SICLOCK TC 400 / TC100 and Redundancy

applications & TOOLS

What possibilities does SICLOCK TC 400 / TC 100 offer for designing highly available time synchronization?

SIEMENS

SICLOCK Application Note AN 0108

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SICLOCK Application Note AN-0114

This application note applies to SICLOCK TC400 and SICLOCK TC100. Even if in the following
application note only TC 400 is mentioned, the functions described also apply to the SICLOCK TC 100 unless it is explicitly stated that the function does not apply to SICLOCK TC 100.

The main difference between SICLOCK 400 and SICLOCK 100 is that the SICLOCK 400 has four independent network connectors but the SICLOCK TC 100 has only one network connector. This means that the cases of redundant networks described in chapter 4 cannot apply to the SICLOCK TC 100.

1 Basic information

Using the SICLOCK TC 400 central system clock enables high-availability, central time synchronization to be implemented by the option of laying out system components redundantly on multiple levels:

- **Redundant radio clocks on a SICLOCK TC 400 → handle radio clock failures**
- Redundancy for networked system components
  - Redundant SICLOCK TC 400 central system clock as time server or timing master → **handles device failure**
  - SICLOCK TC 400 central system clock for redundant networks → **handles network failure**
- Redundancy for non-networked system components
  - Redundant SICLOCK TC 400 central system clock for outputting time signals → **handles device failure**
- Redundancy of the hierarchical levels of the NTP

1.1 Explanation of terms

Various terms used in this application note are explained briefly below.

1.1.1 External synchronization

SICLOCK TC 400 is synchronized externally from a connected radio clock or a time server. The clock time received from such a source is termed external synchronization. This time is typically universal time UTC or the official national time received via the radio clock. This time is also frequently referred to as "absolute time" because it establishes an absolute time reference worldwide or within a time zone. Two systems running independently in respect of clock time can be linked chronologically via the absolute time.

In principle, a SICLOCK TC 400 cannot detect whether or not its external synchronization is to absolute time. The purpose of the device is to constantly synchronize precisely with this time, and then distribute this time in the system.

1.1.2 Internal clock time

SICLOCK TC 400 constantly maintains an internal clock time, which is exactly synchronized with the external synchronization. All time information output into the system is derived exclusively from this time, so time signals can be generated without interruption even in the event of failure of the external synchronization.

The internal clock time in SICLOCK TC 400 is realized with very high, short-time precision so that typical external synchronization outage times can be bridged well. However, in the event of protracted external synchronization outages, an ever increasing deviation from absolute time is unavoidable. This can only be counteracted by redundancy.

1.1.3 Time server and clients

Time server is a function of the central system clock. Time server makes time information available to clients. In the context of this application note, this always means communication via NTP in unicast mode.

The clients send an active time query to the server, which responds to the query. The server(s) used must be configured on the client.

There is a bidirectional communication connection between server and client for every query. This enables symmetrical network effects on the attainable accuracy, such as the number of synchronization switches, to be compensated. However, asymmetrical effects, such as network load, cannot be compensated.

SICLOCK TC 400 can act as both server and client.

Other typical clients are Windows PCs and SIMATIC controllers in NTP mode.

1.1.4 **Timing master and slave**

Timing master is a function of the central system clock. In contrast to the time server, the activity here lies in the time-distributing component. Typically, periodic broadcast or multicast frames containing the exact time at the time of transmission are fed into a subnetwork.

Slaves receive these frames, and can synchronize with them. There is only unidirectional communication from the timing master to the slave. The attainable accuracy is therefore fully subject to both symmetrical and asymmetrical network effects.

Typical slaves are SIMATIC controllers in SIMATIC mode and OS servers in SIMATIC mode. In principle, the less widely used anycast mode of the NTP can also be used here.

A typical timing master is the central system clock or an equivalent master from the SIMATIC world (e.g. CP1613) in SIMATIC mode.

1.1.5 Non-networked system components

Non-networked system components are supplied with a time signal directly from the central system clock via an electrical or optical line, clock signals and frames are distributed.

Devices typically connected are SICLOCK PCON to create optical lines or to change levels, or optocouplers.

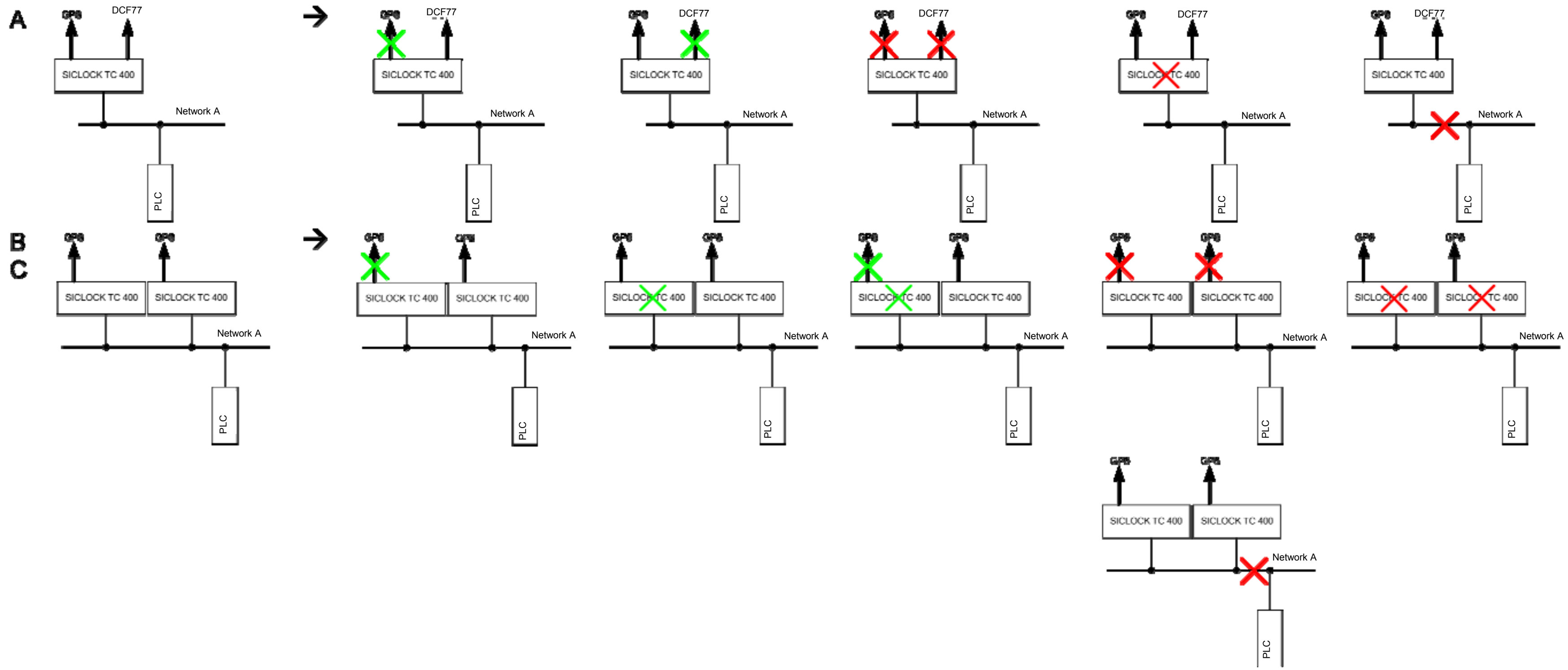
2 Overview

The following overviews illustrate the possible redundant layouts which can be categorized under the following main cases: A, B, C, D and E, as well as various mixed cases.

If system components marked green fail, time synchronization remains available

If system components marked red fail, time synchronization is no longer available

2.1 Main cases



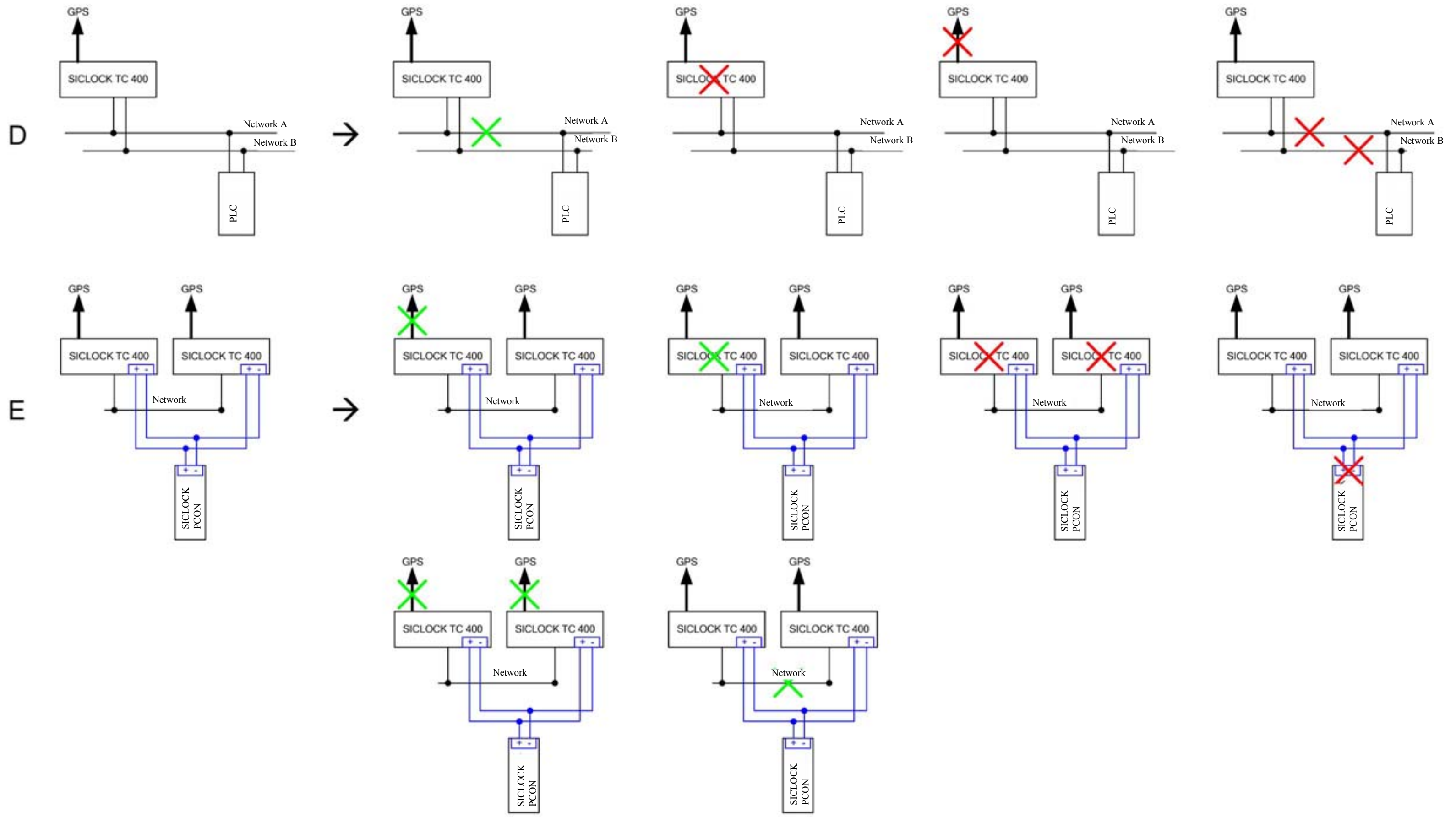


Figure 2-1: Main cases

2.2 Mixed cases

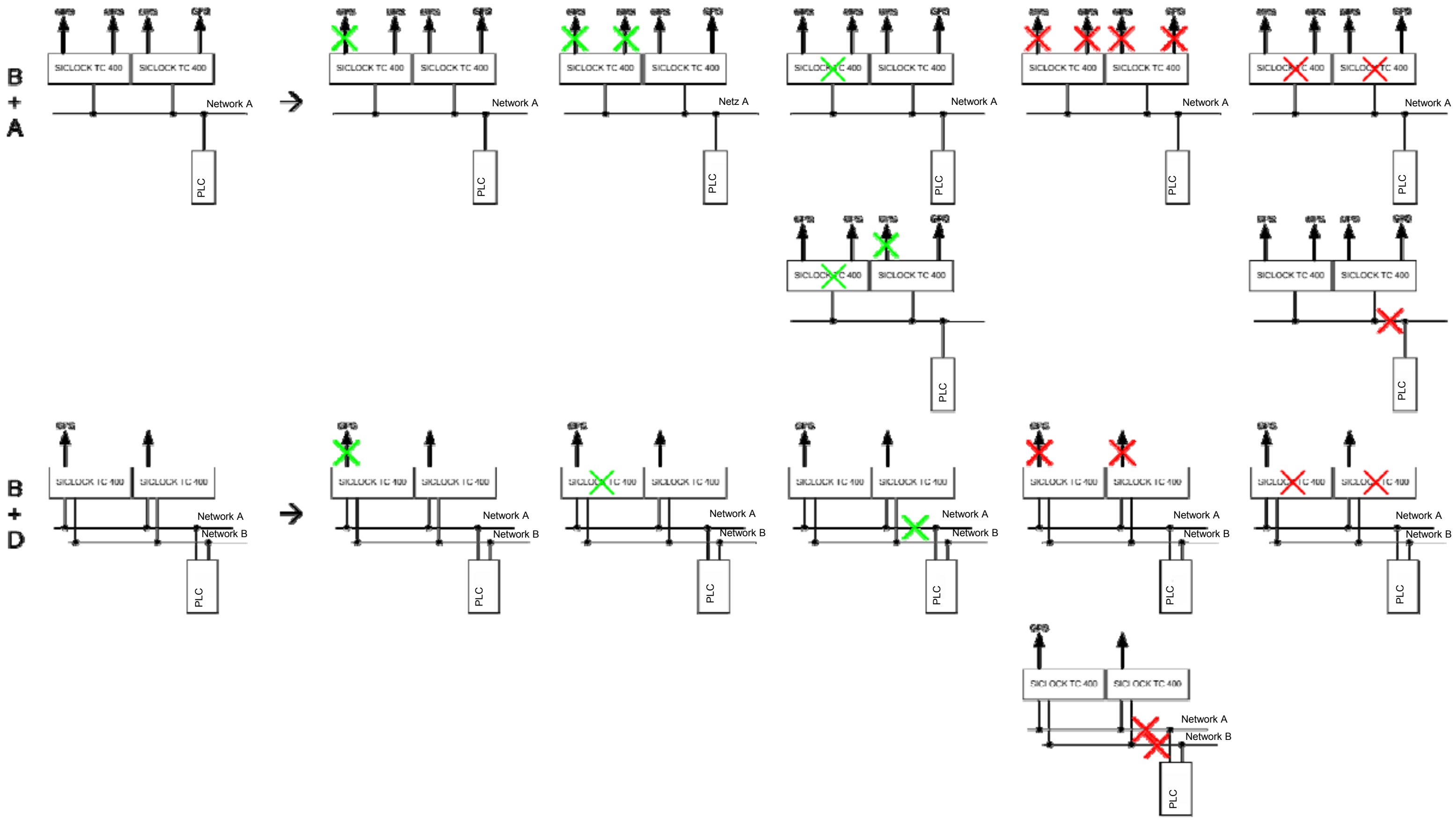


Figure 2-2: Mixed cases

3 Case A: Redundant radio clocks on a SICLOCK TC 400

Radio clocks are usually mounted externally and are therefore subject to increased risk of failure (lightning, environment, long cable routes etc.).

A maximum of two radio clocks can be connected to a SICLOCK TC 400. This enables the reception of the external time signal to be implemented redundantly.

Figure 3-1 shows in case A a SICLOCK TC 400 connected to a GPS and a DCF77 radio clock. Of course, two identical types of radio clock could also be connected. As an example, a slave clock (e.g. a controller) is synchronized by the SICLOCK TC 400 via a network.

There are two physical connectors, RADIO CLOCK 1 and RADIO CLOCK 2, on a SICLOCK TC 400, a radio clock can be connected to each one.

The radio clock connected to RADIO CLOCK 1 has implicit priority, i.e. if RADIO CLOCK 1 fails, RADIO CLOCK 2 is switched in.

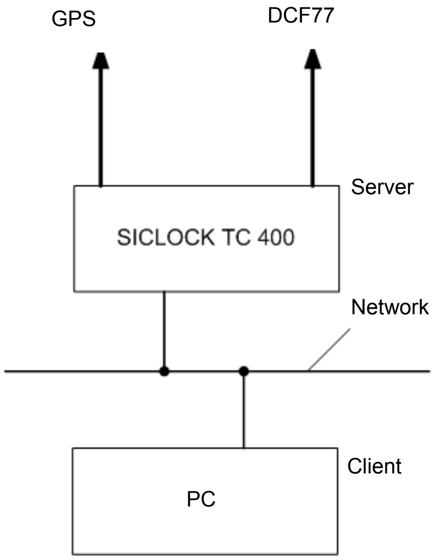


Figure 3-1: SICLOCK TC 400 with two radio clocks connected (a GPS and a DCF77 radio clock)

Figure 2-1 shows for case A the availability and non-availability of the time synchronization in the event of failure of a system component.

3.1 Fault coverage

For example, the GPS radio clock has priority over the DCF77 radio clock, i.e. the SICLOCK TC 400 receives the external synchronization via the GPS radio clock.

If the SICLOCK TC 400 ceases to receive a time signal from the GPS radio clock (e.g. GPS radio clock defective as a result of lightning) it switches to the previously subordinate DCF77 radio clock, so that now its time signal is used for external synchronization.

When the SICLOCK TC 400 receives a time signal from the GPS radio clock defined as priority once again (the GPS radio clock is working again), it switches back from the subordinate DCF77 to the priority GPS radio clock.

SICLOCK TC 400 always has external synchronization despite the failure of one radio clock, and can continue to synchronize the slaves clocks in the system reliably with high accuracy very close to the absolute time.

3.2 Configuration of the SICLOCK TC 400

SICLOCK TC 400 requires no further configuration. Radio clock signals are automatically detected at both inputs and evaluated.

The priority of the two radio clocks is assigned by connecting them to RADIO CLOCK 1 and 2 respectively.

The timeout value in the Redundancy/Redundancy (0.9.00010) parameter defines when the switch is made to the second radio clock. The default value of 30 minutes has to be reduced to meet the accuracy required by the application.

The Inputs/Input 1/Monitoring (0.20.00001) and Inputs/Input 2/Monitoring (0.21.00001) parameters make it possible to monitor both inputs simultaneously for timeouts, and generate alarms or warning signals. The signals can be picked up at the signaling contacts of the device, and further processed, e.g. in the systems control.

3.3 Proxy synchronization mode

Proxy synchronization mode is available with firmware version 1.4.3343 and higher.

SICLOCK TC400 / TC100 offer proxy mode. This can be selected in the parameterization of SICLOCK TC400 / TC100, and ensures that the corresponding SICLOCK continues to work properly and synchronizes the connected clients even without a connection to a DCF or GPS antenna or other source of synchronization, or in the event of their failure.

Proxy synchronization has a lower priority than all regular sources of synchronization. It takes over the synchronization during phases in which no other source of synchronization is available. Proxy synchronization is indicated by the status "PROXY" on the display and in the archive.

In proxy synchronization mode, the synchronization has the accuracy provided by the internal quartz of the SICLOCK.

The main purpose of PROXY synchronization is to ensure that the redundant SICLOCK handles the synchronization task without fail in redundancy scenarios involving failure of all sources of synchronization including the master SICLOCK.

Without PROXY synchronization as the last available fall-back stage, in such cases the "Quality Of Service" contained in the output formats is output as "poor" or "not available", and may no longer be accepted by the system. This applies to both SIMATIC mode and NTP mode.

In "**start synchronized**" mode, the proxy only synchronizes until another source of synchronization is detected, irrespective of whether this remains available or not. This is useful for bridging the generally lengthy phases following system start until synchronization.

This avoids time jumps which the internal source of the SICLOCK might make to synchronize with the returning external source. However, if the time jumps exceed a parameterizable limit, an error message is output in the mode without proxy, and the time jump has to be acknowledged. This also applies to "continue synchronization" mode.

It must be noted that in both this mode as well as in "continuous synchronization" mode, the system startup engineer is responsible for the starting time of the Siclock.

In "**continue synchronization**" mode, the proxy synchronizes as from the point in time at which the loss of another source of synchronization is detected. This is useful for bridging unlimited outage phases, but not for synchronizing the system at system start with an unknown time of day.

In "**continuous synchronization**" mode the proxy synchronizes continuously.

In the event of proxy parameterization "Synchronization status change" is entered in the archive.

The loss of the primary source of synchronization is monitored where it was parameterized irrespective of proxy mode. The associated archive messages are also generated there.

4 Cases B, C and D: Redundancy for networked system components

4.1 Case B: SICLOCK TC 400 as a redundant NTP server

The NTP server supplies time information to NTP clients on request (unicast mode). The information is more than just a time statement, and includes detailed information about the quality and the synchronization status of the server itself.

The system "intelligence" in such scenarios lies initially in the client, which can choose from a number of servers on the basis of this information. The servers are always configured on the client.

The simplest client implementations use a server as long as it still merely remains available, whereas better implementations attempt to select the best quality server.

As an NTP server, SICLOCK TC 400 provides detailed quality information and functionality, and can be very well integrated into setups with alternative servers.

"Redundant NTP servers" means that a network has more than one server, so that in the event of failure of a server, its function can be taken over by another server.

Figure 4-1 shows in case B a network with two servers, i.e. the servers are arranged redundantly.

Both servers are equipped with at least one radio clock. The two servers are connected to each other by a permanent NTP connection.

The first server is defined as the priority server, it uses its connected radio clock for external synchronization, giving it priority over its NTP partner. It identifies itself as a high-quality (primary) server.

The second server is defined as the secondary. It uses the NTP partner for external synchronization, giving it priority over its own radio clock signal. It identifies itself as a secondary server.

For example, a controller is connected as a client via a network. Both servers are defined in the controller. The server information enables the client to choose the primary server.

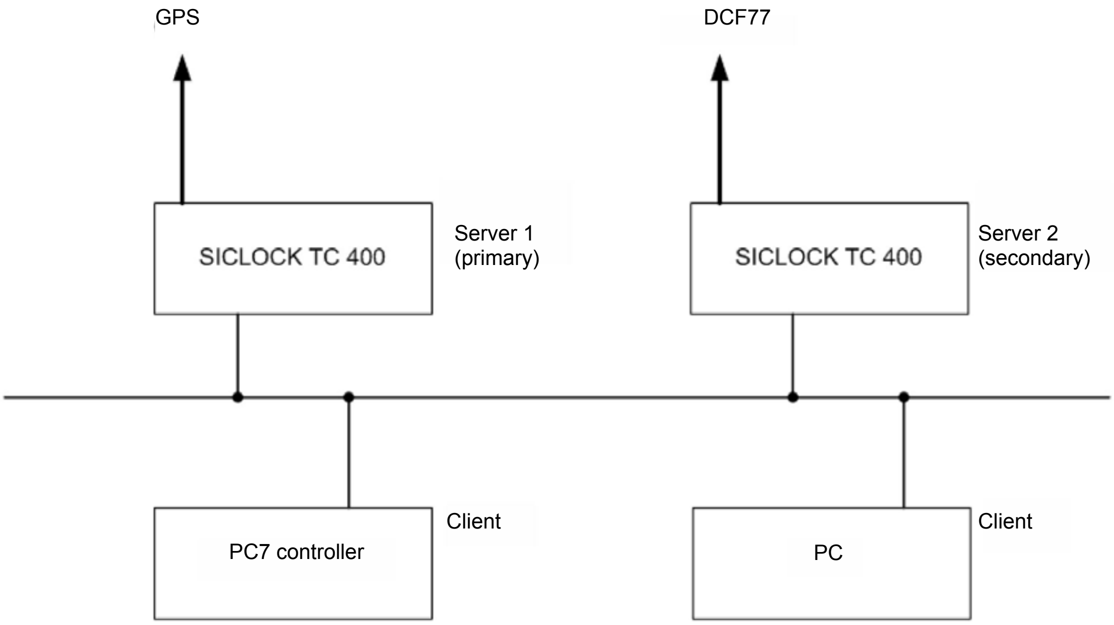


Figure 4-1: Two SICLOCK TC 400s as redundant NTP servers

Figure 2-1 shows for case B the availability and non-availability of the time synchronization in the event of failure of a system component.

4.1.1 Fault coverage

If the primary server ceases to receive a time signal from the GPS radio clock (e.g. GPS radio clock defective as a result of lightning), it switches to its NTP partner for external synchronization, and subsequently identifies itself as a secondary server.

As a result, there would be "ring synchronization" between the two servers (the two mutually synchronizing each other). However, the secondary server detects this ring synchronization with the aid of the auto-information of its NTP partner, and rejects its responses as external synchronization. It thus loses its NTP partner, and switches to its own radio clock.

This completes an automatic exchange of primary and secondary roles between the two servers.

The client can choose the new primary server on the basis of the changed server information. As the second server had been synchronized to the first immediately beforehand, the role change does not lead to a time jump.

If the radio clock signal returns to the first server, then the role assignment switches back to the original situation because of the priority definition.

If the first server fails completely, in the absence of an NTP partner, the secondary server switches to its own radio clock for external synchronization, and subsequently identifies itself as secondary server.

If the first server returns, the system reverts to the original situation.

Notice:

This automatism can only be guaranteed if two SICLOCK TC 400s are used as the pair of servers. Their NTP implementation is specifically designed for this case.

4.1.2 Configuration of the SICLOCK TC 400

The application must be explicitly configured on the two SICLOCK TC 400 devices.

- The NTP server service must be active on both devices, i.e. the mode must be set to "on" in the NTP Server/NTP Server (0.16.00001) parameter.
- The NTP client service must be active on both devices, i.e. the mode must be set to "on" in the NTP Client/NTP Client (0.18.00001) parameter.
- On both devices, the respective NTP partner (i.e. its IP address) must be entered as NTP server at one place in the NTP Client/NTP Server List (0.18.00002) parameter.
- The primary server is defined in the Redundancy/Redundancy (0.9.00010) parameter by the priority value "Master (prefer radio clocks over NTP)".
- The secondary server is defined in the Redundancy/Redundancy (0.9.00010) parameter by the priority value "Slave (prefer NTP over radio clocks)".
- On the second device, the timeout value in the Redundancy/Redundancy (0.9.00010) parameter defines when the switch is made to its own radio clock in the event of loss of server. The default value of 30 minutes has to be reduced to meet the accuracy required by the application.

The Inputs/Input 1/Monitoring (0.20.00001) and NTP Client/Monitoring (0.18.00004) parameters make it possible to monitor its own radio clock inputs as well as the NTP partner, and generate alarms or warning signals. The signals can be picked up at the signaling contacts of the device, and further processed, e.g. in the systems control.

4.1.3 Case A + B: mixed configuration

Cases B and A can, of course, be combined with one another.

Figure 2-2 shows for case A + B the availability and non-availability of the time synchronization in the event of failure of a system component.

4.2 Case D: redundant networks

This case applies to the SICLOCK TC 400 only

"Redundant networks" means that there is more than one server-client structure network so that, despite the failure of one network, the server/client communication continues to remain fully functional.

SICLOCK TC 400 supports the connection of up to four separate networks.

Figure 4-2 shows in case B a server-client structure with two identical networks, i.e. the networks are arranged redundantly.

The server sends the time signal to the clients in the form of data packets in parallel through both networks. The failure of one of the two networks therefore has no effect on the communication between server and clients.

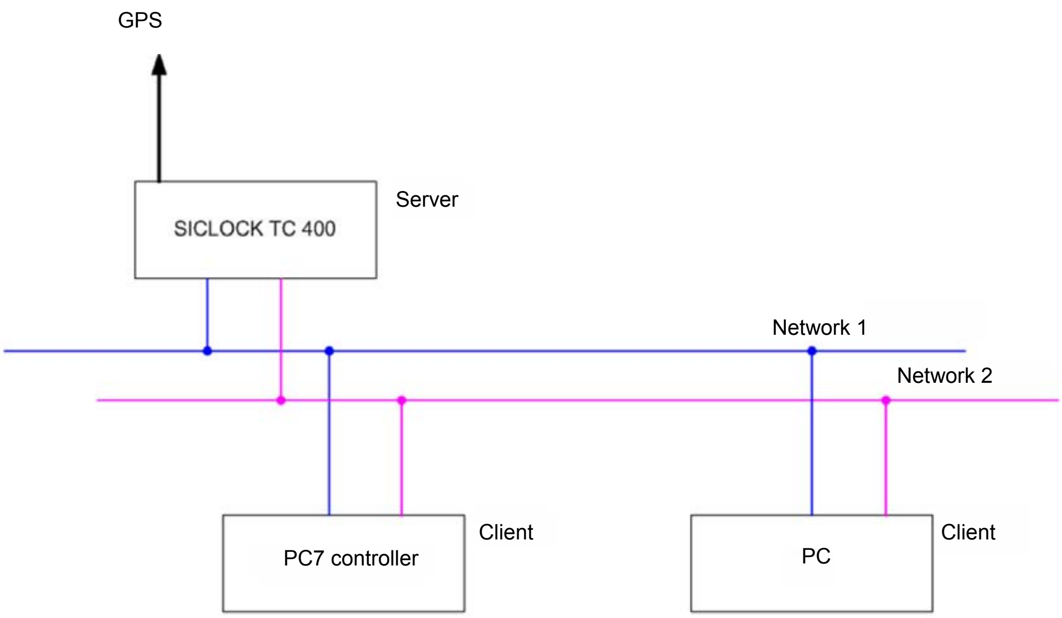


Figure 4-2: One SICLOCK TC 400 server on two networks

Figure 2-1 shows for case D the availability and non-availability of the time synchronization in the event of failure of a system component.

4.2.1 Case A + B + D: mixed configuration "maximum redundancy"

Case D does not apply to SICLOCK TC100

There is maximum redundancy when the radio clocks per server (case A), the servers (case B) as well as the networks (case D) are arranged redundantly.

In this case, the server-client structure continues to remain fully functional if one server, one radio clock of the still intact server, and one network all fail at the same time.

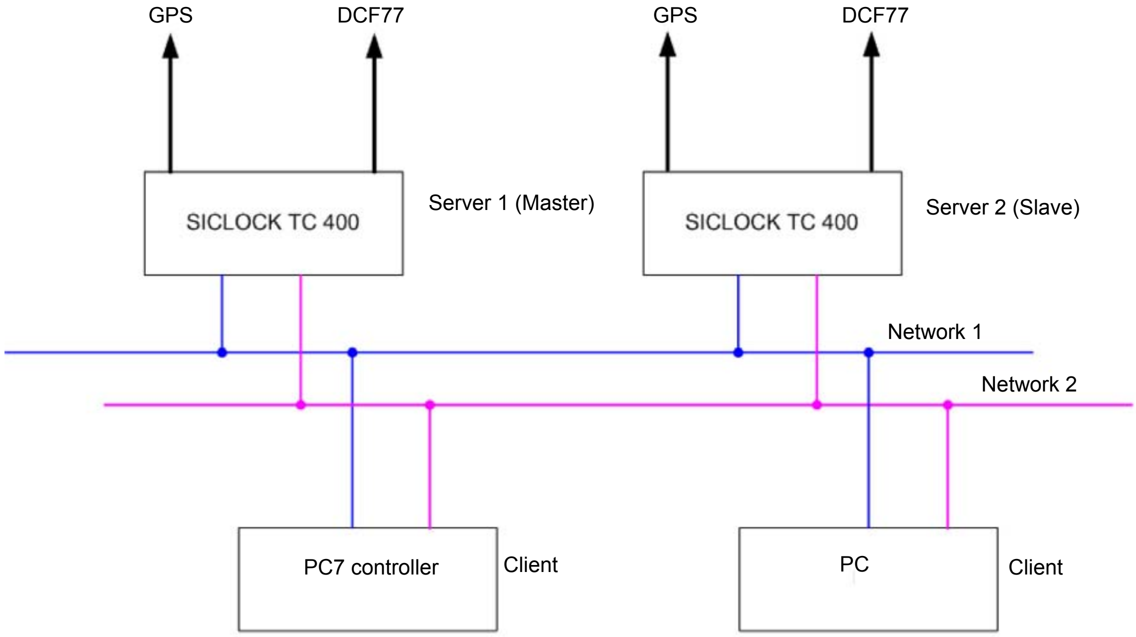


Figure 4-3: Two SICLOCK TC 400 servers (master/slave mode) each with two radio clocks on two identical networks

Figure 2-2 shows for case B + D the availability and non-availability of the time synchronization in the event of failure of a system component.

4.3 Case C: SICLOCK TC 400 as redundant timing master

Timing masters provide the slave clocks with time information without a request (in broadcast or multicast mode). The information is here again more than just a time statement, and includes limited information about the synchronization status of the master itself.

The most typical application is the synchronization of controllers in SIMATIC mode.

Synchronization via NTP multicasts, as used for some systems, is structurally comparable with SIMATIC mode.

Slaves clocks do not usually have any system "intelligence" so, in such scenarios, the timing masters have to actively make the switch and have to appear as a single master to the slaves.

SICLOCK TC 400 can make such a switch in SIMATIC mode.

A transmission takeover is not required for NTP multicast. In contrast to SIMATIC mode, in this case, both devices can be active as NTP multicast transmitters simultaneously because there can be practically no double frames. However, in contrast to case B, as a rule the NTP clients do not include the quality information from the server in their acceptance, so a lower quality server should stop operation autonomously.

"Redundant timing masters" means that a network has more than one timing master so, in the event of failure of a master, another device can be take over its function.

The structure corresponds to case B shown in figure 2-1. Two SICLOCK TC 400s are arranged as redundant timing masters.

Both masters are equipped with at least one radio clock. As in case B, the two servers are connected to each other by a permanent NTP connection. The synchronization therefore takes place between the two devices, not through the SIMATIC mode.

The first device is defined as the active time transmitter, it gives its connected radio clock priority for external synchronization over its NTP partner.

The second device is defined as a passive time transmitter (hot standby). It uses the NTP partner for external synchronization in preference to its own radio clock signal.

For example, a controller is connected as a clock slave in SIMATIC mode via a network.

Figure 2-1 shows for case C the availability and non-availability of the time synchronization in the event of failure of a system component.

4.3.1 Fault coverage in SIMATIC mode

When the master device ceases to receive a time signal from the GPS radio clock (e.g. GPS radio clock defective as a result of lightning) it stops transmission mode as timing master and NTP server. It also switches to its NTP partner for external synchronization, and subsequently identifies itself as a secondary server in the NTP.

The slave device detects the loss of transmission mode of the timing master, and then starts transmission mode itself as timing master. It also loses its NTP partner and switches to its own radio clock. The timing master is thus now fed from the radio clock of the second device.

This completes an automatic change between the two timing masters. As the second device had been synchronized to the first immediately beforehand, the role change does not lead to a time jump. Furthermore, at no time were both devices simultaneously active in the network, so that there was no unwanted double synchronization of the slave clocks.

If the radio clock signal returns to the first device, then the role assignment switches back to the original situation because of the priority definition. This means that the device restarts transmission mode, and the second device immediately returns to hot standby status.

If the first device fails completely, in the absence of the master, the second device becomes the master and, in the absence of an NTP partner, switches to its own radio clock for external synchronization.

If the first server returns, the system reverts to the original situation.

Notice:

Other components (e.g. CPs) are also capable of hot standby. However, their frames are not accepted by SICLOCK TC 400 as permissible master status, so that in every case a SICLOCK TC 400 takes over master status, and any other components withdraw. However, in case C hot standby should not generally be configured on any other components.

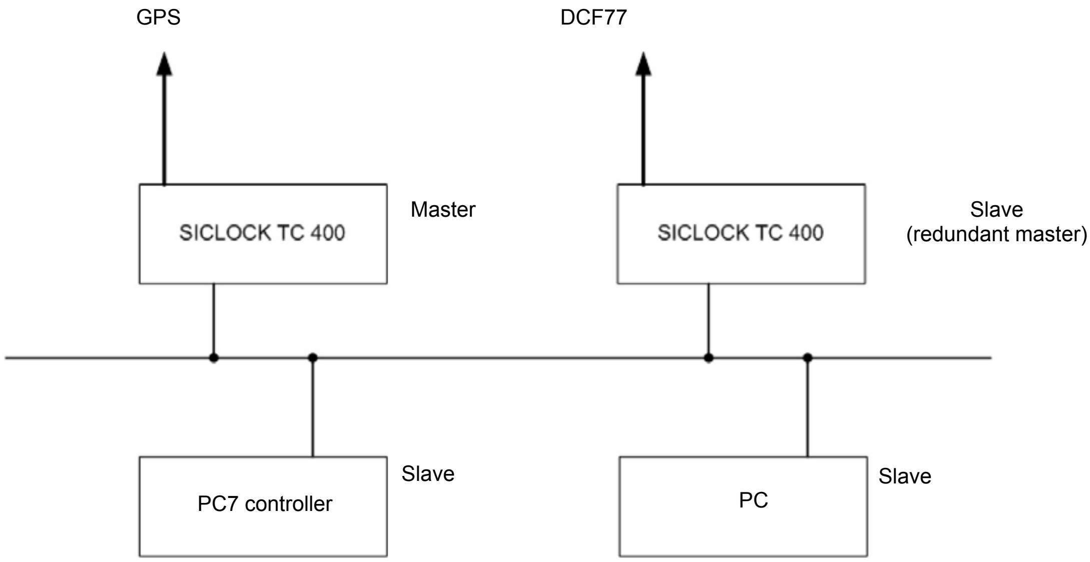


Figure 4-4: Two SICLOCK TC 400s as master and redundant master

4.3.2 Fault coverage with NTP multicast

When the first device ceases to receive a time signal from the GPS radio clock (e.g. GPS radio clock defective as a result of lightning) it stops transmission mode as an NTP multicast transmitter and also as NTP server for the second device. It also switches to its NTP partner for external synchronization, and subsequently identifies itself as secondary server in the NTP.

The second device thus loses its NTP partner, and switches to its own radio clock. It remains as the sole NTP multicast transmitter.

4.3.3 Configuration of the SICLOCK TC 400 in SIMATIC mode

The application must be explicitly configured on the two SICLOCK TC 400 devices.

- The NTP server service must be active on both devices, i.e. the mode must be set to "on" in the NTP Server/NTP Server (0.16.00001) parameter.
- The NTP client service must be active on both devices, i.e. the mode must be set to "on" in the NTP Client/NTP Client (0.18.00001) parameter.
- On both devices, the respective NTP partner (i.e. its IP address) must be entered as NTP server at one place in the NTP Client/NTP Server List (0.18.00002) parameter.
- The first device is defined in the Redundancy/Redundancy (0.9.00010) parameter by the priority value "Master (prefer radio clocks over NTP)".
- The second device is defined in the Redundancy/Redundancy (0.9.00010) parameter by the priority value "Slave (prefer NTP over radio clocks)".
- On the first device, "only if synchronized" is set as the transmission condition in SIMATIC mode in the SIMATIC Mode/Ethernet 1 to 4 (0.15.00001 to 0.15.0004) parameter.
- On the second device, "hot standby" is set as the transmission condition in SIMATIC mode in the SIMATIC Mode/Ethernet 1 to 4 (0.15.00001 to 0.15.0004) parameter.
- On the second device, the timeout value in the Redundancy/Redundancy (0.9.00010) parameter defines when the switch is made to its own radio clock in the event of loss of server. The default value of 30 minutes has to be reduced to meet the accuracy required by the application.

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4.3.4 Configuration of the SICLOCK TC 400 with NTP multicast

The application must be explicitly configured on the two SICLOCK TC 400 devices.

- The NTP server service must be active on both devices, but only with its own synchronization. This means that "only when synchronized" mode must be set in the NTP Server/NTP Server (0.16.00001) parameter.
- The IP multicast addresses (= network address followed by all 1s) are entered on both devices, on the ports of which multicast mode is to be active, in the parameter NTP Server/Multicast (0.16.00002). If a port has, e.g., the IP address 192.168.1.10 and the subnet 255.255.255.0, then the multicast address is 192.168.1.255.
- The NTP client service must be active on both devices, i.e. the mode must be set to "on" in the NTP Client/NTP Client (0.18.00001) parameter.
- On both devices, the respective NTP partner (i.e. its IP address) must be entered as NTP server at one place in the NTP Client/NTP Server List (0.18.00002) parameter.
- The first device is defined in the Redundancy/Redundancy (0.9.00010) parameter by the priority value "Master (prefer radio clocks over NTP)".
- The second device is defined in the Redundancy/Redundancy (0.9.00010) parameter by the priority value "Slave (prefer NTP over radio clocks)".
- On the second device, the timeout value in the Redundancy/Redundancy (0.9.00010) parameter defines when the switch is made to its own radio clock in the event of loss of server. The default value of 30 minutes has to be reduced to meet the accuracy required by the application.

The Inputs/Input 1/Monitoring (0.20.00001) and NTP Client/Monitoring (0.18.00004) parameters make it possible to monitor its own radio clock inputs as well as the NTP partner, and generate alarms or warning signals. The signals can be picked up at the signaling contacts of the device, and further processed, e.g. in the systems control.

4.3.5 Case A + C: mixed configuration

Cases A and C can, of course, be combined with one another. Figure 2-2 shows for case A + B (is identical with case A + C) the availability and non-availability of the time synchronization in the event of failure of a system component.

5 Case E: Redundancy for non-networked system components

Non-networked system components are field devices that are not connected to the SICLOCK TC 400 feed via a network but by a point-to-point connection (2-wire cable).

5.1 Redundant time transmitters (feeding SICLOCK TC 400)

Each of the feeding SICLOCK TC 400s is equipped with a radio clock. Figure 5-1 shows a connection of two feeding SICLOCK TC 400s, i.e. the feeding SICLOCK TC 400s are arranged redundantly.

A SICLOCK PCON is connected as an example of a controlled, non-networked component into which both SICLOCK TC 400s feed in parallel.

There must be a high degree of synchronicity between the time signals fed in parallel simultaneously from the two devices. Otherwise the two time signals fed in in parallel overlap on the field device, as a result of which it can no longer identify the time signal.

Signal overlapping is avoided by synchronizing the time signal of the redundant feeding SICLOCK TC 400 and by restricting use to slow time signals (DCF77, minute pulse or second pulse).

Figure 5-1 shows the two feeding SICLOCK TC 400s connected via a network. In the simplest case, the network is reduced to a patch cable between the two devices. Both SICLOCK TC 400s have been configured redundantly as time transmitters, so that they communicate with one another via the NTP protocol as NTP server (primary server) and NTP client (secondary server).

This enables the secondary server to synchronize itself with the time signal of the primary server. In this way, the secondary server can take over the role of the primary server if it fails, and transmit the time signal as the new primary server.

Furthermore, the primary server is configured in such a way that it stops outputting the signal as soon as it loses its external synchronization. Whereas the secondary server is configured for permanent output.

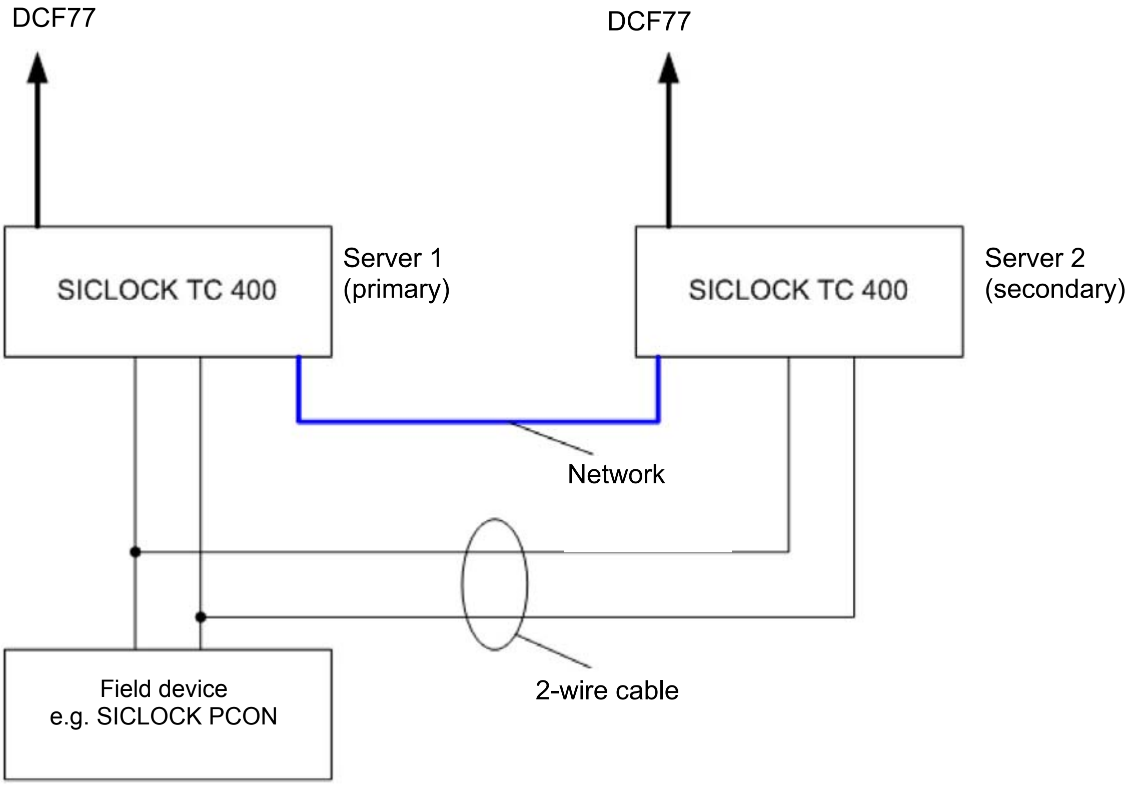

Figure 5-1: Two SICLOCK TC 400 servers as redundant time transmitters are connected via a network

Figure 2-1 shows for case E the availability and non-availability of the time synchronization in the event of failure of a system component.

5.1.1 Fault coverage

When the primary server ceases to receive a time signal from the GPS radio clock (e.g. GPS radio clock defective as a result of lightning) it stops transmitting to the field device. It also switches to its NTP partner for external synchronization, and subsequently identifies itself as secondary server in the NTP.

The secondary server detects the loss of transmission from the primary server. It loses its NTP partner, and switches to its own radio clock. The transmission to the field device is thus now fed from the radio clock of the second device.

The infeed of the signal to the field device continues without interruption. As the second device had been synchronized to the first immediately beforehand, there is no time jump.

If the radio clock signal returns to the first device, then, because of the priority definition, the role assignment switches back to the original situation, and both devices feed in.

If the first device fails completely, in the absence of the primary server, the second device takes over the sole infeed, and switches to its own radio clock for external synchronization.

If the first server returns, the system reverts to the original situation.

If both radio clocks fail, the primary server stops all transmission and infeed, and synchronizes itself with the secondary server. However, the secondary server will maintain the infeed on the basis of its own quartz.

If the radio clocks return, the system reverts to the original situation. Any time discrepancies are reduced via the implicit microstep mode. Microstep mode does not lead to any noticeable signal corruption of the slow clock signals.

If the network connection between the two devices is lost, both maintain the infeed with their radio clocks. The radio synchronization ensures synchronicity between the two infeeds even in this case.

5.1.2 Configuration of the SICLOCK TC 400

The application must be explicitly configured on the two SICLOCK TC 400 devices.

- The NTP server service must be active on both devices, i.e. the mode must be set to "on" in the NTP Server/NTP Server (0.16.00001) parameter.
- The NTP client service must be active on both devices, i.e. the mode must be set to "on" in the NTP Client/NTP Client (0.18.00001) parameter.
- On both devices, the respective NTP partner (i.e. its IP address) must be entered as NTP server at one place in the NTP Client/NTP Server List (0.18.00002) parameter.
- The primary server is defined in the Redundancy/Redundancy (0.9.00010) parameter by the priority value "Master (prefer radio clocks over NTP)".
- The secondary server is defined in the Redundancy/Redundancy (0.9.00010) parameter by the priority value "Slave (prefer NTP over radio clocks)".
- On the second device, the timeout value in the Redundancy/Redundancy (0.9.00010) parameter defines when the switch is made to its own radio clock in the event of loss of server. The default value of 30 minutes has to be reduced to meet the accuracy required by the application.
- The transmission condition "only when synchronized" must be configured on the primary server for the clock output, e.g. in the Outputs/Output 1 (0.12.00001) parameter.
- "No condition" is selected as the transmission condition on the secondary server.

The Inputs/Input 1/Monitoring (0.20.00001) and NTP Client/Monitoring (0.18.00004) parameters make it possible to monitor its own radio clock inputs as well as the NTP partner, and generate alarms or warning signals. The signals can be picked up at the signaling contacts of the device, and further processed, e.g. in the systems control.

6 Redundancy of the hierarchical levels of the NTP

The NTP allows a hierarchical system of levels/layers. The top layer provides the absolute time, e.g. atomic clocks, radio clocks. The underlying layers each contain time servers down to the lowest layer with the end users.

Each layer is assigned to a stratum. A stratum is the hierarchical distance of a time server from the time source, e.g. an atomic clock or radio clock. "Stratum 0" designates the topmost layer, which contains the exact time standard, e.g. atomic clock or radio clock.

If a SICLOCK TC 400 is externally synchronized directly by radio clocks, then it lies as a time server in the layer "Stratum 1", which lies directly below the topmost layer "Stratum 0".

If a SICLOCK TC 400 is not externally synchronized directly by radio clocks, but via the time server (NTP server) of layer "Stratum 1", then it lies as a time server (NTP client) in the next layer down "Stratum 2".

A maximum of 4 NTP servers can be connected to a SICLOCK TC 400 (NTP client).

Figure 6-1 shows a case of the external synchronization of one or more SICLOCK TC 400s (NTP clients) via NTP servers.

The NTP hierarchy is simplified by division into the following three hierarchy levels:

- The level of the NTP server
- The level of the NTP client
- The level of the networked and non-networked system components

The devices configured as NTP servers which provide the time signal for the external synchronization of the NTP clients are located in the upper level of the NTP servers. The NTP server can be represented by a SICLOCK TC 400, the previous model SICLOCK TM/TS or a PC-based server.

The SICLOCK TC 400s configured as NTP clients which are externally synchronized via the NTP servers are located in the middle level of the NTP clients. In its turn, the NTP client provides a central time signal for synchronizing the networked and non-networked system components connected to it.

A SICLOCK TC 400 configured as an NTP client automatically selects the momentarily qualitatively best available NTP server. This selection mechanism has the following very much simplified preferred order:

- Very high quality SICLOCK TC 400 as an NTP server
- High quality: previous model SICLOCK TM/TS as NTP server
- Unreliable quality: a PC-based server as an NTP server

In the scenario shown in figure 6-1, the level of the NTP servers has the following NTP servers (listed in the order of their quality – starting with the highest quality):

- SICLOCK TC 400
- Previous model SICLOCK TM/TS
- The PC-based server

A SICLOCK TC 400 configured as an NTP client automatically selects the NTP according to this order of quality:

- SICLOCK TC 400 NTP server available
  → Select the SICLOCK TC 400 as NTP server
- SICLOCK TC 400 NTP server not currently available
  → Select or switch to the previous model SICLOCK TM/TS as NTP server
- SICLOCK TC 400 NTP server and previous model SICLOCK TM/TS not currently available
  → Select or switch to the PC-based server as NTP server

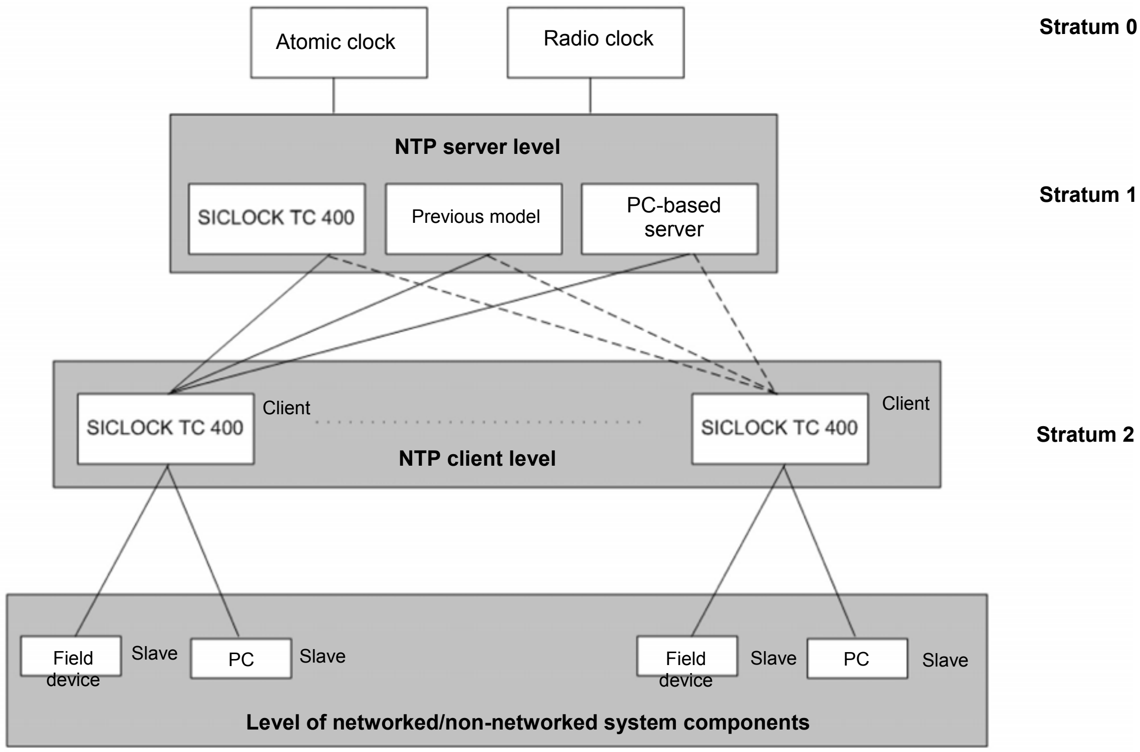

Figure 6-1: Hierarchical levels of the NTP