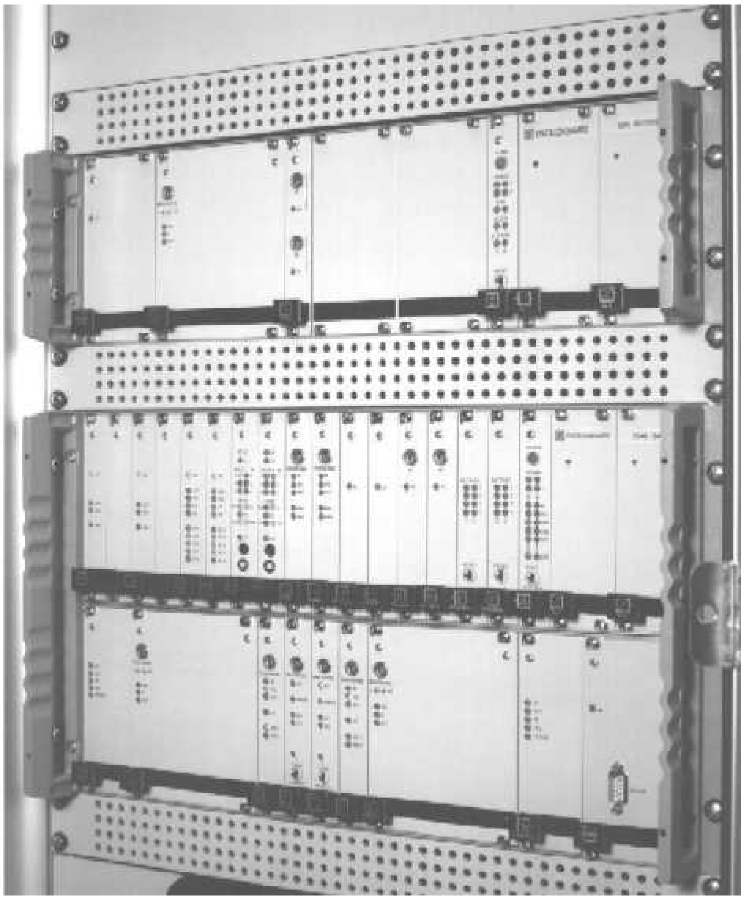
Application Note

Number 01/96 Updated 17.08.11

Multi-site PRC Systems



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Executive Summary

Digital telecommunications networks require a reliable supply of accurate and stable synchronization. The synchronization reference frequency is usually generated by one or several Primary Reference Clocks (PRC) and distributed via a synchronization network. The availability requirements of SDH based networks entail the use of multi-site PRC systems. This application note describes a step-by-step procedure for the design of an Oscilloquartz PRC system for a given network. The procedure consists of the following steps:

1) *Choose a set of PRC sites following section 2.1.*
2) *Choose the Primary Reference Sources (PRS) that shall equip each PRC following sections 2.2 and 2.3.*
3) *Plan the synchronization links to the SASE/SSUs of the network following sections 2.4 and 2.5.*
4) *Decide whether you want to install 'MAJORITY DECISION'; see section 3.*
5) *If appropriate, connect PRCs into master-slave systems according to section 4.*
6) *Decide whether you want to install a* **SyncView™** *management system; see section 5.*
7) *Do the detail planning.*

Detailed reasons for this procedure are discussed in the main text of the application note.

1. Introduction

Digital telecommunications networks are synchronized by a reference frequency that is supplied by one or several Primary Reference Clocks (PRC). In ITU-T Recommendation G.811 [1], the function of a PRC is summarized as follows (section 1: Scope):

"A typical PRC provides the reference signal for the timing or synchronization of other clocks within a network or section of a network. The long-term accuracy of the PRC should be maintained at 1 part in 10^{11} or better with verification to Coordinated Universal Time (UTC).

A PRC may be realized as an autonomous clock, operating independently of other sources. Alternatively, the PRC may be realized as a non-autonomous clock that is disciplined by UTC-derived precision signals received from a radio or satellite system. In either case, the requirements for long-term accuracy and short-term-stability, as specified in this recommendation, apply."

In practice, PRCs are realized with atomic Cesium clocks and/or with GPS receivers (GPS = Global Positioning System) as reference frequency sources. Since the availability of synchronization supply is critical for the functioning of a digital telecommunications network, PRCs are usually implemented with an arrangement of several redundant individual reference frequency sources.

Very often a network is synchronized by several PRCs, which are decentralized on different geographical sites, in order to achieve protection against failures affecting a complete site (e.g. human error, total failure of the site's power supply, destruction of the site by fire, earthquake, lightning, terrorist attack). In this text we will use the term Primary Reference Clock for an arrangement of redundant individual reference frequency sources (i.e. atomic Cesium clocks or GPS receivers), which are located at the same site, and whose outputs deliver reference signals generated by the same reference frequency source of that arrangement at any given time. For sake of simplicity we will call the individual reference frequency source a "Primary Reference Source" (PRS). With this terminology, a typical network is synchronized by one or more decentralized PRCs, each of which consists of one or more PRSs. A set of PRCs synchronizing a network is called a multi-site PRC system.

In this Application Note we will present ways of implementing multi-site PRC systems based on the OSA 6500 PRC product range. Section 2 gives the basic design rules that should be followed in order to obtain a reliable synchronization supply. In most cases, the application of these rules will lead to a system consisting of several PRCs located at different sites.
Sections 3 presents an additional way of enhancing the effectiveness of protection mechanisms in a PRC. This is achieved with a majority decision algorithm for the selection of the appropriate PRS.

Section 4 discusses the question of how to deal with multiple primary reference frequencies in the network. Two ways of reducing the number of individual reference frequencies in the network are presented in sections 4.1 and 4.2. Section 5 gives an introduction to network management related to the management of multi-site PRC systems.

2. Basic Design Rules

Oscilloquartz recommends that some basic rules be followed, when designing a multi-site PRC system for a given network. The following rules were established in order to obtain a high availability of the synchronization supply to the network. It is difficult to give quantitative availability figures, since the probabilities of events that may affect the operation of a PRC system are not always known. The problem is particularly difficult for extreme events like fire, earthquakes, lightning or terrorist attacks. That is why some of the rules stated below are based on qualitative considerations only. Quantitative availability calculations were limited to failure mechanisms that are well known, i.e. failures of technical components and systems. Keeping in mind this limitation, an availability goal can be formulated. An availability figure of a = 0.9995 was used as the basis for the recommendations that follow.

2.1. How many PRCs should the system consist of?

Rule: The minimum number of independent PRCs is given by the condition that, if possible, each SASE/SSU of the network shall get reference signals coming from at least two PRCs over synchronization trails which are routed over geographically separate paths.

Rationale: The availability of a single PRC can be made sufficiently high by installing a sufficient number of redundant PRSs. However, no matter how many PRSs one installs at a site, the maximum obtainable availability will always be limited by the risk of failures affecting the complete site (total failure of the site's power supply, destruction of the site by fire, earthquake, lightning, terrorist attack, etc.). The only solution to this is to install several PRCs located at different sites. In order for the whole network to take advantage of the site protection, each SASE/SSU must get reference signals coming from at least two PRCs.

Example: In the example of figure 1, the connectivity of the synchronization network is such, that it was not possible to follow the rule with just two PRCs. There are not enough synchronization links to provide independent synchronization trails to all SASEs with just two PRCs. To solve the problem, three PRCs are installed. In this way it is possible to provide independent synchronization trails originating from at least two PRCs to each SASE. This is illustrated in the figure by the synchronization trails (dotted lines) for SASEs no. 2 and no. 10.

Notes:

1) In networks with limited connectivity there can be SASE/SSU sites where it is impossible to get reference signals coming from more than one PRC. For such sites there is the possibility to install a co-local GPS receiver which provides an additional primary reference signal to the SASE/SSU.
2) The bloc diagrams shown in this document are logical diagrams, since trails and links are logical concepts. The design step which leads from the logical synchronization plan to the physical plan is mentioned in section 6 as step 7: “ do the detail planning ”.

2.2. Types of PRSs in a PRC

Rule: Both atomic Cesium clocks and GPS receivers may be used as PRSs in a PRC, but at least one of the PRSs should be an atomic Cesium clock and at least one of them a GPS receiver.

Rationale: Basically there are two PRS types that fulfill the frequency accuracy requirements of G.811: the atomic Cesium clock and the GPS receiver combined with a high quality local oscillator (e.g. BVA crystal oscillator). The atomic Cesium clock is an autonomous frequency source using the physical phenomenon that is the basis of the definition of the time and frequency units (the second and the Hertz) by the International System. Therefore the atomic Cesium clock is an autonomous primary frequency standard. The GPS receiver, on the other hand, depends on signals received from a satellite system. The GPS receiver derives a synchronization signal from the received satellite signals.

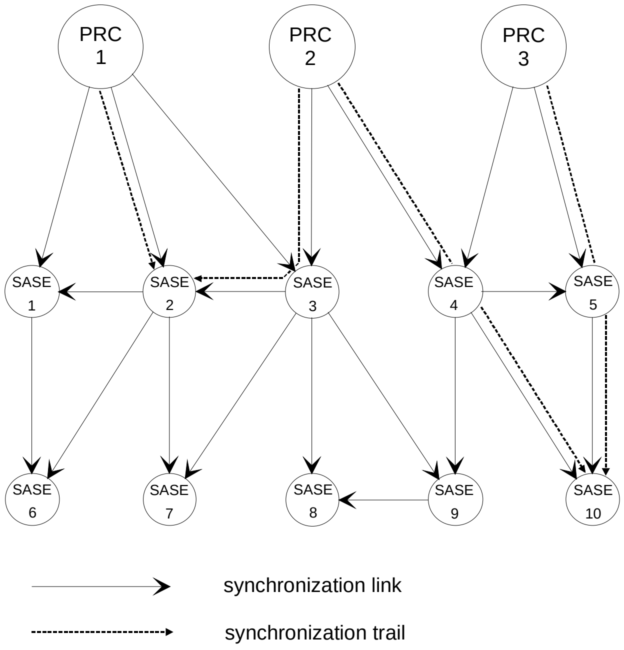


Figure 1: Synchronization network with 3 PRCs

The frequency of this synchronization signal is indirectly linked to the Coordinated Universal Time (UTC) generated by the Bureau International des Poids et Mesures (BIPM) in Paris. There is evidence that GPS satellite signals can get disturbed either by accidental interference or by voluntary jamming using jamming transmitters. Oscilloquartz therefore recommends that at least one of the PRSs in a PRC is an atomic Cesium clock. Because of the importance of synchronization for a telecommunications network, the performance of a PRC should constantly be monitored. Performance specifications recommended in G.811 are defined relative to UTC.

Since GPS satellite signals are linked to UTC, a GPS receiver is an appropriate means for measuring the performance of PRC outputs relative to UTC. It is therefore a good idea to include at least one GPS receiver in a PRC.

Example: Figure 2 shows the architecture of an OSA 6500 PRC with multiple PRSs. The PRC is built around an OSA 5548B SASE. In this example there are two Cesium clocks connected to the SASE. The SASE is equipped with a GPS receiver. Thus the complete PRC features three PRSs.

2.3. Number of PRSs in a PRC

Rule: Each PRC shall contain at least two independent PRSs.

Rationale: The availability of a PRC increases substantially, if one installs two PRSs instead of just one. Reliability calculations done on PRC systems based on the OSA 6500 PRC product range give the following MTBF values:

Number of PRSs	1	2	3
MTBF in years	6.7	670	880
Availability	0.998	0.99998	0.99999

These calculations take into account known failure mechanisms on components and systems. As pointed out earlier, they do not take into account failures affecting the site infrastructure.

(Assumptions:
- MTBFs of subsystems estimated according to MIL HDBK 217F.0
- MTTR assumed to be 3 days
- failures of management functions do not affect the availability of synchronization supply)

2.4. How many links should there be between PRCs and SASEs?

Rule 1: If, for some reason, a SASE/SSU gets its reference signals from a single PRC, then there must be at least two synchronization trails routed over geographically separate paths between the PRC and the SASE/SSU.
Rationale: The availability of a synchronization link is usually around 0.995. The objective is to make synchronization available to the SASE/SSU (i.e. at least one synchronization signal at the inputs of the SASE/SSU is available) with an availability of at least 0.9995. In the case of a single PRC connected to the SASE/SSU under consideration, this can only be achieved by using at least two synchronization links that follow geographically separate routes. With two such independent links, the availability of the synchronization connection between the PRC and the SASE/SSU is better than 0.9999 (this is obtained with the following assumptions: repairable hot redundancy, λ = constant = (60 days)$^{-1}$, μ = constant = (0.3 days)$^{-1}$; see [2], table 6.6). A connection availability of 0.9999 is sufficiently high in order to achieve the availability goal of 0.9995 for the supply of synchronization to the SASEs.

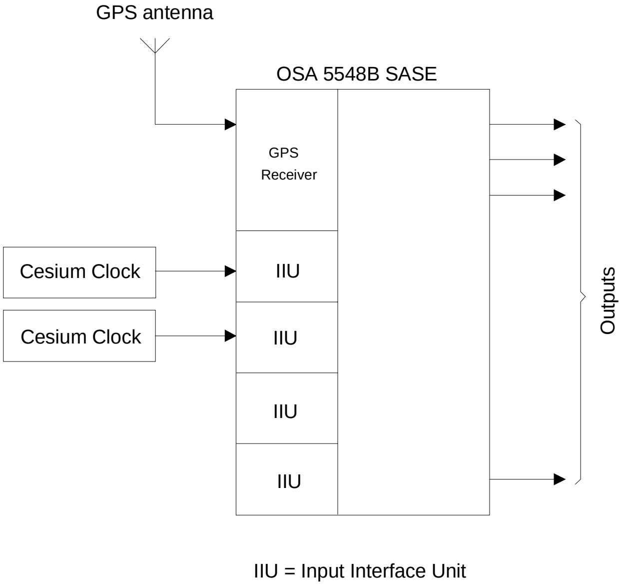


Figure 2: Simplified block diagram of a PRC with multiple PRSs

Rule 2: If the SASE/SSU gets its reference signals from at least two PRCs as described in sections 2.1 to 2.3, then the objective of a 0.9995 availability of synchronization to the SASE/SSU is met by routing each PRC output over just one synchronization link.
Rationale: The availability of a PRC designed according to section 2.3 (at least 0.99998) is much better than that of a synchronization link (typically 0.995, see above). Therefore the availability of a synchronization signal generated by a single PRC and transmitted over a single synchronization link is approximately equal to the availability of the link. Using two PRCs, each of which sends its synchronization signal over one link, results in an availability of synchronization to the SASE/SSU that is approximately equal to the value calculated for two redundant links in the preceding paragraph (better than 0.9999). This is better than the availability goal of 0.9995 that is required for the synchronization supply to the SASEs.

2.5. What types of synchronization links should be used?

Rule 1: In a synchronization trail between a PRC and a SASE/SSU realized by an SDH network, synchronization must be carried by the STM-N signal, and never by a PDH tributary. In this case the synchronization trail is provided by one or more synchronization link connections, each supported by an SDH multiplex section trail.
Rationale: In an SDH network, all STM-N signals are supposed to be synchronous. They are generated by SDH equipment synchronized by the synchronization network. The latter uses the STM-N signals themselves in order to distribute synchronization to all SDH equipment that generate STM-N signals. An SDH element can be clocked by an external reference signal over its Synchronization Interface Port (T3). It can also be clocked by one of the incoming STM-N signals. Furthermore, an SDH element can extract synchronization from one of the incoming STM-N signals and deliver it to its Synchronization Interface Port (T4).
Using these features, synchronization can be carried from the PRC to the SASE/SSU over STM-N signals: at the PRC end, the reference frequency is fed to the SDH equipment over its Synchronization Interface Port (T3) and synchronizes the STM-N signal; at the SASE/SSU end, the STM-N signal rate is extracted and fed to the SASE/SSU over the Synchronization Interface Port (T4) of the SDH equipment.

Now, how do PDH tributaries behave, when they are transported over the SDH network? One of the useful features of SDH is that tributaries are not required to be synchronous with the STM-N signals of that network. The SDH pointer mechanism allows the tributaries to have signal rates that float relative to the STM-N rhythm. The said pointer mechanism affects the transmission rate of outgoing tributaries: the pointer adjustments generate phase jumps. The phase jumps that appear on the outgoing tributaries make the tributary signals unsuitable for transporting synchronization.

Rule 2: In a pure PDH environment (no PDH tributaries transported over SDH), the synchronization trail is provided by one or more synchronization link connections, each supported by a synchronized primary or secondary rate PDH trail.
Rationale: It is a well-known fact that pure PDH trails are transparent for synchronization.

Rule 3: In the case of mixed SDH and PDH environments, where Rule 1 of this section cannot be met, synchronization trails must be implemented as described in ITU-T Recommendation G.803 and European Telecommunication Standard ETS 300 462-2.
Note 1: There are solutions for mixed SDH and PDH environments where, for some reason, PDH link connections are part of the synchronization trail. These cases require very careful planning. The detailed technical solutions, which make use of re-timed G.702 electrical connections as bridges between the PDH and the SDH world, go beyond the scope of this document. They are addressed in the references mentioned above.
Note 2: There are exceptional cases, where PDH tributaries transported over SDH links which do not fulfil rule 3, are nevertheless not affected by pointer adjustments. This is the case, if all SDH network elements of the SDH link are strictly synchronous with the PDH tributary in question. Such PDH links may be suitable for transporting synchronization.

3. Majority Decision

An OSA 6500 PRC typically consists of a number of Oscilloquartz Cesium clocks connected to an OSA 5548B SASE. The OSA 5548 SASE can be fitted with one or two GPS receivers. The SASE performs the function of selecting one of the Cs clocks or GPS receivers as the active PRS. The SASE then filters the short-term phase noise of the selected PRS signal and distributes it to a number of outputs. The user can choose among four different operating modes for the selection of the appropriate PRS. Two of them are manual modes and two are automatic. The first automatic mode is called 'AUTOMATIC', the second one is called 'MAJORITY DECISION'. The 'MAJORITY DECISION' is an optional function. In the 'AUTOMATIC' mode, the PRS is selected according to a user-definable priority table. In 'MAJORITY DECISION' mode, the decision on which PRS to select takes into account the measured frequency differences between the individual PRS signals. The algorithm looks for a majority of PRS signals whose frequencies fit into a configurable frequency interval YTH (expressed as a fractional frequency). The PRSs that are part of the majority (see figure 3) get the highest priorities in the 'Priority Table' of the SASE. Those inputs that do not belong to the majority get the lowest priorities. The SASE selects the appropriate PRS based on this changed 'Priority Table'. The 'MAJORITY DECISION' mode can only be used if there are at least three PRSs.

The 'MAJORITY DECISION' is a very valuable feature. Not only does it add some intelligence to the selection function, but it also allows the detection of a faulty PRS frequency, thus making fault management automatic and more effective. In cases where the PRS contains three or more PRSs, the use of the 'MAJORITY DECISION' option is therefore highly recommended.

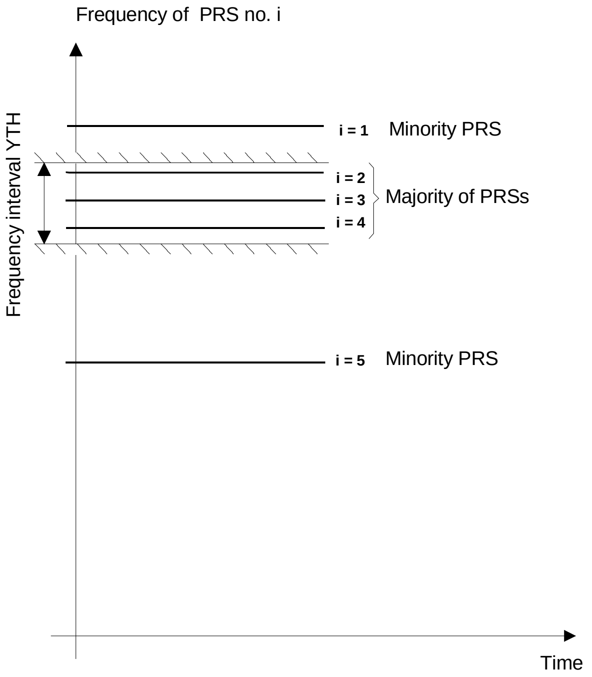


Figure 3: Principle of the 'MAJORITY DECISION' (not to scale)

4. Master-Slave PRC Systems

Section 2 gives rules for the design of a basic PRC system. In most cases, the application of these rules will lead to a system consisting of several PRCs located at different sites. The consequence of this is that there are now several different primary reference frequencies in the network, each of which complies with the frequency accuracy specification of ITU-T Recommendation G.811 [1]. Depending on the architecture of the synchronization network and on the state (OK or KO) of the synchronization links, this may lead to situations, where the network is operating in pseudo-synchronous mode (see Glossary). According to ITU-T Recommendation G.811 this situation is perfectly acceptable. The multiplication of sites allows us to increase the robustness of the network, while keeping the performance within the requirements of G.811. However, G.811 also indicates that there is an upper limit to the multiplication of independent primary reference frequencies in the network. Unfortunately the recommendation only makes a general statement, but does not give a clear answer as to what this limit should be. Oscilloquartz's experience in manufacturing and installing PRC systems shows that this limit is almost never reached in real telecommunication networks. This is due to the fact that commercial Cesium clocks and GPS receivers feature frequency accuracies that are far better than what G.811 is asking for, i.e. of a few parts in 10^{12}. Nevertheless, Oscilloquartz proposes two ways of reducing the number of individual reference frequencies in the network:

1) Static master-slave PRC systems: see section 4.1.
2) Automatic Master-Slave PRC Pairs: see section 4.2.

4.1. Static Master-Slave PRC Systems

In a static master-slave PRC system, one of the PRC sites operates as the master PRC. The other sites are called slave PRCs. They get a reference signal from the master PRC over a synchronization link. In each slave PRC the input connected to the reference signal coming from the master PRC has the highest input selection priority. All PRSs have lower priorities. Under normal operating conditions the slave PRCs simply regenerate the reference signal coming from the master PRC. All their PRSs are in standby. If the reference signal coming from the master PRC fails (failure of the master PRC or failure of the synchronization link), then the slave PRC selects one of its own PRSs as the primary reference and distributes this signal to the network.

Under normal operating conditions the whole network is synchronized by a single reference frequency, the one of the master PRC. Only if synchronization link between the master PRC and a slave PRC fails (see above), will the network be synchronized by two primary reference frequencies. This situation is still acceptable according to ITU-T Recommendation G.811. Although under normal operating conditions the slave PRCs are not actually working as PRCs, they act as a protection against the total failure of one of the other PRC sites. According to section 2.1, protection against total failure of a PRC site is the true reason for installing multiple PRCs.

Figure 4 shows how the synchronization network of figure 1 can be optimized by connecting the three PRCs into a static master-slave PRC system. Figure 5 shows the architecture of a static master-slave PRC system based on two OSA 6500 PRCs.

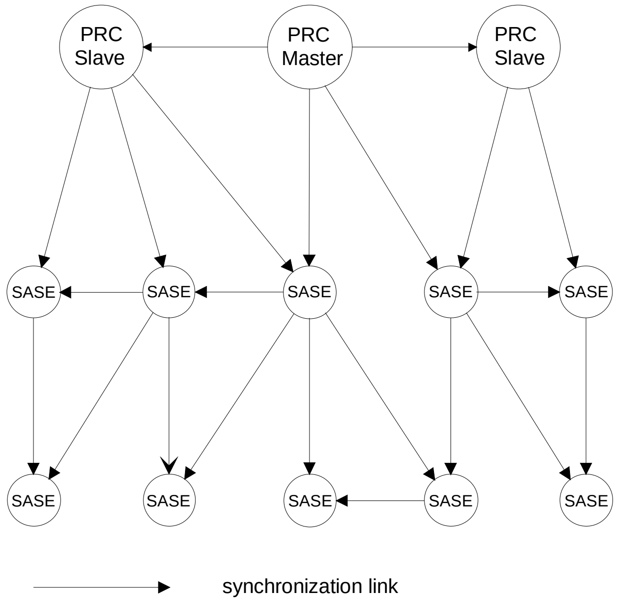


Figure 4: Static Master-Slave PRC System

Important notes:

1) The synchronization links that interconnect the PRCs of the system must fulfill the requirements of section 2.5. Furthermore they must be provisioned in such a way that the synchronization signal terminated at any one of the slave PRCs is squelched when it is not traceable to the master PRC anymore. This behaviour must be very reliable, since its failure would seriously disrupt the synchronization of the network. Often this can only be achieved with a direct link, i.e. a link that does not contain intermediate clocks such as SSUs or SECs.
2) The synchronization links connecting the slave PRCs to the master PRC do not need to be protected by a second redundant link, since in case of link failures, the worst that can happen is that slaves become independent PRCs. As was already stated, this situation is still acceptable according to ITU-T Recommendation G.811.
3) Since the slave PRC is locked to the distant master PRC, the synchronization quality at the outputs of the slave PRC is expected to be that of an SSU (e.g. ETS 300 462-3, network limits at SSU outputs). As a consequence, the rules concerning the maximum length of synchronization chains (e.g. ETS 300 462-3, § 7. Synchronization network reference chain) apply to the synchronization chains originating from the master PRC and including the detour via the slave PRC.

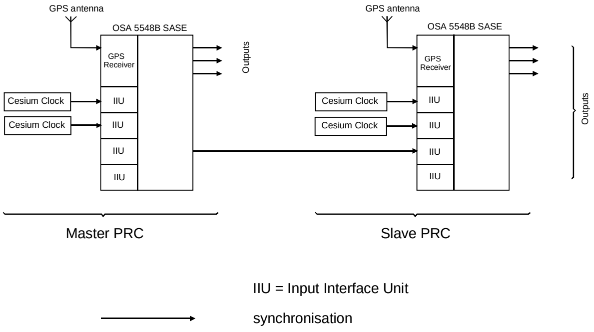


Figure 5: Static master-slave PRC system consisting of two OSA 6500 PRCs

In a multi-site PRC system of the type described in this section, it is always the same PRC site that is the master. This is why it is called a 'static' master-slave PRC system. Making another PRC site become the master is only possible through manual reconfiguration of the input selection priority tables of each PRC in the system. The most practical way of carrying out reconfiguration tasks is through the use of a **SyncView™** management system; see section 5.

4.2. Automatic Master-Slave PRC Pairs

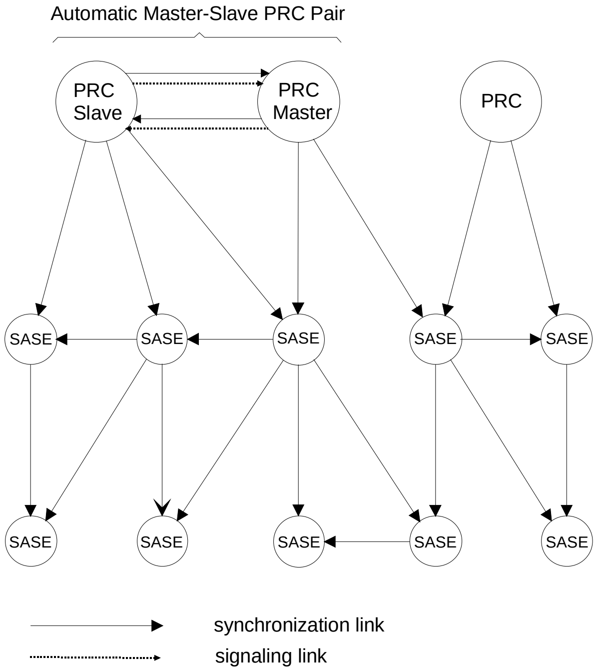
The OSA 6500 PRC product range includes a master-slave option that supports automatic reconfiguration in case of failures: the Automatic Master-Slave PRC Pair. With this option, two PRCs are connected into a master-slave pair. The two PRCs of the system exchange their reference signals over one synchronization link in each direction. At any given time, one of the PRCs is the Master and the other one is the Slave. The Master distributes its reference frequency to the network and to the Slave. The Slave simply regenerates the reference signal coming from the Master and distributes the regenerated signal to the network. All PRSs of the Slave are in standby mode. In the case where all PRSs in the Master fail, the Slave becomes the new Master and vice-versa. The switching is initiated by the old Master, which signals the switching decision to the old Slave via a dedicated 2 Mbit/s signal. The control information is written into the S_{an} bits of Time Slot 0.

An Automatic Master-Slave PRC Pair distributes only one reference frequency to the network, although it consists of two PRCs. By applying this principle to the complete multi-site PRC system, one can reduce the number N of independent primary reference frequencies in the network by a factor of two (more precisely: divide N by two and round up).

Figure 6 shows how the synchronization network of figure 1 can be optimized by connecting two of the PRCs into an Automatic Master-Slave PRC Pair. Figure 7 shows the bloc diagram of such a PRC system based on two OSA 6500 PRCs.

<u>Important notes:</u>

1) The synchronization links that interconnect the two PRCs of the pair must fulfill the requirements of section 2.5. Furthermore they must be provisioned in such a way that the synchronization signal terminated at any one of the PRCs is squelched when it is not traceable to the other PRC anymore. This behaviour must be very reliable, since its failure would seriously disrupt the synchronization of the network. Often this can only be achieved with a direct link, i.e. a link that does not contain intermediate clocks such as SSUs or SECs.
2) Neither the synchronization link nor the signaling link needs to be protected by a second redundant link of the same type, since in case of link failures, the worst that can happen is, that both PRCs of the pair become independent Master PRCs. As was already stated, this situation is still acceptable according to ITU-T Recommendation G.811.
3) The use of separate links for synchronization and signaling is normally required in SDH networks (see section 2.5, rule 1). In the case, where 2 Mbit/s signals transported over a pure PDH network are available, one such link can be used for both synchronization and signaling (see section 2.5, rule 2). There are cases where 2 Mbit/s tributaries transported over SDH networks are suitable for transporting synchronization (see section 2.5, rule 3). In these cases too, one such 2 Mbit/s link can be used for both signaling and synchronization.
4) In the case where separate links are used for synchronization and signaling, the SASEs in figure 7 must be configured in such a way, that they cannot select the signaling inputs as synchronization reference inputs (i.e. inputs to which the SASE can get locked to).
5) Since the Slave PRC is locked to the distant Master PRC, the synchronization quality at the outputs of the Slave PRC is expected to be that of an SSU (e.g. ETS 300 462-3, network limits at SSU outputs). As a consequence, the rules concerning the maximum length of synchronization chains (e.g. ETS 300 462-3, § 7. Synchronization network reference chain) apply to the synchronization chains originating from the Master PRC and including the detour via the Slave PRC.



<u>Figure 6: Introducing an Automatic Master-Slave PRC Pair</u>

6) The 'MAJORITY DECISION' option cannot be used in an OSA 6500 PRC that is part of an Automatic Master-Slave PRC Pair.
7) In certain cases the two methods described in sections 4.1 and 4.2 can be combined. In the case shown in figure 6 for example, the PRC on the right hand side could be slaved to one of the PRCs of the Automatic Master Slave Pair (ideally to the one that is normally the master) using the technique described in section 4.1.

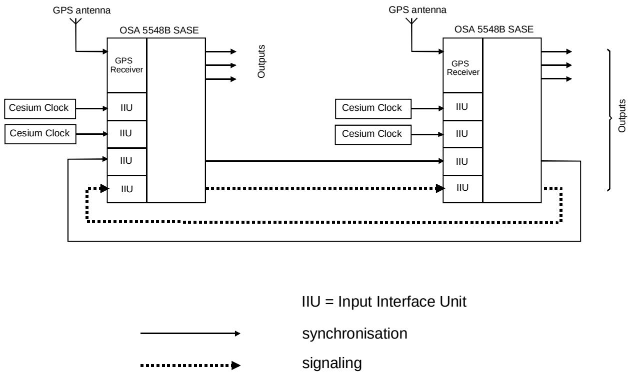


Figure 7: Two OSA 6500 PRCs used as an Automatic Master-Slave PRC Pair

5. **SyncView™** Management System

An OSA 6500 PRC can be managed with the Oscilloquartz **SyncView™** management system. **SyncView™** is a system for the management of Oscilloquartz PRCs and SASEs. **SyncView™** gives the user the possibility to manage all PRCs and SASEs of the synchronization network from a central workstation (the use of several workstations is also possible). **SyncView™** provides a full set of management functions including event management, configuration management, performance management and security management. It features an easy-to-use graphical user interface.

The performance management function is of particular importance for PRCs. It allows the operator to monitor the behaviour of all PRSs using TIE, MTIE and TDEV data. There is also the possibility of configuring alarm thresholds on these measures. **SyncView™** can also be very helpful for reconfiguring the synchronization network during evolution of the network. It is an easy means for configuring an architecture that fulfills the design rules stated in this document.

6. Conclusion

This document is an introduction to the design of modern multi-site PRC systems. It gives the basic design rules for achieving a reliable synchronization supply. The design can be subdivided into the following steps:

1) Choose a set of PRC sites following section 2.1.
2) Choose the PRSs that shall equip each PRC following sections 2.2 and 2.3.
3) Plan the synchronization links to the SASE/SSUs of the network following sections 2.4 and 2.5.
4) Decide whether you want to install 'MAJORITY DECISION'; see section 3.
5) If appropriate, connect PRCs into master-slave systems according to section 4.
6) Decide whether you want to install a **SyncView™** management system; see section 5.
7) Do the detail planning.

Note: Step 7 leads from the logical synchronization plan to the physical plan. This design step is not part of the subject matter of this Application Note. It involves taking into account the properties of the installed equipment base.

The actual design of a PRC system for a given network depends on the topology of the network. It is therefore impossible to give a standard solution that fits all possible applications. Especially in cases of networks with limited connectivity, the PRC system must be tailored to fit the topology. At the same time, the design must take into account the future evolution of the network, in order to make sure that the deployed PRC system can always be adapted to future topology changes by simply reconfiguring the synchronization network.

Should you need more information or assistance in planning your PRC system or synchronization network, please do not hesitate to contact us.

Glossary

(This glossary presents definitions of important terms used in this document. The definitions are cited from ITU-T Recommendation G.810 [3].)

Term	Definition
Primary reference clock	A reference frequency standard that provides a reference frequency signal compliant with G.811
Synchronization supply unit (SSU)	A logical function for frequency reference selection, processing and distribution, having the frequency characteristics given in G.812
Stand alone synchronization equipment (SASE)	The stand alone implementation of the logical SSU function, which incorporates its own management function
Frequency standard	A generator, the output of which is used as a frequency reference
Standard frequency	A frequency with a known relationship to a frequency standard
UTC	The time scale maintained by the Bureau International des Poids et Mesures (BIPM) and the International Earth Rotation Service (IERS), which forms the basis of a coordinated dissemination of standard frequency and time signals
Frequency accuracy	The maximum magnitude of the fractional frequency deviation for a specified time period
Timing signal	A nominally periodic signal generated by a clock used to control the timing of operations in digital equipment and networks...
Reference timing signal	A timing signal of specified performance that can be used as a timing source for a slave clock
Synchronization network	A network to provide reference timing signals. In general, the structure of a synchronization network comprises synchronization network nodes connected by synchronization links.
Synchronization network node	A group of equipment in a physical location which is directly timed by a node clock
Node clock	A clock distributing synchronization to one or more synchronized equipment
Synchronization link	A link between two synchronization nodes over which synchronization is transmitted
Synchronization chain	An active interconnection of synchronization nodes and links
Synchronization trail	The complete connectivity between a synchronization element and a network element or between two synchronization elements
Synchronization element	A clock providing timing services to connected network elements. This would include clocks conforming to G.811, G.812 and G.813.
Pseudo-synchronous mode	A mode where clocks have a long-term frequency accuracy compliant with a primary reference clock as specified in G.811 under normal conditions. Not all clocks in the network will have timing traceable to the same PRC.

References

[1] ITU-T; Draft Recommendation G.811; May 1996; Genève.
[2] ITU-T; Draft Recommendation G.810; August 1995; Genève.
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[4] European Telecommunication Standards Institute; prETS 300 462-3; 1995; Sophia Antipolis.
[5] A. Birolini; Qualität und Zuverlässigkeit technischer Systeme - Theorie, Praxis, Management; Springer-Verlag, Berlin; 1985.