. This relationship is repeated at each boundary clock, cascading out to each of the end nodes or ordinary clocks.

The protocol also segments the network in a minimum spanning tree by reducing the number of Boundary clocks between any ordinary clock (slave) and the Grandmaster.

Figure 5 - Minimum Spanning Tree



In this example, the PTP spanning tree algorithm determined that communication path A-B-C places only two boundary clocks between ordinary clock 3 and the Grandmaster, compared to path A-D-E-C that routes through three boundary clocks. As a result of the extra boundary clock, path E is removed (dashed line) and the downstream PTP port is designated as passive. If changes to the network are made, nodes are removed and/or inserted or the communication path is adjusted; the master-slave hierarchy or PTP port designation will change accordingly.

PTP messages that are sent from the up-stream master are intercepted by the slave PTP port, which are used to synchronize the boundary clock. The PTP messages received by the slave PTP port are not allowed to pass through the switch.

Instead, each master PTP port generates new PTP messages and then passes these messages to the downstream slaves. Due to the inherent segmented nature of boundary clocks, it is not necessary to compensate for communication path delay as time is synchronized from each clock to next.

Boundary clocks are most effective when deployed in networks where the ordinary clocks are not separated by more than a few cascaded boundary clocks from the Grandmaster. Long cascades of boundary clocks between the Grandmaster and Slaves can lead to degradation of the timing accuracy.

This is due to the accumulation of lag in the system as multiple phase-locked loops are cascaded together. For long linear or daisy-chained topologies, up to 50 or more links, a transparent clock is better suited.

Port States on a Boundary Clock

These are examples of how the ports on a boundary clock behave:

- At most, only one port may be in the Slave state—this is the port that has access to a better Master than any other port.
- All other ports must be in either the Master or passive states.
- The passive state is used for network segments where the boundary clock is not good enough to become Master, but the other potential Master clocks on that network segment are not good enough to be chosen over the current Slave port's Master clock. This happens only when there are multiple network paths to the same Grandmaster.
- If the boundary clock is also the Grandmaster, then all ports will be Master.
- The boundary clock synchronizes its clock to the chosen Master on the Slave port, and then uses its local clock as the Master for the remaining ports.

Although boundary clocks use their local oscillator as the time source for synchronization packets broadcast from ports in the Master state, they Announce the quality of the Grandmaster clock to which they are synchronized. The 'steps removed' attribute is incremented to indicate how many boundary clock hops a Slave is from the current Grandmaster.

Transparent Clocks

A transparent clock is a switch (or router). It has more than one port and compensates for delays within the device. It improves time synchronization accuracy by compensating for the delay.

Transparent clocks can do the following:

- Mitigate the effect of highly-variable network loading on CIP Sync time accuracy
- Measure delay through the switch or router
- Add delay to the correction field of PTP event messages.

  Slave nodes use the correction field to adjust time stamps for transparent clock device-resident delays.

Transparent clocks are fundamentally different from boundary clocks. Instead of synchronizing to the next clock in the master-slave hierarchy and establishing master-slave PTP ports, transparent clocks measure the residence time (or the time to propagate through the switch) of the PTP messages as they pass between ports. The measured residence times are used to update the correction fields of the PTP timing messages. The residence time varies packet-to-packet based on network traffic.

In contrast to boundary clocks, transparent clocks operate so they appear as a transparent (their existence is very noticeable and sometimes problematic) interface between master and slave clocks. They also let multiple slaves synchronize directly to one master.

For more information about when you would configure a switch to be a boundary or a transparent clock, refer to these resources:

- Stratix switch web pages
- Stratix 8000 and Stratix 8300 Ethernet Managed Switches User Manual, publication 1783-UM003

TIP	The Stratix 8000 switch is configured as a transparent clock as the default.

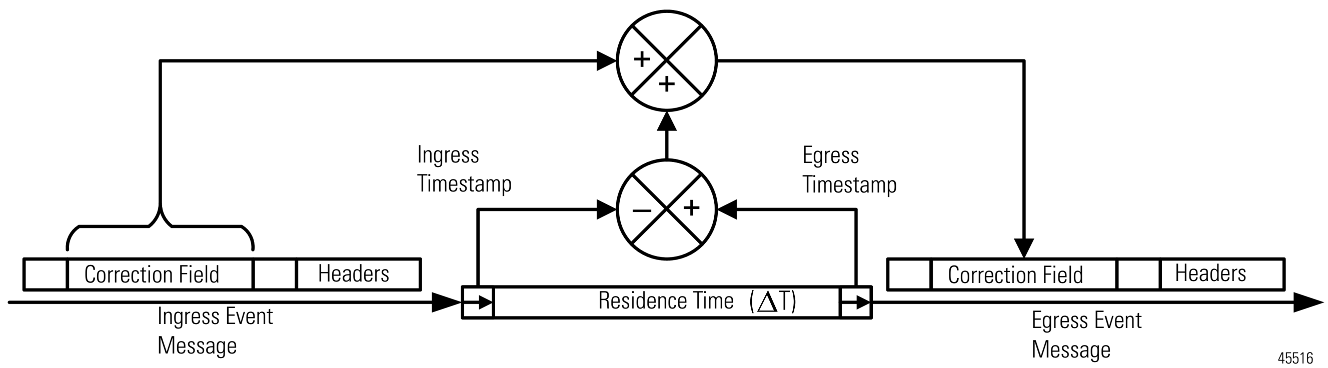
There are two distinct types of transparent clocks, end-to-end and peer-to-peer. Both types compensate for the communication path delay caused by variable switch latency, but are implemented with some notable differences.

End-to-end transparent clocks compensate for the residence time as the PTP messages pass between ports. Peer-to-peer transparent clocks not only measure the residence time as PTP messages pass between ports, but also measure the path delays of the adjacent ports. The remainder of this section describes end-to-end transparent clocks and refers to them as transparent clocks, unless specified otherwise.

TIP	Peer-to-peer transparent clocks are not supported by CIP Sync.

Transparent clocks timestamp PTP timing messages as they enter and leave the switch. As a PTP message first enters the ingress port of a transparent clock, the ingress timestamp is recorded. Similarly, as the PTP message is ready to leave the egress port, the egress timestamp is recorded.

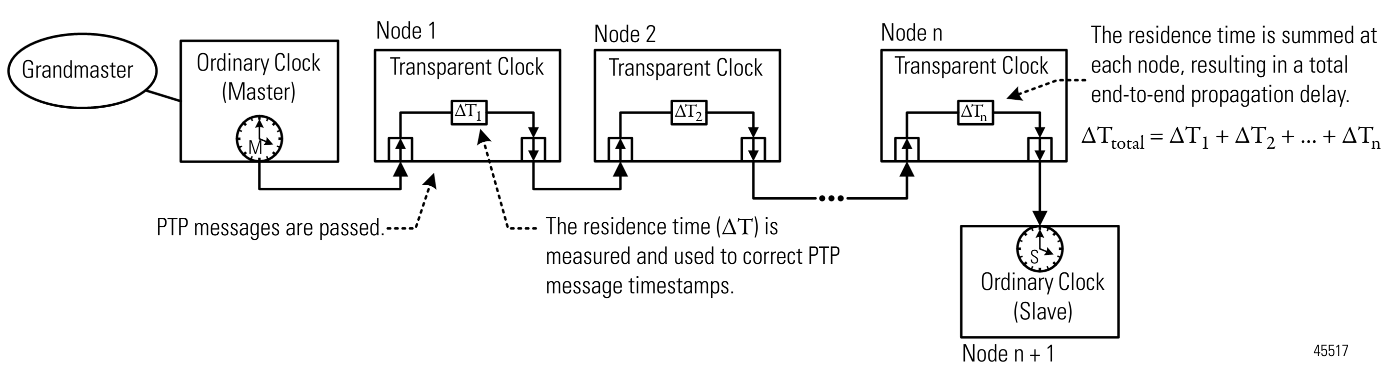
Figure 6 - Transparent Clock Residence Time Calculation



Based on these two timestamps, the residence time or transit time through the transparent clock is calculated. The residence time is then added to the correction field of the PTP packet. This correction field ensures that the downstream clocks will be able to properly compensate for switch latency.

Transparent clocks are effective in long linear or daisy-chained topologies (up to 50 or more links). The inherent nature of a transparent clock allows cascaded connections to properly compensate for end-to-end propagation delay caused by variable switch latency.

Figure 7 - End-to-end Transparent Clock Propagation Delay Example



As PTP messages pass through cascaded transparent clocks, the correction field is summed with the residence time at each node and then passed onto the next. The result is that the node at the end of the line can compensate for communication path delay with minimal impact to timing accuracy.

Hybrid Clocks

Hybrid clocks, for example, a 1756-EN*x*TR, combine two clock functions into one device, for example, an ordinary and transparent clock. These type of clocks are suitable for two port devices when used in daisy chain and ring topologies. For example, the 1732E-IB16M12SOEDR ArmorBlock module is a two port device that implements both transparent clock and ordinary clock functionality.

Grandmaster Clock Selection and Clock Quality

At powerup, when joining a CIP Sync time network, master capable clocks only broadcast their clock quality if they are better than the current Grandmaster. It also listens for CIP Sync announce messages that broadcast the quality attributes of a current Grandmaster that may exist. The Best Master Clock Algorithm in each clock is evaluated to determine if the new clock is better than the current Grandmaster. If it is, the Slave clocks switch to the new Grandmaster clock, and the previous Grandmaster stops behaving as a Master clock.

If the clock's qualities are better than any other clock on the network, the clock assumes the role of Grandmaster on the network. If not, the clock becomes a Slave to the Master on the network and synchronizes its clock to the Master.

IMPORTANT	Each clock performs the Best Master Clock Algorithm independently from all of the other clocks. Because all clocks have the same data sets for this algorithm, they will all eventually select the same Grandmaster; however, the changes will not be instantaneous.

In the event that the current Master is removed from the system, the system will detect the loss of announce messages, and once again go through the process of selecting a Master. During this interval, clock drift between devices should be minimal, as most devices will have synchronized their local clock to the previous Master. Once the new Master is determined, all Slave clocks synchronize to that new Master's time reference.

This algorithm provides a level of system reliability, as it automatically finds the next best clock in the event that a Grandmaster clock fails. However, in a network with multiple controllers and bridge modules, many devices will have clock quality attributes of equal values. When this occurs, the algorithm chooses the device with the lowest identity value (which is based on serial number or Ethernet address, depending on the device).

Configuring Grandmaster Options

Once you have decided on the device you want to use as the Grandmaster, you have several options for implementing that decision in your control system.

Table 3 - Implementation Options

Option	Description
Restricting the available choices	The system automatically selects the Grandmaster you chose because it is the only possible choice.
Providing better clocks	Providing CIP Sync clocks that are clear winners in the Best Master Clock Algorithm, such as GPS-based clocks, or only hand-setting the clock in the devices that you wish to become Masters.
Selecting priorities	Override the Best Master Clock Algorithm to force particular clocks to automatically win arbitration.

IMPORTANT	All of these options require that you restrict network access, allowing only CIP Sync or PTP devices that are configured to work with your system. It is impossible to prevent a better clock from becoming Grandmaster if you let such a device connect to your system's network.

Restricting the Available Choices

CIP Sync messages use multicast packets on the Ethernet network, which normally are restricted to the local subnet. Be aware that switches can effectively interconnect multiple subnets into a single CIP Sync domain, increasing the number of potential Grandmasters, and increasing the length of time it will take to resolve all devices to the same Grandmaster. You should carefully consider how CIP Sync enabled devices are interconnected in your system.

Providing Better Clocks

The Best Master Clock Algorithm is designed to automatically choose the clock that is technically the best. If there is a clock that is a better source of time (such as a GPS-based clock) and all devices are left with default settings, the system will choose this clock as Grandmaster.

Selecting Priorities

These are the cases where you might want to influence the Best Master Clock Algorithm to choose a different Grandmaster:

- There are a number of clocks with similar quality values, and you have additional knowledge about the reliability or availability of these clocks.
- You do not want the clock choice to be based on arbitrary values such as device serial numbers or Ethernet addresses.
- You want to control the clock choice when the Grandmaster clock is replaced.

In these cases, adjusting the Priority values can make it easier to predict or control which clock is chosen as Grandmaster. There are two attributes that you can use to set the priority:

- Master Override (Priority 1)
- Preferred Override (Priority 2)

The Best Master Clock Algorithm evaluates Priority 1 before any other value, and so this value overrides the actual clock quality values.

IMPORTANT	Make any adjustments to Priority 1 with great care. Priority 1 is designed to override the actual clock quality, so any potential improvements to Grandmaster stability incur a risk of reduced clock accuracy. Changing the priority can cause an uninitialized clock to become Grandmaster, thereby resetting the entire CIP Sync domain to 1/1/1970 or some other inaccurate time.

The Best Master Clock Algorithm evaluates Priority 2 after evaluating the clock quality attributes of class, accuracy, and variance. It overrides only the Grandmaster ID value, so this setting is useful for overriding the arbitrary nature of device serial numbers or MAC addresses in clock selection.

Priority values range from 0 (highest priority) to 255 (lowest priority). The default value for both settings is 128.

If you have a large system, and there are only a few devices that you want to avoid using, you can set the priority values for those few devices greater than 128 and let the remaining devices (including new, out-of-box devices you add later) negotiate normally. If you have only a few devices from which you want to choose a Grandmaster, set the priority values to less than 128 for those few; this will block modules with default settings from becoming Grandmaster.

Hand Setting the Grandmaster Clock

Clocks that have not been set are considered to be uninitialized. This state causes lower-quality values for Class and Accuracy, which allows the normal selection algorithm to avoid these clocks as Grandmaster. However, a CIP Sync system that has only uninitialized clocks will still choose one of them as Grandmaster. In the case of a system of unitialized clocks and priorities, the Grandmaster will be selected based on the device identifier.

Because Logix controllers have a real-time clock that continues to measure time while the controller is powered down, they will remember their current clock state and clock quality values through power cycles, and will power up with clock quality values that accurately represent their clock status. For example, a Hand Set controller clock, with battery, will remember that it is hand set after a power cycle and will degrade its clock quality by one.

Depending on the device, a clock may be set by receiving a signal from a primary reference source (such as GPS or atomic clock radio signals), or it may be adjusted by human interaction (hand set), or programming. Once a clock has been set, its accuracy (and possibly class) values will improve, making this clock a better choice for Grandmaster than an uninitialized clock. Because there is no method for measuring traceability or accuracy, hand set clocks are at the low end of the class and accuracy scales.

TIP For information about tools can assist you in understanding, planning, and configuring an Integrated Architecture System, see Integrated Architecture Tools at http://www.rockwellautomation.com/solutions/integratedarchitecture/resources3.html.

Best Master Clock Algorithm

CIP Sync uses the IEEE 1588-2008 Best Master Clock Algorithm for choosing the Grandmaster clock. This algorithm compares clock attributes between potential Masters. The clock with the best attributes is chosen as the best Master.

This table describes the set of attributes and the order that the algorithm compares these attributes for each potential Master clock. When a better clock value is encountered, the comparison is finished. If during a comparison two attributes are equal, the algorithm compares the next attribute. Attributes are compared numerically; generally, a smaller number is a better attribute value.

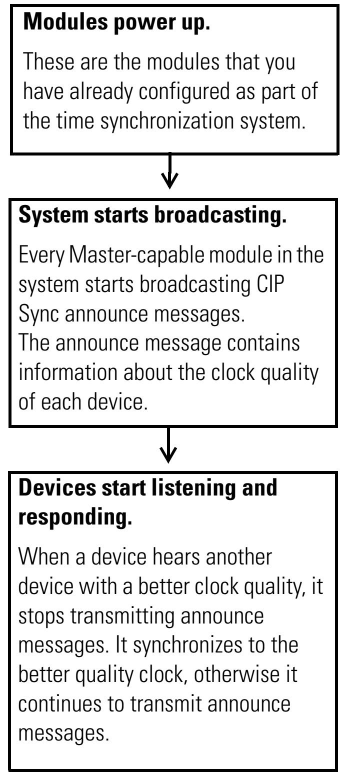
Table 4 - Best Master Clock Algorithm Comparison Order

Order	Attribute	Description
1	Grandmaster Priority 1	A user-settable value that overrides the natural choice for best clock.
2	Grandmaster clock class	A manufacturer or dynamically set value that describes the intended function of the clock.
3	Grandmaster clock accuracy	Represents the expected maximum error between this clock and official UTC time.
4	Grandmaster clock variance	Represents the inherent precision of the clock.
5	Grandmaster Priority 2	A user-settable value to impose a preference between otherwise-identical clocks.
6	Grandmaster identity	A unique manufacturer's value used as a final tie-breaker.
7	Steps removed	Chooses the `shortest' path when multiple boundary clocks offer different paths to the same Grandmaster.

CIP Sync Start-up Protocol

This is the start-up protocol for a device or devices participating in CIP Sync.

Figure 8 - Selects a Grandmaster at Startup



See Best Master Clock Algorithm on page 25.

CIP Sync Steady State Operation

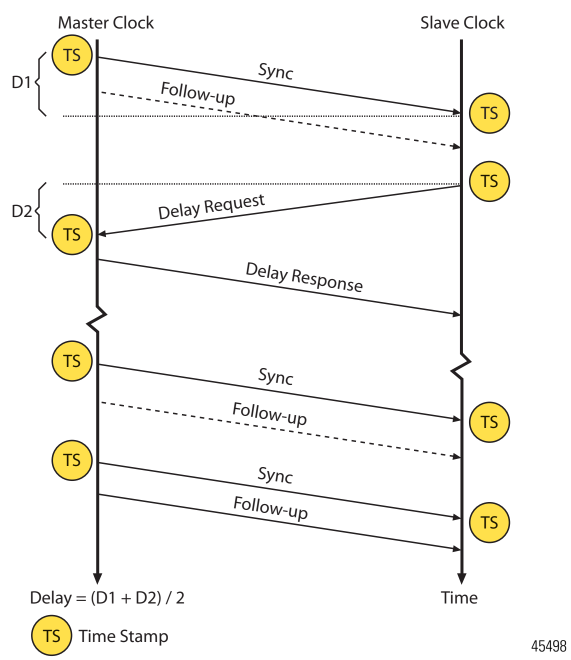
This is the protocol for steady state operation.

Figure 9 - Steady State Protocol

Sync and follow-up messages are sent out.

Once every sync interval, the Grandmaster or Master sends out sync messages. These messages are time stamped when they are sent by the Master and received by the Slave. The sync interval is one second by default.

A follow-up message is also sent once every sync interval. The follow-up message contains the Master clock's sync message time stamp.



Delay request packets are sent out.

The Slave device sends out delay request packets to the Master clock. The Master clock returns a delay response packet.

Slaves use the timing information in the delay response to compensate for path delay in the system. The sync follow-up and delay response messages may also contain transparent clock latency information.

Delay request messages are time stamped when they are sent by the Slave and received by the Master.

Slaves synchronize their clocks.

Slaves use the sync and delay time stamps to synchronize their clocks to the Master clock.

Loss of Grandmaster Operation

When Master-capable Slave devices stop seeing announce messages from the current Grandmaster clock they begin to transmit announce messages to restart the Grandmaster selection process. The device with the best quality clock will continue to send announce messages while all other clocks will discontinue. When the Master clock disappears, the clocks return to their natural frequency. The process of selecting a new Grandmaster may take several seconds.

New Grandmaster Operation

When a new device appears on the network, it listens for announce messages from the current Master. If the device has a better quality than the current Grandmaster, it takes over. If the device does not have a better clock, it becomes a Slave.

CST and System Time Synchronization

CST enabled devices in a ControlLogix backplane synchronize their local clocks by using the CST protocol. Both CST and the PTP protocol are operational in a ControlLogix backplane. CST is used to synchronize the clocks to CST time and PTP is used to synchronize the clocks to System Time.

System Time and CST time are related by System Time = CST time + offset

where offset is the Wall Clock Time (WCT) object CstOffset.

On powerup, a CST Master, such as a 1756-L6*x* or 1756-L7*x* ControlLogix controller, or a 1756-EN*x*T*x* communication module, sends out a CST sync message that causes all CST Slave modules in the chassis to synchronize to the Master's current CST. CST is zero at powerup and then continually increases. Every 4 ms CST update messages are sent out to slowly ramp the modules drift to keep it matched to the Master's CST.

Crystal Accuracy - Drift

Every module has an internal counter clock that starts counting when it is powered up; this is CST. This counter value is produced by a crystal. Due to the inaccuracy of an unsynchronized clock, the counter value will experience a small drift compared to the UTC. Because the clock of Logix controllers is based on this counter value, it may lose or gain time dependent on the crystal accuracy.

Crystal Accuracy

Logix controllers operating in normal temperatures have a crystal drift between 2…20 µs per second (ppm). The drift is also controller and temperature dependent. The following are results measured in a test lab for 1756-L6*x* controllers:

- @ 25 °C (77 °F) rack ambient

  The Logix controller time can be off by as much as 3 minutes, 4 seconds per month and it is more likely to gain time (= 71 ppm).

- @ 60 °C (140 °F) rack ambient

  The Logix controller time can be off by as much as 4 minutes, 19 seconds per month and will always gain time (= 100 ppm).

CST versus System Time – Where did the CST checkbox go?

In RSLogix 5000 software versions prior to 18, CST was enabled by checking the CST checkbox. With RSLogix 5000 software, version 18 or later, checking the Enable Time Synchronization checkbox enables both CST and CIP Sync time synchronization.

The CST feature is always enabled by default on the controller, however, it is enabled to Slave mode only. Thus any other CST Master on the backplane will become the Master for the controller to follow.

See Enable Time Synchronization on page 63.

This table defines CST and System Time.

Table 5 - Clock Concepts Descriptions

Concept	Description
Coordinated System Time (CST)	CST is a backplane clock propagated between all modules on the ControlLogix backplane. Its presence is necessary whenever CST time coordination between modules in the chassis is required. This includes the following systems: • CIP Sync • SERCOS Motion • Integrated Motion on the EtherNet/IP network • Safety • SynchLink • RSLogix 5000 software, version 17 and earlier, SOE systems, for example, coordinated time based outputs, including MAOC operations, and synchronized analog scans CST is a free running clock with microsecond resolution that starts up when power is applied to the chassis.
System Time	This clock is based on UTC (Coordinated Universal Time). It provides a time reference independent of time zone and daylight savings time settings. You use this, for example, these types of systems: • CIP Motion • CIP Sync • Sequence of Events, RSLogix 5000 software, version 18 and later • Scheduled Output System Time relies on a combination of CST and CIP Sync to assure proper delivery through the rack. Additionally, it can be transported via Ethernet bridge modules to other devices that are on the EtherNet/IP network. It is the preferred clock to perform time stamps of events and is ultimately used to synchronize Integrated Motion on the EtherNet/IP network drives.

Clock Setting Storage

Clock settings can come from four places:

- Stored in the project
- Battery backed-up memory
- CompactFlash or Secure Digital (SD) card project backup
- Nonvolatile memory

This table describes how clock settings are stored.

Table 6 - Clock Setting Storage

<table>
<tr><th>Clock Source</th><th>Setting</th><th>Data Storage</th></tr>
<tr><td rowspan="3">Controller
1756-L6x
1756-L7x</td><td>Priority 1 and Priority 2</td><td>• Project
• 1756-L6x, with battery backup
• 1756-L7x, with 1756-ESM module
• CompactFlash or Secure Digital (SD) card</td></tr>
<tr><td>PTP Enable
(Time Synchronization Enable)</td><td>• Project
• 1756-L6x, with battery backup
• 1756-L7x, with 1756-ESM module
• CompactFlash or Secure Digital (SD) card</td></tr>
<tr><td>Port Enable
Announce and Sync Interval
Domain</td><td>• 1756-L6x, with battery backup
• 1756-L7x, with 1756-ESM module
• CompactFlash or Secure Digital (SD) card</td></tr>
<tr><td rowspan="3">1756-ENxTx communication module</td><td>Priority 1 and Priority 2</td><td>• Nonvolatile memory</td></tr>
<tr><td>PTP Enable</td><td>• Volatile: disabled after power cycle
• Set by Time Sync and Motion connection</td></tr>
<tr><td>Port Enable
Announce and Sync Interval
Domain</td><td>• Nonvolatile memory</td></tr>
</table>

Notes:

External Time Sources

Introduction

This chapter describes the use of external time sources for the Grandmaster clock.

Using an External Time Source

While for many applications, simply propagating the controllers hand set wall clock around the architecture provides sufficient accuracy and time relations, in some applications a more precise coordination with outside events is required. This is typically the case in applications that cover larger geographical areas, for example, pipeline or power generation, but can often apply to applications in large facilities or heavily regulated facilities where tighter tracking, traceable timestamps, or logging of events is required.

This chapter discusses technologies that will bring a clock source into the system from some external source. Specifically, this chapter covers the following:

- NTP – Network Time Protocol
- Logix 5000 Clock Update Tool
- GPS interfaces
- IRIG B interfaces

Once this time is delivered to the system, it is distributed over the EtherNet/IP network throughout the rest of the architecture by using CIP Sync as described in CIP Sync Architecture on page 79.

While this certainly covers the more mainstream solutions for getting a time into the Logix architecture, there are other products that can play a role in time that may or may not be compatible with CIP Sync or IEEE 1588-2008. In general, if the device supports IEEE1588-2008, it should work well in any CIP Sync architecture.

Using NTP or SNTP as a Time Source

There are two approaches for importing time into the Logix architecture by using NTP:

- 1756-EWEB module
- 1756HP-TIME module (Hiprom Technologies)

After the 1756-EWEB module, synchronizes with an NTP Server clock source, the NTP time is pushed across the ControlLogix backplane to the Control Logix controller. This is the equivalent of hand setting the Wall Clock Time (WCT) of the Controller. At this point the controller will act as the Grandmaster of time on the network; for other devices to Slave against directly. In this case, the 1756HP-Time module is the Grandmaster of time on the network.

The key difference between the approach of these two devices is the 1756-EWEB module. After synchronizing with a NTP clock source, the 1756-EWEB module takes this time and basically does the equivalent of hand sets to a specific controller. That controller then acts as a clock Master to the rest of the architecture. However, the 1756HP-TIME module takes NTP time and converts it to CIP Sync and broadcasts it out its Ethernet ports for other devices to Slave against directly.

As a technology, you can expect jumps in time with NTP. Typically this is due to network delivery delays in the delivery infrastructure that typically don't exist in pure CIP Sync or IEEE 1588-2008 systems. Some NTP devices can implement a smoothing algorithm to try and level out these time disturbances from the source; however, as an accurate clock, millisecond accuracy is almost never achieved. Accuracy to the second is usually a much more obtainable target with NTP technology.

Better accuracy is typically obtained by limiting the number of hops between the actual time server and the NTP client. For example, collecting time directly from an Internet-based time server will have many delays. Collecting time from a local computer in your facility that has NTP server capability will provide better accuracy.

1756-EWEB Module as an SNTP Time Client

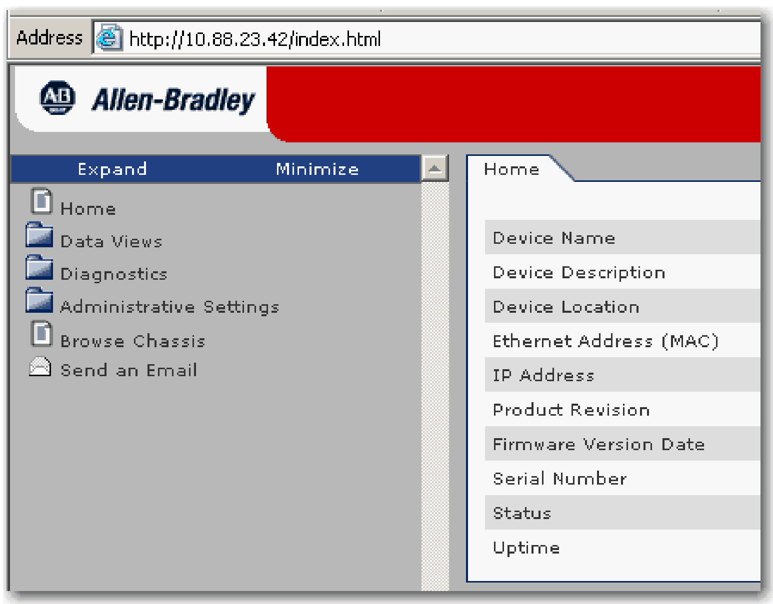
The 1756-EWEB module uses SNTP (Simple Network Time Protocol) to set its local clock. Once its local clock is synchronized, it can be configured to automatically send explicit messages to update the Wall Clock Time (WCT) of the controller in its local rack.

The controller then uses CIP Sync to distribute time to the rest of the architecture as described in CIP Sync Architecture on page 79.

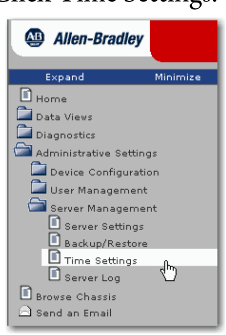
The 1756-EWEB module supports NTP to set its local clock. Once set, the 1756-EWEB module can be configured to set the wallclock of a controller in its local rack. The 1756-EWEB module is not a direct Grandmaster clock, nor does it drive backplane clocks directly. It uses the Logix controller as a time proxy.

Follow these steps to set the controller wall clock.

1. Open the web pages for the 1756-EWEB module.



2. Click Time Settings.



3. Choose Query Controller Clock.

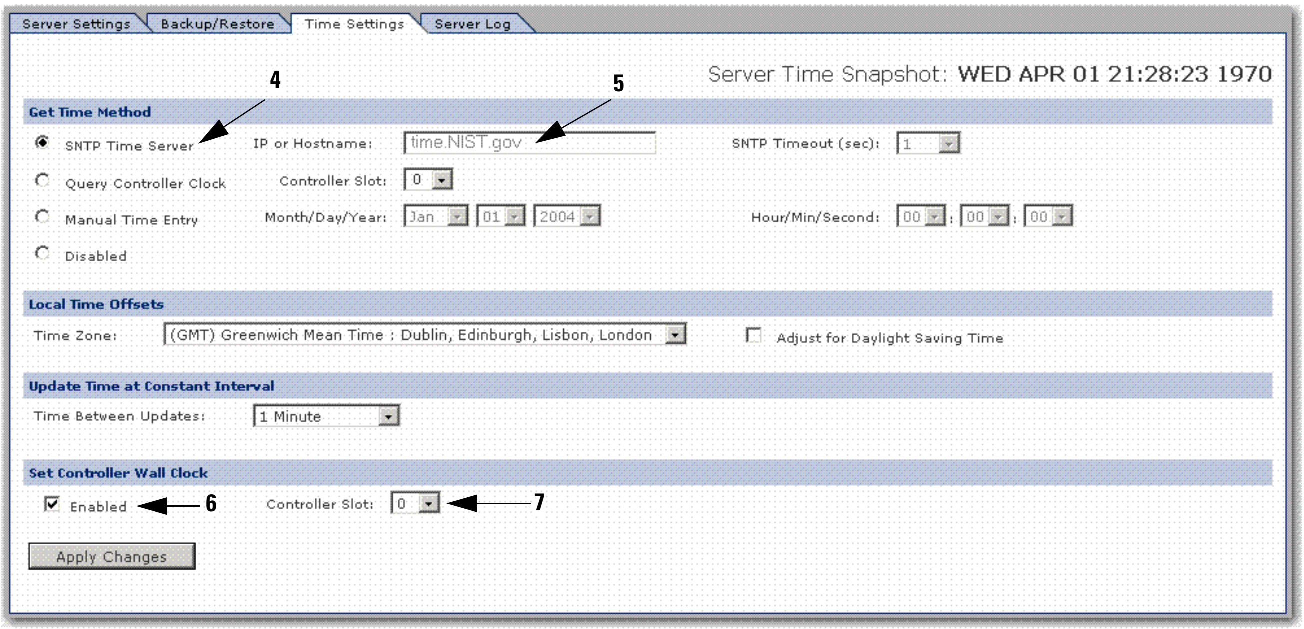
4. Check SNTP Time Server.

5. Assign an IP address or a Hostname.

6. Check Enabled for Set Controller Wall Clock.

7. Enter the slot location of the controller.

8. Click Apply Changes.



We recommend that you not set the Time Zone or check Adjust for Daylight Saving Time for the 1756-EWEB module. Because the controller has separate dialog boxes to manage those, it is best to make those configurations on the dialog boxes of the controller. Your 1756-EWEB module configuration should remain time zone and DST neutral.

Time zone and DST settings do not get transported between controllers by using CIP Sync. Set the Priority 2 level (tie breaker) on the 1756-EWEB module's target wallclock controller to assure it is always the System Time Master.

See Configure Priorities on page 64.

Using the 1756HP-TIME Module

The 1756HP-TIME (GPS) module from Hiprom Technologies has NTP capability built in. Unlike the 1756-EWEB module that uses one controller to distribute time, the 1756HP-TIME module broadcasts time by using CIP Sync after it acquires an NTP time source. This removes some of the inaccuracy inherent in programmatically hand setting a controller wall clock.

For more details on the 1756HP-TIME (GPS) module, see the documentation provided by the manufacturer.

Using the RSLogix 5000 Clock Update Tool

The RSLogix 5000 clock update tool is a free tool provided by Rockwell Automation. This software tool runs on a personal computer or a server and will update the Wall Clock Time (WCT) of one or more Controllers using the PC Clock time. It then distributes it out to one or more controllers. For use with CIP Sync, we recommended that the Clock Update Tool targets only one controller; however, multiple controllers could be selected if you require backup.

Once the clock is set by this tool on one controller, that controller then broadcasts that time to the rest of the system by using CIP Sync. You should set Priority 2 (tie breaker) on the target controller to assure it is always the System Time Master.

See Configure Priorities on page 64.

Using a GPS or IRIG B Interface

Rockwell Automation has partnered with some third-party vendors to create some options for interfacing CIP Sync to a GPS. Specifically, the Hiprom Technologies 1756HP-TIME modules that have interfaces to receive both IRIG B as well as standalone GPS capability. This technology provides the best accuracy for distributed systems. It can reliably provide synchronized time references considerably below 1 ms thresholds across globally distributed systems.

The 1756HP-TIME module has built-in Ethernet ports to directly propagate GPS or IRIG B time received by the module onto the rest of the infrastructure by using CIP Sync. Profiles in RSLogix 5000 software provide simple configuration, setup, and maintenance of the device.

For details on using a 1756HP-TIME module in your system, see the 1756HP-TIME documentation provided by Hiprom Technologies.

Notes:

Setting Up Synchronized Clocks in the Logix System

Introduction

This chapter provides the RSLogix 5000 tasks to configure CIP Sync time. It describes how to set up clock synchronization in Logix systems.

Make sure you verify the CIP Sync time synchronization setup every time you make a change to the system hardware configuration.

Failure to verify the configurations may produce time synchronization errors that can result in injury.

Setup Considerations

CIP Sync time synchronization is designed to function with little or no management. However, depending upon your application requirements, you may want to take on more of the CIP Sync management to obtain specific behaviors.

The following are possible reasons for choosing to manage the CIP Sync system manually you may want to:

- Create a controlled fail-over for replacing a failed Grandmaster.
- Choose the device that sets the time in the control system.
- Prevent time disruptions from occurring when new hardware is added or replaced.

Coordinated Universal Time (UTC) for Time Stamping

By using UTC over a local time throughout the system provides a common time base for events captured over distributed architectures. It is not affected by temporary regional adjustments to time, such as daylight savings time or winter/summer time adjustments or time zone.

For example, an event in Pittsburgh can get time stamped and compared to an event that occurred in Paris by using a common time reference. It also resolves the 1 hour time jump that occurs twice a year as the result of daylight savings time.

For example, FactoryTalk Alarms and Events occurrences are captured time zone independent by using UTC. This shifts the burden of interpreting these time stamps on the visualization tool. When viewed by tools, such as, RSLogix 5000 software or FactoryTalk View SE software, these time stamps get interpreted by the time zone settings of the workstation running the software. This lets you view events that cross multiple time zones by using the same base reference (UTC) with local time overlaid.

Controller Setup

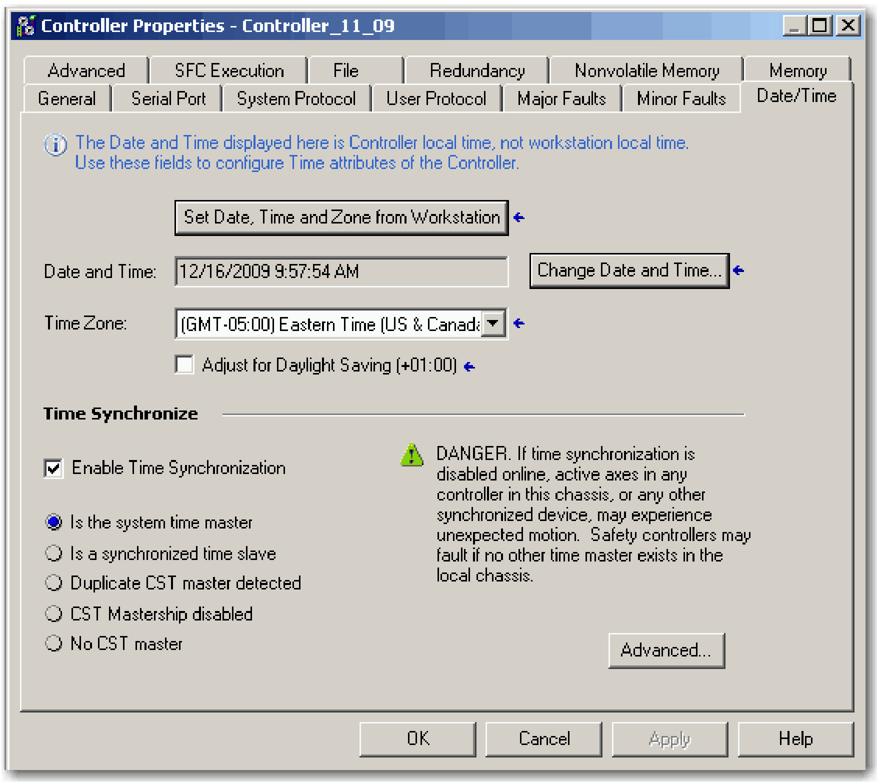
Use the Date/Time tab to configure time and time synchronization for a Logix controller.

Date/Time Tab Parameters

The Date/Time tab parameters include the following:

- Date, Time, and Zone
- Adjust for Daylight Savings Time
- Time Synchronization

Figure 10 - Controller Properties Date/Time Tab



IMPORTANT	Any changes to the Date and Time is propagated to all CIP Sync devices that are synchronized with the controller. CIP Sync does not propagate Time Zone and DST values.

IMPORTANT Setting the time results in a `Hand Set' clock quality. In a system that is not configured, this can result in the controller assuming the Grandmaster role.

SSV and MSG instructions that modify time in the controller will also cause a `Hand Set' clock quality for the controller.

See External Time Sources on page 31.

TIP If you hand set one controller and do not enable and prioritize any of the devices that need to be time synchronized, then the hand set time becomes the Grandmaster.

See CIP Sync System Concepts on page 21 and Grandmaster Clock Selection and Clock Quality on page 26.

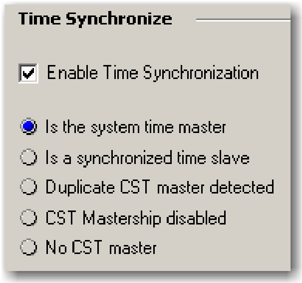
Table 7 - Date/Time Tab Parameters

Parameter	Description
Set Date, Time, and Zone from Workstation	When you click Set Date, Time and Zone from Workstation, RSLogix 5000 software moves the date, time, time zone, and daylight savings settings from the computers' operating system and sends the time settings to the controller. This results in a `Hand Set' clock quality for the controller.
Change Date and Time	Use this parameter to configure the controller date and time. This parameter is disabled when offline. If you have enabled time synchronization, changes to the parameter may not succeed if the device is a Slave. Changes to this parameter could cause this controller to become the Grandmaster of time on the network.
Adjust for Daylight Saving	This checkbox provides a convenient method to determine if the daylight savings time adjustment is currently applied to the wall clock. This provides you with a programmatic way for you to use application code to implement daylight savings time. It is **not** intended to make controller firmware automatically adjust the local clock for Daylight Savings time. Frequent changes to some local standards for the application of daylight savings time (winter/summer time adjustment) would require regular firmware updates for the controller to manage this itself. When you check the DST checkbox, the system immediately adds the DST value (typically 1 hour) to the current value of local time. When you clear the DST checkbox, the system removes the DST value from the clock immediately. It does not perform this operation on any given scheduled time/date scheme unless your application code manages the checkbox. Application sample code is available to configure the actual time and date that your local time zone should implement DST. You can programmatically set or clear the DST checkbox, as well as adjust the amount of offset DST should adjust (typically 1 hour) through the use of GSV and SSV instructions to the wall clock time object. See Where to Find Sample Projects on page 14.

TIP DST settings are not shared between controllers that are using CIP Sync to synchronize.

Table 7 - Date/Time Tab Parameters

Parameter	Description
Time Zone	The Time Zone setting identifies to the controller the offset from the UTC `current value' attributes of the System Time (UTC) versus the `local time' based on the geographical location of the controller. This provides a convenient method to identify the time zone in which the controller resides. You can set system and local time in RSLogix 5000 software. The two attributes are Time Zone and Adjust for Daylight Saving Time. Time Zone identifies the difference between Greenwich Mean Time and the time of your control system's location. Adjust for Daylight Saving Time allows programmatic adjustments through application code to easily adjust for daylight savings time.
TIP	Time Zone settings are not shared between controllers that are using CIP Sync to synchronize.
Enable Time Synchronization	The Enable Time Synchronization checkbox enables time synchronization on the controller. Checking this checkbox enables CIP Sync on the controller to operate as an Ordinary, Master, or Slave clock. See Enable Time Synchronization on page 63.



Status Indicators

This area of the dialog box displays the status time synchronization when you are online. The indicators are blue if the corresponding status condition is true, otherwise it is clear.

Table 8 - Time Synchronize Status Descriptions

Status Indicator	Description
Is the system time master	This controller is the Grandmaster clock for the system. The Grandmaster clock identity matches the local controller clock identity. If this is the only status lamp lit, then this also indicates that this is the CST backplane Master.
Is a synchronized time slave	This controller is not the Master; it is synchronized to another device, which may be the Grandmaster or a boundary clock that provides a communication path to the Grandmaster. If this is the only status indicator highlighted, then this also indicates that this is a CST backplane Slave.
Duplicate CST master detected	This controller is attempting to become the CST Master in the local chassis, but some other device is currently acting as the CST Master. This may be caused by other devices in the chassis running earlier revisions of firmware.
CST Mastership disabled	This controller will not become a CST Master, but it may still become a CST Slave. This is a special condition for compatibility with older devices, and must be set by using a CIP message.
No CST master	No device on the backplane is providing CST Mastership.

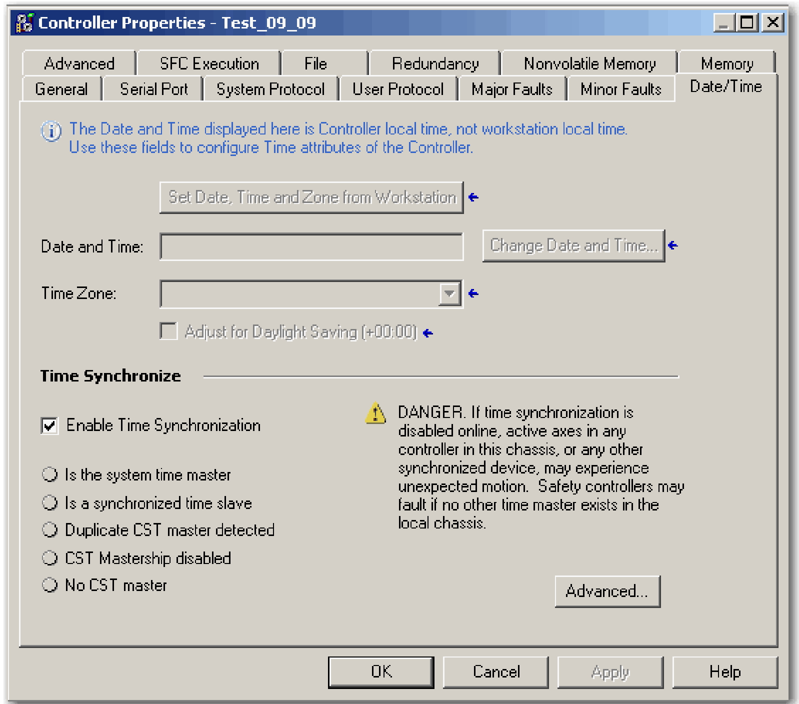
TIP When no status indicators are highlighted and the `Enable Time Sync' checkbox is not checked, the controller is a CST Slave listening to some other CST Master on the backplane.

Enable Time Synchronization

These are the steps to enable time synchronization in the controller.

1. In RSLogix 5000 software, right-click the controller and choose Properties.

2. Click the Date/Time tab for your controllers.



3. Check Enable Time Synchronization.

4. Click OK.

   This enables the controller to participate in time synchronization and also allows the controller to participate in the CIP Sync and CST Master selection process.

TIP You must enable time synchronization for at least one of 1756-EN*x*T*x* communication modules in the chassis if you want time to be shared external to the chassis.

See Communication Modules Set Up on page 66.

In the ControlLogix rack, there are two time references that are propagated on the Logix backplane. One is System Time and the other is CST time. Both are managed by CIP Sync. Typically these two references are driven by the same device in the ControlLogix rack.

Configure Priorities

There are cases where you might want to override the Best Master Clock Algorithm to choose a different Grandmaster:

- There are a number of clocks with similar quality values, and you have additional knowledge about the reliability or availability of these clocks.
- You do not want the clock choice to be based on arbitrary values, such as device serial numbers or MAC addresses.
- You do not want the clock choice to change when modules are replaced for maintenance purposes.

In these cases, changing the Priority 1 or Priority 2 attributes of the clock can make it easier to predict or control which clock is chosen as the Grandmaster.

Set Clock Priorities

Follow these steps to set the clock priorities.

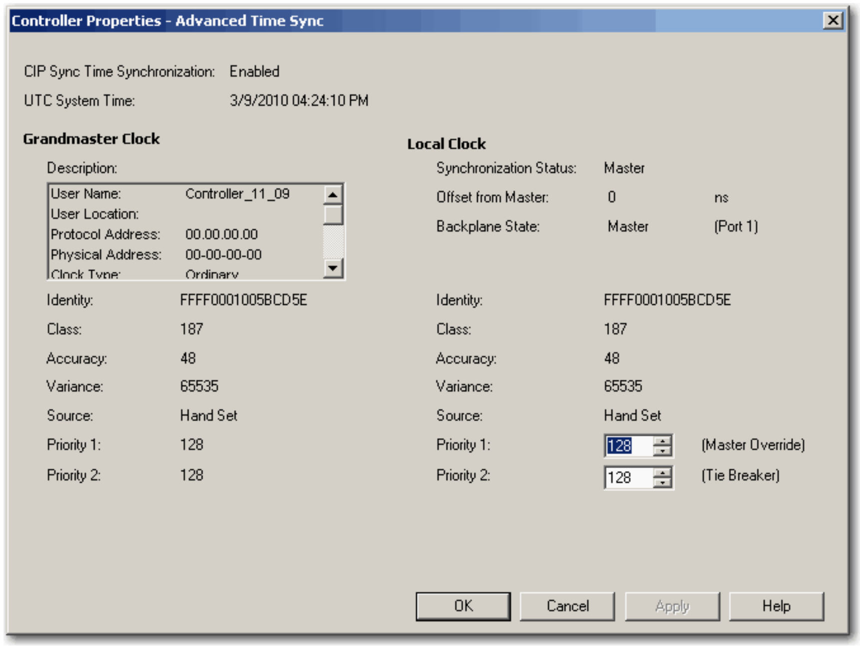
1. In the Controller Organizer, right-click the controller and choose Properties.

   The Controller Properties dialog box appears.

2. Click the Date/Time tab.

3. Click Advanced.

   The Advanced Time Sync dialog box appears.

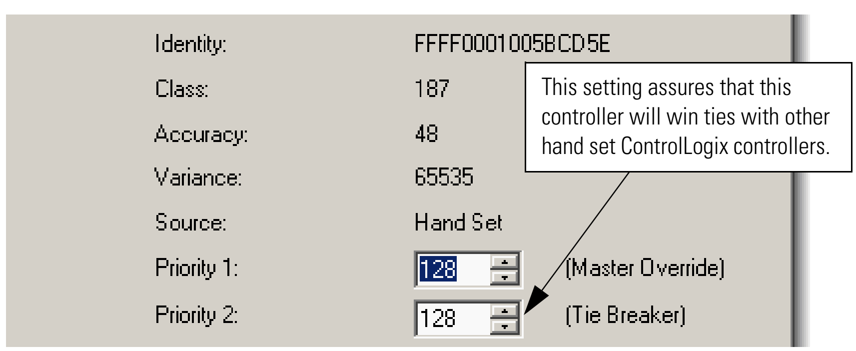


4. Under Local Clock, enter the Priority 1 or Priority 2 value.

   On the controller that you want to be the Grandmaster, choose a lower value than all the other controllers in the system.

IMPORTANT	If you change the Priority settings while online, this may cause a change to the Grandmaster.

Your selection depends on whether you want to override the actual clock quality values (Priority 1) or override a tie (Priority 2) between two devices that are equal in clock quality. The priority values range from 0...255, with zero (0) being the highest priority.



See Best Master Clock Algorithm on page 43.

5. Click Apply.

Communication Modules Set Up

Follow these instructions to add an Ethernet communication module to your project (catalog numbers 1756-EN2T, 1756-EN2F, 1756-EN2TR, 1756-EN3TR).

IMPORTANT	For all communication modules, use the firmware revision that goes with the firmware revision of your controller. See the release notes for your controller's firmware.

In order to have a controller synchronize its clock to a Grandmaster out on the network, or to have a controller in a chassis be the Grandmaster on the network, you must configure at least one 1756-EN*x*T*x* module in the local chassis for Time Sync operation.

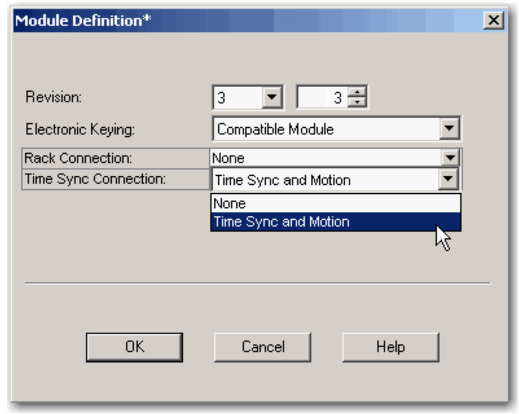
Configure the 1756-EN*x*T*x* Communication Modules

You need to configure the EtherNet/IP communication modules to have the System Time shared between the backplane and Ethernet devices.

Follow these steps to configure the modules.

1. In RSLogix 5000 software, open the Module Properties for your Ethernet communication module.
2. Click Change to open the Module Definition dialog box.

3. From the Time Sync Connection pull-down menu, choose Time Sync and Motion Connection for all the Ethernet modules that you want to participate in CIP Sync.



IMPORTANT	CIP Sync with ControlLogix, revision 18 or later is compatible with the 1756-EN2T, 1756-EN2F, 1756-EN2TR, and 1756-EN3TR communication modules, firmware revision 3.0, or later. Upgrade earlier revisions of these modules to firmware revision 3.0 or later. The 1756-ENBT and 1756-ENET modules are not CIP Sync-capable, but can intermix with other communication modules.

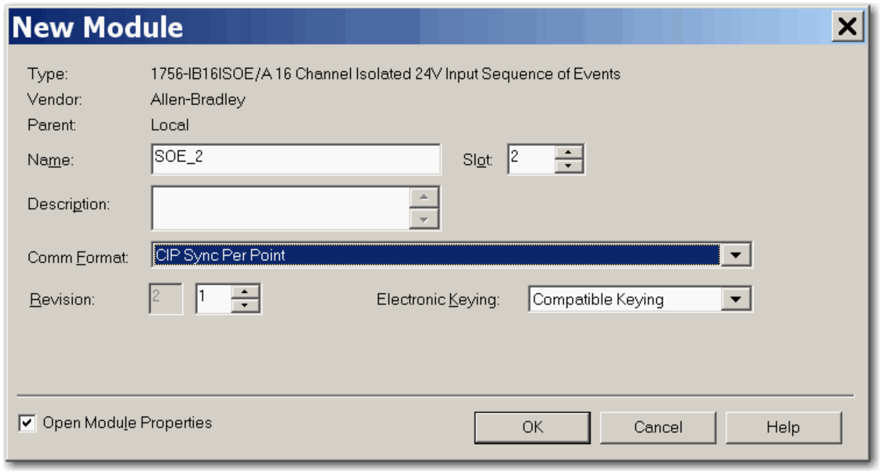
IMPORTANT	Once the Time Sync and Motion connection has been established to the communication module, time synchronization remains enabled until the Time Sync and Motion connection is set to 'None', the project is re-downloaded, and a power cycle has occurred on the module.

Sequence of Events Modules Set Up

In order to have a the I/O modules synchronize to a Grandmaster out on the network, you must configure all 1756-IB16ISOE I/O modules for Time Sync operation.

When you add a new I/O module to your project, enable time synchronization by setting the Communication Format to CIP Sync Per Point.

IMPORTANT	For all I/O modules, use the firmware revision that goes with the firmware revision of your controller. See the release notes for your I/O module's firmware.



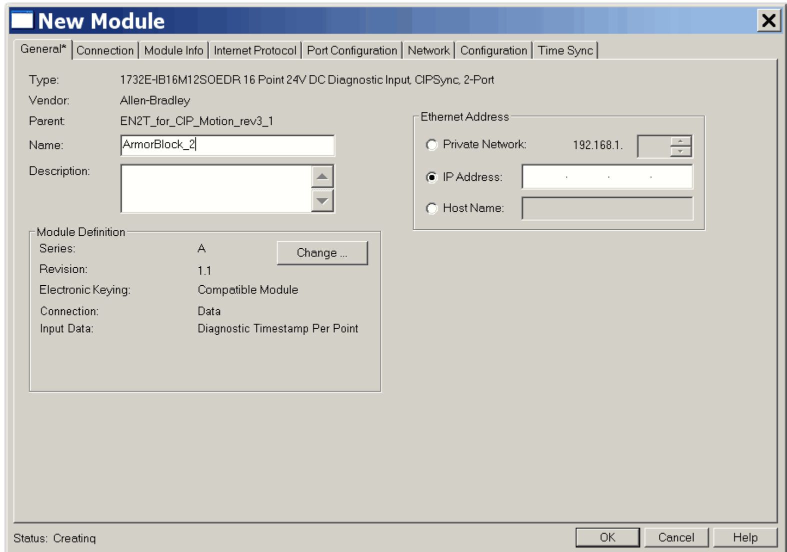
This parameter can be found in 1756-IB16ISOE Module Properties on the General tab.

ArmorBlock 2-Port Ethernet Module Set Up

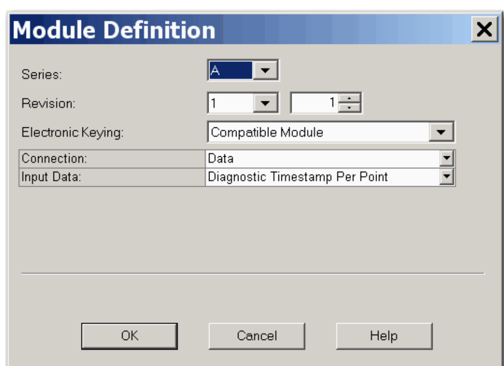
In order to have a the ArmorBlock I/O modules synchronize to a Grandmaster out on the network, you must configure all 1732E-IB16M12SOEDR modules for Time Sync operation.

IMPORTANT	For all I/O modules, use the firmware revision that goes with the firmware revision of your controller. See the release notes for your I/O module's firmware.

When you add a new I/O module to your project, enable Time Sync by changing the Module Definition on the General tab in Module Properties.



1. Go to the General tab in Module Properties.
2. Click Change.
3. The Module Definition dialog box appears.



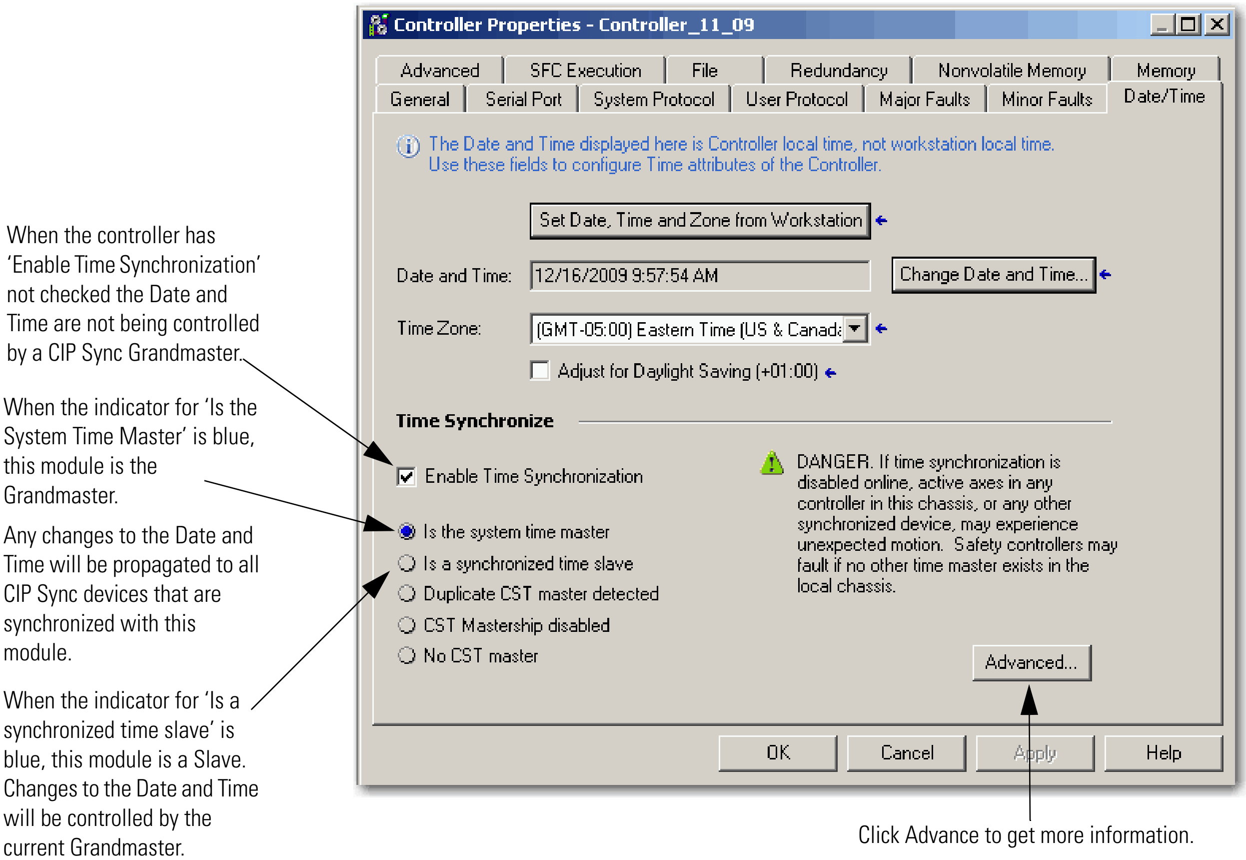
4. In the Input Data field, choose Diagnostic Timestamp Per Point.
5. Click OK.

Time Sync Diagnostics

This section discusses the ways to identify, validate, and diagnose time synchronization.

Identify the Current Grandmaster

To identify which device is currently regulating System Time, use the Controller Properties dialog box, Date/Time tab while you are online with the controller.



See Status Indicators on page 62 for additional descriptions.

Validate the Grandmaster

These are examples of online displays in RSLogix 5000 software illustrating the Grandmaster for these devices:

- 1756-L63 ControlLogix Controller
- 1756-EN2T EtherNet/IP Communication Module
- 1756-IB16ISOE Sequence of Events Module
- 1732E-IB16M12SOEDR ArmorBlock Digital I/O Module
- 1756HP-TIME, Hiprom Technologies GPS Module

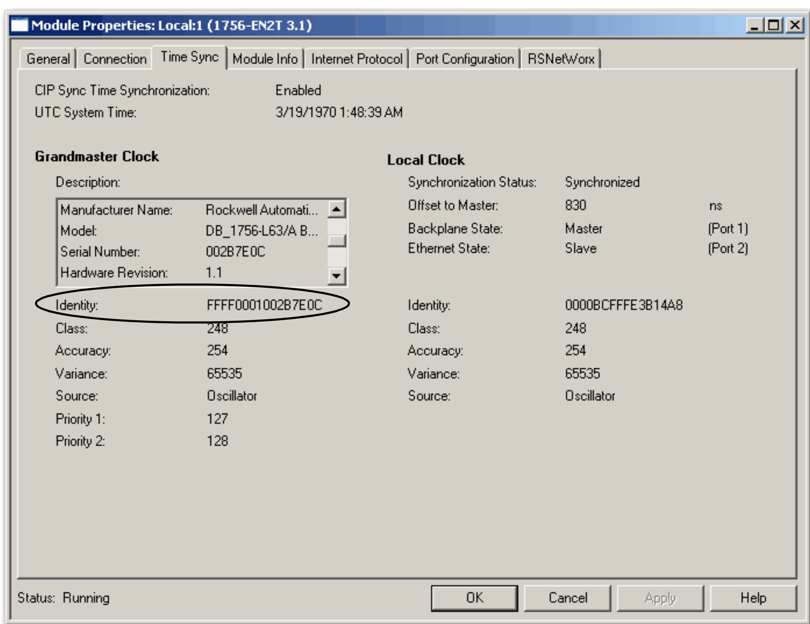
Validate the Controller as a Grandmaster

The local controller clock information, along with information about the current Grandmaster in the system, can be found on the Date/Time Advanced dialog box.

Being synchronized with a Master may not be enough to validate that your system is working as you intended. You need to make sure that all Slaves are synchronized with the Grandmaster.

1. In RSLogix 5000 software, go online with the controller.
2. Click the Date/Time tab for the controller or 1756-EN*x*T*x* module.
3. Click Advanced.

   The Advanced Time Sync dialog box appears.

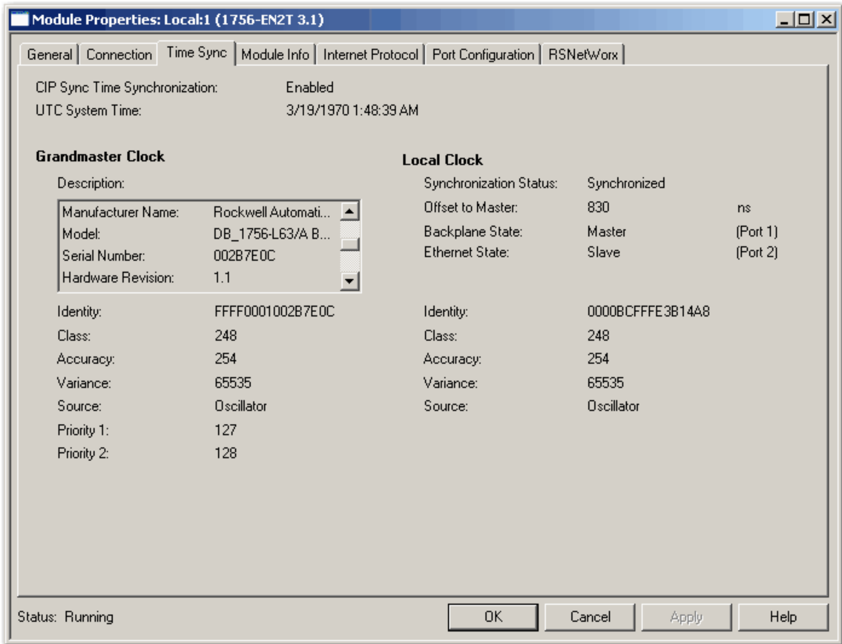


4. Make note of the Grandmaster Identity and verify that all Slaves are synchronized to that controller as the Grandmaster.

See Identity on page 77 for information on how to decode the Identity number.

Validate the 1756-EN2T Communication Module as a Slave

The Time Sync dialog box for the 1756-EN2T communication module shows the Grandmaster for the device.



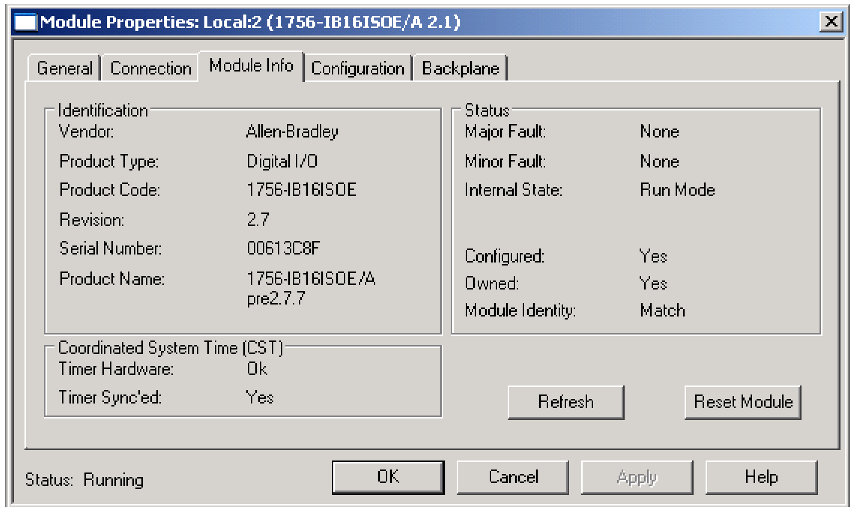
For more information about installing and configuring 1756-EN*x*T*x* communication modules, see Additional Resources on page 15.

Validate the Grandmaster on an SOE Module

The module Timer sync'ed info can be found under the Module Info tab for the 1756-IB16ISOE and 1756-IH16ISOE Sequence of Events modules, firmware revision 2 or later.

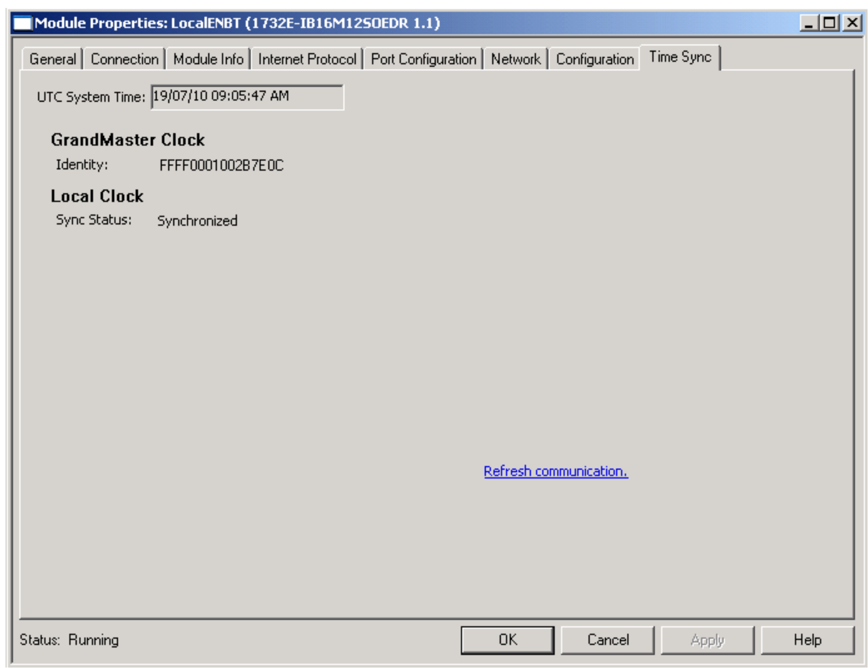
If the Timer Sync'ed displays 'Yes', then the SOE module is synced to the Master of the chassis. This Master could be a 1756-L6*x* or 1756- L7*x* controller or a 1756- EN2T*x* module which in turn should be synced to the Grandmaster on the network.

Figure 11 - 1756-IB16ISOE Module Properties Module Info Tab



This is an example of the online Time Sync tab for the 1732E-IB16M12SOEDR ArmorBlock I/O module.

Figure 12 - 1756-IB16M12SOEDR Module Properties Time Sync Tab



For more information about installing and configuring a 1732E-IB16M12SOEDR ArmorBlock I/O module, see Additional Resources on page 15.

Advanced Time Sync Dialog

The Advanced Time Sync dialog box provides detailed attribute information about the Grandmaster and local clocks. The content of the local clock description is controlled by the local device. The content of the Grandmaster clock description is controlled by the vendor of the Grandmaster device.

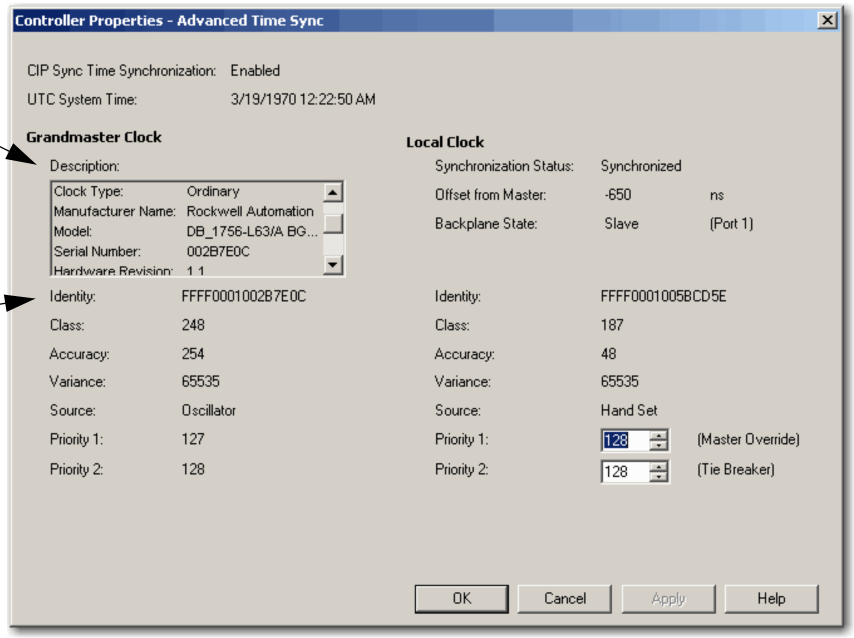
Figure 13 - Controller Properties Advanced Time Sync Dialog Box

The Description field is not always implemented by the device, but does provide the Identity.

Logix controllers automatically insert the Name and Description from the Controller Properties/General tab as the User Name value.

The Identity displays the unique identifier for the clock. The format depends on the network protocol.

See the Identity parameter in the Time Sync Property Parameters on page 77 for an explanation on how to decode the Identity ID.



TIP By comparing the attributes for the Grandmaster (left side) to those on the right side, you see that the current Grandmaster has better quality attributes than the Local device so it has been selected as the Grandmaster.

Time Sync Tab

Most CIP Sync devices have a Time Sync dialog box or a Property page. Use this information to find out which device is currently regulating System Time and to set local clock priorities. You can also determine the synchronization of a device.

The Time Sync dialog box appears for the following:

- 1756-L6*x* or 1756-L7*x* controller properties on the Date/Time tab as an Advanced button
- 1756-EN*x*T*x* communication module properties on the Time Sync tab
- 1756-IB16ISOE Sequence of Events module on the Time Sync tab
- 1732E-IB16M12SOEDR ArmorBlock Sequence of Events module properties on the Module Info and Time Sync tabs
- 1756HP-TIME GPS module on the Time Sync tab
- Drive Profiles module properties on the Time Sync tab

When the controller is offline or Time Synchronization is disabled, all fields except CIP Sync Time Synchronization and priority fields are blank. The priority fields and Time Synchronization state are available when the controller is offline or online.

TIP Clock data appears only when you are online and you have Time Synchronization enabled.

Table 9 - Time Sync Property Parameters

Parameter	Description
CIP Sync Time Synchronization	Indicates if Time Synchronization is enabled or disabled on the controller or in the offline project file.
UTC System Time	Displays the current System Time in Coordinated Universal Time (UTC). The time does not include time zone or daylight savings time offsets.
Grandmaster Clock	Displays the clock property information for the Grandmaster clock.

Table 9 - Time Sync Property Parameters

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>Description</td><td>Displays information about the Grandmaster clock. This information is controlled by the vendor of the Grandmaster device. The following information appears, if available.
<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>User Name</td><td>The name of the device that contains the clock. If the Grandmaster clock is a ControlLogix controller, this is the text entered in the Name and Description field on the General tab in the Controller Properties dialog box.</td></tr>
<tr><td>User Location</td><td>The location of the device.</td></tr>
<tr><td>Protocol Address</td><td>The protocol address of the device, for example, the IP address or slot number for the controller.</td></tr>
<tr><td>Description</td><td>Displays information about the Grandmaster clock. This information is controlled by the vendor of the Grandmaster device. The following information is displayed, if available.</td></tr>
<tr><td>User Name</td><td>The name of the device that contains the clock. If the Grandmaster clock is a ControlLogix controller, this is the text entered in the Name and Description field on the General tab in the Controller Properties dialog box.</td></tr>
<tr><td>User Location</td><td>The location of the device.</td></tr>
<tr><td>Protocol Address</td><td>The protocol address of the device, for example, the IP address or slot number for the controller.</td></tr>
<tr><td>Clock Type</td><td>The type of clock: these are the available clock types.
• Ordinary
• Boundary
• Transparent
• Management</td></tr>
<tr><td>Manufacturer Name</td><td>The name of the manufacturer of the clock.</td></tr>
<tr><td>Model</td><td>The model of the clock.</td></tr>
<tr><td>Serial Number</td><td>The serial number of the clock.</td></tr>
<tr><td>Hardware Revision</td><td>The hardware revision of the clock.</td></tr>
<tr><td>Firmware Revision</td><td>The firmware revision of the clock.</td></tr>
<tr><td>Software Revision</td><td>The software version of the clock.</td></tr>
<tr><td>Profile Identity</td><td>Identifies the PTP profile of the clock.</td></tr>
<tr><td>Physical Protocol</td><td>The physical layer protocol defining the physical address, for example, IEEE 802.3.</td></tr>
<tr><td>Network Protocol</td><td>The upper layer protocol of the network. These are examples:
• UDP/IPv4, for the EtherNet/IP network
• Local, for example, ControlBus</td></tr>
<tr><td>Port Number</td><td>The port number of the device for the port specific parameters.</td></tr>
</table>
</td></tr>
</table>

Table 9 - Time Sync Property Parameters

Parameter	Description
Identity	Displays the unique identifier for the clock. The format depends on the network protocol. For ControlLogix controllers, the Identity is prefixed with FFFF followed by the Rockwell Automation vendor ID (0001) and serial number. For example, if the serial number of a controller was 00221fdb, the CIP Sync Identifier would be FFFF000100221FDB. For Rockwell Automation Ethernet network devices, the MAC address is encoded into the identifier, padded with FFFE in the center. For example, a 1756-EN*x*T*x* module with a MAC address of 00 00 bc 3c 4b 9b would have a CIP Sync Identifier value of 0000BCFFFE3C4B9B.
Class	Displays a measure of the traceability of the clock to primary reference sources. This is predefined by the device manufacturer. Values are defined from 0…255 with zero (0) as the best clock. Clocks with Class values less than 128 may only be Master clocks.
Accuracy	Indicates the expected absolute accuracy of the clock relative to the clock epoch of January 1, 1970. The accuracy is specified as an enumerated logarithmic scale, where 32 indicates time is accurate to within 25 ns, 48 indicates time is accurate to within 10 seconds, and 49 indicates time is accurate to > 10 seconds, and 254 indicates accuracy is unknown. The lower the accuracy value, the better the clock.
Variance	Displays a measure of the inherent stability properties of the clock. The value is represented in offset scaled log units. The lower the variance, the better the clock.
Source	Displays the time source of the clock. These are the available values: • Atomic clock • GPS • Radio • PTP • NTP • HAND set • Other • Oscillator
Priority 1 / Priority 2	Displays the relative priority of the clock to other clocks in the system. The priority values range from 0…255. The highest priority is zero (0). The default value for both settings is 128.
Local Clock	Displays clock property information for the controller's local clock. The definitions for the Identity, Class, Accuracy, Variance, and Source parameters are the same for the local clock and the Grandmaster clock.
Synchronization Status	Specifies whether the local clock is synchronized or not synchronized with the Grandmaster reference clock. A clock is synchronized if it has one port in the Slave state and is receiving updates from the time Master.
Offset from Master	Displays the amount of deviation between the local clock and the Grandmaster clock in nanoseconds, updated every sync interval.

Table 9 - Time Sync Property Parameters

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>Backplane State</td><td>Displays the controller's port state. These are the available values:
• Initializing
• Faulty
• Disabled
• Listening
• PreMaster
• Master
• Passive
• Uncalibrated
• Slave
The devices that have multiple ports, such as 1756-ENxT modules, have independent states for each port.</td></tr>
<tr><td>Priority 1 (Master Override)</td><td>Enter the Priority 1 setting for the controller's local clock. Priority 1 overrides the actual clock quality values (class, accuracy, and variance).

The Best Master Clock Algorithm evaluates Priority 1 before any other value. You can change this value to override the automatic selection of the best Master clock before quality is evaluated.

For example, a GPS clock typically wins arbitration over a 1756-L63 controller. Changing the 1756-L63 controller Priority 1 setting to a lower value lets it win arbitration over the GPS clock.

The priority values range from 0…255. The highest priority is zero (0). The default value is 128.

IMPORTANT Any adjustments to the Priority 1 value should be made with great care. It is designed to override the actual clock quality, so any potential improvements to Grandmaster stability incur a risk of reduced clock accuracy. Changing this value can cause an uninitialized clock to become Grandmaster, thereby resetting the entire CIP Sync domain to 1/1/1970 or some other inaccurate time.</td></tr>
<tr><td>Priority 2 (Tie Breaker)</td><td>Enter the Priority 2 setting for the controller's local clock. The Best Master Clock Algorithm evaluates Priority 2 after evaluating the clock quality (class, accuracy, and variance).

You can change this value to override the automatic selection of the best Master clock after quality has been evaluated. Priority 2 overrides a tie-breaker between two devices that are equal in clock quality.

For example, a system has two 1756-L63 controllers with hand set clocks. Both clocks have the same clock quality. The tie would be decided by the controller's serial number. Changing the Priority 2 setting to a lower value lets you decide which clock wins arbitration instead of the serial number.

The priority values range from 0…255. The highest priority is zero (0). The default value is 128.</td></tr>
</table>

CIP Sync Architecture

Introduction

This chapter outlines different control system architectures that support CIP Sync functionality.

Types of Control System Architectures

The control system architectures illustrated in this section are examples. The intention is to provide you with an overview of possible hardware configurations. The control system architectures include a star, linear, device level ring (DLR), and a combination of the three on the same VLAN system.

Hardware and Software Requirements

This table lists the required and optional components to implement the CIP Sync architecture.

Table 10 - Required and Optional Components

Component	R/ O	Description
RSLogix 5000 programming software, version 18.0.0 or later	R	RSLogix 5000 software offers symbolic programming with structures and arrays, and a comprehensive instruction set that serves many types of applications. It provides ladder logic, structured text, function block diagram, and sequential function chart editors for program development.
1756-L6*x*, 1756-L7*x* ControlLogix controller, firmware revision 18.0.0 or later	R	RSLogix 5000 software, version 18.0 or later, enables these controllers to operate as time Masters or to synchronize its time to other time Masters.
1756-L6*x*, 1756-L7*x* ControlLogix controllers, firmware revision 19.50 or later, configured as a ControlLogix Redundant chassis pair	O	In a ControlLogix redundancy system, revision 19.50 or later, the controller in the Secondary chassis loses arbitration to the controller in the Primary chassis. Enabling Time Synchronization in the Primary controller also enables it in the Secondary controller. Clock quality attributes automatically adjust so the controller in the Secondary chassis will not become Grandmaster.
1756-EN*x*T, 1756-EN*x*TR, and 1756-EN*x*F EtherNet/IP communication modules, firmware revision 3.0 or later	R	These modules operate as a CIP Sync Boundary clock to synchronize the backplane and other Ethernet clocks to ±100 ns with the use of a Stratix 8000, 1588 Ethernet Managed Switch. For ControlLogix redundant systems, the communication modules can reside in the redundant chassis, but only if the controller firmware is at revision 19.50 or later. The communication module firmware must be at revision 4.0 or later.
1756-IB16ISOE or 1756-IH16ISOE input modules, firmware revision 2.0 or later	R/O	These modules are specifically designed for SOE applications. They are capable of returning time stamps with worst case accuracy for all 16 points of 100 µs. They also have the ability to buffer up to 150 I/O point transitions locally to alleviate burst conditions that might otherwise cause data loss at the controller when multiple transitions occur in a short time frame: • The SOE modules return time stamps for each I/O point transition as a 64-bit number (two 32-bit words). • If you choose CIP Sync as the communication format when you add the module to your project, a UTC Time Stamp value is returned and you will have the ability for diagnostics. • If you choose a non-CIP communication format when you add the module to your project, a CST Time Stamp value is returned.

Table 10 - Required and Optional Components

Component	R/ O	Description
1732E-IB16M12SOEDR, EtherNet/IP ArmorBlock I/O module supporting Sequence of Events applications	R/O	This module is specifically designed for SOE applications and can be connected to network topologies that use a Linear and/or Device Level Ring (DLR). They are capable of returning time stamps with worst case accuracy for all 16 points of 100 µs. They also have the ability to buffer up to 150 I/O point transitions locally. This alleviates burst conditions that might otherwise cause data loss at the controller, when multiple transitions occur in a short time frame. The SOE modules return time stamps for each I/O point transition as a 64-bit number (two 32-bit words). When CIP Sync is chosen as the communication format for the module, a UTC Time Stamp value is returned.
1756HP-TIME	R/O	This is a GPS module that can reside in a ControlLogix chassis. It is used as the time source that introduces UTC time into the ControlLogix control system. This module can be used in a single control system or in a system that has multiple subsystems in different geographical areas. This module is equipped with a two port Ethernet switch that has CIP Sync capabilities. This Ethernet switch is a Transparent Clock and the GPS module can be configured as the Grandmaster on the network.
Stratix Ethernet switches: 1783-MS10T Stratix 8000, 1783-EMS08T Stratix 6000, 1783-US08T Stratix 2000	O	The 1783-MS10T Stratix 8000 switch is a fully-functional Layer 2 managed Ethernet switch. It has CIP Sync capabilities and is configured to be in Transparent Clock mode with QoS enabled by default. The switch supports three modes: Transparent Clock, Boundary Clock, and Forward. A Stratix 8000 switch supports only boundary and transparent PTP operation on the base unit (catalog number, 1783- MS10T) chassis. The expansion modules, for example, catalog number 1783-MX08T, revision 5 or earlier, do not operate as boundary or transparent clocks, and do not pass PTP protocol packets when the base unit is set to those modes. Transparent Clock mode compensates for packet propagation delay to improve accuracy. Packet propagation delay increases time synchronization accuracy between the Grandmaster device and its Slave devices. The 1783-EMS08T Stratix 6000 switch is a managed Ethernet switch that will forward PTP packets but has no CIP Sync capabilities. The 1783-US08T Stratix 2000 switch is an unmanaged Ethernet switch that will forward all types of traffic: • If you plan to use an unmanaged Ethernet switch that is not IEEE-2008 compliant, expect some PTP propagation delay. • In most cases, this is not a concern because your average SOE application requires 1 µs resolution. The QoS feature becomes important when you introduce other forms of traffic to the network, like streaming video and/or voice over I/P (VoIP). This traffic may delay the delivery of the more critical PTP packets.

Table 10 - Required and Optional Components

Component	R/ O	Description
Ethernet routers: 1783-RMS06T 4 10/100BASE-T 1783-RMS10T 8 10/100BASE-T	O	These devices are fully-functional Layer 3 routers with IEEE 1588-2008 enabled hardware. When 1756-L6*x* and 1756-L7*x* ControlLogix controllers and 1756-EN*x*T*x* communication modules are acting as Grandmasters, the TTL is set to 1 and does not pass through routers. Within a ControlLogix chassis, enabling CIP Sync on multiple 1756-ENxT modules that are on different EtherNet/IP subnets produces the effect of merging those subnets into a single CIP Sync domain. Other products capable of being a Grandmaster may have the ability to pass through routers. Some routers, such as the Stratix 8300 switch, have IEEE 1588-2008 enabled hardware. This enabled hardware is recommended when crossing subnets.
1756-IF4FXOF2F	O	This is a high-speed analog I/O combination module that provides an analog reference with a time stamp for analog SOE operations. Use CST time instead of UTC time. You can programmatically convert between these time formats. Sample code is available at http://samplecode.rockwellautomation.com. Search for the CIP Sync SOE code by typing the phrase `Clock Timing' in the Technologies and Functionalities search box
1756-OB16IS	O	This is a scheduled output module that lets you schedule the output state up to 16 seconds in the future.

Selecting a Switch for CIP Sync

Because CIP Sync is based on the standard IEEE 1588-2008 protocol, a wide selection of switches to transport that time throughout the infrastructure are available. Your selection of switch should be based on a couple of criteria.

TIP For information about tools that can assist you in understanding, planning, and configuring an Integrated Architecture System, see Integrated Architecture Tools at http://www.rockwellautomation.com/solutions/integratedarchitecture/resources3.html.

The following are questions that you need to answer when selecting a switch. These are examples, your specific application should be evaluated individually.

Table 11 - Criteria for Selecting a Switch

Question	Answer	Transparent Clock	Boundary Clock	No 1588 PTP Clock
How many layers separate your Grandmaster from your furthest end device? (How many switches, boundary clocks, or transparent clocks?)	<7 devices between Master and Slave	✓	✓	✓
	>7 devices between Master and Slave	✓		
What type of precision do you require between your nodes?	Motion Applications <10 µs	✓		
	Most Power Distribution Infrastructure <1 ms	✓	✓	✓
	Most Industrial First Fault and Alarming Applications >1 ms	✓	✓	✓
What kind of traffic will this network see?	Many large packets, for example, streaming video, large print queues ≥ 1500 bytes packet size	✓	✓	
	Normal Automaton Layer Traffic <1500 bytes packet size	✓	✓	✓
Will you be supporting motion control and is there a risk of devices being added to your infrastructure later?	Yes	✓		
How many Slaves per Grandmaster? For example: • 1756HP-TIME module • 1756-EN*x*T*x* module	<100		✓	
	>100	✓	✓	

Once you have answered these questions, you can apply that knowledge when selecting the correct switch for your infrastructure. There are basically three levels of implementation for IEEE 1588-2008 available today in common Ethernet switches: no adoption, boundary clocks, and transparent clocks.

No Adoption

No adoption means the switch has not implemented any portion of the IEEE 1588-2008 standard. These switches can be used quite successfully on many industrial applications that do not have extremely tight synchronization requirements and do not have many layers between the Grandmaster and final Slave nodes.

Large packets, high volumes of traffic, and just the general indeterministic nature of the switch to transport the synchronization packets will, of course, impact the systems overall accuracy. For general time stamping, this switch is usually sufficient.

For applications that contain Integrated Motion on EtherNet/IP, this switch is typically not recommended unless tight control can be placed on the network traffic and devices. Large packets and high volumes of traffic will impact drive performance.

Boundary Clock

When the architecture has many Slave clocks continually requesting delay measurements, this can stress the Grandmaster. Boundary clocks reduce the load on the Grandmaster by responding to the delay requests locally.

A boundary clock lessens the effect of highly-variable network loading on CIP Sync time accuracy. It propagates a high-quality Grandmaster clock to multiple subnets and translates CIP Sync packets between physical network types, for example, translating packets between the EtherNet/IP network and the ControlLogix chassis backplane.

A boundary clock becomes a Slave to a higher quality Grandmaster clock, and a Master clock to the rest of the architecture. These systems do a good job of coordinating time and are less susceptible to architectural depth and system traffic than switches with no level of implementation. They also have the unique ability to present themselves as a Master to the rest of the architecture.

Their final ability to synchronize time, however, is impacted by each individual clocks' ability to synchronize with the Grandmaster clock above it, so any inaccuracy of one clock reflects throughout the architecture. Also, the system's ability to synchronize when transporting large packets of data can interrupt the systems' ability to synchronize tightly. For general time stamping, this switch is usually sufficient.

Transparent Clock

Transparent clock uses the Grandmaster clock and pass through with delay compensation. This implementation uses a correction factor as an offset to the current time. The correction factor is a measurement of the difference between when the PTP packet entered the switch versus when it exited.

Every transparent clock adds its delay time to the correction field of the PTP packet. When the time is then received by an end node, it knows to use the transported time and the correction factor as the real time.

This implementation can create a very accurately synchronized system independent of traffic through the switch, or the number of devices between the Grandmaster clock and the end node. This type of switch provides the highest level of performance for most small-to-medium sized CIP Sync architectures.

Control System Architecture Scenarios

CIP Sync provides a mechanism to tightly synchronize clocks between ControlLogix controllers, a select group of I/O modules, and other automation products in your architecture. Below are scenarios that describe ways that you can lay out a Control System Architecture for Time Sync applications.

Star Topology with the ControlLogix Controller as the Grandmaster

This scenario consists of multiple remote racks using the CIP Sync protocol in a network configured for a Star topology. The time source for the Grandmaster clock is the ControlLogix controller.

Hardware Setup

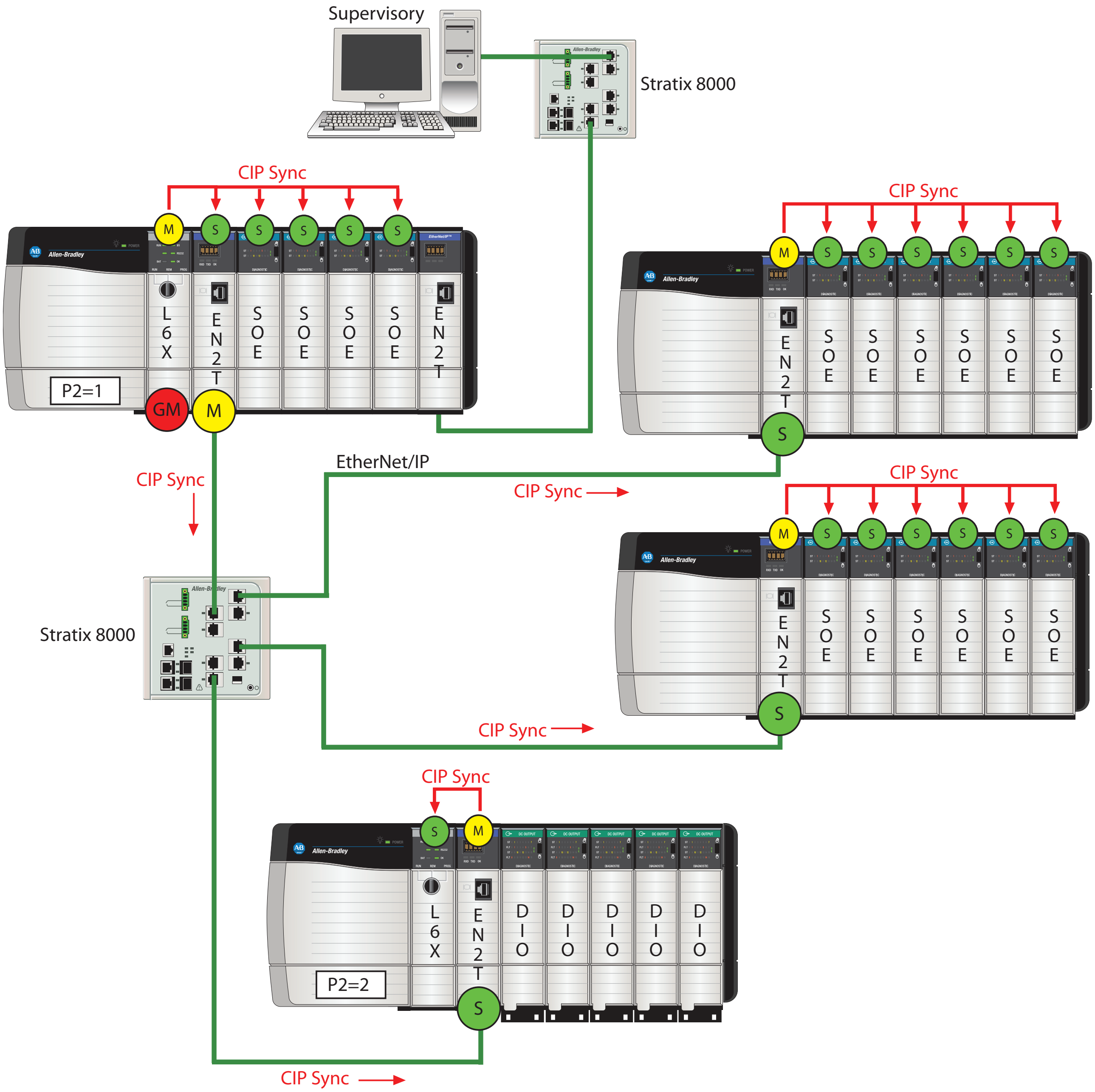
This example system consists of the following hardware:

- One (or multiple) 1756-L6*x* or 1756-L7*x* ControlLogix controller, firmware revision 18.0 or later.
- A Stratix 8000 Ethernet Managed Switch with CIP Sync configured to be a transparent clock with QoS enabled.
- Several 1756-EN*x*T*x* communication modules, firmware revision 3.0 or later.
- Several 1756-IB16ISOE input modules, firmware revision 2.0 or later, that provide time stamps for actual field I/O. This module is also available in 120V DC.
- Supervisory level hardware
  - A Stratix 8000 Ethernet Managed Switch with CIP Sync protocol, configured to be a Transparent Clock with QoS enabled.
  - One 1756-EN*x*T communication module that provides a path to a supervisory computer.
  - A supervisory computer.

  In this scenario, the supervisor is illustrated on its own network. It can just as easily be attached on an existing Stratix 8000 switch.

See Hardware and Software Requirements on page 80 for detailed device descriptions.

Figure 14 - Star Topology with the ControlLogix Controller as the Grandmaster



GM = Grandmaster (time source)

M = Master

S = Slave

P1 and P2 = Priorities

Scenario Setup

This table describes the setup for multiple remote racks using the CIP Sync protocol in a network configured for a Star topology with the ControlLogix controller being the time source for the system.

Table 12 - Set-up Steps for a Star Topology with the ControlLogix Controller as the Grandmaster

Setup	Description
1. Choose what device to use for the Grandmaster time source.	The ControlLogix controller in this example has the best clock quality so it is the Grandmaster. The time value of the controller is represented as WCT. In this example, time is being `Hand Set' in the controller. Priority parameters predict which device wins arbitration and becomes the Grandmaster on the network. Priority 2 values are set in this scenario to resolve ties between multiple controllers. Priority 2 values range from 0 (highest priority) to 255 (Lowest Priority) with the default being 128. See Configure Priorities on page 52.
2. Enable CIP Sync for each controller.	To enable CIP Sync functionality in a ControlLogix controller, check the Enable Time Synchronization checkbox in RSLogix 5000 software. See Enable Time Synchronization on page 63.
3. Enable CIP Sync for each 1756-EN*x*T*x* module.	To enable CIP Sync in all 1756-EN*x*T*x* modules, the Time Sync Connection needs to be set for Time Sync and Motion. This can be found in the 1756-EN*x*T*x* Module Properties on the General tab in the Module Definition section. See Communication Modules Set Up on page 66.
4. Enable CIP Sync for each of the 1756-IB16ISOE modules.	To enable CIP Sync for the SOE modules, the Communication Format needs to be set for CIP Sync Per Point. This parameter can be found in 1756-IB16ISOE Module Properties on the General tab. See Sequence of Events Modules Set Up on page 68. See ControlLogix Sequence of Events Module User Manual, publication 1756-UM528.

Scenario Operation

This table describes the operation for multiple remote racks using the CIP Sync protocol in a network configured for a Star topology with the ControlLogix controller being the time source for the system.

Table 13 - Operation Steps for Star Topology with the ControlLogix Controller as the Grandmaster

Operation	Description
1. The Grandmaster time value is automatically sent to all the 1756-EN*x*T*x* communication modules.	a. Once the controller is designated as the Grandmaster, the controller's WCT is sent automatically to its local 1756-EN*x*T*x* communication module and any local 1756-IB16ISOE modules. b. UTC time is propagated through the control system network via CIP Sync to all other 1756-EN*x*T*x* communication modules on the network.
2. The WCT of each ControlLogix controller is synchronized.	The WCT is automatically updated with a UTC time value. UTC time values are passed automatically from the 1756-EN*x*T*x* communication modules in the remote chassis to the ControlLogix controller in the same chassis.
3. Time stamping with the 1756-IB16ISOE module occurs.	a. UTC time values are also passed automatically from the Slave 1756-EN*x*T modules in the remote chassis to the SOE modules in the same chassis. b. Once an SOE event occurred, a UTC time stamp was recorded and represented in a 2-Dint format. You can display the UTC time stamp in a more readable format, which is a local format, by converting it to a Lint (64-bit) data type displayed as a Date/Time.
4. The SOE time stamps appear on an HMI device or are stored in a database.	A UTC time stamp appears on an Alarms and Events banner within FactoryTalk View SE HMI via application code in the form of an ALMD instruction. The HMI may display the UTC time stamp as the equivalent time for the local time zone. You can also have these time stamps logged to a MSSQL database via the FactoryTalk View SE HMI. See Visualizing Sequence of Events on HMI using FactoryTalk Alarms and Events Instructions on page 125. For information about the ALMD instruction, see the Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.

Star Topology with an NTP Server as the Time Source

This scenario consists of multiple remote racks using the CIP Sync protocol in a Network configured for a Star topology. The time source for the Grandmaster clock is an NTP Server running on a computer.

Hardware Setup

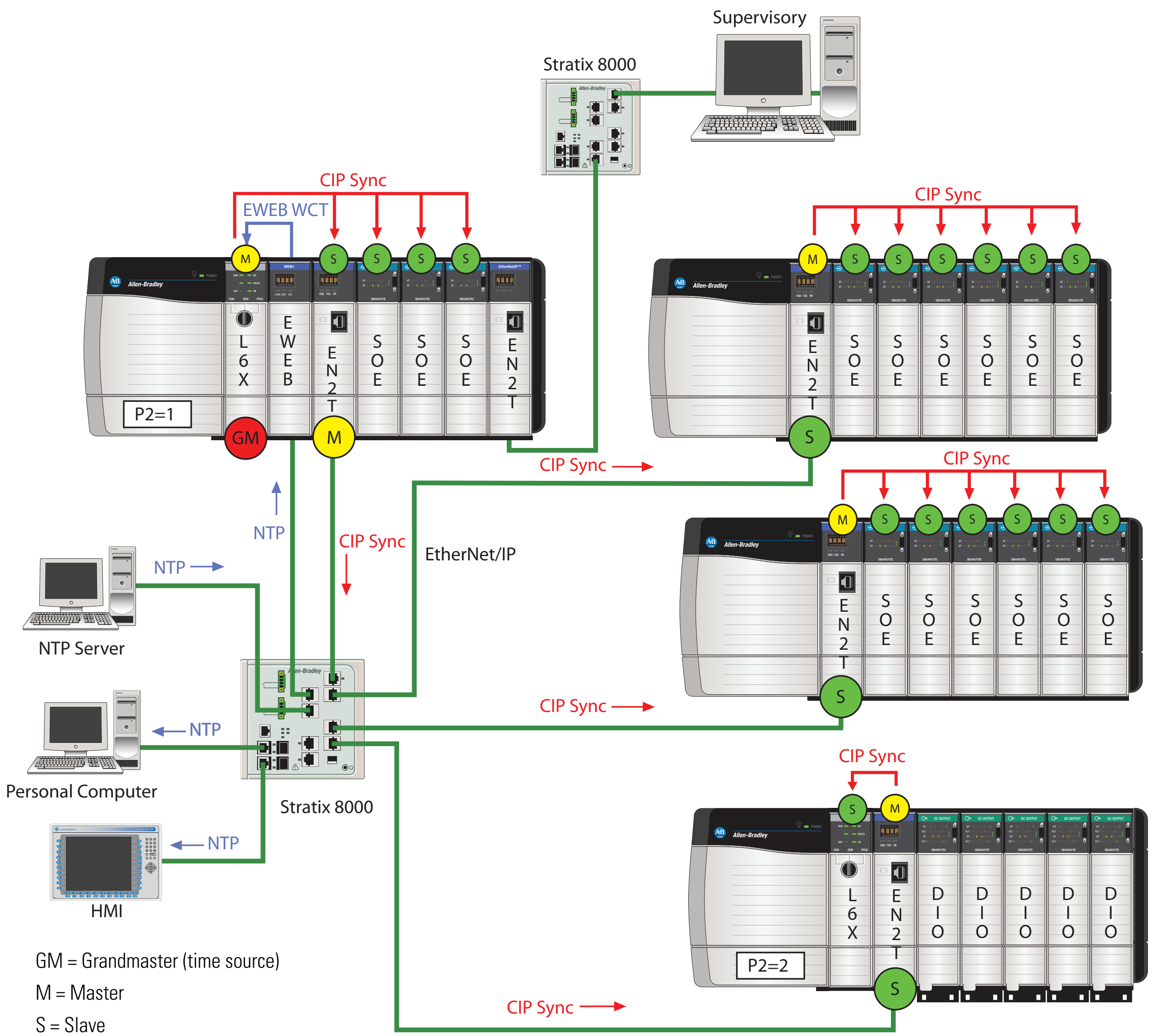
This system consists of the following:

- One (or multiple) 1756-L6*x* or 1756-L7*x* controller, firmware revision 18.0 or later.
- A Stratix 8000 Ethernet Managed Switch with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
- One 1756-EWEB EtherNet/IP module, firmware revision 4.010 or later. This module has no IEEE 1588-2008 capabilities.
- Several 1756-EN*x*T*x* EtherNet/IP modules, firmware revision 3.0 or later.
- Several 1756-IB16ISOE modules, firmware revision 2.0 or later, that provide time stamps for actual field I/O. This module is also available in 120V DC.
- An NTP server.
- A client computer.
- A PanelView HMI interface.
- Supervisory level hardware
  - A Stratix 8000 Ethernet Managed Switch with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
  - Two 1756-EN*x*T communication modules that provide a path to supervisory computers.
  - A supervisory computer.

  In this scenario, the supervisor is illustrated on its own network. It can just as easily be attached on an existing Stratix 8000 switch.

See Hardware and Software Requirements on page 80 for detailed device descriptions.

Figure 15 - Star Topology with an NTP Server as the Time Source



GM = Grandmaster (time source)

M = Master

S = Slave

P1 and P2 = Priorities

NTP = Network Time Protocol

NTP can be served from any NTP server available on the network, such as the 1756HP-TIME (GPS) module.

Scenario Setup

This table describes the setup for multiple remote racks using the CIP Sync protocol in a Network configured for a Star topology. The time source for the system clock is an NTP Server running on a personal computer.

Table 14 - Set-up Steps for Star Topology with an NTP Server as the Time Source

Setup	Description
1. Choose what device to use for the Grandmaster time source.	In this scenario, there are two ControlLogix controllers that could be the Grandmaster. Because NTP time is being routed to the top ControlLogix controller on the left, it is designated to be the Grandmaster. This designation can be guaranteed by setting the Priority 2 value to something less than 128. Priority parameters predict which device wins arbitration and becomes the Grandmaster on the network. Priority 2 values are set in this scenario to resolve ties between multiple controllers. Priority 2 values range from 0 (highest priority) to 255 (lowest priority) with the default being 128. See Configure Priorities on page 52. The time value of the controller is represented as WCT. To propagate NTP time into the control system, a 1756-EWEB module has been placed into the chassis with the Grandmaster. The WCT of the controller is updated with NTP time on a periodic basis.
2. Enable CIP Sync for each controller.	To enable CIP Sync functionality in a ControlLogix controller, check the Enable Time Synchronization checkbox in RSLogix 5000 software. See Enable Time Synchronization on page 63.
3. Enable CIP Sync for each 1756-EN*x*T*x* module.	To enable CIP Sync in all 1756-EN*x*T*x* modules, the Time Sync Connection needs to be set for Time Sync and Motion. See Communication Modules Set Up on page 66.
4. Enable CIP Sync for each of the 1756-IB16ISOE modules.	To enable CIP Sync for the SOE modules, the Communication Format needs to be set for CIP Sync Per Point. This parameter can be found in 1756-IB16ISOE Module Properties on the General tab. See Sequence of Events Modules Set Up on page 68.

Scenario Operation

This table describes the operation for multiple remote racks using the CIP Sync protocol in a Network configured for a Star topology. The time source for the system clock is an NTP Server running on a personal computer.

Table 15 - Operation Steps Star Topology with an NTP Server as the Time Source

Operation	Description
1. The Grandmaster time value is sent to all the 1756-EN*x*T communication modules.	a. Once the controller is designated as the Grandmaster, the controller's WCT is sent automatically to its local 1756-EN*x*T modules and any local 1756-IB16ISOE modules. b. WCT time is propagated through the control system network via CIP Sync to all other 1756-EN*x*T communication modules on the network.
2. The WCT of multiple ControlLogix controllers is synchronized.	The WCT is automatically updated with a UTC time value. UTC time values are passed automatically from the Slave 1756-EN*x*T modules in the remote chassis to the ControlLogix controller in the same chassis.
3. Time stamping with the 1756-IB16ISOE module occurs.	a. UTC time values are also passed automatically from the Slave 1756-EN*x*T modules in the remote chassis to the SOE modules in the same chassis. b. Once an SOE event occurred, a UTC time stamp was recorded and represented in a 2-Dint format. You can display the UTC time stamp in a more readable format, which is a local format, by converting it to a Lint (64-bit) data type displayed as a Date/Time.
4. The SOE time stamps appear on an HMI device or are stored in a database.	A UTC time stamp appears on an Alarms and Events banner within FactoryTalk View SE HMI via application code in the form of an ALMD instruction. The HMI may display the UTC time stamp as the equivalent time for the local time zone. You can also have these time stamps logged to a MSSQL database via the FactoryTalk View SE HMI. See Visualizing Sequence of Events on HMI using FactoryTalk Alarms and Events Instructions on page 125. For information about the ALMD instruction, see the Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.

Nesting Multiple Switches and Multiple Remote Racks in a Linear Topology with a GPS Module as the Grandmaster

This scenario consists of multiple remote racks using the CIP Sync protocol in a network configured as a Linear topology. The time source for the Grandmaster clock is a GPS module.

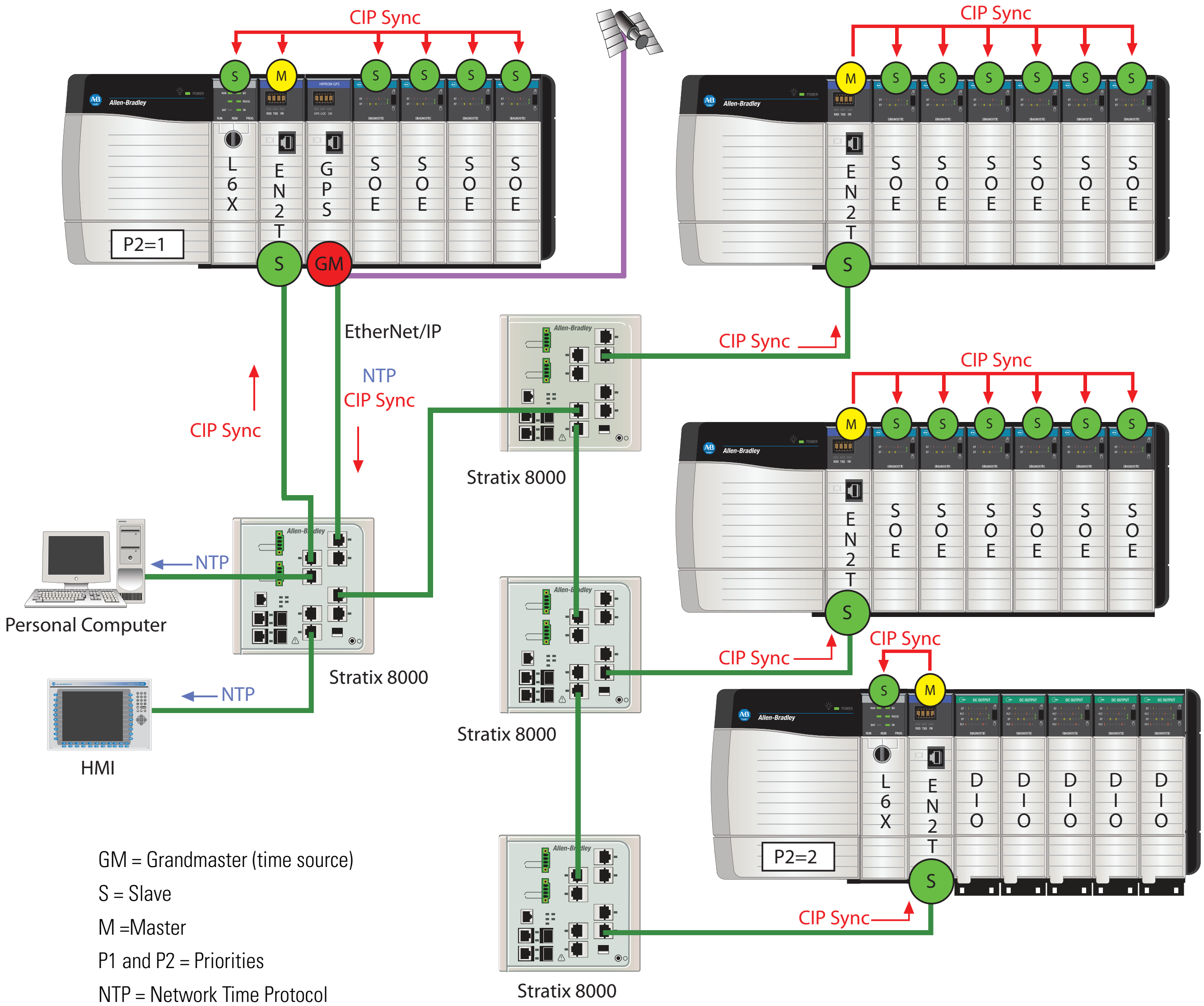
Hardware Setup

This system consists of the following:

- One (or multiple) 1756-L6*x* or 1756-L7*x* controller, firmware revision 18.0 or later.
- A 1756HP-TIME (GPS) module, firmware revision 3.0 or later, with CIP Sync protocol.
- A Stratix 8000 Ethernet Managed Switch with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
- Several 1756-EN*x*T*x* EtherNet/IP communication modules, firmware revision 3.0 or later, with CIP Sync protocol. These are CIP Sync Slave devices on the network.
- Several 1756-IB16ISOE modules, firmware revision 2.0 or later, to provide time stamps for actual field I/O. This module is also available in 120V DC.
- A client computer.
- A PanelView HMI interface.

See Hardware and Software Requirements on page 80 for detailed device descriptions.

Figure 16 - Nesting Multiple Switches and Multiple Remote Racks in a Linear Topology with a GPS Module as the Grandmaster



GM = Grandmaster (time source)

S = Slave

M =Master

P1 and P2 = Priorities

NTP = Network Time Protocol

NTP can be served from any NTP server available on the network, such as the 1756HP-TIME (GPS) module.

Scenario Setup

This table describes the setup for multiple remote racks using the CIP Sync protocol in a network configured as a Linear topology. The time source for the Grandmaster is a GPS module.

Table 16 - Set-up Steps for Multiple Remote Racks in a Linear Topology with a GPS Module as the Grandmaster

Setup	Description
1. Choose what device to use for the Grandmaster time source.	The GPS module has the best clock quality and wins arbitration to become the Grandmaster. The time value of the GPS module is represented as UTC time. Priority parameters can predict which device wins arbitration and becomes the Grandmaster on the network. Priority 2 values are set in this scenario to resolve ties between multiple controllers. Priority 2 values range from 0 (highest priority) to 255 (lowest priority) with the default being 128. See Configure Priorities on page 52.
2. Enable CIP Sync for each controller.	To enable CIP Sync functionality in a ControlLogix controller, check the Enable Time Synchronization checkbox in RSLogix 5000 software. See Enable Time Synchronization on page 63.
3. Enable CIP Sync for each 1756-EN*x*T*x* module.	To enable CIP Sync in all 1756-EN*x*T*x* modules, the Time Sync Connection needs to be set for Time Sync and Motion. See Communication Modules Set Up on page 66.
4. Enable CIP Sync for each 1756-IB16ISOE module.	To enable CIP Sync for the SOE modules, the Communication Format needs to be set for CIP Sync Per Point. This parameter can be found in 1756-IB16ISOE Module Properties on the General tab. See Sequence of Events Modules Set Up on page 68.

Scenario Operation

This table describes the operation for multiple remote racks using the CIP Sync protocol in a network configured as a Linear topology. The time source for the system clock is a GPS module.

Table 17 - Operation Steps for Multiple Remote Racks in a Linear Topology with a GPS Module as the Grandmaster

Operation	Description
1. The WCT of multiple ControlLogix controllers is synchronized.	The WCT is automatically updated with a UTC time value. UTC time values are passed automatically from the Slave 1756-EN*x*T*x* modules in the remote chassis to the ControlLogix controller in the same chassis.
2. Time stamping occurs with the 1756-IB16ISOE module.	UTC time values are also passed automatically from the Slave 1756-EN*x*T*x* modules in the remote chassis to the SOE modules in the same chassis. Once an SOE event occurs, a UTC time stamp is recorded and is sent to the controller via the input connection.
3. The SOE time stamps appear on an HMI device or are stored in a database.	A UTC time stamp appears on an Alarms and Events banner within FactoryTalk View SE HMI via application code in the form of an ALMD instruction. The HMI may display the UTC time stamp as the equivalent time for the local time zone. You can also have these time stamps logged to a MSSQL database via the FactoryTalk View SE HMI. See Visualizing Sequence of Events on HMI using FactoryTalk Alarms and Events Instructions on page 125. For information about the ALMD instruction, see the Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.
4. The NTP clients on the same network are synced.	The GPS module is also equipped to be an NTP Server. It is designed to send time to NTP clients, like a personal computer and an HMI, on the same control network at virtually the same rate as PTP time packets. This tightens the synchronization between PTP and NTP devices. For information about how to enable NTP functionality, see the product documentation from the manufacturer.

Linear/DLR Topology, Multiple Racks with the GPS Module as the Grandmaster

This scenario consists of multiple racks using the CIP Sync protocol in a network configured for a Linear /DLR topology. The time source for the Grandmaster clock is a GPS module.

Hardware Setup

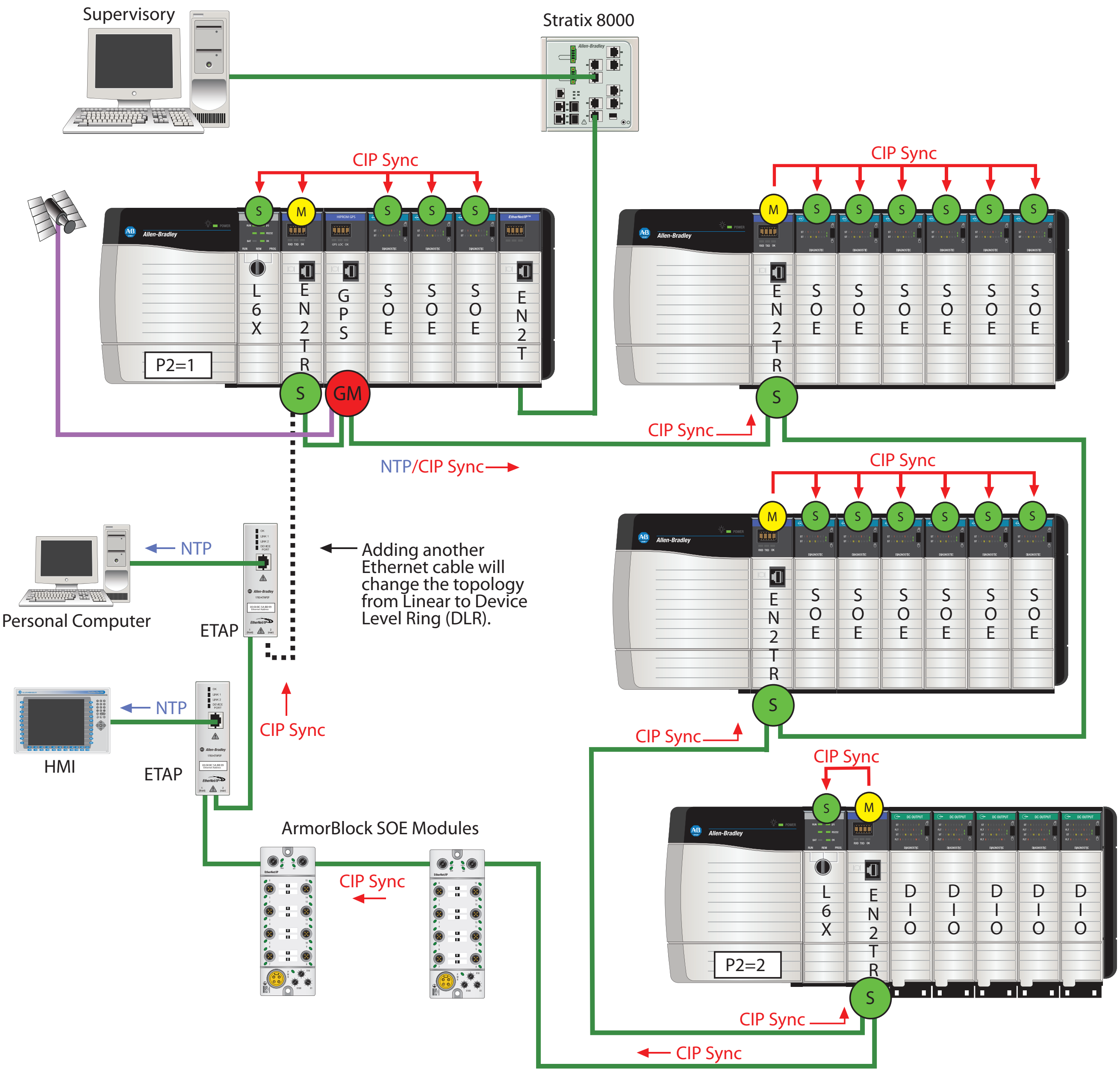
This system consists of the following:

- One (or multiple) 1756-L6*x* or 1756-L7*x* controller, firmware revision 18.0 or later.
- A 1756HP-TIME (GPS) module, firmware revision 3.0 or later, with CIP Sync protocol.
- A Stratix 8000 Ethernet Managed Switch with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
- Several 1756-EN*x*T*x* EtherNet/IP modules, firmware revision 3.0 or later, with CIP Sync protocol. These are CIP Sync Slave devices on the network.
- Several 1756-IB16ISOE modules, firmware revision 2.0 or later, that provide time stamps for actual field I/O. This module is also available in 120V DC.
- Several 1732E-IB16M12SOEDR ArmorBlock I/O modules, firmware revision 1.0 or later, that provide time stamps for actual field I/O.
- A client computer.
- A PanelView HMI interface.
- Supervisory level hardware
  - A Stratix 8000 Ethernet Managed Switch with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
  - One 1756-EN*x*T communication modules that provide a path to a supervisory computer.
  - A supervisory computer.

  In this scenario, the supervisor is illustrated on its own network. It can just as easily be attached on an existing Stratix 8000 switch.

See Hardware and Software Requirements on page 80 for detailed device descriptions.

Figure 17 - Linear/DLR Topology, Multiple Racks with the GPS Module as the Grandmaster



GM = Grandmaster (time source)

M = Master

S = Slave

P1 and P2 = Priorities

NTP = Network Time Protocol

NTP can be served from any NTP server available on the network, such as the 1756HP-TIME (GPS) module.

IMPORTANT	Recovery times may increase if above the recommended 50 node limit for a DLR Ring topology.

Scenario Setup

This table describes the setup for multiple racks using the CIP Sync protocol in a network configured for a Linear/DLR topology. The time source for the system clock is a GPS module.

Table 18 - Set-up Steps for Multiple Racks in a Linear/DLR topology with a GPS Module as the Grandmaster

Setup	Description
1. Choose what device to use for the Grandmaster time source.	The GPS module is equipped with a higher clock quality than either the ControlLogix controller or the 1756-EN*x*T*x* module, so it wins arbitration. The time value of the GPS module is represented as UTC time. Priority parameters predict which device wins arbitration and becomes the Grandmaster on the network. Priority 2 values are set in this scenario to resolve ties between multiple controllers. Priority 2 values range from 0 (highest priority) to 255 (lowest priority) with the default being 128. See Configure Priorities on page 64.
2. Enable CIP Sync for each controller.	To enable CIP Sync functionality in a ControlLogix controller, check the Enable Time Synchronization checkbox in RSLogix 5000 software. See Enable Time Synchronization on page 63.
3. Enable CIP Sync for each 1756-EN*x*TR module.	To enable CIP Sync in all 1756-EN*x*TR modules, the Time Sync Connection needs to be set for Time Sync and Motion. This can be found in the 1756-EN*x*TR Module Properties on the General tab in the Module Definition section. See Communication Modules Set Up on page 66.
4. Enable CIP Sync for each 1756-IB16ISOE module.	To enable CIP Sync for the SOE modules, the Communication Format needs to be set for CIP Sync Per Point. This parameter can be found in 1756-IB16ISOE Module Properties on the General tab. See Sequence of Events Modules Set Up on page 68.
5. Assign a DLR Ring Supervisor.	In order for the DLR ring to function, you need to assign a DLR Ring Supervisor. For more information about the DLR Ring Supervisor, see the EtherNet/IP Embedded Switch Technology DLR Application Guide, publication ENET-AP005.
6. Enable CIP Sync for each 1732E-IB16M12SOEDR module.	To enable CIP Sync for the ArmorBlock modules, the Input Data field must be set to Diagnostic Timestamp Per Point. See ArmorBlock 2-Port Ethernet Module Set Up on page 69.

Scenario Operation

This table describes the operation for multiple racks using the CIP Sync protocol in a network configured for a Linear/DLR topology. The time source for the system clock is a GPS module.

Table 19 - Operation Steps for Multiple Racks in a Linear or a DLR topology with a GPS Module as the Grandmaster

Operation	Description
1. The Grandmaster time value is sent to all 1756-EN*x*TR modules.	The UTC time is propagated through the control system network via CIP Sync to all other 1756-EN*x*TR Slave devices on the network.
2. The WCT of multiple ControlLogix controllers is synchronized.	UTC time values are passed automatically from the Slave 1756-EN*x*TR modules in the remote chassis to the ControlLogix controller in the same chassis. The WCT is automatically updated with a UTC time value.
3. Time stamping occurs with the 1756-IB16ISOE module.	UTC time values are also passed automatically from the Slave 1756-EN*x*TR modules in the remote chassis to the SOE modules in the same chassis. Once an SOE event occurs, a UTC time stamp is recorded and sent to the controller via the input connection.
4. The SOE time stamps appear on an HMI device or are stored in a database.	A UTC time stamp appears on an Alarms and Events banner within FactoryTalk View SE HMI via application code in the form of an ALMD instruction. The HMI may display the UTC time stamp as the equivalent time for the local time zone. You can also have these local time stamps logged to a MSSQL database via the FactoryTalk View SE HMI. See Visualizing Sequence of Events on HMI using FactoryTalk Alarms and Events Instructions on page 125. For information about the ALMD instruction, see the Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.
5. Sync the NTP Clients on the same network.	The GPS module is equipped to be an NTP Server. It is designed to send time to NTP clients, like a personal computer or an HMI, on the same control network at virtually the same rate as PTP time packets. This tightens the synchronization between PTP and NTP devices. For information about how to enable NTP functionality, see the product documentation from the manufacturer.

Multiple Substations in Star Topologies with the GPS Module as the Grandmaster

This scenario consists of multiple substations using the CIP Sync protocol in a network configured for a Star topology. The time source for the Grandmaster clock is a GPS module.

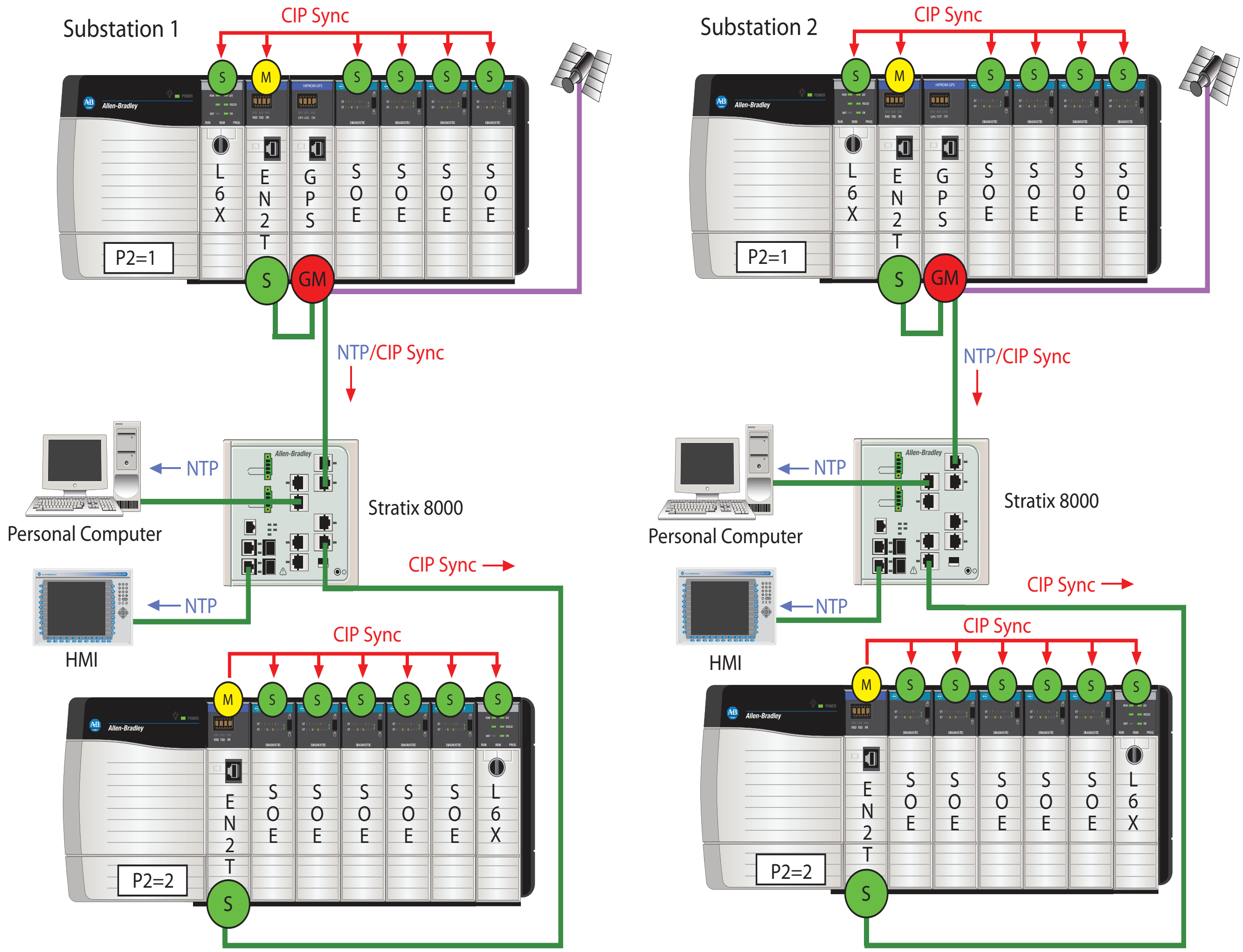
Hardware Setup

This system consists of the following:

- One (or multiple) 1756-L6*x* or 1756-L7*x* controller, firmware revision 18.0 or later.
- GPS, 1756HP-TIME modules, firmware revision 3.0 or later, with CIP Sync protocol.
- A Stratix 8000 Ethernet Managed Switch with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
- Several 1756-EN*x*T*x* EtherNet/IP modules, firmware revision 3.0 or later, with CIP Sync protocol. They are CIP Sync Slave devices on the network.
- Several 1756-IB16ISOE modules, firmware revision 2.0 or later, that provide time stamps for actual field I/O. This module is also available in 120V DC.
- A client computer.
- A PanelView HMI interface.

See Hardware and Software Requirements on page 80 for detailed device descriptions.

Figure 18 - Multiple Substations in a Star Topology with the GPS Module as the Grandmaster



GM = Grandmaster (time source)

M = Master

S = Slave

P1 and P2 = Priorities

NTP = Network Time Protocol

NTP can be served from any NTP server available on the network, such as the 1756HP-TIME (GPS) module.

Scenario Setup

This table describes the setup for multiple substations using the CIP Sync protocol in a network configured for a Star topology. The time source for the Grandmaster clock is a GPS module.

Table 20 - Set-up Steps for Multiple Substations in Star Topologies with a GPS Module as the Grandmaster

Setup	Description
1. Choose what device to use for the Grandmaster time source.	In this scenario, there are two control substations that are geographically separated, but need to have the same time reference for accurate time stamping. There is no cabling (copper and/or F.O.) connecting the two substations together. To achieve time synchronization between substations, there is a GPS module installed at each substation. Everything else is treated the same as configuring a single control system. The GPS module has the best clock quality and wins arbitration to become the Grandmaster. The time value of the GPS module is represented as UTC time. Priority parameters predict which device wins arbitration and becomes the Grandmaster on the network. Priority 2 values are set in this scenario to resolve ties between multiple controllers. Priority 2 values range from 0 (highest priority) to 255 (lowest priority) with the default being 128. See Configure Priorities on page 64.
2. Enable CIP Sync for each controller.	To enable CIP Sync functionality in a ControlLogix controller, check the Enable Time Synchronization checkbox in RSLogix 5000 software. See Enable Time Synchronization on page 63.
3. Enable CIP Sync for each 1756-EN*x*T*x* module.	The setting to Enable Time Synchronization for the 1756-EN*x*T*x* modules in the Primary are crossloaded to the Secondary 1756-EN*x*T*x* modules. The clock quality attributes of the Secondary modules automatically adjusts so that they do not become the Grandmaster. See Communication Modules Set Up on page 66.
4. Enable CIP Sync for each 1756-IB16ISOE module.	To enable CIP Sync for the SOE modules, the Communication Format needs to be set for CIP Sync Per Point. This parameter can be found in 1756-IB16ISOE Module Properties on the General tab. See Sequence of Events Modules Set Up on page 68.

Scenario Operation

This table describes the operation for multiple substations using the CIP Sync protocol in a network configured for a Star topology. The two substations reside geographically miles apart. Because there are copper and fiber-optic cable length restrictions, this topology requires a separate time module for each substation.

The time source for the system clock are the GPS modules.

Table 21 - Operation Steps for Multiple Substations in Star Topologies with a GPS Module as the Time Source

Operation	Description
1. The Grandmaster time value is sent to all 1756-EN*x*T*x* modules.	Once the GPS module is designated the Grandmaster, the UTC time is propagated through the control system network via CIP Sync to all 1756-EN*x*T*x* Slave devices on the network.
2. The WCT of multiple ControlLogix controller are synchronized.	The WCT is automatically updated with a UTC time value. UTC time values are passed automatically from the Slave 1756-EN*x*T modules in the remote chassis to the ControlLogix controller in the same chassis.
3. Time stamping with the 1756-IB16ISOE module.	UTC time values are also passed automatically from the Slave 1756-EN*x*T modules in the remote chassis to the SOE modules in the same chassis. Once an SOE event occurred, a UTC time stamp was recorded and represented in a 2-Dint format. You can display the UTC time stamp in a more readable format, which is a local format, by converting it to a Lint (64-bit) data type displayed as a Date/Time.
4. The SOE time stamps appear on an HMI device or are stored in a database.	A UTC time stamp appears on an Alarms and Events banner within FactoryTalk View SE HMI via application code in the form of an ALMD instruction. The HMI may display the UTC time stamp as the equivalent time for the local time zone. You can also have these local time stamps logged to a MSSQL database via the FactoryTalk View SE HMI. See Visualizing Sequence of Events on HMI using FactoryTalk Alarms and Events Instructions on page 125. For information about the ALMD instruction, see the Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.
5. Sync the NTP Clients on the same network.	The GPS module is equipped to be an NTP Server. It is designed to send time to NTP clients, like a personal computer and an HMI, on the same control network at virtually the same rate as PTP time packets. This tightens the synchronization between PTP and NTP devices. For information about how to enable NTP functionality, see the product documentation from the manufacturer.

ControlLogix Redundancy System in a Star Topology Controlling I/O over the EtherNet/IP Network with a GPS Module as the Grandmaster

This scenario consists of a ControlLogix redundancy system, revision 19.50 or later, controlling I/O over the EtherNet/IP network using the CIP Sync protocol in a network configured for a Star topology. The time source for the Grandmaster clock is the GPS module.

Hardware Setup

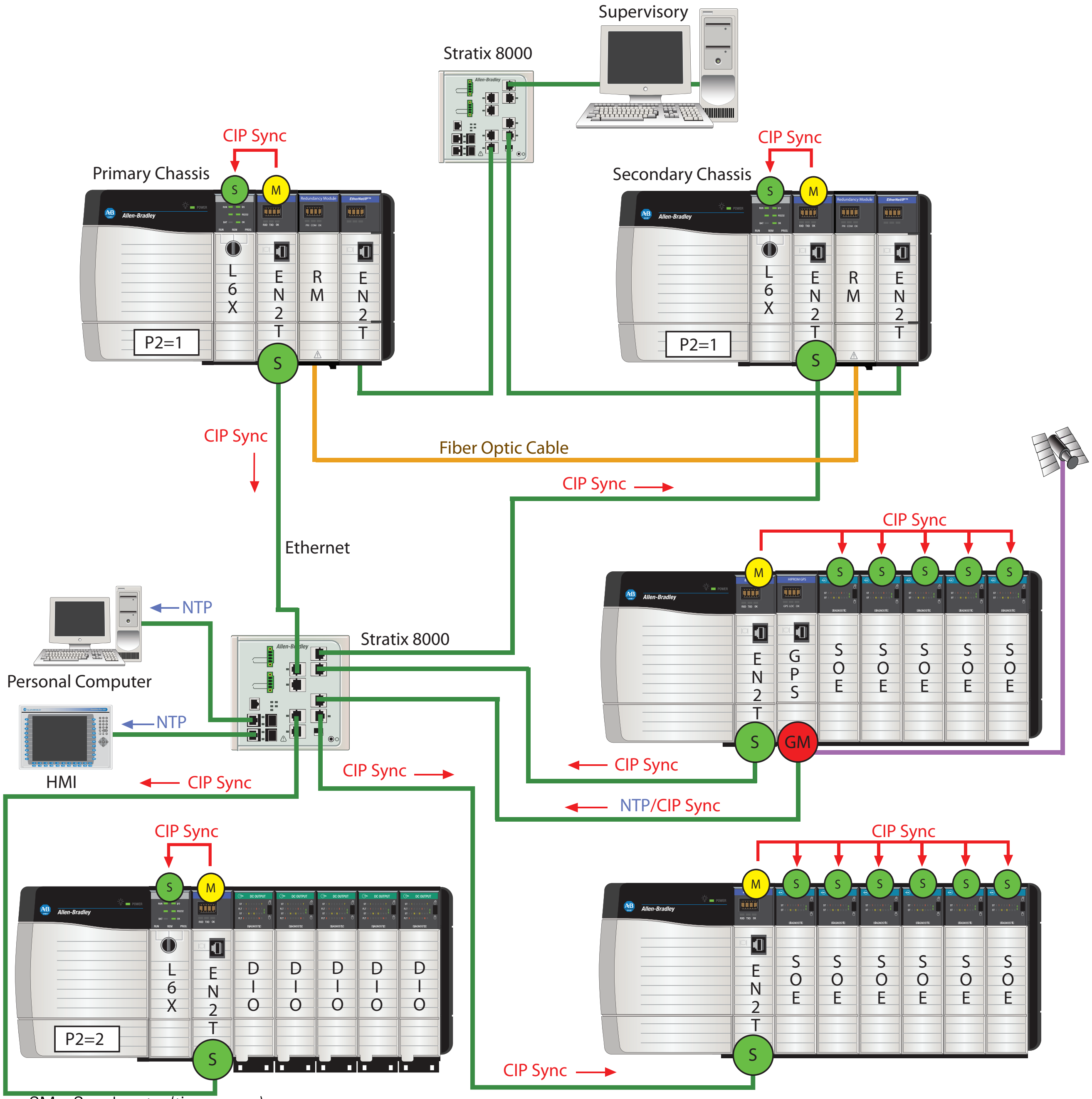
This system consists of the following hardware:

- One Redundant Chassis Pair with a 1756-L6*x* or a 1756-L7*x* controller, firmware revision 19.50 or later.
- A 1756HP-TIME (GPS) module, firmware revision 3.0 or later, with CIP Sync protocol.
- A Stratix 8000, Ethernet Managed Switch with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
- In this example, five 1756-EN*x*T communication modules, firmware revision 4.0 or later, with CIP Sync protocol. These are CIP Sync Slave devices. Control of I/O is being accomplished via the EtherNet/IP network.
- Two 1756-RM Redundancy modules needed for crossloading of data from Primary to Secondary controllers.
- Several 1756-IB16ISOE modules, firmware revision 2.0 or later, that provide time stamps for actual field I/O. This module is also available in 120V DC.
- A client computer.
- A PanelView HMI interface.
- Supervisory level hardware
  - A Stratix 8000 Ethernet Managed Switch with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
  - Two 1756-EN*x*T communication modules that provide a path to supervisory computer.
  - A supervisory computer.

  In this scenario, the supervisor is illustrated on its own network. It can just as easily be attached on an existing Stratix 8000 switch.

See Hardware and Software Requirements on page 80 for detailed device descriptions.

Figure 19 - ControlLogix Redundancy System in a Star Topology Controlling I/O over the EtherNet/IP Network with a GPS Module as the Grandmaster



GM = Grandmaster (time source)

S = Slave

M = Master

P1 and P2 = Priorities

NTP = Network Time Protocol

NTP can be served from any NTP server available on the network, such as the 1756HP-TIME (GPS) module.

Scenario Setup

This table describes the setup for a ControlLogix redundancy system, revision 19.50 or later, controlling I/O over the EtherNet/IP network using the CIP Sync protocol in a network configured for a Star topology.

Table 22 - Set-up Steps for a Redundancy System Controlling I/O over EtherNet/IP Network in a Star Topology with a GPS Module as the Grandmaster

Setup	Description
1. Choose what device to use for the Grandmaster time source.	In this scenario, a ControlLogix redundancy system needs to synchronize time throughout the network for accurate time stamping. This should be treated no differently than a single ControlLogix controller system. The GPS module has the best clock quality and wins arbitration to become the Grandmaster. The time value of the GPS module is represented as UTC time. The clock quality attributes of the Secondary controller will be automatically adjusted so that it will not become Grandmaster. For more information about choosing a device as the Grandmaster, see Grandmaster Clock Selection and Clock Quality on page 39. Priority parameters predict which device wins arbitration and becomes the Grandmaster on the network. Priority 2 values are set in this scenario to resolve ties between multiple controllers. Priority 2 values range from 0 (highest priority) to 255 (lowest priority) with the default being 128. See Configure Priorities on page 64.
2. Enable CIP Sync for each controller.	The setting to Enable Time Synchronization in the Primary controller is crossloaded to the Secondary controller. The clock quality attributes of the Secondary controller automatically adjusts so that it does not become the Grandmaster. To enable CIP Sync functionality in a ControlLogix controller, check the Enable Time Synchronization checkbox in RSLogix 5000 software. **IMPORTANT** If you enable CIP Sync in the controller, but do not enable CIP Sync in the local 1756-ENxTx module, located in the RCP, the Primary and Secondary RCP's will never Qualify and time will not be synchronized between controllers. Remember, time is synchronized between controllers via their 1756-EN*x*T*x* modules. The 1756-EN*x*T*x* modules must be CIP Sync enabled as well. See Enable Time Synchronization on page 63.
3. Enable CIP Sync for each 1756-EN*x*T module.	The setting to Enable Time Synchronization for the 1756-EN*x*T*x* modules in the Primary are crossloaded to the Secondary 1756-EN*x*T*x* modules. The clock quality attributes of the Secondary modules automatically adjusts so that they do not become the Grandmaster. See Communication Modules Set Up on page 66.
4. Enable CIP Sync for each 1756-IB16ISOE module.	To enable CIP Sync for the SOE modules, the Communication Format needs to be set for CIP Sync Per Point. This parameter can be found in 1756-IB16ISOE Module Properties on the General tab. See Sequence of Events Modules Set Up on page 68.

Scenario Operation

This table describes the operation for a ControlLogix redundancy system, revision 19.50 or later, controlling I/O over the EtherNet/IP network using the CIP Sync protocol in a network configured for a Star topology.

Table 23 - Operation Steps for a ControlLogix Redundancy System Controlling I/O over the EtherNet/IP Network in a Star topology with a GPS Module as the Grandmaster

Operation	Description
1. The Grandmaster time value is sent to all the 1756-EN*x*T communication modules.	The controller's WCT is sent automatically to its local 1756-EN*x*T module. WCT time is propagated through the control system network via CIP Sync to all other 1756-EN*x*T communication modules on the network.
2. The WCT of multiple ControlLogix controllers is synchronized.	The WCT is automatically updated with a UTC time value. UTC time values are passed automatically from the Slave 1756-EN*x*T modules in the remote chassis to the ControlLogix controller in the same chassis.
3. Time stamping with the 1756-IB16ISOE Module.	UTC time values are also passed automatically from the Slave 1756-EN*x*T modules in the remote chassis to the SOE modules in the same chassis. Once an SOE event occurs, a UTC time stamp is recorded and is sent to the controller via the input connection.
4. The SOE time stamps appear on an HMI device or are stored in a database.	A UTC time stamp appears on an Alarms and Events banner within FactoryTalk View SE HMI via application code in the form of an ALMD instruction. The HMI may display the UTC time stamp as the equivalent time for the local time zone. You can also have these local time stamps logged to a MSSQL database via the FactoryTalk View SE HMI. See Visualizing Sequence of Events on HMI using FactoryTalk Alarms and Events Instructions on page 125. For information about the ALMD instruction, see the Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.

IMPORTANT **ControlLogix Redundancy Systems and Switchovers**

- Data is crossloaded continually, so that the Redundant system is ready for a switchover.
  The setting to Enable Time Synchronization in the Primary controller will be crossloaded to the Secondary controller. The Secondary controller will always lose clock quality arbitration to the Primary controller.
- The quality of the clock becomes `Hand Set' when a clock class upgrade occurs during a switchover.
  Hand-setting the Primary also hand-sets the Secondary, but the Secondary masks this improved quality to avoid becoming Grandmaster.
- If the old Primary was hand-set, the new Primary will also be hand-set after a switchover.

ControlLogix Redundancy System in a Ring Topology with the GPS Module as the Grandmaster

This scenario consists of a ControlLogix Redundancy System, revision 19.50 or later, using the CIP Sync protocol in a network configured for a Ring topology. The time source for the Grandmaster clock is the GPS module.

Hardware Setup

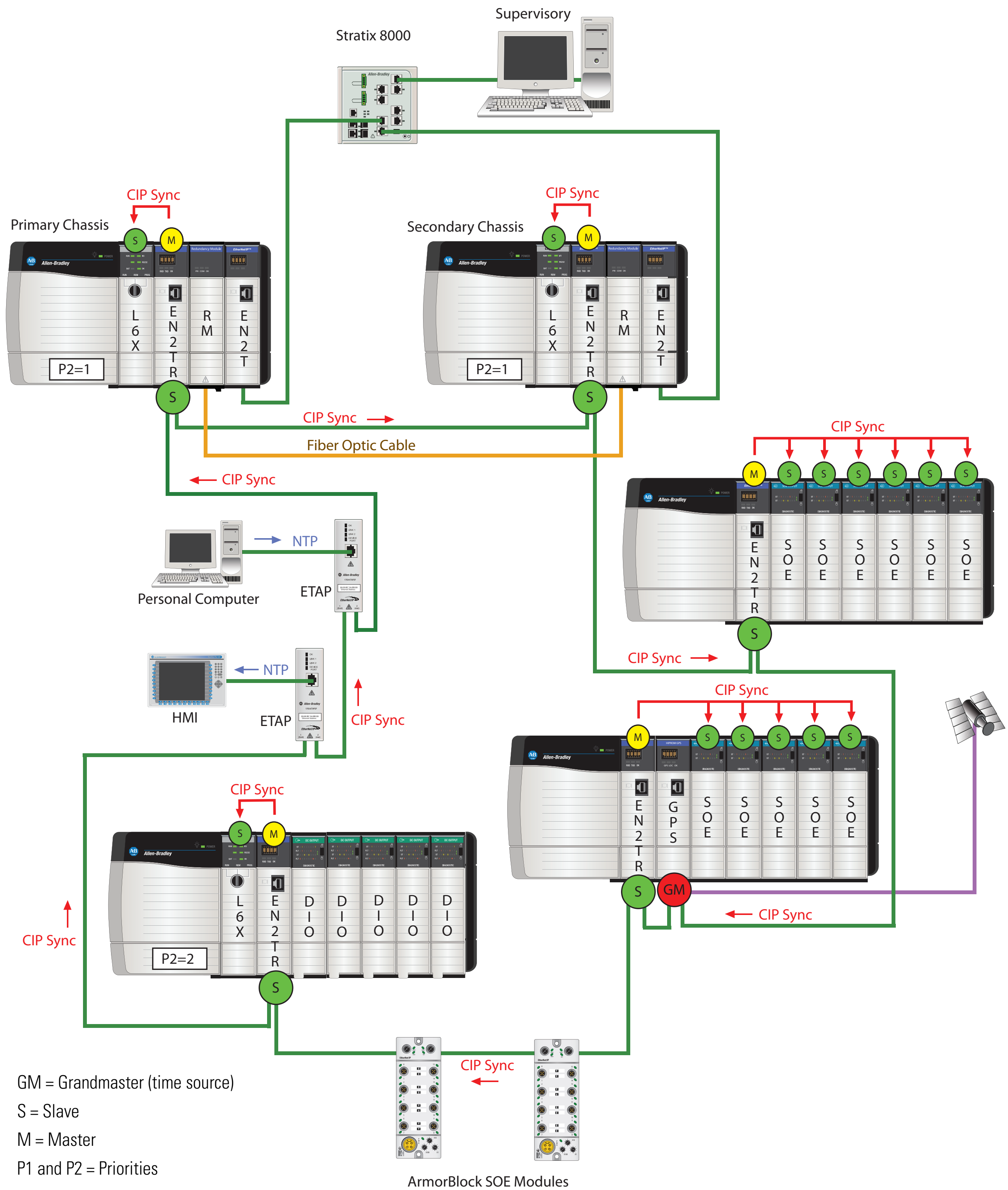
This system consists of the following:

- One Redundant Chassis Pair with a 1756-L6*x* or a 1756-L7*x* controller, firmware revision 19.50 or later.
- A 1756HP-TIME (GPS) module, firmware revision 3.0 or later, with CIP Sync protocol.
- Two 1756-ETAP adapters for an HMI and a personal computer providing NTP time for the HMI.
- In this example, five 1756-EN2TR modules, firmware revision 4.0 or later, with CIP Sync protocol. These are CIP Sync Slave devices.
- Two 1756-RM Redundancy modules needed for crossloading of data from Primary to Secondary controller.
- Several 1756-IB16ISOE modules, firmware revision 2.0 or later, that provide time stamps for actual field I/O. This module is also available in 120V DC.
- One 1756-L6*x* or 1756-L7*x* ControlLogix controller in a rack for Digital I/O. This is optional.
- A client computer.
- A PanelView HMI interface.
- Supervisory level hardware, optional
  - A Stratix 8000 Ethernet Managed Switch with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
  - Two 1756-EN*x*T communication modules that provide a path to supervisory computers.
  - A supervisory computer.

  In this scenario, the supervisor is illustrated on its own network. It can just as easily be attached on an existing Stratix 8000 switch.

See Hardware and Software Requirements on page 80 for detailed device descriptions.

Figure 20 - ControlLogix Redundancy System in a Ring Topology with the GPS Module as the Grandmaster



GM = Grandmaster (time source)

S = Slave

M = Master

P1 and P2 = Priorities

NTP = Network Time Protocol

NTP can be served from any NTP server available on the network, such as the 1756HP-TIME (GPS) module.

Scenario Setup

This table describes the setup for a ControlLogix Redundancy System, version 19.50 or later, using the CIP Sync protocol in a network configured for a Ring topology.

Table 24 - Set-up Steps for a ControlLogix Redundancy System in a Ring Topology with the GPS Module as the Grandmaster

Setup	Description
1. Choose what device to use for the Grandmaster time source.	In this scenario, a ControlLogix redundancy system needs to synchronize time throughout the network for accurate time stamping. This should be treated no differently than a single ControlLogix controller system. The GPS module is equipped with a more accurate clock than the ControlLogix controller or the 1756-ENxT module, so it wins arbitration and becomes the Grandmaster. The time in the GPS module is represented as UTC. In a redundant system, the Secondary controller will always lose clock quality arbitration to the Primary controller. Priority parameters predict which device wins arbitration and becomes the Grandmaster on the network. Priority 2 values are set in this scenario to resolve ties between multiple controllers. Priority 2 values range from 0 (highest priority) to 255 (lowest priority) with the default being 128. See Configure Priorities on page 52.
2. Enable CIP Sync for each controller.	The setting to Enable Time Synchronization in the Primary controller is crossloaded to the Secondary controller. The clock quality attributes of the Secondary controller automatically adjusts so that it does not become the Grandmaster. To enable CIP Sync functionality in a ControlLogix controller, check the Enable Time Synchronization checkbox in RSLogix 5000 software. See Enable Time Synchronization on page 63.
3. Enable CIP Sync for each 1756-EN*x*T*x* module.	The settings to Enable Time Synchronization from the 1756-EN*x*T*x* modules in the Primary are crossloaded to the Secondary 1756-EN*x*T*x* modules. The clock quality attributes of the Secondary modules automatically adjusts so that they do not become the Grandmaster. To enable CIP Sync in all 1756-EN*x*T*x* modules, the Time Sync Connection needs to be set for each module for Time Sync and Motion. See Communication Modules Set Up on page 66.
4. Enable CIP Sync for each 1756-IB16ISOE module.	To enable CIP Sync for the SOE modules, the Communication Format needs to be set for CIP Sync Per Point. This parameter can be found in 1756-IB16ISOE Module Properties on the General tab. See Sequence of Events Modules Set Up on page 68.
5. Enable CIP Sync for each 1732E-IB16M12SOEDR module.	To enable CIP Sync for the ArmorBlock modules, the Input Data field must be set to Diagnostic Timestamp Per Point. See ArmorBlock 2-Port Ethernet Module Set Up on page 69.
6. Assign a DLR Ring Supervisor.	In order for the DLR ring to function, you need to assign a DLR Ring Supervisor. For more information about the DLR Ring Supervisor, see the EtherNet/IP Embedded Switch Technology DLR Application Guide, publication ENET-AP005.

Scenario Operation

This table describes the operation for a ControlLogix redundancy system, revision 19.50 or later, using the CIP Sync protocol in a network configured for a Ring topology.

Table 25 - Operation Steps for a ControlLogix Redundancy System in a Ring Topology

Operation	Description
1. The Grandmaster time value is sent to all 1756-EN*x*T*x* communication modules.	In this scenario, a ControlLogix redundancy system needs to synchronize time throughout the network for accurate time stamping. This should be treated no differently than a single ControlLogix controller system. Because there is a GPS module in the control system, it is chosen as the Grandmaster time source. The time in the GPS module is represented as UTC. In a redundant system, the Secondary controller will always lose clock quality arbitration to the Primary controller.
2. The WCT of multiple ControlLogix controllers is synchronized.	The WCT automatically is updated with a UTC time value. UTC time values are passed automatically from the Slave 1756-EN*x*T*x* modules in the remote chassis to the ControlLogix controller in the same chassis.
3. Time stamping with the 1756-IB16ISOE module occurs.	UTC time values are also passed automatically from the Slave 1756-EN*x*T*x* modules in the remote chassis to the SOE modules in the same chassis. Once an SOE event occurs, a UTC time stamp is recorded and sent to the controller via the input connection.
4. The SOE time stamps appear on an HMI device or are stored in a database.	A UTC time stamp appears on an Alarms and Events banner within FactoryTalk View SE HMI via application code in the form of an ALMD instruction. The HMI may display the UTC time stamp as the equivalent time for the local time zone. You can also have these local time stamps logged to a MSSQL database via the FactoryTalk View SE HMI. See Visualizing Sequence of Events on HMI using FactoryTalk Alarms and Events Instructions on page 125. For information about the ALMD instruction, see the Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.

IMPORTANT **ControlLogix Redundancy Systems and Switchovers**

- Data is crossloaded continually, so that the Redundant system is ready for a switch over.
  The setting to Enable Time Synchronization in the Primary controller will be crossloaded to the Secondary controller. The Secondary controller will always lose clock quality arbitration to the Primary controller.
- The quality of the clock becomes `Hand Set' when a clock class upgrade occurs during a switchover.
  Hand-setting the Primary also hand-sets the Secondary, but the Secondary masks this improved quality to avoid becoming Grandmaster.
- If the old Primary was hand-set, the new Primary will also be hand-set after a switchover.

ControlLogix Redundancy System in a Star Topology with the Primary Controller as the Grandmaster

This scenario consists of a ControlLogix redundancy system, revision 19.50 or later, using the CIP Sync protocol in a network configured for a Star topology. The time source for the Grandmaster clock is the controller in the Primary chassis.

Hardware Setup

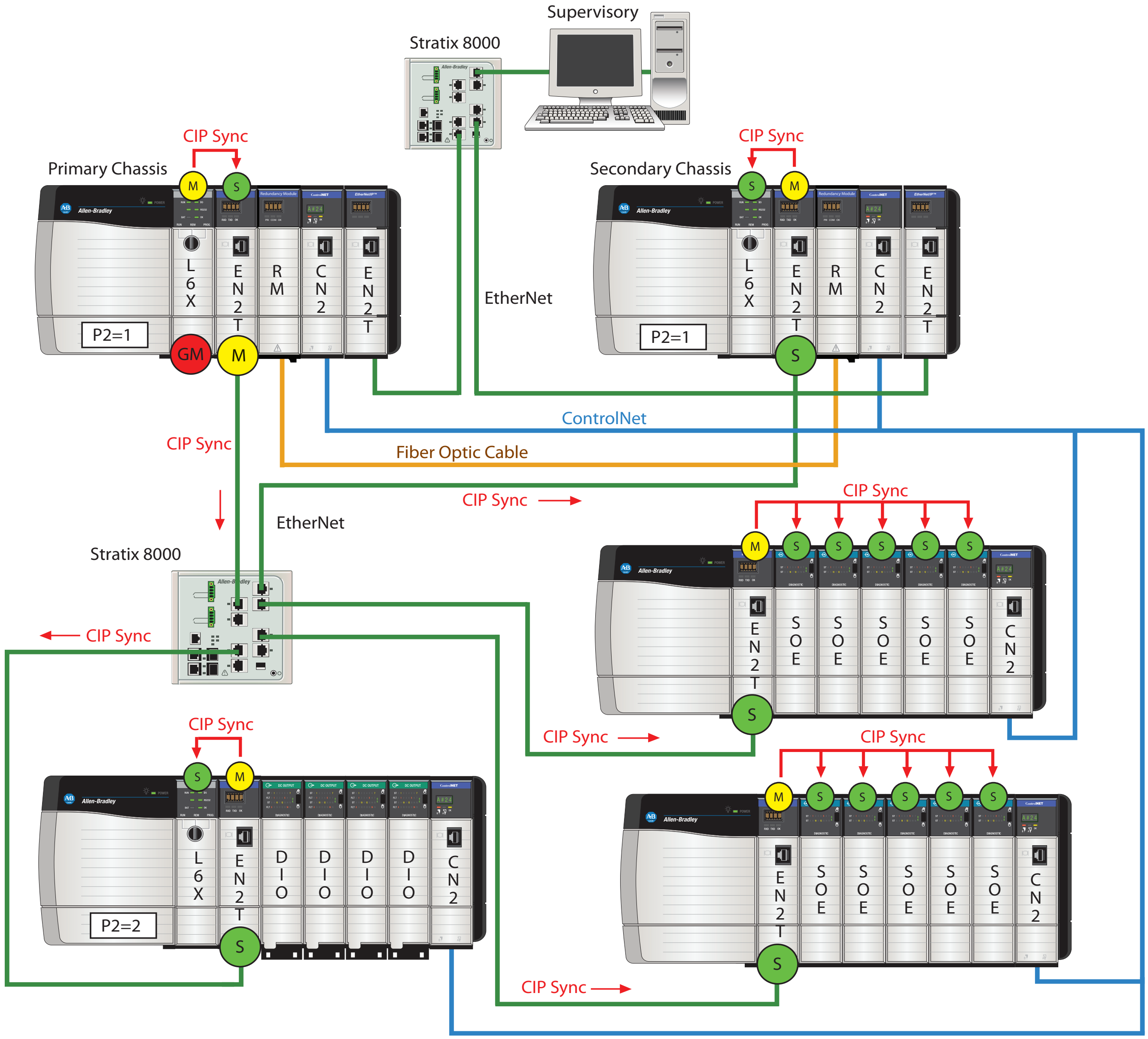
This system consists of the following:

- One Redundant Chassis Pair with a 1756-L6*x* or a 1756-L7*x* controller, firmware revision 19.50.
- Two Stratix 8000 Ethernet Managed Switches with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
- In this example, five 1756-EN2T communication modules, firmware revision 3.0 or later, with time synchronization enabled. These are CIP Sync Slave devices.
- Two 1756-RM Redundancy modules needed for crossloading of data from Primary to Secondary controller.
- In ControlLogix redundancy system, revision 19.50 or later, supports both ControlNet and EtherNet/IP I/O communication. In this example, two (optional) 1756-CN2 ControlNet communication modules are needed to establish a connection between the ControlLogix controller and its I/O modules.
- Several 1756-IB16ISOE modules, firmware revision 2.0 or later, that provide time stamps for actual field I/O. This module is also available in 120V DC.
- Supervisory level hardware
  - A Stratix 8000 Ethernet Managed Switch with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
  - Two 1756-EN*x*T communication modules that provide a path to supervisory computers.
  - A supervisory computer.

  In this scenario, the supervisor is illustrated on its own network. It can just as easily be attached on an existing Stratix 8000 switch.

See Hardware and Software Requirements on page 80 for detailed device descriptions.

Figure 21 - ControlLogix Redundancy System in a Star Topology with the Primary Controller as the Grandmaster



GM = Grandmaster (time source)

M = Master

S = Slave

P1 and P2 = Priorities

Scenario Setup

This table describes the setup for a ControlLogix redundancy system, revision 19.50 or later, using the CIP Sync protocol in a network configured for a Star topology.

Table 26 - Set-up Steps for a ControlLogix Redundancy System in a Star Topology with the Primary Controller as the Grandmaster

Setup	Description
1. Choose what device to use for the Grandmaster time source.	In this scenario, a ControlLogix redundancy system needs to synchronize time throughout the network for accurate time stamping. This should be treated no differently than a single ControlLogix controller system. Because there is no GPS module in the control system, choose the 1756-L6*x* or 1756-L7*x* controller as the Grandmaster. The time value of the controller is represented as WCT. In this example, time is being Hand Set in the controller. In a redundant system, the Secondary controller will always lose clock quality arbitration to the Primary controller. Priority parameters predict which device wins arbitration and becomes the Grandmaster on the network. Priority 2 values are set in this scenario to resolve ties between multiple controllers. Priority 2 values range from 0 (highest priority) to 255 (Lowest Priority) with the default being 128. See Configure Priorities on page 64.
2. Enable CIP Sync for each controller.	The setting to Enable Time Synchronization in the Primary controller is crossloaded to the Secondary controller. The clock quality attributes of the Secondary controller automatically adjusts so that it does not become the Grandmaster. To enable CIP Sync Functionality in a ControlLogix controller, check the Enable Time Synchronization box in RSLogix 5000 software. See Enable Time Synchronization on page 63.
3. Enable CIP Sync for each 1756-EN*x*T*x* module.	The setting to Enable Time Synchronization for the 1756-EN*x*T*x* modules in the Primary are crossloaded to the Secondary 1756-EN*x*T*x* modules. The clock quality attributes of the Secondary modules automatically adjusts so that they do not become the Grandmaster. To enable CIP Sync in all 1756-EN*x*T*x* modules, the Time Sync Connection needs to be set for each module for Time Sync and Motion. See Communication Modules Set Up on page 66.
4. Enable CIP Sync for each 1756-IB16ISOE module.	To enable CIP Sync for the SOE modules, the Communication Format needs to be set for CIP Sync Per Point. This parameter can be found in 1756-IB16ISOE Module Properties on the General tab. See Sequence of Events Modules Set Up on page 68.

Scenario Operation

This table describes the operation for a ControlLogix redundancy system, revision 19.50 or later, using the CIP Sync protocol in a network configured for a Star topology.

Table 27 - Operation Steps for a ControlLogix Redundancy System in a Star Topology with the Primary Controller as the Grandmaster

Operation	Description
1. The Grandmaster time value is sent to all 1756-EN*x*T*x* communication modules.	The controller's WCT is sent automatically to its local 1756-EN*x*T module. WCT time is propagated through the control system network via CIP Sync to all other 1756-EN*x*T*x* communication modules on the network.
2. The WCT of multiple ControlLogix controllers is synchronized.	The WCT automatically is updated with a UTC time value. UTC time values are passed automatically from the Slave 1756-EN*x*T modules in the remote chassis to the ControlLogix controller in the same chassis.
3. Time stamping with the 1756-IB16ISOE module occurs.	UTC time values are also passed automatically from the Slave 1756-EN*x*T modules in the remote chassis to the SOE modules in the same chassis. Once an SOE event occurs, a UTC time stamp is recorded and sent to the controller via the input connection.
4. The SOE time stamps appear on an HMI device or are stored in a database.	A UTC time stamp appears on an Alarms and Events banner within FactoryTalk View SE HMI via application code in the form of an ALMD instruction. The HMI may display the UTC time stamp as the equivalent time for the local time zone. You can also have these local time stamps logged to a MSSQL database via the FactoryTalk View SE HMI. See Visualizing Sequence of Events on HMI using FactoryTalk Alarms and Events Instructions on page 125. For information about the ALMD instruction, see the Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.

IMPORTANT **ControlLogix Redundancy Systems and Switchovers**

- Data is crossloaded continually, so that the Redundant system is ready for a switch over.
  The setting to Enable Time Synchronization in the Primary controller will be crossloaded to the Secondary controller. The Secondary controller will always lose clock quality arbitration to the Primary controller.
- The quality of the clock becomes `Hand Set' when a clock class upgrade occurs during a switchover.
  Hand-setting the Primary also hand-sets the Secondary, but the Secondary masks this improved quality to avoid becoming Grandmaster.
- If the old Primary was hand-set, the new Primary will also be hand-set after a switchover.

ControlLogix Redundancy System in a Star Topology with a GPS Module as the Grandmaster

This scenario consists of a ControlLogix redundancy system, revision 19.50 or later, using the CIP Sync protocol in a network configured for a Star topology. The time source for the Grandmaster clock is the GPS module.

Hardware Setup

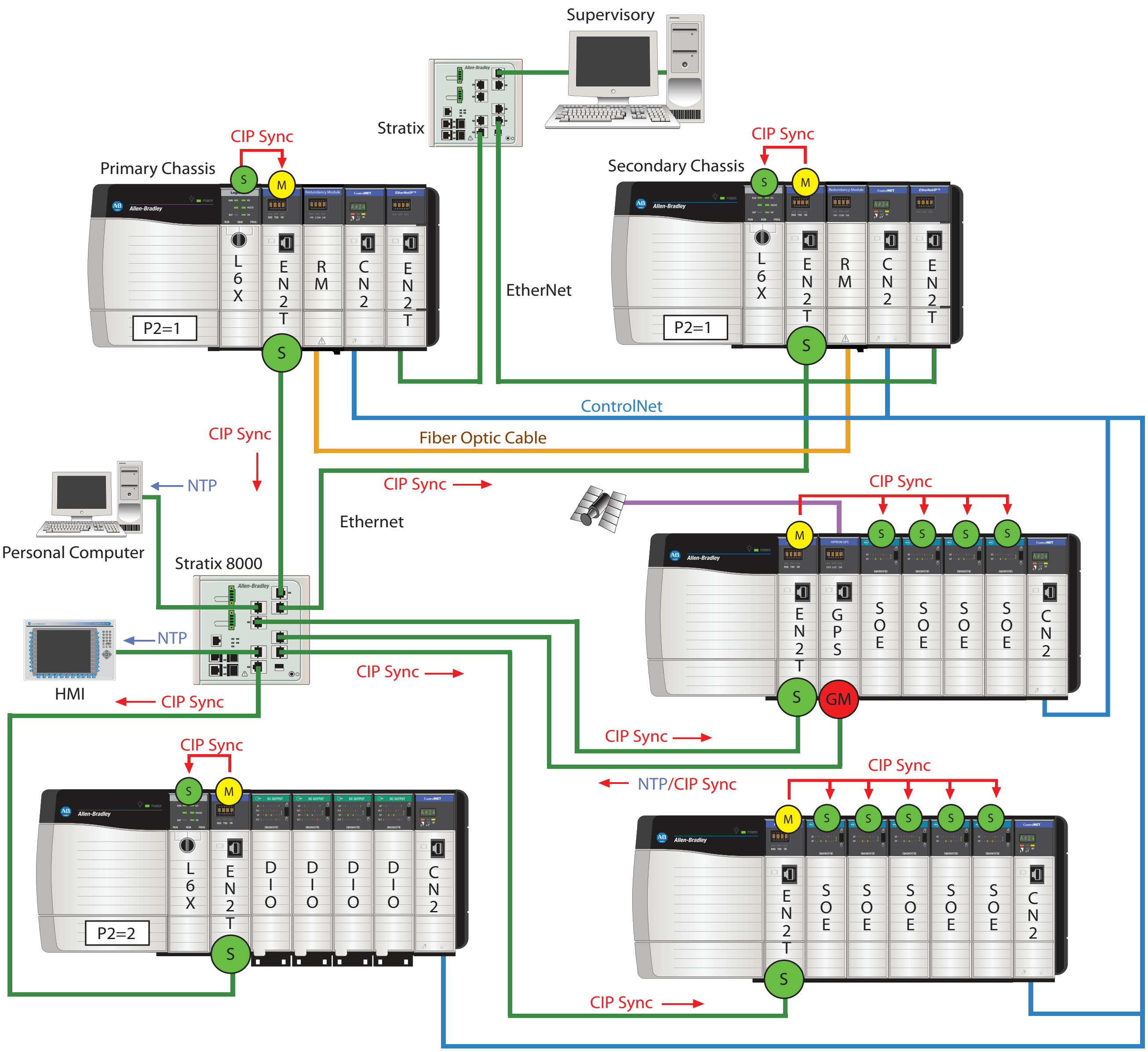
This system consists of the following:

- One Redundant Chassis Pair with a 1756-L6*x* or a 1756-L7*x* controller, firmware revision 19.50 or later.
- A 1756HP-TIME (GPS) module, firmware revision 3.0 or later, with CIP Sync protocol.
- Two Stratix 8000 Ethernet Managed Switches with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
- In this example, five 1756-EN*x*T communication modules, firmware revision 3.0 or later, with CIP Sync protocol. These are CIP Sync Slave devices on the network.
- Two 1756-RM Redundancy modules needed for crossloading of data from Primary to Secondary controller.
- In ControlLogix redundancy system, revision 19.50 or later, supports both ControlNet and EtherNet/IP I/O communication. In this example, two 1756-CN2 ControlNet communication modules are needed to establish a connection between the ControlLogix controller and its I/O modules.
- Several 1756-IB16ISOE modules, firmware revision 2.0 or later, to provide time stamps for actual field I/O. This module is also available in 120V DC.
- A client computer.
- A PanelView HMI interface.
- Supervisory level hardware
  - A Stratix 8000 Ethernet Managed Switch with CIP Sync protocol, configured to be a transparent clock with QoS enabled.
  - Two 1756-EN*x*T communication modules that provide a path to supervisory computers.
  - A supervisory computer.

  In this scenario, the supervisor is illustrated on its own network. It can just as easily be attached on an existing Stratix 8000 switch.

See Hardware and Software Requirements on page 80 for detailed device descriptions.

Figure 22 - ControlLogix Redundancy System in a Star Topology with the GPS Module as the Grandmaster



GM = Grandmaster (time source)

S = Slave

M = Master

P1 and P2 = Priorities

NTP = Network Time Protocol

NTP can be served from any NTP server available on the network, such as the 1756HP-TIME (GPS) module.

Scenario Setup

This table describes the setup for a ControlLogix redundancy system, revision 19.50 or later, using the CIP Sync protocol in a network configured for a Star topology.

Table 28 - Set-up Steps for a ControlLogix Redundancy System in a Star Topology with a GPS Module as the Grandmaster

Setup	Description
1. Choose what device to use for the Grandmaster time source.	In this scenario, a ControlLogix redundancy system needs to synchronize time throughout the network for accurate time stamping. This should be treated no differently than a single ControlLogix controller system. The GPS module is equipped with a higher clock quality than either the ControlLogix controller or the 1756-EN*x*T module, so it wins arbitration and becomes the Grandmaster on the network. The time value of the GPS module is represented as UTC. In a redundant system, the Secondary controller will always lose clock quality arbitration to the Primary controller. Priority parameters predict which device wins arbitration and becomes the Grandmaster on the network. Priority 2 values are set in this scenario to resolve ties between multiple controllers. Priority 2 values range from 0 (highest priority) to 255 (lowest priority) with the default being 128. See Configure Priorities on page 52.
2. Enable CIP Sync for each controller.	The setting to Enable Time Synchronization in the Primary controller is crossloaded to the Secondary controller. The clock quality attributes of the Secondary controller automatically adjusts so that it does not become the Grandmaster. To enable CIP Sync functionality in a ControlLogix controller, check the Enable Time Synchronization checkbox in RSLogix 5000 software. See Enable Time Synchronization on page 63.
3. Enable CIP Sync for each 1756-EN*x*T module.	The setting to Enable Time Synchronization for the 1756-EN*x*T*x* modules in the Primary are crossloaded to the Secondary 1756-EN*x*T*x* modules.The clock quality attributes of the Secondary modules automatically adjusts so that they do not become the Grandmaster. To enable CIP Sync in all 1756-EN*x*T*x* modules, the Time Sync Connection needs to be set for each module for Time Sync and Motion. See Communication Modules Set Up on page 66.
4. Enable CIP Sync for each of the 1756-IB16ISOE modules.	To enable CIP Sync for the SOE modules, the Communication Format needs to be set for CIP Sync Per Point. This parameter can be found in 1756-IB16ISOE Module Properties on the General tab. See Sequence of Events Modules Set Up on page 68.

Scenario Operation

This table describes the operation for a ControlLogix redundancy system, revision 19.50 or later, using the CIP Sync protocol in a network configured for a Star topology.

Table 29 - Operation Steps for a ControlLogix Redundancy System in a Star Topology with a GPS Module as the Grandmaster

Operation	Description
1. The Grandmaster time value is sent to all 1756-EN*x*T*x* communication modules.	The controller's WCT is sent automatically to its local 1756-EN*x*T module. WCT time is propagated through the control system network via CIP Sync to all other 1756-EN*x*T*x* communication modules on the network.
2. The WCT of multiple ControlLogix controllers is synchronized.	The WCT is automatically updated with a UTC time value. UTC time values are passed automatically from the Slave 1756-EN*x*T modules in the remote chassis to the ControlLogix controller in the same chassis.
3. Time stamping with the 1756-IB16ISOE module.	UTC time values are also passed automatically from the Slave 1756-EN*x*T modules in the remote chassis to the SOE modules in the same chassis. Once an SOE event occurs, a UTC time stamp is recorded and sent to the controller via the input connection.
4. The SOE time stamps appear on an HMI device or are stored in a database.	A UTC time stamp appears on an Alarms and Events banner within FactoryTalk View SE HMI via application code in the form of an ALMD instruction. The HMI may display the UTC time stamp as the equivalent time for the local time zone. You can also have these local time stamps logged to a MSSQL database via the FactoryTalk View SE HMI. See Visualizing Sequence of Events on HMI using FactoryTalk Alarms and Events Instructions on page 125. For information about the ALMD instruction, see the Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.

IMPORTANT **ControlLogix Redundancy Systems and Switchovers**

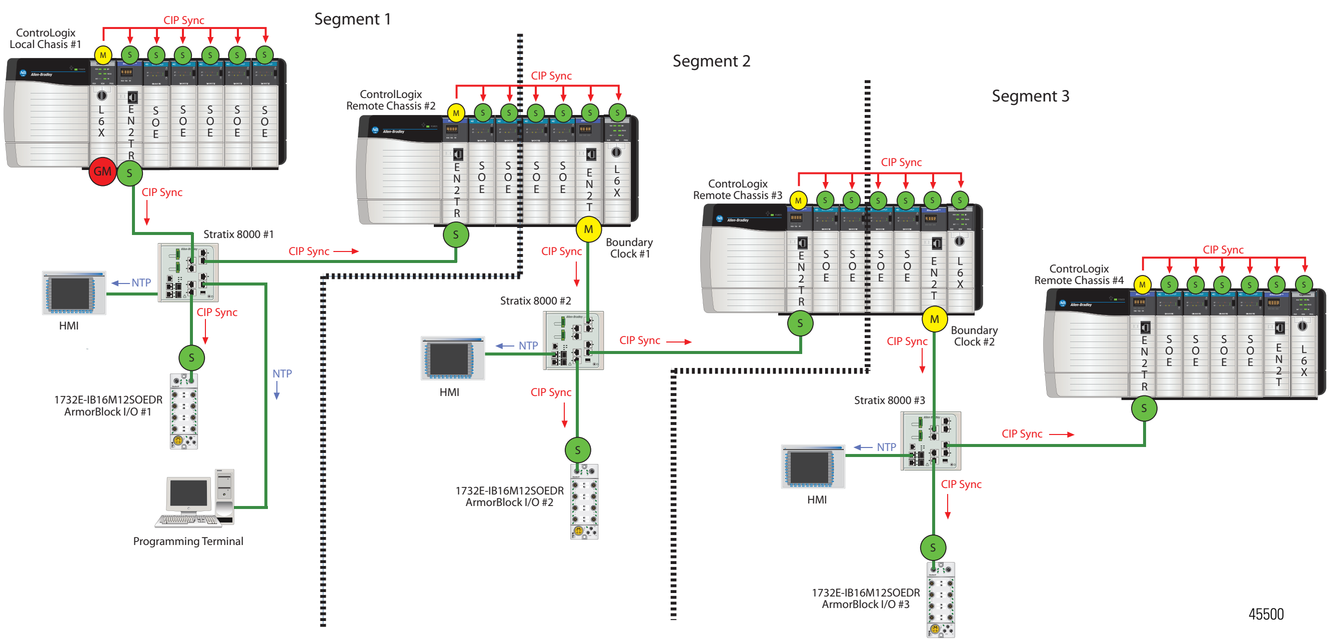
- Data is crossloaded continually, so that the Redundant system is ready for a switch over.
  The setting to Enable Time Synchronization in the Primary controller will be crossloaded to the Secondary controller. The Secondary controller will always lose clock quality arbitration to the Primary controller.
- The quality of the clock becomes `Hand Set' when a clock class upgrade occurs during a switchover.
  Hand-setting the Primary also hand-sets the Secondary, but the Secondary masks this improved quality to avoid becoming Grandmaster.
- If the old Primary was hand-set, the new Primary will also be hand-set after a switchover.

Network Segmentation using 1756-EN2T modules in Boundary Clock Mode

An alternative to segmenting the network via VLAN's you can segment a network by using 1756-EN2T modules and Stratix 8000 switches as boundary clocks. CIP Sync works across the segments enabling synchronization using one Grandmaster. Segmentation reduces the impact of broadcast and multicast traffic.

For more information about networks in manufacturing and network segmentation see the Reference Architectures for Manufacturing White Paper, publication ENET-WP004.

Figure 23 - Network Segmentation using 1756-EN2T's in Boundary Clock Mode



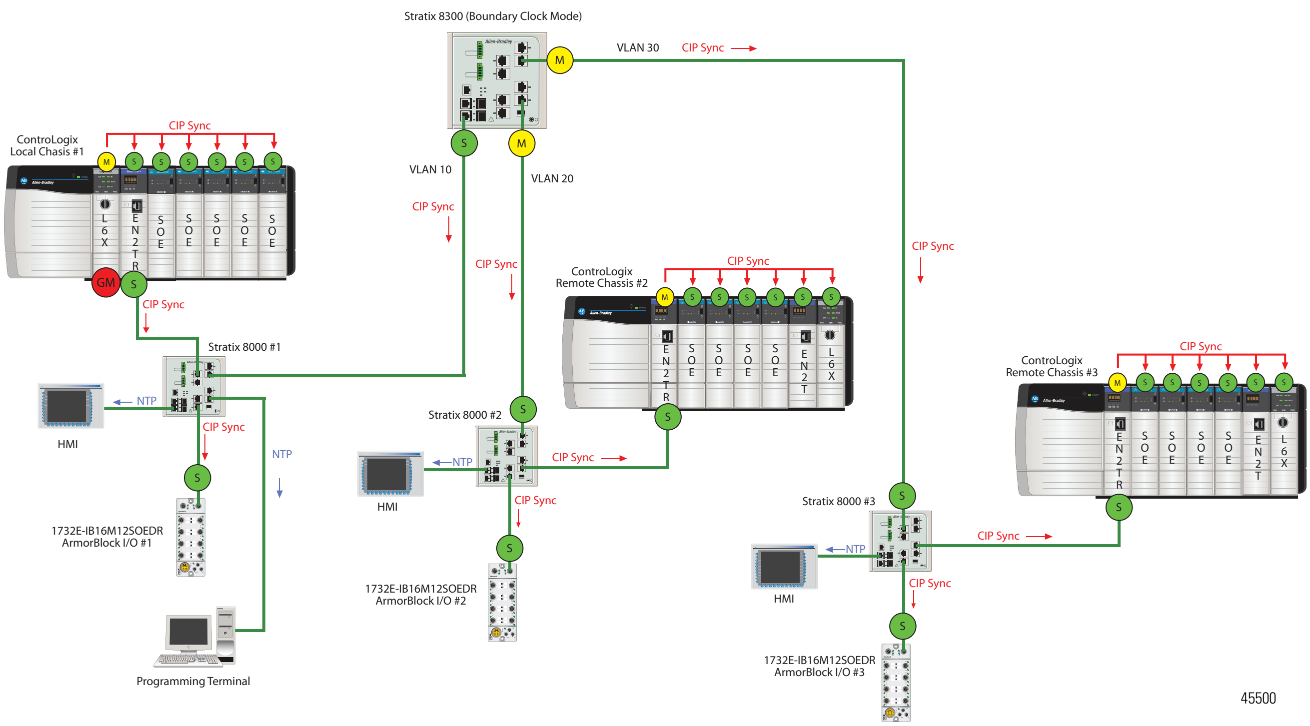
Network Segmentation using VLANS and a Stratix 8300 Switch in Boundary Clock Mode

An alternative to segmenting the network via VLAN's you can segment a network by using VLANs, 1756-EN2T modules, and a Stratix 8300 switch in Boundary Clock mode. CIP Sync works across the segments enabling synchronization using one Grandmaster.

By dividing a network by function and geographic area into smaller local area networks, the 3-tier network model provides natural segmentation. This lessens the impact of traffic management and security.

For more information about networks in manufacturing and network segmentation, see the Reference Architectures for Manufacturing White Paper, publication ENET-WP004.

Figure 24 - Network Segmentation using VLANs and a Stratix 8300 Switch in Boundary Clock Mode



Notes:

Visualizing Sequence of Events on HMI using FactoryTalk Alarms and Events Instructions

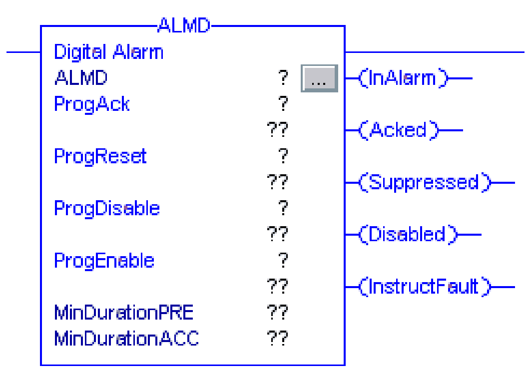
Introduction

This chapter discusses how to propagate time stamped alarms up to a FactoryTalk View SE HMI by using FactoryTalk Alarm and Events instructions.

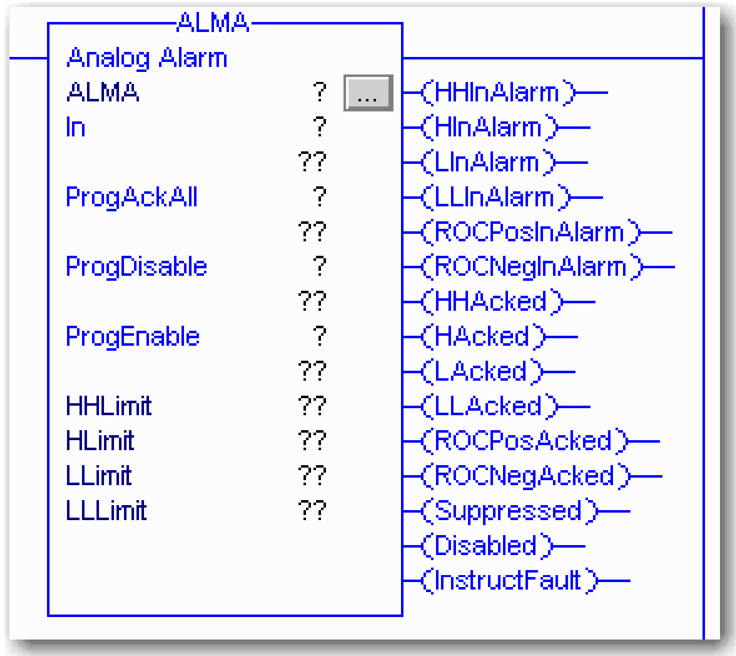
Alarm and Events Instructions

These Alarm and Events instructions reside in the RSLogix 5000 programming environment and come in two forms: ALMD for discrete alarming and ALMA for analog alarming:

- The ALMD instruction detects alarms based on boolean (true/false) conditions.



- The ALMA instruction detects alarms based on the level or rate of change of an analog value.



There are two different time sources that you can use with Alarm and Events instructions, instruction-initiated time stamps and program-initiated time stamps:

- Instruction-initiated time stamps

  The Controller Wall Clock Time is used as the time source for the Alarm and Events instruction better know as System Time.

- Program-initiated time stamps

  The CIP Sync capable I/O Module Time Stamps, for example, the 1756-IB16ISOE module, is used as the time source for the FactoryTalk Alarms and Events instruction.

Generating a Time Stamped Alarm and Event by using an Instruction-initiated System Time Stamp

Lets say you have a steam application, where you want to monitor alarms when a particular steam valve opens, and monitor the steam pressure. If the pressure goes above or below certain limits, you want operators to be notified about this on the HMI Alarm Summary screens.

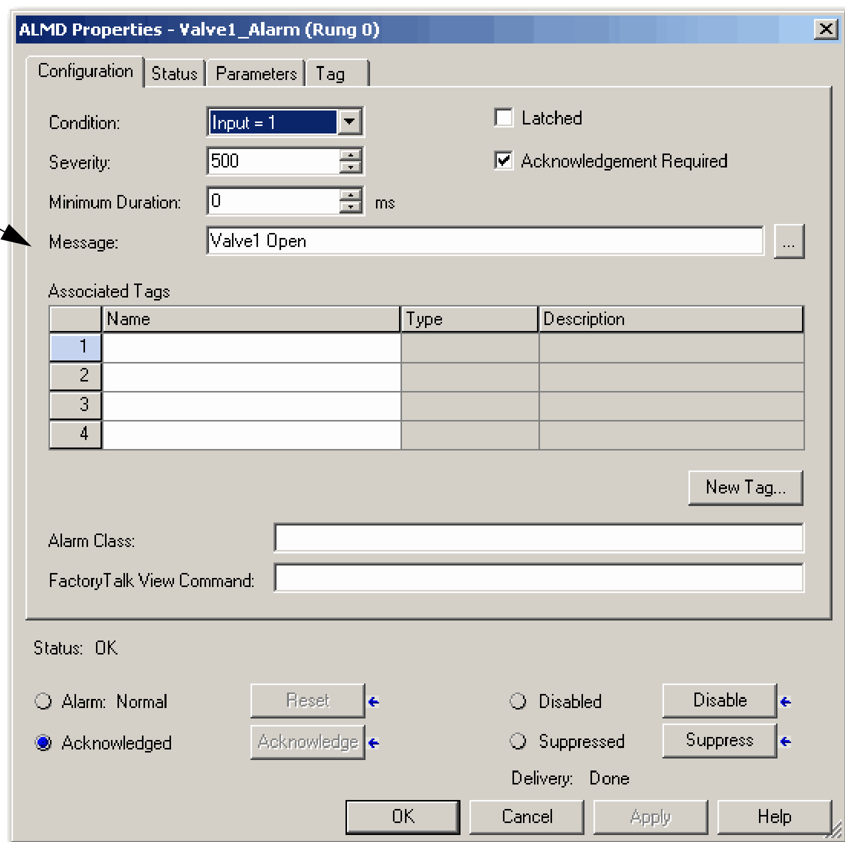
Example 1, ALMD (discrete alarm)

How do you produce an alarm on an HMI screen with status about the alarm and a System Time stamp as well?

This example shows how to use the ALMD instruction in its simplest form, meaning the minimum to configure it. The condition for this alarm is a valve in its open condition and the ALMD instruction generates the time stamp.

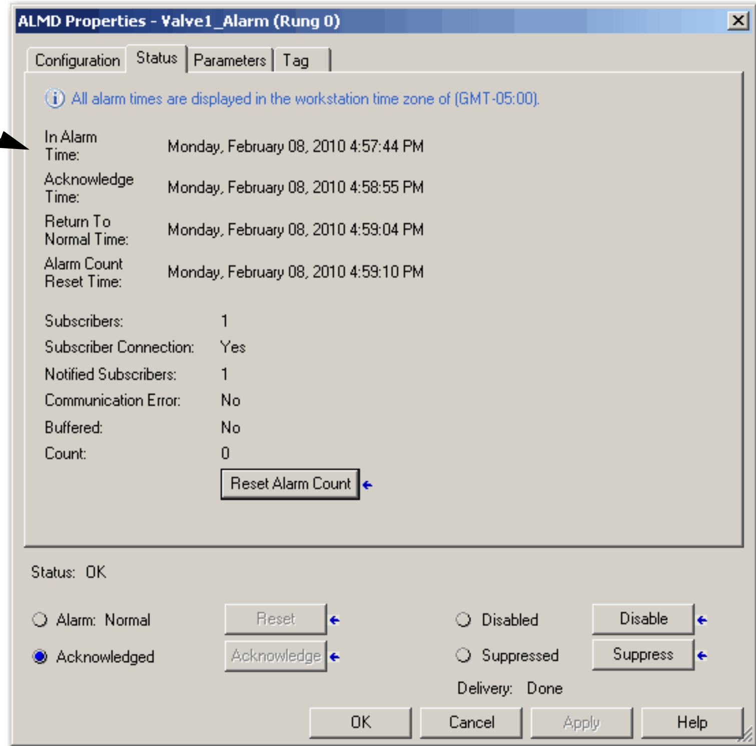
ALMD Properties Dialog Box: Configuration Tab

Valve1 Open appears on the HMI Alarm Summary dialog box.



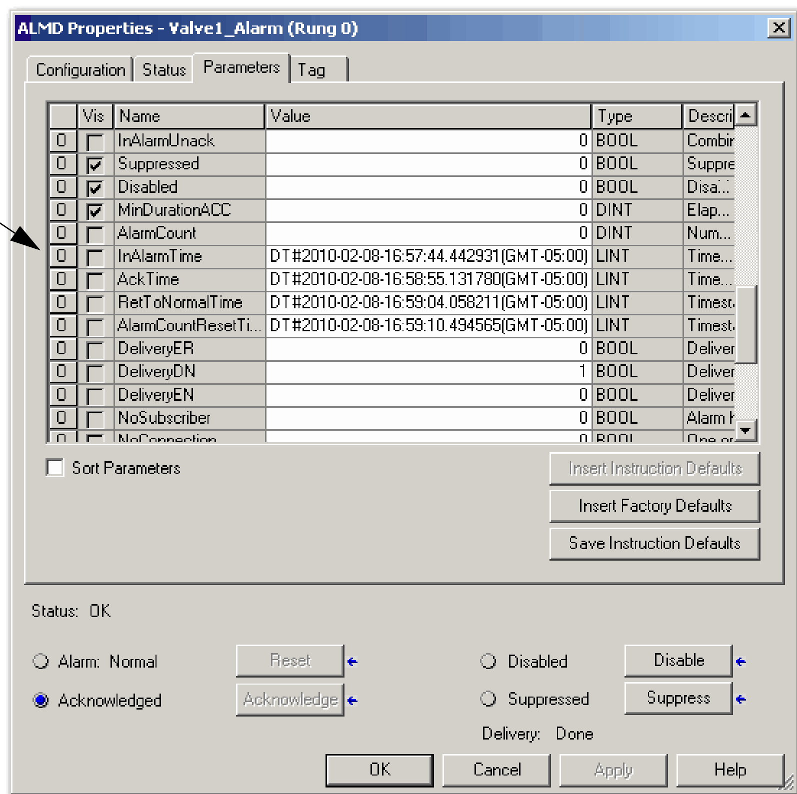
ALMD Properties Dialog Box: Status Tab

When Valve1 opens or becomes true, various time stamps display on the Status tab.



ALMD Properties Dialog Box: Parameters Tab

Various time stamps in the ALMD tags display on the Parameters tab.

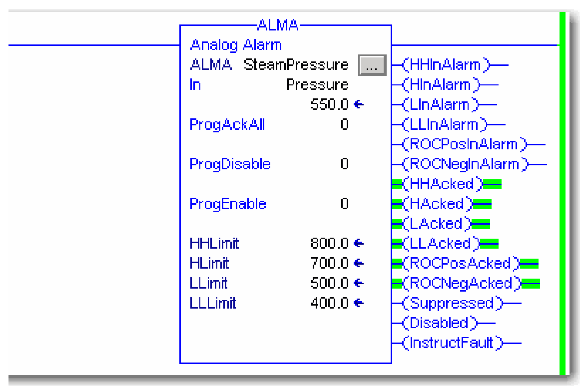


FactoryTalk View SE HMI Display

The same alarm information appears on the FactoryTalk View SE Alarm Summary screen.

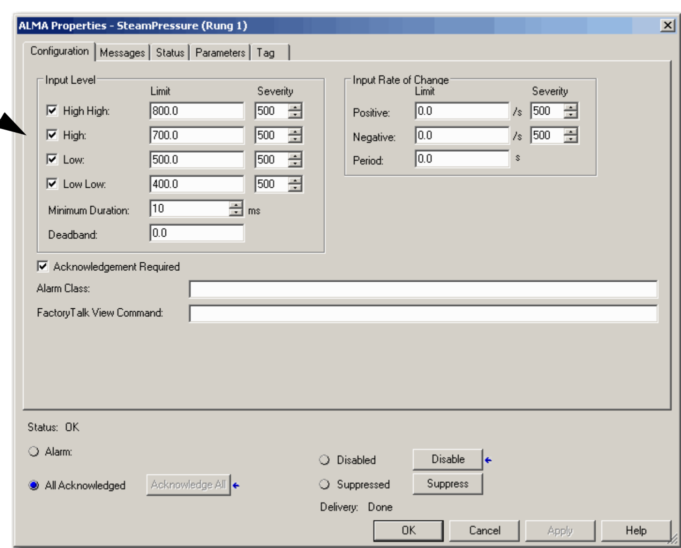
Example 2, ALMA (analog alarm)

This example uses the ALMA instruction to monitor Steam Pressure. If the steam pressure stays between 501…699 psi, the ALMA instruction will not alarm. If the steam pressure is ≥ 700 or ≤ 500, then various alarm limits will be met or exceeded. A time stamp and alarm will be generated for each. Once again, this example shows the simplest ALMA configuration.



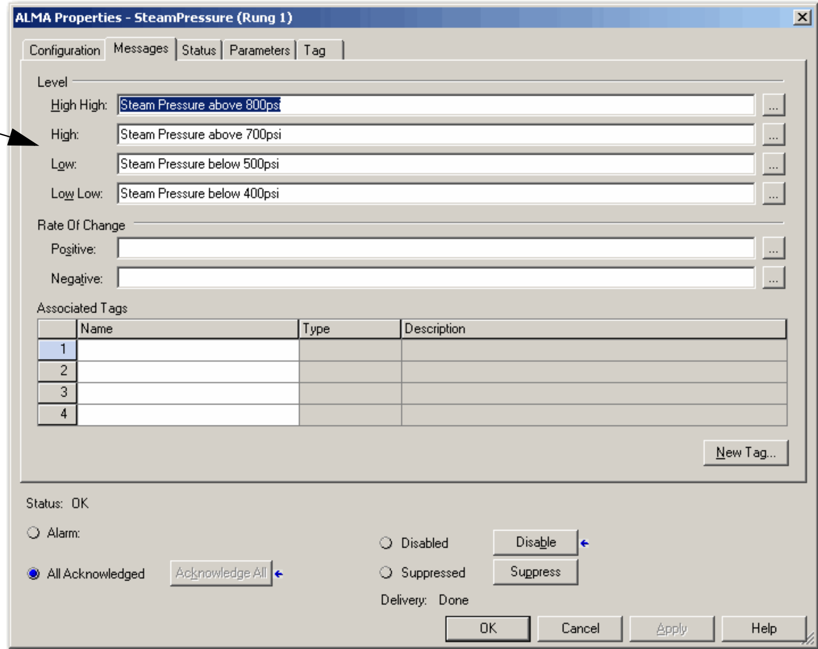
ALMA Properties Dialog Box: Configuration Tab

On the Configuration tab, set the limits to determine if steam pressure has risen above 699 psi (High Alarm) or fallen below 501 psi (Low Alarm) with a minimum duration of 10 ms.



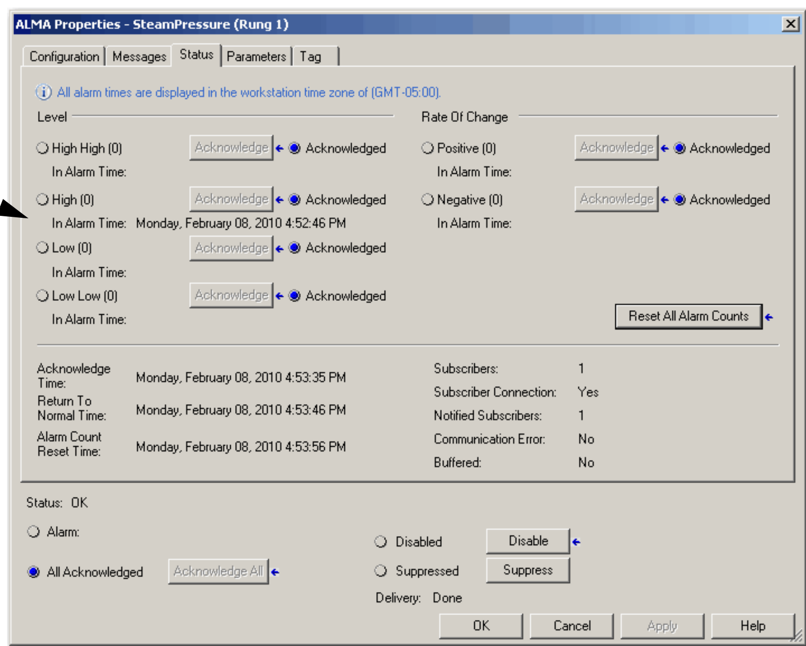
ALMA Properties Dialog Box: Messages Tab

On the Messages tab, create the messages that display on the HMI dialog box.



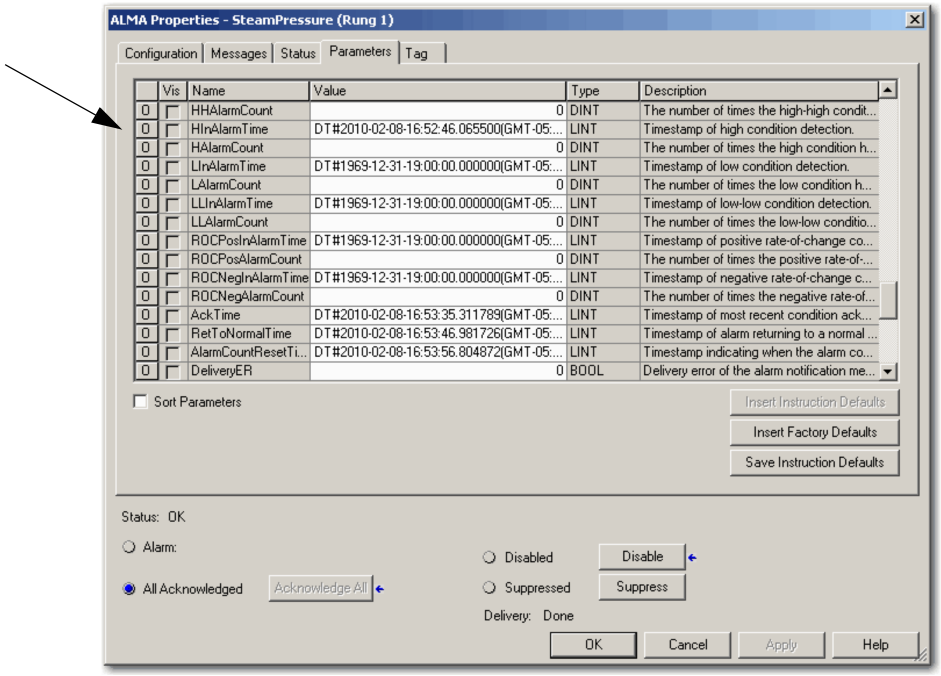
ALMA Properties Dialog Box: Status Tab

Various time stamps display on the Status tab.



ALMA Properties Dialog Box: Parameters Tab

Various time stamps display in the ALMA tags on the Parameters tab.



FactoryTalk View SE HMI Display

The same alarm information appears on the FactoryTalk View SE Alarm Summary screen.

Generating a Time Stamped FactoryTalk Alarms and Events by using a Program-initiated System Time Stamp

A program-initiated time stamp programmatically sends a time stamp value. This value, previously captured by an external device, is sent to the ALMD before enabling the instruction. The time stamp that is captured by the external device is published in the Alarms Summary page of FactoryTalk View SE software.

Why use a program-initiated time stamp?

Because an alarming system is often the key to tracing the history of a process or application event, it is very important for time stamps to be as accurate as possible. Instruction-based time stamps are significantly more accurate than traditional HMI-driven time stamps.

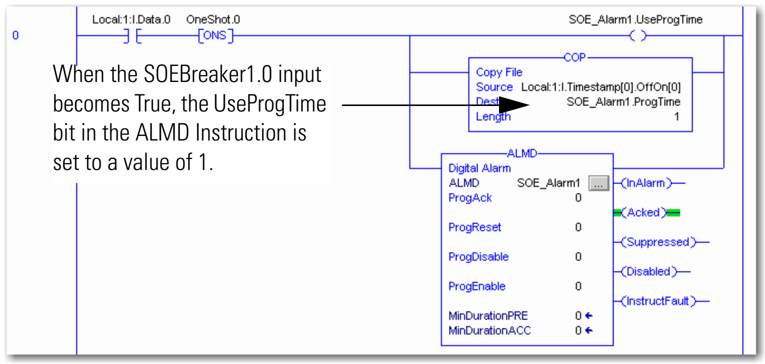
Instruction-based time stamps do not have the overhead associated with polling every controller in a serial fashion for alarms. While significantly more accurate, they are limited to the detection ability of the controller. So, an instruction-based time stamp cannot exceed the accuracy of the actual rate that the instruction is scanned.

Improved accuracy can be obtained if the actual device or I/O module that is causing the alarm time stamps the event. This takes the controllers scan time out of the equation and allows a significantly more accurate time stamp for an event. For example, the 1756-IB16ISOE module is capable of time stamping events to 50 μs accuracy, significantly faster than the scan time of even the leanest controller application code.

Example 1, ALMD (discrete alarm)

This example uses the ALMD instruction and the 1756-IB16ISOE module to monitor the electrical breakers that help produce and distribute power to the grid. Because of the extremely fast response time of these breakers, higher accuracy on the time stamp of the event is necessary to recreate the cause of a system failure.

Ladder Logix

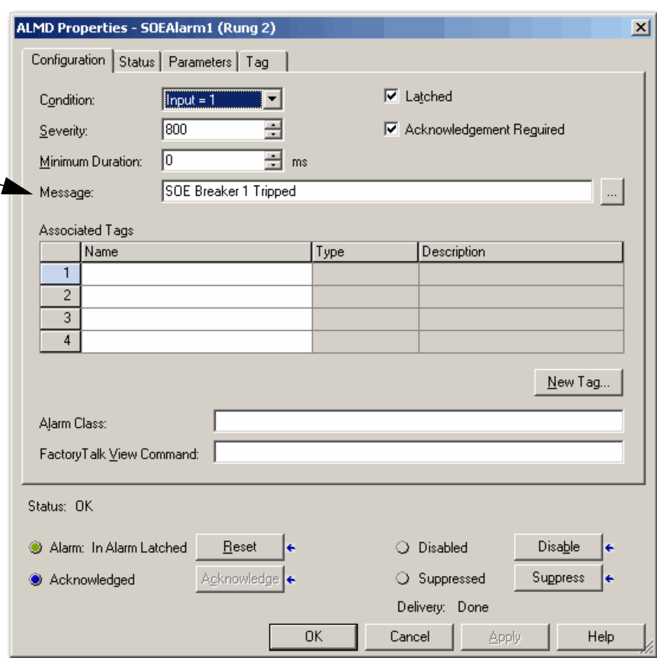


This prepares the ALMD Instruction to accept the SOE modules time stamp data. The SOE time stamp is converted from a 2-DINT 32-bit format into a 1-LINT 64-bit format and inserted into the SOEAlarm1.ProgTime register by using the COP Instruction.

When the ALMD Instruction executes, it will publish the time stamp that was collected by the SOE module.

ALMD Properties Dialog Box: Configuration Tab

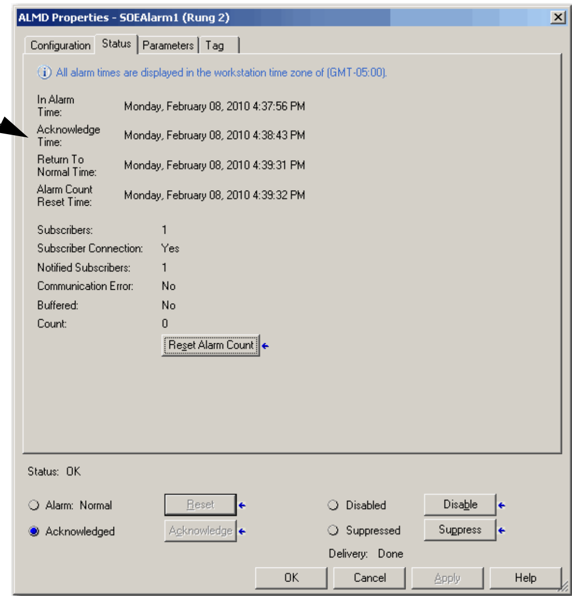
On the Configuration tab, the message SOE Breaker 1 Tripped appears on the HMI Alarm Summary dialog.



When SOE Breaker 1 closes or becomes true, time stamps display on the Status tab.

ALMD Properties Dialog Box: Status Tab

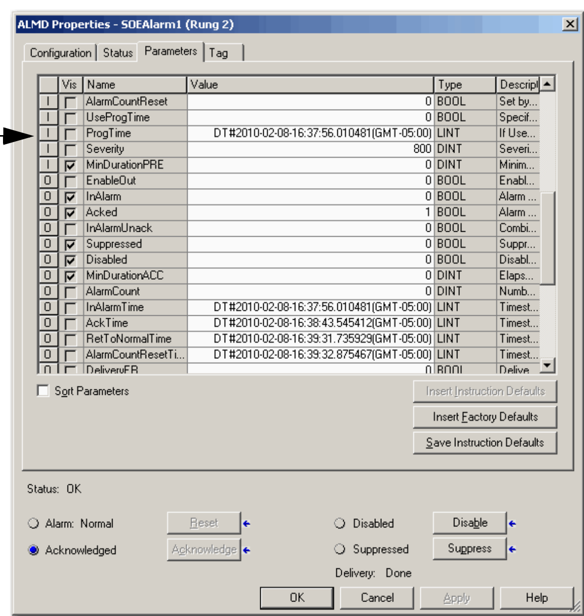
Various time stamps display on the Status tab.



ALMD Properties Dialog Box: Parameters Tab

Various time stamps display in the ALMD tags on the Parameters tab.

Notice that the ProgTime time stamp is the same as the InAlarmTime time stamp; that is because you placed it there with the COP Instruction.



FactoryTalk View SE HMI Display

The same alarm information appears on the FactoryTalk View SE Alarm Summary screen.

Time Stamps with Computer Tag Based Alarms

If your alarming system is configured to use Tag Based alarming to collect alarms (uses traditional polling to monitor alarm bits), your time stamp will come from the alarm server running FactoryTalk and RSLinx Enterprise software. To successfully integrate these time stamps with Logix Instruction based alarming, you need to synchronize the computer's Wall Clock with the clock for your control system.

See the FactoryTalk Alarms and Events Quick Start, publication FTAE-QS001.

The easiest way to synchronize this type of system would be to insert an Ethernet device in the network that would propagate PTP time packets of data to PAC control devices, for example 1756-L6*x* and 1756-L7*x* controllers, 1756-EN*x*T*x* communication modules, 1756-IB16ISOE Sequence of Events modules, 1732E-IB16M12SOEDR ArmorBlock module, and NTP time packets of data to computer based devices.

The 1756HP-Time (GPS) module and the 1756-EWEB module are examples products that can be used to convert between N TP and CIP Sync.

Tag Based Alarms for Non-Logix Applications

If you need to gather alarms from processors such as PLC-5 or SLC 500 or even third-party controllers, they can still use the FactoryTalk Alarms and Events feature through the use of tag based alarms. These alarms, created at the HMI, mimic the functionality of Logix-based alarms and will appear on the new Alarm Summary and Alarm Banner objects in FactoryTalk View SE software.

Importing Time Stamps without FactoryTalk View SE Software

While FactoryTalk View SE software provides an excellent container for displaying and sorting alarms, it is optional in an SOE system. The FactoryTalk Alarms and Events service comes with the FactoryTalk Service Platform software and does not require FactoryTalk View SE software to subscribe and log alarm events.

Follow these steps to import time stamps without FactoryTalk View SE software.

1. Use ALMD and ALMA instructions in the controller by using the techniques described previously to move the SOE time stamps into the alarm instructions.

2. Trigger the alarm instructions as needed to deliver the events and time stamps.

3. On your computer, install FactoryTalk Service Platform software with the Alarms and Events service.

   The Alarms and Events service comes with RSLinx Enterprise software and is available with RSLogix 5000 software and as a separate installation.

4. Configure the FactoryTalk Alarms and Events service to subscribe to the controller by using the FactoryTalk Administration Console service.

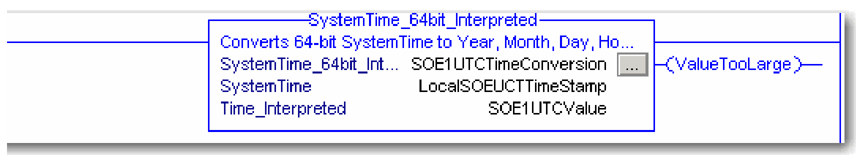
5. Configure the FactoryTalk Alarm and Event Service to log the alarms in an SQL database with the FactoryTalk Administration Console.

6. Create SQL Queries and deliver the data from these Queries to your target application or HMI.

If you chose not to use the alarming infrastructure to deliver your SOE time stamps to your system you can directly move these time stamps and their events to the target application. RSLinx Enterprise and RSLinx Classic software both support 64 bit LINT values by using OPC. These values must be interpreted as time values at the target application level.

The application receiving the 64 bit integers must interpret them as time stamps by converting them through your applications. The time stamp from Logix controllers and SOE modules are 64 bit number representation of the number of microseconds that have passed since 1970-01-01-00:00:00.000000(+00:00).

If this code is too difficult to create in your target application, the RSLogix 5000 software Sample Code website provides an Add-On Instruction that will convert the 64-bit time stamps into Gregorian time at the controller. The time stamps could then be uploaded as Gregorian (Year, Month, Day, Hour, Minute, Second, Microsecond) in a 7-Dint format.



Follow these steps to find the System Time 64-bit Interpreted Add-On Instruction.

1. Go to this URL:

http://samplecode.rockwellautomation.com/idc/groups/public/documents/webassets/sc_home_page.hcst

2. From the Technologies & Functionalities pull-down menu, choose Clock Timing.

3. Download the Add-On Instruction:
System Time 64-bit Interpreted AOI.

Importing Time Stamps

While FT View SE software provides an excellent way to display and sort alarms, it is optional in an SOE system.

The FactoryTalk Alarm and Event service comes with the Factory Talk Service Platform and does not require FT View SE software to subscribe and log alarm events.

Import Time Stamps without FT View SE Software

Follow these steps to import time stamps without FT View SE software.

1. Use ALMD and ALMA instructions in the controller to move the SOE time stamps into the alarm instructions.

   See Generating a Time Stamped Alarm and Event by using an Instruction-initiated System Time Stamp on page 127.

2. Trigger the alarm instructions as needed to deliver the events and time stamps.

3. On the PC, install Factory Talk Service Platform with the Alarm and Event Service.

   The Alarm and Events service comes with RSLinx Enterprise and is available with RSLogix 5000 and as a separate installation.

4. Configure the FT Alarm and Event Service to subscribe to the controller using the Factory Talk Administration Console.

5. Configure the FT Alarm and Event Service to Log the alarms in an SQL database with the Factory Talk Administration Console.

6. Create SQL Queries and deliver the data from these Quires to your target application or HMI.

Import Time Stamps without FT Alarms and Events

If you chose not to use the alarming infrastructure to deliver your SOE time stamps to your system you can directly move these time stamps and their events to the target application. RSLinx Enterprise and RSLinx Classic both support 64 bit LINT values using OPC. These values must be interpreted as time values at the application level.

The application receiving the 64 bit integers must interpret them as time stamps by converting them through your applications. The time stamp from Logix controllers and SOE modules are 64 bit number representation of the number of Microseconds that have passed since 1970-01-01-00:00:00.000000(+00:00).

If this code is too difficult to create in your target application, the RSLogix sample code web site provides an add on instruction that will convert the 64 bit time stamps into Gregorian time at the controller. The time stamps could then be uploaded as Gregorian.

See Where to Find Sample Projects on page 14.

System Specifications

Introduction

These are the CIP Sync technology specifications. Refer to specific product documentation for device specifications.

Item	Description
Typical Rack to Rack (1756-EN*x*T to 1756-EN*x*t) Synchronization	< 100 ns
Maximum number of daisy chain transparent clocks[1]	100
Maximum number of nodes in a device level ring (DLR)	50
Maximum number of Ethernet switches deep	• 15 switch max, no IEEE 1588-2008 implementation • 7 switch max with boundary clock • 64 switch max with transparent clocks
Maximum number of Slaves per Master	64 1756-EN2T, 1756-EN2F 100 1756-EN2TR, 1756-EN3TR 100 Stratix 8000 switch, if in boundary clock 128 1756HP-TIME (GPS)
Time stamp accuracy of Sequence of Events Modules: 1756-IB16ISOE 1756-IH16ISOE 1732E-IB16M12SOEDR	< 100 μs

(1) A Stratix 8*xxx* series switch, configured as a transparent clock and in the path between the system Grandmaster and its time slaves, may reduce the max number of devices supported.

Notes:

Time Sync Object Attributes

Introduction

The Time Sync object provides a Common Industrial Protocol (CIP) interface to the IEEE 1588-2008 standard for a precision clock synchronization protocol for networked measurement and control systems. You can collect diagnostic information for single-port devices, for example, controllers.

For information about 1756-EN*x*T*x*, dual port devices, see the EtherNet/IP Modules in Logix5000 Control Systems User Manual, publication ENET-UM001.

Accessing Attributes

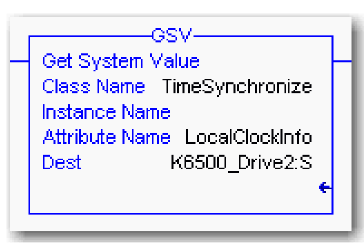
You can access attributes in RSLogix 5000 software in several ways.

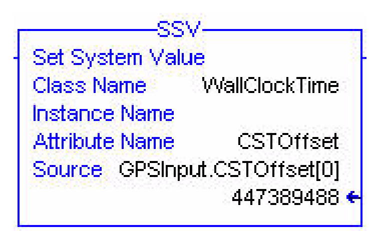
Generally Get/Set applies to messaging. You can access the controller attributes also with a GSV/SSV,

- Get System Value (GSV)
- Set System Value (SSV)
- CIP Message (MSG)

Accessing the Attributes via GSV/SSV

You can access TimeSynchronize through the GSV/SSV instructions from the local controller.





GSV/SSV Example

The Access column shows how to access the attribute in RSLogix 5000 programming software.

Grandmaster Clock Info Attribute Name

Attribute ID Number

ID	Data Type	Access	Description
8	DINT[6]	GSV	Property information about the Grandmaster clock.

Use a Get System Value (GSV) to get the value.

Priority 2 Attribute Name

ID	Data Type	Access	Description
17	SINT	SSV	Priority 2 (Tie Breaker) value for the local clock. Value is Unsigned.

Use a Set System Value (SSV) instruction to set or change the value.

Accessing the Attributes via a MSG Instruction

For complete information on how to access data by using a MSG instruction, see the Logix5000 Controllers Messages Programming Manual, publication 1756-UM012.

MSG Example

The Access column shows how to access the attribute in RSLogix 5000 programming software.

Grandmaster Clock Info Attribute Name

Attribute ID Number

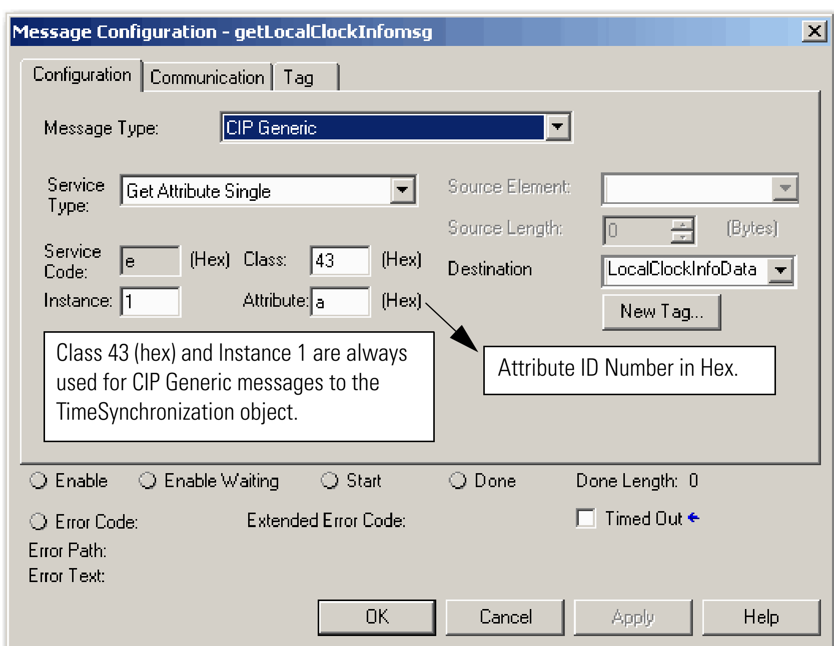
ID	Data Type	Access	Description
8	DINT[6]	GSV	Property information about the Grandmaster clock.

Use Get Attribute Single to get the value.

Priority 2 Attribute Name

ID	Data Type	Access	Description
17	SINT	SSV	Priority 2 (Tie Breaker) value for the local clock. Value is Unsigned.

Use a Set Attribute Single to set or change the value.



Time Sync Attributes

These are the attributes associated with the Time Sync object.

Table 30 - PTP Enable

ID	Data Type	Access	Description
1	UDINT	SSV GET/SET	The enable status for CIP Sync/PTP/Time Synchronization on the device. 0 = Disable 1 = Enabled

Table 31 - Is Synchronized

ID	Data Type	Access	Description
2	UDINT	GSV GET	Local clock is synchronized with a Master. 0 = Not synchronized 1 = Synchronized Is Synchronized is read only (GSV), and cannot be set. The message instruction will fail if this attribute is written to the Time Sync object.

Table 32 - System Time Microseconds

ID	Data Type	Access	Description
3	ULINT	SSV GET/SET	Current value of System Time in microseconds.

Table 33 - System Time Nanoseconds

ID	Data Type	Access	Description
4	ULINT	SSV GET/SET	Current value of System Time in nanoseconds.

Table 34 - Offset From Master

ID	Data Type	Access	Description
5	LINT	GSV Get	The calculated difference between the local clock and the Master clock, based on the most recent Sync message, in nanoseconds.

Table 35 - Max Offset From Master

ID	Data Type	Access	Description
6	ULINT	SSV GET/SET	Maximum offset from Master in nanoseconds. Specifies the absolute value of the maximum amount of deviation between the local clock and the master clock in nanoseconds since last set. It is typically set to 0.

Table 36 - Mean Path Delay To Master

ID	Data Type	Access	Description
7	LINT	GSV Get	Average path delay from Master to local clock in nanoseconds.

Table 37 - Grandmaster Clock Info

ID	Data Type	Access	Description
8	STRUCT of	GSV Get	Property information about the Grandmaster clock.

Table 38 - Grandmaster Clock Information Structure

Attribute	Data Type
Clock Identity	USINT[8]
Clock Class	UINT
Time Accuracy	UINT
Offset Scaled Log Variance	UINT
Current Utc Offset	UINT
Time Property Flags	WORD
Time Source	UINT
Priority 1	UINT
Priority 2	UINT

Clock Class

ClockClass specifies the class of the clock quality. The clock class represents a relative measure of the clock quality used by the Best Master Algorithm to determine the Grandmaster. The class is a value between 0 and 255, with 0 as the best clock. These are the values most likely to be used in CIP Sync. Refer to the 1588 specification for a complete list of values.

Table 39 - Clock Class Values

Clock Class	Value
Primary Reference	6
Primary Reference (Hold)	7
Degraded Reference A (Master only)	52
Degraded Reference B (Master / Slave)	187
Default	248
Slave Only	255
See 1588 specification	All others

Time Accuracy

TimeAccuracy specifies the expected absolute accuracy of the clock relative to the PTP epoch. TimeAccuracy is the accuracy measure of clock quality used by the Best Master Algorithm to determine the Grandmaster. The accuracy is specified as a graduated scale starting at 25 μs and ending at greater than 10 seconds or unknown. A GPS time source will have an accuracy of approximately 250 nanoseconds. A HAND set clock will typically have accuracy less than 10 seconds. The lower the accuracy value, the better the clock.

Table 40 - Time Accuracy Values

Clock Accuracy	Value
Reserved	0x00-0x1F
The time is accurate to within 25 ns	0x20
The time is accurate to within 100 ns	0x21
The time is accurate to within 250 ns	0x22
The time is accurate to within 1 us	0x23
The time is accurate to within 2.5 us	0x24
The time is accurate to within 10 us	0x25
The time is accurate to within 25 us	0x26
The time is accurate to within 100 us	0x27
The time is accurate to within 250 us	0x28
The time is accurate to within 1 ms	0x29
The time is accurate to within 2.5 ms	0x2A
The time is accurate to within 10 ms	0x2B
The time is accurate to within 25 ms	0x2C
The time is accurate to within 100 ms	0x2D
The time is accurate to within 250 ms	0x2E
The time is accurate to within 1 s	0x2F
The time is accurate to within 10 s	0x30
The time is accurate to >10 s	0x31
Reserved	0x32-0x7F
For use by alternate PTP profiles	0x80-0xFD
Unknown	0xFE
Reserved	0xFF

Table 41 - Parent Clock Info

ID	Data Type	Access	Description
9	STRUCT of	GSV Get	Property information about the parent clock.

Table 42 - Parent Clock Information Structure

Attribute	Data Type	Description
Clock Identity	USINT[8]	
Port Number	UINT	
Observed Offset Scaled Log Variance	UINT	ObservedOffsetScaledLogVariance specifies an estimated measure of the parent clock's variance as observed by the slave clock. OffsetScaledLogVariance specifies a measure of the inherent stability properties of the clock. OffsetScaledLogVariance is the variance measure of clock quality used by the Best Master Algorithm to determine the Grandmaster. The value is represented in offset scaled log units. The lower the variance, the better the clock.
Observed Phase Change Rate	UDINT	ObservedPhaseChangeRate specifies an estimated measure of the parent clock's drift as observed by the slave clock.

Clock Identity Structure

ClockIdentity specifies the unique identifier for the clock. The format of the identifier depends on the network protocol. Ethernet encodes the MAC address into the identifier. DeviceNet and ControlNet encode the Vendor ID and Serial Number.

Table 43 - Clock Identity Encoding for Different Network Implementations

Network	Octet 0	Octet 1	Octet 2	Octet 3	Octet 4	Octet 5	Octet 6	Octet 7
Ethernet/IP	MAC Address			FF	FE	MAC Address		
DeviceNet	FF	01	Vendor ID		Serial Number			
ControlNet	FF	02	Vendor ID		Serial Number			
Local or closed	FF	FF	Vendor ID		Serial Number			
All others	See 1588 PTP Specification							

Table 44 - Local Clock Info

ID	Data Type	Access	Description
10	STRUCT of	GSV Get	Property information about the local clock. GrandmasterClockInfo, ParentClockInfo, and LocalClockInfo specify clock property information for the Grandmaster, Master and Local PTP clock respectively. The data is extracted from the PTP data sets maintained by the PTP device.

Table 45 - Local Clock Information Structure

<table>
<tr><th>Attribute</th><th>Data Type</th></tr>
<tr><td>Clock Identity</td><td>USINT[8]</td></tr>
<tr><td>Clock Class</td><td>UINT</td></tr>
<tr><td>Time Accuracy</td><td>UINT</td></tr>
<tr><td>Offset Scaled Log Variance</td><td>UINT</td></tr>
<tr><td>Current Utc Offset
CurrentUtcOffset specifies the current UTC offset in seconds from International Atomic Time (TAI) of the clock. As of 0 hours 1 January 2006 UTC, the offset was 33 seconds.</td><td>UINT</td></tr>
<tr><td>Time Property Flags
TimePropertyFlags specifies the time property flags of the clock.</td><td>WORD
<table>
<tr><th>Time Property Flags</th><th>Bit Index</th></tr>
<tr><td>Leap indicator 61</td><td>0</td></tr>
<tr><td>Leap indicator 59</td><td>1</td></tr>
<tr><td>Current UTC offset valid</td><td>2</td></tr>
<tr><td>PTP timescale</td><td>3</td></tr>
<tr><td>Time traceable</td><td>4</td></tr>
<tr><td>Frequency traceable</td><td>5</td></tr>
</table></td></tr>
<tr><td>Time Source
TimeSource specifies the primary time source of the clock.</td><td>UINT
<table>
<tr><th>Time Source</th><th>Value</th></tr>
<tr><td>ATOMIC CLOCK</td><td>0x10</td></tr>
<tr><td>GPS</td><td>0x20</td></tr>
<tr><td>TERRESTRIAL RADIO</td><td>0x30</td></tr>
<tr><td>PTP</td><td>0x40</td></tr>
<tr><td>NTP</td><td>0x50</td></tr>
<tr><td>HAND SET</td><td>0x60</td></tr>
<tr><td>OTHER</td><td>0x90</td></tr>
<tr><td>INTERNAL OSCILLATOR</td><td>0xA0</td></tr>
<tr><td>For use by alternate PTP profiles</td><td>0xF0-0xFE</td></tr>
<tr><td>Reserved</td><td>0xFF</td></tr>
</table></td></tr>
</table>

Table 46 - Number Of Ports

ID	Data Type	Access	Description
11	UINT	GSV Get	The number of PTP ports on the device. PTP Ordinary clocks have one port. PTP Boundary and Transparent clocks have more than one port.

Table 47 - Port State Info

ID	Data Type	Access	Description
12	STRUCT of	GSV Get	The current state of each PTP port on the device.

Table 48 - Port State Structure

Attribute	Data Type
Number Of Ports	UINT
Port Number	UINT
Port State	UINT

Port State	Value
Initializing	1
Faulty	2
Disabled	3
Listening	4
Pre_Master	5
Master	6
Passive	7
Uncalibrated	8
Slave	9
Reserved	> 9

Table 49 - Port Enable Cfg

ID	Data Type	Access	Description
13	STRUCT of	GSV/SSV Get/Set	The port enable configuration of each port on the device. The default value is Enabled. Enabled = 1 Disabled = 0

Table 50 - Port Enable Status Structure

Attribute	Data Type
Number Of Ports	UINT
Port Number	UINT
Port Enable	UINT

Table 51 - Port Log Announce Interval Cfg

ID	Data Type	Access	Description
14	STRUCT of	GSV/SSV Get/Set	The interval between successive `Announce' messages issued by a Master clock on each PTP port of the device. Default = 1 Range = 0…4

Table 52 - Port Log Announce Interval Structure

Attribute	Data Type
Number Of Ports	UINT
Port Number	UINT
Port Log Announce Interval	UINT

Table 53 - Port Log Sync Interval Cfg

ID	Data Type	Access	Description
15	STRUCT of	GSV Get	The interval between successive Sync messages issued by a Master on each PTP port of the device. Default = 0 Range = -1…+1

Table 54 - Port Log Sync Interval Structure

Attribute	Data Type
Number Of Ports	UINT
Port Number	UINT
Port Log Announce Interval	UINT

Table 55 - Priority 1

ID	Data Type	Access	Description
16	USINT	GSV/SSV Get/Set	Specifies the priority1 setting of the PTP Best Master Algorithm. This attribute specifies the Best Master ranking of this clock and supersedes the clock quality (class, accuracy, and variance). This attribute let you override the automatic selection of the Grandmaster (Best Master Clock) before any quality measures are evaluated. Default = 128 The value is between 0 and 255. The highest priority is 0.

Table 56 - Priority 2

ID	Data Type	Access	Description
17	USINT	GSV/SSV Get/Set	Specifies the priority2 setting of the PTP Best Master Algorithm. This attribute specifies the Best Master ranking of this clock after clock quality (class, accuracy, and variance) has been evaluated and supersedes the tie-breaker. This attribute lets you override the automatic selection of the Grandmaster (Best Master Clock) after quality measures have been evaluated. For example: Choosing the best Grandmaster from a set of clocks of equal quality. The value is between 0…255. The highest priority is 0.

Table 57 - Domain Number

ID	Data Type	Access	Description
18	USINT	GSV Get	Specifies the PTP clock domain. The value is between 0…255. The default is 0.

Table 58 - Clock Type

ID	Data Type	Access	Description
19	WORD	GSV Get	The type of clock. Bits 0 = Ordinary Clock 1 = Boundary Clock 2 = Peer-to-peer transparent clock 3 = End-to-end transparent clock 4 = Management Node All other bits are reserved.

The value of ClockType indicates the type of PTP node. A one value for the bit indicates that the description applies to the node. More than one bit may be set, for example, an ordinary clock combined with an end-to-end transparent clock. The first word indicates configured clock type behavior.

Configured Clock Type Bits								**Word**
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**	0
Ordinary Clock	Boundary Clock	0	End-to-End Transparent Clock	Management Node	0	0	0	
15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	
0	0	0	0	0	0	0	Slave Only	

Table 59 - Manufacture Identity

ID	Data Type	Access	Description
20	USINT[4]	GSV Get	The IEEE OUI (Organization Unique Identity) for the manufacturer.

Table 60 - Product Description

ID	Data Type	Access	Description
21	STRUCT of	GSV Get	Size = UDINT Description = USINT[Size] Specifies the product description of the device that contains the clock. The format is the following: • The name of manufacture of the device followed by a semicolon. • The model number of the device followed by a semicolon. • The serial number. For example, ACME Manufacturing; C2901;123456. The format is UTF-8 Unicode. The maximum number of symbols is 64. The size field of the STRING data type is the total number of bytes for the attribute. Convert the number of symbols to bytes.

Table 61 - Revision Data

ID	Data Type	Access	Description
22	STRUCT of	GSV Get	Size = UDINT Revision = USINT[Size} Specifies the revision data of the device that contains the clock. The format is: • The hardware revision of the clock followed by a semicolon. • The firmware revision of the clock followed by a semicolon. • The software version of the clock. For example, 1.2;2.3;3.0.1. The format is UTF-8 Unicode. The maximum number of symbols is 32. The size field of the STRING data type is the total number of bytes for the attribute. Convert the number of symbols to bytes.

Table 62 - User Description

ID	Data Type	Access	Description
23	STRUCT of	GSV Get	Size = UDINT Description = USINT[Size] Specifies the user description of the device that contains the clock. The format is the following: • A user defined name or description of the device followed by a semicolon. • A user defined physical location of the device. For example, Sensor-1; Section-7 Cabinet-2 Rack-3. The format is UTF-8 Unicode. The maximum number of symbols is 128. The size field of the STRING data type is the total number of bytes for the attribute. Convert the number of symbols to bytes.

Table 63 - Port Profile Identity Info

ID	Data Type	Access	Description
24	STRUCT of	GSV Get	Number of Ports = UINT Port Number = UINT Port Profile Identity = USINT[Size] Port Number = UINT Port Profile Identity = USINT[8] Specifies the PTP profile of each port of the device. The attribute returns the profile identity of the currently active profile. The profile identity is contained in the first 6 bytes of the array. The last two octets should be set to zero.

Table 64 - Port Physical Address Info

ID	Data Type	Access	Description
25	STRUCT of	GSV Get	Number of Ports = UINT Port Number Physical Protocol = USINT[16] Size of Address = UINT Port Physical Address = USINT[16] Specifies the physical protocol and physical address of each port of the device, for example, the MAC address. The maximum number of characters is 16. Unused array elements are zero-filled.

Table 65 - Port Protocol Address Info

ID	Data Type	Access	Description
26	STRUCT of	GSV Get	Number of Ports =UINT Port Address = UINT Network Protocol = UINT Size of Address = UINT Port Protocol Address = USINT[16] Specifies the network and protocol address of each port of the device, for example, the IP address. The Network Protocol specifies the protocol for the network.

Network Protocol	Value
UDP/IPv4 For example, EtherNet/IP	1
UDP/IPv6	2
IEEE 802.3	3
DeviceNet	4
ControlNet	5
Local or unknown protocol	FFFF
Reserved	All others

Table 66 - Steps Removed

ID	Data Type	Access	Description
27	UINT	GSV Get	The number of CIP Sync Regions between the local clock and the Grandmaster, that is, the number of boundary clocks +1.

System Time And Offset

ID	Data Type	Access	Description
28	STRUCT of	GSV Get	System Time = ULINT System Offset = ULINT System Time in microseconds and the offset to the local clock value. The responding device returns the current System Time and Offset.

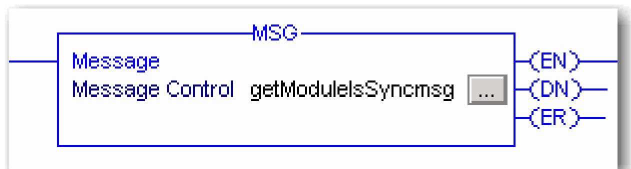
CIP Sync Diagnostics

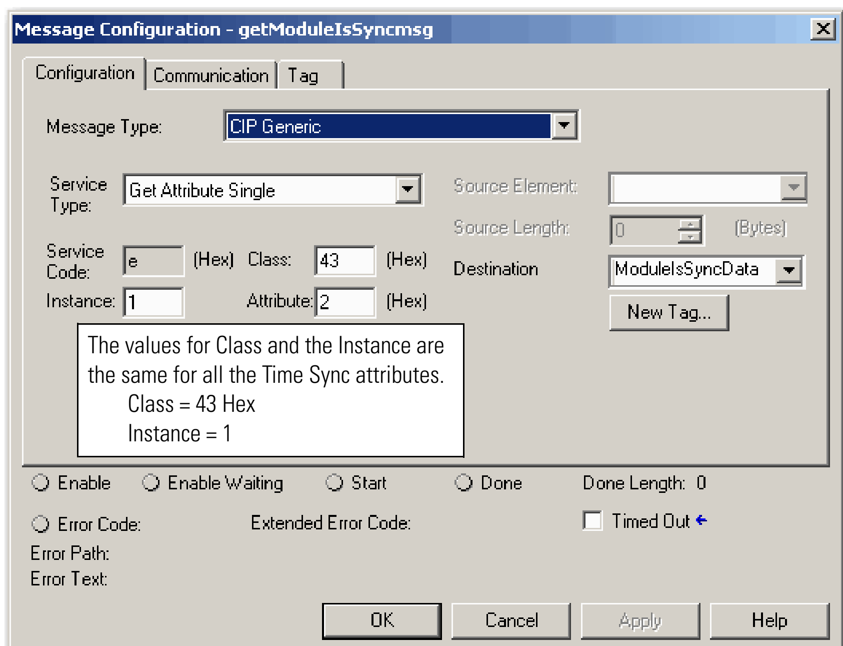
Access the Time Sync Object for other local and remote modules:

- Remote 1756-L6*x*, 1756-L7*x* Controllers
- Local and/or Remote 1756-EN*x*T*x* Ethernet Communication Modules
- Local and/or Remote 1756HP-Time (GPS) Modules

Is Synchronized Bit

To understand if all devices are synchronized to a GM programmatically, configure this CIP MSG to gather the Is Synchronize bit data from all devices listed above.

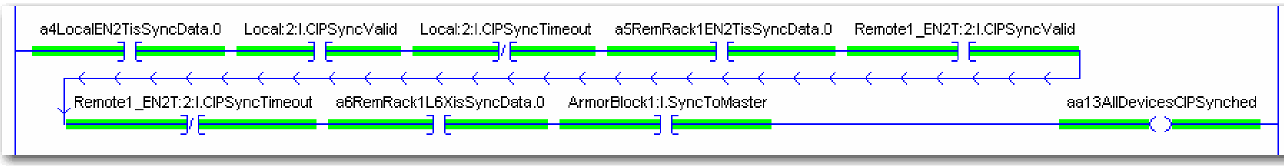




These synchronized status bits can be combined with the 1756-IB16ISOE or the 1756-IH16ISOE modules (CIPSyncValid, CIPSyncTimeout) and 1732E-IB16M12SOEDR module (SyncToMaster) module synchronized bits to understand if all devices are synchronized.

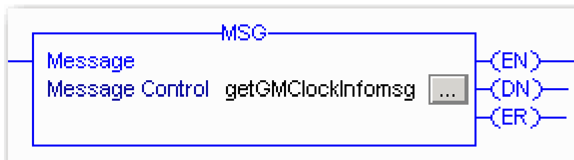
Table 67 - Is Synchronized

ID	Data Type	Access	Description
2	DINT	GSV Get	Local clock is synchronized with a Master. 0 = Not synchronized 1 = Synchronized



Grandmaster Clock Info

To understand if all devices are synchronized to the same GM programmatically, you will need to configure this CIP MSG to gather the Grandmaster Clock Info data from all devices listed above.



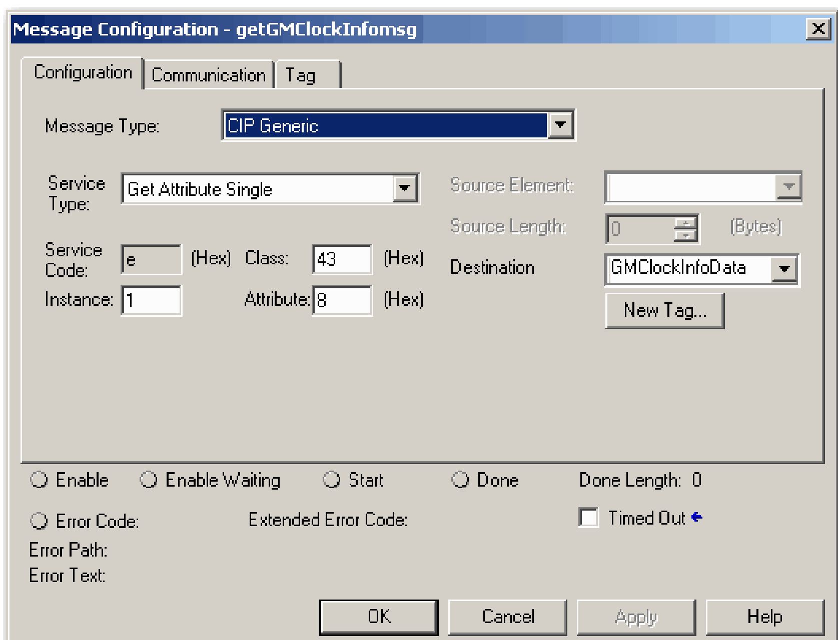


Table 68 - Grandmaster Clock Information

ID	Data Type	Access	Description
8	DINT[6]	GSV Get	Property information about the Grandmaster clock.

Table 69 - Grandmaster Clock Information Structure

Attribute	Data Type	
Clock Identity	SINT[8]	
Clock Class	INT	
Time Accuracy	INT	
Offset Scaled Log Variance	INT	OffsetScaledLogVariance specifies a measure of the inherent stability properties of the clock. OffsetScaledLogVariance is the variance measure of clock quality used by the Best Master Algorithm to determine the Grandmaster. The value is represented in offset scaled log units. The lower the variance, the better the clock.
Current Utc Offset	INT	CurrentUtcOffset specifies the current UTC offset in seconds from International Atomic Time (TAI) of the clock. As of 0 hours 1 January 2006 UTC, the offset was 33 seconds.
Time Property Flags	INT	TimePropertyFlags specifies the time property flags of the clock. Time Property Flags — Bit Index Leap indicator 61 — 0 Leap indicator 59 — 1 Current UTC offset valid — 2 PTP timescale — 3 Time traceable — 4 Frequency traceable — 5

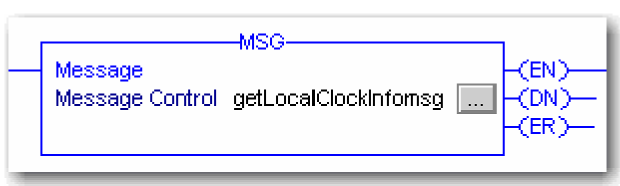
Table 69 - Grandmaster Clock Information Structure

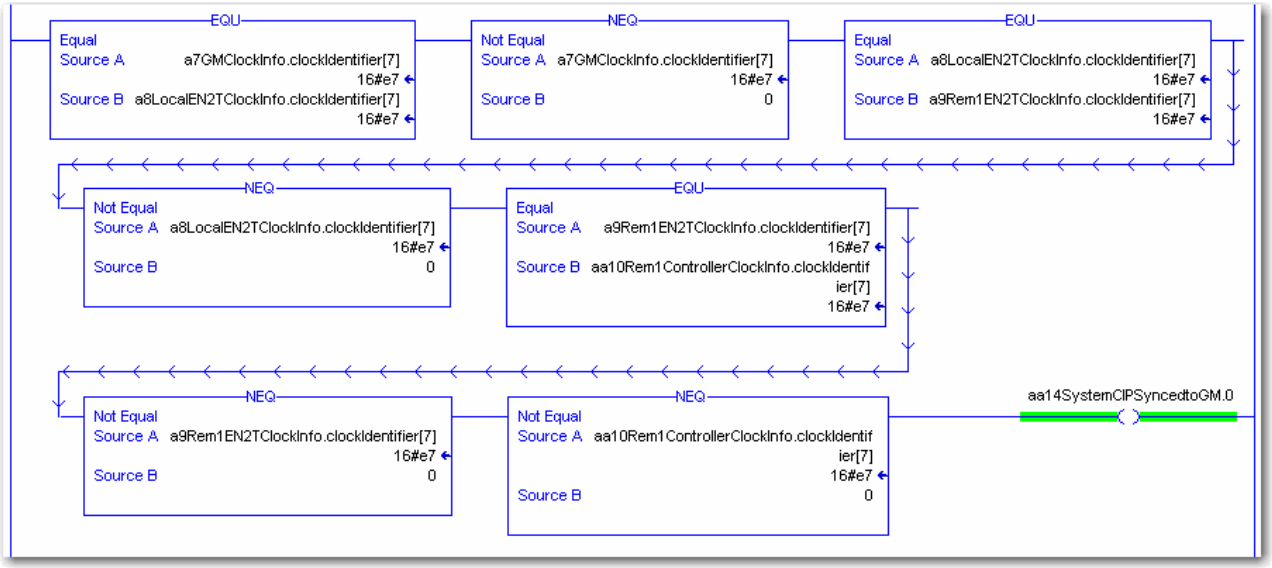
Attribute	Data Type		
Time Source	INT	ATOMIC CLOCK	0x10
		GPS	0x20
		TERRESTRIAL RADIO	0x30
		PTP	0x40
		NTP	0x50
		HAND SET	0x60
		OTHER	0x90
		INTERNAL OSCILLATOR	0xA0
		For use by alternate PTP profiles	0xF0-0xFE
		reserved	0xFF
Priority 1	INT	Priority1 and Priority2 values specify the relative priority of the grandmaster clock to other clocks in the system. See priority1 and priority2 attributes 16 and 17 respectively.	
Priority 2	INT	Priority1 and Priority2 values specify the relative priority of the grandmaster clock to other clocks in the system. See priority1 and priority2 attributes 16 and 17 respectively.	

Once the Grandmaster Clock Info. is collected from each device, the Clock Identity data can be compared and if all Clock Identity data values match, all devices are synchronized to the same Grandmaster. In most cases comparing the last Clock Identity Hex element [7] will be enough to differentiate one device from another. But if you have two devices with the same Local Clock Identity element [7], you may need to compare Clock Identity Hex element [7] and [6]. If the Grandmaster Clock Identity number is all zero's, this means the device is not synchronized to a Grandmaster.

Local Clock Information

To understand which device is the GM programmatically, you will need to configure this CIP MSG to gather the Local Clock Information data from all devices listed above.





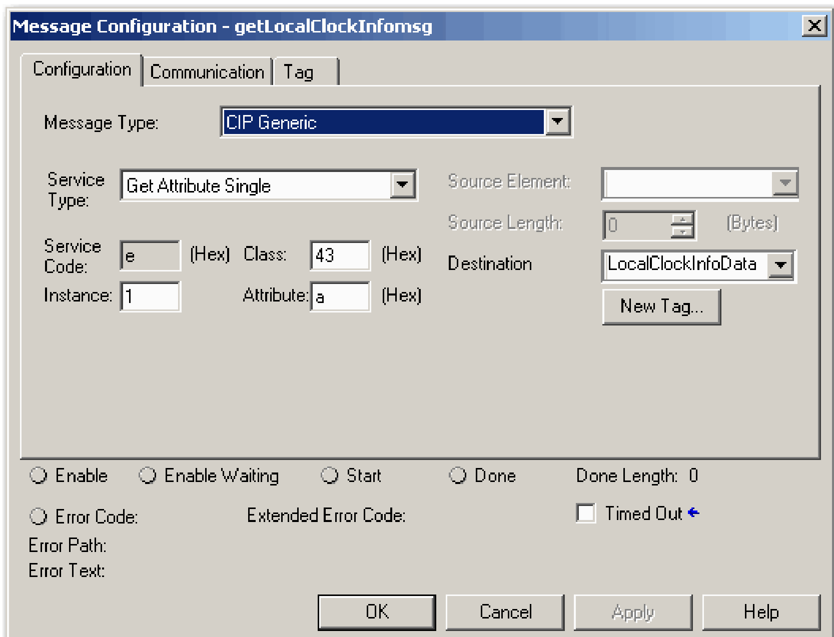


Table 70 - Local Clock Information

ID	Data Type	Access	Description
1	DINT	GSV Get	Property information about the local clock.

Table 71 - Local Clock Information Structure

Attribute	Data Type
Clock Identity	SINT[8]
Clock Class	INT
Time Accuracy	INT

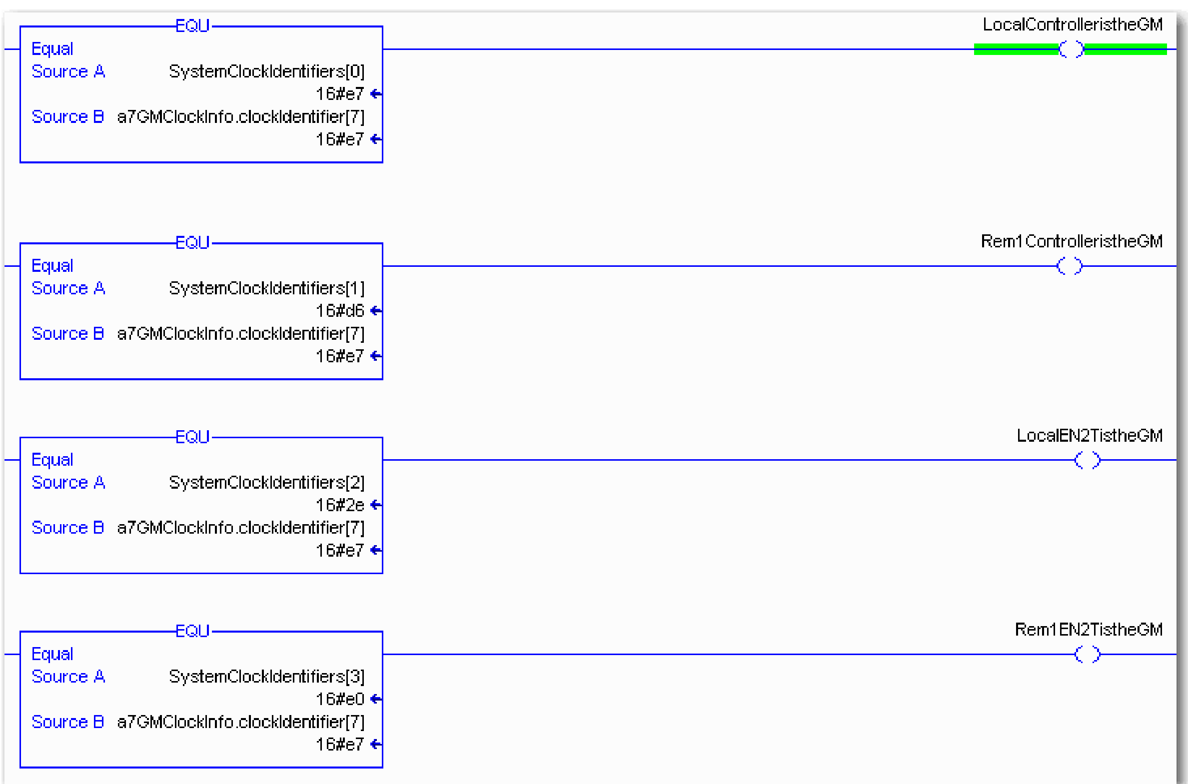
Table 71 - Local Clock Information Structure

Attribute	Data Type
Offset Scaled Log Variance	INT
Current Utc Offset	INT
Time Property Flags	INT
Time Source	INT
Priority 1	INT
Priority 2	INT

Once the Local Clock Info. is collected from each device, the Clock Identity data can be stored in a an array. Once stored in an array, the Local Clock Identity can be compared with the Grandmaster Clock Identity to indicate which device is the Grandmaster on the system.

In most cases comparing the last Clock Identity Hex element [7] will be enough to differentiate one device from another. But if you have two devices with the same Local Clock Identity element [7], you may need to compare Clock Identity Hex element [7] and [6].

Each device has its own Local Clock Identity number. If a module is replaced with a different module, collecting the Local Clock Info programmatically will guaranty the accuracy of who is the Grandmaster of the system.



WallClockTime Attributes

These are the attributes associated with the WallClockTime object.

Table 72 - CST Offset

ID	Data Type	Access	Description
3	DINT[2] or LINT	SSV Get/Set	This is the offset between the backplane CST time and the wall clocks UTC, see Current Value attribute. Positive offset from the Current Value of the CST (Coordinated System Time) object. DINT[0] contains the lower 32 bits of the value. DINT[1] contains the upper 32 bits of the value. Value in microseconds. The default is 0.

Table 73 - Local Date Time

ID	Data Type	Access	Description
5	DINT[7]	SSV Get/Set	This is an array of the current local value of the wallclock. This contains all active offsets to the UTC value including any daylight savings or time zone offset values. It is returned as an array containing individual integer elements for: Year/Month/Day/hours/minutes/seconds/Microseconds. The controller local date and time in human readable format, as follows. DINT[0] = Year DINT[1] = Month (1...12) DINT[2] = Day (1...31) DINT[3] = Hour (0...59) DINT[4] = Minute (0...59) DINT[5] = Seconds (0...59) DINT[6] = Microseconds (0...999,999)

Table 74 - Current Value

ID	Data Type	Access	Description
6	LINT	SSV Get/Set	The current 64 bit UTC value of the wallclock. This does not contain any daylight savings or time zone offset values. It is raw UTC time. DINT[0] contains the lower 32 bits of the value. DINT[1] contains the upper 32 bits of the value. The value is the number of microseconds that have elapsed since 0000 hours January 1, 1970. The CST and WallClockTime objects are mathematically related in the controller. For example, if you add the CST Current Value and the WallClockTime CST Offset, the result is the WallClockTime Current value.

Table 75 - Date Time

ID	Data Type	Access	Description
7	DINT[7]	SSV Get/Set	This is an array of the UTC value of the wallclock. This does not contain any daylight savings or time zone offset values. It is raw UTC time. It is returned as an array containing individual integer elements for: Year/Month/Day/hours/minutes/seconds/ Microseconds. The Date and Time in human readable format as follows: DINT[0] = Year DINT[1] = Month (1…12) DINT[2] = Day (1…31) DINT[3] = Hour (0…59) DINT[4] = Minute (0…59) DINT[5] = Seconds (0…59) DINT[6] = Microseconds (0…999,999)

Table 76 - Time Zone String

ID	Data Type	Access	Description
8	STRING	SSV Get/Set	Time zone for the time value. This is the value of the adjustment for the time zone. It's in the form of a string. For example, -05:00 Eastern Time, indicates the local time is offset from UTC by -5 hours. This offset gets applied when viewing any 'local' time values. Length of the Data array can be from 0 to 82.

Table 77 - DST Adjustment

ID	Data Type	Access	Description
9	INT	SSV Get/Set	This is the value of the adjustment for daylight savings time, typically this is a 1 hour adjustment. This offset gets applied to create local time values when the checkbox for DST is enabled. The number of minutes to adjust for Daylight Savings Time.

Table 78 - Enable DST

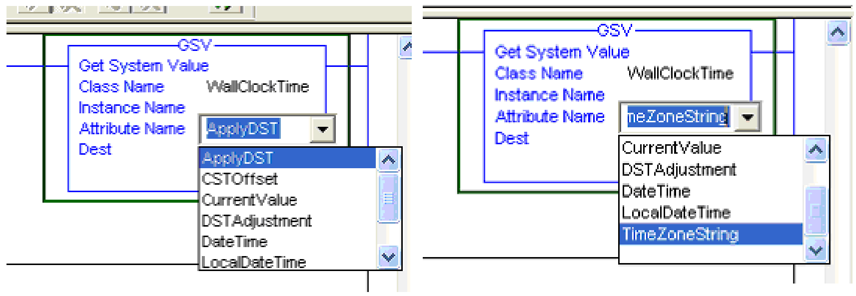
ID	Data Type	Access	Description
10	USINT	SSV Get/Set	It specifies if you are in daylight saving time or not. You need to manually set daylight savings. TRUE – Apply daylight saving time adjustment. FALSE – Don't apply daylight saving time adjustment.

Table 79 - Apply DST

ID	Data Type	Access	Description
11	SINT	GSV/SSV Get/Set	Identifies whether to enable Daylight Savings Time. Turns on or off the check box to enable the Daylight Savings Time Offset. 0 = Do not adjust for Daylight Savings Time. non zero = Adjust for Daylight Savings Time.

Accessing the WallClockTime Object

The WallClockTime object provides a time stamp that the controller can use for scheduling. These attributes can be obtained from a controller by using a GSV/SSV to the WallClockTime object.



RSLogix 5000 Software, Version 16 or Earlier

Existing applications that depended on the equivalent of local time access via a GSV will require changes to the application code in RSLogix 5000 software, version 16 or earlier.

In RSLogix 5000 software, version 18 or later, the DateTime attribute of the Wall Clock object returns UTC time instead of the current local time that was previously returned. These GSV instructions need to change to point to the new LocalDateTime attribute that is the sum of UTC and time zone and daylight saving adjustments.

Another change made to the time system in the Logix architecture altered the base clock value. If viewing the wall clock object as a 64 bit number, the interpretation of that number is now based on January 01, 1970. Previous Logix implementations based this time on January 01, 1972. The 1970 time base provides more consistency with common SW and programming API's.

Interoperability with CIP Sync IEEE 1588-2008

Introduction

The IEEE 1588-2008 protocol standard defines many optional parameters that supports a wide variety of industries and applications. To maintain interoperability for a given industry or application, the standard defines the concept of a profile. A profile defines the set of parameters that guarantees that a set of devices will inter-operate with each other.

CIP Sync Profile

A CIP Sync profile has been defined as part of the ODVA CIP Common Standard to guarantee interoperability among CIP Sync compliant devices. Other IEEE 1588-2008 non-CIP Sync devices may inter-operate with the CIP Sync profile by default or through manual configuration of the device. For these devices, check the following parameters to determine whether these devices are compatible with your CIP Sync system.Version

IEEE 1588-2008. CIP Sync will not inter-operate with version IEEE 1588-2002.

Transport

UDP/IPV4, Transport of PTP over User Datagram Protocol (UDP) over Internet Protocol Version 4 (IPV4).

Profile Identification

The CIP Sync profile is identified in the following table. The profile is compatible with the default profile as defined by the IEEE 1588-2002 standard.

Table 80 - CIP Sync Profile

Profile Identifier	CIP Sync	IEEE 1588-2002
PTP profile description	CIP Sync Profile	Default PTP profile for use with the delay request-response mechanism
Version	1.0	1.0
Profile identifier	00-21-6C-00-01-00	00-1B-19-00-01-00
Specifying organization	ODVA	Precise Networked Clock Synchronization Working Group of the IM/ST Committee

Default Settings and Ranges

The CIP Sync PTP attribute defaults and ranges are specified in the following table.

Table 81 - Profile Default Settings and Ranges

PTP Attribute	Attribute ID[1]	Default	Range
Log announce interval	14	1	0…4 log seconds
Log sync interval	15	0	-3…+1 log seconds
Priority1	16	128	0…255
Priority2	17	128	0…255
Domain	18	0	0…128
Announce receipt timeout interval		3	2…10 sync intervals
Minimum Delay Request Interval		0	0…5 log seconds

(1) CIP Time Sync Object (hex 43). See System Specifications on page 139.

PTP Domain

The PTP domain is limited to one domain on a subnet in CIP Sync. For Device Level Ring support, the domain must be 0.

Path Delay Mechanism

Only the delay request-response path delay measurement mechanism is supported by CIP Sync. The peer-to-peer path delay measurement mechanism is not supported.

TTL (time to live)

Rockwell products have their TTL set to 1. Products from other manufacturers may have their TTL set to a higher value.

Multicast/Unicast

Only Multicast is supported by CIP Sync.

Frequently Asked Questions

Introduction

This table lists some of the FAQ's about implementing the CIP Sync protocol.

CIP Sync Frequently Asked Questions

Question	Answer
What is CIP Sync?	CIP Sync is an ODVA implementation of the open standard IEEE 1588-2008. This standard defines a protocol for setting and synchronizing clocks over standard unmodified Ethernet.
What's the difference between CIP Sync and IEEE 1588-2008?	At the core, there is no difference in the actual protocol. The ODVA implementation of IEEE 1588-2008 adds the definitions of objects to interact with the IEEE 1588-2008IEEE 1588-2008 standard protocol. This provides access to the configuration, diagnostic, and clock access for industrial hardware. CIP Sync follows the IEEE 1588-2008 default protocol so any device compliant with this profile will be interoperable. See Appendix C, Interoperability with CIP Sync IEEE 1588-2008 on page 165 for additional compatibility details.
What products support CIP Sync?	• 1756-L6x or 1756-L7x ControlLogix controller, firmware revision 18 or later and 19.50 or later for redundancy. • 1756-EN2T, 1756-EN2TR, 1756-EN3TR, and 1756-EN2F Ethernet communication modules, firmware revision 3 or later. • 1756-IB16ISOE or the 1756-IH16ISOE Sequence of Events modules, firmware revision 2 or later. • An optional, Managed Ethernet Switch, one that is fully capable of CIP Sync IEEE 1588-2008 protocol, for example, the 1783-MS10T Stratix 8000 switch, revision, 12.252SE2. This switch is not needed for most CIP Sync applications. • RSLogix 5000 programming software, version 18 or later. • RSLinx Classic software, version 2.53 or later. • 1756HP-TIME GPS module. • 1732E-IB16M12SOEDR, EtherNet/IP ArmorBlock I/O module supporting Sequence of Events. • 1756-IF4FXOF2F, High Speed Analog I/O module. • 1756-OB16IS, Scheduled Output module. • 2094-EN02D-M01-SO, Kinetix 6500 drive and power modules (various catalog numbers). • 20G PowerFlex 755 Embedded EtherNet/IP adapter. Any products that support IEEE 1588-2008 specification are generally compatible with CIP SYNC.

CIP Sync Frequently Asked Questions

Question	Answer
Why would I use CIP Sync?	CIP SYNC will operate only on an existing Ethernet infrastructure. It is a low cost solution to provide a common system clock throughout the integrated architecture. The application of a common system clock range from simply setting the clocks on all the controllers in the architecture to data logging with accurate time stamps, First Fault Detection, or Factory Talk Alarms and Events.
What is a Grandmaster Clock?	A Grandmaster clock is a device that provides the time reference for you system. See Chapter 2, CIP Sync System Concepts on page 21 for detailed information.
Can I have Multiple Grandmasters in my CIP Sync System?	Yes, while only one Grandmaster will be driving the system at any one time, CIP Sync has the unique ability to self arbitrate and automatically identify who the best Master clock in the system is and make that the Grandmaster.
Can I select a specific device to be a Grandmaster Clock?	Yes, you can override the default system arbitration which normally automatically selects the best clock, by raising the clock priorities on a device.
What happens when my Grandmaster Clock fails or disconnects from the network?	If one Grandmaster fails or disconnects from the network, the system self-arbitrates until it finds the next best clock in the system. Because this is automatic, it minimizes any drift that can occur for the brief period of time the system searches for the best clock.
How accurately can CIP Sync synchronize a ControlLogix rack?	Between multiple 1756-EN*x*T*x* modules and external IEEE 1588-2008 Grandmaster clocks, < 100 ns synchronization is not uncommon. Because the ControlLogix backplane clock has a 1microsecond resolution clock, that is the best accuracy possible within a specific rack. Generating time stamps across geographically separated control systems is easily accomplished by using a GPS interface. See the devices' user manual for details on how accurately the end device can use the System Time to generate time stamps.
Why won't my WCT change on the controller Date/Time dialog box?	WCT can be changed only at the Grandmaster. See Identify the Current Grandmaster on page 70.
Why isn't the 1756-EN*x*T*x* sending time to the controller?	• If you are using an older 1756-EN*x*T*x* communication module, make sure you flash all the modules with the firmware revision 3 or later. • Review the web page for the 1756-EN*x*T*x* modules. • Did you enable time synchronize on the controller and the communication module. See Communication Modules Set Up on page 66.

CIP Sync Frequently Asked Questions

Question	Answer
Why am I seeing poor synchronization as indicated by the `Offset to Master' on the Time Sync tab?	• How much traffic do you have relative to your architecture? • Does the infrastructure support CIP SYNC? See Selecting a Switch for CIP Sync on page 83.
Can I use CIP Sync to set all the ControlLogix controller wall clocks in my architectures?	Yes, as long as they are in the same backplane or connected through 1756-ENxT*x* modules with CIP Sync enabled or some other CIP Sync enabled Ethernet router.
Can I use CIP Sync to set the clock on other non-ControlLogix hardware?	See Hardware and Software Requirements on page 80.
Can I use CIP Sync to time stamp I/O in a remote rack?	Yes, placing an 1756-EN2T module in a remote rack can provide the synchronized System Time to the remote rack. When a 1756-IB16ISOE module, firmware revision 2.0 or later, is placed in the rack, it can then be told to timestamp by using UTC.
Can you use a 1756-OB16IS in a remote rack?	No, the 1756-OB16IS has to be the same rack as a controller.
Do I still need to use the Clock Sync Update Tool?	For use with CIP Sync, it is recommended that the Clock Update Tool only targets one controller, however multiple controllers could be selected if you require backup. See Using the RSLogix 5000 Clock Update Tool on page 55.
Can I use SynchLink in combination with CIP SYNC?	Yes, see the Knowlegebase document number 67839.
How can I time stamp events by using the CIP Sync protocol and CompactLogix controllers?	Today the only modules released are for ControlLogix hardware. In the future other Rockwell devices will adopt CIP Sync as the preferred method to synchronize time. You can however use a 1732E-IB16M12SOEDR, EtherNet/IP ArmorBlock I/O module supporting Sequence of Events to generate time stamps by using the a CIP Sync synchronization mechanism. See Design Your System to Select the Optimal Grandmaster Clock on page 21.
How do I get more information on CIP Sync?	See Where to Find Sample Projects on page 14.
Do I need special Ethernet infrastructure hardware to implement CIP Sync?	No, CIP SYNC is based on the IEEE 1588-2008 standard. Depending on your system requirements for actual synchronization, some infrastructure components implement IEEE 1588-2008 to different degrees. See Hardware and Software Requirements on page 80.
Do I need a GPS to use CIP Sync?	No, while a GPS works well in a CIP Sync synchronized architecture, it is not required. Products like HiProm's in rack 1756HP-TIME (GPS) or other IEEE 1588-2008 Grandmaster clocks are compatible with CIP Sync. Clock synchronization can ultimately be driven from a variety of sources including NTP or your controllers wall clock.

CIP Sync Frequently Asked Questions

Question	Answer
Can I bridge subnets with CIP Sync?	By the IEEE 1588-2008 specification the time to live parameter (number of routers an Ethernet packet can cross) is set to 1, which means it will not typically pass through any routers. This typically limits CIP Sync to remaining on the local subnet. If you need to cross subnets without making the investment in another Grandmaster clock, you can solve this with hardware. For example, there are some IEEE 1588-2008 compliant routers that packets to pass through them. A boundary clock can also successfully bridge two subnets together, for example, a ControlLogix rack with two 1756-EN*x*T*x* communication modules that reside on different subnets. For more information about using boundary clocks bridging subnets, see Network Segmentation using VLANS and a Stratix 8300 Switch in Boundary Clock Mode on page 123.
How much Ethernet traffic does CIP Sync add to perform synchronization?	Very little messaging is required for CIP Sync to keep a system synchronized. The protocol requires only a couple of packets once a second to a device to maintain tight clock synchronization.
Can I use NTP as a Clock Source for CIP Sync?	Yes, there are several mechanisms for importing NTP into your architecture as a GrandMaster. These range from using the 1756-EWEB module, a personal computer with NTP, and messaged down to a controller, or purchasing a third-party NTP to IEEE 1588-2008 device. See Star Topology with an NTP Server as the Time Source on page 90.
Can I use IRIGB as a Clock Source for CIP Sync?	Yes, the 1756HP-TIME module provides the capability to importing IRIGB into the ControlLogix system.

If you have any other questions, complete this form, publication RA-DU002, available at http://www.rockwellautomation.com/literature/.

The following terms and abbreviations are used throughout this manual. For definitions of terms not listed here, refer to the Allen-Bradley Industrial Automation Glossary, publication AG-7.1.

Add-On Instruction Add-On Instructions are custom RSLogix 5000 software instructions that you design and create. With Add-On Instructions, you can create new instructions for sets of commonly-used logic, provide a common interface to this logic, and provide documentation for the instruction.

See the Logix5000 Controllers Add-On Instructions Programming Manual, publication 1756-PM010.

ALMD for Discrete Alarming and ALMA for Analog Alarming The RSLogix 5000 software instruction ALMD detects alarms based on boolean (true/ false) conditions. The RSLogix 5000 software instruction ALMA detects alarms based on the level or rate of change of an analog value.

See the Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.

ArmorBlock Module The 1732E-IB16M12SOEDR module supports Sequence of Events on the EtherNet/IP network. This module provides time stamps for actual field I/O.

See the 1732E EtherNet/IP ArmorBlock Supporting Sequence of Events User Manual, publication 1732E-UM002.

Best Master Clock Algorithm The algorithm performed by each node to determine the clock that will become the Master clock on a subnet and the Grandmaster clock for the domain. The algorithm primarily compares priority1, clock quality, priority2, and source identity to determine the best Master among available candidates.

See Best Master Clock Algorithm on page 43.

Boundary Clock A Boundary clock has more than one port, for example, a managed Ethernet switch, and perform the duties as a Master or Slave clock.

See Boundary Clocks on page 33.

Common Industrial Protocol (CIP) The Common Industrial Protocol (CIP) is an open industrial protocol for industrial automation applications.

CIP Sync CIP Sync is the ODVA implementation of the IEEE 1588-2008 standard. The protocol provides a mechanism to synchronize clocks between controllers, I/O devices, and other automation products.

See What is CIP Sync? on page 17.

CIP Sync Profile Specifies the unique selections of attribute values and optional features of the protocol that, when using the same transport protocol, will inter-work and achieve a performance that meets the requirements of a particular application.

Clock A node participating in the PTP protocol that is capable of providing a measurement of the passage of time since a defined epoch. There are three types of clocks in IEEE 1588-2008: boundary, transparent, and ordinary clocks.

Coordinated System Time (CST) In its simplest form, CST is a backplane clock propagated between all modules on the ControlLogix backplane. Its presence is necessary whenever time coordination between modules in the chassis is required.

Device Level Ring (DLR) A DLR network is a single-fault tolerant ring network intended for the interconnection of automation devices. This topology is also implemented at the device level. No additional switches are required.

Domain A logical grouping of clocks that synchronize to each other by using the PTP protocol, but that are not necessarily synchronized to clocks in another domain.

Domain Name System Associates various information with domain names; most importantly, it serves as the 'phone book' or the Internet by translating human-readable computer hostnames, for example, www.example.com, into IP addresses, for example, 208.77.188.166, which networking equipment needs to deliver information. It also stores other information, such as, the list of mail servers that accept e-mail for a given domain. In providing a worldwide keyword-based redirection service, the Domain Name System is an essential component of contemporary Internet use.

Electronic Keying You can use electronic keying to help prevent communication to a module that does not match the type and revision expected.

First Fault Detection First Fault measures the time between events with no correlation to events outside of that system.

Greenwhich Mean Time (GMT) GMT is the mean solar time of the longitude (0°) of the former Royal Observatory at Greenwich, England, or Greenwich meridian. UTC replaced GMT as the basis for the main reference time scale or civil time in various regions on 1 January 1970.

Global Positioning System (GPS) GPS is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS provides reliable timing services (as well as positioning and navigation) on a continuous basis in all weather, day and night, anywhere on or near the Earth that has an unobstructed view of four or more GPS satellites.

Grandmaster (GM) Within a domain, a clock that is the ultimate source of time for clock synchronization by using the CIP Sync protocol.

Local Clock The clock on a device.

Master Clock (M) In the context of a single CIP Sync communication path, a clock that is the source of time to which all other clocks on that path synchronize on a local subnet.

Network Time Protocol (NTP) A protocol for synchronizing the clocks of computer systems over packet-switched, variable-latency data networks.

Passive State The state of a clock where the boundary clock is not good enough to become Master, but other potential Master clocks on that network segment are not good enough to be chosen over the current Slave port's Master clock. This should happen only when there are multiple network paths to the same Grandmaster.

Priorities (P1 and P2) Parameters that can override the Best Master Clock Algorithm to choose a different Grandmaster.

See Configure Priorities on page 64.

Precision Time Protocol (PTP) The PTP protocol is a time-transfer protocol defined in the CIP Sync IEEE 1588-2008 standard that allows precise synchronization of networks.

See CIP Sync on page 171.

Quality of Service (QoS) QoS is a function that guarantees a bandwidth relationship between individual applications or protocols.

Redundant Chassis Pair (RPC) The ControlLogix redundancy system uses an identical pair of ControlLogix chassis to keep a machine or process running if a problem occurs with any hardware in one of the chassis.

Slave Clock A clock that synchronizes its local clock to a Master time.

Sequence of Events (SOE) Sequence of Events are any events that needs to be compared against a second event.

Synchronized Clocks Two clocks are synchronized to a specified uncertainty if they have the same epoch and their measurements of the time of a single event at an arbitrary time differ by no more than that uncertainty.

System Time The absolute time value as defined by CIP Sync in the context of a distributed time system where all devices have a local clock that is synchronized with a common Master clock. System Time is a 64-bit integer value in units of nanoseconds or microseconds with a value of 0 corresponding to an epoch of January 1, 1970.

Time Sync Object The Time Sync object provides a Common Industrial Protocol (CIP) interface to the IEEE 1588 (IEC 61588) Standard for a precision clock synchronization protocol for networked measurement and control systems. This information can be collected to be used in diagnostics.

Transparent Clocks A device that measures the time taken for a PTP event message to transit the device and provides this information to clocks receiving this PTP event message.

Coordinated Universal Time (UTC) The time standard for 'civil time', representing time at the Prime Meridian (0° longitude). The time does not include time zone or daylight savings time offsets. System Time is the same as UTC.

Voice over IP (VoIP) A protocol that transports audio data in real time over IP networks. It is commonly used to enable voice calls over broadband internet connections instead of using a phone line.

Wall Clock Time (WCT) Wall Clock Time is the controller's time based on UTC System Time.

T

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Rockwell Automation Support

Rockwell Automation provides technical information on the Web to assist you in using its products. At http://www.rockwellautomation.com/support/, you can find technical manuals, a knowledge base of FAQs, technical and application notes, sample code and links to software service packs, and a MySupport feature that you can customize to make the best use of these tools.

For an additional level of technical phone support for installation, configuration, and troubleshooting, we offer TechConnect support programs. For more information, contact your local distributor or Rockwell Automation representative, or visit http://www.rockwellautomation.com/support/.

Installation Assistance

If you experience a problem within the first 24 hours of installation, review the information that is contained in this manual. You can contact Customer Support for initial help in getting your product up and running.

United States or Canada	1.440.646.3434
Outside United States or Canada	Use the Worldwide Locator at http://www.rockwellautomation.com/support/americas/phone_en.html, or contact your local Rockwell Automation representative.

New Product Satisfaction Return

Rockwell Automation tests all of its products to ensure that they are fully operational when shipped from the manufacturing facility. However, if your product is not functioning and needs to be returned, follow these procedures.

United States	Contact your distributor. You must provide a Customer Support case number (call the phone number above to obtain one) to your distributor to complete the return process.
Outside United States	Please contact your local Rockwell Automation representative for the return procedure.

Documentation Feedback

Your comments will help us serve your documentation needs better. If you have any suggestions on how to improve this document, complete this form, publication RA-DU002, available at http://www.rockwellautomation.com/literature/.

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