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PROJECT TITLE: TIME SYNCHRONIZATION OF IED

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ABSTRACT:

The precise operation of Intelligent Electronic Devices (IEDs) is critical for the stability of industrial power systems. This report examines the importance of time synchronization for IEDs, focusing on communication protocols and the IEC 61850 standard. IEEE 1588 Precision Time Protocol (PTP) is highlighted for its role in achieving high-precision synchronization over Ethernet networks. IEC 61850 standardizes communication protocols and data models, facilitating interoperability among IEDs in substation automation. The report details the structure and components of IEC 61850, including Generic Object-Oriented Substation Event (GOOSE) messages and Sampled Values (SV). Practical applications of time synchronization and IEC 61850 in industrial settings, particularly at Reliance Industries Limited, are discussed. The use of GPS clocks, network switches, and time servers to achieve synchronized operations is examined. This report underscores the importance of robust time synchronization mechanisms and the integration of IEC 61850 with IEEE 1588 PTP in enhancing IED performance and reliability in industrial power systems.

BONAFIDE CERTIFICATE

Certified that this Project report is the Bonafide work of "

DINESH KUMAR SAHU" who carried

out the Internship in the following industry.

S no.	Company detail	Duration		No. Of days
		From	To	
1.	RELIANCE INDUSTRIES LIMITED, DMD, CES - RMC	21.05.24	13.06.24	54

DINESH KUMAR SAHU has undergone Internship for 54 days (about 2 months) under the guidance of **Mr. MAYUR KHAJANCHI**

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CENTRAL ENGINEERING SERVICES

DAHEJ MANUFACTURING DIVISION

GUJARAT

Introduction to Time Synchronization in Industrial Automation

Time synchronization is a critical aspect of industrial automation, ensuring that various components and systems operate in unison. Accurate timekeeping is essential for coordinating activities, managing events, and maintaining the reliability and efficiency of industrial processes. In complex automation environments, precise time synchronization enables seamless communication and coordination among numerous devices and systems, such as sensors, actuators, controllers, and monitoring equipment.

Several communication protocols are used to achieve time synchronization in industrial settings. Each protocol has its unique features and applications, catering to different requirements of industrial automation. This introduction provides an overview of time synchronization and hints at the various protocols used, such as **Modbus, IEC 61850, PROFIBUS, and serial communication.**

INTEGRATED ELECTRONIC DEVICES (IED)

Integrated Electronic Devices (IEDs) play a crucial role in the automation and control of industrial power systems. These devices perform various protective, control, and monitoring functions essential for the efficient operation of electrical networks. This report aims to elucidate the working principles of IEDs, the communication protocols that facilitate their operation, and the practical applications within industrial environments.

Significance of IEDs

IEDs are crucial for modern power systems due to their ability to perform multiple functions with high accuracy and reliability. They offer several advantages over conventional devices:

- **Multifunctionality**: IEDs can perform various protective, control, and monitoring functions within a single device.
- **Improved Reliability**: The use of advanced algorithms and self-diagnostic features enhances the reliability and performance of IEDs.
- **Flexibility**: IEDs can be easily configured and reprogrammed to adapt to changing system requirements.
- **Enhanced Communication**: IEDs support modern communication protocols, enabling seamless data exchange and integration with other devices and systems.

Working Principles of IEDs

IEDs operate by continuously monitoring electrical parameters such as voltage, current, frequency, and phase angle. They use this data to perform various functions:

- **Protection**: IEDs detect faults and abnormal conditions within the power system and initiate protective actions such as tripping circuit breakers to isolate faulty sections.
- **Control**: IEDs control the operation of electrical equipment such as transformers, capacitors, and circuit breakers to maintain system stability and efficiency.
- **Monitoring**: IEDs provide real-time monitoring of electrical parameters and system conditions, enabling operators to make informed decisions.

Key Components of IEDs

- **Microprocessor**: The central processing unit that executes the protective, control, and monitoring algorithms.
- **Analog-to-Digital Converter (ADC)**: Converts analog signals from the power system into digital data for processing.
- **Digital Inputs/Outputs**: Interfaces for receiving status signals and sending control commands.
- **Communication Interface**: Supports communication with other devices and systems using standard protocols.

Communication Protocols and Standards

IEC 61850 Standard

IEC 61850 is a global standard for the design of electrical substation automation. It standardizes communication protocols and data models, ensuring interoperability among IEDs from different manufacturers. The standard comprises several parts that cover various aspects of substation automation,

including communication requirements, system architecture, and data modeling.

Structure and Components of IEC 61850

- **Data Modeling**: IEC 61850 defines a comprehensive data model for representing the functions and capabilities of substation devices. This model is organized into Logical Nodes (LNs), each representing a specific function, and Data Objects (DOs), which represent specific attributes or properties of these functions.
- **Communication Services**: The standard specifies a range of communication services to facilitate data exchange between devices. These include reporting, logging, and control services.
- **System Configuration Language (SCL)**: SCL is an XML-based language used for describing the configuration of substation devices and systems. It allows for the seamless integration and interoperability of devices from different vendors.

Working and functioning of IEC 61850

IEC 61850 employs several key components to achieve seamless communication and operation of IEDs:

- **Generic Object-Oriented Substation Event (GOOSE) Messages**: These messages enable high-speed, real-time communication of critical data between IEDs. GOOSE messages are used for time-critical applications, such as protection and control, where rapid exchange of information is essential.
- **Sampled Values (SV)**: This mechanism allows for the real-time exchange of sampled analog values, facilitating accurate monitoring and control. SV is used for applications such as digital measurement of voltage and current signals.
- **MMS (Manufacturing Message Specification)**: A protocol used for exchanging information between devices and systems within a substation. MMS supports a wide range of communication services, including reporting, logging, and file transfer.

Precision Time Protocol (PTP)

IEEE 1588 Precision Time Protocol (PTP) is a widely used protocol for achieving high-precision time synchronization over Ethernet networks. It ensures that all connected IEDs operate in a coordinated manner, which is crucial for the accurate performance of protection and control functions.

Working of IEEE 1588 PTP

- **Clock Synchronization**: PTP operates by synchronizing the clocks of all devices within a network to a master clock. This master clock distributes timing information to slave clocks using a series of timestamped messages.
- **Timestamping**: Accurate timestamping of messages is critical for achieving high-precision synchronization. PTP uses hardware timestamping to minimize delays and ensure precise timing.
- **Delay Measurement**: PTP measures the delay between the master and slave clocks by exchanging delay request and response messages. This information is used to adjust the clocks and maintain synchronization.

Practical Implementation in Industrial Settings

Equipment and Technologies

The implementation of IEDs in industrial environments, such as Reliance Industries Limited, involves various technologies and equipment to ensure reliable operation:

- **GPS Clocks**: Provide accurate time signals to synchronize all IEDs within the network. GPS clocks receive time signals from satellites and distribute them to connected devices, ensuring precise time synchronization.
- **Network Switches**: Facilitate the communication between IEDs by routing data packets efficiently. Managed switches with support for IEEE 1588 PTP are commonly used to ensure low-latency communication and accurate time synchronization.
- **Time Servers**: Distribute accurate time information to IEDs across the network. Time servers typically use GPS or other time sources to maintain precise time and distribute it to connected devices.
- **IEDs**: Perform protective, control, and monitoring functions. These devices are equipped with communication interfaces to exchange data with other devices and systems.

Application in Reliance Industries Limited

Reliance Industries Limited, a major player in the industrial sector, employs IEDs extensively for the automation and control of their power systems. The implementation of IEDs within their facilities involves several key aspects:

- **Substation Automation**: IEDs are used to automate the operation of substations, enhancing their reliability and efficiency. They perform functions such as protection, control, and monitoring of electrical equipment.
- **Process Control**: IEDs are integrated into the process control systems to ensure the efficient operation of industrial processes. They monitor and control various parameters, such as temperature, pressure, and flow rates.
- **Fault Detection and Isolation**: IEDs play a critical role in detecting and isolating faults within the electrical network. They ensure rapid response to faults, minimizing the impact on the overall system.

Challenges and Solutions

The implementation of IEDs in industrial environments presents several challenges, including:

- **Interoperability**: Ensuring seamless communication between IEDs from different manufacturers can be challenging. IEC 61850 addresses this issue by standardizing communication protocols and data models.
- **Time Synchronization**: Achieving precise time synchronization across a large network of devices requires careful planning and implementation. IEEE 1588 PTP provides a robust solution for high-precision time synchronization.

- **Network Latency**: Minimizing network latency is crucial for the accurate performance of protection and control functions. Managed switches and network optimization techniques are used to address this issue.

MOD BUS

Modbus is a robust and widely used communication protocol in industrial automation systems. It was developed by Modicon (now Schneider Electric) in 1979 for use with its programmable logic controllers (PLCs). Modbus allows for the transmission of data over serial and Ethernet networks, facilitating communication between a wide range of devices. This report aims to elucidate the working principles of Modbus, its different variants, and its practical applications in industrial settings.

Working Principles of Modbus

Modbus operates on a primary-secondary device (or client-server) architecture, where the master device initiates communication, and the secondary device devices respond. The protocol is designed to be simple and easy to implement, making it a popular choice for industrial applications.

Modbus Data Model

The Modbus protocol uses a simple data model to organize information. This model includes four primary data types:

1. **Coils**: Represent binary outputs that can be read or written.
2. **Discrete Inputs**: Represent binary inputs that can only be read.
3. **Holding Registers**: Represent 16-bit analog outputs that can be read or written.
4. **Input Registers**: Represent 16-bit analog inputs that can only be read.

Modbus Function Codes

Modbus uses function codes to specify the actions to be performed. Each function code corresponds to a specific operation, such as reading or writing data. Some common Modbus function codes include:

- **01**: Read Coils

- **02**: Read Discrete Inputs
- **03**: Read Holding Registers
- **04**: Read Input Registers
- **05**: Write Single Coil
- **06**: Write Single Register
- **15**: Write Multiple Coils
- **16**: Write Multiple Registers

Modbus Variants

Modbus RTU (Remote Terminal Unit)

Modbus RTU is the most used variant of the Modbus protocol. It transmits data in a compact binary format, making it efficient for communication over serial lines (RS-232, RS-485). Modbus RTU is known for its reliability and simplicity.

Modbus ASCII

Modbus ASCII uses ASCII characters to transmit data, making it easier to read and debug compared to Modbus RTU. However, it is less efficient due to the larger size of the transmitted data. Modbus ASCII is suitable for applications where readability is more important than efficiency.

Modbus TCP/IP

Modbus TCP/IP extends the Modbus protocol to Ethernet networks, allowing for communication over TCP/IP. This variant enables the integration of Modbus devices into modern network infrastructures, providing greater flexibility and scalability. Modbus TCP/IP is commonly used in industrial Ethernet applications.

Practical Applications of Modbus

Industrial Automation

Modbus is widely used in industrial automation for communication between PLCs, sensors, actuators, and other field devices. Its simplicity and reliability make it an ideal choice for controlling and monitoring industrial processes. Modbus allows for the transmission of data over serial and Ethernet networks, facilitating communication between a wide range of devices. This report elucidates the working principles of Modbus, its different variants, and its practical applications in industrial settings. Modbus operates on a primary-secondary device (or client-server) architecture, where the master device initiates communication, and the secondary device devices respond. The protocol is designed to be simple and easy to implement, making it a popular choice for industrial applications.

Example: Manufacturing Industry

In manufacturing, Modbus is used to connect various equipment, such as conveyor belts, robotic arms, and sensors, to a central control system. This allows for efficient monitoring and control of production processes, improving operational efficiency and reducing downtime.

Power Generation and Distribution

Modbus is employed in power generation and distribution systems to facilitate communication between different components, such as generators, transformers, and meters. It enables real-time monitoring and control of power systems, enhancing reliability and performance.

Example: Substation Automation

In substation automation, Modbus is used to connect IEDs (Intelligent Electronic Devices) with supervisory control and data acquisition (SCADA) systems. This integration allows for real-time monitoring and control of substation equipment, improving the reliability and efficiency of power distribution.

Building Automation

Modbus is also used in building automation systems to control and monitor HVAC (Heating, Ventilation, and Air Conditioning), lighting, and security systems. Its ability to integrate with various devices makes it a versatile choice for building management.

Example: HVAC Systems

In HVAC systems, Modbus is used to connect thermostats, air handlers, and chillers to a central control system. This enables precise control of temperature and air quality, enhancing occupant comfort and energy efficiency.

Challenges and Solutions

Integration with Modern Networks

Integrating Modbus with modern network infrastructures, such as Ethernet and wireless networks, can be challenging due to compatibility issues. Modbus TCP/IP addresses this challenge by enabling Modbus communication over Ethernet networks, providing greater flexibility and scalability.

Security Concerns

Modbus was not originally designed with security in mind, making it vulnerable to cyber-attacks. To address this, several security measures can be implemented, such as using secure communication channels (e.g., VPNs), deploying firewalls, and implementing access controls.

Limited Data Throughput

Modbus RTU and ASCII have limited data throughput, which can be a constraint in high-speed applications. Modbus TCP/IP offers higher data throughput, making it suitable for applications requiring faster communication.

Profibus

PROFIBUS is a widely used fieldbus communication protocol developed in the late 1980s by a consortium of European companies and institutions. It is designed to provide high-speed, deterministic data exchange in industrial automation environments. This report aims to elucidate the working principles of PROFIBUS, its different variants, and its practical applications in industrial settings.

Working Principles of PROFIBUS

PROFIBUS operates on a primary-secondary device (or master-master) architecture, where master devices initiate communication and secondary device devices respond. The protocol is designed to handle a wide range of automation tasks, from simple sensor/actuator communication to complex process control.

PROFIBUS Data Model

The PROFIBUS protocol uses a hierarchical data model to organize information. This model includes several key components:

5. **Masters**: Devices that control the network and initiate communication.
6. **Slaves**: Devices that respond to the masters' requests.
7. **Field Devices**: Sensors, actuators, and other devices that interact with the physical process.

PROFIBUS Function Codes

PROFIBUS uses a variety of function codes to specify the actions to be performed. These codes correspond to specific operations, such as reading or writing data, and configuring devices. Some common PROFIBUS function codes include:

- **Read Data**: Retrieves data from a field device.
- **Write Data**: Sends data to a field device.
- **Diagnostics**: Retrieves diagnostic information from a device.
- **Parameterization**: Configures device parameters.

Practical Applications of PROFIBUS in Reliance Industrial Automation

Manufacturing Industry

In the manufacturing industry, PROFIBUS is used to connect various equipment, such as CNC machines, robotic arms, and conveyor systems, to a central control system. This setup allows for efficient monitoring and control of production processes, improving operational efficiency and reducing downtime. For instance, a PLC can use PROFIBUS to receive data from proximity sensors and send control signals to robotic arms, ensuring precise and synchronized operation.

Process Control

PROFIBUS is employed in process control systems to facilitate communication between different components, such as controllers, sensors, and actuators. It enables real-time monitoring and control of processes, enhancing reliability and performance.

Example: Chemical Industry

In the chemical industry, PROFIBUS PA is used to connect field devices, such as flow meters, pressure transmitters, and valve actuators, to a Distributed Control System (DCS). This integration allows for real-time monitoring and control of chemical processes, ensuring product quality and safety. PROFIBUS PA's intrinsic safety features make it suitable for use in hazardous environments, where explosive gases and liquids may be present.

Power Generation and Distribution

PROFIBUS is used in power generation and distribution systems to facilitate communication between different components, such as generators, transformers, and meters. It enables real-time monitoring and control of power systems, enhancing reliability and performance.

Example: Substation Automation

In substation automation, PROFIBUS DP is used to connect Intelligent Electronic Devices (IEDs) with supervisory control and data acquisition (SCADA) systems. This integration allows for real-time monitoring and control of substation equipment, improving the reliability and efficiency of power distribution. PROFIBUS facilitates the transmission of critical data such as voltage levels, current flows, and fault conditions, enabling quick and accurate responses to system anomalies.

Building Automation

PROFIBUS is also used in building automation systems to control and monitor HVAC (Heating, Ventilation, and Air Conditioning), lighting, and security systems. Its ability to integrate with various devices makes it a versatile choice for building management.

Example: HVAC Systems

In HVAC systems, PROFIBUS DP is used to connect thermostats, air handlers, and chillers to a central control system. This enables precise control of temperature and air quality, enhancing occupant comfort and energy efficiency. For example, a PROFIBUS-enabled HVAC system can continuously monitor indoor temperature and humidity levels and adjust the operation of heating and cooling units accordingly to maintain a comfortable environment while minimizing energy consumption.

Challenges and Solutions

Network Configuration

Configuring a PROFIBUS network can be complex, particularly in large installations with many devices. Proper network planning and use of configuration tools can simplify this process. Additionally, adherence to PROFIBUS guidelines and standards ensures reliable network performance.

Integration with Modern Technologies

Integrating PROFIBUS with modern network infrastructures, such as Ethernet and wireless networks, can be challenging. The use of gateways and protocol converters can bridge different communication standards, enabling seamless integration. For instance, PROFIBUS-to-Ethernet gateways allow PROFIBUS devices to communicate over Ethernet networks, providing greater flexibility and scalability.

Security Concerns

Like other industrial communication protocols, PROFIBUS faces security challenges. Implementing robust security measures, such as network segmentation, firewalls, and secure communication channels (e.g., VPNs), can mitigate these risks. Additionally, regular security audits and updates can help protect the network from cyber threats.

Interoperability

Ensuring interoperability between devices from different manufacturers can be challenging due to variations in implementation. Adhering to standard PROFIBUS specifications and using certified devices can help mitigate this issue. Additionally, thorough testing and validation of communication setups can ensure that devices work together seamlessly.

Role of Communication Protocols in Time Synchronization

Introduction

Time synchronization is a critical component of industrial automation, ensuring that all devices and systems within a network operate in unison. Accurate timekeeping is essential for coordinating activities, managing events, and maintaining the reliability and efficiency of industrial processes. Communication protocols play a vital role in achieving precise time synchronization, enabling seamless communication and coordination among various devices such as sensors, actuators, controllers, and monitoring equipment.

Role of Communication Protocols in Time Synchronization

Precision Time Delivery

Communication protocols are designed to deliver time information with high precision. For instance, the IEEE 1588 Precision Time Protocol (PTP) used in IEC 61850 provides nanosecond-level accuracy. This level of precision is crucial for applications requiring exact timing, such as substation automation and protection systems.

Interoperability

Protocols like IEC 61850 ensure interoperability between devices from different manufacturers. By adhering to standardized data models and communication services, these protocols enable diverse devices to synchronize time seamlessly. This interoperability is essential for creating cohesive and reliable industrial networks.

Scalability

Scalability is another significant benefit provided by communication protocols. For example, the Network Time Protocol (NTP) allows time synchronization across extensive and complex networks. This scalability ensures that even large-scale industrial systems can maintain synchronized operations efficiently.

Deterministic Communication

Protocols such as PROFIBUS and Modbus support deterministic communication, ensuring timely and predictable data exchange. Deterministic communication is vital for synchronized operations, as it guarantees that time-critical messages are delivered within specified time frames.

Common Causes of Failure

Network Delays and Jitter

Variability in network transmission times, known as jitter, can affect synchronization accuracy. Network delays and jitter can introduce timing errors, making it challenging to maintain precise synchronization.

Clock Drift

Internal clocks in devices may drift over time, leading to synchronization issues. Without regular correction, clock drift can cause devices to operate on different time references, disrupting synchronized operations.

Protocol Misconfigurations

Incorrect setup or misconfiguration of synchronization protocols can lead to failures. Proper configuration is essential for ensuring that protocols function as intended and provide accurate time synchronization.

Hardware Failures

Failures in network devices or time synchronization hardware can disrupt synchronization. Hardware reliability is crucial for maintaining continuous and accurate time synchronization.

Recommendations

To mitigate synchronization failures and enhance reliability, the following recommendations are proposed:

Use Robust Protocols

Implement high-precision protocols like IEEE 1588 PTP for applications requiring nanosecond accuracy. Robust protocols ensure precise time delivery and enhance synchronization reliability.

Regular Monitoring

Continuously monitor synchronization status and performance to detect and address issues promptly. Monitoring helps identify potential problems before they impact operations.

Redundant Systems

Deploy redundant time servers and synchronization paths to ensure reliability in case of failures. Redundancy provides a backup mechanism, maintaining synchronization even if primary systems fail.

Network Quality

Ensure high-quality, low-latency networks to minimize delays and jitter affecting synchronization. A reliable network infrastructure is essential for accurate and consistent time synchronization.

Firmware and Software Updates

Keep device firmware and synchronization software up to date to leverage improvements and fixes. Regular updates ensure that devices operate with the latest enhancements and security measures.

Periodic Calibration

Regularly calibrate and test synchronization hardware to ensure ongoing accuracy. Calibration helps maintain the precision of synchronization systems over time

Communication Protocol	Key Features	Applications
Modbus	- Simple and easy to implement	- Monitoring and control of industrial equipment
	- Supports serial and Ethernet networks	- Data acquisition from sensors and meters
	- Master-slave (client-server) architecture	- Integration of PLCs, HMIs, and SCADA systems
	- Widely adopted and supported by many devices and manufacturers	
IEC 61850	- High-precision time synchronization using Precision Time Protocol (PTP)	- Substation automation and protection
	- Standardized data model and communication services	- Real-time monitoring and control of power systems
	- Ensures interoperability between devices from different vendors	- Integration of renewable energy sources and smart grid applications
	- Scalable for small to large-scale substation automation systems	
PROFIBUS	- High-speed communication (up to 12 Mbps with PROFIBUS DP)	- Factory automation and process control
	- Deterministic and predictable data exchange	- Communication between PLCs, sensors, actuators, and other field devices
	- Robust and reliable	- Substation automation and power distribution
Serial Communication	- Simple and cost-effective	- Communication between microcontrollers, sensors, and actuators
	- Supports a wide range of transmission speeds and distances	- Data acquisition and monitoring systems
	- Suitable for point-to-point or multi-drop communication	- Integration of legacy equipment in modern automation systems
	- Widely used for legacy systems	

Need for Time Synchronization in Communication Protocols

Time synchronization is essential for effective and reliable communication in various industrial and automation systems. Each communication protocol used in these systems—such as IEC 61850, Modbus, DNP3, and others—relies on precise time coordination to ensure accurate data exchange, process control, and system integration. The need for time synchronization across communication protocols can be understood through the following key aspects:

Data Consistency and Accuracy:

- **Temporal Ordering:** Time synchronization ensures that data is accurately timestamped, preserving the order of events. This is crucial for applications where the sequence of events affects decision-making and analysis, such as in substation automation or real-time monitoring systems.
- **Event Correlation:** Accurate time synchronization allows for the correct correlation of events across different devices and systems. This is important for diagnosing issues, troubleshooting, and understanding the interactions between various components.

System Reliability and Coordination:

- **Coordinated Operations:** In systems where, multiple devices must operate in unison, such as in electrical substations or distributed control systems, precise timing ensures that all devices execute their tasks at the correct moments. This prevents timing mismatches that could lead to system inefficiencies or failures.
- **Fault Tolerance:** Synchronized time helps in the detection and isolation of faults by providing a consistent time reference for logging and analyzing system events. This aids in maintaining the reliability and robustness of the system.

Protocol-Specific Requirements:

- **Real-Time Messaging:** Protocols like GOOSE (in IEC 61850) require high-speed, real-time event communication where timing accuracy is critical. Time synchronization ensures that event messages are delivered promptly and in the correct sequence.

- **Sampled Values:** For protocols like SV (Sampled Values), which transmit high-frequency analog data, synchronization is crucial for aligning data samples with accurate timestamps. This enables precise measurement and analysis of analog signals.

Compliance and Interoperability:

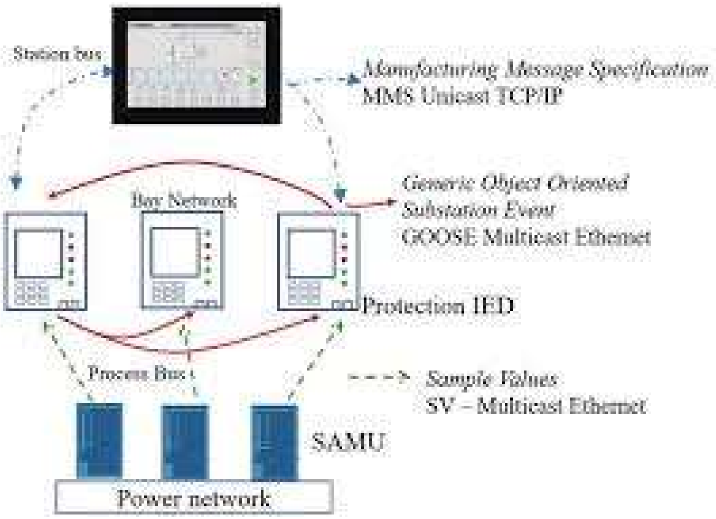
- **Standard Adherence:** Many communication protocols have specific time synchronization requirements to comply with industry standards. For instance, IEEE 1588 PTP used in IEC 61850 mandates high-precision time synchronization to meet the standard's performance criteria.
- **Interoperability:** Synchronizing time across different protocols and devices ensures seamless interoperability. This is particularly important in heterogeneous systems where devices from various manufacturers need to work together harmoniously.

Security and Data Integrity:

- **Accurate Logging:** Time synchronization helps in maintaining accurate logs of system activities and security events. This is crucial for detecting anomalies, ensuring data integrity, and performing forensic analysis in case of security breaches or operational issues.
- **Audit Trails:** Consistent timestamps across all communication channels create reliable audit trails, which are important for regulatory compliance and operational oversight.

Functioning of IEC 61850

IEC 61850 standardizes communication within electrical substations through a structured data model, communication protocols, and configuration practices. It utilizes Logical Nodes (LNs) to represent functional elements, Data Objects (DOs) for specific attributes, and Common Data Classes (CDCs) for standardized data types. Communication is achieved via MMS (Manufacturing Message Specification) for structured data exchange, GOOSE (Generic Object-Oriented Substation Event) for real-time event messaging, and SV (Sampled Values) for high-frequency analog data transmission. Precision Time Protocol (PTP) ensures synchronization across devices. Configuration is managed with Substation Configuration Language (SCL), an XML-based format.



Failures and Recommendations

Despite its robustness, IEC 61850 systems can encounter various issues that impact their performance and reliability. One common problem is data inconsistencies, which may occur due to synchronization errors or incorrect configurations, leading to unreliable event logs and compromised decision-making. Communication delays or packet loss can disrupt real-time data exchange, affecting operational efficiency and system responsiveness. Misconfigurations of MMS, GOOSE, or SV protocols can result in failures in data handling or event processing, thus undermining the system's functionality. Additionally, clock drift in devices can cause timing errors, impacting time-dependent processes and event accuracy. Hardware failures, including those in network devices or time synchronization components, can lead to communication breakdowns and data loss. Security vulnerabilities also pose a significant risk, as inadequate protection measures can expose the system to cyber threats, unauthorized access, or data breaches.

To address these challenges, several recommendations can be implemented. Firstly, robust time synchronization should be ensured by effectively utilizing Precision Time Protocol (PTP) and regularly verifying that all devices are accurately synchronized. Network performance must be optimized by maintaining high-quality infrastructure that minimizes latency and jitter, thereby supporting reliable and real-time data exchange. Regular updates and thorough verification of MMS, GOOSE, and SV configurations are crucial to prevent misconfigurations and ensure proper system operation. Ongoing maintenance and testing of hardware components can help detect and rectify failures promptly. Enhancing security measures with strong cybersecurity protocols is essential to protect against unauthorized access and potential attacks, safeguarding system integrity. Additionally, establishing redundancy and backup systems, such as redundant communication paths and backup devices, can ensure continuous operation and data integrity in the event of primary system failures. By addressing these issues and implementing these recommendations, the reliability and efficiency of IEC 61850 systems can be significantly improved, ensuring effective and secure substation automation.

Time Synchronization

Introduction

Time synchronization is a critical component in modern communication systems, particularly within industrial automation, electrical substations, and distributed control environments. The synchronization of time across various devices and communication protocols is vital for maintaining accurate data exchange, system coordination, and operational reliability. This report examines the significance of time synchronization, the methodologies employed to achieve it, and its implications on communication protocols and system performance.

Importance of Time Synchronization

Time synchronization ensures that all devices and systems within a network adhere to a unified time reference. This uniformity is crucial for several key reasons:

Data Consistency and Accuracy:

- **Temporal Ordering:** Precise timestamps are essential for maintaining the correct sequence of events. Accurate temporal ordering ensures that data is interpreted correctly and that processes are executed as intended.
- **Event Correlation:** Synchronizing time across devices facilitates accurate correlation of events, which is critical for diagnosing issues, troubleshooting, and understanding interactions within the system.

System Reliability and Coordination:

- **Coordinated Operations:** For systems that require precise timing, such as electrical substations or distributed control systems, accurate time synchronization ensures that tasks are performed synchronously, thereby preventing operational discrepancies and enhancing overall system reliability.
- **Fault Detection:** Reliable time references support effective fault detection and isolation, contributing to the system's robustness and operational integrity.

Protocol-Specific Requirements:

- **Real-Time Messaging:** Protocols like GOOSE (Generic Object-Oriented Substation Event) in IEC 61850 require precise time synchronization to ensure the timely and accurate delivery of real-time event messages.
- **High-Frequency Data Transmission:** Protocols such as SV (Sampled Values) rely on synchronized timing to align data samples accurately, which is crucial for precise measurement and analysis of analog signals.

Compliance and Interoperability:

- **Standard Adherence:** Many communication protocols necessitate specific time synchronization practices to comply with industry standards. For instance, IEEE 1588 Precision Time Protocol (PTP) is mandated by IEC 61850 for high-precision time synchronization.
- **Interoperability:** Effective time synchronization ensures that devices from different manufacturers can operate seamlessly together, facilitating integration and consistent performance across diverse systems.

Security and Data Integrity:

- **Accurate Logging:** Consistent timestamps enable accurate logging of system activities and security events, which is essential for detecting anomalies, ensuring data integrity, and conducting forensic analysis.
- **Audit Trails:** Reliable time synchronization provides consistent audit trails, which are vital for regulatory compliance and operational oversight.

Methods of Achieving Time Synchronization

Several methods and protocols are employed to achieve accurate time synchronization across networks and systems:

Network Time Protocol (NTP):

- **Overview:** NTP is a widely utilized protocol for synchronizing time over IP networks. It operates using a hierarchical system of time sources, including atomic clocks and GPS receivers.
- **Accuracy:** NTP typically provides accuracy within a few milliseconds, which is suitable for most applications.

Precision Time Protocol (PTP):

- **Overview:** Defined by IEEE 1588, PTP offers higher precision than NTP, achieving sub-microsecond accuracy. It is used in applications requiring high precision, such as IEC 61850 systems.
- **Operation:** PTP employs a master-slave architecture and synchronization messages to maintain precise time across devices.

Global Navigation Satellite Systems (GNSS):

- **Overview:** GNSS, including GPS, GLONASS, and Galileo, provides highly accurate time signals based on satellite data.
- **Usage:** GNSS is used as a time source in systems demanding extreme accuracy, such as telecommunications and financial transactions.

IEEE 802.1AS (Time-Sensitive Networking):

- **Overview:** IEEE 802.1AS is a standard for time synchronization in Ethernet networks, designed to support time-sensitive applications.
- **Function:** It extends PTP capabilities to Ethernet-based systems, ensuring coordinated communication for real-time data exchange.

Challenges and Recommendations

Challenges:

Network Latency and Jitter: Variability in network latency and jitter can impact synchronization accuracy. Ensuring high-quality network infrastructure is essential to minimizing delays and maintaining precise time.

Clock Drift: Internal clock drift can lead to synchronization errors. Regular calibration and time correction are necessary to mitigate this issue.

Protocol Compatibility: Different protocols may have varying synchronization requirements, complicating integration. Ensuring compatibility and adherence to standards is crucial.

Security Risks: Time synchronization systems can be vulnerable to cyber-attacks or tampering. Robust security measures are required to safeguard synchronization processes.

Recommendations:

Implement High-Precision Protocols: Utilize Precision Time Protocol (PTP) for applications requiring high accuracy and Network Time Protocol (NTP) for general synchronization needs.

Optimize Network Quality: Enhance network infrastructure to reduce latency and jitter, supporting reliable and accurate time synchronization.

Regular Calibration: Conduct regular calibration and synchronization checks on devices to counteract clock drift and maintain time accuracy.

Adopt Robust Security Measures: Protect time synchronization systems with advanced security protocols and monitoring to prevent unauthorized access and tampering.

Ensure Standard Compliance: Adhere to industry standards and best practices for time synchronization to ensure interoperability and reliable system performance.

Time Synchronization in RIL DMD

n Reliance Industries, precise time synchronization is essential to ensuring the smooth operation of its extensive industrial and IT infrastructure. Accurate timekeeping is critical for maintaining operational efficiency, coordinating complex processes, and ensuring data integrity across diverse sectors including petrochemicals, refining, oil exploration, telecommunications, and retail.

Time synchronization enables operational efficiency by ensuring that various industrial processes and systems operate in harmony. For instance, in refining and chemical production, coordinated timing prevents delays and enhances process efficiency. Real-time monitoring and control also depend on precise timestamps to track performance metrics and make timely adjustments.

Data integrity is another crucial aspect influenced by time synchronization. Reliable event logging, which records all system activities with accurate timestamps, supports precise data analysis and reporting. Furthermore, accurate historical data correlation from various sources facilitates comprehensive analysis and informed decision-making.

System reliability and integration benefit significantly from effective time synchronization. With a diverse range of systems and equipment across different sectors, ensuring that all devices operate with a unified time reference is vital for interoperability and seamless integration. Precise time synchronization also aids in detecting and diagnosing faults accurately by providing a consistent reference for analyzing system events.

Compliance with industry standards and regulatory requirements often necessitates accurate timekeeping. In Reliance Industries, time synchronization helps ensure adherence to safety and environmental regulations. Additionally, accurate time synchronization supports the integrity and security of operational data, making it easier to detect and investigate potential security incidents.

To achieve effective time synchronization, Reliance Industries employs several methods. Network Time Protocol (NTP) is used for general synchronization across IT networks, ensuring consistent time references for data processing and communication. For applications requiring higher precision, such as manufacturing and process control, Precision Time Protocol (PTP) provides sub-microsecond accuracy. Global Navigation Satellite Systems (GNSS), including GPS, offer highly accurate time signals for external synchronization and as a reference for internal systems. Time-Sensitive Networking (TSN) standards, like IEEE 802.1AS, support high precision and low latency in Ethernet-based industrial networks.

Despite these methods, several challenges must be addressed. Network latency and jitter can affect synchronization accuracy, necessitating high-quality infrastructure to minimize these issues. Clock drift in devices can lead to synchronization errors, which requires regular calibration and correction. Integrating various time synchronization protocols across different systems can be complex, emphasizing the need for compatibility and standardization. Additionally, time synchronization systems are vulnerable to cyber threats, highlighting the importance of robust security measures to protect against unauthorized access and ensure data integrity.

Recommendations for improving time synchronization in Reliance Industries include implementing high-precision protocols such as PTP for critical applications and NTP for general needs. Optimizing network infrastructure to reduce latency and jitter will support reliable synchronization. Regular calibration and continuous monitoring of timekeeping devices are necessary to address clock drift and synchronization issues. Adopting advanced security protocols will safeguard time synchronization systems from potential cyber threats. Standardizing time synchronization protocols across systems and devices will facilitate seamless integration and operation.

In conclusion, effective time synchronization is fundamental to maintaining operational efficiency, data integrity, and system reliability within Reliance Industries. By employing appropriate synchronization methods and addressing related challenges, the company can enhance its operational success and efficiency across its complex industrial and IT environments.

Importance of Time Synchronization in Relays

- **Accurate Event Logging:** Time synchronization ensures that faults and events are recorded with precise timestamps. This chronological accuracy is crucial for analyzing the sequence of events leading up to a fault, aiding in troubleshooting and understanding system behavior.
- **Coordinated Protection:** Protection schemes often involve multiple relays working together to isolate faults and prevent damage. Accurate time synchronization allows these relays to coordinate their actions effectively, ensuring that protective measures are applied in the correct sequence.
- **Real-Time Control:** Many relays are involved in automated control processes, such as triggering circuit breakers or other devices. Precise timekeeping ensures that these actions are executed accurately and timely, enhancing system reliability and response.
- **Communication Protocols:** Modern relays often use communication protocols like IEC 61850, which require precise time synchronization (e.g., IEEE 1588) to ensure accurate data exchange. This is particularly important for time-sensitive communications such as GOOSE (Generic Object-Oriented Substation Event) messages and Sampled Values (SV).
- **Event Correlation:** In systems with multiple relays, accurate time synchronization helps correlate events across different devices. This is essential for diagnosing faults that may involve interactions between various protection devices and network components.
- **Fault Detection and Diagnostics:** Synchronized time allows for effective analysis of fault records and system logs. It helps in identifying the causes and impacts of

electrical disturbances, improving fault detection, and optimizing system performance.

Time Synchronization in PRP and HSR

Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR) are advanced network protocols designed to enhance network reliability and availability through redundancy. Time synchronization plays a crucial role in the effective operation of these protocols, ensuring that data redundancy and fault tolerance are managed accurately and efficiently.

Parallel Redundancy Protocol (PRP)

PRP is a network protocol used to provide seamless redundancy for Ethernet networks. It works by sending duplicate data packets simultaneously through two separate network paths. This redundancy ensures that if one path fails, the other can continue to deliver the data without interruption.

- **Role of Time Synchronization:** In PRP, precise time synchronization is necessary to manage the timing of data packets across redundant paths. Accurate timekeeping ensures that duplicate packets are sent and received in sync, allowing for consistent and reliable data delivery. Time synchronization helps in identifying and correcting discrepancies between the two redundant paths, ensuring seamless operation and minimizing data loss.

High-availability Seamless Redundancy (HSR)

HSR is another protocol designed to provide high availability and fault tolerance in Ethernet networks. It achieves this by creating a ring topology in which data is circulated continuously. If a fault occurs in the network, the protocol reroutes the data through the ring, maintaining communication without any disruption.

- **Role of Time Synchronization:** For HSR, accurate time synchronization is critical to maintaining consistent data flow and managing the ring topology effectively. Precise timing helps in coordinating the circulation of data packets and ensures that data is not duplicated or lost as it traverses the network. Time synchronization also supports fault detection and recovery processes, allowing HSR to quickly adapt to network changes and maintain high availability.

ABB REL670: Protection and Control Relay

Introduction

The ABB REL670 is a high-performance protection and control relay designed for use in electrical substations. It plays a critical role in the protection, monitoring, and control of electrical systems, ensuring operational reliability and safety. Time synchronization is a fundamental aspect of the REL670's functionality, supporting accurate event logging, coordinated protection, and efficient communication.

Functionality

Protection and Control:

-
- **Versatile Protection:** The REL670 provides comprehensive protection features, including distance protection, differential protection, and overcurrent protection. It is designed to detect and isolate faults in electrical networks, minimizing damage and maintaining system stability.
- **Control Functions:** The relay also supports various control functions such as circuit breaker operation, load shedding, and automation tasks. These functions are crucial for maintaining the optimal operation of electrical systems.

Time Synchronization:

- **Accurate Event Logging:** Time synchronization allows the REL670 to accurately timestamp and log electrical events. This chronological accuracy is essential for analyzing fault sequences, troubleshooting issues, and understanding system behavior.

- **Coordinated Protection:** The relay's protection schemes often involve coordination with other relays and devices. Precise time synchronization ensures that protection actions are executed in the correct sequence, enhancing the reliability of fault isolation and preventing damage.
- **IEC 61850 Compliance:** The REL670 supports the IEC 61850 standard, which requires precise time synchronization using IEEE 1588 (Precision Time Protocol). This ensures that time-sensitive communications, such as GOOSE (Generic Object-Oriented Substation Event) messages and Sampled Values (SV), are accurately coordinated.

Communication:

-
- **Network Integration:** The REL670 integrates with other devices and systems through various communication protocols, including IEC 61850. Time synchronization ensures that data exchange and communication within the substation are accurate and reliable.
- **Real-Time Messaging:** Accurate timing is critical for real-time messaging and data exchange. Time synchronization supports the relay's ability to send and receive time-sensitive information, contributing to effective system management and control.

Importance of Time Synchronization

Enhanced Reliability: Time synchronization enhances the reliability of the REL670 by ensuring that protection and control actions are executed in a timely and coordinated manner. This reduces the risk of operational disruptions and improves system stability.
Effective Fault Analysis: Accurate timestamps on event logs facilitate detailed fault analysis and system diagnostics. This helps in identifying the root causes of faults and optimizing system performance.
Compliance and Integration: Adherence to industry standards, such as IEC 61850, requires precise time synchronization. This ensures that the REL670 operates effectively within a standardized framework and integrates seamlessly with other devices and systems.

High-availability Seamless Redundancy (HSR)

HSR is another protocol designed to provide high availability and fault tolerance in Ethernet networks. It achieves this by creating a ring topology in which data is circulated continuously. If a fault occurs in the network, the protocol reroutes the data through the ring, maintaining communication without any disruption.

- **Role of Time Synchronization:** For HSR, accurate time synchronization is critical to maintaining consistent data flow and managing the ring topology effectively. Precise timing helps in coordinating the circulation of data packets and ensures that data is not duplicated or lost as it traverses the network. Time synchronization also supports fault detection and recovery processes, allowing HSR to quickly adapt to network changes and maintain high availability.

Checking the IP Address of ABB REL670 Relay

- **Access the Relay's Front Panel:**
  Go to the physical location of the ABB REL670 relay and access its front panel. ➡️

- **Navigate the Menu:**
  Use the navigation buttons on the relay's front panel to access the main menu. ➡️

- **Find Network Settings:**
  Navigate through the menu options to find the "Network Settings" or a similar section. This section typically contains network configuration details, including the IP address. ➡️

- **View IP Address:**
  Once you are in the Network Settings section, look for the IP address setting. The current IP address of the relay should be displayed on the screen. ➡️

Configurations for time synchronization of a PCS 7

Overview of recommended configurations

Introduction

Various techniques are possible for time synchronization. The structure of a PCS 7 plant with time synchronization requires careful planning to prevent any undesired results. Use one of the following configurations to support you in planning your PCS 7 plant.

Rules for time synchronization in PCS 7

● A network may only contain one active time master.
● If the time within the PCS 7 plant is to match the local time, then time synchronization with an external time source (e.g., GPS, DCF 77) is required.
● Central plant clocks (synchronized with an external time source wherever possible) are high- grade internal time sources for PCS 7 plants.
● A time slave can be the time master for lower-level components and systems.
● Any domain controllers that are available in a network can synchronize all of the nodes in this network. A synchronization cycle using domain controllers has a duration of 8 hours by default. For reasons of precision, additional synchronization corrections using integrated PCS 7 tools (WinCC time synchronization) are required. You can define an interval at which the OS synchronizes its time with that of an external time source.
● The WinCC "time synchronization" application can be used to configure an OS server as a time master, a cooperative time master, and a time slave.
● An OS server can be configured as a time master either with or without external time synchronization.
● If the "High-precision time stamping" function is used for selected signals in an automation
system, then the direct time synchronization of the plant bus via a central plant clock is Required. If the central plant clock fails, the time accuracy is not sufficient for the high-precision time stamping.
The chronological order of the signals displayed remains intact.
Time synchronization using NTP. The following components are synchronized using NTP:
● PC stations that are not operated as OS client or OS servers
● CPU types with integrated Ethernet interface that support only the NTP mode.

Please note the following restrictions:

When there is a connection to OSM (6GK1105-0AA00), SIMATIC NET - Update 2000/025
(Incompatibility with tagged frames in Industrial Ethernet OSM networks)

(https://upport.industry.siemens.com/cs/ww/en/view/4247019) must be noted. Criteria for time synchronization in existing PCS 7 plants. Compare the configuration of your existing PCS 7 plant with the configurations outlined in this documentation, and configure the time synchronization according to the present configuration

Time synchronization using NTP

The following components are synchronized using NTP:
● PC stations that are not operated as OS client or OS servers
● CPU types with integrated Ethernet interface that support only the NTP mode.

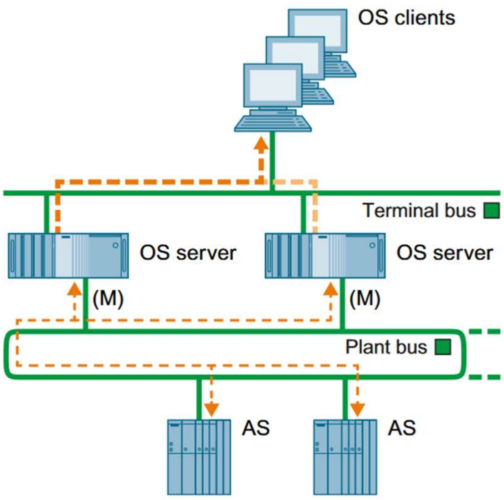
Criteria for time synchronization in existing PCS 7 plants

Compare the configuration of your existing PCS 7 plant with the configurations outlined in this documentation and configure the time synchronization according to the present configuration.

Configurations for time synchronization in a work group

Configuration in a work group with central time master

The following figure is a schematic representation of how time synchronization of a work group with central time master should ideally be configured.



Time master

Central plant clock on the plant bus. The central plant clock is either synchronized with an external signal (e.g. GPS) or operates with the internal real-time clock.

Time synchronization on the terminal bus

● An OS server sends the time frame for process control that it receives from the plant bus to the terminal bus.
● The OS clients are configured as time slaves in the OS project in WinCC Editor in the "Time Synchronization" editor and receive their time frame from an OS server from which server data are loaded.
● PC stations that do not have the WinCC Time Synchronization function, e.g. SIMATIC BATCH stations or engineering stations, are synchronized using the NTP mode or a DCF 77 reception service (must be additionally installed).
An OS server is possible as a time master.

Time synchronization on the plant bus

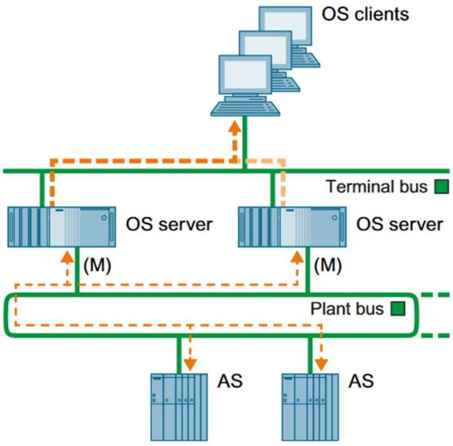
● Time master connected to the plant bus as the central plant clock.
The SIMATIC mode must be activated for synchronization of the OS servers on the plant bus.
The central plant clock sends a high-precision broadcast time signal to the plant bus (SIMATIC mode) and can additionally make the NTP mode available on the plant bus.
● The OS servers are configured as so-called cooperative time masters.
If the central plant clock stops sending time frames, an OS server becomes the active time master and now starts sending time frames on the plant bus by way of substitution.
● Configuring the automation systems:
– The automation system with an external CP 443-1 as communication interface is configured as a time slave (SIMATIC mode).
– The CPU with integrated Ethernet interface receives the time frames via the internal PROFINET IO interface and synchronizes its internal clock.
The CPU with integrated Ethernet interface is a time slave on the plant bus.
● SIMATIC PCS 7 BOX RTX and SIMATIC PCS 7 AS RTX are configured.
The time synchronization is configured with "WinAC Time Synchronization".

The "CP" SIMATIC mode and the "PC time" NTP mode are available for selection. To select one of these, select the desired option in the "Configuration" group of the "WinAC Time Synchronization" dialog box. For the NTP mode, the NTP server must be configured in the Windows time setting.

Configuration in a work group without central time master

Configuration

The following figure schematically shows the recommended configuration of a PCS 7 plant with time synchronization in a work group without central time master:



Time master

The OS servers are time master's for the PCS 7 plant on the plant bus/terminal bus.

Time synchronization on the terminal bus

● The OS clients are configured as time slaves in the OS project in WinCC Editor in the "Time Synchronization" editor and receive their time frame from an OS server from which server data are loaded.

● PC stations that do not have the WinCC Time Synchronization function, e.g. SIMATIC BATCH stations or engineering stations, are synchronized using the NTP mode or a DCF 77 reception service (must be additionally installed).

An OS server is possible as a time master

Time synchronization on the plant bus

● The OS servers are configured as so-called cooperative time masters.
An OS server transmits the time frame to the plant bus.
● Configuring the automation systems:
– The automation system with an external CP 443-1 as communication interface is configured as a time slave (SIMATIC mode).
– The CPU with integrated Ethernet interface receives the time frames via the internal
PROFINET IO interface and synchronizes its internal clock.
● SIMATIC PCS 7 BOX and SIMATIC PCS 7 AS RTX are configured.
The time synchronization is configured with "WinAC Time Synchronization" and the "CP" SIMATIC mode is selected. You activate the "CP" SIMATIC mode in the "Configuration"group of the "WinAC Time Synchronization" dialog box.

Configuration for time synchronization in a Windows domain

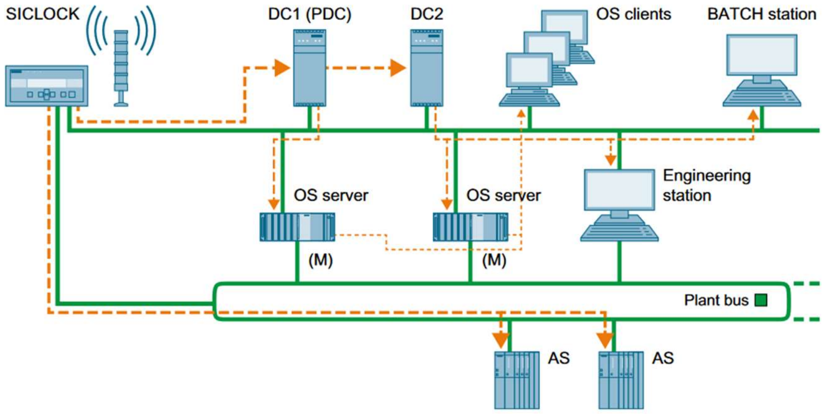
Configuration in a Windows domain with a hierarchy with central time master

Introduction

In a Windows domain, you should synchronize the terminal bus and the plant bus directly using the central plant clock. The recommended central plant clock is SICLOCK TC 400 (which has 4 independents Ethernet interfaces) or Buerk DTS 4138S timer (which has 2 Ethernet interfaces).

Configuration

The following figure illustrates the recommended configuration for a PCS 7 plant in a Windows domain with a central time master:



Time master

Central plant clock on the plant bus and the terminal bus

The central plant clock is either synchronized with an external signal (e.g. GPS) or operates with the internal real-time clock.

Time synchronization on the terminal bus

● Active time master:

The time master is the domain controller (DC), which is configured as the PDC emulator (usually the first domain controller installed).

● Time source:

The domain controller obtains the time from the central plant clock. The central plant clock is connected to the bus terminal via an Ethernet connection. Domain controllers are synchronized from the central plant clock via NTP.

● The Windows time service (w32tm) synchronizes the date and time of all computers of a Windows domain. Since the Windows-internal time synchronization is synchronized only every eight hours, the OS servers are additionally configured as time slaves of the domain controller (PDC emulator) via the WinCC Time Synchronization.

The PDC emulator is an operations master role of a domain controller.

The domain controller with the operation's master role PDC emulator synchronizes the members of the Windows domain every 8 hours.

● Passive time master:

If the authenticated domain controller (PDC operation master) fails, the operations master "PDC Emulator" must transfer to another domain controller manually.

● Time slaves:

All other system PCs are automatically time slaves of the domain controller (PDC emulator) due to their membership in the Windows domain.

● The OS servers are configured as time slaves in the OS project in WinCC Explorer in the "Time Synchronization" editor.

● The OS clients are configured as time slaves in the OS project in WinCC Editor in the "Time Synchronization" editor and receive their time frame from an OS server from which server data are loaded.

● PC stations that do not have the WinCC Time Synchronization function, e.g., SIMATIC BATCH stations or engineering stations, are synchronized using the NTP mode or a DCF 77 reception service (must be additionally installed) or a time master. One of the domain controllers can be used as a time master here.

time synchronization on the plant bus

● Time master is connected to the plant bus as the central plant clock.

The central plant clock sends a high-precision broadcast time signal to the plant bus (SIMATIC mode) and can additionally make the NTP mode available on the plant bus.

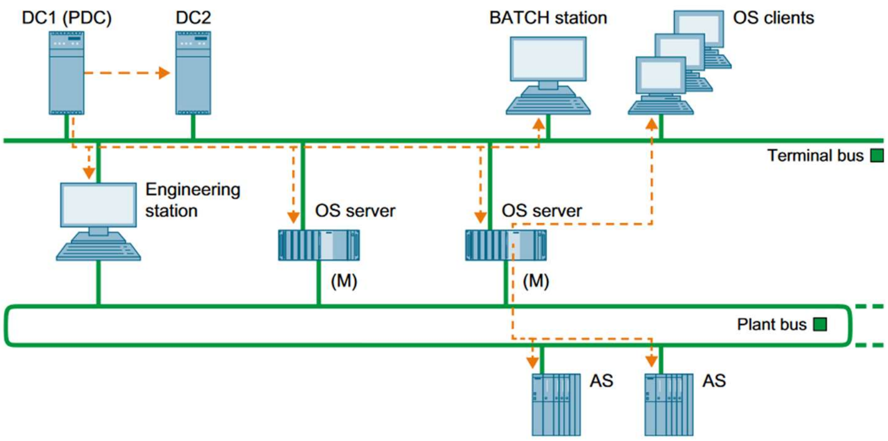
● The OS servers are configured as so-called cooperative masters.

If the central plant clock stops sending time frames, an OS server becomes the active time master and now starts sending time frames on the plant bus by way of substitution.

Configuration in a Windows domain with a hierarchy without central time master

Configuration

The figure below illustrates the recommended configuration of a PCS 7 plant with time synchronization and without a central time master in a Windows domain.



Time master

Domain controller (DC) with PDC emulator operation master role

Time synchronization on the terminal bus

● Time source:

The domain controller receives the time via an NTP time server or a time receiver (DCF 77 or GPS module) that contains the exact time.

● The Windows time service (w32tm) synchronizes the date and time of all computers of a Windows domain.Since the Windows-internal time synchronization is synchronized only every eight hours, the OS servers are additionally configured as time slaves of the domain controller (PDCemulator) via the WinCC Time Synchronization. The PDC emulator is an operations master role of a domain controller.

The domain controller with the operation's master role PDC emulator synchronizes the members of the Windows domain every 8 hours.

● Passive time master:

If the authenticated domain controller (PDC emulator operation master) fails, the operations Master role "PDC Emulator" must transfer to another domain controller manually.

● Time slaves:

All other system PCs are time slaves of the domain controller due to their membership in the Windows domain.

● The OS servers are configured as time slaves in the OS project in WinCC Explorer in the "Time Synchronization" editor.

● The OS clients are configured as time slaves in the OS project in WinCC Editor in the "Time Synchronization" editor and receive their time frame from an OS server from which server data are loaded.
● PC stations that do not have the WinCC Time Synchronization function, e.g., SIMATIC BATCH stations or engineering stations, are synchronized using the NTP mode or a DCF 77 reception service (must be additionally installed) or a time master. One of the domain controllers can be used as a time master here.

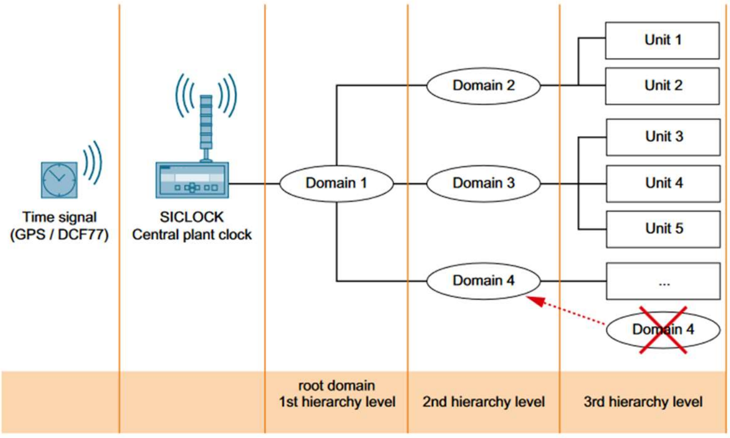
Time synchronization on the plant bus

● The OS servers receive the time frame from the authoritative domain controller (Cooperation master) via the bus terminal. The OS servers are configured as so-called cooperative time masters.
An OS server transmits the time frame to the plant bus.
● Configuring the automation systems:
– The automation system with an external CP 443-1 as communication interface is configured as a time slave (SIMATIC mode).
● SIMATIC PCS 7 BOX and SIMATIC PCS 7 AS RTX are configured.
The time synchronization is configured with "WinAC Time Synchronization" and the "CP" SIMATIC mode is selected. You activate the "CP" SIMATIC mode in the "Configuration" group of the "WinAC Time Synchronization" dialog box.

Configuration in a Windows domain with multiple hierarchies

Configuration

The following figure shows an example configuration for time synchronization in a Windows domain with multiple hierarchies:



Rules

To avoid time jumps, observe the following rules when configuring the hierarchy for the PCS 7 plants within a Windows domain that contains multiple hierarchies:

● All identical structures must be assigned to the same levels in a Windows domain that contains multiple hierarchy levels. This prevents unwanted time differences. You can find additional information in the section "Time levels of a PCS 7 plant (stratum)

● Create only one hierarchy level under the root domain. Configure additional Windows domains you may require on the same hierarchy level as the existing subdomains.