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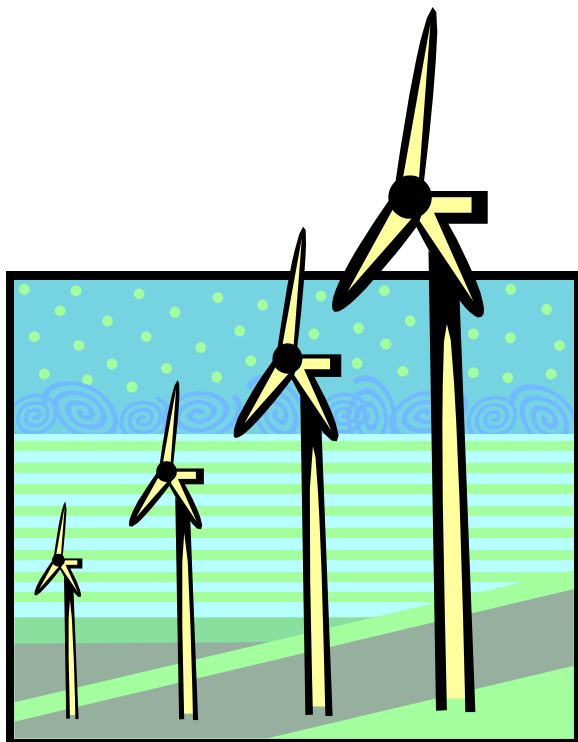
# Application Note

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## Synchronization Equipment for Power Distribution Networks



## ABSTRACT

This paper presents the power distribution network, its telecommunication network and the associated synchronization network as a layered system, in which lower network layers provide critical services for higher layer networks. The synchronization network distributes accurate, stable and reliable synchronization signals to all telecom equipment. This high quality synchronization supply is of paramount importance, since synchronization quality has a direct impact on the reliability and the real-time performance of the telecommunication services. These two properties are particularly important for telecommunication networks servicing power distribution networks, since they must be able to handle mission-critical communication traffic in failure situations such as over-voltage and short-circuit events. It appears that a well designed synchronization network is a pre-condition for the safe and reliable operation of any power distribution network.

## 1. INTRODUCTION

Telecommunication networks are an essential infrastructure for the operation of any power distribution network. The telecommunication services used by power companies can be divided into two classes. First there are the services corresponding to the general communication needs such as telephone services and general data communication services for the operation of the enterprise computer network. Secondly there are special communication needs related to the operation of the physical power distribution network. Operating the power network involves capabilities such as remotely controlling the power distribution hardware, remotely monitoring the state of the power network, and, last but not least, automatic protection switching in case of failures such as short-circuits and over-voltage phenomena. These failures can have heavy consequences, if the protective actions are not executed very rapidly: power supply service interruptions, material damages to power network hardware, and even safety threats to personnel.

There are well established technical means used to mitigate consequences of short-circuit and over-voltage events (see [2]). Some of them require very fast action, e.g. in case of short-circuit currents that must be interrupted with a fraction of a second. This requires monitoring the state of the network in real-time, communicating monitoring data and event messages without delay to the centralized protection system, and transmitting protection switching commands

instantly to the right switches. In a typical short-circuit scenario, a large number of power lines experience abnormal current surges. Based on many received event messages, the centralized protection system must decide upon protection switching actions which minimize the size of the sub-network that will be disconnected. The communication system, on the other hand, must communicate monitoring data, event messages and commands reliably and within tight delay constraints. Therefore power companies impose particularly stringent requirements on the aspects of reliability and real-time performance of their telecommunication networks and services.

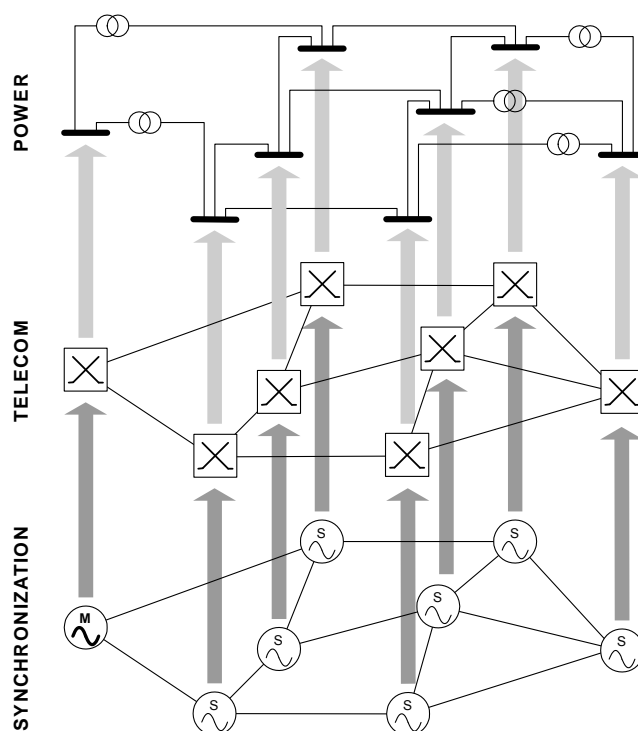
## 2. CLIENT AND SERVER NETWORKS

Figure 1 shows three separate but closely related networks, the power distribution network, the telecommunication network and the synchronization network. There are client-server relationships between adjacent network layers. As was already mentioned in the introduction section, the telecommunication network provides important and critical communication services to the power distribution network. The same type of relationship exists between the synchronization network and the telecommunication network. Digital telecom equipments contain internal clocks called equipment clocks, which drive the digital processing functions. The synchronization network delivers synchronization signals to all telecom equipment in order to have all equipment clocks run at the same or nearly the same frequency (see [1]). This section will show, how the quality of the synchronization service affects the reliability and the real-time performance of the telecommunication services.

The reliability of a telecommunication service is determined mainly by two factors, first by the availability of the telecom equipment, and secondly by the achieved bit error rate. Adequate equipment availability can be obtained with redundant network architectures and redundant equipment hardware configurations. Bit error rate, however, is mainly influenced by the accuracy and stability of the equipment clocks. The fundamental way to have all equipment clocks run at the same accurate and stable frequency consists in locking them to an accurate and stable master clock called Primary Reference Clock or PRC. The job of the synchronization network is to distribute synchronization generated by the PRC reliably and without degradation to all equipment clocks. When equipment clocks are synchronized, then data travels from node to node without data loss. In the opposite case, i.e. when there are frequency differences between equipment clocks,

some of the transmitted data gets lost. It follows that reliable communication is only possible if the

telecommunication network gets accurate, stable and reliable synchronization.



**Figure 1: The synchronization network as a service network**

The real-time capability of a telecommunication network is also dependent on the quality of the network synchronization. So-called time-division-multiplexing (TDM) transmission networks guarantee minimum transmission delay if they are well synchronized. TDM means that data pertaining to a given communication session is transmitted in periodic time-slots, i.e. is transmitted in chunks, one chunk every 125  $\mu$ s. This method provides for minimal, stable and predictable transmission delays. Since the periodic time-slots used by a given communication session are reserved exclusively for this session, there are no waiting lines and therefore no stochastic waiting time variations. Here again, in order for a TDM transmission network to fully deploy its real-time capability, it must be well synchronized. SDH (Synchronous Digital Hierarchy) and SONET (Synchronous Optical Network) networks are examples of synchronous TDM transmission networks.

It appears that the synchronization network delivers a crucial service to the telecommunication network. The reliability and the real-time performance of the telecommunication services depend directly on the accuracy, stability and

reliability of the synchronization signals delivered by the synchronization network.

### 3. THE IMPLEMENTATION OF SYNCHRONIZATION NETWORKS

Figure 2 shows one way of implementing a good synchronization network. It is based on SDH or SONET transmission technology (see [3] and [4]). SDH and SONET transmission networks are TDM networks, hence they require synchronization. At the same time the SDH links can be used to transport synchronization. In Figure 2 a PRC (Primary Reference Clock) generates an accurate and stable reference synchronization signal. Primary Reference Clocks are usually realized with atomic Caesium clocks or with GPS-receivers (Global Positioning System), or with a combination of both. The output signal of the PRC drives a so-called SSU (Synchronization Supply Unit) or BITS clock (Building Integrated Timing Supply). The SSU/BITS acts as a node clock and supplies all telecom equipment of the node or building with adequate synchronization signals. In Figure 2 the SSU/BITS on the right supplies a Digital Switch and an SDH multiplexer. For the

transmission of synchronization over long distances, SDH transmission signals are used as carriers. The physical data rate of the SDH data signal, being driven by the SDH multiplexer's synchronized equipment clock, conveys synchronization which is derived from the PRC. At the receiving end, an SSU/BITS eliminates

synchronization degradations such as jitter and wander and distributes clean synchronization signals to telecom equipment in the node or building. The SSU/BITS is also there to provide a backup synchronization source in case the traceability to the PRC is lost.

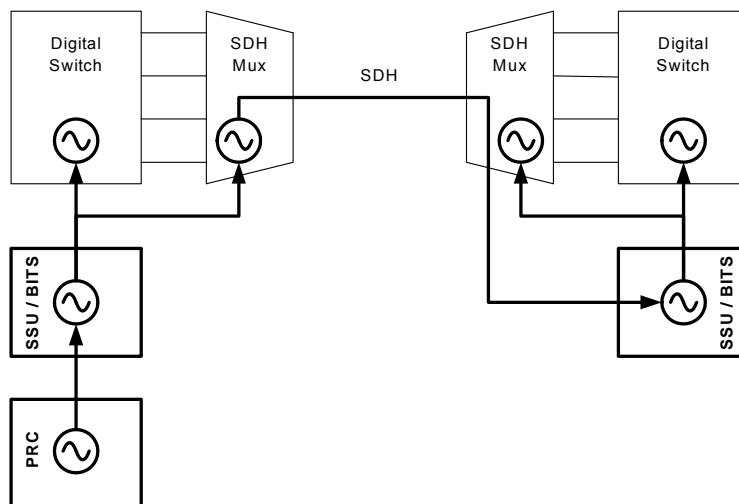


Figure 2: **Synchronization distribution based on the SDH transmission network**

Oscilloquartz SA, an equipment manufacturer based in Switzerland, offers all building blocks needed to implement cost-effective and high quality synchronization networks. Figure 3 shows some of the equipment types mentioned earlier. The atomic Caesium clock on the right and the GPS-receiver at the bottom are used as Primary Reference Clocks. The equipment depicted on the left is a Synchronization Supply Unit or BITS clock. Oscilloquartz synchronization equipment can be managed locally or remotely via software-based management systems (upper left). Because of its high performance and its high quality, Oscilloquartz equipment is particularly well suited for telecommunication networks servicing critical applications such as the operation of power distribution networks.

#### 4. CONCLUSIONS

The power distribution network, its telecommunications network and the associated synchronization network can be seen as a layered system, in which lower network layers provide critical services for higher network layers.

The synchronization network distributes accurate, stable and reliable synchronization signals to all telecom equipment. This high quality synchronization supply is of paramount importance for the telecommunication network, since synchronization quality has a direct impact on the reliability and the real-time performance of the telecommunication services. Synchronizing TDM transmission networks such as SDH and SONET networks eliminates data losses due to data rate differences. Furthermore TDM networks show minimal, stable and predictable transmission delays when they are well synchronized.



Figure 3: **Synchronization solutions from Oscilloquartz SA**

Reliability and real-time capability are particularly important for telecommunication networks servicing power distribution networks, since they must be able to handle mission-critical communication traffic in failure situations such as over-voltage and short-circuit events.

It appears that a well designed synchronization network is a pre-condition for the safe and reliable operation of any power distribution network.

## 5. REFERENCES

- [1] St. Bregni; "Synchronization of Digital Telecommunications Networks"; John Wiley & Sons, Chichester, England; 2002.
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