Study Committee D2

Information Systems and Telecommunication

Paper 10686_2022

INCREASING THE AVAILABILITY OF MODERN DIGITAL GRID APPLICATIONS BY OFFERING ACCURATE TIME OF DAY INFORMATION AS A SERVICE OF THE OPERATIONAL TELECOMMUNICATION NETWORK

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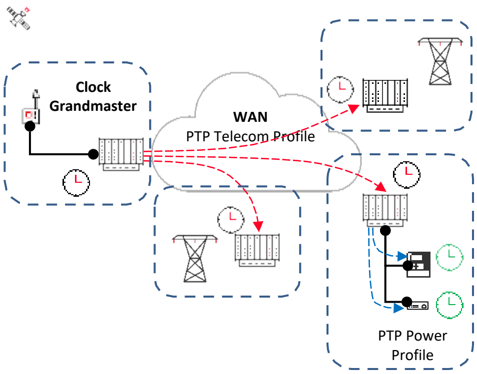
Motivation

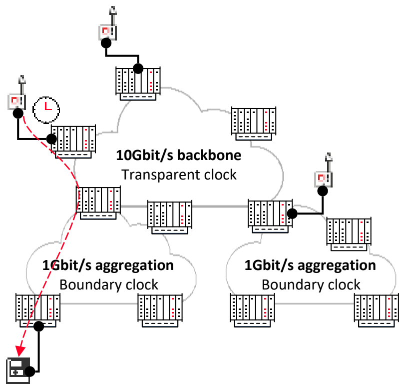
- Massive integration of renewables as well as increased demand e.g., by electric vehicles demand for new modern concepts of grid operation
- Many new concepts such as IEC 61850 digital substations or wide area monitoring and protection depend on availability of highly accurate time of day information
- Locally installed GNSS are typically used today but have clear limitations in terms of availability, increased operational costs and attack surface

Network clock – time of day as a service



Grid Control Network (GCN) at CKW

- Network clock concept was deployed in the CKW operational communication network (GCN)
- The GCN network is synchronized with 3 distributed Grandmaster clocks
- Communication network consists out of FOX615 devices from equipped with CESM3 central cards
- The network is structured in a 10 Gbit/s MPLS-TP backbone network with transparent clock synchronization scheme and a 1 Gbit/s aggregation network with boundary clock synchronization scheme
- TEGO1 interface card is used to act as IEC 61850 gateway and to translate between the different PTP profiles



GCN structure and test setup

Requirements on time distribution

- IEC 61850 demands a 1µs (T5) accuracy for synchrophasor application
- Availability of critical applications needs to be 99.999% at least
- Scaling of solutions is required to hundreds of substations and thousands of end devices
- Different PTP profiles exist with specific strengths adapted to its use case. For time of day as a service in an entire power grid environment translation between different profiles is needed

Conclusion

- Scalable networks are only possible with a combination of Transparent and Boundary clock functionality and PTP profile translation
- For highest availability redundant clock distribution paths as well as extended holdover times with high accurate local oscillators is needed
- All measurement result with all the different failure scenarios applied are well within the accuracy requirement of 1µs
- Network clock concepts provide an attractive alternative or backup to distributed GNSS and with encryption applied increases the security level of the network

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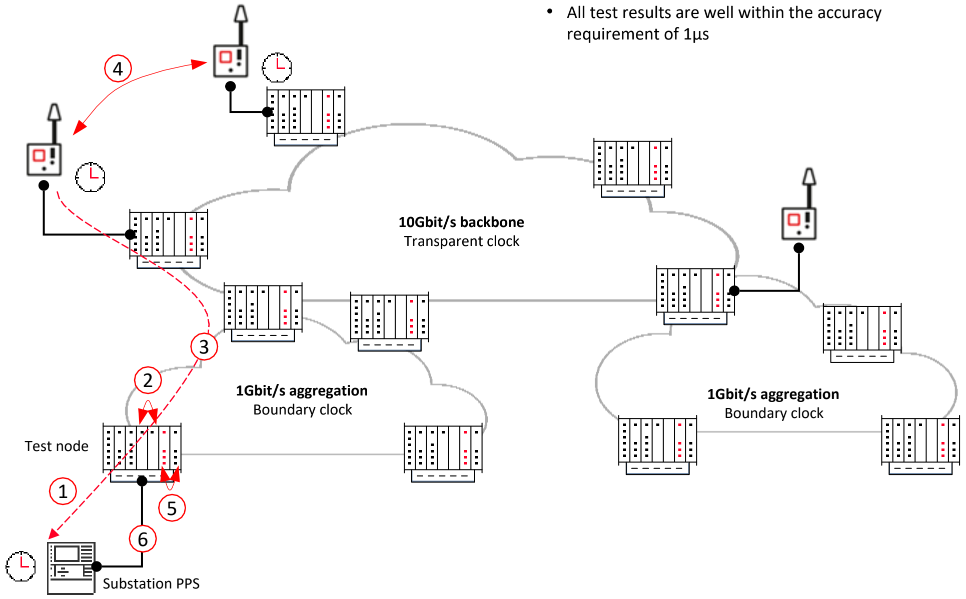
continued

Test cases

1. PTP accuracy under normal conditions (reference measurement)
2. PTP accuracy during local central card switchover in the multiplexer
3. PTP accuracy during fiber break
4. PTP accuracy during network clock switchover
5. PTP accuracy during active PTP Power Profile source switchover
6. PTP accuracy during link failure in PRP network

Discussion

- For PTP testing it is essential to have the system in a stable state where all clock slaves are synchronized properly
- The static offset in the range of 200ns – 500ns originated out of non compensated antenna cable length and signal amplifiers as well as other inaccuracies leading to a static offset
- For test case 2 slightly different Jitter values have been measured while switching from active to redundant central card and back
- Jitter is the critical performance criteria since it can't be compensated
- All test results are well within the accuracy requirement of 1µs



Test case	Test node PPS		Substation PPS	
	Static offset [ns]	Jitter [ns]	Static offset [ns]	Jitter [ns]
1	360	40	280	170
2	380	40	280	170
	380	40	280	200
3	380	40	280	200
4	500	100	500	550
5	450	40	420	200
6	400	40	300	140

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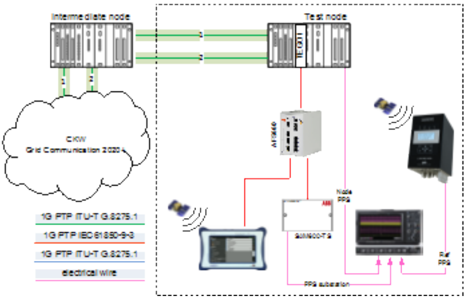
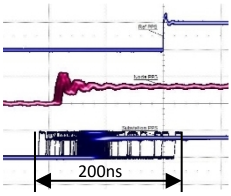
continued

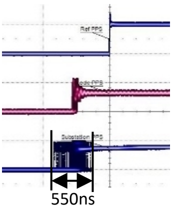
Measurement test setup for test case 1 -4



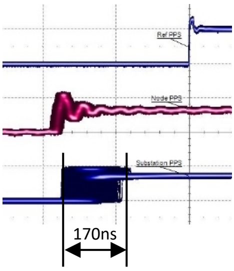
Test results test case 3



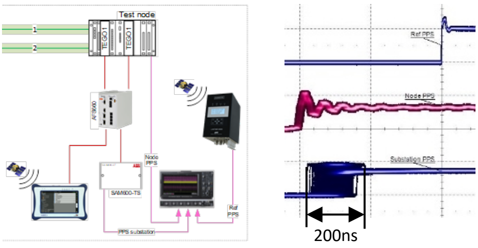
Test results test case 4



Test results test case 1

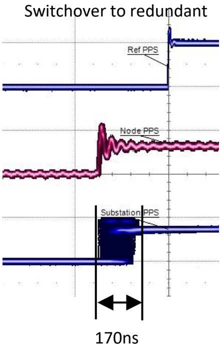


Measurement test setup and results for test case 5

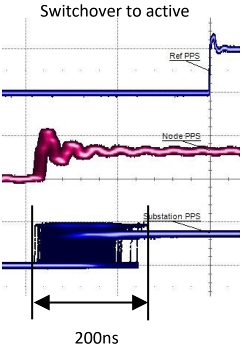


Test results test case 2

Switchover to redundant



Switchover to active



Measurement test setup and results for test case 6