PRC-traceable reference to backup PRTC distributed functions (in a brownfield environment)

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Agenda

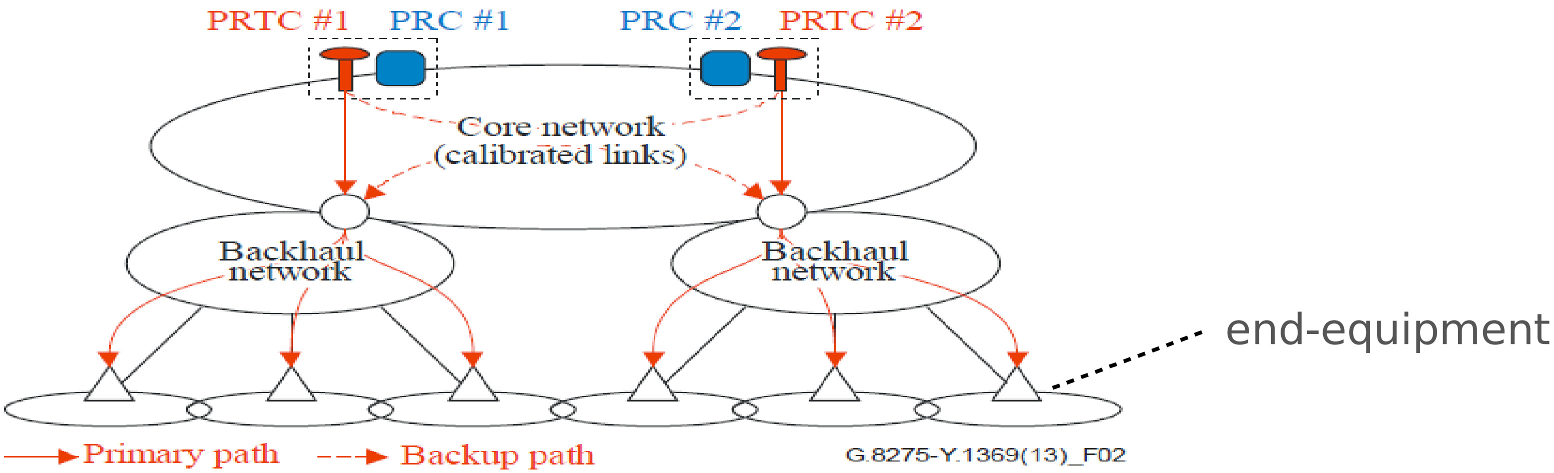
- Primary Reference Time Clock Architecture options
- Primary Reference Clock frequency to backup PRTC's
- PRC frequency distribution in a (brownfield) network
- Add SyncE functionality to already deployed equipment
- SyncE Frequency measurements
- Conclusion

Primary Reference Time Clock (PRTC)

- The PRTC function is locked to GNSS.
- The PRTC function delivers Time/Phase information a.k.a. Time of Day.
  - ToD is needed for end-equipment at network edge (e.g. Base-station).
  - ToD can be distributed towards end-equipment via the network.
  - Network must be compliant with G.8275.1 “full timing support” which is IEEE1588 (PTP) on top of SyncE.

Centralized PRTC Architecture

- PRTC #1 and PRTC #2 are each other's backup via PTP (IEEE1588)
- ***Whole*** network requires G.8275.1 “full timing support” (SyncE + PTP)

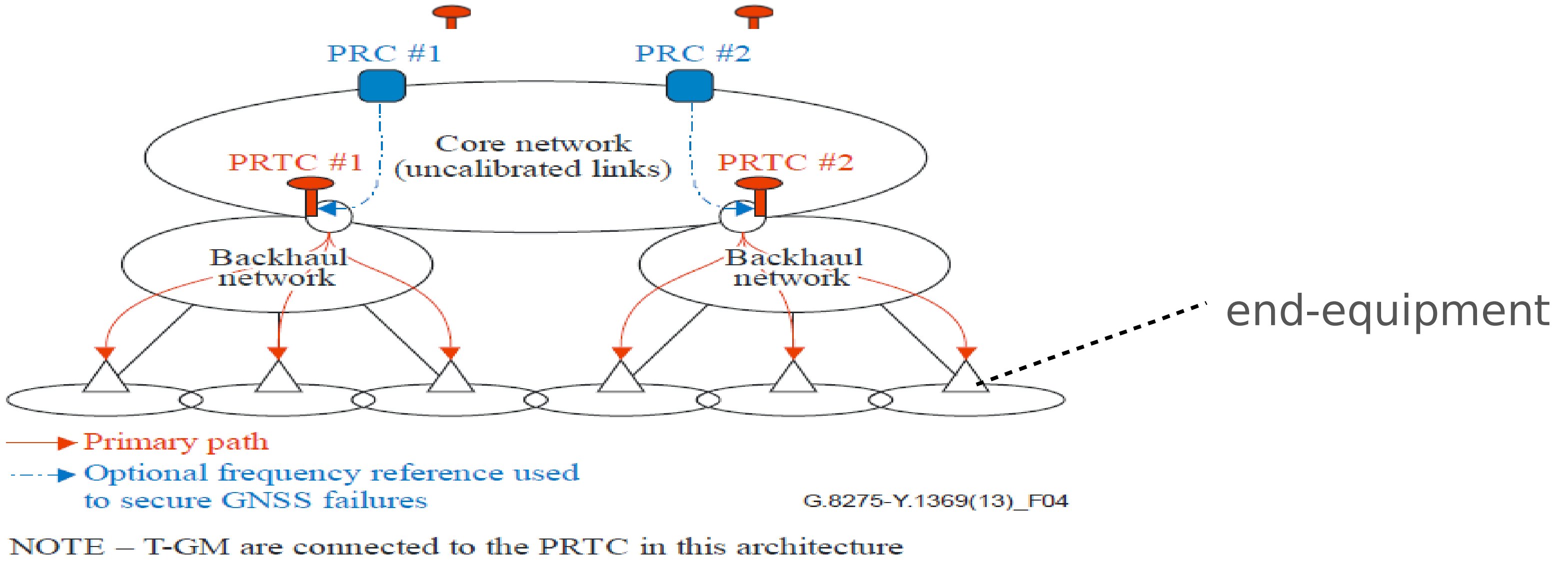


NOTE – T-GM are connected to the PRTC in this architecture

G.8275/ Figure 2 – Architecture with centralized PRTC functions co-located with PRC

Distributed PRTC Architecture

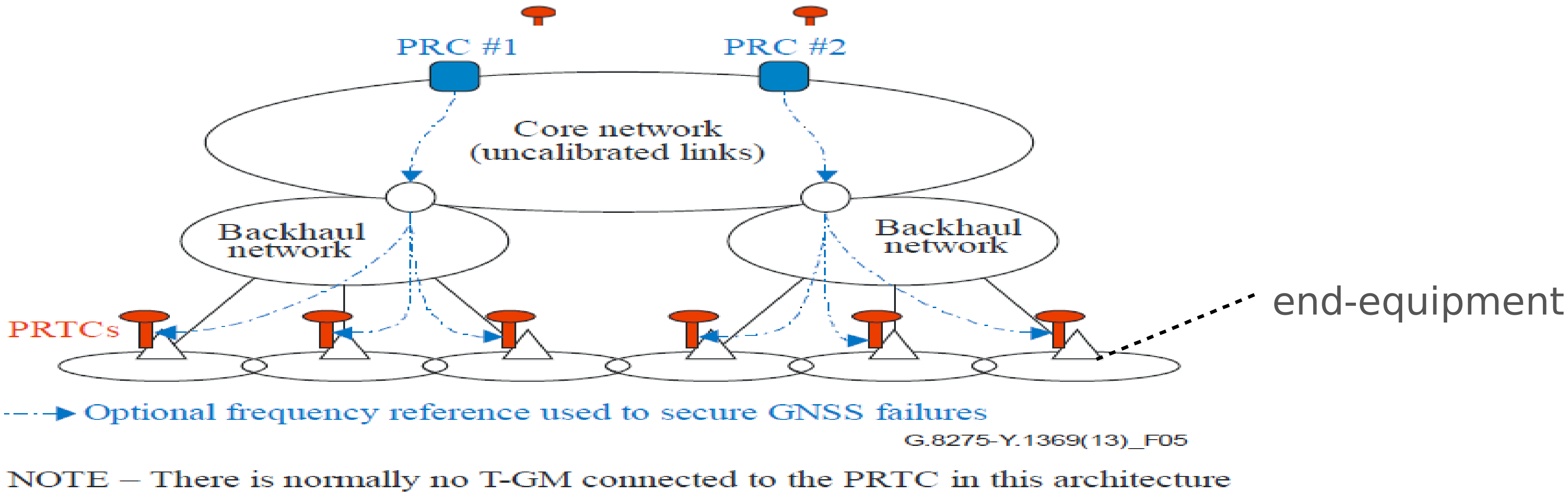
- PRTC per Backhaul network, physical layer freq. backup PRC #1 or #2
- ***Only*** Backhaul network requires G.8275.1 “full timing support”
- PRC's must be frequency synchronized to GNSS



G.8275/**Figure 4 – Architecture with PRTC functions distributed in aggregation sites**

End-point distributed PRTC Architecture

- PRTC inside end-equipment, physical layer freq. backup PRC #1 or #2
- PRC's must be frequency synchronized to GNSS
- ***No*** need for G.8275.1 “full timing support” (no PTP, SyncE needed)



G.8275/ **Figure 5 – Architecture with PRTC functions distributed at cell sites**

Which PRTC Architecture should be used?

- The architecture choice is the result of the current available network.

- Centralized PRTC Architecture:
  - For greenfield applications OR Networks that fully supports G.8275.1
  - Protection done via the network (PTP + SyncE)

- Distributed PRTC Architecture:
  - For (new) Backhaul networks that fully supports G.8275.1 (PTP + SyncE)
  - Requires physical layer freq. backup over core network during GNSS failure

- End-point Distributed PRTC Architecture:
  - (New) End-equipment (base-station) have an associated PRTC.
    PTP is not used because the whole network does NOT supports G.8275.1.
  - Requires physical layer frequency backup for PRTC's during GNSS failures

- Due to network diversity a combination of all 3 options are used.

PRTC Architecture Observations

1) From PRTC to end-equipment Network must be G.8275.1 compliant

2) PRTC's can only backup each other via G.8275.1 compliant network

3) Physical layer frequency backup, if traceable to GNSS, is very good backup strategy for PRTC but requires SyncE compliant networks.

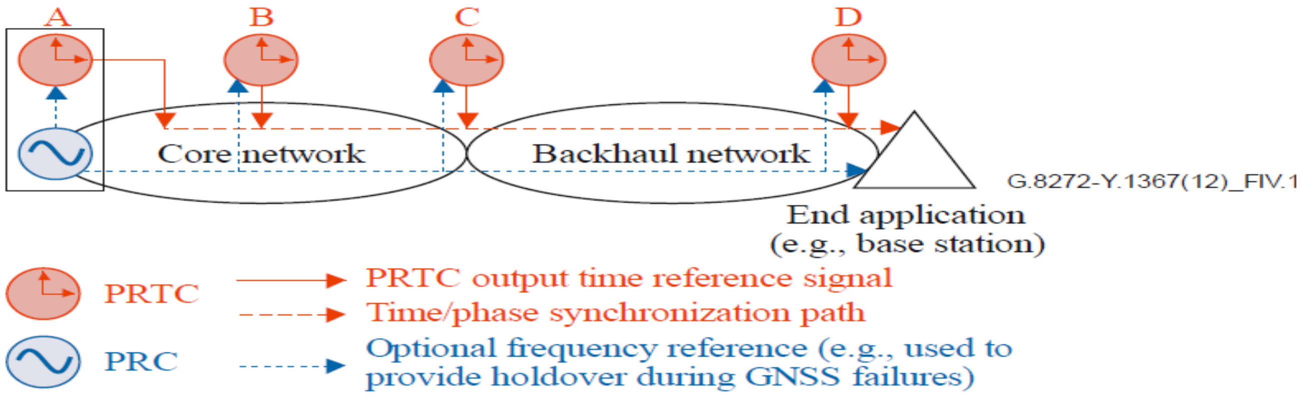


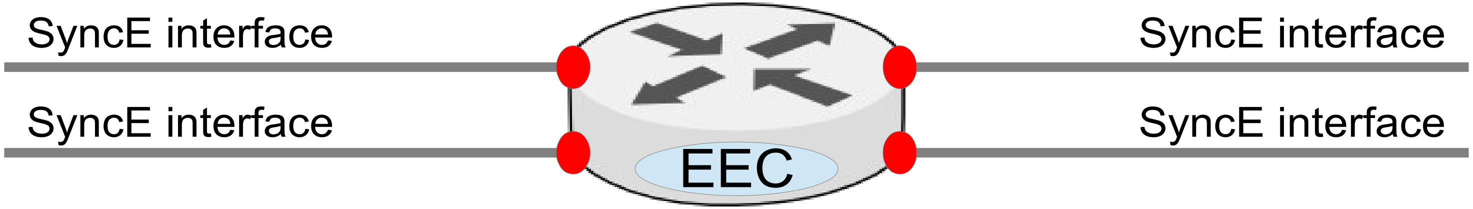
Figure IV.1 – Generic locations for a PRTC function

Physical Layer frequency backup (SyncE)

- Principle of SyncE is a mature method already used in SONET/SDH
- Physical layer frequency distribution (SyncE) is not troubled by a-symmetry, PDV, cable length differences, DCF filter difference, etc.
- Physical layer frequency (SyncE) must be GNSS traceble to backup a PRTC by just incrementing the ToD counter during a GNSS failure.
- Also in a G.8275.1 compliant network the Physical layer frequency distribution is required (IEEE1588 on top of SyncE) and as such also available as backup during a PTP packet stream failure.
- What about brownfield networks, NE's without SyncE and without G.8275.1 ???

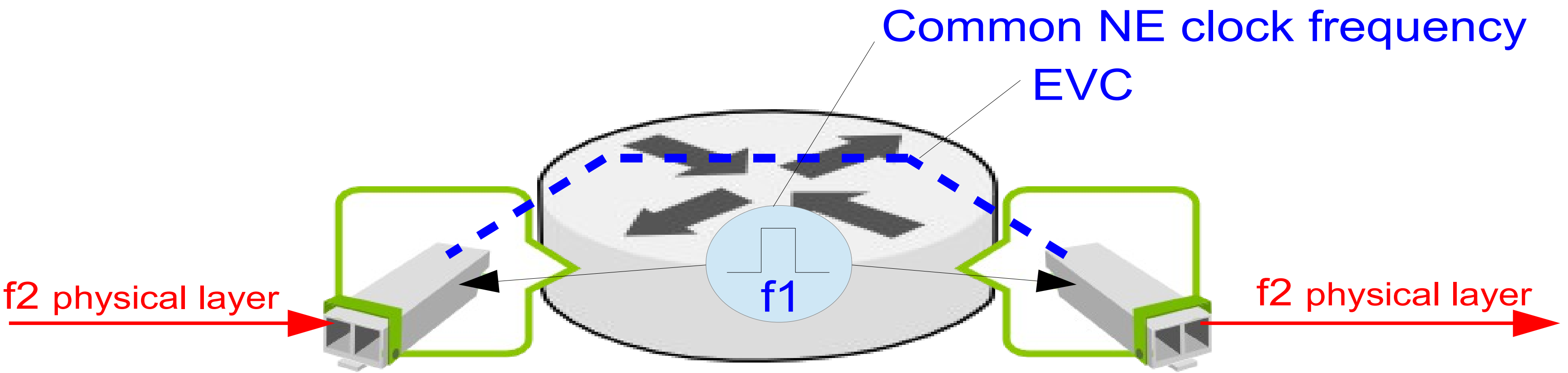
SyncE Basic functionality

- Covers the Ethernet Equipment Clock (EEC) funcion (PLL filtering)
- SyncE input interface:
  - Receives at least once every 5 seconds an ESMC packet
  - Can extract the frequency from the incoming physical layer signal
  - Process incoming ESMC message and interpret the SSM value
  - Selects one input as the timing reference (based on G.781)
- SyncE output interface:
  - Physical output frequency of all outputs is locked to the selected input
  - Transmits every second an ESMC message with the correct SSM value



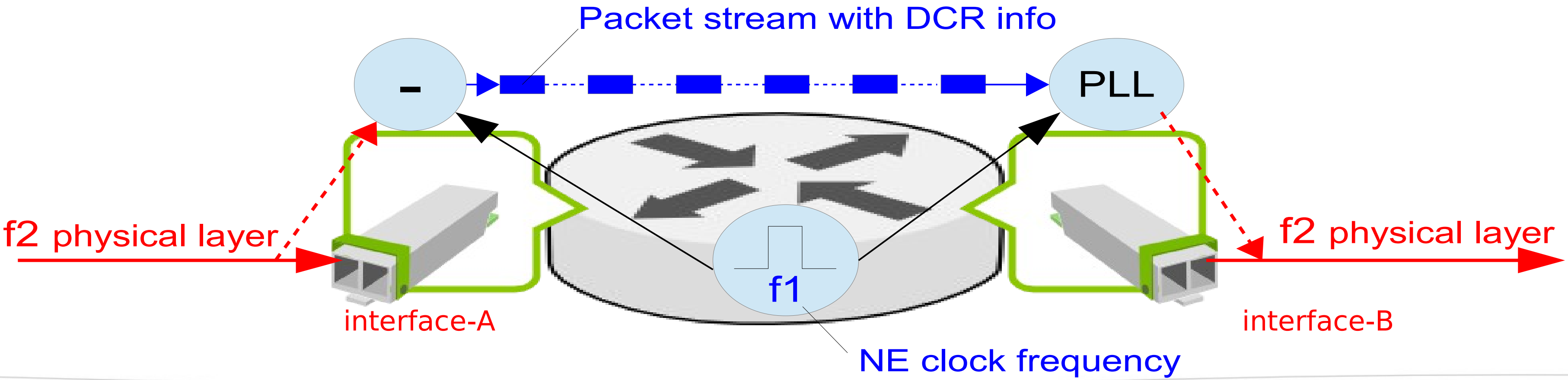
Add SyncE to a NE via Smart SFPs

- Network Element must provide:
  1. Common frequency towards all Ethernet output ports
  2. Ethernet Virtual Connection (EVC) through NE to allow SFP communication



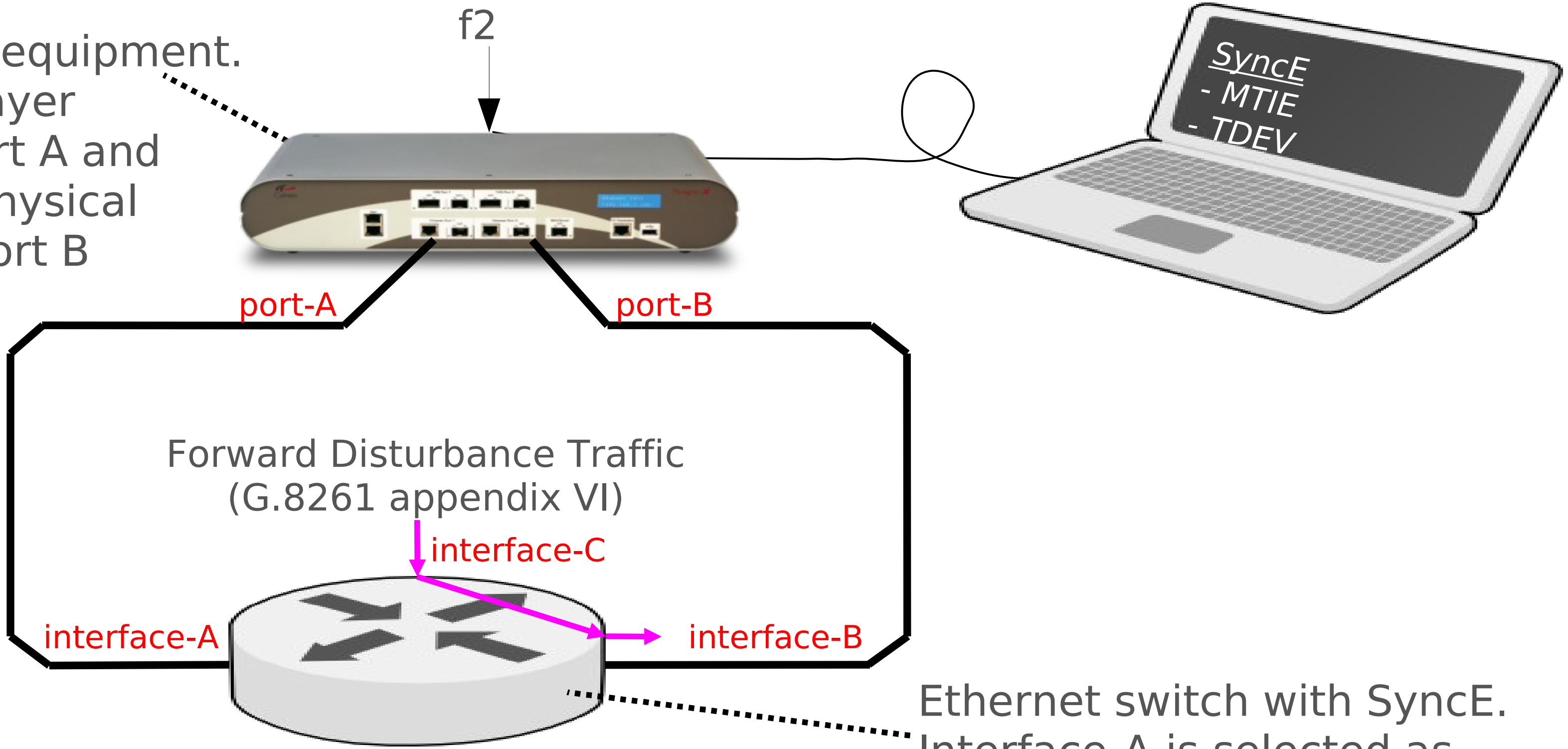
Principle to add SyncE to a NE

- Based on well known mature principle which is standardized as:
  - Differential Clock Recovery method in Circuit Emulation (RFC 4554 / 5086)
- The principle, which is PDV tolerant, works as follows:
  - On interface-A the frequency/phase difference between “f1” and “f2” is measured and added into a dedicated packet towards interface-B
  - At interface-B the packet information is used and together with “f1” the original frequency and phase of “f2” is recovered.



Physical Layer frequency Test Setup (1)

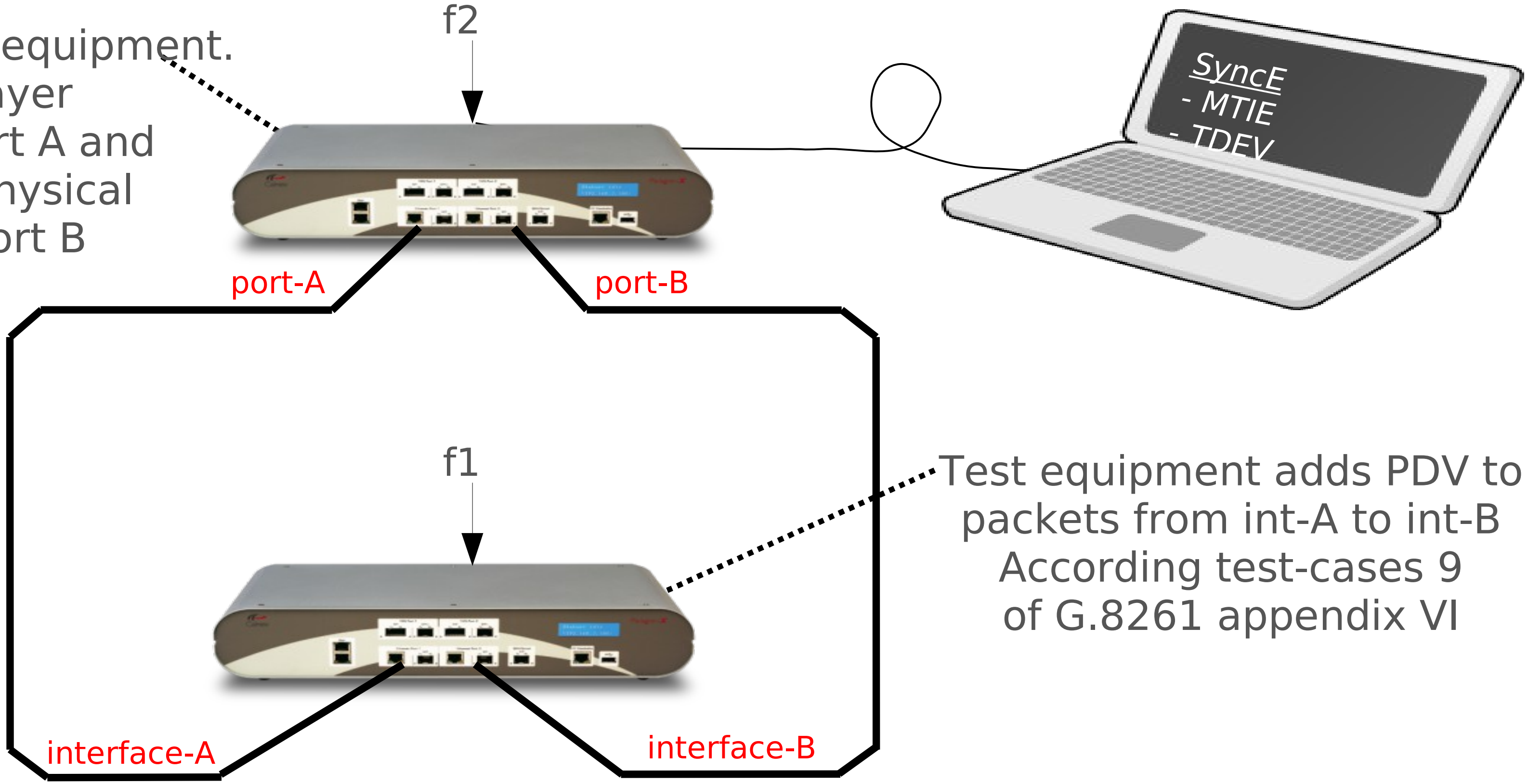
SyncE measurement equipment. Generates physical layer frequency “f2” on Port A and measures phase of physical layer frequency on port B



Ethernet switch with SyncE. Interface-A is selected as frequency reference and the frequency output of interface-B is locked to interface-A

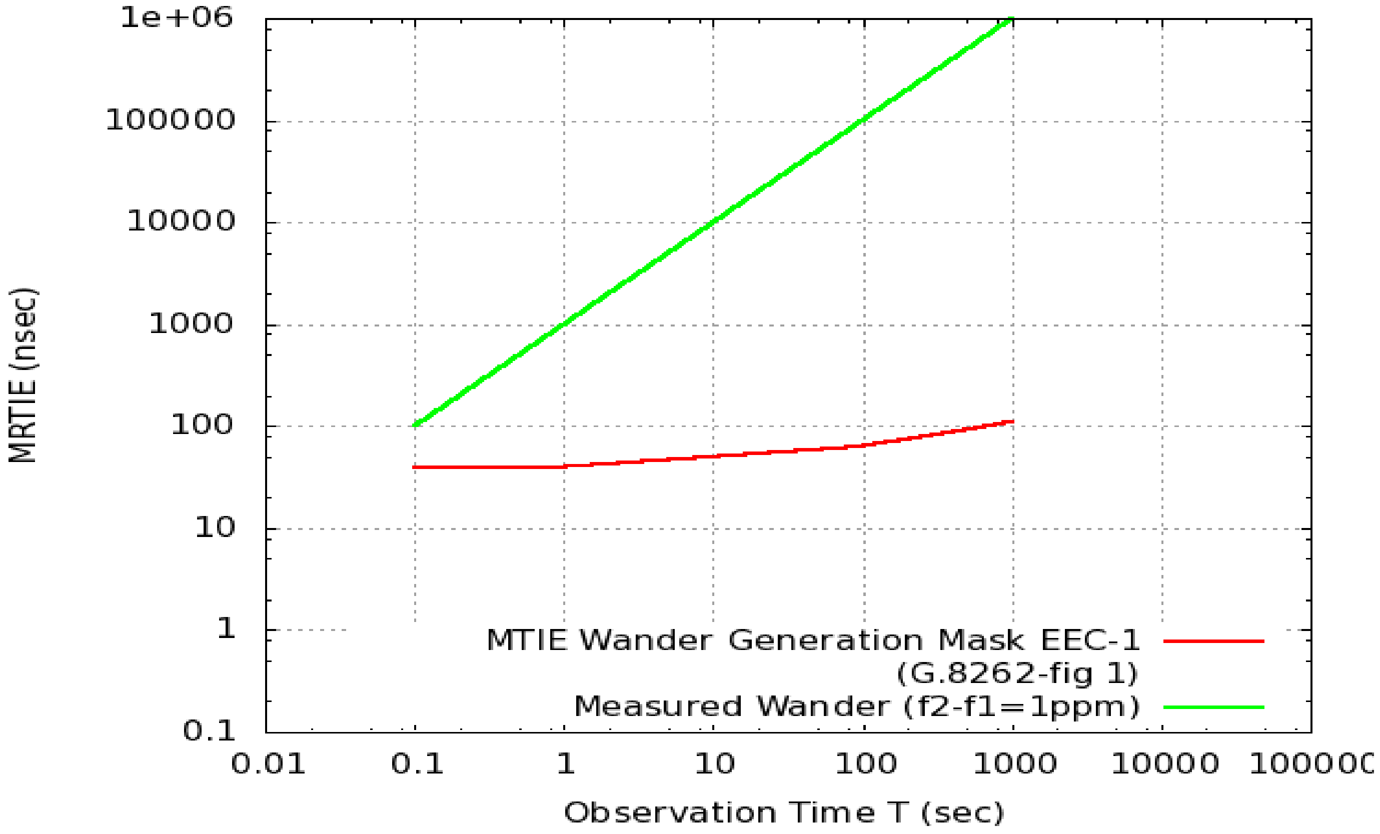
Physical Layer frequency Test Setup (2)

SyncE measurement equipment. Generates physical layer frequency “f2” on Port A and measures phase of physical layer frequency on port B



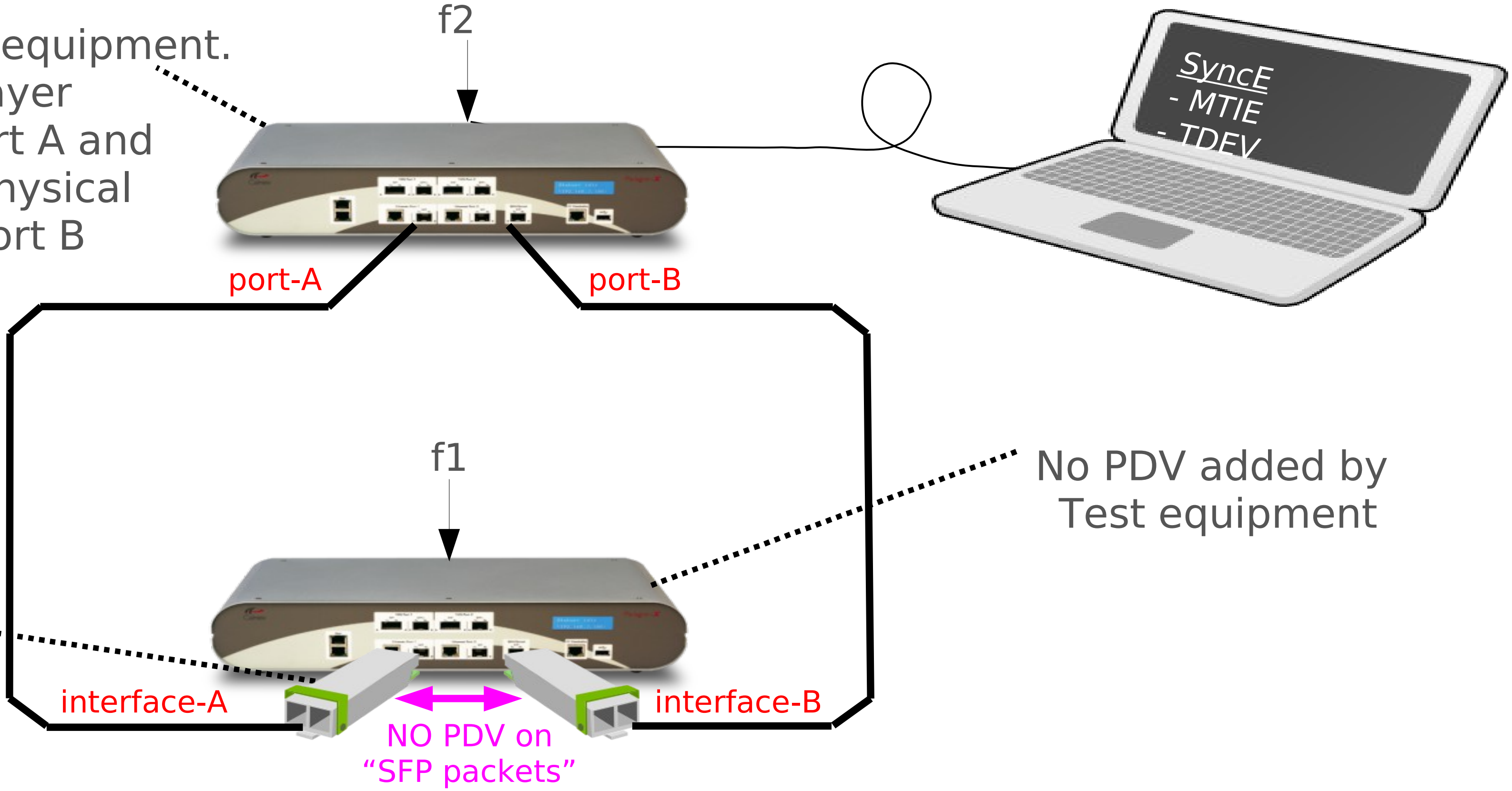
Test equipment adds PDV to packets from int-A to int-B According test-cases 9 of G.8261 appendix VI

MTIE SyncE measurement – No SyncE



Physical Layer frequency Test Setup (3)

SyncE measurement equipment.
Generates physical layer frequency “f2” on Port A and measures phase of physical layer frequency on port B

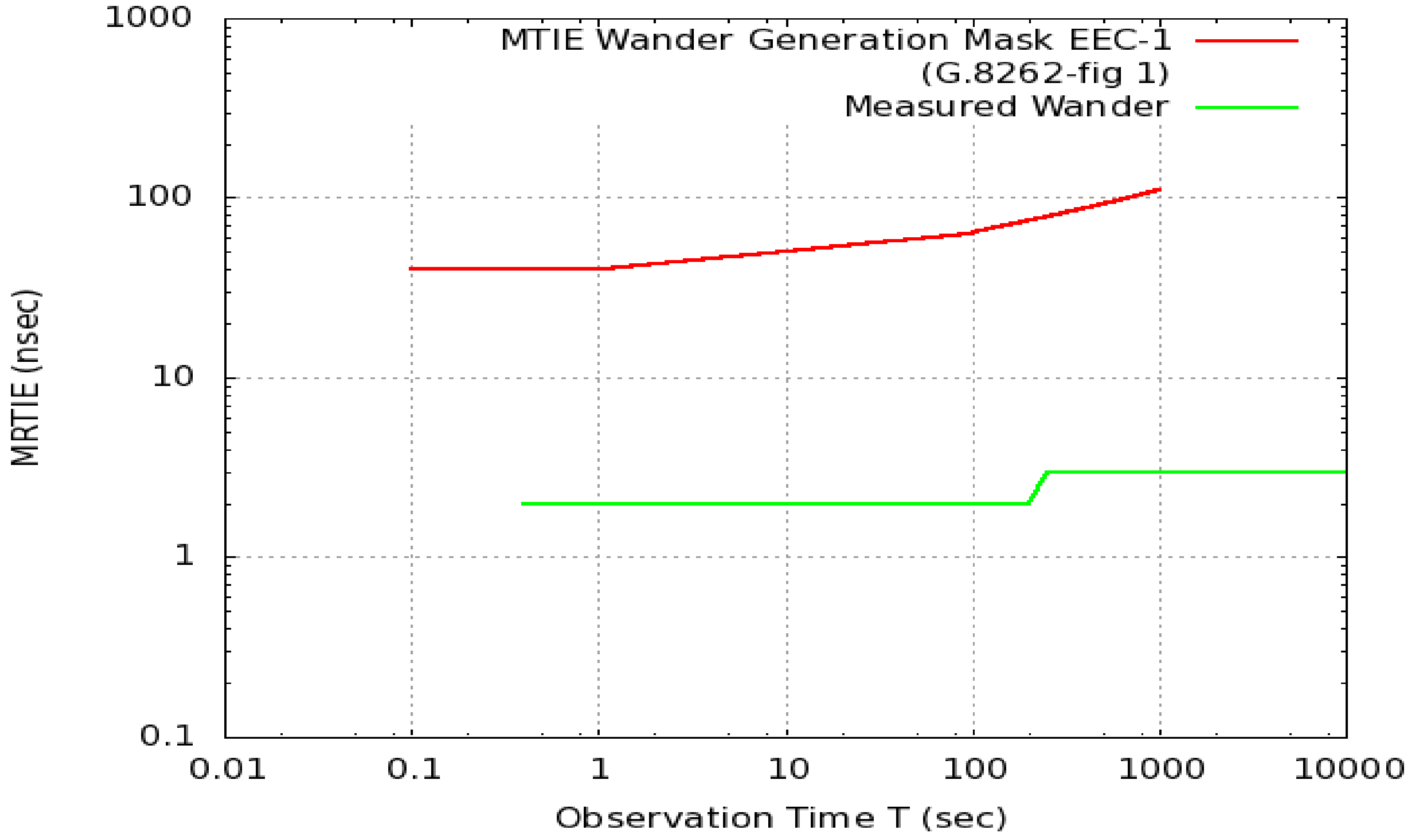


No PDV added by Test equipment

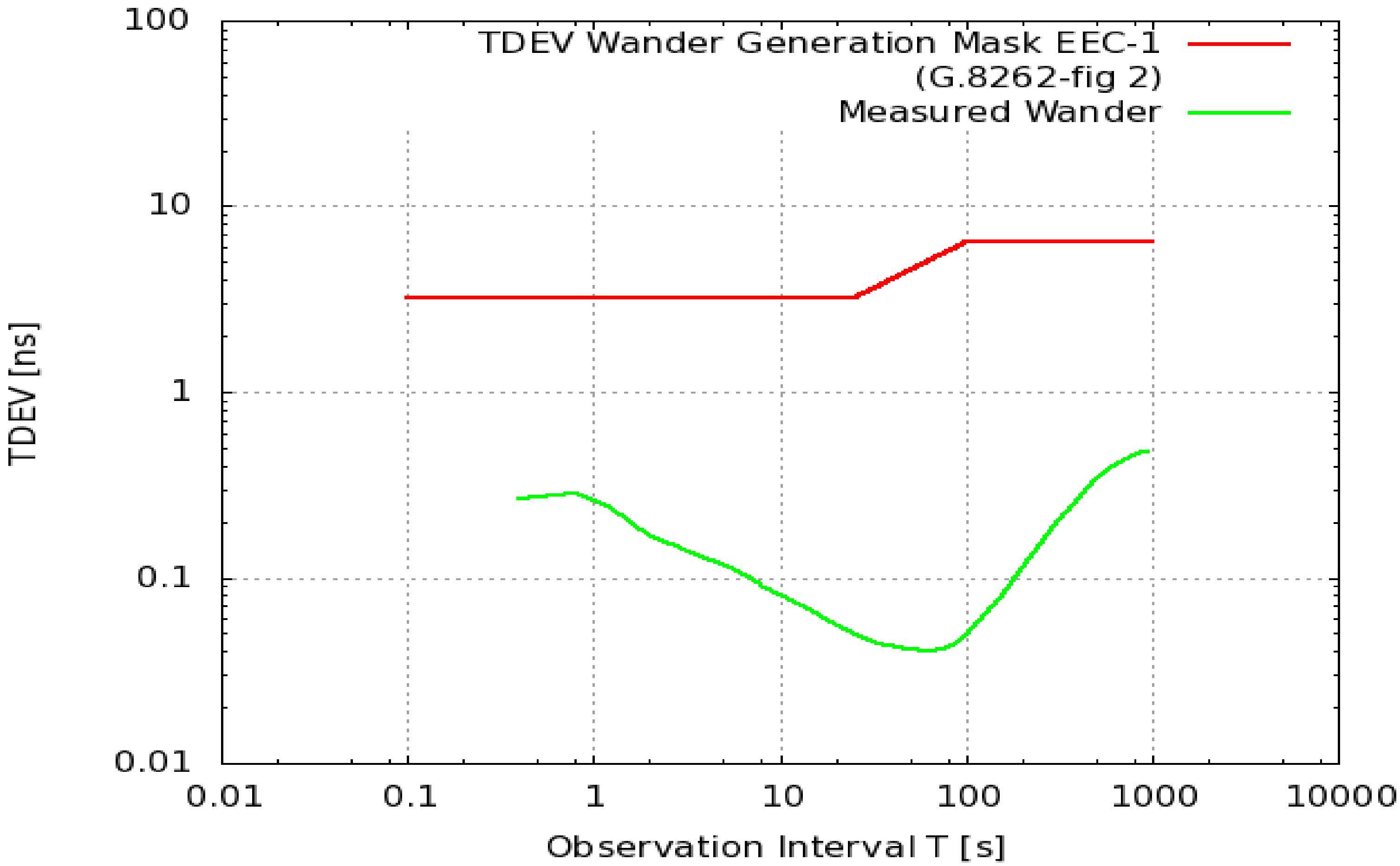
Smart SFP's “add” SyncE function to Test equipment

The frequency output of interface-B is locked to interface-A (SyncE)

MTIE with NO PDV on “SFP packets”

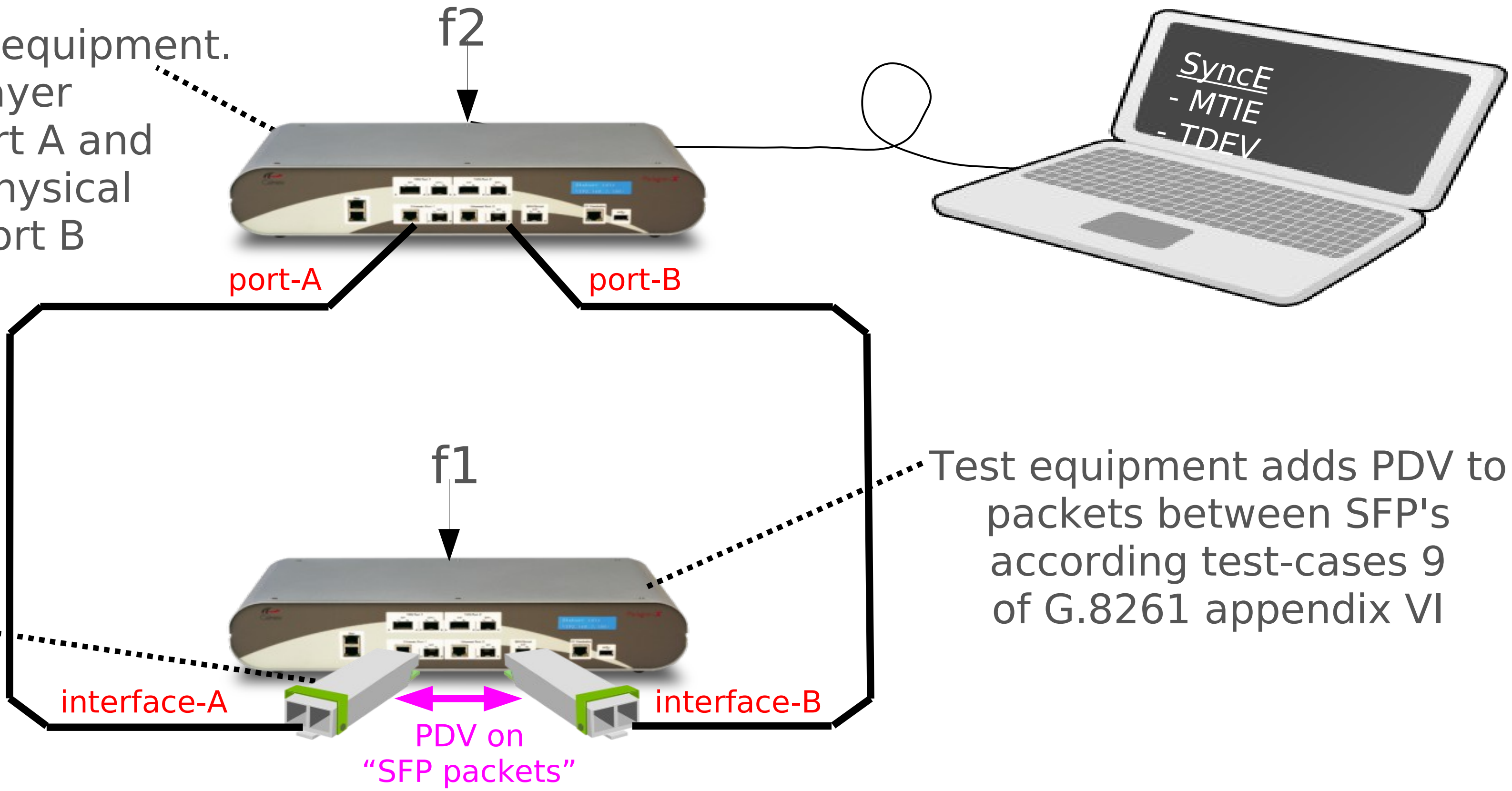


TDEV with NO PDV on “SFP packets”



Physical Layer frequency Test Setup (3)

SyncE measurement equipment. Generates physical layer frequency “f2” on Port A and measures phase of physical layer frequency on port B

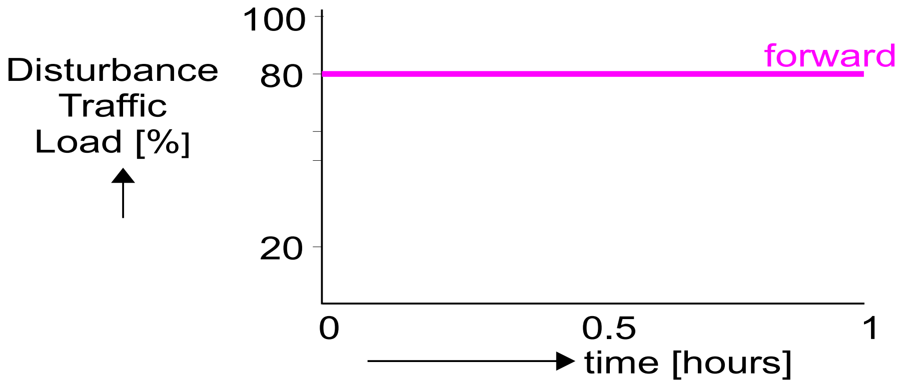


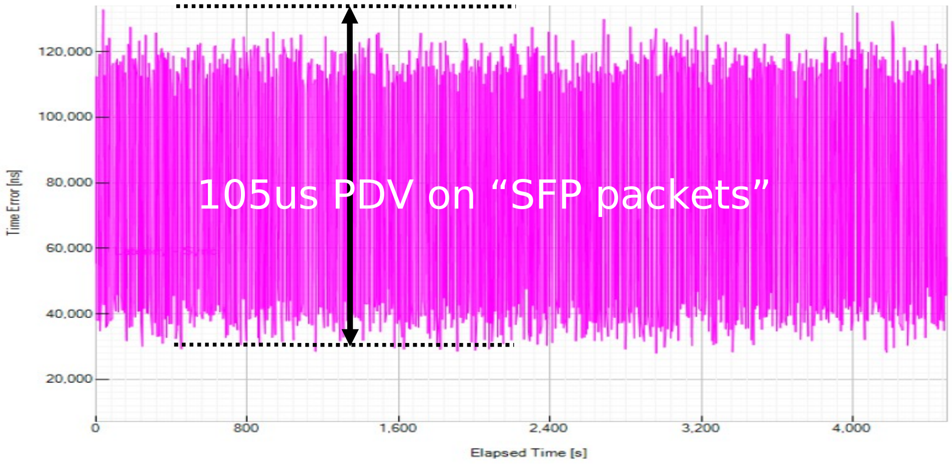
Smart SFP's “add” SyncE function to Test equipment

Test equipment adds PDV to packets between SFP's according test-cases 9 of G.8261 appendix VI

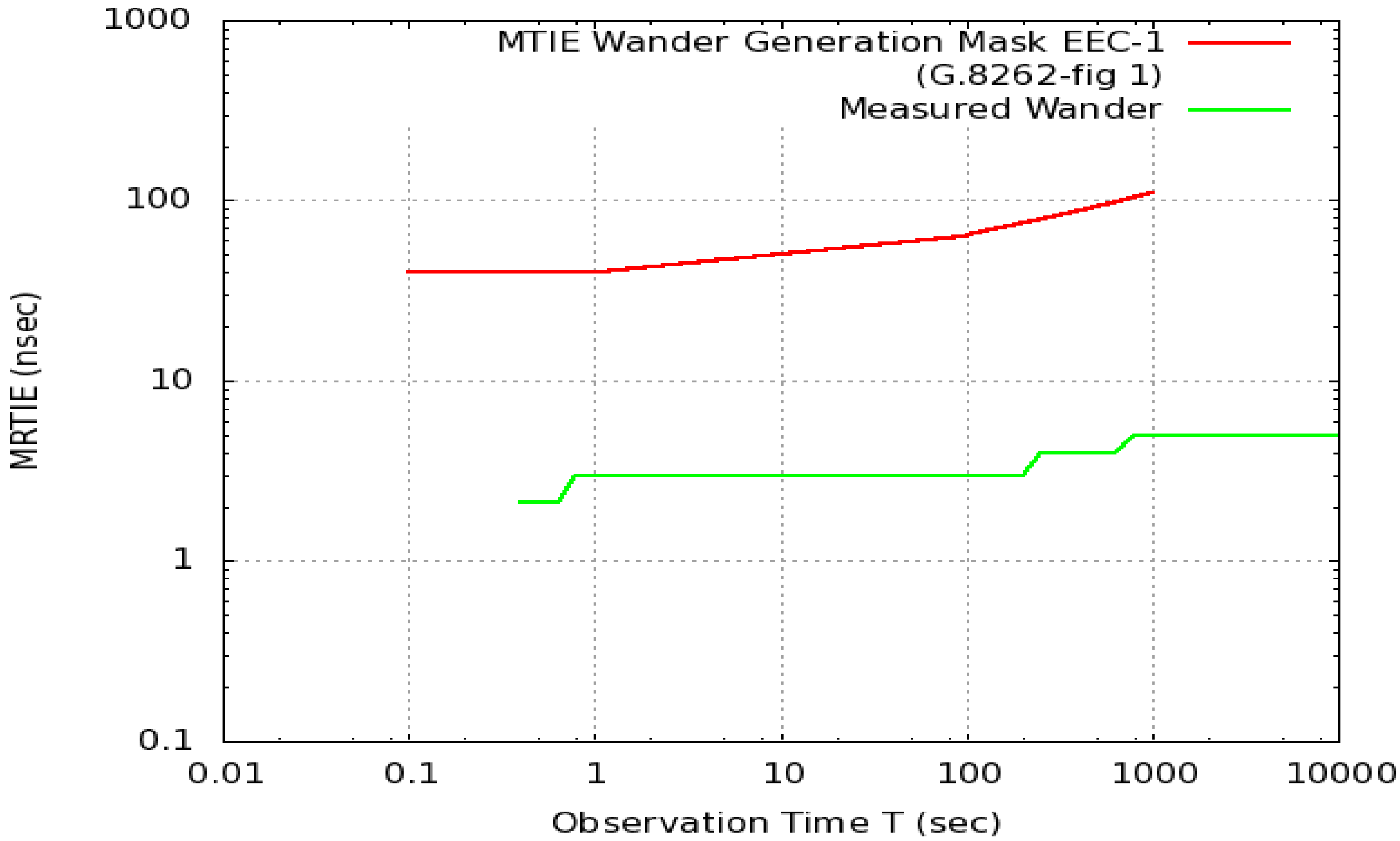
The frequency output of interface-B is locked to interface-A (SyncE)

G.8261-testcase 9 PDV on “SFP packets”

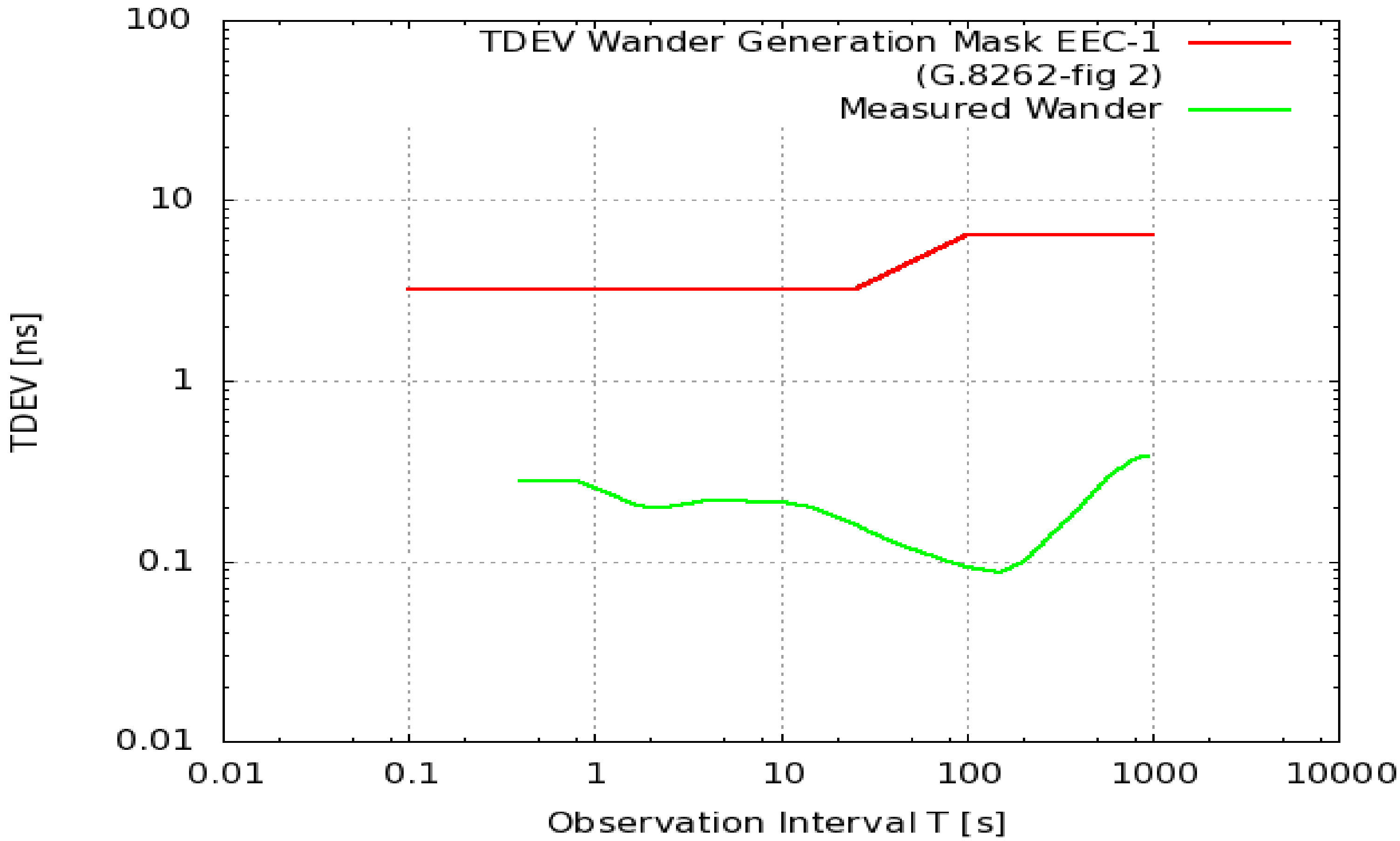




MTIE with G.8261-t.c. 9 PDV on "SFP packets"

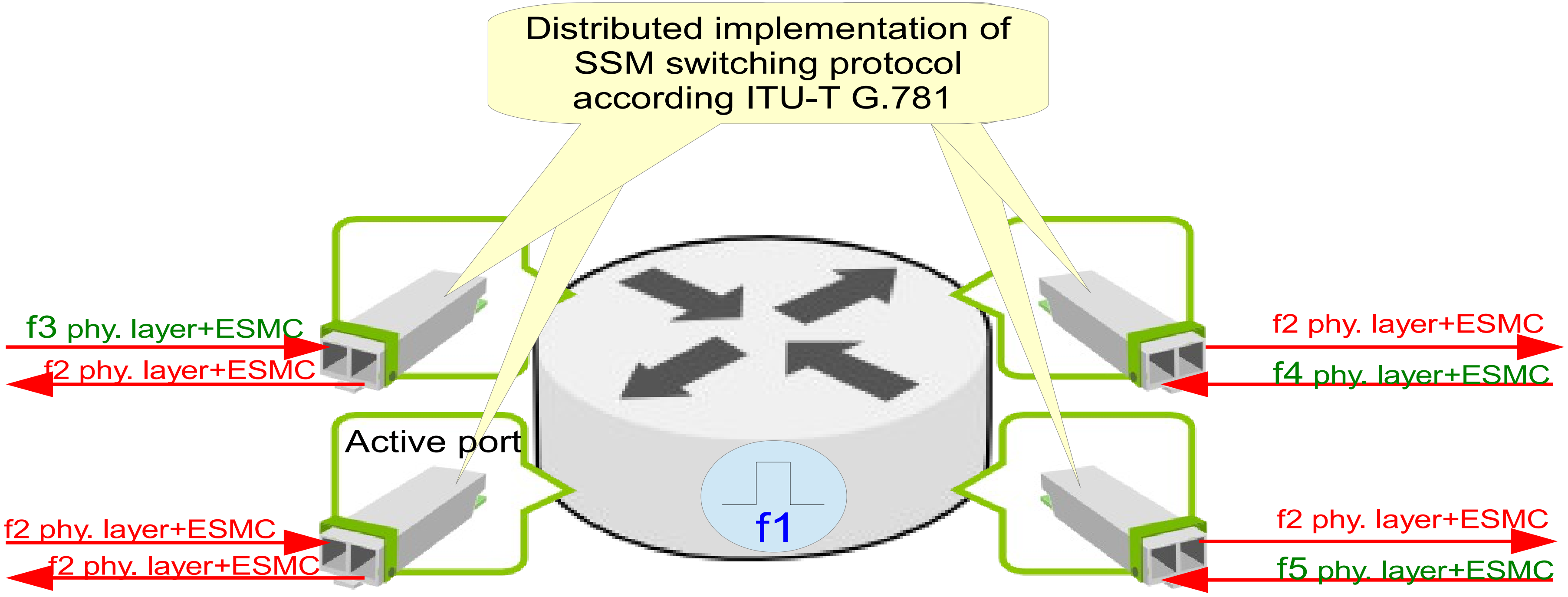


TDEV with G.8261-t.c. 9 PDV on "SFP packets"



Add SSM switching protocol (G.781) to a NE

- All Smart SFP's together implement the ITU-T G.781 SSM protocol:
  - One port is selected as active timing reference based on priority/SSM
  - All other ports TX the SSM value + frequency (f2) of the active port.



Conclusion / take aways

- A PRTC function can be backed-up by:
  - Other PRTC functions in the network
    (requires G.8275.1 capable networks)
  - Physical layer frequency (SyncE) if traceable to GNSS
    (requires SyncE capable networks)

- SyncE functionality can be added to already deployed equipment via Smart SFP's

- The SSM protocol according G.781 is running on the SFP's and makes it possible to support the automatic switching based on SSM info.

Thank you

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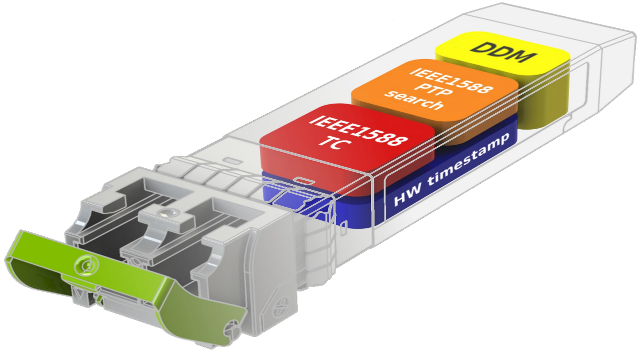

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