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SYSTEM DESCRIPTION

FOX61x R15A
Product Features and Characteristics

ABB

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Contents

1   Preface

This document gives a technical description of the network elements of the FOX61x family:

- FOX615 R2,
- FOX615,
- FOX612,
- FOX611.
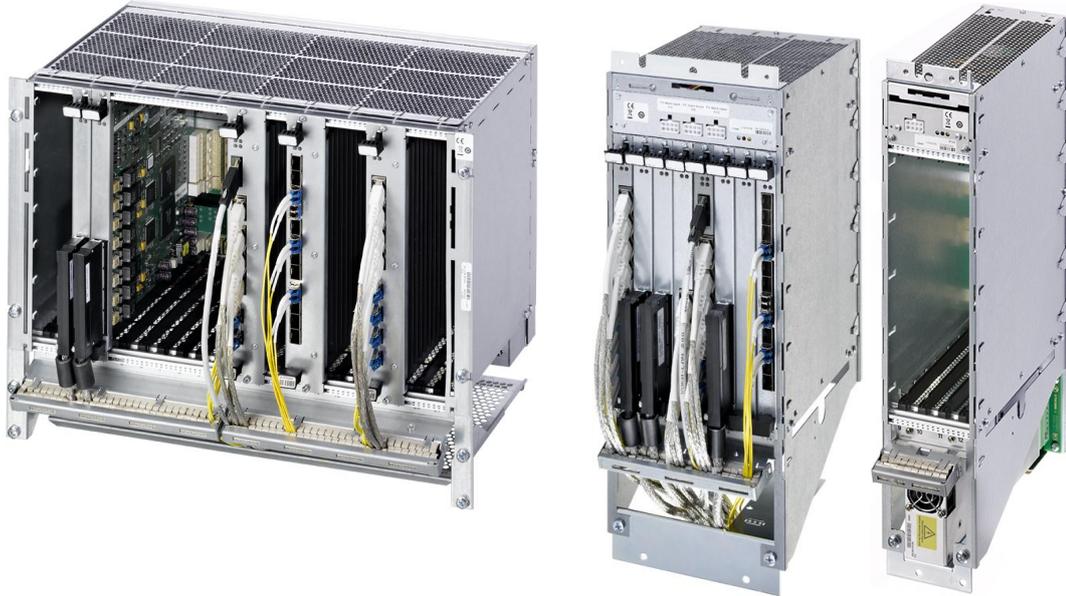
Figure 1:   FOX615 R2 and FOX615 (left), FOX612 (middle) and FOX611 (right)

The network element types offer generally the same capabilities and specifications. The term "FOX61x" is thus used to name the network element type FOX615 R2, FOX615, FOX612 or FOX611. Where certain features or characteristics apply to a specific network element type only, the respective network element type is named explicitly.

1.1   General

The FOX61x network elements act as multi-service access nodes and are based on the following concept:

- All in one compact subrack:
  - Multi-service access for voice, narrow- and broadband TDM data circuits, narrow- and broadband Ethernet data service delivery.
  - Multi-transport supporting electrical and optical Ethernet up to 10 Gbit/s, SDH transport up to STM-16, PDH transport with E1 and SHDSL copper transmission.
  - Multi-technology within a single chassis, providing an extensive circuit-based core with a 128 x 2 Mbit/s cross connect as well as packet-based core functionality with a switching capacity of up to 258 Gbit/s.
  - Protocol/format conversions.
- Very high modularity and flexibility allows for unequaled variety of network element configurations.
- High density, compact size, high scalability and outdoor capability.
- Active or passive cooling.
- "Any service, any slot" architecture.

1.2   FOX61x Network Elements

1.2.1   FOX615 R2

The FOX615 R2 is a network element of medium to large capacity. It can be used either as multiservice access system for point of presence applications or as a network element carrying out networking functions (e.g. digital cross-connect, gateway, channel bank).

The FOX615 R2 uses a 19-inch subrack with 21 slots, 1 or 2 core units, and up to 20 or 19 service units as interface to the subscribers' premises.

The FOX615 R2 is powered from a DC power supply (-48 VDC or -60 VDC nominal voltage), and optionally via a dual power interface from two redundant primary power supplies.

The FOX615 R2 subrack can be operated with a fan unit (active cooling) or without a fan unit (passive cooling). Interfaces for external alarm inputs and outputs are available on the fan unit (active cooling) or on the alarm unit (passive cooling).

1.2.2   FOX615

The FOX615 is a network element with the same size and characteristics as the FOX615 R2 network element, with the exception of the lower backplane transport capacity.

1.2.3   FOX612

The FOX612 is a compact network element of medium capacity. It can be used either as multiservice access system for customer located applications or as a versatile compact transmission system.

The FOX612 relies on the system design of the FOX615 and offers the same services as the FOX615. It uses a 19-inch rack mountable subrack with 8 slots, housing 1 or 2 core units, and up to 7 or 6 service units as interface to the subscribers' premises.

The design of the FOX612 allows versatile equipment installation vertically and horizontally in racks and cabinets.

The FOX612 is powered from a DC power supply (-48 VDC or -60 VDC nominal voltage), and optionally via a dual power interface from two redundant primary power supplies.

The FOX612 subrack can be operated with a fan unit (active cooling) or without a fan unit (passive cooling). Interfaces for external alarm inputs and outputs are available on the fan unit (active cooling) or on the alarm unit (passive cooling).

1.2.4   FOX611

The FOX611 is a compact network element of small capacity. It can be used either as multiservice access system for customer located applications or as a versatile compact transmission system.

The FOX611 relies on the system design of the FOX612 and offers the same services as the FOX612 and FOX615. It uses a 19-inch rack mountable subrack with 4 slots, housing 1 core unit, and up to 3 service units as interface to the subscribers' premises.

The design of the FOX611 allows versatile equipment installation vertically and horizontally in racks and cabinets.

The FOX611 is powered from a DC power supply (-48 VDC or -60 VDC nominal voltage), and optionally via a dual power interface from two redundant primary power supplies.

The FOX611 can alternatively be powered from an AC power supply together with an optional battery backup DC power supply.

The FOX611 subrack can be operated with a fan unit (active cooling) or without a fan unit (passive cooling). Interfaces for external alarm inputs are available on the fan unit. The subrack operated without a fan unit provides no external alarm interfaces.

1.2.5   FOX61x Packet Based Core

The packet based core of the FOX61x is built up from several individual Ethernet switching devices located on the core unit and on the Ethernet service units. Together these inter-connected switching devices emulate one physical switching device, called "FOX61x Switch".

Each Ethernet service unit and the core unit plugged and assigned in the FOX61x subrack contributes its switch ports to the FOX61x Switch, i.e. the FOX61x Switch ports are located on the core unit and on the service units. From a spanning tree protocol view-point, the FOX61x behaves as one RSTP entity.

But there are also some Ethernet service units operating as a stand alone bridge with its own RSTP entity. These units access the FOX61x Switch via an Ethernet connection on the FOX61x backplane. These backplane ports are handled like an external port of the FOX61x Switch.

For an overview of all FOX61x service units please refer to section 1.2.8 FOX61x Core and Service Units Overview (on page 12).

The physical interconnection of all switching devices is done with 40 Gbit/s, 10 Gbit/s or 1 Gbit/s Ethernet links from the service unit to the active core unit and to the standby core unit. All Ethernet links present three types of Ethernet stars.

- the 40 Gbit/s Ethernet links form the 40GbE star,
- the 10 Gbit/s Ethernet links form the 10GbE star,
- the 1 Gbit/s Ethernet links form the 1GbE star.

The active and the standby core unit are in addition connected with two 10 Gbit/s Ether-net links.

The maximum switching capacity of the FOX615 R2 subrack is 258 Gbit/s.
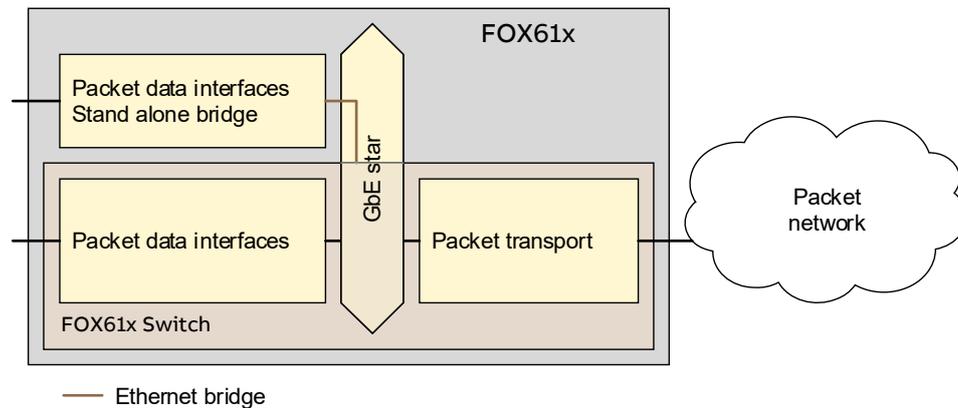
Figure 2:   FOX61x packet based core with FOX61x Switch and stand alone bridge

The FOX61x Switch supports two functions:

- VLAN Bridge

  In IEEE standard 802.1Q (2011) terminology the VLAN Bridge function of the FOX61x Switch is a Customer Bridge. In a customer bridged network (CBN), C-tags are used to separate different VLANs (i.e. C-VLANs).

- MPLS-TP Transport

Both functions can be used simultaneously in one FOX61x network element.

(STOP) **Risk of operating trouble!**

There are no restrictions to use the VLAN Bridge and the MPLS-TP Transport functions simultaneously in small applications. However both functions are very powerful and need a lot of resources.

→ For this reason ABB Power Grids does not recommend to use both functions simultaneously in one FOX61x network element for larger applications.

1.2.6 FOX61x Circuit Based Core

The circuit based core of the FOX61x is built around the TDM bus in the subracks backplane. The TDM bus with the corresponding access circuits presents a distributed cross connect system with an access capacity of 128 x 2 Mbit/s. Cross connections are available at the P12 layer (up to 128 x P12) or at the P0 layer (up to 4096 x P0).

Each TDM based service unit and the core unit have write access to the TDM bus according to the service units or core units TDM traffic capacity. Each TDM based service unit and the core unit have read access to the whole TDM bus

The TDM bus allows to configure unidirectional and bidirectional cross connections between any port or channel of any TDM based service unit or the core unit.

—— TDM cross connection
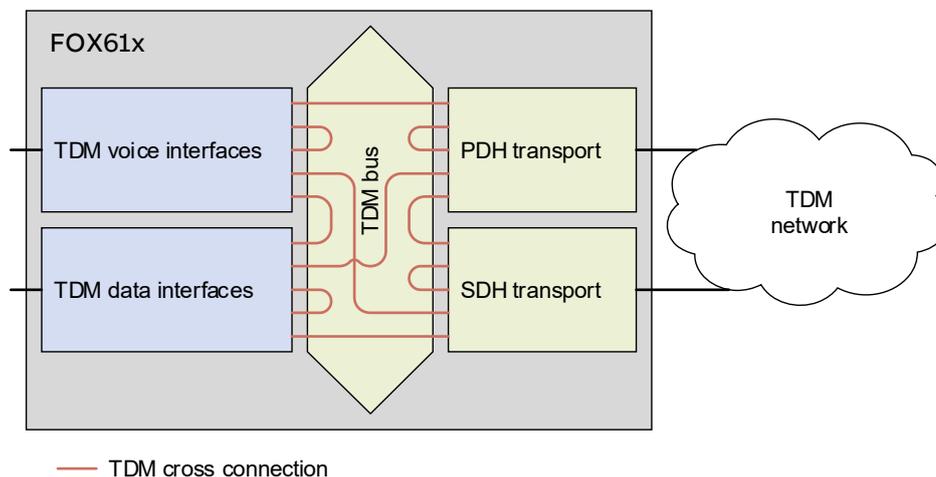
Figure 3:   FOX61x circuit based core

1.2.7 FOX61x Protocol Conversion

For an overview of all FOX61x service units please refer to section 1.2.8 FOX61x Core and Service Units Overview (on page 12).

1.2.7.1 Ethernet over PDH

The FOX61x comprises Ethernet service units providing access to the TDM bus. Ethernet traffic from the front port or the backplane Gbit/s Ethernet interface can be transported in PDH channels of up to 16 x 2 Mbit/s via the TDM bus to a PDH or SDH transport unit.

Note that the PDH channel carrying the Ethernet traffic can be transported in a VC-12 via the SDH network.
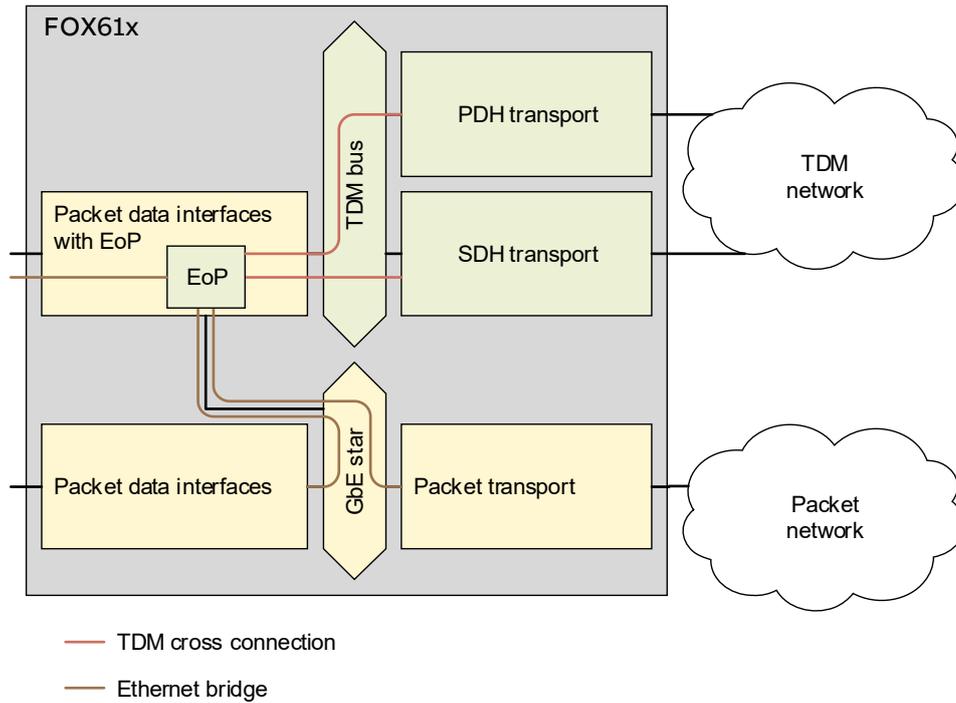
Figure 4:   FOX61x EoP protocol conversion

1.2.7.2   Ethernet over SDH

The FOX61x comprises SDH service units providing the Ethernet over SDH functionality. Ethernet traffic from the front port or the backplane Gbit/s Ethernet interface can be transported in SDH channels of up to 12 x VC-4 via the SDH transport unit.
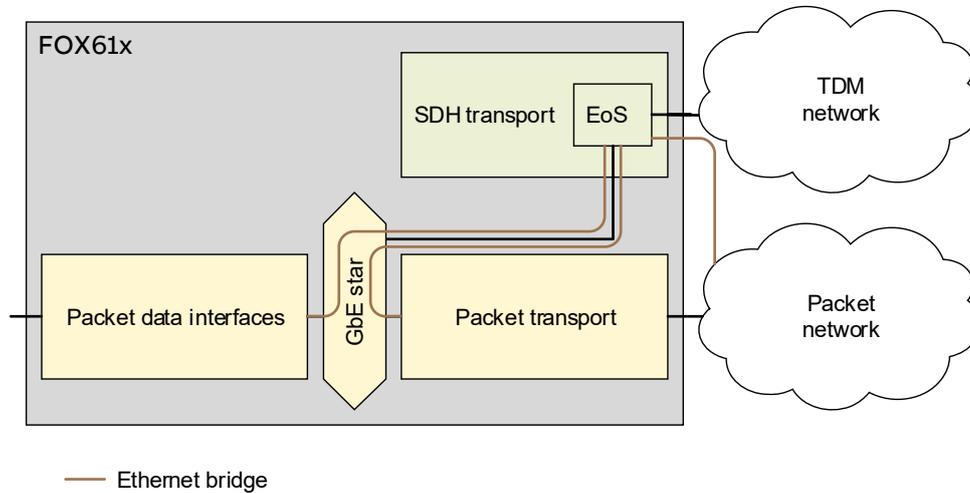
Figure 5:   FOX61x EoS protocol conversion

1.2.7.3   PDH over Ethernet

The FOX61x comprises a circuit emulation service unit providing the transport of TDM based data traffic via IP packets. The service unit accesses up to 8 x P12 TDM based data traffic in structured or unstructured format from the TDM bus, maps the TDM traffic into IP packets and forwards the IP packets via the GbE star to the packet transport unit.

The circuit emulation service supports the following protocols:

- Structure Agnostic Transport over Packet (SAToP),
- Circuit Emulation Service over Packet Switched Network (CESoPSN),
- Circuit Emulation Services over Ethernet (CESoETH).
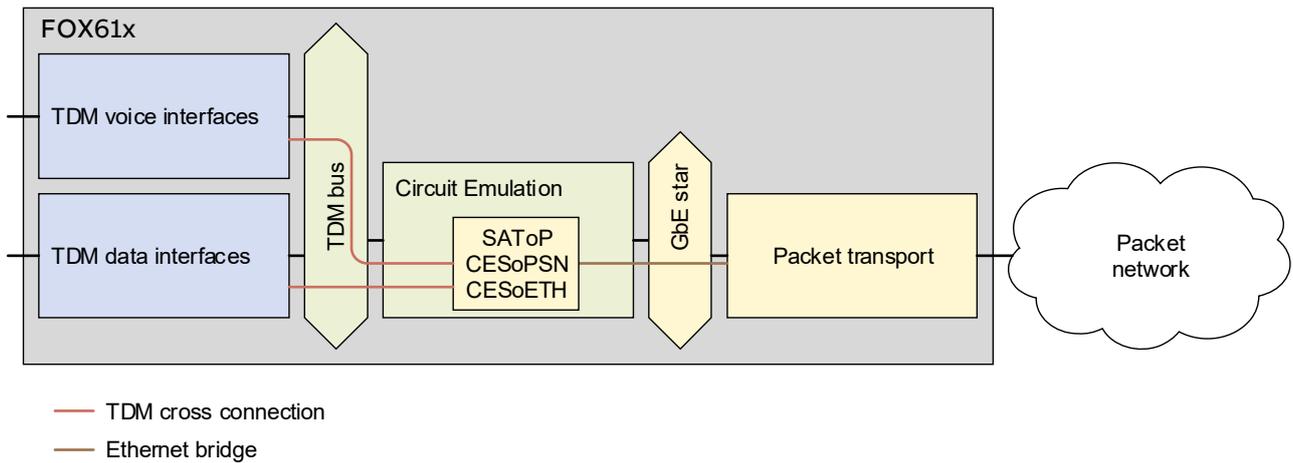
Figure 6:   FOX61x circuit emulation protocol conversion

1.2.7.4   Voice over IP

The FOX61x provides a voice gateway service unit for the transport of TDM based voice traffic via IP packets using the SIP protocol, i.e. offering the voice over IP (VoIP) service. The service unit can serve up to 1216 PSTN subscribers. It accesses the voice signals from the TDM bus, maps the TDM traffic into IP packets and forwards the IP packets via the GbE star to the packet transport unit.

The VoIP service uses the "Real-Time Transport Protocol" (RTP) protocol for the encapsulation of the voice streams.
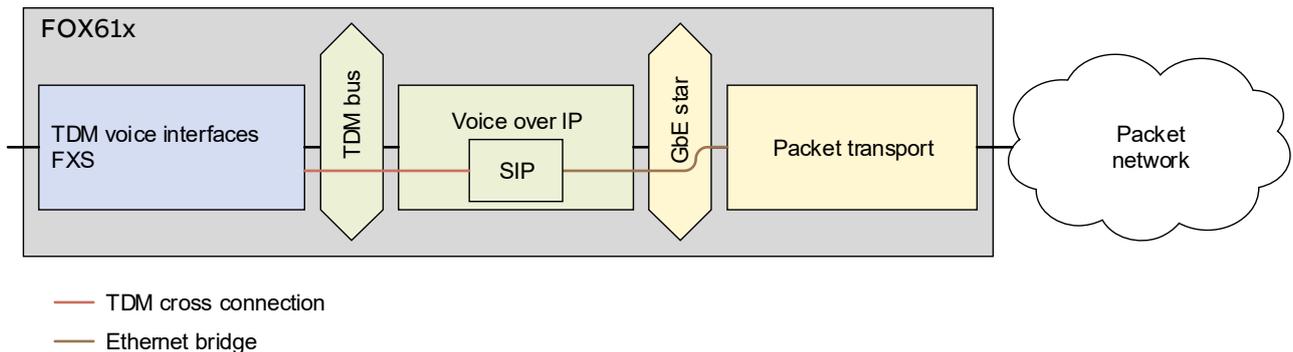
Figure 7:   FOX61x VoIP protocol conversion

1.2.8   FOX61x Core and Service Units Overview

The following plug-in units are available for the FOX61x:

- The core unit CESM3 implements the control function and a central Ethernet switch with VLAN support (IEEE, 802.1Q). It offers four SFP/SFP+ cages for electrical or optical GbE or 10 GbE interfaces and one electrical 10/100/1000BASE-T Ethernet interface.

  The CESM3 implements a routing function for the data communication network and the PDH timing functions.

- The core unit CESM2 implements the control function and a central Ethernet switch with VLAN support (IEEE, 802.1Q). It offers two SFP/SFP+ cages for electrical or optical GbE or 10 GbE interfaces, two SFP cages for electrical or optical GbE interfaces and one electrical 10/100/1000BASE-T Ethernet interface.

  The CESM2 implements a routing function for the data communication network and the PDH timing functions.

  The core unit CESM2-F provides the same functionality as the CESM2 but can be operated in a subrack with passive cooling. The CESM2-F is two slots wide.

- The core unit CESM1 implements the control function and a central Ethernet switch with VLAN support (IEEE, 802.1Q). It offers two SFP/SFP+ cages for electrical or optical GbE or 10 GbE interfaces and three electrical 10/100/1000BASE-T Ethernet interfaces.

  The CESM1 implements a routing function for the data communication network and the PDH timing functions.

  The core unit CESM1-F provides the same functionality as the CESM1 but can be operated in a subrack with passive cooling. The CESM1-F is two slots wide.

- The WAN port expansion unit EPEX1 offers 4 SFP+ based 10 Gbit/s Ethernet interfaces and one QSFP+ based 40 Gbit/s Ethernet interface (available in a future release). The unit expands the number of WAN ports of the CESM3 core unit. The Ethernet front ports are directly attached to the switch circuit of the core unit.

  The EPEX1 unit is operable in the FOX615 R2 subrack with the CESM3 core unit.

- Encryption units with Ethernet interfaces towards the core unit and towards the MPLS transport network:

  - The encryption unit SENC1-8 implements four encryption engines for the encryption of four bidirectional Ethernet streams, each with up to 1024 LSPs, partitioned into two independent functional units. It offers eight SFP cages for Ethernet traffic interfaces and one electrical 10/100/1000BASE-T Ethernet interface for the management of the two functional units.

    The encryption unit SENC1F8 provides the same functionality as the SENC1-8 but can be operated in a subrack with passive cooling. The SENC1F8 is two slots wide.

  - The encryption unit SENC1-4 implements two encryption engines for the encryption of two bidirectional Ethernet streams, contained in one functional unit. It offers four SFP cages for Ethernet traffic interfaces and one electrical 10/100/1000BASE-T Ethernet interface for the management of the functional unit.

    The encryption unit SENC1F4 provides the same functionality as the SENC1-4 but can be operated in a subrack with passive cooling. The SENC1F4 is two slots wide.

- Service units with Ethernet interfaces towards the subscribers:

  - ELET1: 24 electrical 10/100/1000BASE-T Ethernet interfaces.
  - ETOP1: 12 SFP based 100 or 1000 Mbit/s Ethernet interfaces.

    The service unit ETOP1-F provides the same functionality as the ETOP1 but can be operated in a subrack with passive cooling. The ETOP1-F is two slots wide.

  - EPOI1: 12 electrical 10/100/1000BASE-T Ethernet interfaces with power over Ethernet (PoE) support.

- The service unit DEFM1 offers 24 SHDSL EFM (Ethernet in the First Mile) interfaces towards the subscribers.

  The service unit DEFM1-F provides the same functionality as the DEFM1 but can be operated in a subrack with passive cooling. The DEFM1-F is two slots wide.

- The service unit EROP1 offers 12 SFP based 100 or 1000 Mbit/s Ethernet interfaces. The unit performs (stand alone) routing functions with up to 16 virtual router instances.

  The service unit EROP1-F provides the same functionality as the EROP1 but can be operated in a subrack with passive cooling. The EROP1-F is two slots wide.

- Service units with Ethernet interfaces towards the subscribers and performing stand alone switching functions:

  - ESOP1: 12 SFP based 100 or 1000 Mbit/s Ethernet interfaces. The unit performs (stand alone) switching functions.

    The service unit ESOP1-F provides the same functionality as the ESOP1 but can be operated in a subrack with passive cooling. The ESOP1-F is two slots wide.

    The ESOP1 and ESOP1-F service units use the same hardware as the ETOP1 and ETOP1-F service units.

  - ESPO1: 12 electrical 10/100/1000BASE-T Ethernet interfaces with power over Ethernet (PoE) support. The unit performs (stand alone) switching functions.

    The ESPO1 service unit uses the same hardware as the EPOI1 service unit.

- The service unit EPSI1 offers 4 electrical 10/100BASE-T Ethernet interfaces towards the subscribers. The unit performs (stand alone) switching and routing functions and offers Ethernet over PDH transport with a maximum capacity of 16 x 2 Mbit/s.
- Service unit with PSTN a/b (POTS, FXS) interfaces towards the subscribers:
  - LESU1: 16 interfaces.
- The service unit LEDA1 offers 8 E&M interfaces towards the subscribers, each consisting of a 2-wire or 4-wire voice interface and 2 E&M signaling interfaces.
- The service unit LEXI1 offers 12 POTS voice a/b interfaces towards the local exchange (FXO).
- The service unit LEDS1 offers 4 TDM data interfaces according to V.24/V.28, V.35, X.24/V.11 or RS485. The available port bandwidth is in the range from 0.3 kbit/s up to 1984 kbit/s.

  In addition the service unit offers 1 electrical 10/100BASE-T Ethernet interface with Ethernet over PDH transport with a maximum bandwidth of 1'984 kbit/s.

- The service unit LECO1 offers 8 codirectional E0 interfaces or alternatively 2 contradirectional E0 interfaces towards the subscribers.
- The service unit DATI1 offers eight SHDSL interfaces towards SHDSL CPEs for TDM services or towards another DATI1 unit using the trunk mode.
- The service unit LEDE1 offers 8 E1 interfaces towards other G.703/G.704 interfaces or local exchanges.
- The service unit SAMO1 is an SDH service unit offering 2 STM-4/STM-1 interfaces and 2 STM-1 interfaces. Four electrical 10/100/1000BASE-T Ethernet interfaces are used for EoS applications.
- The service units SAMO2, SAMO2-F and SAMO3 are SDH service units offering 2 STM-16/STM-4 interfaces and 2 STM-4/STM-1 interfaces. The service units SAMO5 and SAMO5-F are SDH service units offering 2 STM-4 interfaces and 2 STM-4/STM-1 interfaces. Four electrical 10/100/1000BASE-T Ethernet interfaces are used for EoS applications.

  The SAMO5-F or SAMO2-F unit provides the same functionality as the SAMO5 or SAMO2 unit but can be operated in a subrack with passive cooling. The SAMO5-F or SAMO2-F unit is two slots wide.

  The service unit SAMO3 provides the same functionality as the SAMO2 but provides in addition 48 E12 front ports for the transport over SDH. The SAMO3 unit is two slots wide.

- The service units TEPI1 and TEPI2 offer 4 electrical interfaces for distance protection commands towards the protection relay. In addition the service unit offers a variety of additional auxiliary features:
  - binary signal transmission,
  - external alarm acquisition and monitoring,
  - alarm output signals,
  - remote controls, and
  - time synchronization / event recording.

  The TEPI1 uses TDM transport for the protection commands and binary signals.

  The TEPI2 uses packet transport for the protection commands and binary signals.

- The service units OPIC1 and OPIC2 offer 4 optical interfaces for differential protection complying to the IEEE C37.94 standard or to the proprietary FOX6plus compatible optical transmission protocol (ABB Power Grids TPE) or the FO5 protection interface type (OPIC2 only) for differential protection applications.

  The OPIC1 uses TDM transport for the differential protection traffic.

  The OPIC2 uses packet transport with circuit emulation for the differential protection traffic. Each transport channel can alternatively be used for the transport of P0_nc signals from the FOX61x TDM bus.

- The service unit TEGO1 offers 4 optical interfaces to access an IEC 61850 station bus. TEGO1 is an IED acting as a proxy gateway for IEC 61850 GOOSE and/or SV (Sampled Values) messages between substations.

  The TEGO1 uses packet transport for the GOOSE and/or SV (Sampled Values) messages and provides PRP redundancy.

- The service unit CEPI1 provides a circuit emulation service with a capacity of 8 x P12 from the FOX61x TDM bus. It supports the SAToP, CESoPSN and CESoETH protocols for the encapsulation of TDM bit streams using up to 64 Pseudo Wires. In addition it provides 8 E1 interfaces at the unit front ports.

- The service unit COSI1 acts as a SIP gateway for voice over IP, serving up to 1216 PSTN subscribers from the FOX61x TDM bus. It uses the SIP protocol for the call setup and the RTP protocol for the encapsulation of the voice streams.

- The service unit VFTLF acts as a voice frequency processing unit. It provides echo cancelers for up to 2 x 208 PSTN subscribers from the FOX61x TDM bus.

The traffic units are explained in detail in section 2.2 FOX61x Traffic Units (on page 50).

1.2.9   FOX61x Auxiliary Units Overview

The following auxiliary units are available for the FOX615 R2 and FOX615:

- The auxiliary dual-connection unit DUPF1 allows the powering of the FOX615 R2 or FOX615 subrack from two redundant primary power supplies.

- The auxiliary dual-connection unit DUPF1-R allows the powering of the FOX615 R2 or FOX615 subrack from two redundant primary power supplies. The DUPF1-R has separate power feeding up to the FOX615 R2 or FOX615 subrack.

- The auxiliary fan unit FAMO1 provides the active cooling of the FOX615 R2 or FOX615 subrack and the external alarm interfaces.

- The auxiliary alarm unit FAMO1-F provides the same alarm interfaces as the FAMO1 and can be used for the passive cooling application of the FOX615 R2 or FOX615 subrack.

The following auxiliary units are available for the FOX612:

- The auxiliary dual-connection unit DUPF2 allows the powering of the FOX612 subrack from two redundant primary power supplies.

- The auxiliary fan unit FAMO2 provides the active cooling of the FOX612 subrack and the external alarm interfaces.

- The auxiliary alarm unit FAMO2-F provides the same alarm interfaces as the FAMO2 (R3) and can be used for the passive cooling application of the FOX612 subrack.

The following auxiliary units are available for the FOX611:

- The auxiliary dual-connection unit DUPF2 allows the powering of the FOX611 subrack from two redundant primary power supplies.

- The auxiliary fan unit FAMO3 provides the active cooling of the FOX611 subrack and the external alarm interfaces.

- The auxiliary alarm unit FAMO3-F provides the same alarm interfaces as the FAMO3 (R2) and can be used for the passive cooling application of the FOX611 subrack.

- The auxiliary FOX611 AC power kit, consisting of the POAC1 AC/DC converter, the AC/DC backplane and the required assembly material, provides the AC powering for the FOX611 with an optional battery backup.

- The auxiliary air flow optimization unit AFOU1 allows the operation of the FOX61x subrack, equipped with SFP-based core and service units, in ambient temperatures up to 65°C.

The auxiliary units are explained in detail in section 2.3 FOX61x Auxiliary Units (on page 105).

1.3   FOX61x Traffic Services and Applications

1.3.1   Traffic Services Overview

The FOX61x offers the following traffic interfaces:

Table 1:   FOX61x traffic interfaces

Interface	FOX615 R2	FOX615	FOX612	FOX611
Optical Ethernet up to 40 Gbit/s	X [1]	-	-	-
Optical Ethernet up to 10 Gbit/s	X	X	X	X
Electrical and optical Ethernet up to 1 Gbit/s	X	X	X	X
SHDSL EFM (ITU-T G.991.2, Annex B and G)	X	X	X	X
SHDSL TDM (ITU-T G.991.2, Annex B and G)	X	X	X	X
PSTN (analog POTS interface, FXS)	X	X	X	X
PSTN (analog POTS interface, FXO)	X	X	X	X
E&M voice 2-wire and 4-wire, plus signaling	X	X	X	X
E0 (G.703)	X	X	X	X
E1 (G.703 / G.704, CO or desktop CPE)	X	X	X	X
STM-1 (optical or electrical)	X	X	X	X
STM-4 (optical)	X	X	X	X
STM-16 (optical)	X	X	X	X
Ethernet over SDH (EoS) for up to 12 x VC-4	X	X	X	X
Ethernet over PDH (EoP) for up to 2 Mbit/s	X	X	X	X
X.24 / V.11	X	X	X	X
V.35	X	X	X	X
V.24 / V.28	X	X	X	X
RS485 2-wire and 4-wire	X	X	X	X
V.36 (via desktop CPE)	X	X	X	X
Teleprotection tripping commands	X	X	X	X
Binary signals	X	X	X	X
Optical differential protection	X	X	X	X
IEC 61850 GOOSE/SV	X	X	X	X

1.   Will be available in a future release

The FOX61x offers the gateway services:

Table 2:   FOX61x gateway services

Interface	FOX615 R2	FOX615	FOX612	FOX611
Circuit Emulation Service (CESoP) for up to 2 Mbit/s	X	X	X	X
Voice over IP (VoIP) for up to 1216 POTS ports	X	X	X	X
Proxy gateway for IEC 61850 GOOSE/SV messages	X	X	X	X
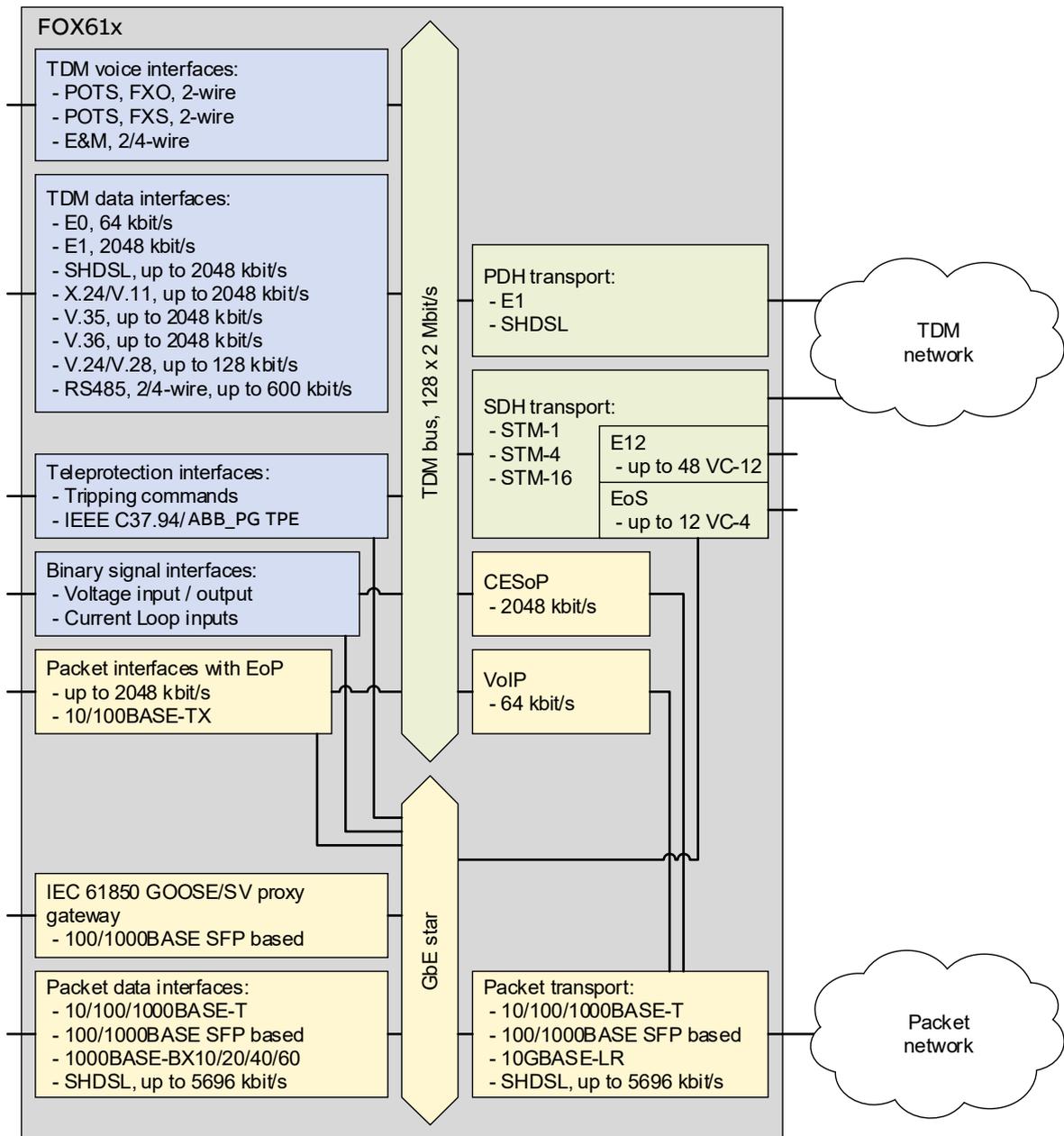
Figure 8:   FOX61x multi-service and multi-transport capabilities

Legend:
- – EoP: Ethernet over PDH
- – EoS: Ethernet over SDH
- – CESoP: Circuit Emulation Service over Packet
- – VoIP: Voice over IP

1.3.2   FOX61x Management

The FOX61x management concept is based on the FOX61x network element manager (FOXCST) for local and remote management and the FOXMAN-UN network element manager for remote management from the Network Management Centre / Network Operation Centre.

The FOXMAN-UN offers Northbound Interfaces (NBI) for the OSS integration. The FOXMAN-UN can manage both, FOX61x network elements and FOX61x networks, while the FOXCST manages single FOX61x network elements only.

1.3.3 Application Description

The variety of interfaces supports the following services and applications:

- Ethernet frame transport over packet networks,
- Ethernet frame switching:
  - untagged frames,
  - priority tagged frames,
  - C-VLAN ID tagged frames,
- Ethernet frame transport over MPLS:
  - untagged frames,
  - priority tagged frames,
  - C-VLAN ID tagged frames,
- Ethernet frame transport over PDH,
- Ethernet frame transport over SDH,
- Ethernet frame transport over SHDSL,
- IP packet routing,
- TDM transport over PDH,
- TDM transport over SHDSL,
- TDM transport over SDH,
- circuit emulation service, i.e. TDM transport over packet networks,
- voice over IP service, i.e. TDM voice transport over packet networks,
- legacy data services,
- voice services.

All the above services are offered in parallel.

Several network scenarios can be implemented with the FOX61x. The three basic topologies are

- the star,
- the linear-chain, and
- the ring topology.

The FOX61x can be deployed in clusters, i.e. several FOX61x subracks are located at the same location with a common backhaul interface.

1.3.3.1 Ethernet Frame Switching and Transport over Packet Networks

The FOX61x Switch can be configured to function as a VLAN aware Ethernet bridge. Ethernet ports on service units and SHDSL EFM ports assigned to the VLAN Bridge can be configured to play different roles. Depending of the role and the incoming and outgoing tagging the frames are handled differently.

- Ingress direction
  - Untagged frames and priority tagged frames become tagged with the port VLAN ID and are forwarded, or are dropped.
  - Tagged frames are forwarded, or are dropped.
  - Tagged frames get a VLAN tag added with the port VLAN ID and are forwarded (Q-in-Q).
- Egress direction
  - All frames are forwarded.
  - Frames tagged with the port VLAN ID get the VLAN tag removed and are forwarded.
  - Frames not tagged with the port VLAN ID are forwarded unchanged.
  - Frames not tagged with the port VLAN ID are dropped.

The SFP based Ethernet ports on the core unit and WAN port expansion unit support link speeds up to 10 Gbit/s. Typically these ports are used to access the packet network.

The other Ethernet ports on the core unit and the Ethernet ports on the service units support link speeds up to 1 Gbit/s. The SHDSL EFM ports support up to 22.7 Mbit/s using the aggregation function.

The FOX61x supports class of service (CoS) handling, according to IEEE 802.1Q. The 8 priority levels are mapped to traffic classes. The traffic classes correspond to queues in the FOX61x Switch. The core and the service units have 8 queues in egress direction.

The FOX61x Switch behaves as one RSTP entity.

1.3.3.2   Ethernet Frame Transport over MPLS Networks

The FOX61x Switch can be configured to function as an MPLS-TP Transport equipment. In this case the FOX61x can act as a Label Switching Router (LSR) or Label Edge Router (LER). The MPLS-TP implementation with FOX61x supports the VPWS service, VPLS service, OAM features, QoS and protection switching.

Ethernet ports pointing to the customer side and used for an MPLS-TP VPWS service have to be configured as Pseudo Wire Access Circuits (PWAC). PWAC ports are located on Ethernet service units, on the core units or on the WAN port expansion units. PWAC ports are attached to a Virtual Private Wire Service with one of the following service types:

- AC (Attachment Circuit) Port Based, No Change

  Untagged, priority tagged and VLAN tagged frames are forwarded unchanged.
- AC Port Based, Add PW Tag

  Untagged, priority tagged and VLAN tagged frames are forwarded with an added Pseudo Wire VLAN tag.
- AC VLAN Based, No Change

  VLAN tagged frames with the configured VLAN tag ID are forwarded unchanged.
- AC VLAN Based, Change Tag

  VLAN tagged frames with the configured VLAN ID are forwarded with a modified VLAN ID.
- AC VLAN Based, Add PW Tag

  VLAN tagged frames with the configured VLAN ID are forwarded with an added Pseudo Wire VLAN tag.
- AC Untagged, No Change

  Untagged frames are forwarded unchanged.
- AC Untagged, Add PW Tag

  Untagged frames are forwarded with an added Pseudo Wire VLAN tag.

Ethernet ports pointing to the customer side and used for an MPLS-TP VPLS service have to be configured as Customer VLAN Ports (CVP). CVP ports are located on Ethernet service units, on the core units or on the WAN port expansion units. CVP ports are attached to the FOX61x Switch, the FOX61x Switch is attached to the VPLS pseudo wires via the switch virtual interface (SVI), using one of the following service types:

- Change VLAN

  VLAN tagged frames with the configured SVI VLAN ID are forwarded with a modified VLAN ID.
- No Change

  VLAN tagged frames with the configured SVI VLAN ID are forwarded unchanged.

Ethernet ports pointing to the network side and used for an MPLS-TP Transport service have to be configured as MPLS-TP ports. MPLS-TP ports are located on the core units or the WAN port expansion units. MPLS-TP ports forward Ethernet packets with LSP MPLS labels and Pseudo Wire MPLS labels.

MPLS-TP ports can also be VLAN tagged, i.e. they are logical subinterfaces assigned to physical transport interface.

The FOX61x supports co-routed LSPs, i.e. forward and reverse direction LSPs are routed over the same path. MPLS tunnels can be protected or unprotected.

The SFP based Ethernet ports on the core unit and WAN port expansion unit support link speeds up to 10 Gbit/s. Typically these ports are used to access the packet network.

The other Ethernet ports on the core unit and the Ethernet ports on the service units support link speeds up to 1 Gbit/s.

As a security feature the ingress rate of an Ethernet port can be limited. In addition rate limiters can be applied for MPLS-TP tunnels.

1.3.3.3   IP Packet Routing

The FOX61x core unit implements an IP router. This router is used for the management communication via a data communication network (DCN).

The router has therefore

- up to 16 numbered or unnumbered PPP links accessing the DCN,
- up to 10 numbered or unnumbered MCC (MPLS-TP management communication channel) links accessing the DCN, and
- two (CESM1 and CESM2) or eight (CESM3) Ethernet interface to connect a network manager.

The FOX61x service unit EPSI1 implements a general purpose IP router. The router has

- up to 64 numbered or unnumbered PPP and multilink PPP links with configurable HDLC framing.

The FOX61x service units EROP1 and EROP1-F implement up to 16 virtual router instances usable as general purpose IP routers. The routers have

- up to 256 virtual router interfaces, and
- up to 32 loopback interfaces.

All routers support the OSPF protocol and static routing.

1.3.3.4   TDM Transport Services

TDM transport services are often used for legacy applications or for the MAC frame transport via a TDM network.

FOX61x offers the following SDH, PDH and SHDSL interfaces:

- STM-16, STM-4 and STM-1 interfaces:
  - SDH Terminal Multiplexer application
  - SDH Add/Drop Multiplexer application
  - Termination of 2 Mbit/s TDM signals
  - Ethernet over SDH (EoS) application
- E1 interfaces:
  - Transparent P12 signal transport
  - Terminated P12 signal transport
  - Ethernet over PDH (EoP) application
- SHDSL TDM interfaces:
  - Transparent P12 signal transport
  - Terminated P12 signal transport
  - Partially filled P12 signal transport
  - Ethernet over PDH (EoP) application

1.3.3.5   Circuit Emulation Service

Circuit Emulation Service over packet (CESoP) provides the emulation of a legacy TDM service over a packet network. The packet network can be an Ethernet network, an IP net-

work, or even a MPLS network. Interworking functions (IWF) perform the mapping of the TDM signals into packets and vice versa.

The CESoP application with FOX61x provides the following benefits:

- Transport of n x 64 kbit/s and structured and unstructured 2 Mbit/s TDM signals over the packet network.
- Transport of TDM timing signals over the packet network.
- Synchronous operation of the gateway functions, i.e. the traffic signals are all synchronized to the NE timing which is traceable to a primary reference clock (PRC).
- Plesiochronous operation of the gateway functions, i.e. the traffic signals are transported using the customer originated service timing.
- Transport of differential protection with constant and symmetrical end to end delay (OPIC2).

1.3.3.6 Voice over IP Service

Voice over IP (VoIP) provides the conversion of legacy voice signals to IP packets and vice versa.

The analog voice is transported to the PSTN unit of the FOX61x in the base-band. The PSTN unit implements the analog telephone subscriber interfaces.

The VoIP application with FOX61x is based on the SIP protocol. The SIP access gateway functionality is implemented in a separate unit, mapping and demapping the voice signals to and from IP packets.

The VoIP application with FOX61x provides the following benefits:

- Transport of PSTN (POTS) TDM signals over the packet network using the RTP protocol, i.e. no requirement for a direct access to the PSTN network.
- Termination of the inband and out-of-band signaling and conversion to the SIP protocol.

1.3.3.7 Legacy Data Services

The FOX61x offers the access to legacy data services. All these legacy services make use of the TDM transport facilities of the FOX61x.

FOX61x offers the following data services:

- Data interfaces:
  - E0 interface (64 kbit/s)
  - V.24/V.28 interface
  - V.35 interface
  - X.24/V.11 interface
  - RS485 interface
  - Subrates asynchronous from 0.3 kbit/s to 38.4 kbit/s
  - Subrates synchronous from 0.3 kbit/s to 56 kbit/s
  - Synchronous data rates from 64 kbit/s to 1984 kbit/s
  - Data conferencing function for linear and star network applications
- Ethernet interfaces with PDH transport:
  - 10/100BASE-T interface
  - Ethernet switching and routing
  - OSPF and static IP routing
  - Support of HDLC, PPP and MLPPP
  - PDH transport with a maximum bandwidth of 16*2 Mbit/s

1.3.3.8   Voice Services

The FOX61x offers the access to legacy voice services. All these legacy services make use of the TDM transport facilities of the FOX61x.

FOX61x offers the following voice services:

- Voice interfaces:
  - Voice 2-wire analog interface (FXS)
  - Voice 2-wire analog interface (FXO)
  - Voice 2/4-wire interface with E&M signaling
  - Voice conferencing function for linear and star network applications

1.3.3.9   Teleprotection Services

The FOX61x offers the access to legacy teleprotection services. These services are available for the TDM transport facilities and for transport over packet networks.

FOX61x offers the following dedicated teleprotection services:

- Distance protection interfaces:
  - tripping commands for 24, 48, 60, 110, 125, 220, 250 V_{DC}
- Differential protection interfaces:
  - IEEE C37.94
  - proprietary FOX6plus compatible optical transmission protocol (ABB Power Grids TPE)
  - FO5

For other types of interfaces FOX61x offers data transport suitable for differential protection applications.

1.3.3.10   IEC 61850 GOOSE/SV Proxy Gateway Service

The IEC 61850 GOOSE/SV Proxy Gateway Service provides sophisticated GOOSE and SV based communication between substations on the FOX61x multiplexer platform. Common applications for GOOSE and SV messages in an IEC 61850-based substation automation system include for example:

- Tripping commands
- Interlocking information
- Status
- SV stream for differential protection
- Measurement functionality (Synchrophasor)

The IEC 61850 GOOSE/SV Proxy Gateways communicate over packet networks.

1.3.3.11   Auxiliary Signals

The FOX61x offers auxiliary signals. These signals are available for the TDM transport facilities and for transport over packet networks.

FOX61x offers the following auxiliary signals:

- Binary signal transmission interfaces:
  - Voltage inputs and outputs,
  - Current loop inputs,
  - Mechanical switchover relay outputs.
- External alarm acquisition and monitoring interfaces:
  - Voltage inputs,
  - Current loop inputs.
- Alarm signal output interfaces:
  - Voltage outputs,

- – Mechanical switchover relay outputs.
- Remote control interfaces:
  - – Mechanical switchover relay outputs.
- Time synchronization / event recording interfaces:
  - – IRIG-B inputs,
  - – IRIG-B outputs,
  - – PPS outputs.

1.4   Content Changes

This section provides an overview on content that has been changed with the current FOX61x system release "R15A" with respect to the last release, and content that has been added or changed in previous system releases.

For more information about feature availability please refer to [1KHW028777] Release Note "FOX61x System Release R15A" of the current system release.

The following table provides information about functionality that has been added or enhanced with the current system release.

Table 3:   Changes provided with the release "R15A"

Area	Features		Details	Units
Network element	New high capacity network element type FOX615 R2	new	section 1.2.1 FOX615 R2 (on page 8)	FOX615 R2
Services and functional unit	WAN port expansion unit with four 10 Gbit/s Ethernet ports and one 40 Gbit/s Ethernet port	new	section 2.2.4 WAN Port Expansion Unit EPEX1 (on page 64)	EPEX1
Voice processing	Voice frequency processing unit with echo cancelers	new	section 2.2.22 Voice Frequency Processing Unit VFTLF (on page 92)	VFTLF
Voice processing	Support of PSTN FXO subscribers	enhanced	section 2.2.21 Media Gateway Unit COSI1 (on page 90)	COSI1
Services and functional unit	New protection interface type FO5 on two ports of OPIC2	enhanced	section 2.2.31 Differential Protection Service Unit OPIC2 (on page 103)	OPIC2
Management	New user class "support" available, providing the user with expanded troubleshooting data.	enhanced	section 6.4.2.4 Management Access (on page 188)	FOX615 R2, FOX615, FOX612, FOX611
Management	IPSec for management communication no longer supported	reduced	section 6.4.2.4 Management Access (on page 188)	FOX615, FOX612, FOX611
Network element	New network element type FOX611: - Subrack FOX611 with 4 slots - 1 slot for core unit - 3 slots for service units - Fan unit FAMO3 - Alarm unit FAMO3-F - Dual power supply unit DUPF2 - AC/DC power converter POAC1	new	section 6.6 FOX611 Characteristics (on page 209)	FOX611
Services	MEF 3.0 CE (Carrier Ethernet) certification	enhancement	section 6.1.1 Customer VLAN Bridge Functionality (on page 162)	CESM3

Table 3:   Changes provided with the release "R15A" (continued)

Area	Features		Details	Units
QoS	LSP rate limiters for MPLS-TP tunnels.	enhanced	section 4.2.5.2 Rate Limiters (on page 138)	CESM1, CESM2
Services	MPLS-TP ports as VLAN based subinterfaces can be encrypted with the SENC1 encryption unit	enhancement	section 2.2.5 Encryption Unit SENC1-4, SENC1F4, SENC1-8 and SENC1F8 (on page 65)	SENC1
Synchronization	Support of UDP/IPv4 based PTP transport. Fully compliant to ITU-T G.8275.2 and IEEE1588-2019.	enhancement	section 6.1.5 TDM Timing Source (on page 168)	FOX615, FOX612, FOX611
Synchronization	PTP Master Clock support with UDP/IPv4 based PTP transport.	enhancement	section 6.1.5 TDM Timing Source (on page 168)	FOX615, FOX612, FOX611
Synchronization	PPS output on the core unit CESM3	enhancement	section 6.2.3 Synchronization Interfaces (on page 177)	CESM3
Data Interfaces	Synchronous data transport up to 2048 kbit/s	enhancement	section 2.2.26 Data Service Unit LEDS1 (on page 97)	LEDS1

Table 4:   Changes provided with the release "R14A"

Area	Features		Details	Units
Network access	Provider edge dual homing access via two provider network elements.	enhancement	section 4.1.4 Network Scenario for Provider Network Access with Dual Homing (on page 132)	FOX61x
QoS	LSP rate limiters for MPLS-TP tunnels.	new	section 4.2.5.2 Rate Limiters (on page 138)	CESM3
QoS	Egress shaper per class type on MPLS-TP ports.	new	section 4.2.5.4 Egress Class Type Shapers (on page 138)	CESM3
Management	Two VLAN based management interfaces.	enhanced		CESM1, CESM2
Synchronization	Support of "PTP Ordinary/Boundary and Transparent Clock" mode with PTP VLAN based synchronization.	enhanced		CESM1, CESM2
Network element	Maximum ambient temperature for the operation of the FOX61x network element increased from 60°C to 65°C.	enhanced	section 6.8.1.3 Operation (on page 222)	FOX61x
OAM	TDM pattern generator and analyzer usable for diagnostics.	new	section 6.3.1 System Level (on page 181)	FOX61x
Synchronization	Support of FOX61x operating as PTP (IEEE 1588v2) Grand Master removed	reduced	section 3.6 Synchronization (on page 124)	FOX61x
Synchronization	The IRIG-B outputs can also be configured to use the PPS format	enhanced	section 3.10 PPS (on page 126)	TEPI2, OPIC2, TEGO1
Synchronization	PTP gateway between the PTP telecom profile and the PTP power profile	new	section 3.8 PTP (on page 125)	TEGO1

Table 5:   Changes provided with the release "R3B_SP01"

Area	Features		Details	Units
Network element	The slot 13 of the FOX615 and FOX612 subracks is usable for TDM service units independent of the core unit type plugged in slot 11.	enhanced	section 6.4.1 Architecture (on page 184) and section 6.5.1 Architecture (on page 196)	FOX615, FOX612
Management	Authentication of the network element manager FOXMAN-UN via public/private key exchange	enhanced	section 5.2 FOXCST (on page 156)	FOX615, FOX612

Table 6:   Changes provided with the release "R3B"

Area	Features		Details	Units
Services and functional unit	Encryption units with two or four encryption engines, managed by FOXMAN-UN and the DIRAC server. The new units are the successors of the SENC1 and SENC1-F encryption units.	new	section 2.2.5 Encryption Unit SENC1-4, SENC1F4, SENC1-8 and SENC1F8 (on page 65)	SENC1-4, SENC1F4, SENC1-8, SENC1F8
Management	Key management server DIRAC for the generation and deployment of encryption Master Keys	new	section 5.6 DIRAC (on page 160)	DIRAC
Network element	Update of referenced EMC standards	enhanced	section 6.7 EMC/ESD and Safety (on page 220)	FOX615, FOX612
Services and functional unit	Routing unit with up to 16 virtual routers and DHCP relay agent	enhanced	section 2.2.10 Ethernet Service Units EROP1 and EROP1-F (on page 74)	EROP1, EROP1-F
Management	Update of the SNMP MIBs.	enhanced	section 5.4 SNMP (on page 157)	FOX615, FOX612

Table 7:   Changes provided with the release "R3A_SP01"

Area	Features		Details	Units
Services and functional unit	Ethernet standalone switching units with optical Ethernet ports	new	section 2.2.11 Ethernet Service Units ESOP1 and ESOP1-F (on page 75)	ESOP1, ESOP1-F
Services and functional unit	Ethernet standalone switching units with electrical (PoE) Ethernet ports	new	section 2.2.12 Ethernet Service Unit ESPO1 (on page 77)	ESPO1
Powering	Dual power feeding unit DUPF1-R with separate power connections up to the FOX615 subrack.	new	section 2.3.2 Dual Power Input Unit DUPF1-R (FOX615 R2 and FOX615) (on page 106)	DUPF1-R
Core unit	Fast equipment protection	enhanced	section 2.2.1 Core Unit CESM3 (on page 55)	CESM3
Synchronization	Simultaneous support of PTP Transparent Clock and Boundary Clock with the CESM3 core unit.	enhanced	section 3.6 Synchronization (on page 124)	FOX615, FOX612, CESM1
Synchronization	Network element timing transfer via SHDSL from LT to NT.	enhanced	section 2.2.9 Ethernet service unit DEFM1 and DEFM1-F (on page 72)	DEFM1, DEFM1-F

Table 7:   Changes provided with the release "R3A_SP01" (continued)

Area	Features		Details	Units
Synchronization	Full compliance of the Network Element Clock with ITU-T G.8262/Y.1362 (07/2010) Option 1. Maximum frequency tolerance reduced.	enhanced	section 6.2.3 Synchronization Interfaces (on page 177)	FOX615, FOX612
Management	Enhanced GUI for the packet connectivity. Graphical view for G.826 performance data.	enhanced		FOX615, FOX612

Table 8:   Changes provided with the release "R3A"

Area	Features		Details	Units
Core unit	Core unit with access to the 10 GbE star of the FOX61x backplane. Fast equipment protection switchover. Increased number of VLAN based ports of the management router.	new	section 2.2.1 Core Unit CESM3 (on page 55)	CESM3
Services and functional unit	SHDSL EFM transport unit, 24 subscriber ports	new	section 2.2.9 Ethernet service unit DEFM1 and DEFM1-F (on page 72)	DEFM1, DEFM1-F
QoS	Port shaping at the FOX61x Switch egress ports	new	section 4.2.5.3 Egress Port Shapers (on page 138)	FOX61x

Table 9:   Changes provided with the release "R2D"

Area	Features		Details	Units
Management	Export restriction free element manager FOXCST, and ESW for the core unit CESM1 removed	enhanced		FOXCST FOX61x
Document	ABB Power Grids branding. New document number	enhanced	-	-
Services and functional unit	STM-4, STM-1 transport unit, 4 electrical Ethernet front ports. Up to 8 EoS groups.	new	section 2.2.17 SDH and EoS Service Unit SAMO5 and SAMO5-F (on page 84)	SAMO5
Network element	Revised MTTF values of the fan units.	enhanced	section 6.4 FOX615 R2 and FOX615 Characteristics (on page 184), section 6.5 FOX612 Characteristics (on page 196)	FAMO1, FAMO2
QoS	Enhanced rate limiters: 1 Rate - 3 Color, and 2 Rate - 3 Color.	enhanced	section 4.2.5.2 Rate Limiters (on page 138)	FOX615, FOX612
Services and functional unit	Routing unit with four virtual routers and 12 Ethernet front interfaces	new	section 2.2.10 Ethernet Service Units EROP1 and EROP1-F (on page 74)	EROP1, EROP1-F

Table 9:   Changes provided with the release "R2D" (continued)

Area	Features		Details	Units
Network access	MPLS-TP ports as VLAN based subinterfaces.	enhancement	section 4.2.1 MPLS-TP Transport (on page 132)	FOX615, FOX612
Network access	Customer network access to the core network via two provider edges (dual homing)	enhancement	section 4.1.3 Network Scenario for LAN Island Interconnection using VPLS (on page 131)	

Table 10:   Changes provided with the release "R2C"

Area	Features		Details	Units
Services and functional unit	Encryption unit with four encryption engines	new	section 2.2.5 Encryption Unit SENC1-4, SENC1F4, SENC1-8 and SENC1F8 (on page 65)	SENC1
Management	Export restriction free element manager FOXCST, and ESW for the core unit CESM1	new	section 5.2 FOXCST (on page 156)	FOXCST FOX61x
Link Protection	R- supported for FOX61x bridge ports for Ethernet and MPLS interworking	enhanced	section 4.1.3 Network Scenario for LAN Island Interconnection using VPLS (on page 131)	FOX615, FOX612
Link Protection	RSTP supported for FOX61x bridge ports	enhanced	section 4.6.4.2 Rapid spanning tree protocol (RSTP) (on page 152)	FOX615, FOX612
Services and functional unit	Configurable queue management on the CESM1 unit	enhanced	section 2.2.3 Core Unit CESM1 and CESM1-F (on page 61)	CESM1
Services and functional unit	Fast equipment protection for the core unit CESM1	enhanced	section 6.4.2.1 Control System (on page 186), section 6.5.2.1 Control System (on page 198)	CESM1
Services and functional unit	Teleprotection for Distance Protection over Packet Services, 4 Commands, Binary Signal Transmission	new	section 2.2.29 Teleprotection Signaling and Binary Signal Service Unit TEPI2 (on page 101)	TEPI2
Services and functional unit	Teleprotection for Differential Protection over Packet Services, 4 Ports	new	section 2.2.31 Differential Protection Service Unit OPIC2 (on page 103)	OPIC2
Services and functional unit	IEC 61850 GOOSE/SV Proxy Gateway, Packet Services, 4 Ports	new	section 2.2.32 IEC 61850 GOOSE and SV Proxy Gateway Unit TEGO1 (on page 104)	TEGO1
Services and functional unit	Support of circuit emulation protocols CESoPSN and CESoETH on the CEPI1 unit.	enhanced	section 2.2.19 E1 Circuit Emulation Service Unit CEPI1 (on page 87)	CEPI1

Table 10:   Changes provided with the release "R2C" (continued)

Area	Features		Details	Units
Management	Update of the supported Windows operating systems for the Element Manager FOXCST and the Network Element Manager FOXMAN-UN	enhanced	section 5.2 FOXCST (on page 156), section 5.5 FOXMAN-UN (on page 158)	FOXCST, FOX-MAN-UN
Management	Support of SNMP v1, v2c and v3 for fault management	new	section 5.4 SNMP (on page 157)	FOX615, FOX612
Network access	Support of MPLS-TP Virtual Private LAN Services	enhanced	section 4.2.1.2 VPLS Transport Function (on page 133)	
OAM	Support of LSP Ping and Trace Route on MPLS-TP ports	enhanced	section 1.3.3.2 Ethernet Frame Transport over MPLS Networks (on page 19)	
QoS	Configurable mapping of attachment circuits PCP to pseudo wire EXP	enhanced	section 4.2.1.3 Traffic Prioritisation (on page 134)	
Security	Rate limiters on Ethernet ports	new	section 4.2.5.2 Rate Limiters (on page 138)	
Link Protection	ERPS, RSTP and MSTP no longer supported	reduced		
Synchronization	Support of PTP (IEEE 1588v2) Grand Master Clock mode	enhanced	section 3.6 Synchronization (on page 124)	FOX615, FOX612, CESM1
TDM encapsulation	Support of the Circuit Emulation Service over Packet Switch Network (CESoPSN)	enhanced	section 2.2.19 E1 Circuit Emulation Service Unit CEPI1 (on page 87)	CEPI1
Service unit name	HW name for the COSI1 unit corrected	changed	section 2.2.21 Media Gateway Unit COSI1 (on page 90)	COSI1
Network element	New FOX615 subrack revisions R3A and R3B with modified front cover: - Subrack revision R3A with maximum power supply current 30 A - Subrack revision R3B with maximum power supply current 45 A	enhanced	section 3.12.1 DC Power Supply Interfaces (on page 127)	FOX615
Synchronization	Support of PTP (IEEE 1588v2) for the PETS synchronization using CESM1 ports	enhanced	section 3.6 Synchronization (on page 124)	FOX615, FOX612, CESM1
Network access	Support of the MPLS-TP Transport function with FOX61x as Label Edge Router (LER) or Label Switching Router (LSR), using CESM1 ports as MPLS-TP uplink ports	new	section 4.2.1 MPLS-TP Transport (on page 132)	FOX615, FOX612, CESM1

Table 11:   Changes provided with the release "R1D"

Area	Features		Details	Units
Data interfaces	Transition coding for data interfaces up to 19.2 kbit/s	enhanced	section 2.2.26 Data Service Unit LEDS1 (on page 97)	LEDS1
Voice gateway	Maximum number of subscribers increased to 1216. MFC-R2 port type added. ISDN-PRA port type added.	enhanced	section 2.2.21 Media Gateway Unit COSI1 (on page 90)	COSI1

Table 11:   Changes provided with the release "R1D" (continued)

Area	Features		Details	Units
Services and functional unit	Faster equipment protection switchover time. Maximum EoS capacity reduced to 12 VC-4 equivalents.	enhanced / reduced	section 2.2.15 SDH and EoS Service Unit SAMO2 and SAMO2-F (on page 81), section 2.2.16 SDH and EoS Service Unit SAMO3 (on page 83)	SAMO2, SAMO3

Table 12:   Changes provided with the release "R1C"

Area	Features		Details	Units
Data interfaces	Contradirectional 64 kbit/s interface according to G.703	enhanced	section 2.2.27 E0 Service Unit LECO1 (on page 99)	LECO1
Services and functional unit	STM-16, STM-4, STM-1 transport unit, 4 electrical Ethernet front ports, 48 E12 front ports. Up to 32 EoS groups.	new	section 2.2.16 SDH and EoS Service Unit SAMO3 (on page 83)	SAMO3

2   Architecture and Views

2.1   FOX61x Subracks

2.1.1   Architecture

2.1.1.1   FOX615 R2

The FOX615 R2 uses a 19-inch subrack with 21 slots, one or two core units and up to 20 or 19 service units.

The FOX615 R2 supports core and service units as listed in section 2.2 FOX61x Traffic Units (on page 50).

The FOX615 R2 allows to implement 1:1 equipment protection for the core unit. The slots for the working core unit and the protecting core unit are slots 11 and 13, respectively. The slot concept with and without redundancy is shown in Figure 10.

> **i** **Please note:**
> The slot 13 of the FOX615 R2 subrack is not usable for Ethernet service units.

> **i** **Please note:**
> The slot 9 and slot 15 of the FOX615 R2 subrack using the CESM3 core unit can be equipped with the 40 Gb Ethernet WAN port expansion unit EPEX1.

> **i** **Please note:**
> The slot 1, slot 8 to slot 15, and slot 21 of the FOX615 R2 subrack using the CESM3 core unit are not usable for 10 Gb Ethernet service units.
>
> → The support of 10 Gb Ethernet service units in the slot 9 and slot 15 of the FOX615 R2 subrack using the CESM3 core unit will be available in a future release.
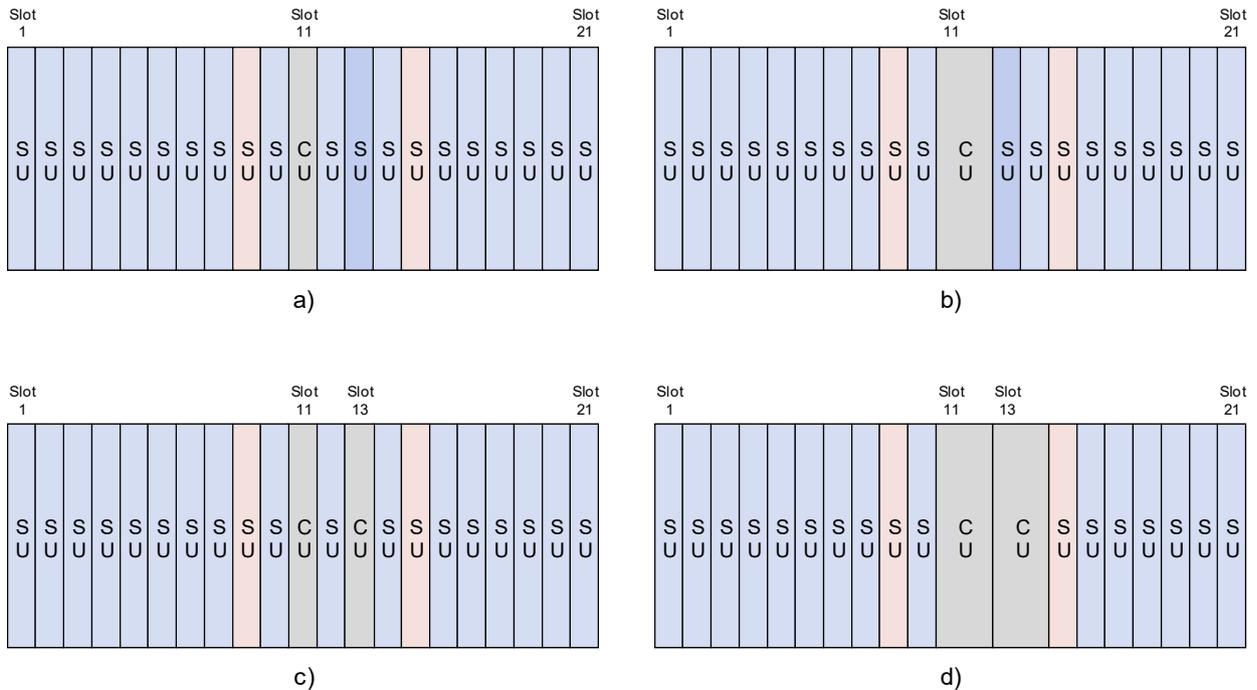
Figure 9:   Slot concept of the FOX615 R2

Legend:

a FOX615 R2 without core unit (CU) redundancy
   core unit with single slot width
   20 service units (SU)

b FOX615 R2 without core unit (CU) redundancy
   core unit with double slot width
   19 service units (SU)

c FOX615 R2 with core unit (CU) redundancy
   core unit with single slot width
   19 service units (SU)

d FOX615 R2 with core unit (CU) redundancy
   core unit with double slot width
   17 service units (SU)

The service unit ELET1 offers 24 interfaces towards the subscribers; other service units offer 4 to 16 interfaces towards the subscribers.

The units in the subrack are powered from the DC power supply (-48 VDC or -60 VDC nominal voltage) via the backplane, and optionally via DUPF1 or DUPF1-R (dual power interface). Each unit has its own power converter, i.e. no dedicated power converter units are used. The optional dual power supply unit DUPF1 or DUPF1-R allows the powering of the FOX615 R2 subrack from 2 redundant primary power supplies.

The FAMO1 fan unit provides active cooling for the FOX615 R2 and implements external alarm interfaces. Active cooling of the subrack allows to deploy any available core or service unit.

Without the FAMO1 unit, i.e. with passive cooling only the following core and service units can be used:

- CESM1-F [1],
- CESM2-F [1],
- SENC1F4,
- SENC1F8,
- SAMO5-F,
- SAMO2-F,
- ETOP1-F, ESOP1-F,
- DEFM1-F,
- EROP1-F,
- ELET1 [1], EPOI1, ESPO1,
- LEDE1, CEPI1 [2], SAMO1 [1], DATI1, EPSI1,
- LESU1,
- COSI1 [1],
- VFTLF [1],
- LEDS1, LECO1, LEDA1, LEXI1,
- TEPI1, TEPI2, OPIC1, OPIC2, TEGO1.

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1. The core units CESM1-F and CESM2-F will be supported in the FOX615 R2 subrack in a future release.
2. Passive cooling is restricted to specific hardware releases. Refer to section 2.2 FOX61x Traffic Units (on page 50).

> **i**
>
> **Please note:**
> The dual power supply unit DUPF1 or DUPF1-R feeding up to 30 A requires active cooling.
> → It must only be operated in a subrack equipped with the optional fan unit FAMO1.

> **i**
>
> **Please note:**
> The dual power supply unit DUPF1 or DUPF1-R feeding up to 25 A can be operated without active cooling.

The alarm unit FAMO1-F can be used in a passive cooling application to provide the external alarm interfaces for the FOX615 R2.

2.1.1.2 FOX615

The FOX615 uses a 19-inch subrack with 21 slots, one or two core units and up to 20 or 19 service units.

The FOX615 supports core and service units as listed in section 2.2 FOX61x Traffic Units (on page 50).

The FOX615 allows to implement 1:1 equipment protection for the core unit. The slots for the working core unit and the protecting core unit are slots 11 and 13, respectively. The slot concept with and without redundancy is shown in Figure 10.

> **i**
>
> **Please note:**
> The slot 13 of the FOX615 subrack is not usable for Ethernet service units.
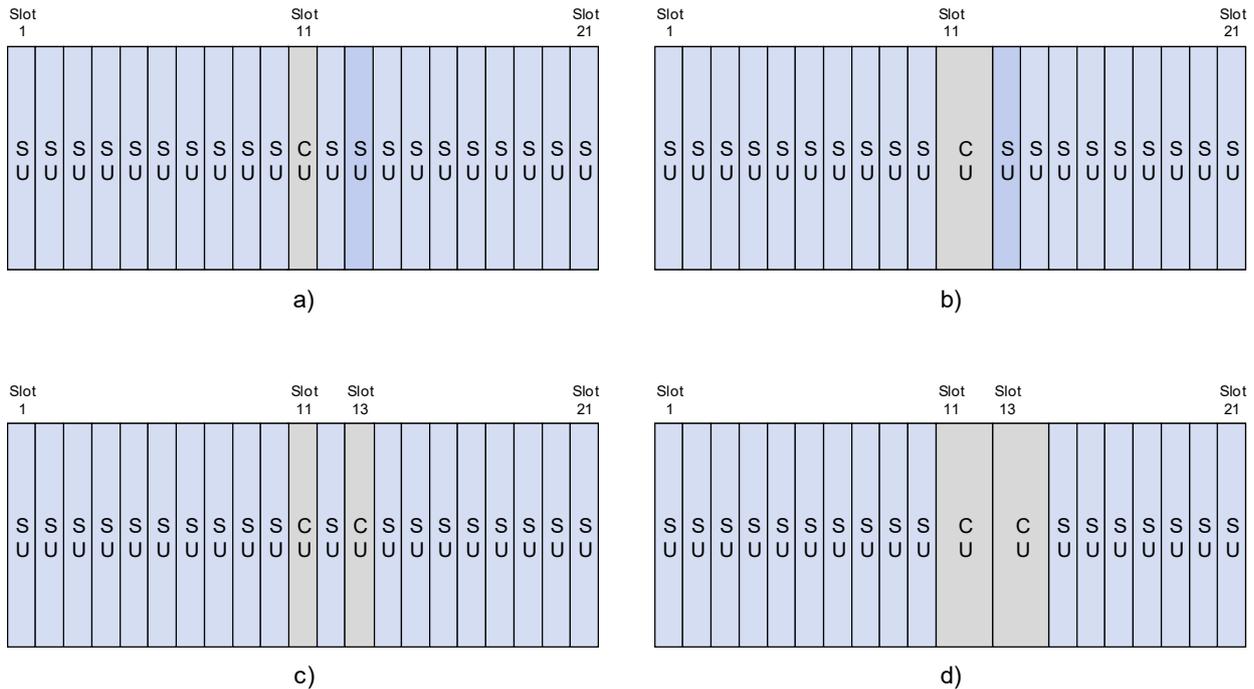
Figure 10:   Slot concept of the FOX615

Legend:

a FOX615 without core unit (CU) redundancy
   core unit with single slot width
   20 service units (SU)

b FOX615 without core unit (CU) redundancy
   core unit with double slot width
   19 service units (SU)

c   FOX615 with core unit (CU) redundancy
core unit with single slot width
19 service units (SU)

d   FOX615 with core unit (CU) redundancy
core unit with double slot width
17 service units (SU)

The service unit ELET1 offers 24 interfaces towards the subscribers; other service units offer 4 to 16 interfaces towards the subscribers.

The units in the subrack are powered from the DC power supply (-48 VDC or -60 VDC nominal voltage) via the backplane, and optionally via DUPF1 or DUPF1-R (dual power interface). Each unit has its own power converter, i.e. no dedicated power converter units are used. The optional dual power supply unit DUPF1 or DUPF1-R allows the powering of the FOX615 subrack from 2 redundant primary power supplies.

The FAMO1 fan unit provides active cooling for the FOX615 and implements external alarm interfaces. Active cooling of the subrack allows to deploy any available core or service unit.

Without the FAMO1 unit, i.e. with passive cooling only the following core and service units can be used:

- CESM1-F,
- CESM2-F,
- SENC1F4,
- SENC1F8,
- SAMO5-F,
- SAMO2-F,
- ETOP1-F, ESOP1-F,
- DEFM1-F,
- EROP1-F,
- ELET1 [1], EPOI1, ESPO1,
- LEDE1, CEPI1 [1], SAMO1 [1], DATI1, EPSI1,
- LESU1,
- COSI1 [1],
- VFTLF [1],
- LEDS1, LECO1, LEDA1, LEXI1,
- TEPI1, TEPI2, OPIC1, OPIC2, TEGO1.

> **i**   **Please note:**
> The dual power supply unit DUPF1 or DUPF1-R feeding up to 30 A requires active cooling.
>
> → It must only be operated in a subrack equipped with the optional fan unit FAMO1.

> **i**   **Please note:**
> The dual power supply unit DUPF1 or DUPF1-R feeding up to 25 A can be operated without active cooling.

The alarm unit FAMO1-F can be used in a passive cooling application to provide the external alarm interfaces for the FOX615.

---

1. Passive cooling is restricted to specific hardware releases. Refer to section 2.2 FOX61x Traffic Units (on page 50).

2.1.1.3   FOX612

The FOX612 uses a rack-mountable 19-inch subrack with 8 slots, used with one or two core units, and up to 6 or 7 of the service units.

The subrack is mounted horizontally into a 19-inch rack. Alternatively, the FOX612 can also be mounted vertically, e.g. on a wall.

The same core units and service units as with the FOX615 are used; please refer to section 2.2 FOX61x Traffic Units (on page 50).

The FOX612 allows to implement 1:1 equipment protection for the core unit. The slots for the working core unit and the protecting core unit are slots 11 and 13, as in the FOX615. The slot concept with and without redundancy is shown in Figure 11.

> **i**
>
> **Please note:**
> The slot 13 of the FOX612 subrack is not usable for Ethernet service units.
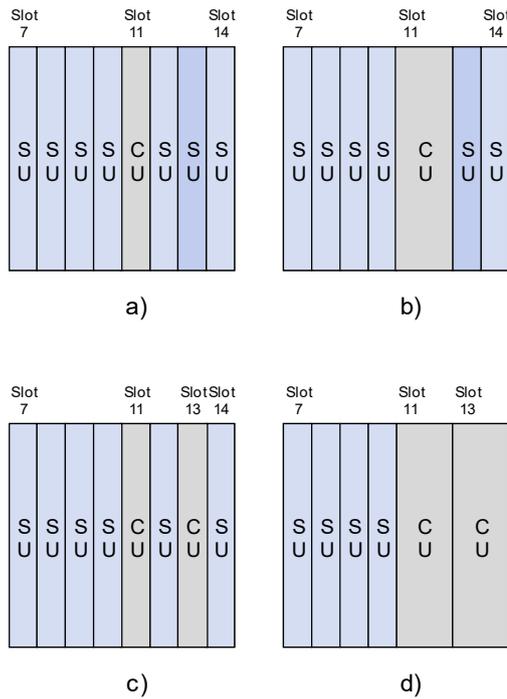
Figure 11:   Slot concept of the FOX612

Legend:

a   FOX612 without core unit (CU) redundancy
    core unit with single slot width
    7 service units (SU)

b   FOX612 without core unit (CU) redundancy
    core unit with double slot width
    6 service units (SU)

c   FOX612 with core unit (CU) redundancy
    core unit with single slot width
    6 service units (SU)

d   FOX612 with core unit (CU) redundancy
    core unit with double slot width
    4 service units (SU)

The units in the subrack are powered from the DC power supply (-48 VDC or -60 VDC nominal voltage) via the backplane, and optionally via DUPF2 (dual power interface). Each unit has its own power converter, i.e. no dedicated power converter units are used. The optional dual power supply unit DUPF2 allows the powering of the FOX612 subrack from 2 redundant primary power supplies.

The FAMO2 fan unit provides the active cooling for the FOX612 and implements external alarm interfaces. Active cooling of the subrack allows to deploy any available core or service unit.

Without the FAMO2 unit, i.e. with passive cooling, only the following core and service units can be used:

- CESM1-F,
- CESM2-F,
- SENC1F4,
- SENC1F8,
- SAMO5-F,
- SAMO2-F,
- ETOP1-F, ESOP1-F,
- DEFM1-F,
- EROP1-F,
- ELET1 [1], EPOI1, ESPO1,
- LEDE1, CEPI1 [1], SAMO1 [1], DATI1, EPSI1,
- LESU1,
- COSI1 [1],
- VFTLF [1],
- LEDS1, LECO1, LEDA1, LEXI1,
- TEPI1, TEPI2, OPIC1, OPIC2, TEGO1.

The alarm unit FAMO2-F can be used in a passive cooling application to provide the external alarm interfaces for the FOX612.

> [i] **Please note:**
> Passive cooling with the horizontally mounted FOX612 subrack is not possible.
> → A horizontally mounted FOX612 subrack requires active cooling with a fan unit.

2.1.1.4   FOX611

The FOX611 uses a rack-mountable 19-inch subrack with 4 slots, used with one core unit, and up to 3 of the service units.

The subrack is mounted horizontally into a 19-inch rack. Alternatively, the FOX611 can also be mounted vertically, e.g. on a wall.

The FOX611 supports the core units CESM1 and CESM2. The same service units as with the FOX615 are used; please refer to section 2.2 FOX61x Traffic Units (on page 50).

The FOX611 supports no 1:1 equipment protection for the core unit.

---

1. Passive cooling is restricted to specific hardware releases. Refer to section 2.2 FOX61x Traffic Units (on page 50).
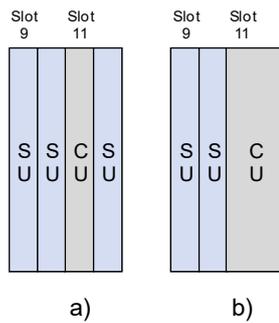
Figure 12:   Slot concept of the FOX611

Legend:

a   FOX611 with core unit (CU) with single slot width
    3 service units (SU)

b   FOX611 with core unit (CU) with double slot width
    2 service units (SU)

The units in the subrack are powered from the DC power supply (-48 VDC or -60 VDC nominal voltage) via the backplane, and optionally via DUPF2 (dual power interface). The DC power can also be provided by the optional AC/DC power converter POAC1. Each unit has its own power converter, i.e. no dedicated power converter units are used. The optional dual power supply unit DUPF2 allows the powering of the FOX611 subrack from 2 redundant primary power supplies.

The FAMO3 fan unit provides the active cooling for the FOX611 and implements external alarm interfaces. Active cooling of the subrack allows to deploy any available core or service unit.

Without the FAMO3 unit, i.e. with passive cooling, only the following core and service units can be used:

- CESM1-F,
- CESM2-F,
- SENC1F4,
- SENC1F8,
- SAMO5-F,
- SAMO2-F,
- ETOP1-F, ESOP1-F,
- DEFM1-F,
- EROP1-F,
- ELET1 [1], EPOI1, ESPO1,
- LEDE1, CEPI1 [1], SAMO1 [1], DATI1, EPSI1,
- LESU1,
- COSI1 [1],
- VFTLF [1],
- LEDS1, LECO1, LEDA1, LEXI1,
- TEPI1, TEPI2, OPIC1, OPIC2, TEGO1.

The alarm unit FAMO3-F can be used in a passive cooling application to provide the external alarm interfaces for the FOX611.

---

1. Passive cooling is restricted to specific hardware releases. Refer to section 2.2 FOX61x Traffic Units (on page 50).

| i |

Please note:

Passive cooling with the horizontally mounted FOX611 subrack is not possible.

→ A horizontally mounted FOX611 subrack requires active cooling with a fan unit.

2.1.2 Mechanical Design

2.1.2.1 Subrack Construction

The FOX615 R2, FOX615, FOX612 and FOX611 subracks provide the mechanical packaging for the units and the backplane with electrical connections to the bus structures and the power supply. The subracks are compact constructions with removable front covers. The covers provide apertures so that the LED indicators on the unit fronts remain visible even with the front cover installed. The FOX615 R2, the FOX615 and the FOX612 subracks are provided with a cable tray. The FOX611 has a 19-inch adapter used for the mounting of the optional AC/DC power converter POAC1.

The basic construction practice for the subracks and their auxiliary elements relies on the 19-inch standard. Adapters are available for ETSI installations.

Illustrations of the subracks with and without front cover are provided in

- Figure 21: "FOX615 R2 and FOX615 with front cover" (on page 47), and Figure 22: "FOX615 R2 and FOX615 subrack (sample) and cable tray without front cover" (on page 47) (both for FOX615 R2 and FOX615);
- Figure 24: "FOX612 with front cover (horizontal mounting)" (on page 49), and Figure 25: "FOX612 subrack (sample) without front cover (horizontal mounting)" (on page 49) (both for FOX612);
- Figure 26: "FOX611 with front cover (horizontal mounting)" (on page 50), and Figure 27: "FOX611 subrack (sample) without front cover (horizontal mounting)" (on page 50) (both for FOX611).

2.1.2.2 FOX615 R2 and FOX615 Subrack

The main dimensions of the FOX615 R2 and FOX615 subracks and the auxiliary elements are provided in Figure 13.

The total width, including mounting flanges for 19-inch mounting, of the FOX615 R2 and FOX615 subracks is 482.6 mm. The width of the subracks main body without the mounting flanges is 448.7 mm.
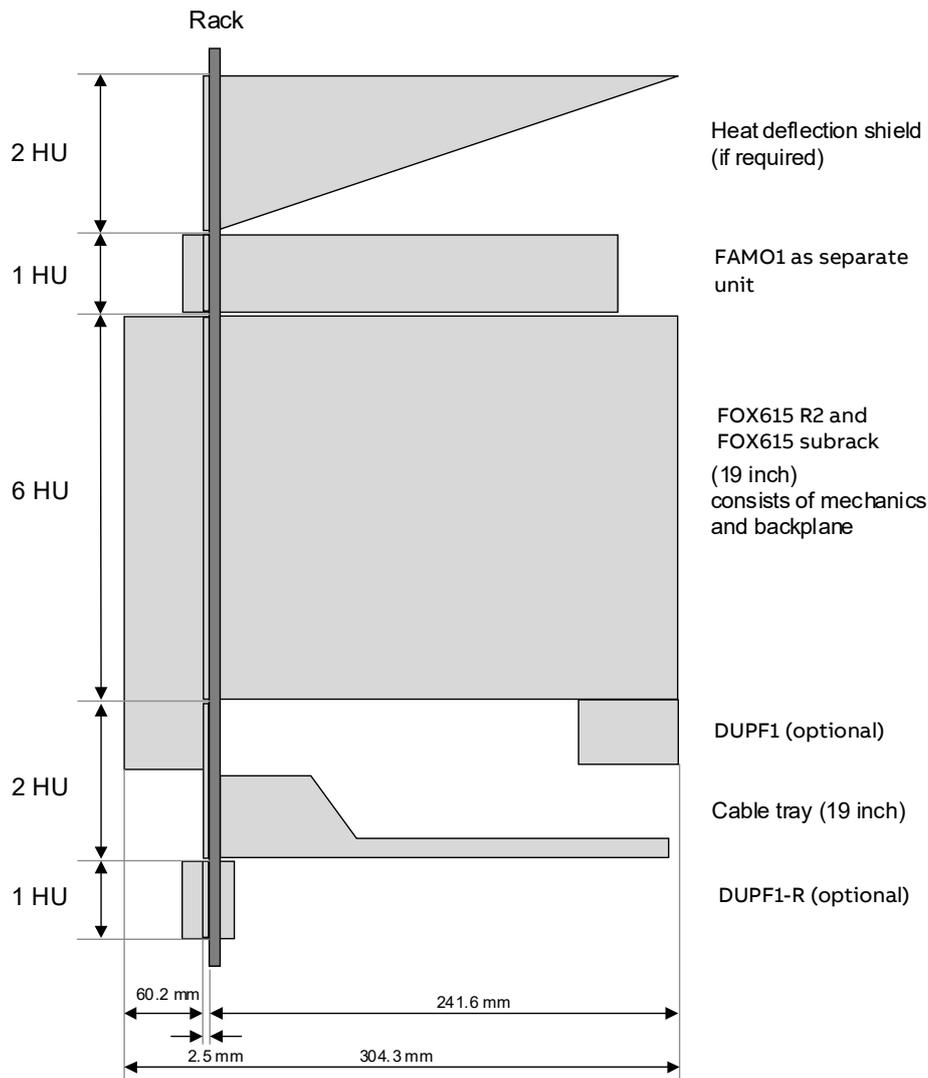
Figure 13:   FOX615 R2 and FOX615 subrack design and main dimensions (side view)

> ℹ **Please note:**
> The standard heat deflection shield has a height of 2 HU. For subrack installations with constricted room in a rack a heat deflection shield with a reduced height of 1 HU is available.

2.1.2.3   FOX612 Subrack

The main dimensions of the FOX612 subrack are provided in Figure 14.

The total width, including mounting flanges for 19-inch mounting, of the FOX612 subrack is 482.6 mm when mounted horizontally. The width of the subrack main body without the mounting flanges is 443.0 mm.
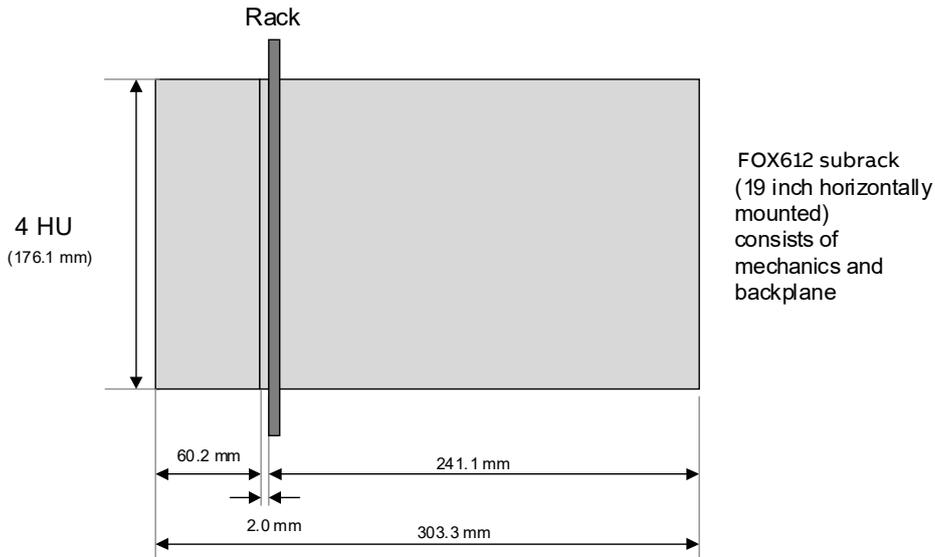
Figure 14:   FOX612 subrack design and main dimensions (side view)

2.1.2.4   FOX611 Subrack

The main dimensions of the FOX611 subrack are provided in Figure 15.

The total width, including mounting flanges for 19-inch mounting, of the FOX611 subrack is 482.6 mm when mounted horizontally. The width of the subrack main body without the mounting flanges is 437.3 mm.
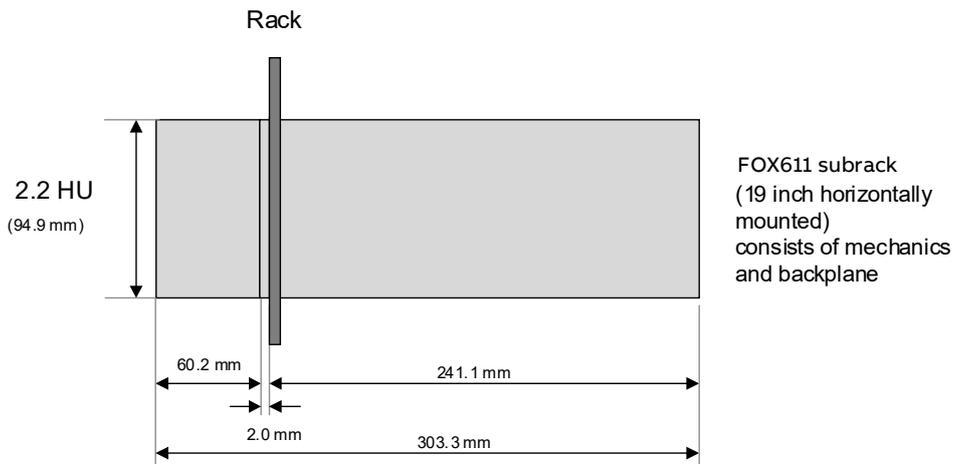
Figure 15:   FOX611 subrack design and main dimensions (side view)

2.1.2.5   Plug-in Units

All the plug-in units of the FOX61x are designed for standard subracks of 6 HU and have the same height, the same depth, and typically the same width (20.32 mm). The PCB size is 233 x 220 mm. The plug-in units fit into the FOX615 R2, FOX615, FOX612 and FOX611 subrack.

> **i**
>
> **Please note:**
> There are units using the double width of the typical plug-in units:
> → Width 40.64 mm.
> → FOX61x units with double width:
>   - CESM1-F
>   - CESM2-F
>   - SENC1F4

      - SENC1F8
      - SAMO5-F
      - SAMO2-F
      - SAMO3
      - ETOP1-F
      - ESOP1-F
      - EROP1-F
      - ELET1
      - DEFM1-F.

Two fixing screws secure the units plugged into the subrack. Two pull-out handles at the top and the bottom of the front of the unit help you to insert the units into and remove the units from the subrack.

A standardized connector system connects the signals of the units to the backplane. All units have access to the -48V / -60V DC power supply voltage. Packet based units feature connectors providing access to the 1 GbE star and/or to the 10 GbE star and to the sub-rack internal control bus (CBUS). TDM based units as e.g. the LEDE1, DATI1, or LESU1 have access to the TDM bus (PBUS) and to the CBUS.

Front connectors are provided for traffic and control signal interfaces. The standard con-nector for traffic signal interfaces provides a latching system that can be released with-out tools.
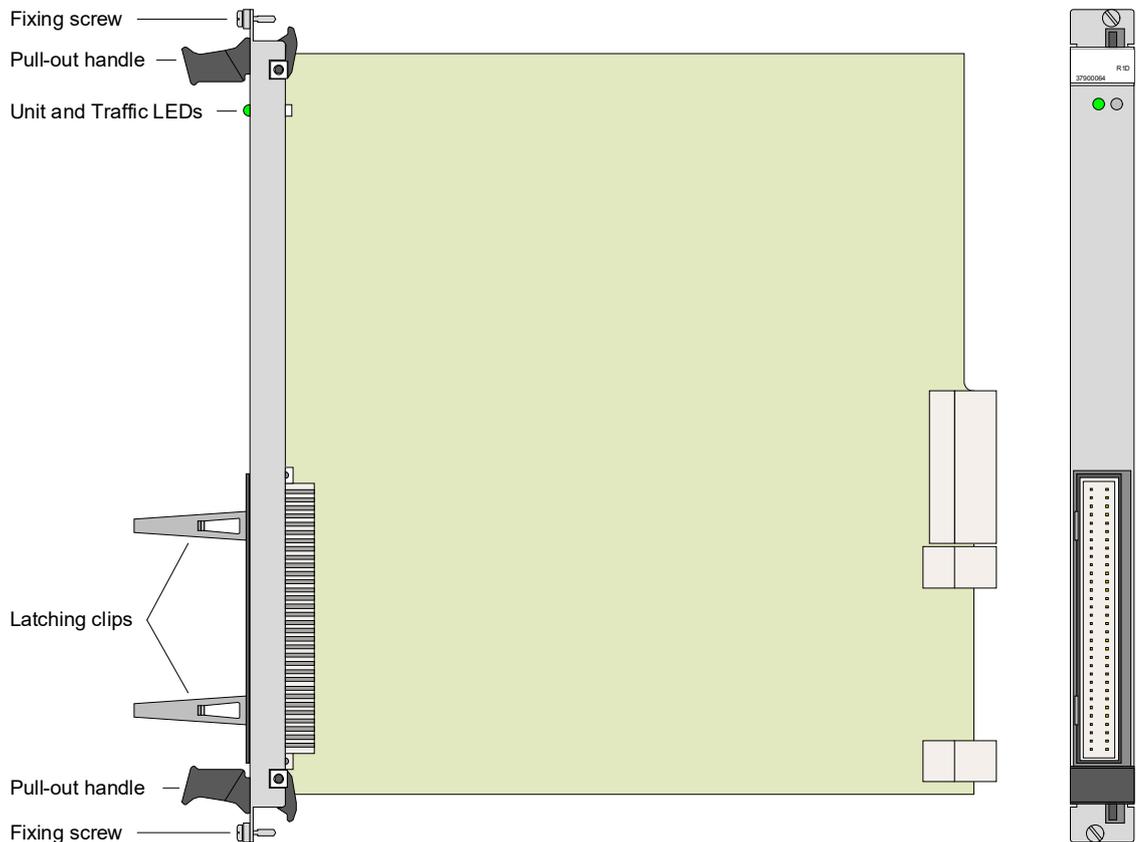
Figure 16:   Plug-in unit with standard front connector (sample)

2.1.2.6   Auxiliary Units

A fan unit (FAMO1) and a heat deflection shield for controlled air convection are available for the FOX615 R2 and FOX615. The monitoring of the fan operation is integrated in the FOX615 R2 and FOX615 monitoring and alarm system.

In applications with passive cooling, i.e. without the FAMO1 unit the optional alarm unit FAMO1-F can be deployed. FAMO1-F offers the same external alarm interfaces as the FAMO1.

The FOX615 R2 or FOX615 is powered from a single power supply (-48 VDC or -60 VDC). The connector is placed on the backplane. With the optional DUPF1 or DUPF1-R multi-connection device, the FOX615 R2 or FOX615 supports dual power supply from primary power supplies (-48 VDC or -60 VDC). The DUPF1 is incorporated in the FOX615 R2 or FOX615 subrack when installed. The DUPF1-R is installed below the cable tray of the FOX615 R2 or FOX615 subrack. The monitoring of the supplying batteries is integrated in the FOX615 R2 or FOX615 alarm system.

The FOX612 fan unit FAMO2 is mounted into a special slot of the subrack. The FAMO2 unit is monitored by the core unit. The monitoring of the fan operation is integrated in the FOX612 monitoring and alarm system.

In applications with passive cooling, i.e. without the FAMO2 unit the optional alarm unit FAMO2-F can be deployed. FAMO2-F offers the same external alarm interfaces as the FAMO2 (R3).

The FOX612 is powered from a single power supply (-48 VDC or -60 VDC). The connector is placed on the backplane. With the optional DUPF2 multi-connection device, the FOX612 supports dual power supply from primary power supplies (-48 VDC or -60 VDC). The connection device is mounted on the FOX612 cable tray when installed.

The FOX611 fan unit FAMO3 is mounted into a special slot of the subrack. The FAMO3 unit is monitored by the core unit. The monitoring of the fan operation is integrated in the FOX611 monitoring and alarm system.

In applications with passive cooling, i.e. without the FAMO3 unit the optional alarm unit FAMO3-F can be deployed. FAMO3-F offers the same external alarm interfaces as the FAMO3 (R2).

The FOX611 is powered from a single power supply (-48 VDC or -60 VDC). The connector is placed on the backplane. With the optional DUPF2 multi-connection device, the FOX611 supports dual power supply from primary power supplies (-48 VDC or -60 VDC). The connection device is mounted on the FOX611 19-inch adapter when installed.

The FOX611 can alternatively be powered from an mains power source. The AC/DC converter POAC1, as part of the FOX611 AC power kit, provides the necessary -48 VDC voltage for the subrack. The POAC1 unit is placed on the FOX611 19-inch adapter when installed.

2.1.2.7   Installation

The FOX615 R2 or FOX615 allows installation in 19-inch and ETSI racks. Four FOX615 R2 or FOX615 subracks can be installed in a 7 feet high 19-inch rack.

The FOX612 allows installation in 19-inch and ETSI racks. The FOX612 is typically mounted horizontally. Please refer to Figure 24: "FOX612 with front cover (horizontal mounting)" (on page 49) for a view on a horizontally mounted FOX612 subrack.

Vertical mounting of the FOX612 subrack is not typical for rack installations. ABB Power Grids provides no installation material to support this type of installation. Vertical installation is typically used with a wall mounting adapter.

The FOX611 can be installed in 19-inch racks. The FOX611 is typically mounted horizontally. Please refer to Figure 26: "FOX611 with front cover (horizontal mounting)" (on page 50) for a view on a horizontally mounted FOX611 subrack.

Vertical mounting of the FOX611 subrack can be done e.g. directly on a wall. ABB Power Grids provides no installation material to support this type of installation.

2.1.3   Internal Traffic Communication

2.1.3.1   FOX615 R2

> **i**
>
> **Please note:**
> The core units CESM1, CESM1-F, CESM2 and CESM2-F will be supported in the FOX615 R2 subrack in a future release.

> ℹ️ **Please note:**
> The core units CESM1, CESM1-F, CESM2 and CESM2-F do not support the 40 GbE double star.
>
> → To access the double 40 GbE star you have to use the core unit CESM3.

> ℹ️ **Please note:**
> The core units CESM1, CESM1-F, CESM2 and CESM2-F do not support the 10 GbE double star.
>
> → To access the double 10 GbE star you have to use the core unit CESM3.

The FOX615 R2 provides a set of bus systems in the backplane for the internal traffic transport:

- 40 GbE double star:

  A double star architecture interconnecting independently slot 9 and slot 15 with 40 Gbit/s to the core unit slot and 40 Gbit/s to the redundant core unit slot. Accordingly, each 40 GbE star consists of 2 serial 40 Gbit/s Ethernet links.

  The 40 GbE double star provides the internal Ethernet connections for the WAN port expansion unit EPEX1.

- 10 GbE double star:

  A double star architecture interconnecting independently every slot with 10 Gbit/s to the core unit slot and 10 Gbit/s to the redundant core unit slot. Accordingly, each 10 GbE star consists of 20 serial 10 Gbit/s Ethernet links, plus two 10 Gbit/s Ethernet point-to-point connections between the two core unit slots, which are used with core unit equipment protection (see section 4.6 Protection Concept (on page 150)).

  The 10 GbE double star can provide the internal Ethernet connections of the FOX61x Switch and the external connections to stand alone bridge units.

- 10 Gbit/s point-to-point connections:

  There are additional 10 Gbit/s point-to-point connections between the service units in slot 4 and 6 and between service units in slot 18 and 20.

  These connections can be used for equipment protection of service units, e.g. SAMO2.

- GbE double star:

  A double star architecture interconnecting independently every slot with 1 Gbit/s to the core unit slot and 1 Gbit/s to the redundant core unit slot. Accordingly, each GbE star consists of 20 serial Gbit/s Ethernet links, including a 1 Gbit/s Ethernet point-to-point connection between the two core unit slots, which is used with core unit equipment protection (see section 4.6 Protection Concept (on page 150)).

  The GbE double star can provide the internal Ethernet connections of the FOX61x Switch and the external connections to stand alone bridge units.

- CBUS:

  The CBUS contains signals used for the interworking of the units in a subrack, like control signals, clock lines, chassis ground and power supply.

- PBUS:

  The PBUS is a TDM bus offering a capacity of 128 x 2 Mbit/s for TDM traffic. The PBUS is used in the TDM voice and data applications. The PBUS allows placement of any TDM service unit in any of the slots 1 to 21 (except slot 11 which is reserved for the core unit), and creation of cross connections between these TDM service units. For more details refer to section 6.4.1 Architecture (on page 184).

Figure 17: FOX615 R2 internal bus systems

2.1.3.2 FOX615

| i |

Please note:
The core units CESM1, CESM1-F, CESM2 and CESM2-F do not support the 10 GbE double star.

→ To access the double 10 GbE star you have to use the core unit CESM3.

The FOX615 provides a set of bus systems in the backplane for the internal traffic transport:

- 10 GbE double star:

  A double star architecture interconnecting independently every slot with 10 Gbit/s to the core unit slot and 10 Gbit/s to the redundant core unit slot. Accordingly, each 10 GbE star consists of 20 serial 10 Gbit/s Ethernet links, plus two 10 Gbit/s Ethernet point-to-point connections between the two core unit slots, which are used with core unit equipment protection (see section 4.6 Protection Concept (on page 150)).

  The 10 GbE double star can provide the internal Ethernet connections of the FOX61x Switch and the external connections to stand alone bridge units.

43

- 10 Gbit/s point-to-point connections:

  There are additional 10 Gbit/s point-to-point connections between the service units in slot 4 and 6 and between service units in slot 18 and 20.

  These connections can be used for equipment protection of service units, e.g. SAMO2.

- GbE double star:

  A double star architecture interconnecting independently every slot with 1 Gbit/s to the core unit slot and 1 Gbit/s to the redundant core unit slot. Accordingly, each GbE star consists of 20 serial Gbit/s Ethernet links, including a 1 Gbit/s Ethernet point-to-point connection between the two core unit slots, which is used with core unit equipment protection (see section 4.6 Protection Concept (on page 150)).

  The GbE double star can provide the internal Ethernet connections of the FOX61x Switch and the external connections to stand alone bridge units.

- CBUS:

  The CBUS contains signals used for the interworking of the units in a subrack, like control signals, clock lines, chassis ground and power supply.

- PBUS:

  The PBUS is a TDM bus offering a capacity of 128 x 2 Mbit/s for TDM traffic. The PBUS is used in the TDM voice and data applications. The PBUS allows placement of any TDM service unit in any of the slots 1 to 21 (except slot 11 which is reserved for the core unit), and creation of cross connections between these TDM service units. For more details refer to section 6.4.1 Architecture (on page 184).

Figure 18:   FOX615 internal bus systems

2.1.3.3   FOX612

> **i**
>
> **Please note:**
> The core units CESM1, CESM1-F, CESM2 and CESM2-F do not support the 10 GbE double star.
>
> → To access the double 10 GbE star you have to use the core unit CESM3.

The FOX612 provides basically the same set of bus systems in the backplane for the internal traffic transport as the FOX615:

- 10 GbE double star:

  A double star architecture interconnecting independently every slot with 10 Gbit/s to the core unit slot and 10 Gbit/s to the redundant core unit slot. Accordingly, each 10 GbE star consists of 7 serial 10 Gbit/s Ethernet links, plus two 10 Gbit/s Ethernet point-to-point connections between the two core unit slots, which are used with core unit equipment protection (see section 4.6 Protection Concept (on page 150)).

  The 10 GbE double star can provide the internal Ethernet connections of the FOX61x Switch and the external connections to stand alone bridge units.

- 10 Gbit/s point-to-point connections:

  There are additional 10 Gbit/s point-to-point connections between service units in slot 7 and 9.

  These connections can be used for equipment protection of service units, e.g. SAMO2.

- GbE double star:

  A double star architecture interconnecting independently every slot with 1 Gbit/s to the core unit slot and 1 Gbit/s to the redundant core unit slot. Accordingly, each GbE star consists of 7 serial Gbit/s Ethernet links, including a 1 Gbit/s Ethernet point-to-point connection between the two core unit slots, which is used with core unit equipment protection (see section 4.6 Protection Concept (on page 150)).

  The GbE double star can provide the internal Ethernet connections of the FOX61x Switch and the external connections to stand alone bridge units.

- CBUS:

  The CBUS contains signals used for the interworking of the units in a subrack, like control signals, clock lines, chassis ground and power supply.

- PBUS:

  The PBUS is a TDM bus offering a capacity of 128 x 2 Mbit/s for TDM traffic. The PBUS is used in the TDM voice and data applications. The PBUS allows placement of any TDM service unit in any of the slots 7 to 14 (except slot 11 which is reserved for the core unit), and creation of cross connections between these TDM service units. For more details refer to section 6.4.1 Architecture (on page 184).
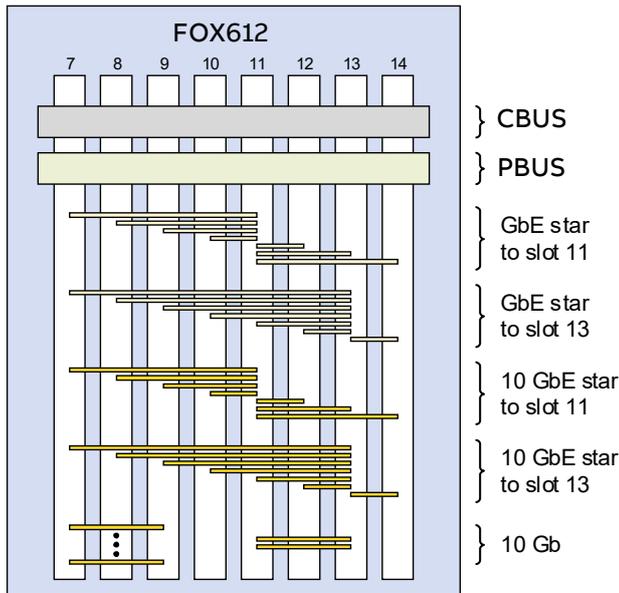
Figure 19:   FOX612 internal bus systems

2.1.3.4   FOX611

The FOX611 bus systems in the backplane are a subset of the FOX615 bus system:

- GbE star:

  A star architecture interconnecting independently every slot with 1 Gbit/s to the core unit slot. Accordingly, each GbE star consists of 3 serial Gbit/s Ethernet links.

  The GbE star can provide the internal Ethernet connections of the FOX61x Switch and the external connections to stand alone bridge units.

- CBUS:

  The CBUS contains signals used for the interworking of the units in a subrack, like control signals, clock lines, chassis ground and power supply.

- PBUS:

  The PBUS is a TDM bus offering a capacity of 128 x 2 Mbit/s for TDM traffic. The PBUS is used in the TDM voice and data applications. The PBUS allows placement of any TDM service unit in any of the slots 9 to 12 (except slot 11 which is reserved for the core unit), and creation of cross connections between these TDM service units. For more details refer to section 6.4.1 Architecture (on page 184).
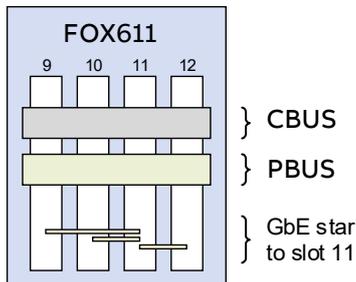
Figure 20:   FOX611 internal bus systems

2.1.4   Views

2.1.4.1   FOX615 R2 and FOX615

The FOX615 R2 and FOX615 have front access for all signal and power cables. A removable cover closes the front of the subrack. The cable tray below the subrack allows for an easy installation of the signal cables.

The construction of the subrack and the cable connections provide Faraday cage like EMC characteristics, provided that the front cover is installed and that the signal cables have been installed and shielded as instructed.
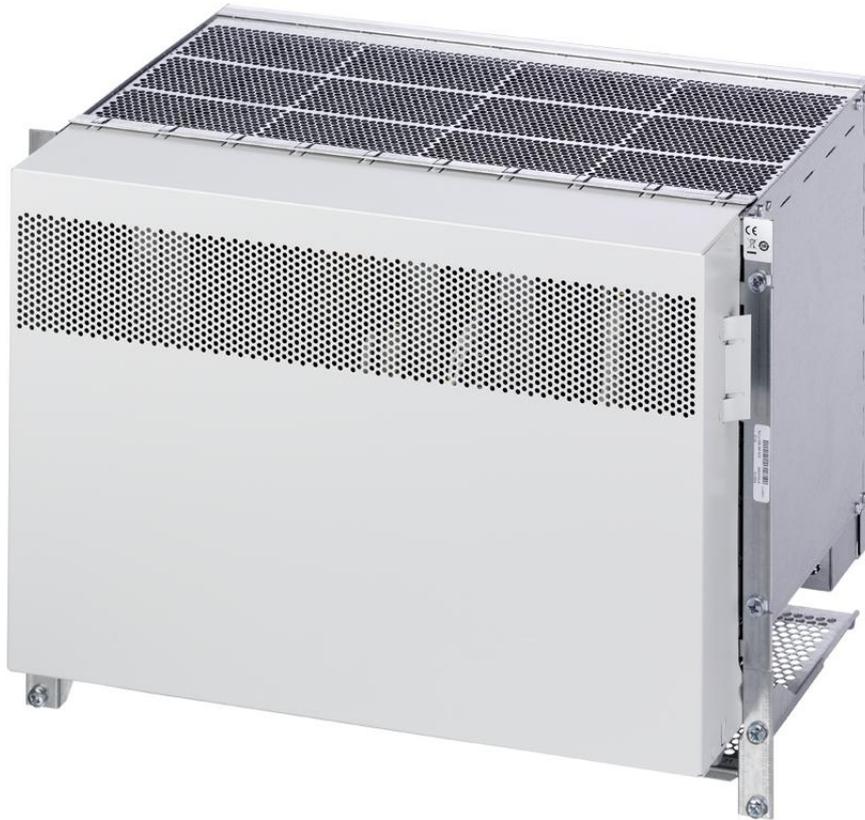
Figure 21:   FOX615 R2 and FOX615 with front cover

Figure 22:   FOX615 R2 and FOX615 subrack (sample) and cable tray without front cover
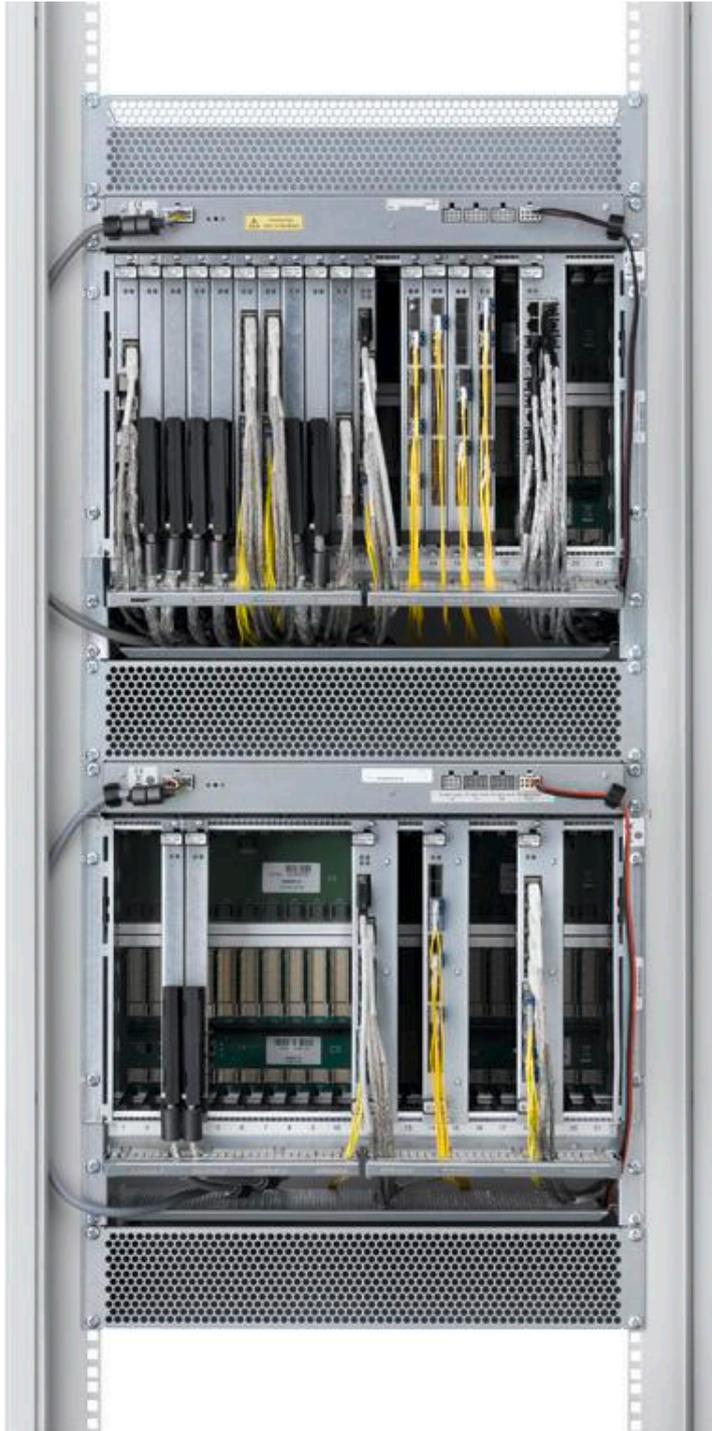
Figure 23:   FOX615 R2 and FOX615 installation with FAMO1 and heat deflection shields

2.1.4.2   FOX612

The FOX612 has front access for all signal and power cables. A removable cover closes the front of the subrack. The cables are led to the right side of the horizontally mounted subrack and are fixed to a cable flange as shown in Figure 25.

As for the FOX615 R2 or FOX615, the construction of the subrack and the cable connections provide Faraday cage like EMC characteristics, provided that the front cover is installed (as shown in Figure 24) and that the signal cables have been installed and shielded as instructed.

Figure 24:   FOX612 with front cover (horizontal mounting)
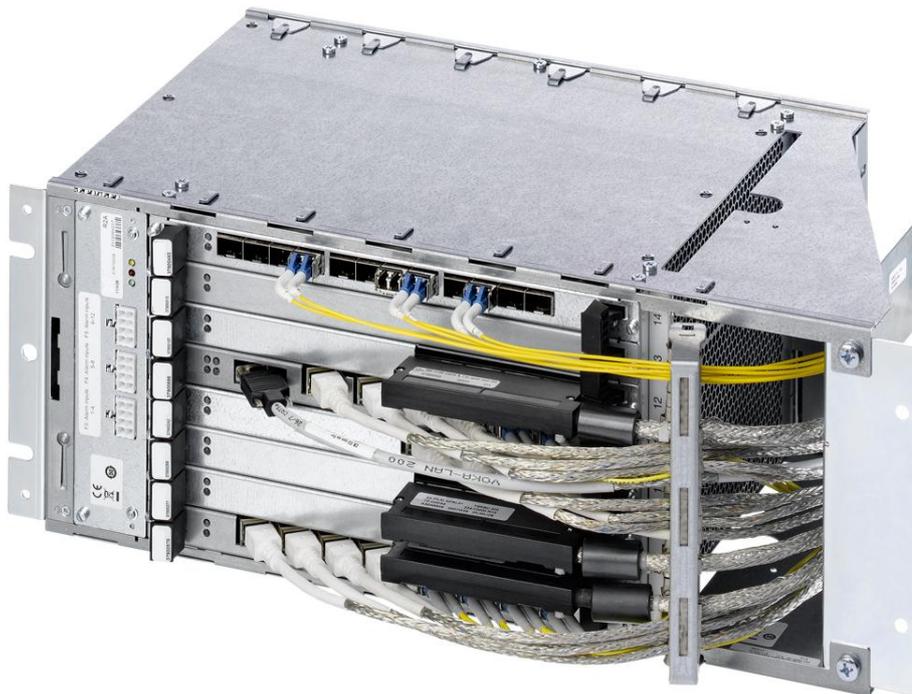
Figure 25:   FOX612 subrack (sample) without front cover (horizontal mounting)

2.1.4.3   FOX611

The FOX611 has front access for all signal and power cables. A removable cover closes the front of the subrack. The cables are led to the right side of the horizontally mounted subrack.

As for the FOX615 R2 or FOX615, the construction of the subrack and the cable connections provide Faraday cage like EMC characteristics, provided that the front cover is

installed (as shown in Figure 26) and that the signal cables have been installed and shielded as instructed.

Figure 26:   FOX611 with front cover (horizontal mounting)

Figure 27:   FOX611 subrack (sample) without front cover (horizontal mounting)

2.2   FOX61x Traffic Units

There are eight different groups of FOX61x units:
- Core units with access to the GbE star:
  - CESM3 (refer to section 2.2.1 Core Unit CESM3 (on page 55))
  - CESM2 and CESM2-F (refer to section 2.2.2 Core Unit CESM2 and CESM2-F (on page 58))
  - CESM1 and CESM1-F (refer to section 2.2.3 Core Unit CESM1 and CESM1-F (on page 61))
- Core units with access to the 10 GbE star:
  - CESM3 (refer to section 2.2.1 Core Unit CESM3 (on page 55))
- Service units with access to the GbE star:

> **i** **Please note:**
> The service units ETOP1, ELET1, EPOI1, ESOP1, ESPO1, DEFM1, EROP1, SAMO2, SAMO3, SAMO5 use the GbE star access only, when the subrack is operated with a CESM1 or CESM2 core unit. When the subrack is operated with a CESM3 core unit the service units access the 10 GbE star for the transport of user traffic.

- SENC1-4, SENC1F4, SENC1-8 and SENC1F8, if enabled by a DIP-switch (refer to section 2.2.5 Encryption Unit SENC1-4, SENC1F4, SENC1-8 and SENC1F8 (on page 65))
- ETOP1 and ETOP1-F (refer to section 2.2.6 Ethernet Service Units ETOP1 and ETOP1-F (on page 68)). The GbE star is only used with the core unit CESM1 or CESM2.
- ELET1 (refer to section 2.2.7 Ethernet Service Unit ELET1 (on page 69))
- EPOI1 (refer to section 2.2.8 Ethernet Service Unit EPOI1 (on page 71))
- ESOP1 and ESOP1-F (refer to section 2.2.11 Ethernet Service Units ESOP1 and ESOP1-F (on page 75))
- ESPO1 (refer to section 2.2.12 Ethernet Service Unit ESPO1 (on page 77))
- DEFM1 and DEFM1-F (refer to section 2.2.9 Ethernet service unit DEFM1 and DEFM1-F (on page 72))
- EROP1 and EROP1-F (refer to section 2.2.10 Ethernet Service Units EROP1 and EROP1-F (on page 74))
- SAMO1 (refer to section 2.2.14 SDH and EoS Service Unit SAMO1 (on page 80))
- SAMO2 and SAMO2-F (refer to section 2.2.15 SDH and EoS Service Unit SAMO2 and SAMO2-F (on page 81))
- SAMO3 (refer to section 2.2.16 SDH and EoS Service Unit SAMO3 (on page 83))
- SAMO5 and SAMO5-F (refer to section 2.2.17 SDH and EoS Service Unit SAMO5 and SAMO5-F (on page 84))
- CEPI1 (refer to section 2.2.19 E1 Circuit Emulation Service Unit CEPI1 (on page 87))
- COSI1 (refer to section 2.2.21 Media Gateway Unit COSI1 (on page 90))
- EPSI1 (refer to section 2.2.13 Ethernet Service Unit EPSI1 (on page 78))
- TEPI2 (refer to section 2.2.29 Teleprotection Signaling and Binary Signal Service Unit TEPI2 (on page 101))
- OPIC2 (refer to section 2.2.31 Differential Protection Service Unit OPIC2 (on page 103))
- TEGO1 (refer to section 2.2.32 IEC 61850 GOOSE and SV Proxy Gateway Unit TEGO1 (on page 104))
- Service units with access to the 10 GbE star:

> **i** **Please note:**
> The slot 1, slot 8 to slot 15, and slot 21 of the FOX615 R2 subrack using the CESM3 core unit are not usable for 10 Gb Ethernet service units.
> → The support of 10 Gb Ethernet service units in the slot 9 and slot 15 of the FOX615 R2 subrack using the CESM3 core unit will be available in a future release.

- ETOP1 and ETOP1-F (refer to section 2.2.6 Ethernet Service Units ETOP1 and ETOP1-F (on page 68))
- ELET1 (refer to section 2.2.7 Ethernet Service Unit ELET1 (on page 69))
- EPOI1 (refer to section 2.2.8 Ethernet Service Unit EPOI1 (on page 71))
- ESOP1 and ESOP1-F (refer to section 2.2.11 Ethernet Service Units ESOP1 and ESOP1-F (on page 75))
- ESPO1 (refer to section 2.2.12 Ethernet Service Unit ESPO1 (on page 77))
- DEFM1 and DEFM1-F (refer to section 2.2.9 Ethernet service unit DEFM1 and DEFM1-F (on page 72))

- EROP1 and EROP1-F (refer to section 2.2.10 Ethernet Service Units EROP1 and EROP1-F (on page 74))
- SAMO2 and SAMO2-F (refer to section 2.2.15 SDH and EoS Service Unit SAMO2 and SAMO2-F (on page 81))
- SAMO3 (refer to section 2.2.16 SDH and EoS Service Unit SAMO3 (on page 83))
- SAMO5 and SAMO5-F (refer to section 2.2.17 SDH and EoS Service Unit SAMO5 and SAMO5-F (on page 84))
- Service units with access to the 40 GbE star:
  - EPEX1 (refer to section 2.2.4 WAN Port Expansion Unit EPEX1 (on page 64))
- Service units with access to the PBUS (TDM bus):
  - LESU1 (refer to section 2.2.23 PSTN Service Units LESU1 (on page 93))
  - LEDA1 (refer to section 2.2.24 E&M Voice Service Unit LEDA1 (on page 94))
  - LEXI1 (refer to section 2.2.25 FXO Voice Service Unit LEXI1 (on page 95))
  - LEDS1 (refer to section 2.2.26 Data Service Unit LEDS1 (on page 97))
  - LECO1 (refer to section 2.2.27 E0 Service Unit LECO1 (on page 99))
  - LEDE1 (refer to section 2.2.18 E1 Service Unit LEDE1 (on page 86))
  - DATI1 (refer to section 2.2.20 TDM SHDSL Service Unit DATI1 (on page 88))
  - SAMO1 (refer to section 2.2.14 SDH and EoS Service Unit SAMO1 (on page 80))
  - SAMO2 and SAMO2-F (refer to section 2.2.15 SDH and EoS Service Unit SAMO2 and SAMO2-F (on page 81))
  - SAMO3 (refer to section 2.2.16 SDH and EoS Service Unit SAMO3 (on page 83))
  - SAMO5 and SAMO5-F (refer to section 2.2.17 SDH and EoS Service Unit SAMO5 and SAMO5-F (on page 84))
  - CEPI1 (refer to section 2.2.19 E1 Circuit Emulation Service Unit CEPI1 (on page 87))
  - COSI1 (refer to section 2.2.21 Media Gateway Unit COSI1 (on page 90))
  - VFTLF (refer to section 2.2.22 Voice Frequency Processing Unit VFTLF (on page 92))
  - EPSI1 (refer to section 2.2.13 Ethernet Service Unit EPSI1 (on page 78))
  - TEPI1 (refer to section 2.2.28 Teleprotection Signaling and Binary Signal Service Unit TEPI1 (on page 100))
  - OPIC1 (refer to section 2.2.30 Differential Protection Service Unit OPIC1 (on page 102))
  - OPIC2 (refer to section 2.2.31 Differential Protection Service Unit OPIC2 (on page 103))
- Service units with no backplane traffic access:
  - SENC1-4, SENC1F4, SENC1-8 and SENC1F8, if disabled by a DIP-switch (refer to section 2.2.5 Encryption Unit SENC1-4, SENC1F4, SENC1-8 and SENC1F8 (on page 65))
- Auxiliary units:
  - DUPF1 (FOX615 R2 and FOX615, refer to section 2.3.1 Dual Power Input Unit DUPF1 (FOX615 R2 and FOX615) (on page 105))
  - DUPF1-R (FOX615 R2 and FOX615 only, refer to section 2.3.2 Dual Power Input Unit DUPF1-R (FOX615 R2 and FOX615) (on page 106))
  - DUPF2 (FOX612 and FOX611, refer to section 2.3.3 Dual Power Input Unit DUPF2 (FOX612 and FOX611) (on page 107))
  - FAMO1 (FOX615 R2 and FOX615, refer to section 2.3.4 Fan Unit FAMO1 (FOX615 R2 and FOX615) (on page 108))
  - FAMO2 (FOX612 only, refer to section 2.3.5 Fan Unit FAMO2 (FOX612) (on page 109))
  - FAMO3 (FOX611 only, refer to section 2.3.6 Fan Unit FAMO3 (FOX611) (on page 110))
  - FAMO1-F (FOX615 R2 and FOX615, refer to section 2.3.7 Alarm Unit FAMO1-F (FOX615 R2 and FOX615) (on page 110))

- – FAMO2-F (FOX612 only, refer to section 2.3.8 Alarm Unit FAMO2-F (FOX612) (on page 111))
- – FAMO3-F (FOX611 only, refer to section 2.3.9 Alarm Unit FAMO3-F (FOX611) (on page 112))
- – AFOU1 (refer to section 2.3.10 Air Flow Optimization Unit AFOU1 (on page 112))

The Figure 28 shows the implementation of the core unit and the different service units in the FOX615 R2, FOX615, FOX612 or FOX611. The traffic flow is from the network side to the customer side and vice versa.

Further below you will find a view and a description of the features of each of the FOX61x units.
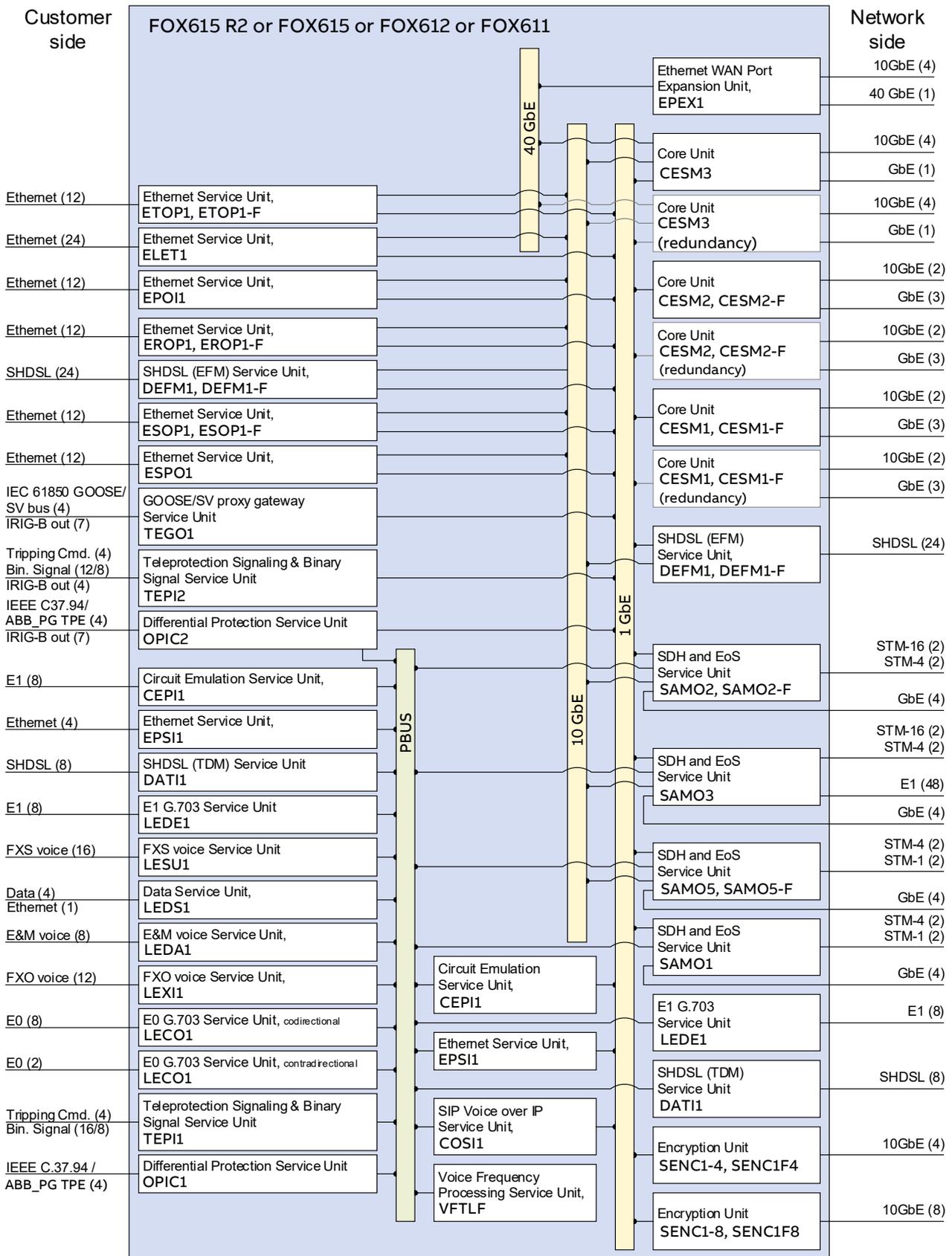
Figure 28: Unit implementation in the FOX615 R2, FOX615, FOX612 and FOX611

> **ⓘ** **Please note:**
> The FOX611 does not support a redundant core unit.

> **ⓘ** **Please note:**
> The term "ABB_PG" in Figure 28 stands for "ABB Power Grids".

2.2.1 Core Unit CESM3

Figure 29: CESM3 unit view

The CESM3 is the 1-slot wide core unit of the FOX615 R2, FOX615 and FOX612. It must be operated in an actively cooled FOX61x subrack.

The core unit CESM3 comprises functions for the whole network element (NE) and for the core unit itself:

Main NE functions:

- Management and control of the FOX61x subrack and all plug-in units,
- Database to store management information,
- Control of the system operation.
- Monitoring of the system performance.
- PDH and Ethernet synchronization functions.
- Local management Ethernet interface.
- Management communication, including routing functions.
  - Support of SSH for the management communication.

- – Support of SNMP for the management communication.
- Access to the alarm interfaces on the fan or alarm unit.

Main core unit functions:

- Ethernet VLAN Bridge as function of the FOX61x Switch between the CESM3 Ethernet front ports and the Ethernet service unit ports.
- MPLS-TP Transport as function of the FOX61x Switch between the CESM3 Ethernet front ports and the Ethernet service unit ports.
- Five Ethernet traffic front ports, four SFP+ based 10 GbE interfaces and one 10/100/ 1000BASE-T interface.
- Support of PTP for electrical and optical Ethernet traffic front interfaces.
  - – PTP Boundary Clock
  - – PTP Ordinary Clock
  - – PTP Transparent Clock
- Support of RSTP (802.1D-2004, compatible with STP) for electrical and optical Ethernet traffic front interfaces.
- Support of VLAN QoS with Class of Service (CoS) handling (802.1Q): 8 CoS by eight priority queues, with strict priority scheduling or weighted round robin (WRR) scheduling per queue.
- Configurable egress queue sizes using a customer specific CPS.

The core unit features 1:1 equipment protection with switch-over time below 50 ms (for details refer to section 4.6.2 Equipment Protection of the Core Unit (on page 150)).

The interfaces at the front panel of the core unit CESM3 are shown in Figure 30.

ESI/ESO synchronization
interfaces

ETR synchronization interfaces

Electrical 10/100/1000BASE-T interface
(local management port)

Electrical 10/100/1000BASE-T interface
(traffic interface)

SFP/SFP+ module cages:
Optical GbE or 10GbE interfaces
(traffic interfaces)
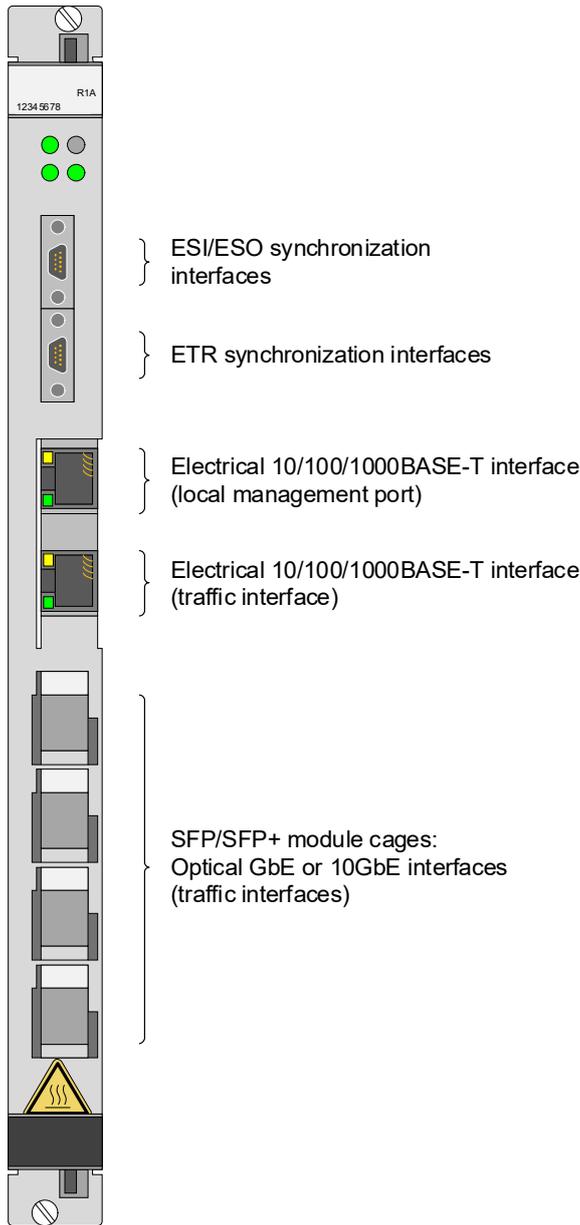
Figure 30:   CESM3 interfaces

CESM3 comprises four SFP+ (Small Form factor Pluggable) cages which can be equipped
with industry standard electrical or optical 1000BASE-xx transceivers (SFP modules), or
optical 10GBASE-xx transceivers (SFP+ modules) and used as traffic interfaces. The SFP or
SFP+ modules are not included with the CESM3 unit by default.

One electrical 10/100/1000BASE-T interfaces is also usable as traffic interface.

For the VLAN Bridge function all five traffic interfaces can be configured to be used as
access port, trunk port, trunk with native VLAN port or general port, individually per port.

For the MPLS-TP Transport function all five traffic interfaces can be configured to be used
as Pseudo Wire Access Circuit port or as MPLS-TP physical port or as MPLS-TP logical port
(subinterface), individually per port.

Four of the five Ethernet ports support the PTP protocol and can be used as slave or mas-
ter PTP ports.

In addition, the core unit also offers an Ethernet port for the local management access
(electrical 10/100BASE-TX).

The CESM3 unit offers synchronization I/O signals (two symmetrical clock inputs and two
symmetrical clock outputs, 120 Ohm, 2048kHz). Two inputs and one output are used for

PDH reference clock signals on the FOX61x. One input and one output are used for SDH reference clock signals.

The ETR interface provides a PPS output to synchronize external equipment.

> **i**   **Please note:**
> The "time of day" input/output and the "pulse per second" input interfaces will be supported in a future release.

The CESM3 has four LEDs for the indication of unit and traffic failures.

2.2.2   Core Unit CESM2 and CESM2-F

Figure 31:   CESM2 (left) and CESM2-F (right) unit view

> **i**   **Please note:**
> The core units CESM2 and CESM2-F will be supported in the FOX615 R2 sub-rack in a future release.

The CESM2 is the 1-slot wide core unit of the FOX615 R2, FOX615, FOX612 and FOX611. It must be operated in an actively cooled FOX61x subrack.

The CESM2-F is the 2-slot wide core unit of the FOX615 R2, FOX615, FOX612 and FOX611. It can be operated in actively and passively cooled FOX61x subracks.

CESM2 and CESM2-F are functionally identical. In the following the term "CESM2" is thus used to name the core units CESM2 and CESM2-F.

The core unit CESM2 comprises functions for the whole network element (NE) and for the core unit itself:

Main NE functions:

- Management and control of the FOX61x subrack and all plug-in units,
- Database to store management information,
- Control of the system operation.
- Monitoring of the system performance.
- PDH and Ethernet synchronization functions.
- Local management Ethernet interface.
- Management communication, including routing functions.
  - Support of SSH for the management communication.
  - Support of SNMP for the management communication.
- Access to the alarm interfaces on the fan or alarm unit.
- Management of the feature licenses.

Main core unit functions:

- Ethernet VLAN Bridge as function of the FOX61x Switch between the CESM2 Ethernet front ports and the Ethernet service unit ports.
- MPLS-TP Transport as function of the FOX61x Switch between the CESM2 Ethernet front ports and the Ethernet service unit ports.
- Five Ethernet traffic front ports, two SFP+ based 10 GbE interfaces, two SFP based 1 GbE interfaces and one 10/100/1000BASE-T interface.
- Support of PTP for electrical and optical Ethernet traffic front interfaces.
  - PTP Grand Master Clock
  - PTP Boundary Clock
  - PTP Ordinary Clock
  - PTP Transparent Clock
- Support of RSTP (802.1D-2004, compatible with STP) and MSTP (802.1Q) for electrical and optical Ethernet traffic front interfaces.
- Support of VLAN QoS with Class of Service (CoS) handling (802.1Q): 8 CoS by eight priority queues, with strict priority scheduling or weighted round robin (WRR) scheduling per queue.
- Configurable egress queue sizes using a customer specific CPS.

The core unit features 1:1 equipment protection (for details refer to section 4.6.2 Equipment Protection of the Core Unit (on page 150)).

The interfaces at the front panel of the core unit CESM2 are shown in Figure 32.
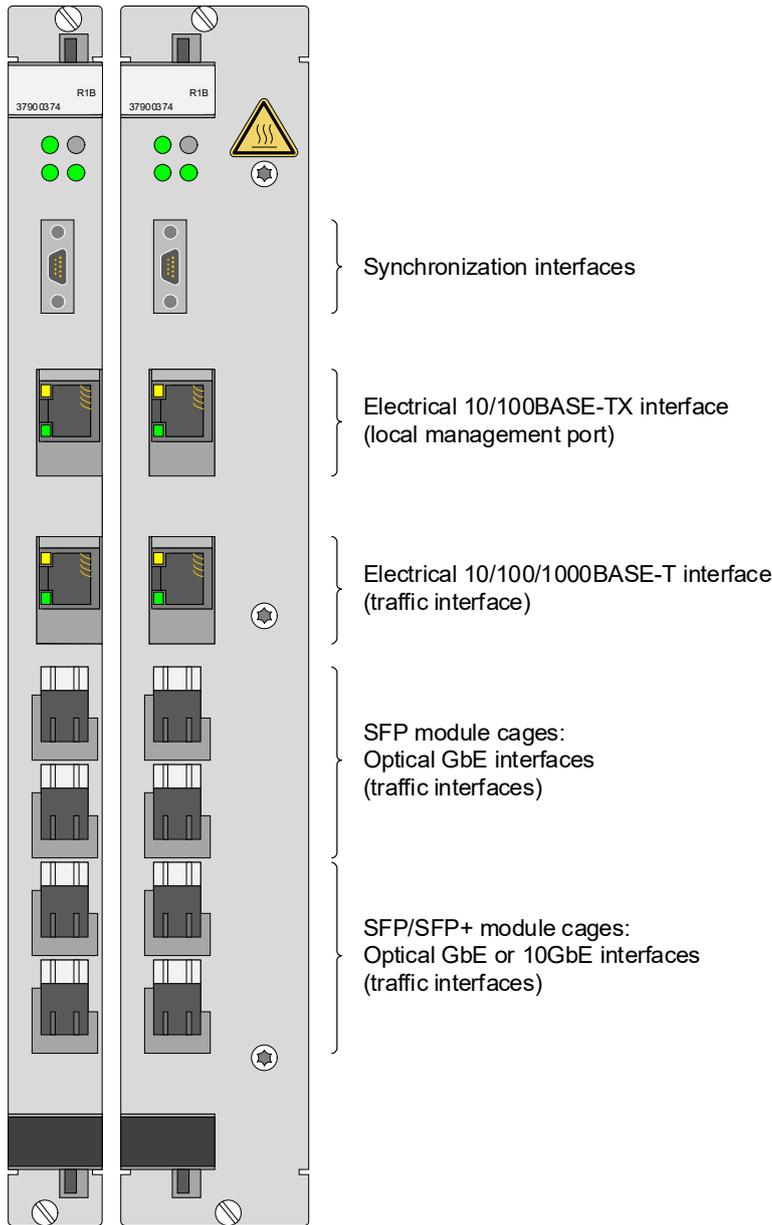
Figure 32:   CESM2 (left) and CESM2-F (right) interfaces

CESM2 comprises two SFP+ (Small Form factor Pluggable) cages which can be equipped with industry standard electrical or optical 1000BASE-xx transceivers (SFP modules), or optical 10GBASE-xx transceivers (SFP+ modules) and used as traffic interfaces. The SFP or SFP+ modules are not included with the CESM2 unit by default.

CESM2 comprises two SFP (Small Form factor Pluggable) cages which can be equipped with industry standard electrical or optical 1000BASE-xx transceivers (SFP modules) and used as traffic interfaces. The SFP modules are not included with the CESM2 unit by default.

One electrical 10/100/1000BASE-T interface is also usable as traffic interface.

For the VLAN Bridge function all five traffic interfaces can be configured to be used as access port, trunk port, trunk with native VLAN port or general port, individually per port.

For the MPLS-TP Transport function all five traffic interfaces can be configured to be used as Pseudo Wire Access Circuit port or as MPLS-TP physical port or as MPLS-TP logical port (subinterface), individually per port.

Four of the five Ethernet ports support the PTP protocol and can be used as slave or master PTP ports.

In addition, the core unit also offers an Ethernet port for the local management access (electrical 10/100BASE-TX).

The CESM2 unit offers synchronization I/O signals (two symmetrical clock inputs and two symmetrical clock outputs, 120 Ohm, 2048kHz). Two inputs and one output are used for PDH reference clock signals on the FOX61x. One input and one output are used for SDH reference clock signals.

The CESM2 has four LEDs for the indication of unit and traffic failures.

2.2.3 Core Unit CESM1 and CESM1-F

Figure 33:   CESM1 (left) and CESM1-F (right) unit view

> **i**
>
> **Please note:**
> The core units CESM1 and CESM1-F will be supported in the FOX615 R2 sub-rack in a future release.

The CESM1 is the 1-slot wide core unit of the FOX615 R2, FOX615, FOX612 and FOX611. It must be operated in an actively cooled FOX61x subrack.

The CESM1-F is the 2-slot wide core unit of the FOX615 R2, FOX615, FOX612 and FOX611. It can be operated in actively and passively cooled FOX61x subracks.

CESM1 and CESM1-F are functionally identical. In the following the term "CESM1" is thus used to name the core units CESM1 and CESM1-F.

The core unit CESM1 comprises functions for the whole network element (NE) and for the core unit itself:

Main NE functions:

- Management and control of the FOX61x subrack and all plug-in units,
- Database to store management information,
- Control of the system operation.
- Monitoring of the system performance.
- PDH and Ethernet synchronization functions.
- Local management Ethernet interface.
- Management communication, including routing functions.
  - Support of SSH for the management communication.
  - Support of SNMP for the management communication.
- Access to the alarm interfaces on the fan or alarm unit.

Main core unit functions:

- Ethernet VLAN Bridge as function of the FOX61x Switch between the CESM1 Ethernet front ports and the Ethernet service unit ports.
- MPLS-TP Transport as function of the FOX61x Switch between the CESM1 Ethernet front ports and the Ethernet service unit ports.
- Five Ethernet traffic front ports, two SFP+ based 10 GbE interfaces and three 10/100/1000BASE-T interfaces.
- Support of PTP for electrical and optical Ethernet traffic front interfaces.
  - PTP Boundary Clock
  - PTP Ordinary Clock
  - PTP Transparent Clock
- Support of RSTP (802.1D-2004, compatible with STP) for electrical and optical Ethernet traffic front interfaces.
- Support of VLAN QoS with Class of Service (CoS) handling (802.1Q): 8 CoS by eight priority queues, with strict priority scheduling or weighted round robin (WRR) scheduling per queue.
- Configurable egress queue sizes using a customer specific CPS.

The core unit features 1:1 equipment protection (for details refer to section 4.6.2 Equipment Protection of the Core Unit (on page 150)).

The interfaces at the front panel of the core unit CESM1 are shown in Figure 34.
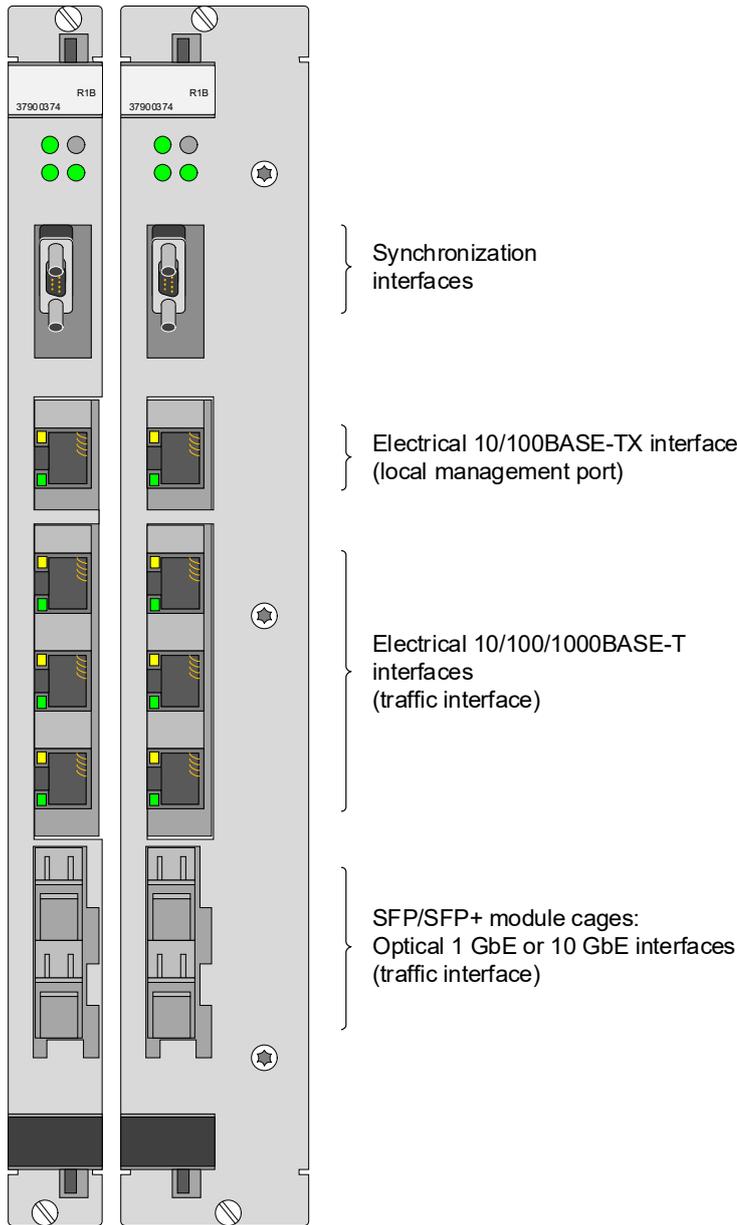
Figure 34:   CESM1 (left) and CESM1-F (right) interfaces

CESM1 comprises two SFP+ (Small Form factor Pluggable) cages which can be equipped with industry standard electrical or optical 1000BASE-xx transceivers (SFP modules), or optical 10GBASE-xx transceivers (SFP+ modules) and used as traffic interfaces. The SFP or SFP+ modules are not included with the CESM1 unit by default.

Three electrical 10/100/1000BASE-T interfaces are also usable as traffic interfaces.

For the VLAN Bridge function all five traffic interfaces can be configured to be used as access port, trunk port, trunk with native VLAN port or general port, individually per port.

For the MPLS-TP Transport function all five traffic interfaces can be configured to be used as Pseudo Wire Access Circuit port or as MPLS-TP physical port or as MPLS-TP logical port (subinterface), individually per port.

Four of the five Ethernet ports support the PTP protocol and can be used as slave or master PTP ports.

In addition, the core unit also offers an Ethernet port for the local management access (electrical 10/100BASE-TX).

The CESM1 unit offers synchronization I/O signals (two symmetrical clock inputs and two symmetrical clock outputs, 120 Ohm, 2048kHz). Two inputs and one output are used for

PDH reference clock signals on the FOX61x. One input and one output are used for SDH reference clock signals.

The CESM1 has four LEDs for the indication of unit and traffic failures.

2.2.4   **WAN Port Expansion Unit EPEX1**

Figure 35:   EPEX1 unit view

The EPEX1 is a 1-slot wide WAN port expansion unit of the FOX61x. It must be operated in an actively cooled FOX61x subrack.

It provides four SFP+ based 10 Gbit/s Ethernet ports and one QSFP+ based 40 Gbit/s Ethernet port (future release). The SFP+ or QSFP+ modules are not included with the EPEX1 unit by default.

The unit is connected to the CESM3 core unit via the double 40 GbE star of the FOX615 R2 subrack.

The EPEX1 unit provides the following functions:

- Front ports usable as WAN ports.
- The EPEX1 unit front ports are connected via the 40 GbE star to the switching circuit of the CESM3 core unit.
- The front ports can be operated as Ethernet traffic ports or as MPLS-TP ports.

- Support of RSTP (802.1D-2004, compatible with STP) for optical Ethernet traffic front interfaces.
- Support of VLAN QoS with Class of Service (CoS) handling (802.1Q): 8 CoS by eight priority queues, with strict priority scheduling or weighted round robin (WRR) scheduling per queue.
- Hardware ready for synchronous Ethernet.
- Hardware ready for PTP.
- Maximum eight 10 Gbit/s ports per FOX615 R2 subrack (2 units).
- Aggregate throughput rate up to 40 Gbit/s (upstream and downstream) at frame sizes < 9194 bytes.
- MAC frame sizes from 64 to 9216 bytes.
- Security features:
  - Rate limiter for subscriber traffic.

The EPEX1 has two LEDs for unit- and traffic failure indication.

2.2.5 Encryption Unit SENC1-4, SENC1F4, SENC1-8 and SENC1F8

Figure 36:   SENC1-4 (left) and SENC1F4 (right) unit view

Figure 37:   SENC1-8 (left) and SENC1F8 (right) unit view

The SENC1-4 and SENC1-8 are the 1-slot wide encryption units of the FOX615 R2, FOX615, FOX612 and FOX611. They must be operated in an actively cooled FOX61x subrack.

The SENC1F4 and SENC1F8 are the 2-slot wide encryption units of the FOX615 R2, FOX615, FOX612 and FOX611. They can be operated in actively and passively cooled FOX61x sub-racks.

SENC1-4 and SENC1F4 are functionally identical, SENC1-8 and SENC1F8 are functionally identical. In the following the term "SENC1" is used to name the encryption units SENC1-4, SENC1F4, SENC1-8 and SENC1F8. Where certain features or characteristics apply to a specific encryption unit only, the SENC1-4, SENC1F4, SENC1-8 or SENC1F8 is named explicitly.

The encryption unit SENC1 provides the following main features:

- The SENC1 unit plugged in a FOX61x subrack is powered from the subrack.
- The SENC1 unit provides a TRNG (True Random Number Generator) realized with a QRNG (Quantum Random Number Generator).
- The SENC1 unit has two LEDs for the indication of unit and traffic failures.
- The SENC1 unit is managed either
  - via the backplane Gb Ethernet connection to the core unit(s), if the front management port is disabled via DIP-switch, or
  - via the front management port (electrical Ethernet 10/100/1000BASE-T interface), if the front management port is enabled via DIP-switch.
- The SENC1 unit provides one (SENC1-4 and SENC1F4) or two (SENC1-8 and SENC1F8) functional units.

Each functional unit provides the following functions (if managed via the backplane Gb Ethernet connection):

- Four SFP+ (Small Form factor Pluggable) cages which can be equipped with industry standard optical 1000BASE-xx transceivers (SFP modules), or optical 10GBASE-xx transceivers (SFP+ modules). The SFP or SFP+ modules are not included with the SENC1 unit by default.
- Two encryption engines per functional unit.
- Two bidirectional Ethernet streams can be encrypted and unencrypted.
    - The unencrypted port of an encryption engine is connected to a local MPLS-TP port or a local MPLS-TP subinterface (VLAN based) of a core unit or WAN port expansion unit.
    - The encrypted port of an encryption engine provides the WAN connection.
- AES-256 GCM encryption mode per traffic flow.
- MPLS tunnel configuration via FOXMAN-UN and DIRAC servers.
- Master key generation via DIRAC server, acting as key management server.
- 2048 keys per encryption engine, i.e. 1024 encrypted LSPs with two master keys each per engine to arbitrary endpoints.
- Management channel between local and remote SENC1 units.
- Transparency for OAM messages.
- Packet delay compensation for PTP.
- Access to the FOX61x Switch only for management traffic. No user traffic accesses the FOX61x Switch.
- Tamper protection of sensitive signals and data with mechanical shields on the boards component and solder sides.
- CLI based management access to SENC1.

If the SENC1 unit is managed via the front management port the following items differ from the above functional unit functions:

- Manual configuration of the MPLS tunnels via CLI.
- Manual configuration of the master keys via CLI.
- No management access via the FOX61x Switch.
- No subrack internal management access.

2.2.6   Ethernet Service Units ETOP1 and ETOP1-F

Figure 38:   ETOP1 (left) and ETOP1-F (right) unit view

> **i**   **Please note:**
> The service units ETOP1 and ESOP1 use the same hardware unit named ETOP1.

> **i**   **Please note:**
> The service units ETOP1-F and ESOP1-F use the same hardware unit named ETOP1-F.

The ETOP1 is a 1-slot wide Ethernet service unit of the FOX61x. It has 12 SFP-based optical or electrical 100 Mbit/s or 1000 Mbit/s Ethernet interfaces. The unit must be operated in an actively cooled FOX61x subrack.

The ETOP1-F is a 2-slot wide Ethernet service unit of the FOX61x. It can be operated in actively and passively cooled FOX61x subracks.

ETOP1 and ETOP1-F are functionally identical. In the following the term "ETOP1" is thus used to name the Ethernet service units ETOP1 and ETOP1-F.

The ETOP1 unit is connected to the core unit via the double GbE star and the double 10 GbE star.

The ETOP1 unit provides the following functions:

- 12 SFP-based Ethernet interfaces for the connection of standard Ethernet equipment.

- Electrical or optical 100 Mbit/s or 1000 Mbit/s Ethernet port; connector type, transport medium and reach according to the plugged SFP module.

- Hardware ready for synchronous Ethernet.
- Maximum 240 ports per FOX615 R2 or FOX615 subrack (20 units).
- Maximum 84 ports per FOX612 subrack (7 units).
- Maximum 36 ports per FOX611 subrack (3 units).
- Ethernet switch with VLAN support as part of the FOX61x Switch between the units Ethernet front ports and other Ethernet service unit and core unit ports.
- Support of RSTP (802.1D-2004, compatible with STP) for electrical and optical Ethernet front interfaces.
- Support of VLAN QoS with Class of Service (CoS) handling (802.1Q): 8 CoS by eight priority queues, with strict priority scheduling or weighted round robin (WRR) scheduling per queue.
- Aggregate throughput rate up to 10 Gbit/s (upstream and downstream) at frame sizes < 1522 bytes.
- MAC frame sizes from 64 to 9216 bytes.
- Security features:
    - Rate limiter for subscriber traffic.
- Configurable egress queue sizes using a customer specific CPS.

The ETOP1 has two LEDs for unit- and traffic failure indication.

2.2.7 Ethernet Service Unit ELET1

Figure 39:   ELET1 unit view

The ELET1 is a 2-slot wide Ethernet service unit of the FOX61x. It provides 24 electrical Ethernet interfaces 10/100/1000BASE-T. The unit is connected to the core unit via the double GbE star and the double 10 GbE star. The unit with HW release R1x must be operated in an actively cooled FOX61x subrack. The unit with HW release R2A or newer can be operated in actively and passively cooled FOX61x subracks.

The ELET1 unit provides the following functions:

- 24 electrical interfaces 10/100/1000BASE-T for the connection of standard Ethernet equipment.
- Hardware ready for synchronous Ethernet.
- Maximum 240 ports per FOX615 R2 or FOX615 subrack (10 units).
- Maximum 72 ports per FOX612 subrack (3 units).
- Maximum 24 ports per FOX611 subrack (1 unit).
- Ethernet switch with VLAN support as part of the FOX61x Switch between the units Ethernet front ports and other Ethernet service unit and core unit ports.
- Support of RSTP (802.1D-2004, compatible with STP) for electrical Ethernet front interfaces.
- Support of VLAN QoS with Class of Service (CoS) handling (802.1Q): 8 CoS by eight priority queues, with strict priority scheduling or weighted round robin (WRR) scheduling per queue.
- Aggregate throughput rate up to 10 Gbit/s (upstream and downstream) at frame sizes < 1522 bytes.
- MAC frame sizes from 64 to 9216 bytes.
- Security features:
  - Rate limiter for subscriber traffic.
- Configurable egress queue sizes using a customer specific CPS.

The ELET1 has two LEDs for unit- and traffic failure indication.

2.2.8   Ethernet Service Unit EPOI1
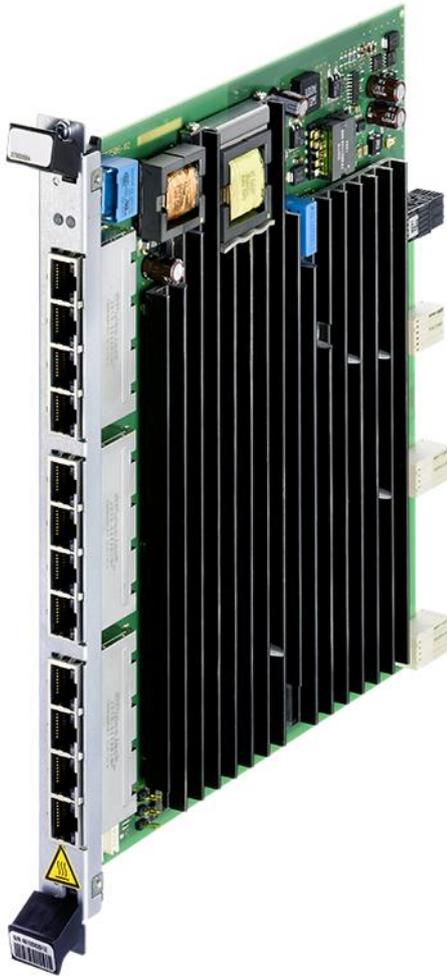
Figure 40:   EPOI1 unit view

> **i**
>
> **Please note:**
> The service units EPOI1 and ESPO1 use the same hardware unit named EPOI1.

The EPOI1 is a 1-slot wide Ethernet service unit of the FOX61x. It provides 12 electrical Ethernet interfaces 10/100/1000BASE-T supporting power over Ethernet. The unit is connected to the core unit via the double GbE star and the double 10 GbE star. It can be operated in actively and passively cooled FOX61x subracks.

The EPOI1 unit provides the following functions:

- 12 electrical interfaces 10/100/1000BASE-T for the connection of standard Ethernet equipment.
- Power over Ethernet with up to 30 W per port (PoE+). Up to 84 W of accumulated power budget for all PoE ports.
- Isolation for indoor PoE applications.
- Hardware ready for synchronous Ethernet.
- Maximum 240 ports per FOX615 R2 or FOX615 subrack (20 units).
- Maximum 84 ports per FOX612 subrack (7 units).
- Maximum 36 ports per FOX611 subrack (3 units).
- Ethernet switch with VLAN support as part of the FOX61x Switch between the units Ethernet front ports and other Ethernet service unit and core unit ports.
- Support of RSTP (802.1D-2004, compatible with STP) for electrical Ethernet front interfaces.

- Support of VLAN QoS with Class of Service (CoS) handling (802.1Q): 8 CoS by eight priority queues, with strict priority scheduling or weighted round robin (WRR) scheduling per queue.
- Aggregate throughput rate up to 10 Gbit/s (upstream and downstream) at frame sizes < 1522 bytes.
- MAC frame sizes from 64 to 9216 bytes.
- Security features:
  - Rate limiter for subscriber traffic.
- Configurable egress queue sizes using a customer specific CPS.

The EPOI1 has two LEDs for unit- and traffic failure indication.

2.2.9 Ethernet service unit DEFM1 and DEFM1-F

Figure 41: DEFM1 (left) and DEFM1-F (right) unit view

The DEFM1 is a 1-slot wide service unit of the FOX61x. It has 24 SHDSL EFM subscriber interfaces. The unit must be operated in an actively cooled FOX61x subrack.

The DEFM1-F is a 2-slot wide Ethernet service unit of the FOX61x. It can be operated in actively and passively cooled FOX61x subracks.

DEFM1 and DEFM1-F are functionally identical. In the following the term "DEFM1" is thus used to name the service units DEFM1 and DEFM1-F.

The DEFM1 unit is connected to the core unit via the double GbE star and the double 10 GbE star.

The DEFM1 unit provides the following functions:

- 24 SHDSL EFM interfaces according ITU-T G.991.2, Annexes A, B, F and G.
- Handshaking procedures according to ITU-T G.994.1.
- EFM compliance according to IEEE 802.3-2012 section five.
- Line codes TCPAM 16, TCPAM 32 and TCPAM 64.
- Maximum user data rate per line interface 11.4 Mbit/s.
- Line aggregation 1 to 4 lines, user data rate up to 22.78 Mbit/s.
- Support of different rates on aggregated lines.
- Support of the trunk application.
- Network element timing forwarding in the trunk application from LT to NT.
- Configurable user bandwidth.
- Configurable power backoff.
- Maximum 480 ports per FOX615 R2 or FOX615 subrack (20 units).
- Maximum 168 ports per FOX612 subrack (7 units).
- Maximum 72 ports per FOX612 subrack (3 units).
- Ethernet switch with VLAN support as part of the FOX61x Switch between the units SHDSL front ports and other Ethernet service unit and core unit ports.
- Support of RSTP (802.1D-2004, compatible with STP) for electrical Ethernet front interfaces.
- Support of VLAN QoS with Class of Service (CoS) handling (802.1Q): 8 CoS by eight priority queues, with strict priority scheduling or weighted round robin (WRR) scheduling per queue.
- Aggregate throughput rate up to 136 Mbit/s (upstream and downstream).
- Ethernet frame sizes from 42 to 2024 bytes.
- Security features:
    - Rate limiter for subscriber traffic.
- Configurable egress queue sizes using a customer specific CPS.

The DEFM1 has two LEDs for unit- and traffic failure indication.

2.2.10 Ethernet Service Units EROP1 and EROP1-F

Figure 42: EROP1 (left) and EROP1-F (right) unit view

The EROP1 is a 1-slot wide Ethernet service unit of the FOX61x. It has 12 SFP-based optical or electrical 100 Mbit/s or 1000 Mbit/s Ethernet interfaces. The unit must be operated in an actively cooled FOX61x subrack.

The EROP1-F is a 2-slot wide Ethernet service unit of the FOX61x. It can be operated in actively and passively cooled FOX61x subracks.

EROP1 and EROP1-F are functionally identical. In the following the term "EROP1" is thus used to name the Ethernet service units EROP1 and EROP1-F.

The EROP1 unit is connected to the core unit via the double GbE star and the double 10 GbE star.

The EROP1 unit provides the following functions:

- 12 SFP-based Ethernet interfaces for the connection of standard Ethernet equipment.
- Electrical or optical 100 Mbit/s or 1000 Mbit/s Ethernet port; connector type, transport medium and reach according to the plugged SFP module.
- Hardware ready for synchronous Ethernet.
- Maximum 240 ports per FOX615 R2 or FOX615 subrack (20 units).
- Maximum 84 ports per FOX612 subrack (7 units).
- Maximum 36 ports per FOX611 subrack (3 units).
- IPv4 routing with up to 16 virtual router instances.
- OSPF routing and static routing.

- Up to 256 virtual router interfaces, untagged, priority tagged or VLAN tagged.
- Up to 32 loopback interfaces.
- DHCP relay agent.
- Support of VLAN QoS with Class of Service (CoS) handling (802.1Q): 8 CoS by eight priority queues, with strict priority scheduling or weighted round robin (WRR) scheduling per queue.
- Wire speed packet forwarding.
- IP MTU size up to 1500 bytes. Hardware ready for MTU size up to 9000 bytes.
- Security features:
    - Rate limiter for the virtual router interfaces.
- 1:1 equipment protection. [1]

The EROP1 has two LEDs for unit- and traffic failure indication.

2.2.11   Ethernet Service Units ESOP1 and ESOP1-F

Figure 43:   ESOP1 (left) and ESOP1-F (right) unit view

> **Please note:**
> The service units ETOP1 and ESOP1 use the same hardware unit named ETOP1.

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1. Equipment protection with the EROP1 unit is only supported up to the ESW release r2.

> ⓘ **Please note:**
> The service units ETOP1-F and ESOP1-F use the same hardware unit named ETOP1-F.

The ESOP1 is a 1-slot wide Ethernet service unit of the FOX61x. It has 12 SFP-based optical or electrical 100 Mbit/s or 1000 Mbit/s Ethernet interfaces. The unit must be operated in an actively cooled FOX61x subrack.

The ESOP1-F is a 2-slot wide Ethernet service unit of the FOX61x. It can be operated in actively and passively cooled FOX61x subracks.

ESOP1 and ESOP1-F are functionally identical. In the following the term "ESOP1" is thus used to name the Ethernet service units ESOP1 and ESOP1-F.

The ESOP1 unit is connected to the core unit via the double GbE star and the double 10 GbE star.

The ESOP1 unit provides the following functions:

- 12 SFP-based Ethernet interfaces for the connection of standard Ethernet equipment.
- Electrical or optical 100 Mbit/s or 1000 Mbit/s Ethernet port; connector type, transport medium and reach according to the plugged SFP module.
- Hardware ready for synchronous Ethernet.
- Maximum 240 ports per FOX615 R2 or FOX615 subrack (20 units).
- Maximum 84 ports per FOX612 subrack (7 units).
- Maximum 36 ports per FOX611 subrack (3 units).
- Local Ethernet switch with VLAN support.
- Support of RSTP (802.1D-2004, compatible with STP) for electrical and optical Ethernet front interfaces.
- Support of VLAN QoS with Class of Service (CoS) handling (802.1Q): 8 CoS by eight priority queues, with strict priority scheduling or weighted round robin (WRR) scheduling per queue.
- Aggregate switching capacity up to 12 Gbit/s at frame sizes < 1522 bytes.
- MAC frame sizes from 64 to 9216 bytes.
- Security features:
  - Rate limiter for subscriber traffic.
- Configurable egress queue sizes using a customer specific CPS.

The ESOP1 has two LEDs for unit- and traffic failure indication.

> ⓘ **Please note:**
> The bridge on the ESOP1 unit is not part of the FOX61x Switch.
> → The ESOP1 bridge accesses the FOX61x Switch via the backplane 1 Gbit/s or 10 Gbit/s Ethernet link as an external port.

2.2.12   Ethernet Service Unit ESPO1
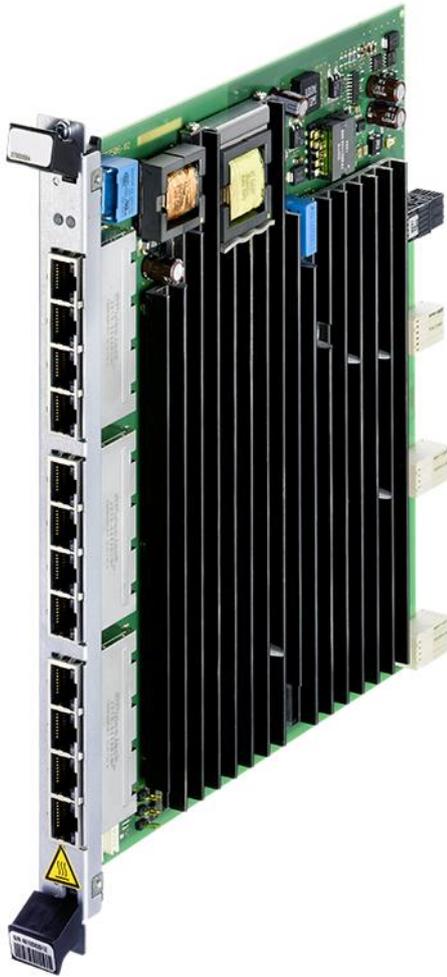
Figure 44:   ESPO1 unit view

| i | **Please note:** |

The service units EPOI1 and ESPO1 use the same hardware unit named EPOI1.

The ESPO1 is a 1-slot wide Ethernet service unit of the FOX61x. It provides 12 electrical Ethernet interfaces 10/100/1000BASE-T supporting power over Ethernet. The unit is connected to the core unit via the double GbE star and the double 10 GbE star. It can be operated in actively and passively cooled FOX61x subracks.

The ESPO1 unit provides the following functions:

- 12 electrical interfaces 10/100/1000BASE-T for the connection of standard Ethernet equipment.
- Power over Ethernet with up to 30 W per port (PoE+). Up to 84 W of accumulated power budget for all PoE ports.
- Isolation for indoor PoE applications.
- Hardware ready for synchronous Ethernet.
- Maximum 240 ports per FOX615 R2 or FOX615 subrack (20 units).
- Maximum 84 ports per FOX612 subrack (7 units).
- Maximum 36 ports per FOX611 subrack (3 units).
- Local Ethernet switch with VLAN support.
- Support of RSTP (802.1D-2004, compatible with STP) for electrical Ethernet front interfaces.

- Support of VLAN QoS with Class of Service (CoS) handling (802.1Q): 8 CoS by eight priority queues, with strict priority scheduling or weighted round robin (WRR) scheduling per queue.
- Aggregate switching capacity up to 12 Gbit/s at frame sizes < 1522 bytes.
- MAC frame sizes from 64 to 9216 bytes.
- Security features:
  - Rate limiter for subscriber traffic.
- Configurable egress queue sizes using a customer specific CPS.

The ESPO1 has two LEDs for unit- and traffic failure indication.

> ℹ️ **Please note:**
> The bridge on the ESPO1 unit is not part of the FOX61x Switch.
> → The ESPO1 bridge accesses the FOX61x Switch via the backplane 1 Gbit/s or 10 Gbit/s Ethernet link as an external port.

2.2.13   Ethernet Service Unit EPSI1

Figure 45:   EPSI1 unit view

The EPSI1 is a 1-slot wide Ethernet service unit of the FOX61x. It is a versatile networking unit with the main purpose of connecting Ethernet LANs over TDM links. It provides 4 electrical Ethernet interfaces 10/100BASE-T and accesses the PBUS with a maximum capacity of 16 x P12. The unit provides also access to the GbE star. It can be operated in actively and passively cooled FOX61x subracks.

The EPSI1 unit provides the following functions:

- 4 Ethernet LAN front interfaces:
  - 10/100Base-TX.
  - Bridge port type (access/trunk) user configurable.
- Up to 64 TDM WAN interfaces on the PBUS:
  - Bandwidth per interface 1x64 kbit/s up to 2048 kbit/s, with multilink PPP up to the total WAN bandwidth.
  - Total bandwidth 8x2 Mbit/s or 16x2 Mbit/s depending on unit mode.
  - PPP/HDLC user configurable.
  - Multilink PPP.
  - Bridge port type (access/trunk) user configurable.
- Virtual interface:
  - Selective routing per VLAN.
  - Inter-VLAN routing.
  - Connection between bridged and routed network segments.
- Bridge:
  - Transparent MAC bridging.
  - VLAN aware MAC bridging.
  - RSTP (STP).
  - Multiple bridge instances.
- IP router:
  - Static routing.
  - OSPF routing.
  - RIP routing.
  - Virtual router redundancy protocol, VRRP.
- QoS functions:
  - 4 TX queues per interface.
  - Strict priority scheduling.
- 1:1 equipment protection.

> **i**
>
> **Please note:**
> The bridge on the EPSI1 unit is not part of the FOX61x Switch.
> → The EPSI1 bridge accesses the FOX61x Switch via the backplane Gbit/s Ethernet link as an external port.

2.2.14   SDH and EoS Service Unit SAMO1

Figure 46:   SAMO1 unit view

The SAMO1 is a 1-slot wide SDH uplink service unit of the FOX61x. It provides 2 STM-4/ STM-1 dual speed and 2 STM-1 single speed ports and 4 10/100/1000BASE-T ports for the Ethernet over SDH (EoS) application. SAMO1 accesses the PBUS with a maximum capacity of 67 x P12 and also connects to the Gb-Ethernet star. The unit with HW release R1x must be operated in an actively cooled FOX61x subrack. The unit with HW release R2A or newer can be operated in actively and passively cooled FOX61x subracks.

The SAMO1 unit can be configured as an SDH access system with termination and add/ drop functionality from STM-4 and STM-1 trunks. The interfaces can be used as aggregate interfaces, or as tributary interfaces for the access to subtended network elements. The interfaces are implemented on SAMO1 with four SFP cages.

Ethernet traffic from the front Ethernet ports or from the core unit is transported over up to four Ethernet over SDH (EoS) channels. Two of the four EoS channels are shared with the connections to the Gb-Ethernet star.

The SAMO1 unit implements also the synchronous equipment timing source (SETS) for the unit.

The SAMO1 unit provides the following functions:

*   2 STM-4/STM-1 dual speed ports, STM-4 with optical SFP modules, STM-1 with optical or electrical SFP modules.
*   2 STM-1 single speed ports, with optical or electrical SFP modules.
*   SDH cross connect for 18x18 AU-4, 33x33 TU-3 and 693x693 TU-12.
*   Access to the PBUS with up to 67 P12 signals.

- Four 10/100/1000BASE-T Ethernet ports used for the Ethernet over SDH (EoS) application.
- EoS framing procedure GFP according ITU-T G.7041.
- Virtual concatenation according to ITU-T G.783.
- Link capacity adjustment (LCAS) scheme according to ITU-T G.7042.
- Synchronous equipment timing source (SETS) with local oscillator.
- Multiplex section protection on the unit.
- Subnetwork connection protection between any virtual channels on the unit.
- 1:1 equipment protection.
- Performance monitoring according to ITU-T G.826.

> **i** **Please note:**
> The Eos links on the SAMO1 unit are not part of the FOX61x Switch.
> → The FOX61x Switch accesses one of the EoS links via the backplane Gbit/s Ethernet link as an external port.

The SAMO1 has two LEDs for unit- and traffic related failure indication.

2.2.15   SDH and EoS Service Unit SAMO2 and SAMO2-F
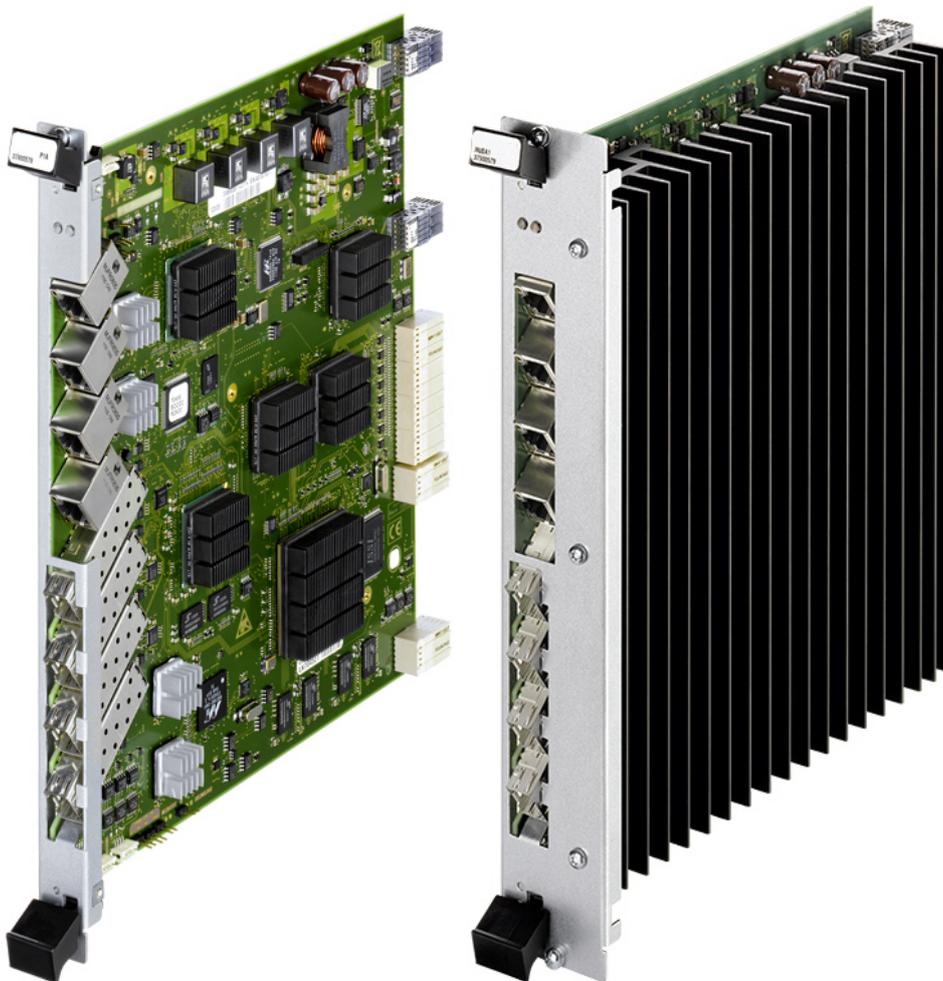
Figure 47:   SAMO2 (left) and SAMO2-F (right) unit view

The SAMO2 is a 1-slot wide SDH uplink service unit of the FOX61x. It provides 2 STM-16/ STM-4 dual speed and 2 STM-4/STM-1 dual speed ports and 4 10/100/1000BASE-T ports for the Ethernet over SDH (EoS) application. SAMO2 accesses the PBUS with a maximum

capacity of 64 x P12 and also connects to the Gb-Ethernet star. The unit must be operated in an actively cooled FOX61x subrack.

The SAMO2-F is a 2-slot wide SDH and EoS service unit of the FOX61x. It can be operated in actively and passively cooled FOX61x subracks.

SAMO2 and SAMO2-F are functionally identical. In the following the term "SAMO2" is thus used to name the SDH and EoS service units SAMO2 and SAMO2-F.

The SAMO2 unit can be configured as an SDH access system with termination and add/drop functionality from STM-16, STM-4 and STM-1 trunks. The interfaces can be used as aggregate interfaces or as tributary interfaces for the access to subtended network elements. The interfaces are implemented on SAMO2 with four SFP cages.

Ethernet traffic from the front Ethernet ports or from the FOX61x Switch is transported over up to 32 Ethernet over SDH (EoS) channels.

The SAMO2 unit implements also the synchronous equipment timing source (SETS) for the unit.

The SAMO2 unit provides the following functions:

- 2 STM-16/STM-4 dual speed ports with optical SFP modules.
- 2 STM-4/STM-1 dual speed ports, STM-4 with optical SFP modules, STM-1 with optical or electrical SFP modules.
- SDH cross connect for 125x125 AU-4, 48x48 TU-3 and 1261x1261 TU-12.
- Access to the PBUS with up to 64 P12 signals.
- Four 10/100/1000BASE-T Ethernet ports used for the Ethernet over SDH (EoS) application.
- Up to 32 EoS channels.
- EoS framing procedure GFP according ITU-T G.7041.
- Virtual concatenation according to ITU-T G.783.
- Link capacity adjustment (LCAS) scheme according to ITU-T G.7042.
- Synchronous equipment timing source (SETS) with local oscillator.
- Multiplex section protection on the unit or with a protecting unit in a dedicated subrack slot.
- Subnetwork connection protection between any virtual channels on the unit.
- 1:1 equipment protection.
- Performance monitoring according to ITU-T G.826.

The SAMO2 has two LEDs for unit- and traffic related failure indication.

2.2.16   SDH and EoS Service Unit SAMO3

Figure 48:   SAMO3 unit view

The SAMO3 is a 2-slot wide SDH uplink service unit of the FOX61x. It provides 2 STM-16/STM-4 dual speed and 2 STM-4/STM-1 dual speed ports, 4 10/100/1000BASE-T ports for the Ethernet over SDH (EoS) application and 48 E12 ports for the SDH transport. SAMO3 accesses the PBUS with a maximum capacity of 64 x P12 and also connects to the Gb-Ethernet star. The unit must be operated in an actively cooled FOX61x subrack.

The SAMO3 unit can be configured as an SDH access system with termination and add/drop functionality from STM-16, STM-4 and STM-1 trunks. The interfaces can be used as aggregate interfaces or as tributary interfaces for the access to subtended network elements. The interfaces are implemented on SAMO3 with four SFP cages.

Ethernet traffic from the front Ethernet ports or from the FOX61x Switch is transported over up to 32 Ethernet over SDH (EoS) channels.

PDH traffic from the front E12 ports is transported transparently via VC-12 over SDH.

The SAMO3 unit implements also the synchronous equipment timing source (SETS) for the unit.

The SAMO3 unit provides the following functions:

- 2 STM-16/STM-4 dual speed ports with optical SFP modules.
- 2 STM-4/STM-1 dual speed ports, STM-4 with optical SFP modules, STM-1 with optical or electrical SFP modules.
- SDH cross connect for 125x125 AU-4, 48x48 TU-3 and 1309x1309 TU-12.
- Access to the PBUS with up to 64 P12 signals.
- 48 E12 (G.703) ports used for the transparent PDH transport over SDH application.

- Four 10/100/1000BASE-T Ethernet ports used for the Ethernet over SDH (EoS) application.
- Up to 32 EoS channels.
- EoS framing procedure GFP according ITU-T G.7041.
- Virtual concatenation according to ITU-T G.783.
- Link capacity adjustment (LCAS) scheme according to ITU-T G.7042.
- Synchronous equipment timing source (SETS) with local oscillator.
- Multiplex section protection on the unit or with a protecting unit in a dedicated subrack slot.
- Subnetwork connection protection between any virtual channels on the unit.
- 1:1 equipment protection.
- Performance monitoring according to ITU-T G.826.

The SAMO3 has two LEDs for unit- and traffic related failure indication.

2.2.17   SDH and EoS Service Unit SAMO5 and SAMO5-F
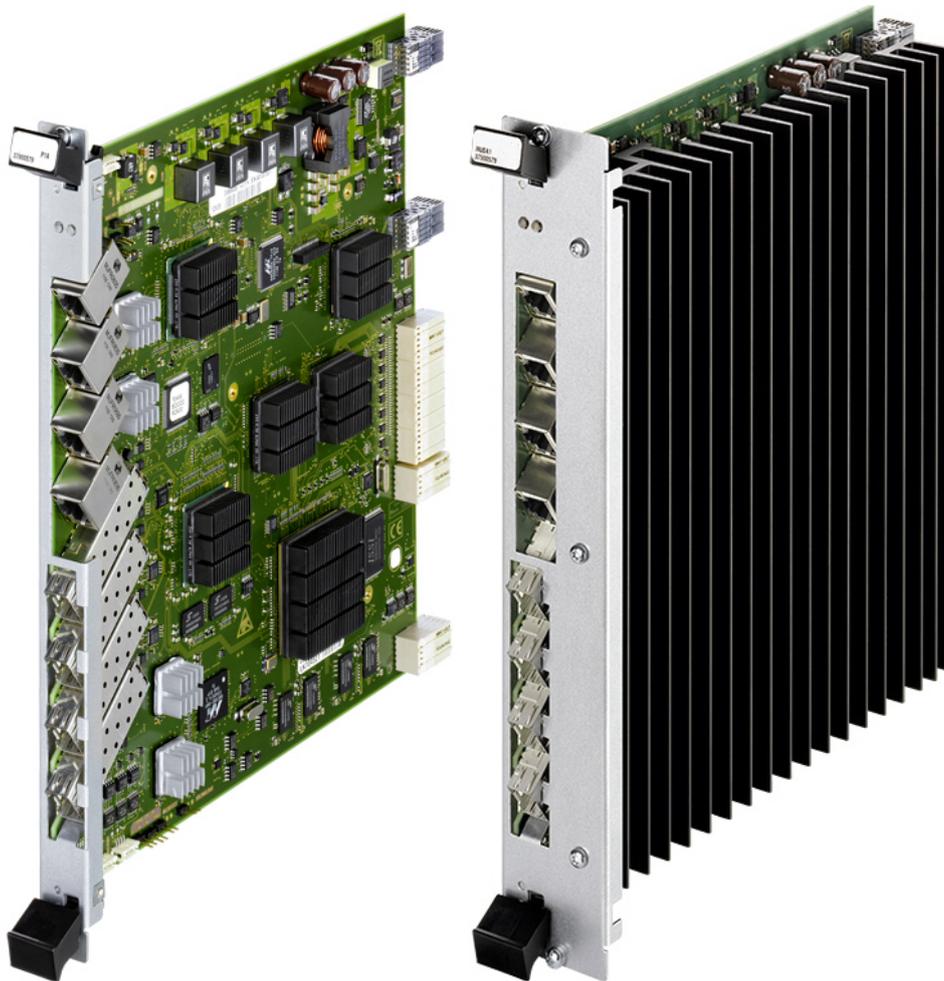
Figure 49:   SAMO5 (left) and SAMO5-F (right) unit view

The SAMO5 is a 1-slot wide SDH uplink service unit of the FOX61x. It provides 2 STM-4 single speed and 2 STM-4/STM-1 dual speed ports and 4 10/100/1000BASE-T ports for the Ethernet over SDH (EoS) application. SAMO5 accesses the PBUS with a maximum capacity of 64 x P12 and also connects to the Gb-Ethernet star. The unit must be operated in an actively cooled FOX61x subrack.

The SAMO5-F is a 2-slot wide SDH and EoS service unit of the FOX61x. It can be operated in actively and passively cooled FOX61x subracks.

SAMO5 and SAMO5-F are functionally identical. In the following the term "SAMO5" is thus used to name the SDH and EoS service units SAMO5 and SAMO5-F.

The SAMO5 unit can be configured as an SDH access system with termination and add/drop functionality from STM-4 and STM-1 trunks. The interfaces can be used as aggregate interfaces or as tributary interfaces for the access to subtended network elements. The interfaces are implemented on SAMO5 with four SFP cages.

Ethernet traffic from the front Ethernet ports or from the FOX61x Switch is transported over up to 8 Ethernet over SDH (EoS) channels.

The SAMO5 unit implements also the synchronous equipment timing source (SETS) for the unit.

The SAMO5 unit provides the following functions:

- 2 STM-4 single speed ports with optical SFP modules.
- 2 STM-4/STM-1 dual speed ports, STM-4 with optical SFP modules, STM-1 with optical or electrical SFP modules.
- SDH cross connect for 125x125 AU-4, 48x48 TU-3 and 1261x1261 TU-12.
- Access to the PBUS with up to 64 P12 signals.
- Four 10/100/1000BASE-T Ethernet ports used for the Ethernet over SDH (EoS) application.
- Up to 8 EoS channels.
- EoS framing procedure GFP according ITU-T G.7041.
- Virtual concatenation according to ITU-T G.783.
- Link capacity adjustment (LCAS) scheme according to ITU-T G.7042.
- Synchronous equipment timing source (SETS) with local oscillator.
- Multiplex section protection on the unit or with a protecting unit in a dedicated subrack slot.
- Subnetwork connection protection between any virtual channels on the unit.
- 1:1 equipment protection.
- Performance monitoring according to ITU-T G.826.

The SAMO5 has two LEDs for unit- and traffic related failure indication.

2.2.18   E1 Service Unit LEDE1
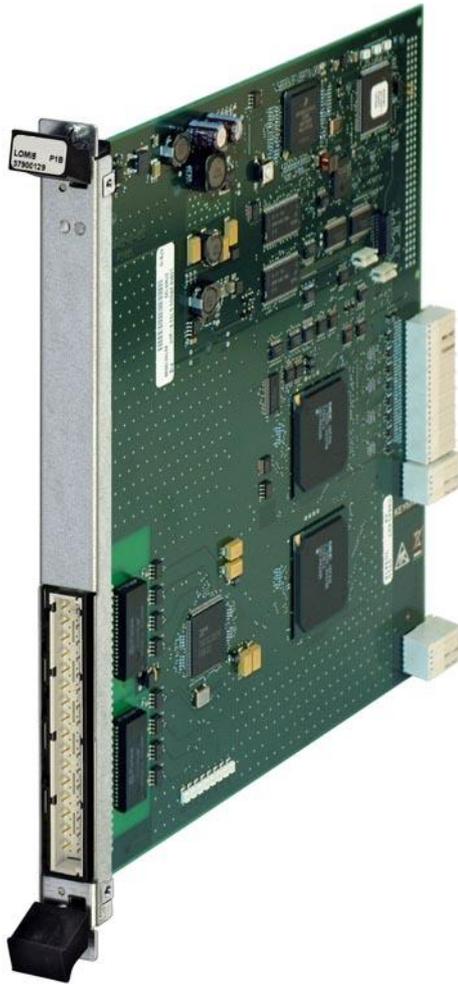
Figure 50:   LEDE1 unit view

The LEDE1 is a 1-slot wide E1 (2048 kbit/s) service unit of the FOX61x. It provides 8 E1 (2048 kbit/s) ports according to ITU-T G.703 / G.704. The unit can be operated in actively and passively cooled FOX61x subracks.

The LEDE1 is connected to other TDM units as e.g. DATI1 or LESU1 via the backplane of the FOX61x giving access to TDM based services.

It supports TDM voice and data services.

The LEDE1 unit provides the following functions:

- 8 E1 ports (8 x 2048 kbit/s according to ITU-T G.703).
- 120 Ω symmetrical and 75 Ω asymmetrical line impedances.
- Frame alignment and multiframe alignment according to ITU-T G.704.
- Transparent handling of 2048 kbit/s signals or termination of n x 64 kbit/s frame structure.
- Access to the TDM bus in the FOX61x and cross connection for PDH P12 and P0 signals.
- Diagnostic loop activation: Loop 1, 1A and 2.
- Performance monitoring according to ITU-T G.826.

The LEDE1 has two LEDs for unit- and traffic related failure indication.

2.2.19   E1 Circuit Emulation Service Unit CEPI1

Figure 51:   CEPI1 unit view

The CEPI1 unit is a 1-slot wide circuit emulation service over packet (CESoP) unit for the FOX61x. CEPI1 provides up to 64 Pseudo Wires towards the packet network with a total capacity of 8 x 2048 kbit/s. The unit provides also 8 E1 front ports. In total up to 64 Pseudo Wires and 8 E1 ports access the TDM bus (PBUS) on the backplane of the FOX61x subrack.

The unit with HW release R1x must be operated in an actively cooled FOX61x subrack. The unit with HW release R2A or newer can be operated in actively and passively cooled FOX-61x subracks.

The CEPI1 unit maps TDM based data traffic into packet based Pseudo Wires. It accesses P0_nc (n x 64 kbit/s) and P12 (2048 kbit/s) voice and data signals via PBUS from any other TDM unit accessing the PBUS.

The Pseudo Wires are connected to the GbE packet bus on the backplane of the FOX61x subrack.

The CEPI1 unit provides the following functions:

- 8 structure agnostic Pseudo Wires (8 x 2048 kbit/s), or
- 64 structure aware Pseudo Wires (64 x N x 64 kbit/s),
- 8 E1 TDM trunk ports (8 x 2048 kbit/s according to ITU-T G.703),
- 120 Ω symmetrical and 75 Ω asymmetrical line impedances,
- Frame alignment and multiframe alignment according to ITU-T G.704,

- Transparent handling of 2048 kbit/s signals or termination of n x 64 kbit/s frame structure,
- Access to the TDM bus in the FOX61x and cross connection for PDH P12 and P0 signals.
- Diagnostic loop activation,
- TDM pattern generator and analyzer for bit error rate tests and round trip delay measurements,
- Performance monitoring according to ITU-T G.826,
- Front panel access for the E1 ports. One shielded cable is connected to the front panel. It carries all 8 subscriber lines,
- Support of SAToP (Structure Agnostic TDM over Packet) service,
- Support of CESoPSN (Circuit Emulation Service over Packet Switched Networks),
- Support of CESoETH (Circuit Emulation Service over Ethernet, MEF8), structure agnostic and structure aware,
- Adaptive and synchronous clock recovery modes for all Pseudo Wires.

The CEPI1 has two LEDs for unit- and traffic related failure indication.

2.2.20   TDM SHDSL Service Unit DATI1

Figure 52:   DATI1 unit view

The DATI1 unit is a 1-slot wide SHDSL (TDM) service unit for the FOX61x. It has 8 SHDSL interfaces towards the subscriber CPEs or to another DATI1 unit (trunk mode) and is connected to the TDM bus on the backplane of the FOX61x subrack. It can be operated in actively and passively cooled FOX61x subracks.

DATI1 is used for SHDSL according to ITU-T G.991.2.

The DATI1 unit provides the following functions:

- 8 SHDSL interfaces according to
  - ITU-T, G.991.2, Annex B (SHDSL in European networks).
- Support of data rates up to 2'048 kbit/s.
- Support of pair bonding (4-wire mode).
- Support of the following applications:
  - Transparent 2 Mbit/s client link.
  - Structured 2 Mbit/s client link.
  - Fractional 2 Mbit/s client link.
  - n x 64 kbit/s data link.
  - Fractional n x 64 kbit/s data link.
  - Trunk application.
- Support of X.21 interfaces (on CPE).
- Support of V.35 and V.36 interfaces (on CPE).
- Support of Ethernet interfaces (on CPE).
- Support of E1 interfaces (on CPE).
- Support of regenerators.
- Handshaking procedures according to G.994.1.
- Remote power feeding for CPEs.
- DSL test loops.

The DATI1 has two LEDs for unit- and traffic failure indication.

2.2.21   Media Gateway Unit COSI1

Figure 53:   COSI1 hardware unit view

i	**Please note:** The service units COSI1 and VFTLF use the same hardware unit named COSI1.

The COSI1 unit acts as a SIP media gateway for voice over IP for PSTN user ports. The unit with HW release up to R1C must be operated in an actively cooled FOX61x subrack. The unit with HW release R1D or newer can be operated in actively and passively cooled FOX-61x subracks.

COSI1 plays the role of a user agent in the SIP architecture and communicates with SIP call servers. POTS signaling is terminated and packetized to SIP. The COSI1 unit converts TDM based voice traffic into IP packets. It accesses PSTN (FXS and FXO, POTS) services via PBUS from the LESU1 (PSTN FXS) and LEXI1 (PSTN FXO) units.

The IP data signal is connected to the core unit via the double GbE star.

The COSI1 unit provides the following functions:

- Up to 1216 PSTN FXS or FXO subscribers,
- Up to 20 ISDN-PRA ports,
- Up to 96 MFC-R2 ports,
- Up to 200 active voice channels (the COSI1 unit supports up to 80 active voice channels when using the G.729A codec. The G.711 codec is used for the remainder of the channels up to 200),
- G.711 codec and support of silence suppression,
- G.729A codec and support of silence suppression,

- Traffic handling capacity of up to 9'750 BHCA,
- Inband transport of modem- and Fax-data with the G.711 codec,
- Fax relay service according to T.38,
- Transport of 64 kbit/s clear channel data,
- DTMF relay according to RFC 2833,
- The SIP protocol is used for setting up / tearing down the connection between a TDM based voice channel and an IP based channel,
- The SIP protocol is used for the conversion of PSTN signaling into SIP messages and vice versa,
- IP traffic transport via the GbE star on the backplane of the FOX61x subrack to/from the core unit,
- IP QoS with DSCP control for control and media paths,
- VLAN tagging according to 802.1Q for control and media paths,
- Priority tagging according to 802.1p for control and media paths,
- RTP transport protocol for voice and data,
- RTCP support for maintenance data collection,
- 1:1 equipment protection,
- DTMF for CLIP,
- Session Timer,
- Overlap Dialing,
- Private Extension according to RFC 3325 (IMS adaptation).

The COSI1 unit has two LEDs for unit- and traffic failure indication.

2.2.22   Voice Frequency Processing Unit VFTLF

Figure 54:   VFTLF unit view

> **i**   **Please note:**
> The service units COSI1 and VFTLF use the same hardware unit named COSI1.

The VFTLF unit acts as a voice frequency processing unit. For each bidirectional channel the VFTLF unit provides two echo cancelers, eliminating the echo coming from the subscriber connected to the near end linecard, and eliminating the echo coming from the subscriber connected to the far end linecard.

The unit with HW release up to R1C must be operated in an actively cooled FOX61x subrack. The unit with HW release R1D or newer can be operated in actively and passively cooled FOX61x subracks.

The VFTLF unit provides the following functions:

- Up to 208 voice frequency processes,
- two echo cancelers per voice frequency process for PSTN subscribers,
- transparent forwarding of CAS,
- 1:1 equipment protection.

The VFTLF unit has two LEDs for unit- and traffic failure indication.

2.2.23   PSTN Service Units LESU1
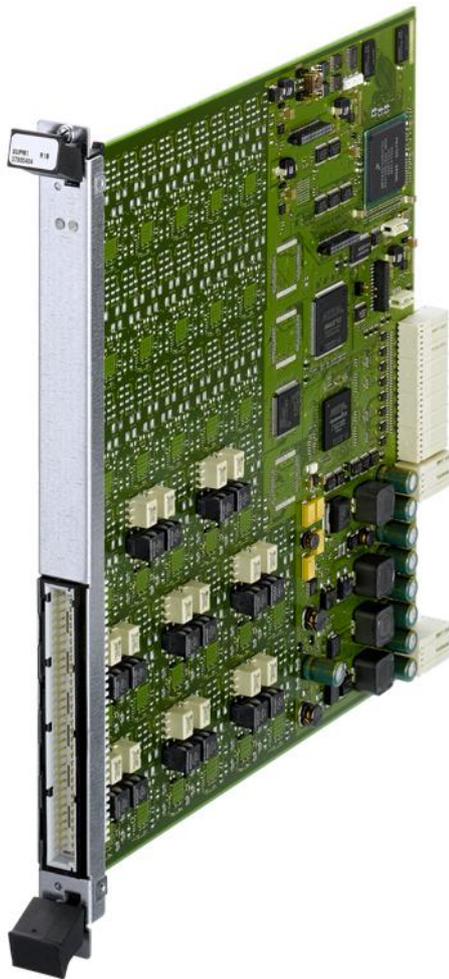
Figure 55:   LESU1 unit view

The LESU1 unit is a 1-slot wide service unit of the FOX61x offering PSTN FXS voice user ports. This type of user ports is also called 2-wire analog interface, or a/b-interface, or POTS port.

The LESU1 unit can be operated in actively and passively cooled FOX61x subracks [1].

The PSTN units are connected to a P12 transport unit (SAMO1, SAMO2, SAMO3, SAMO5, LEDE1, DATI1) via the PBUS in the backplane of the FOX61x.

The LESU1 offers 16 user ports.

The LESU1 unit provides the following functions:

- PSTN user ports according to ITU-T Q.552.
- BORSCHT functionality:
    - Battery feed.
    - Overvoltage protection.
    - Ringing injection.
    - Supervision.
    - Codec.
    - Hybrid.
    - Testing.
- Voice impedances configurable for different countries and applications.

---

1. When operating the LESU1 unit in a passively cooled subrack the loop current is limited to 23.5 mA.

- Input and output level configuration.
- V5CAS operation mode (internal communication).
- Onboard ringing generator.
- Onboard line-test function.
- Thermal management.
- Protection against equipment damage caused by faulty installation of cables.

The LESU1 unit has two LEDs for unit- and traffic failure indication.

2.2.24 E&M Voice Service Unit LEDA1

Figure 56:   LEDA1 unit view

The LEDA1 unit is a 1-slot wide service unit of the FOX61x. It has 8 E&M user ports. Each E&M user port consists of one 2-wire or 4-wire voice port and two E&M signaling ports. The unit can be operated in actively and passively cooled FOX61x subracks.

The main applications of the LEDA1 unit are:

- Inter-exchange connections, supporting E&M interface types I to V.
- Terminal equipment connections, e.g. for party line subscriber sets or modems for data over voice transmission.

LEDA1 is connected to a P12 transport unit (SAMO1, SAMO2, SAMO3, SAMO5, LEDE1, DATI1) via the PBUS in the backplane of the FOX61x.

The LEDA1 unit provides the following functions:

- 8 analog voice interfaces with a telephony bandwidth of 300 Hz to 3.4 kHz, configurable to 2-wire or 4-wire access mode, ITU-T G.711.

- 16 E&M signaling interfaces, where each voice channel offers 2 E&M signaling channels.
- Voice conferences with participants from the LEDA1 unit or any voice circuit available in FOX61x:
  - Up to 10 conferences per unit.
  - Up to 17 participants per conference.
  - Up to 32 participants per unit.
- Conference type:
  - Multipoint-to-multipoint.
  - Point-to-multipoint.
- 1:1 equipment protection.
- 1+1 linear trail protection (LTP).
- 1+1 subnetwork connection protection with inherent monitoring (SNC/I).
- Performance monitoring.
- Maintenance functions:
  - Test signal insertion, per user port and conference participant.
  - Out of service, per user port and conference participant.
  - Loops, voice and signaling front -to-front loop and back-to-back loop.

The LEDA1 has two LEDs for unit- and traffic failure indication.

2.2.25   FXO Voice Service Unit LEXI1

Figure 57:   LEXI1 unit view

The LEXI1 unit is a 1-slot wide service unit of the FOX61x. It has PSTN FXO voice user ports voice interfaces. It can be operated in actively and passively cooled FOX61x subracks.

The LEXI1 unit connects its FXO interface to a local exchange FXS interface, simulating the functions of a telephone set. With the LEXI1 unit the telephone connection to an exchange can be extended via a TDM network.

The LEXI1 offers 12 user ports.

LEXI1 is connected to a P12 transport unit (SAMO1, SAMO2, SAMO3, SAMO5, LEDE1, DATI1) via the PBUS in the backplane of the FOX61x.

The LEXI1 unit provides the following functions:

- Analog voice interfaces (FXO) with a telephony bandwidth of 300 Hz to 3.4 kHz, 2-wire access mode, ITU-T G.711.
- Out-of-band signaling functions:
  - On-hook and off-hook.
  - Hook flash.
  - Pulse dialing.
  - Ground key function.
  - Ringing.
  - Metering.
  - Polarity reversal.
- Wide range of configurable line impedances.
- 1+1 linear trail protection (LTP).
- 1+1 subnetwork connection protection with inherent monitoring (SNC/I).
- Performance monitoring.
- Maintenance functions:
  - Test signal insertion, per user port.
  - Voice back-to-back loop.

The LEXI1 has two LEDs for unit- and traffic failure indication.

2.2.26 Data Service Unit LEDS1

Figure 58:   LEDS1 unit view

The LEDS1 unit is a 1-slot wide service unit of the FOX61x. It has four TDM data ports. Each data port is configurable to

- – V.24/V.28, or
- – V.35 (Appendix II), or
- – X.24/V.11, or
- – RS485 2-wire, or
- – RS485 4 wire.

In addition it provides one electrical Ethernet interfaces 10/100BASE-T for Ethernet over PDH (EoP) transport.

The unit can be operated in actively and passively cooled FOX61x subracks.

LEDS1 is connected to a P12 transport unit (SAMO1, SAMO2, SAMO3, SAMO5, LEDE1, DATI1) via the PBUS in the backplane of the FOX61x.

The LEDS1 unit provides the following functions:

- Four data interfaces, independently configurable as DCE interface type.
- The DCE interfaces support the transmission modes:
  - – Asynchronous mode for subrates from 0.6 kbit/s to 38.4 kbit/s.
  - – Synchronous mode for subrates from 0.6 kbit/s to 56 kbit/s.
  - – Synchronous mode for nx64 data rates from 1x64 kbit/s to 32x64 kbit/s.
  - – Oversampling mode for data rates from 0 kbit/s to 600 kbit/s.

- – Transition coding for data rates from 0 kbit/s to 19.2 kbit/s.
- The synchronous nx64 transmission modes provide the codirectional or contradirectional timing operation.
- Data conferences with participants from the LEDS1 unit or any TDM circuit available in FOX61x:
  - – Up to 212 conferences per unit.
  - – Up to 16 participants per conference.
  - – Maximum participant bandwidth is 31x64 kbit/s.
  - – Maximum conferencing bandwidth per unit is 848x64 kbit/s.
- Conference type:
  - – Multipoint-to-multipoint.
  - – Point-to-multipoint.
- One Ethernet interface 10/100BASE-T for Ethernet over PDH transport.
- 1:1 equipment protection.
- 1+1 linear trail protection (LTP).
- 1+1 subnetwork connection protection with inherent monitoring (SNC/I).
- Performance monitoring.
- Maintenance functions:
  - – Test signal insertion, per user port and conference participant.
  - – Out of service, per user port and conference participant.
  - – Loops, data front -to-front loop and back-to-back loop.

The LEDS1 has two LEDs for unit- and traffic failure indication.

2.2.27   E0 Service Unit LECO1

Figure 59:   LECO1 unit view

The LECO1 unit is a 1-slot wide service unit of the FOX61x. It has 8 E0 (G.703) codirectional interfaces. Alternatively the LECO1 unit can be operated with 2 E0 (G.703) contradirectional interfaces. It can be operated in actively and passively cooled FOX61x subracks.

LECO1 is connected to a P12 transport unit (SAMO1, SAMO2, SAMO3, SAMO5, LEDE1, DATI1) via the PBUS in the backplane of the FOX61x.

The LECO1 unit provides the following functions:

- 8 full duplex codirectional data interfaces according to ITU-T G.703, independently configurable, or
- 2 full duplex contradirectional data interfaces according to ITU-T G.703, independently configurable.
- Synchronous 64 kbit/s transmission with co- or contradirectional timing operation.
- Timing adaptation of asynchronous transmit signals with octet slips.
- 1+1 linear trail protection (LTP).
- 1+1 subnetwork connection protection with inherent monitoring (SNC/I).
- Performance monitoring.
- Maintenance functions:
    - Front-to-front loop.
    - Back-to-back loop.

The LECO1 has two LEDs for unit- and traffic failure indication.

2.2.28   Teleprotection Signaling and Binary Signal Service Unit TEPI1

Figure 60:   TEPI1 unit view

The TEPI1 unit is a 1-slot wide service unit of the FOX61x. It offers 4 electrical distance protection commands towards the protection relay. In addition the service unit offers a variety of additional auxiliary features.

The unit can be operated in actively and passively cooled FOX61x subracks.

TEPI1 is connected to a P12 transport unit (SAMO1, SAMO2, LEDE1, DATI1) via the TDM bus in the backplane of the FOX61x.

The TEPI1 unit provides the following functions:

- Teleprotection signaling, IEC 60834-1 Ed. 2
- Binary signal transmission
- External alarm acquisition
- Remote control
- Time synchronization via IRIG-B input
- Event recording
- Proprietary trail protection at 64kbit/s level for fast switching
- Performance monitoring
- Maintenance functions:
    - P0 front-to-front loop.
    - P0 back-to-back loop.
    - Cmd front-to-front loop.

The TEPI1 has two LEDs for unit- and traffic failure indication.

2.2.29   Teleprotection Signaling and Binary Signal Service Unit TEPI2

Figure 61:   TEPI2 unit view

The TEPI2 unit is a 1-slot wide service unit of the FOX61x. It offers 4 electrical distance protection commands towards the protection relay. In addition the service unit offers a variety of additional auxiliary features.

The unit can be operated in actively and passively cooled FOX61x subracks.

The packetized data signal is connected to the core unit via the double GbE star.

The TEPI2 unit provides the following functions:

- Teleprotection signaling, IEC 60834-1 Ed. 2
- Binary signal transmission
- External alarm acquisition
- Remote control
- Time synchronization via IRIG-B input and output, and PPS output
- Event recording
- Redundant transmission for hitless operation
- Maintenance functions:
    - Traffic front-to-front loop.
    - Traffic back-to-back loop.
    - Cmd front-to-front loop.

The TEPI2 has two LEDs for unit- and traffic failure indication.

2.2.30   Differential Protection Service Unit OPIC1

Figure 62:   OPIC1 unit view

The OPIC1 unit is a 1-slot wide service unit of the FOX61x. It offers 4 optical differential protection interfaces complying to IEEE C37.94 standard, or to the proprietary FOX6plus compatible optical transmission protocol (ABB Power Grids TPE) for differential protection applications.

The unit can be operated in actively and passively cooled FOX61x subracks.

OPIC1 is connected to a P12 transport unit (SAMO1, SAMO2, LEDE1, DATI1) via the PBUS in the backplane of the FOX61x.

The OPIC1 unit provides the following functions:

- SFP interfaces
- Optical interfaces for differential protection, IEEE C37.94 (IEC 62843) or ABB Power Grids TPE
- Proprietary trail protection at n x 64kbit/s level with symmetrical bi-directional switching algorithm.
- Performance monitoring
- Maintenance functions:
  - P0_nc back-to-back loop (local and remote).
  - P0_nc front-to-front loop.

The OPIC1 has two LEDs for unit- and traffic failure indication.

2.2.31   Differential Protection Service Unit OPIC2

Figure 63:   OPIC2 unit view

The OPIC2 unit is a 1-slot wide service unit of the FOX61x It offers 4 optical interfaces for differential protection complying to IEEE C37.94 standard or to the proprietary FOX6plus compatible optical transmission protocol (ABB Power Grids TPE) for differential protection applications. In addition it provides on 2 of the 4 ports the FO5 protection interface type.

The unit can be operated in actively and passively cooled FOX61x subracks.

The teleprotection signals are transported in specific packets via circuit emulation channels. The packetized data signal is connected to the core unit via the double GbE star.

Alternatively the OPIC2 is connected to a P12 transport unit (SAMO1, SAMO2, LEDE1, DATI1) via the PBUS in the backplane of the FOX61x to transport the teleprotection signals.

The OPIC2 unit provides the following functions:

- SFP interfaces
- Optical interfaces for differential protection, IEEE C37.94 (IEC 62843) or ABB Power Grids TPE or FO5
- Access to the PBUS for generic circuit emulation service of P0_nc or P12 signals (specifically intended for differential protection applications)
- IRIG-B optical and electrical outputs, and PPS outputs
- Redundant transmission for hitless operation
- Performance monitoring

- Maintenance functions:
  - Traffic back-to-back loop (local and remote).
  - Traffic front-to-front loop.

The OPIC2 has two LEDs for unit- and traffic failure indication.

2.2.32   IEC 61850 GOOSE and SV Proxy Gateway Unit TEGO1
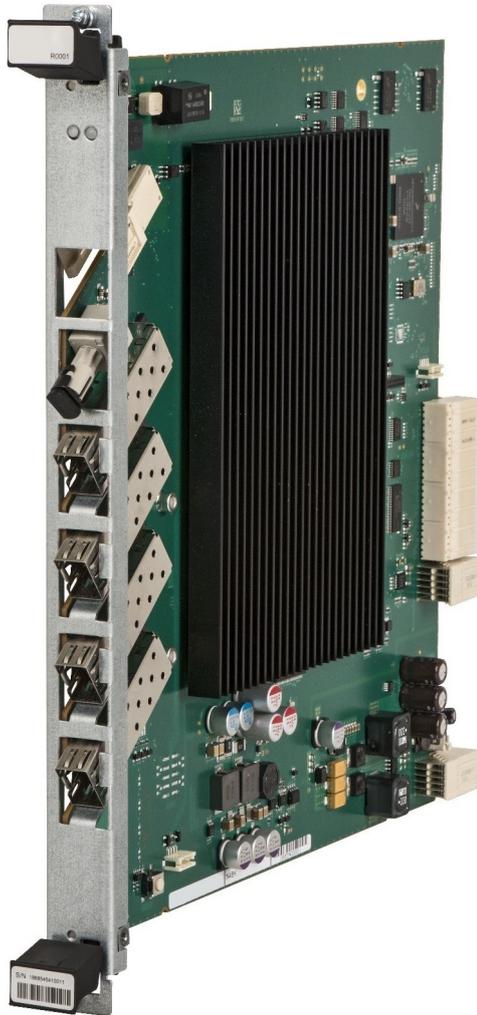
Figure 64:   TEGO1 unit view

The TEGO1 unit is a 1-slot wide service unit of the FOX61x. The unit can be operated in actively and passively cooled FOX61x subracks.

The TEGO1 unit offers 4 optical station bus interfaces complying to the IEC 61850 standard. On the LAN side TEGO1 accesses GOOSE and/or SV messages on the IEC 61850 station bus. TEGO1 is an IED acting as a proxy gateway for GOOSE and/or SV messages between substations. GOOSE and/or SV messages are transported to remote substations via up to eight WAN channels.

The packetized data signal is connected to the core unit via the double GbE star.

The TEGO1 unit provides the following functions:

- SFP interfaces
- Optical LAN interface for IEC 61850
- LAN redundancy protocol PRP
- IRIG-B optical and electrical outputs, and PPS outputs
- Internal and external synchronization sources

- PTP gateway support for the optical Ethernet traffic front interfaces. The PTP telecom profile used by the FOX61x core unit is translated to the PTP power profile (IEC 61850-9-3). The TEGO1 is acting as a PTP master clock.
- Monitoring of round trip delay and communication status

The TEGO1 has two LEDs for unit- and traffic failure indication.

2.3   FOX61x Auxiliary Units

2.3.1   Dual Power Input Unit DUPF1 (FOX615 R2 and FOX615)

With the DUPF1 multi-connection unit, it is possible to power the FOX615 R2 and FOX615 subrack from two redundant primary power supplies.

The DUPF1 is installed in the FOX615 R2 or FOX615 subrack on the bottom of the back-plane.

> **i**   **Please note:**
> The dual power supply unit DUPF1 feeding up to 30 A requires active cooling.
> → It must only be operated in a subrack equipped with the optional fan unit FAMO1.

> **i**   **Please note:**
> The dual power supply unit DUPF1 feeding up to 25 A can be operated without active cooling.

Figure 65:   DUPF1 unit view

The DUPF1 unit provides the following functions:

- Two external power supplies are connected in parallel to the DUPF1. DUPF1 provides the power supply for the subrack.
- The nominal values for the primary voltage are -48 VDC and -60 VDC with the 0 volt potential connected to signal ground. The maximum current is 30 A.

> **i**   **Please note:**
> The FOX615 R2 subrack and the FOX615 subrack revisions R2A, R2B and R3B provide a maximum power supply current of 45 A. When using the DUPF1 the maximum power supply current is limited to 30 A.
> → If you need dual power input with a higher current rating please contact your ABB Power Grids sales representative.

- The availability of both power supplies is supervised and a failure is alarmed. For this purpose, the DUPF1 has an alarm interface with two alarm signals. This alarm interface is connected to the alarm input interface of the FAMO1 or FAMO1-F unit. The FAMO1 or FAMO1-F alarm input interfaces are connected to the core unit for alarm processing.
- Surge protection on power supply input side.

- Protection against reverse polarity.

2.3.2   Dual Power Input Unit DUPF1-R (FOX615 R2 and FOX615)

With the DUPF1-R multi-connection unit, it is possible to power the FOX615 R2 and FOX615 subrack from two redundant primary power supplies.

The DUPF1-R is installed below the cable tray of the FOX615 R2 or FOX615 subrack.

> **i**   **Please note:**
> The dual power supply unit DUPF1-R feeding up to 30 A requires active cooling.
> → It must only be operated in a subrack equipped with the optional fan unit FAMO1.

> **i**   **Please note:**
> The dual power supply unit DUPF1-R feeding up to 25 A can be operated without active cooling.
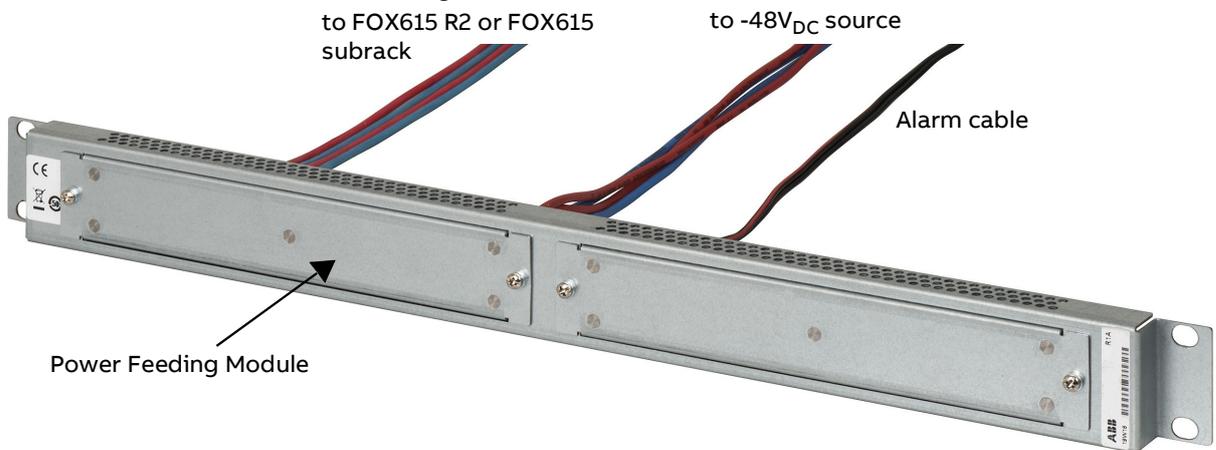
Figure 66:   DUPF1-R unit view with two Power Feeding Modules, including the power cables of one module

Figure 67:   DUPF1-R Power Feeding Module, front and rear views

The DUPF1-R unit provides the following functions:

- The DUPF1-R provides two fully independent Power Feeding Modules. The two Power feeding Modules are mounted to the DUPF1-R housing.

> ⓘ **Please note:**
>
> The Power Feeding Modules (right (main) or left (backup)) of the DUPF1-R can be exchanged or replaced independently without any service interruption.

- Two external power supplies are connected in parallel to the two Power Feeding Modules of the DUPF1-R. The two Power Feeding Modules of the DUPF1-R provide two independent power supplies for the subrack.
- The nominal values for the primary voltage are -48 VDC and -60 VDC with the 0 volt potential connected to signal ground. The maximum current is 30 A.

> ⓘ **Please note:**
>
> The FOX615 R2 subrack and the FOX615 subrack revisions R2A, R2B and R3B provide a maximum power supply current of 45 A. When using the DUPF1-R the maximum power supply current is limited to 30 A.
>
> → If you need dual power input with a higher current rating please contact your ABB Power Grids sales representative.

- The availability of both power supplies is supervised and a failure is alarmed. For this purpose, each Power Feeding Module has an alarm interface with one alarm signal. The alarm interfaces of both Power Feeding Modules are connected to the alarm input interface of the FAMO1 or FAMO1-F unit. The FAMO1 or FAMO1-F alarm input interfaces are connected to the core unit for alarm processing.
- Surge protection on power supply input side.
- Protection against reverse polarity.

2.3.3   Dual Power Input Unit DUPF2 (FOX612 and FOX611)

With the DUPF2 multi-connection unit, it is possible to power the FOX612 or FOX611 subrack from two redundant primary power supplies.

The DUPF2 is installed on the cable tray of the FOX612 or on the 19-inch adapter of the FOX611. A specific cable tray for the FOX612 is available for this purpose.

Figure 68:   DUPF2 unit view

The DUPF2 unit provides the following functions:

- Two external power supplies are connected in parallel to the DUPF2. DUPF2 provides the power supply for the subrack. The nominal values for the primary voltage are -48 VDC and -60 VDC with the 0 volt potential connected to signal ground. The maximum current is 15 A.
- The availability of both power supplies is supervised and a failure is alarmed. For this purpose, the DUPF2 has an alarm interface with two alarm signals. This alarm interface is connected to the alarm input interface of the FAMO2, FAMO2-F, FAMO3 or FAMO3-F

unit. The FAMO2, FAMO2-F, FAMO3 or FAMO3-F alarm input interfaces are connected to the core unit for alarm processing.

- Surge protection on power supply input side.
- Protection against reverse polarity.

2.3.4 Fan Unit FAMO1 (FOX615 R2 and FOX615)

The FOX615 R2 and FOX615 applications with active cooling require the fan unit FAMO1 for the forced ventilation of the subrack. All FOX61x units which can be operated with passive cooling are listed in section 2.1.1.1 FOX615 R2 (on page 30) and section 2.1.1.2 FOX615 (on page 32). With all other units active cooling is mandatory to evacuate the locally dissipated heat.

The FAMO1 has 10 individually monitored fans that are integrated in a 19-inch subrack (1 HU). The FAMO1 is powered from the FOX615 R2 or FOX615 subrack while the core unit monitors the alarms from the fan unit.

The fan unit FAMO1 mounted in the rack just above the FOX615 R2 or FOX615 subrack, without any distance between the two parts. It has the performance to evacuate up to 1800 W from the FOX615 R2 or FOX615 subrack.

The speed of the fans is temperature controlled, in order to optimize the noise behavior and the MTTF. The fans turn with low speed for air temperatures below the lower threshold temperature (20°C) and with their maximum speed for air temperatures above the upper threshold temperature (35°C). Between the temperature thresholds, the speed of the fans is proportional to the air temperature. Please note that the air temperature is measured at the point where it leaves the subrack.

The FAMO1 has 2 completely separate internal power supply circuits which facilitate redundant power supply for the fans. 3 LEDs indicate the status of the power supply and the fans.

The FAMO1 provides 2 alarm output interfaces and 12 alarm input interfaces. These alarm interfaces are connected to the core unit for alarm processing via a power and alarm cable from the FAMO1 front to the backplane. The alarm output interfaces can be used e.g. for the control of alarm lamps or bells. The alarm input interfaces are used for the reception of the DUPF1 or DUPF1-R alarms and may be used for the reception of external equipment alarms, like "battery low", "air condition failure", "door open" etc.

Figure 69:   FAMO1 unit view

A heat deflection shield for the evacuation of the hot air to the front or to the rear of the rack can be installed above the subrack or below the cable tray.

Figure 70:   Heat deflection shield view

2.3.5   Fan Unit FAMO2 (FOX612)

The FOX612 applications with active cooling require the fan unit FAMO2 for the forced ventilation of the subrack. All FOX61x units which can be operated with passive cooling are listed in section 2.1.1.3 FOX612 (on page 34). With all other units active cooling is mandatory to evacuate the locally dissipated heat.

Active cooling is also mandatory for the horizontally mounted FOX612 subrack, regardless of the unit types deployed.

Figure 71:   View of the FAMO2 (R3) fan unit

The FAMO2 fan unit has four individually monitored fans that are integrated into a pluggable unit.

The FAMO2 unit is plugged into the top part of the vertically mounted subrack, or into the left hand side when mounted horizontally, respectively. It has the performance to evacuate up to 600 W from the FOX612 subrack.

The speed of the fans is temperature controlled, in order to optimize the noise behavior and the MTTF. The fans turn with low speed for air temperatures below the lower threshold temperature and with their maximum speed for air temperatures above the upper threshold temperature. Between the temperature thresholds, the speed of the fans is proportional to the air temperature. Please note that the air temperature is measured at the point where it leaves the subrack.

The FAMO2 has 4 separate internal power supply circuits to power the fans individually. 3 LEDs indicate the status of the power supply and the fans.

The FAMO2 provides 12 alarm input interfaces on its front. These alarm interfaces are connected to the core unit via the backplane for alarm processing. The alarm input interfaces are used for the reception of external equipment alarms, like "battery low", "air condition failure", "door open" etc.

Moreover, the FAMO2 (R3) provides 2 alarm output interfaces, which can be used e.g. for the control of alarm lamps or bells.

2.3.6　Fan Unit FAMO3 (FOX611)

The FOX611 applications with active cooling require the fan unit FAMO3 for the forced ventilation of the subrack. All FOX61x units which can be operated with passive cooling are listed in section 2.1.1.4 FOX611 (on page 35). With all other units active cooling is mandatory to evacuate the locally dissipated heat.

Active cooling is also mandatory for the horizontally mounted FOX611 subrack, regardless of the unit types deployed.

Figure 72:　View of the FAMO3 (R1) fan unit

The FAMO3 fan unit has two individually monitored fans that are integrated into a pluggable unit.

The FAMO3 unit is plugged into the top part of the vertically mounted subrack, or into the left hand side when mounted horizontally, respectively. It has the performance to evacuate up to 380 W from the FOX611 subrack.

The speed of the fans is temperature controlled, in order to optimize the noise behavior and the MTTF. The fans turn with low speed for air temperatures below the lower threshold temperature and with their maximum speed for air temperatures above the upper threshold temperature. Between the temperature thresholds, the speed of the fans is proportional to the air temperature. Please note that the air temperature is measured at the point where it leaves the subrack.

The FAMO3 has 2 separate internal power supply circuits to power the fans individually. 3 LEDs indicate the status of the power supply and the fans.

The FAMO3 provides 4 alarm input interfaces on its front. These alarm interfaces are connected to the core unit via the backplane for alarm processing. The alarm input interfaces are used for the reception of external equipment alarms, like "battery low", "air condition failure", "door open" etc.

Moreover, the FAMO3 (R2) provides 2 alarm output interfaces, which can be used e.g. for the control of alarm lamps or bells.

2.3.7　Alarm Unit FAMO1-F (FOX615 R2 and FOX615)

The FAMO1-F is an alarm unit used in place of the fan unit FAMO1 in a passively cooled FOX615 R2 or FOX615.

The FAMO1-F has the same alarm interfaces as the FAMO1. The FAMO1-F provides 2 alarm output interfaces and 12 alarm input interfaces. The interfaces for the alarm signals and the FAMO1-F power supply are on the unit front panel.

The FAMO1-F is powered from the FOX615 R2 or FOX615 subrack while the core unit monitors the alarms from the alarm unit.

The FAMO1-F is typically installed above the FOX615 R2 or FOX615 subrack.

Figure 73:   FAMO1-F R1B unit

2.3.8   Alarm Unit FAMO2-F (FOX612)

The FAMO2-F is an alarm unit used in place of the fan unit FAMO2 in a passively cooled FOX612.

> **i**   **Please note:**
> Passive cooling with the horizontally mounted FOX612 subrack is not possible.
> → A horizontally mounted FOX612 subrack requires active cooling with a fan unit.

The FAMO2-F has the same alarm interfaces and the same mechanical specification as the FAMO2 (R3). The FAMO2-F provides 2 alarm output interfaces and 12 alarm input interfaces. The interfaces for the alarm signals are on the unit front panel.

The FAMO2-F is internally powered from the FOX612 subrack while the FOX612 core unit monitors the alarms from the alarm unit.
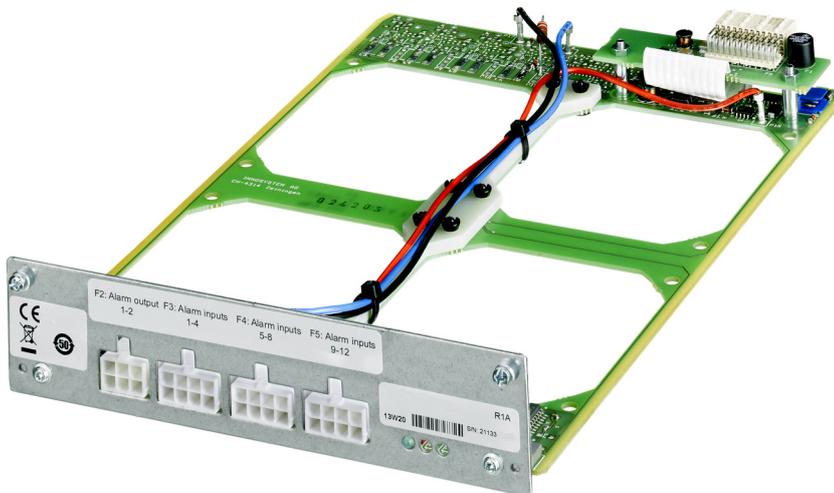
Figure 74:   FAMO2-F unit

2.3.9   Alarm Unit FAMO3-F (FOX611)

The FAMO3-F is an alarm unit used in place of the fan unit FAMO3 in a passively cooled FOX611.

> **i**   **Please note:**
> Passive cooling with the horizontally mounted FOX611 subrack is not possible.
> → A horizontally mounted FOX611 subrack requires active cooling with a fan unit.

The FAMO3-F has the same alarm interfaces and the same mechanical specification as the FAMO3 (R2). The FAMO3-F provides 2 alarm output interfaces and 4 alarm input interfaces. The interfaces for the alarm signals are on the unit front panel.

The FAMO3-F is internally powered from the FOX611 subrack while the FOX611 core unit monitors the alarms from the alarm unit.

Figure 75:   FAMO3-F unit

2.3.10   Air Flow Optimization Unit AFOU1

When increasing the maximum ambient temperature of the FOX61x subrack from +60°C to +65°C without taking any measures the SFP module temperature can exceed the maximum allowed case temperature.

To lower the SFP case temperature the cooling of the SFP modules must be improved. The airflow has to be improved by placing specific air flow optimization units in the neighboring subrack slots of units with SFP interfaces. The air flow optimization unit for FOX61x is named AFOU1.

The AFOU1 is a purely passive unit and provides no LEDs at the unit front or any other electrical components on the unit.

> **i**   **Please note:**
> It is also possible to use FOX61x service units with a low power dissipation instead of an air flow optimization unit.

Figure 76:   AFOU1 unit

For further information please refer to [1KHW029122] Application Note "Extended Temperature Range Operation".

2.4   Cabling and Connections

2.4.1   Electrical Signal Interfaces

All signal cables are connected to the corresponding service or core units via front connectors.

The FOX61x uses the following connectors for its electrical front interfaces:

- Standard connector for traffic signals (LESU1, LEDA1, LEXI1, LECO1, LEDE1, DATI1, CEPI1, DEFM1) and auxiliary signals (TEPI1, TEPI2);

   The standard connector for the FOX61x service units features connector frames based on the standard DIN 41 612. The connector caps of the cables can be locked to the units by means of latching clips (refer to Figure 16: "Plug-in unit with standard front connector (sample)" (on page 40));

- Special connector, based on the standard DIN 41 612, with increased dielectric property for teleprotection tripping command signals (TEPI1, TEPI2);

- Metral ® with 4x6 male contacts for data interfaces or IRIG-B/PPS interfaces (LEDS1, OPIC2, TEGO1);

- RJ45 for Ethernet interfaces (CESM3, CESM2, CESM1, ELET1, EPOI1, ESPO1, SAMO1, EPSI1, LEDS1);

- SFP modules with electrical STM-1 interfaces (coaxial; SAMO1, SAMO5, SAMO2, SAMO3);

- SFP modules with electrical Gigabit Ethernet interfaces (RJ45; CESM3, CESM2, CESM1, ETOP1, ESOP1, EROP1);
- Micro DSub-9 Connector, symmetrical clock input/output 120 Ω (CESM3, CESM2, CESM1);
- Micro DSub-9 Connector, "time of day" and "pulse per second" input/output 120 Ω (CESM3);
- Molex Mini-Fit, for alarm input (8 pins) and output (6 pins) interfaces (FAMO1, FAMO2, FAMO3, FAMO1-F, FAMO2-F, FAMO3-F).

2.4.2 Optical Signal Interfaces

All optical signal cables are connected to the corresponding service or core units via front connectors.

The FOX61x uses the following connectors for its optical front interfaces:

- QSFP+ modules with optical 40 Gigabit Ethernet interfaces (LC; EPEX1, future release);
- SFP+ modules with optical 10 Gigabit Ethernet interfaces (LC; CESM3, CESM2, CESM1, SENC1, EPEX1);
- SFP modules with optical Gigabit Ethernet interfaces (LC, SC; CESM3, CESM2, CESM1, SENC1, ETOP1, ESOP1, EROP1, TEGO1);
- SFP modules with optical STM-4 and STM-1 interfaces (LC; SAMO5, SAMO1);
- SFP modules with optical STM-16, STM-4 and STM-1 interfaces (LC; SAMO2, SAMO3);
- SFP modules with optical 2 Mbit/s, 4 Mbit/s interfaces (LC; OPIC1, OPIC2);
- IRIG-B/PPS output (ST connector; OPIC2, TEGO1).

The FOX61x uses the SFP cages, supporting those SFP modules that comply with the INF-8074i specification. In most cases, LC connectors are used.

2.4.3 Power Interfaces

Power cables are connected to the power interface of the corresponding network element.

The FOX61x uses the following connectors for its power interfaces:

- Terminal block with 2 x 4 terminals (+, -) for -48 VDC /-60 VDC connection (FOX615 R2 and FOX615),
- Terminal block with 2 x 3 clamp terminals (+, -, ⏚), for -48 VDC / -60 VDC connection (FOX612 and FOX611).

2.4.4 FOX61x Cable Tray and Grounding Bar

The signal cables are fed to the FOX615 R2 or FOX615 cable tray or to the FOX612 cable tray below the subrack (refer to Figure 77 or to Figure 78).

The cable tray provides strain relief and holds the cables in position for the units in the subrack above. The cable tray also features two connection points for the power supply. Thus, the subrack can be installed and removed independently from the cable tray and any installed cables.

The FOX611 subrack with its 19-inch adapter provides no cable tray. The signal cables have to be fixed directly to the rack.

The grounding bar for signal cables is in front at the bottom of the subrack. It connects the screens of the signal cables to the equipment ground. A simple clamping mechanism holds and connects the cable screens to the grounding bar. The grounding bar is a part of the construction of the subrack and consists of two independent halves (FOX615 R2 and FOX615).

The bar features a thread for the connection of the protective earth or it can also be used as a bonding point for wrist straps for maintenance.
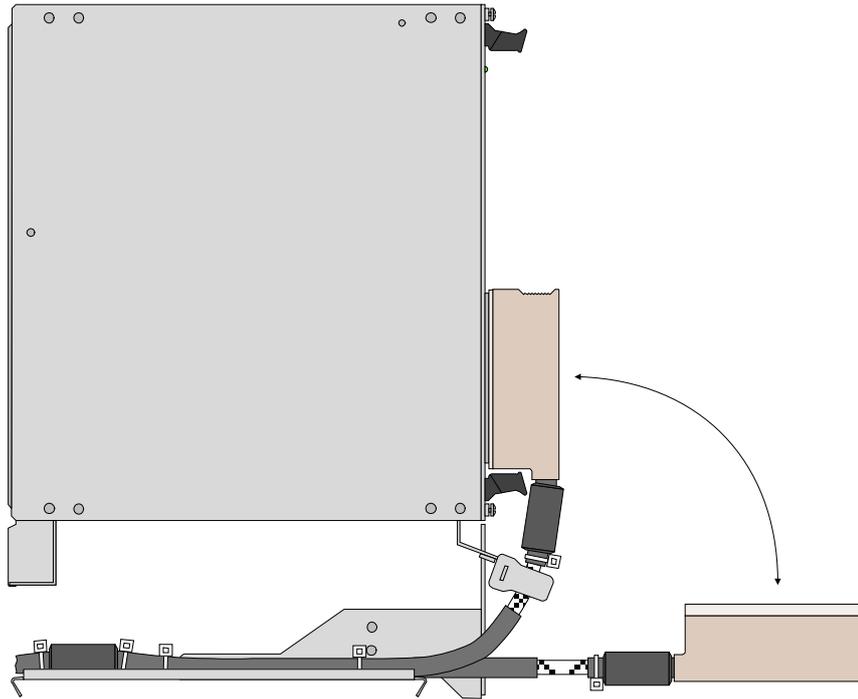
Figure 77:   Signal cables and grounding bar in the FOX615 R2 and FOX615

The cable tray provides the connection point for the primary power supply circuit. The standard connection point is for 1 DC power supply circuit.

For the FOX612, the cables are fixed to the cable tray as shown in Figure 78.
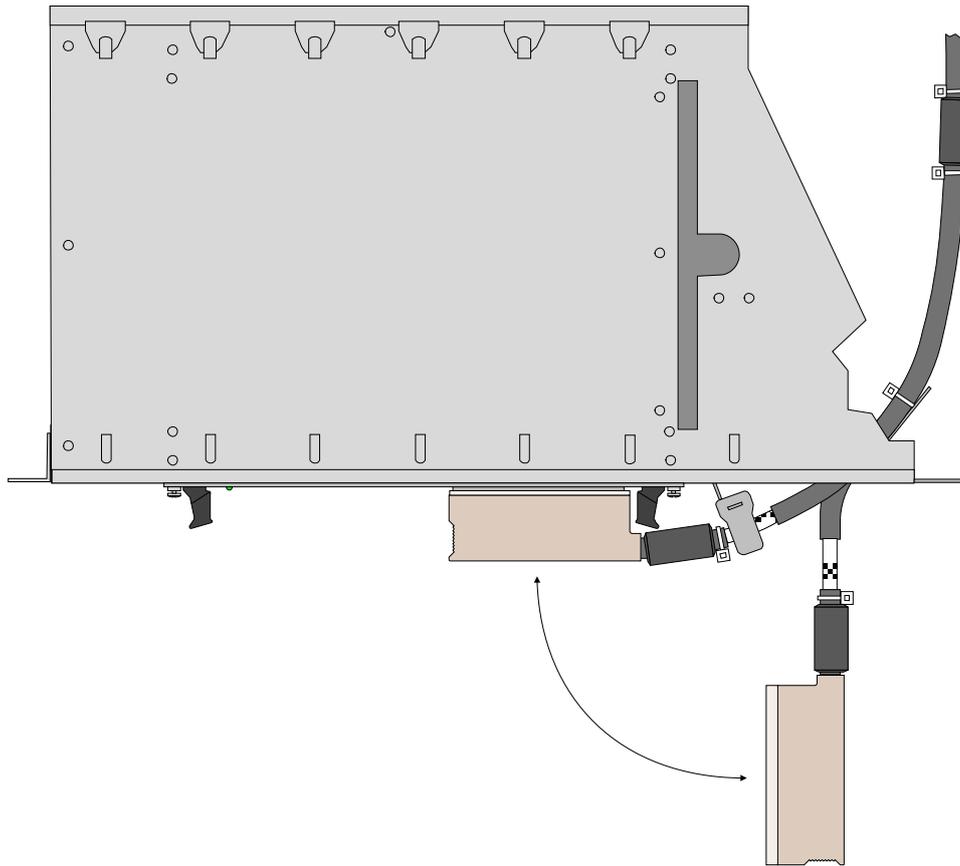
Figure 78:   Fixing signal cables in the FOX612 (top view for horizontal mounting)

Figure 79:   FOX615 R2 and FOX615 cabling practice

2.4.5   FAMO1 and FAMO1-F Cable

The FAMO1 unit or the FAMO1-F unit is connected to the FOX615 R2 or FOX615 backplane with a cable. This cable provides the power supply of the FAMO1 or FAMO1-F and it also connects the alarm I/O control and the FAMO1 or FAMO1-F alarm control signals to the core unit via a backplane connector. Hence, the 2 alarm output- and the 12 alarm input interfaces on the FAMO1 or FAMO1-F front are connected to the core unit via this cable.

2.4.6   DUPF1 and DUPF1-R Alarm Cable

The DUPF1 and the DUPF1-R have an alarm cable that is connected to a dedicated alarm input interface of the FAMO1 unit in the FOX615 R2 or FOX615.

2.4.7   DUPF2 Alarm Cable

The DUPF2 has an alarm cable that is connected to a dedicated alarm input interface of the FAMO2, FAMO2-F, FAMO3 or FAMO3-F unit in the FOX612 or FOX611.

2.5   ESD/EMC, Grounding and Earthing

The subrack with the front cover installed represents a Faraday cage like construction if the cables are connected to the cable grounding bar as instructed. Conductive metal sheets all around the subrack protect the FOX61x from ESD and electromagnetic fields.

The 19-inch mounting flanges of the subrack are conductive and provide a conductive contact to the rack if the rails of the rack provide a conductive surface.

When in operation, the FOX61x is protected against ESD in accordance with IEC 61000-4-2 and in accordance with the specified EMC properties, provided that

- all parts have been installed as instructed in the technical customer documentation,
- all the equipment is properly grounded,
- the FOX61x subrack is installed with its front cover,
- ABB Power Grids approved cables are used.

    ABB Power Grids gives no warranty for cables manufactured by third party and will not accept liability for EMC/ESD compliance if its equipment is operated with cables that are not approved by ABB Power Grids.

The positive potential of the primary DC power supply is connected with the system ground. The system ground connects internally to the construction of the subrack.

Earthing and bonding of FOX61x equipment in telecommunication centers is in relation to safety, functional performance and EMC:

- The FOX61x complies with the principles of Common Bonding Networks (CBN) as described in the standard ETSI EN 300 253 V2.1.1 (2002-04). It is designed for the integration according to the configuration shown in EN 300 253, Figure 2: "Example of a CBN/MESH-BN configuration with common d.c. return conductor connected to the CBN at multiple points".

3   FOX61x System Services

3.1   System Control

3.1.1   Principles

The system control of the FOX61x relies on processors on the service units (traffic units) and on a central control block. The central control block is placed on the core unit of the FOX61x.

The main tasks of the central control block are:

- Management of the NE configuration.
- Control of the system operation.
- Management communication.
- PDH synchronization.
- Monitoring of the system performance.

The system control uses decentralized processing for the different tasks. The service units provide local unit control and control of their traffic interfaces.

Most service unit processors use a dedicated communication channel (ICN = Internal Communication Network) for the communication between the core unit and the service units. The ICN is embedded in the physical structure of the backplane.

Some newer service units use the Gb Ethernet star connection to the core unit for the management communication.

> ℹ️ **Please note:**
> When operating the FOX61x subrack with the CESM1 or CESM2 core unit, the user traffic makes also use of the GbE star instead of the 10 GbE star.
>
> → The GbE star bandwidth must be shared between the user traffic and the management traffic.

Table 13:   Service units managed via the GbE star connection

Service/core unit	introduced with FOX61x release
CESM3	R3A
CESM2	R2D
CESM1	R1C
EPEX1	R15A
ETOP1	R1C
ELET1	R1C
EPOI1	R1C
ESPO1	R3A_SP01
ESOP1	R3A_SP01
DEFM1	R1D
SAMO5	R2D
SAMO2	R1C
SAMO3	R1C
EROP1	R2D

The unit management via the Gb Ethernet star is tagged with the VLAN ID 4094 and uses the queue of the traffic class 7.

3.1.2   Core Unit

A major task of the central control block, which is a part of the core unit CESM3 or CESM2 or CESM1 is the maintenance of the NE database, which stores the complete NE configuration. This information will serve to reconfigure units that have been restarted or replaced. All the information on system or unit configuration is stored and administrated via the management information database.

The FOX61x provides 1:1 equipment protection for the core unit. The description of this function is given in section 4.6.2 Equipment Protection of the Core Unit (on page 150).

The core unit also contains the interfaces for the local NE management communication (with the FOXCST/FOXMAN-UN).

The core unit has two high performance on-board CPUs and uses software download for its unit and network element specific embedded softwares (ESWs).

3.1.3   Service Units

Service units are units with specialized traffic functions and interfaces. The local control handles all aspects of the local unit management and traffic processing. This includes (traffic function related activities are not considered here):

- Monitoring of the local unit,
- Provisioning of the local unit configuration,
- Access to local inventory data,
- Driving local function indicators (alarm LEDs),
- Local storage of ESW,
- Communication with the core unit.

The service units use software download for their local embedded software (ESW).

3.2   ESW and Feature Management

3.2.1   ESW Management

Download of embedded software (ESW) is a standard commissioning and maintenance process for the core and service units of the FOX61x.

With the FOX61x, ESW can be downloaded and installed on NE level.

The download procedure is executed during normal system operation without disturbing running services. At least 2 ESW versions can be stored on one unit. The first ESW is currently executed, while the second one is a new version to be launched. The ESW is stored directly in the flash memory of the unit. This mechanism speeds up the activation of the new software. Activation of a new software version can be performed either on schedule or immediately. Scheduled activation allows operators to launch a new version at a given time, for instance within a maintenance window, without any further manual intervention. Immediate activation is used for maintenance activities performed on the system.

Launching a new ESW release requires rebooting of the unit.

ESW download is integrated in the management concept of the FOX61x with corresponding diagnostic functions:

- The ESW installation is configured via the FOXCST/FOXMAN-UN.
- Installed ESW can be checked at any time with the built-in inventory management function and the SW installation status function.

Accordingly, there is no need for local access to the NE, since the ESW download uses the same management communication channels as the standard management functions with local and remote access.

3.2.2   Feature License Management

Feature license management allows customers to buy equipment with standard functionality (hardware and/or software) at a basic price and to add functions as needed simply by buying new licenses.

With the feature license management scheme, only one ESW per unit is required. This ESW supports all the unit features.

With the appropriate license a customer gets the certified right to use the functions and features listed on the FOX61x R15A Feature License in addition to the basic functions.

3.3   Inventory

The FOX61x inventory function provides detailed information on the installed hardware and ESW in the subrack.

Inventory data includes:

- Unit name,
- Name of the installed ESW and detailed version identification,
- Name of the bootloader and detailed version identification,
- Supplier part number and version identification,
- Manufacturer identification,
- Manufacturer part and serial number.

All inventory data – with the exception of the installed ESW – is stored in protected local memory during the manufacturing and provisioning process.

Beyond this function, the DATI1 and DEFM1 units supports the request of inventory data from the connected 3rd party or ABB Power Grids CPE.

3.4   Fault Management

The FOX61x fault management detects equipment, function and transmission failures, or more generally monitors the availability of the equipment and transmission paths. This includes an alarm system with various interfaces for the indication of faults and failures. These interfaces include local alarm indication and, depending on configured options, entries in the alarm list, the alarm logbook, the syslog message list and SNMP trap reporting.

There are dedicated logbooks available, i.e.:

- Alarm logbook.
- Configuration logbook.
- Equipment logbook.
- Event logbook.
- Session logbook.

The alarm logbook provides the details generated by the fault management as shown in Figure 80.
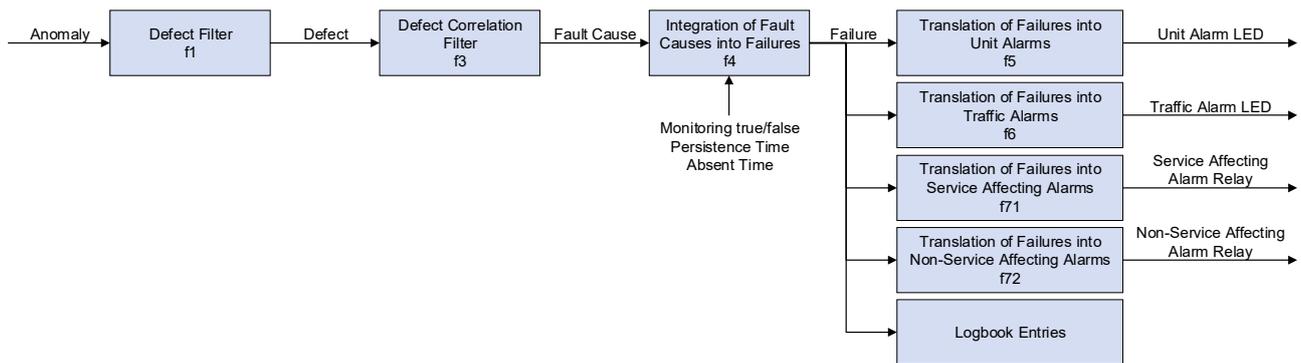
Figure 80:   Fault management filters and indications

- Alarm generation (according to ETS 300 417-1-1):

  Each unit of the FOX61x NE is able to detect equipment and/or traffic related defects and anomalies. For further processing, these defects and anomalies are transformed into fault causes with the defect correlation filter.

  For each of the fault causes you can set a reporting option (via the FOXCST/FOXMAN-UN) which enables or blocks the further processing of the fault causes (monitoring true or false). Only fault causes with the monitoring set to true will be considered for further processing. Fault causes with the monitoring set to false will not be considered.

  A fault cause is declared a failure if the fault cause persists for a certain time, called the persistence time (Set Threshold). The failure is cleared if the fault cause is absent for a certain time, called the absent time (Clear Threshold). You can set persistence time and absent time individually per fault cause.

- Alarm processing and indication:

  The FOX61x is able to store time stamped information on events and failures in dedicated logbooks. It is possible to transfer the contents of the logbooks and the pending alarms of the NE to the FOXCST/FOXMAN-UN for display and inspection. Alarms are generated based on failures.

  The FOX61x system provides six severity levels for the alarms according to ITU X.733. The severity levels which represent service affecting and non-service affecting conditions ordered from most severe to least severe are Critical, Major, Minor and Warning:

  - Critical

    This severity level indicates that a service affecting condition has occurred and an immediate corrective action is required.

  - Major

    This severity level indicates that a service affecting condition has developed and an urgent corrective action is required.

  - Minor

    This severity level indicates the existence of a non-service affecting fault condition and that corrective action should be taken in order to prevent a more serious (for example, service affecting) fault.

  - Warning

    This severity level indicates the detection of a potential or impending service affecting fault (i.e. a non-service affecting fault condition), before any significant effects have been felt. Action should be taken to further diagnose (if necessary) and correct the problem in order to prevent it from becoming a more serious service-affecting fault.

  - Cleared

    The cleared severity level indicates the clearing of one or more previously reported alarms.

- Notification

    There is an additional alarm severity not according to ITU-T X.733. The Notification is used for FOX61x external alarm or status notifications. No FOX61x NE alarm severity and no relay contact is activated when a notification alarm is active.

An alarm or entry to the alarm logbook is created only if the alarm monitoring is set to true. With an active failure, the corresponding unit or traffic alarm indicator LED on the front panel of the unit is activated. All unit failures and traffic related fault causes are signaled via the local fault indication LEDs on the front panel of the affected unit(s).

With a critical or major alarm condition, the "service affecting alarm" relay contact is switched over. With a minor or warning alarm condition, the "non-service affecting alarm" relay contact is switched over. The relay contacts are implemented on FAMO1, FAMO1-F, FAMO2, FAMO2-F, FAMO3 and FAMO3-F.

> **i** **Please note:**
> The active "service affecting alarm" relay releases the "non-service affecting alarm" relay.
> → Only one of the two alarm relays can be active.

The current alarm condition and the logbooks can be loaded for display and inspection to the FOXCST/FOXMAN-UN at any time.

The alarm list available with the FOXMAN-UN polling shows the current alarm state for the polled network elements, i.e. the access network.

- Notifications:

    Important system functions and some unit processes can generate notifications. The notification function helps you to find out the relationship between NE internal events and possible failures associated with these events. Notifications create an entry in the event logbook of the NE.

- Syslog:

    Changes in system or in logbooks facilities as
    - System,
    - Alarm logbook,
    - Event logbook,
    - Configuration logbook,
    - Equipment logbook,
    - Session logbook,

    can be reported to a remote syslog server via the syslog function. The FOX61x allows configuration of up to 10 syslog destinations, each with its individual severity threshold and facility sources.

- SNMP traps can be reported to an SNMP manager.

3.5 Operation and Maintenance for Traffic Functions

The FOX61x has functions and features to support the operation and maintenance of the FOX61x traffic functions. This includes status and maintenance functions as well as performance monitoring.

3.5.1 Status and Maintenance

The FOX61x offers status and maintenance functions for the supervision and active testing of functions and traffic signals. Status and maintenance commands are executed immediately and are not part of the persistent configuration.

Examples of status and maintenance functions are:

- Link status of Ethernet interfaces.

- Bridge and router status.
- TDM traffic signal status.
- DSL line status
  - line state,
  - attenuation,
  - SNR margin,
  - power back-off.
- Loops
  - front-end loop,
  - back-end loop.
- Traffic tests
  - test signal insertion,
  - out of service of a port.

The detailed list of all status and maintenance functions is contained in the specification section of this document. Please refer to section 6.3.2 Traffic Functions (on page 181).

3.5.2 Performance Monitoring

The FOX61x supports performance monitoring for the traffic of the certain service units. Performance monitoring data are stored in the local unit database. Depending on the processed traffic, different performance monitoring groups are available:

- ITU-T G.826 performance monitoring group:

  Based on counts of anomalies and faults of the traffic signal in one-second periods, G.826 performance monitoring evaluates the following parameters per traffic measurement point:
  - ES (Errored Seconds),
  - SES (Severely Errored Seconds),
  - BBE (Background Block Errors),
  - UAT (Unavailable Time).
- Other performance monitoring groups:

  Other performance monitoring groups count specific events associated with the traffic signal per traffic measurement point, e.g. with packet counters on Ethernet ports. This includes, among others, the following counter groups:
  - MIB-2 interface table,
  - Miscellaneous port statistics.

The performance is calculated for 24-hours intervals (up to 8 records), and 15-minutes intervals (up to 108 records).

The detailed list of all performance management counters is contained in the specification section of this document. Please refer to section 6.3.2 Traffic Functions (on page 181).

3.5.3 Ethernet Port Maintenance

The FOX61x Switch Ethernet ports support the mirroring maintenance function. Any of the FOX61x Switch ports can be configured as mirror port which copies ingress and/or egress traffic of any other FOX61x Switch port to the mirror port.

In addition the FOX61x Switch ports provide statistics counters according to the following MIBs:

- IF MIB
  - In octets
  - In unicast packets

- – In multicast packets
- – In broadcast packets
- – In errors
- – Out octets
- – Out unicast packets
- – Out multicast packets
- – Out broadcast packets
- – Out errors
- EtherLike MIB
  - – In pause frames
  - – Out pause frames
  - – FCS errors
  - – MAC transmit errors
  - – MAC receive errors
  - – In frames too long
  - – Deferred transmissions
  - – Late collisions
  - – Excessive collisions
- RMON MIB
  - – Drop events
  - – CRC align errors
  - – In undersize packets
  - – In oversize packets
  - – In fragment packets
  - – In jabber packets
  - – Collisions
  - – In packets
  - – In octets
  - – In packets of different sizes

3.6   Synchronization

Due to the nature of Ethernet frame based traffic, there are no synchronization functions required in the FOX61x using Ethernet traffic exclusively.

However, a PETS (Plesiochronous Equipment Timing Source) function is implemented on the core unit for TDM voice and data traffic functions and functions like E1 circuit emulation.

The following sources can be used for the synchronization of the PETS:

- Internal oscillator,
- 2.048 MHz synchronization input signal,
- Ethernet timing of a core unit front port (synchronous Ethernet),
- PTP timing of a core unit front port (IEEE 1588 v2), port based or VLAN based,
- Received clock from a service unit (e.g. LEDE1, SAMO1),
- TCXO of the CEPI1 unit,
- SETS of a SAMO1, SAMO5, SAMO2 or SAMO3 unit.

Accordingly, the PETS clock of a FOX61x NE can be synchronized to the PETS clock of another FOX61x NE or to an external clock signal.

The FOX61x NE performs the PETS clock source selection according to a predefined priority for each clock source, or according to the received quality level (QL). The QL is transported in the SSM of a PDH or SDH traffic signal or in the ESMC of an Ethernet traffic signal.

Moreover, the synchronization output interface can be used for the synchronization of external equipment.

The CEPI1 unit provides a clock source with its on-board TCXO. This clock source is used as timing reference for the adaptive timing recovery circuits of the Pseudo Wires on the CEPI1 unit.

The SAMO1, SAMO5, SAMO2 and SAMO3 units implement the synchronous equipment timing source (SETS) for the synchronization of the units SDH traffic. SDH synchronization is not part of the core unit synchronization function.

The core unit is configurable to be a PTP Ordinary Clock, a PTP Boundary Clock, a PTP Transparent Clock, using the core unit Ethernet front ports as PTP slave or PTP master ports. If a core unit port is configured as Boundary Clock or Ordinary clock slave port, the PTP timing can be used to synchronize the frequency and phase of the PETS.

If the PTP packet transport is VLAN based the PTP packet stream can be used simultaneously as Ordinary or Boundary Clock to synchronize the network element, and as Transparent Clock to forward PTP packets with time stamp corrections.

3.7   SNTP

SNTP (simple network time protocol) is used for the synchronization of time and date of the FOX61x NE to the time and date provided by an SNTP server. The SNTP server can be installed on any computer, e.g. on a workstation with running FOXMAN-UN, or on a PC with running FOXCST. Some SNTP servers return the time from an atomic clock or a highly accurate radio frequency clock.

The FOX61x acts as an SNTP client when configured in unicast operation mode. The client uses the UDP transport protocol and sends a request packet to the server. The server then responds with a specially formatted data packet that contains the time information and some information that allows for the calculation of the packet delay. The protocol specifies that the returned time is sent in UTC (coordinated universal time, also known as Greenwich mean time). The time is displayed in local time on the FOX61x NE. You can configure a NE local time zone for the FOX61x.

When configured in broadcast operation mode, the FOX61x can also receive timing information from SNTPv3 broadcast servers. Note that SNTPv4 is not supported in the current release.

3.8   PTP

PTP (Precision Time Protocol) is used for the synchronization of time and date of the FOX61x NE to the time and date provided by a GPS Receiver acting as IEEE 1588 Grand Master Clock. The PTP time and date is distributed to the FOX61x NEs through a packet switched network and received by FOX61x NEs on the Ethernet ports of the core units CESM1, CESM2 and CESM3.

The PTP packet transport can be Ethernet based for physical and logical (VLAN) ports, or it can be UDP/IP based for logical (VLAN) ports.

A FOX61x network element with the CESM3 core unit, using the UDP/IPv4 based packet transport, can act as PTP master for up to 32 subordinate network elements, allowing a scalable PTP network layout.

The PTP information can be forwarded by the TEGO1 unit to the IEC 61850 station bus via the four Ethernet front ports. In this case the TEGO1 unit acts as a PTP Boundary Clock using the PTP power profile.

3.9   IRIG-B

FOX61x allows to synchronize its clock to a GPS time and date source. The physical interface to connect to the GPS receiver is located on the (optional) TEPI1 and TEPI2 units. Each TEPI1 or TEPI2 provides one IRIG-B input.

In addition to the internal and the SNTP timing source, up to four external timing sources of type IRIG-B006 can be selected as the network element timing source. Priorities are individually settable for each selected timing source.

The TEPI2, OPIC2 and TEGO1 provide electrical IRIG-B outputs to synchronize any external equipment to the FOX61x timing. The OPIC2 and TEGO1 provide in addition one optical IRIG-B output.

3.10   PPS

The CESM3, TEPI2, OPIC2 and TEGO1 provide electrical PPS outputs to synchronize any external equipment to the FOX61x timing. The OPIC2 and TEGO1 provide in addition one optical IRIG-B output.

3.11   Heat Management

When using active cooling the FOX615 R2, FOX615, FOX612 and FOX611 are designed for operation in the ambient temperature range of −25° C up to +65° C, according to ETSI EN 300 019-1 (equivalent to class 3.3, extended range). Active cooling requires the usage of the fan unit FAMO1 (FOX615 R2 and FOX615), FAMO2 (FOX612) or FAMO3 (FOX611).

With passive cooling operation, i.e. without the fan unit, the ambient temperature range is reduced to −25° C up to +55° C, according to ETSI EN 300 019-1 (equivalent to class 3.3).

The FAMO1 of the FOX615 R2 and FOX615 has ten individually monitored fans that are integrated in a 19-inch subrack.

The FAMO2 of the FOX612 has four individually monitored fans.

The FAMO3 of the FOX611 has two individually monitored fans.

The speed of the fans of FAMO1, FAMO2 and FAMO3 is temperature controlled, in order to optimize the noise behavior and the MTTF.

The failure of one fan is indicated by a non-service affecting alarm. This has no impact on the MTTF, if the failed fan is replaced within 48 hours. The failure of more than one fan is indicated by a service affecting alarm. In this case, the failed fans have to be replaced immediately or the system has to be shut down, in order to prevent an MTTF reduction or even equipment damage.

There are several temperature sensors implemented on the FOX61x boards. They allow the monitoring of the temperature inside the subrack and reducing or even switching off services in the case of local overheating.

Temperature limits can be set on network element level that generate an alarm when crossed. Current, minimum, and maximum temperature can be read out via the element manager. Both minimum temperature and maximum temperature can be reset via the element manager.

When stacking FOX61x subracks, heat evacuation requires the installation of heat deflection shields. A heat deflection shield directs the hot air from the electronic equipment to the front or to the rear of the rack. For FOX612 and FOX611 a heat deflection shield is required particularly when vertical mounting is selected.

The maximum heat evacuation per FOX615 R2 and FOX615 subrack is 1800 W. With passive cooling operation, i.e. without the fan unit, the maximum heat evacuation is reduced to 500 W.

The maximum heat evacuation per FOX612 subrack is 600 W. With passive cooling operation, i.e. without the fan unit, the maximum heat evacuation is reduced to 200 W.

The maximum heat evacuation per FOX611 subrack is 380 W. With passive cooling operation, i.e. without the fan unit, the maximum heat evacuation is reduced to 80 W. Passive cooling is only possible without the AC/DC converter POAC1.

3.12 Power Supply

3.12.1 DC Power Supply Interfaces

The units of the FOX61x subrack are directly powered from the DC power supply with a nominal voltage of -48 VDC or -60 VDC, according to ETSI EN 300 132-2. Each unit has its own power converter, i.e. no dedicated power converter units are required. The DUPF1 or DUPF1-R unit allows the powering of the FOX615 R2 and FOX615 subrack from 2 redundant primary power supplies (batteries), whereas the DUPF2 allows the same for the FOX612 and FOX611.

The FOX61x interfaces for external DC power supply are specified as follows:

- FOX615 R2:
  - Nominal voltage: -48 VDC or -60 VDC
  - Voltage range: -40.0 VDC … -72 VDC with DUPF1 or DUPF1-R
  - Voltage range: -39.5 VDC … -72 VDC without DUPF1 or DUPF1-R
  - Maximum continuous current:

	FOX615 R2
With DUPF1 or DUPF1-R	30 A
Without DUPF1 or DUPF1-R	45 A

- FOX615:
  - Nominal voltage: -48 VDC or -60 VDC
  - Voltage range: -40.0 VDC … -72 VDC with DUPF1 or DUPF1-R
  - Voltage range: -39.5 VDC … -72 VDC without DUPF1 or DUPF1-R
  - Maximum continuous current:

	FOX615 subrack revisions R2A, R2B and R3B	**FOX615 subrack revision R3A**
With DUPF1 or DUPF1-R	30 A	30 A
Without DUPF1 or DUPF1-R	45 A	30 A

- FOX612:
  - Nominal voltage: -48 VDC or -60 VDC
  - Voltage range: -40.0 VDC … -72 VDC with DUPF2
  - Voltage range: -39.5 VDC … -72 VDC without DUPF2
  - Maximum continuous current:

	FOX612
With DUPF2	15 A
Without DUPF2	15 A

- FOX611:
  - Nominal voltage: -48 VDC or -60 VDC
  - Voltage range: -40.0 VDC … -72 VDC with DUPF2
  - Voltage range: -39.5 VDC … -72 VDC without DUPF2

– Maximum continuous current:

	FOX611
With DUPF2	8 A
Without DUPF2	8 A

The FOX615 R2 subrack and the FOX615 subrack revisionsR2 (and later) with active cooling are designed for a maximum power consumption of 1800 W. The FOX612 subrack with active cooling is designed for a maximum power consumption of 600 W. The FOX611 subrack with active cooling is designed for a maximum power consumption of 380 W.

The contribution of each unit to the power consumption on the external power supply is available with the technical specifications (user manuals) of the units. The total power consumption has to be considered for the specification of the capacity of the external power supply.

Please note that the primary DC input voltage is not generally monitored as this is considered to be a function of the battery supervision/power rectifier. Only the DUPF1, DUPF1-R and DUPF2 units will monitor the input voltages and generate alarms if the voltages are too low. The power converters on the units are switching off if the input voltage is too low.

3.12.2   AC Power Supply Interfaces

The hardware supplement FOX611 AC power kit available for the FOX611 subrack provides direct AC powering for the subrack from a mains power supply.

The FOX611 AC power kit consists of

- POAC1 AC/DC converter,
- AC/DC backplane, and
- assembly material for the backplane.

The POAC1 interfaces for external AC power supply are specified as follows:

– Nominal input voltage: 115 VAC or 230 VAC
– Input voltage range: 90.0 VAC … 264 VAC
– Maximum continuous input current:

	POAC1
115 V_{AC}	4.5 A
230 V_{AC}	2.2 A

– Output voltage range: 52.0 VDC … 53.0 VDC
– Maximum continuous output current: 8 A
– Maximum continuous output power: 350 W

As a supplement to the AC powering a 48 V lead-gel battery with a capacity of 10 Ah to 40 Ah can be connected to the POAC1 unit. In case of an AC mains failure the supply of the FOX611 is secured by the battery.

The backup battery is charged by the POAC1 AC/DC converter with a maximum current of 2 A.

The battery is not provided by ABB Power Grids

The POAC1 unit supervises the AC mains voltage and the AC/DC converter output voltage, failures are alarmed.

4   FOX61x Traffic and Equipment Functions

4.1   Network Aspects

The FOX61x using MPLS-TP offers two types of layer 2 virtual private networks (L2 VPN):

- Virtual Private Wire Service (VPWS), and
- Virtual Private LAN Service (VPLS).

4.1.1   Network Scenarios for MPLS-TP Virtual Private Wire Services

In case of VPWS two Label Edge Router (LER) devices provide a logical connection such that a pair of CE devices appears to be connected by a single logical layer 2 circuit.

LER devices act as layer 2 circuit switches. Layer 2 circuits are attached to pseudo wires and then mapped onto tunnels in the service providers network. A tunnel is transported on a pair of bidirectional Label Switch Paths (LSP). A tunnel can either be specific to a particular VPWS, or be shared among several pseudo wires of VPWS or VPLS.

A tunnel provides a point-to-point connection between the two LER devices where the CE devices are attached to. The LER devices can be connected directly or via one or several Label Switch Router (LSR) devices.

The FOX61x can be configured to be a LER, a LSR or a network element providing the LER and LSR functionality simultaneously. The FOX61x supports up to 2000 tunnel terminations in a LER and up to 3500 bidirectional LSPs in a LSR.
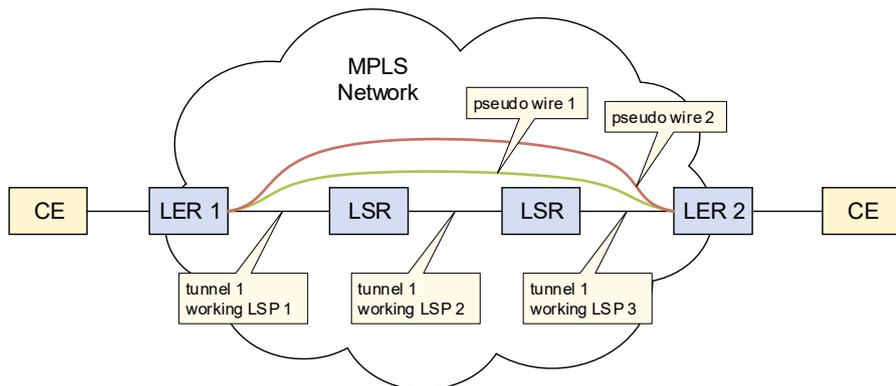
Figure 81:   VPWS with one unprotected tunnel

In order to increase the availability of the L2 VPN, the tunnel can be a extended with a second pair of LSPs, providing a protection path between the two LER devices. In case of a failure in one of the working LSPs the traffic is rerouted via the protection LSPs.
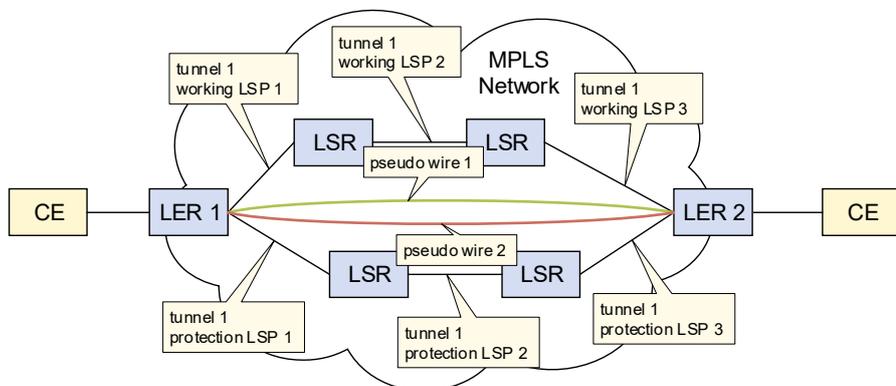
Figure 82:   VPWS with one protected tunnel

4.1.2   Network Scenarios for MPLS-TP Virtual Private LAN Services

In case of VPLS, several LER devices provide a logical connection such that CE devices belonging to a specific VPLS appear to be connected by a single LAN.

In a VPLS, a CE device attaches, possibly through an access network, to a bridge module inside the LER. The bridge module attaches to a VPLS forwarder and to one or more pseudo wires. Tunnels connect all the LERs in the virtual LAN. A tunnel is transported on a pair of bidirectional Label Switch Paths (LSP). It can either be specific to a particular VPLS, or be shared among several pseudo wires of VPWS or VPLS.

Typically a full mesh connectivity is implemented between the LERs, but the FOX61x supports also the setup of hierarchical VPLS (H-VPLS) for large scale deployments.

The LER performs forwarding of user data packets based on information in the layer 2 header, such as a MAC destination address and VLAN tags.

The FOX61x supports up to 100 VPLS instances in a LER.
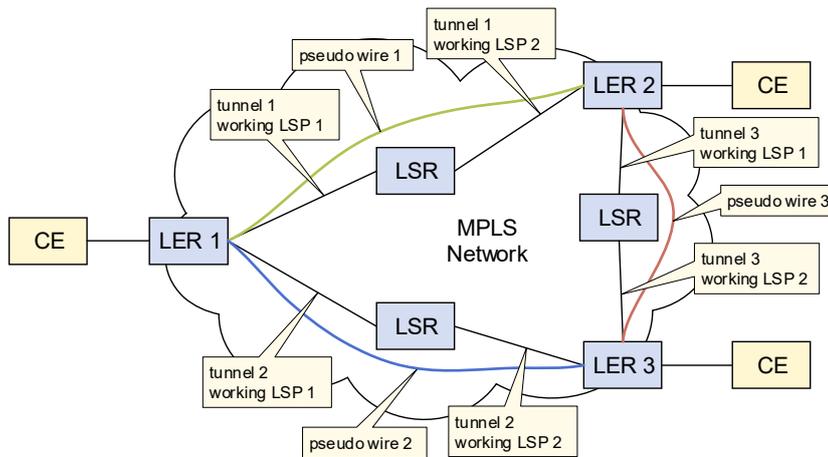
Figure 83:   VPLS with tree unprotected tunnels

In order to increase the availability of the L2 VPN, a tunnel can be a extended with a second pair of LSPs, providing a protection path between the two LER devices. In case of a failure in one of the working LSPs the traffic is rerouted via the protection LSPs.

Figure 84 shows the working and the protection paths for the tunnel 1 between LER 1 and LER 2. The tunnel 2 between LER 1 and LER 3, and the tunnel 3 between LER 2 and LER 3 are not labeled.
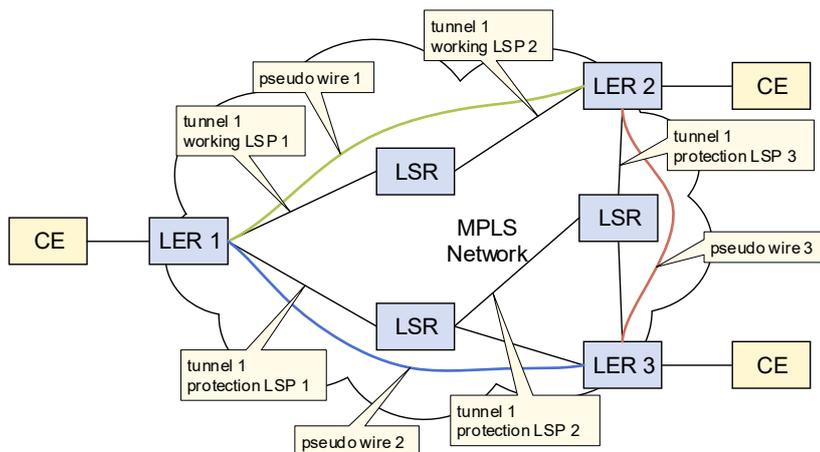
Figure 84:   VPLS with one protected tunnel and two unprotected tunnels

4.1.3 Network Scenario for LAN Island Interconnection using VPLS

In the examples above the customer network is connected via a single CE to the LER of the MPLS core network.

In case the customer network is connected via two CE devices to a LER there is a risk of a MAC address black hole issue when using RSTP on the CE facing ports. In this case the CE facing ports on the LER must be configured to the R-L2GP (Reverse L2 Gateway Protocol) mode.
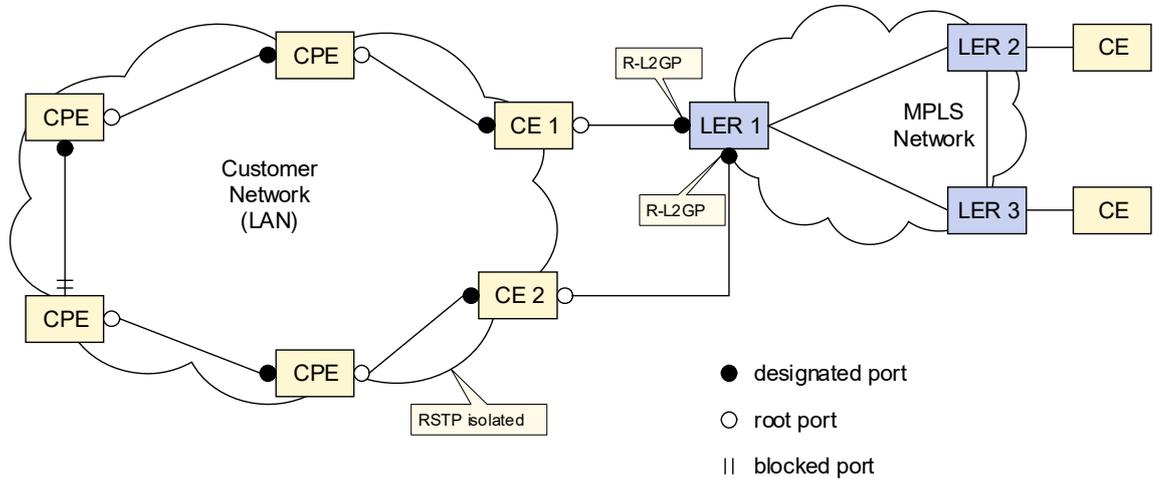
Figure 85:   Customer network connected with two CE to the LER

The LER sends BPDUs to the CE 1 and CE2 presenting itself as a root bridge. In symmetric LAN ring topologies the blocked port is on the opposite side of the root bridge.

In case the customer network is connected via two CE devices to two LER (CE dual homing) the CE facing ports on the LER must be configured to the R-L2GP mode.
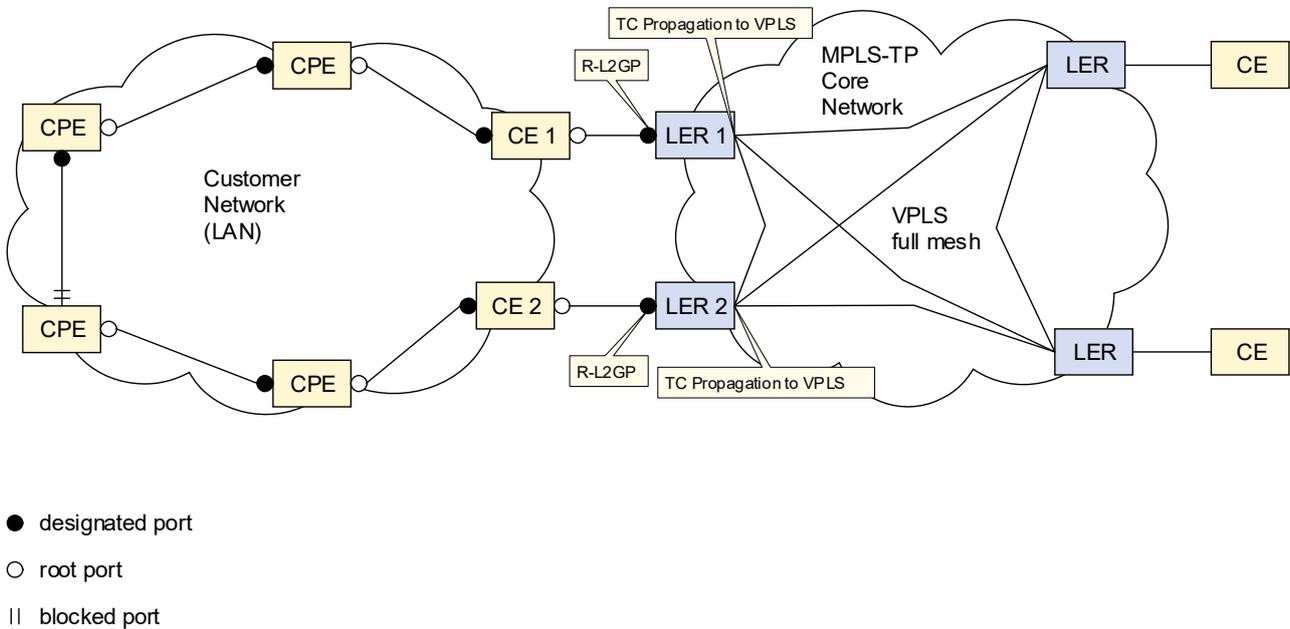
Figure 86:   Customer network connected with two CE to two LER

Any topology change (TC) notification received by LER 1 or LER 2 from the customer network must be forwarded to all LER being part of the affected VPLS: The LER must be aware which LER, LER 1 or LER 2, must be addressed to access the CPEs in the customers network. The CE dual homing setup is restricted to the MPLS-TP VPLS service type.

In LER 1 (and LER 2) a TC notification received from LER 2 (or LER 1) must be forwarded to the spanning tree of the customer network.

The forwarding of TC notifications inside the VPLS uses the PW OAM message "MAC withdraw".

> **i**   **Please note:**
> No BPDUs are sent over the MPLS core network.
> → The spanning tree is isolated in the customer network.

4.1.4   Network Scenario for Provider Network Access with Dual Homing

In a hierarchical VPLS (H-VPLS) the provider edge (PE) network element is connected to the provider MPLS-TP core network with a spoke connection. To increase the availability of the MPLS-TP network the PE network can be attached with two Pseudo Wires to two provider network elements in parallel (PE dual homing).
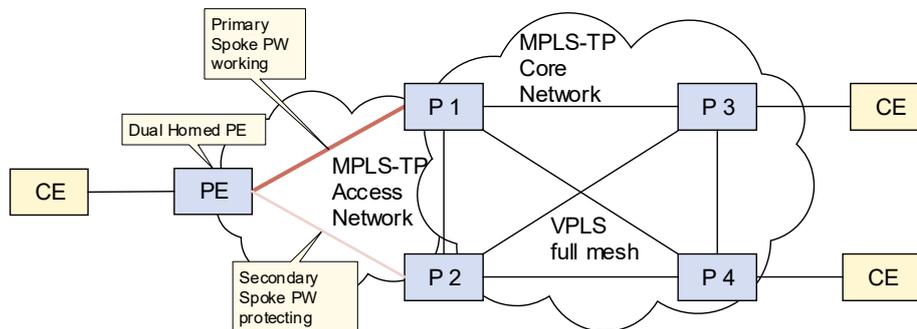
Figure 87:   Provider Edge network element connected with two PW to the core network

During normal operation only the working Pseudo Wire connecting the PE to the core network (P1) is active. The protecting Pseudo Wire to P 2 is deactivated.

In case the primary spoke Pseudo Wire fails or the P1 network element fails the working Pseudo Wire is deactivated and the protecting Pseudo Wire is activated.

The MAC address tables in all provider network elements participating in the affected VPLS must be flushed: The P1 to P4 network elements must be aware which network element must be addressed to access the PE network element in the MPLS-TP access network. The forwarding of the flush command inside the VPLS uses the PW OAM message "MAC withdraw".

The PE dual homing setup is restricted to the MPLS-TP VPLS service type.

4.2   Ethernet Traffic Functions

4.2.1   MPLS-TP Transport

One of the main Ethernet traffic functions of the FOX61x is the MPLS-TP Transport (based on RFC 5921). This function is implemented on the core unit, the WAN port expansion unit, and on the Ethernet service units ETOP1, ELET1, EPOI1, DEFM1, SAMO5, SAMO2 and SAMO3.

4.2.1.1   VPWS Transport Function

Any port that is configured as Pseudo Wire Attachment Circuit (PWAC) or as Customer VLAN Port (CVP) connects to a Virtual Private Wire Service (VPWS).

Any port on a core unit or WAN port expansion unit that is configured as MPLS-TP port is used as uplink port towards the MPLS network.

An MPLS-TP port can be a physical port or can be a logical port. In this case it is a VLAN based subinterface attached to a physical Ethernet port.
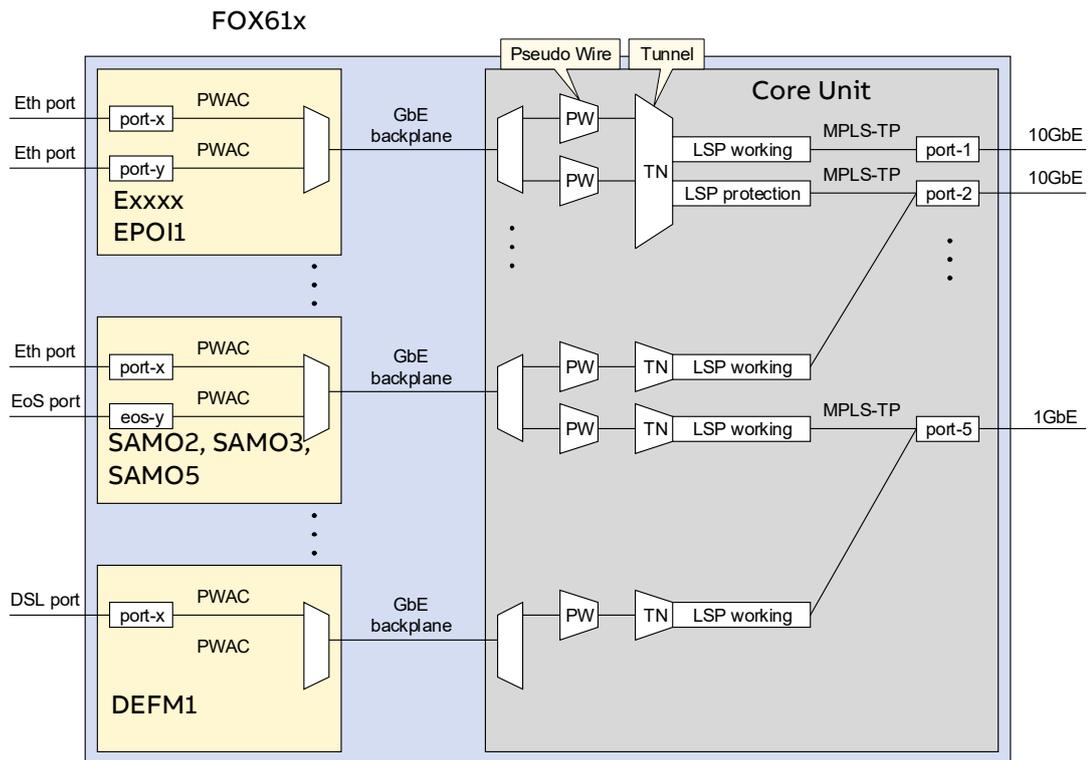
Figure 88:   MPLS-TP VPWS transport in FOX61x

> **i**   **Please note:**
> As an alternative to a MPLS-TP port on the core unit, a MPLS-TP port on a WAN port expansion unit can be used.

4.2.1.2   VPLS Transport Function

Any port that is configured as Customer VLAN Port (CVP) connects to the VLAN Bridge, based on the FOX61x Switch, and via the switch virtual interface (SVI) to the pseudo wires of a Virtual Private LAN Service (VPLS).

The FOX61x Switch consists of all switch elements implemented on the core unit and the Ethernet service units and which are interconnected via the GbE-star or the 10 GbE-star.

Any port on a core unit or WAN port expansion unit that is configured as MPLS-TP port is used as uplink port towards the MPLS network.

An MPLS-TP port can be a physical port or can be a logical port. In this case it is a VLAN based subinterface attached to a physical Ethernet port.
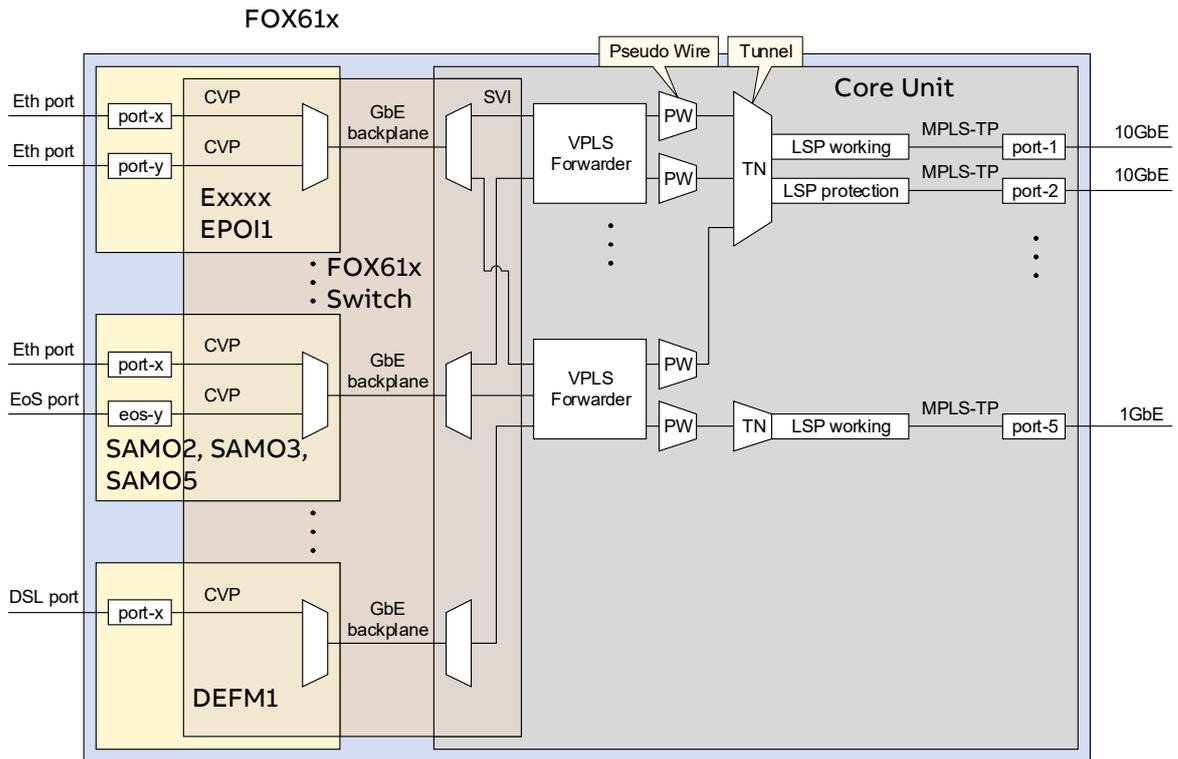
Figure 89:   MPLS-TP VPLS transport in FOX61x

> **ℹ Please note:**
> As an alternative to a MPLS-TP port on the core unit, a MPLS-TP port on a WAN port expansion unit can be used.

4.2.1.3   Traffic Prioritisation

The MPLS-TP Transport function supports the pipe model according to RFC 3270 to perform the following tasks:

- Ingress QoS information of the user traffic is tunneled transparently through an MPLS-TP network, and
- Control the LSP QoS information used during the packet transport through the MPLS-TP network.

4.2.1.4   Traffic Scheduling

The FOX61x Switch Ethernet ports all have 8 queues in egress direction. Also the FOX61x Switch internal ports to the GbE star have 8 queues in egress direction. Hence, all external and internal FOX61x Switch ports support 8 traffic classes.

Traffic scheduling controls the order of sending packets from the 8 queues (traffic classes) at the egress side of the Ethernet ports.

The FOX61x supports five scheduling profiles, configured per network element. At each physical port of the FOX61x Switch one of the five profiles is configured to be applied.

The FOX61x supports two scheduling algorithms:

- Strict Priority (SP)
- Weighted Round Robin (WRR)

4.2.2   Ethernet Switch with VLAN Support

4.2.2.1   Ethernet Transport

One of the main Ethernet traffic functions of the FOX61x is the VLAN Bridge (based on IEEE 802.1Q). This function is implemented on the core unit and on the Ethernet service units ETOP1, ELET1, EPOI1, DEFM1, SAMO5, SAMO2 and SAMO3. Any port that is configured as Customer VLAN Port (CVP) connects to the VLAN Bridge, based on the FOX61x Switch.

The FOX61x Switch consists of all switch elements implemented on the core unit and the Ethernet service units and which are interconnected via the GbE-star or the 10 GbE-star.

> **i**   **Please note:**
> The WAN port expansion unit EPEX1 implements no switch element.

For more detailed information please refer to [1KHW028566] User Manual "Ethernet Switching".
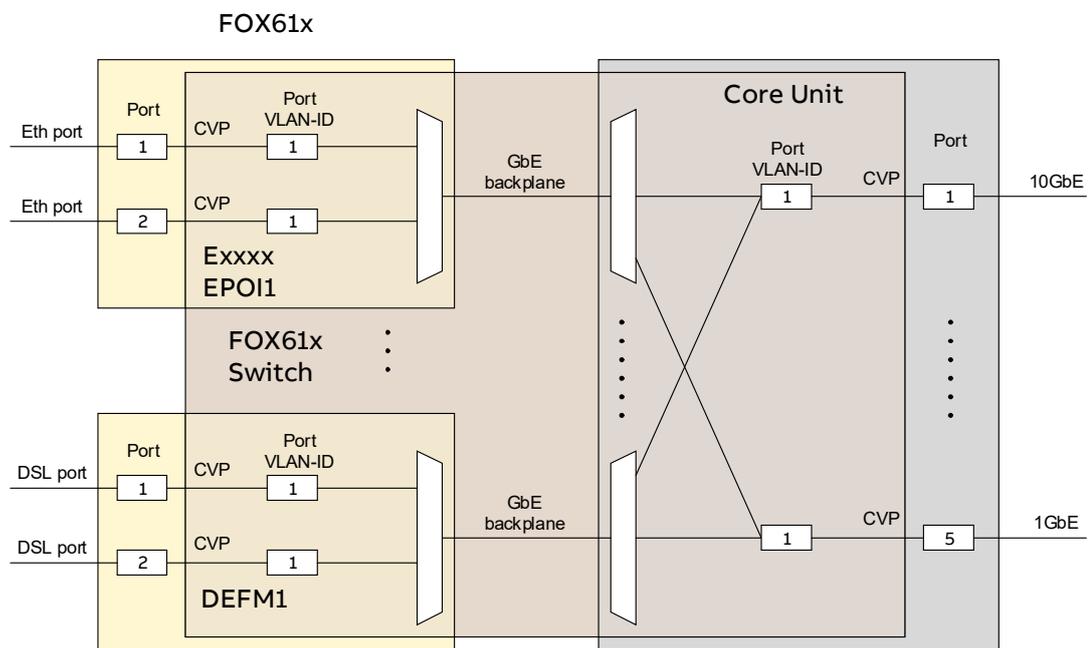
Figure 90:   VLAN bridging with single tagging in FOX61x

> **i**   **Please note:**
> As an alternative to an uplink port on the core unit, an uplink port on a WAN port expansion unit can be used.

4.2.2.2   Traffic Prioritisation

The transport requirements for the various types of services (voice, video, data) are completely different. Whereas delay and retransmission is not a problem for data traffic real-time voice traffic is very delay sensitive. For this reason it is essential to give more important network traffic precedence over less important traffic. However there is no guarantee that a packet arrives on time; it means only the packet will be handled before other packets with a lower priority.

The FOX61x Switch supports class of service (CoS) handling, according to IEEE 802.1Q. This approach is considered as relative Quality of Service (QoS).

Alternatively to the layer 2 priority the FOX61x supports IPv4 DSCP (differentiated services code point) for layer 3 traffic classification.

4.2.2.3   Traffic Scheduling

Refer to section 4.2.1.4 Traffic Scheduling (on page 134).

4.2.3   Circuit Emulation Service

The FOX61x supports the transport of P12 TDM signals over the packet based network, based on the circuit emulation service over packet (CESoP). This enables a smooth migration from legacy TDM networks to packet based transport without changing the customer's equipment.
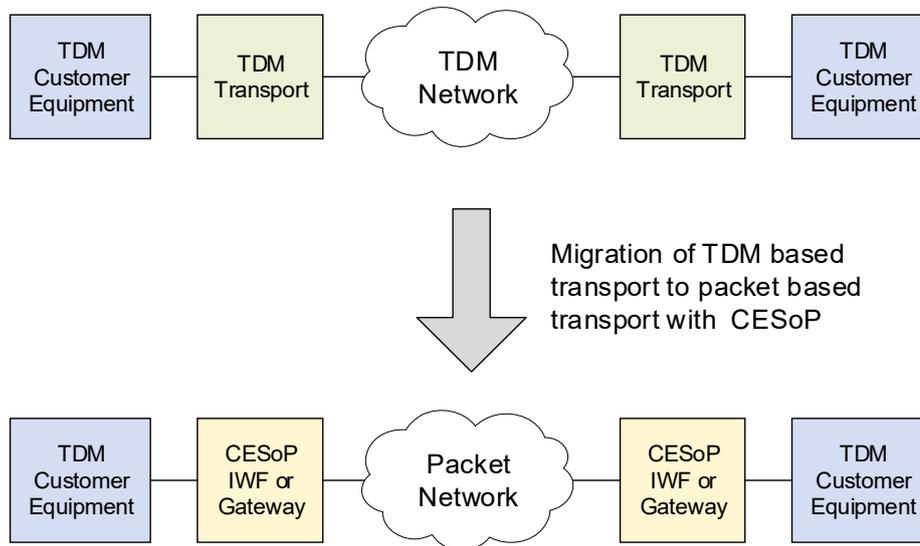
Figure 91:   Migration from TDM transport to packet based transport

The FOX61x supports several circuit emulation protocols for the encapsulation of TDM bit streams as Pseudo Wires over packet switching networks (PSN):

- SAToP protocol and structure agnostic CESoETH protocol:

  With this method, FOX61x provides transport of 2'048 kbit/s signals and of n x 64 kbit/s in structured 2'048 kbit/s (P12) signals.

- CESoPSN protocol and the structure aware CESoETH protocol:

  With this method, FOX61x provides transport of n x 64 kbit/ signals and of n x 64 kbit/s in structured 2'048 kbit/s (P12) signals.

Separation of different CESoP services is done with VLANs.

With the CESoP services, the FOX61x provides applications as

- PABX connection,
- Leased line,
- Network element synchronization,
- Mobile base station access,
- CESoP aggregation node,
- n x 64 kbit/s signal grooming.

For more detailed information please refer to [1KHW028556] User Manual "CEPI1".

4.2.4   NGN Voice Application

Next Generation Network (NGN) is a convergence of different networks to provide all types of services, from basic voice services to advanced broadband multimedia services. With NGN, the traffic is transported in packets. NGN can be grouped in two categories:

- Telephony NGN

  Telephony NGN provides telephony services to legacy terminals such as analog phones that are not NGN capable (PSTN emulation). It focuses on class 5 and class 4 switch replacements.

- Multimedia NGN

  Multimedia NGN provides advanced multimedia services to intelligent terminals (e.g. IP phones).

In a SIP NGN, the signaling and transport functions are both located in the gateway. The SIP softswitch functions "proxy server" and "registrar server" just support the routing of the calls, they are not mandatory. Accordingly, the following elements are introduced by the SIP NGN architecture:

- The gateway (GW) is responsible for the media stream conversion, i.e. the conversion of TDM based voice signals into IP packets and the signaling protocol termination. In Figure 92, two types of Media Gateways are shown, the Access Gateway and the Trunking Gateway:

  - The Access Gateway (AG) supports line side interfaces, e.g. for analog phones.

  - The Trunking Gateway is located between the PSTN and the packet network. It terminates circuit-switched trunks in the PSTN and virtual circuits in the packet network. It is controlled by a SIP enabled softswitch with the H.248/MEGACO protocol.

- There are two types of softswitches:

  - The SIP softswitch contains the SIP proxy server and SIP registrar server functions.

    The registrar makes the location of a subscriber available to the proxy server.

    The proxy forwards the SIP call control messages into the network.

  - The SIP/MEGACO softswitch handles both the SIP and the H.248/MEGACO protocols. This type of softswitch controls the trunking gateway and implements also the signaling gateway to the SS7.
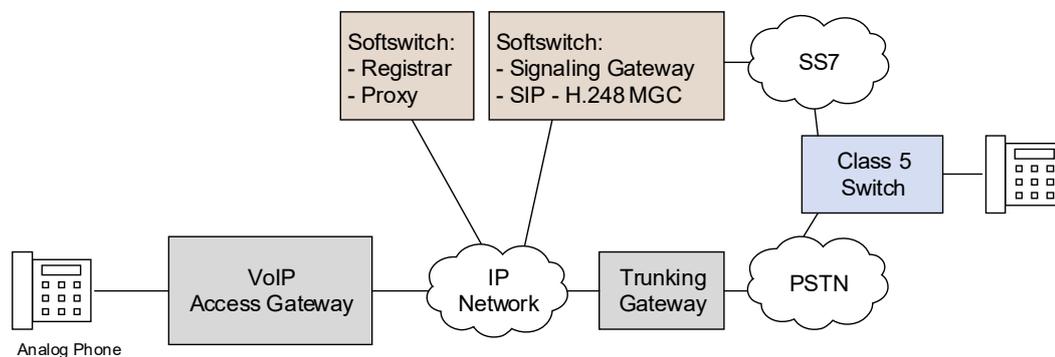
Figure 92:   Basic architecture of SIP NGN telephony with FOX61x

The FOX61x provides the functions of an access gateway for the telephony NGN, serving PSTN (POTS) subscribers.

On the line side, PSTN units (LESU1) provide the PSTN service access.

The IP subscriber (media) gateway unit (COSI1) provides the media conversion and bridges the traditional telephone to telephony NGN.

The IP traffic transport to the core network is provided by the core unit or WAN port expansion unit with its electrical and optical GbE interfaces.

For more detailed information please refer to [1KHW028559] User Manual "COSI1".

4.2.5   Security Features

The FOX61x offers security features to protect the NE from attacks of a malicious user.

4.2.5.1 Ingress Storm Control

The ingress storm control feature limits the ingress traffic of the following traffic types:

- Unknown unicast,
- Known unicast,
- Multicast, and
- Broadcast.

The traffic types can be enabled individually per VLAN Bridge port. The traffic threshold is configurable between 0% and 100% of the selected port speed.

4.2.5.2 Rate Limiters

The rate limiting (policing) function is available for **Customer VLAN Ports** (CVP), for Pseudo Wire Access Circuit (PWAC) ports and for Router Ports as a rate limiter. It is available on the following core and service units:

- CESM3,
- CESM2, CESM2-F,
- CESM1, CESM1-F,
- EPEX1,
- ELET1,
- ETOP1, ETOP1-F,
- EPOI1,
- EROP1, EROP1-F,
- ESPO1,
- ESOP1, ESOP1-F,
- SAMO5, SAMO5-F,
- SAMO2, SAMO2-F,
- SAMO3.

The rate limiter can be configured to

- – 1 Rate - 2 Color,
- – 1 Rate - 3 Color, or
- – 2 Rate - 3 Color.

The rate limiters are implemented according to MEF 10.3. The Coupling Flag is fixed to 1, the Color Mode is fixed to Color Blind. The rate limiter can be **port based or VLAN based**.

When using the FOX61x as MPLS-TP network element the incoming traffic on an **MPLS-TP tunnel** can be rate limited using LSP rate limiters.

The rate limiter operates in the 1 Rate - 2 Color mode and is implemented according to MEF 10.3. The Coupling Flag is fixed to 1, the Color Mode is fixed to Color Blind.

4.2.5.3 Egress Port Shapers

The FOX61x network element implements on all egress ports of the FOX61x Switch port based shapers.

The port shaper is implemented using a token bucket with a constant fill rate, corresponding to the shaping rate, and a token bucket size corresponding to the burst size.

The egress shaper has the goal to limit the egress traffic to a mean bit rate.

4.2.5.4 Egress Class Type Shapers

The FOX61x network element implements on the egress ports port-1 to port-4 of the CESM3 core unit class type based shapers.

The class type shaper is implemented using a token bucket with a constant fill rate, corresponding to the shaping rate, and a token bucket size corresponding to the burst size.

The egress class type shaper has the goal to limit the egress traffic of certain class type traffic flows to a mean bit rate.

4.2.5.5 Firewalls

The FOX61x network element implements a SW and a HW firewall to protect the NE CPU.

The SW firewall has the goal to defend the system against an NE CPU overload and against forwarding of unsolicited packets.

The HW firewall covers the core and service units Ethernet front ports managed by the FOX61x Switch, excluding the local management interface. The HW firewall implements an overall rate limiter.

4.3 TDM Traffic Functions

4.3.1 SDH Transport

The SDH service units SAMO1, SAMO5, SAMO2 and SAMO3 can be configured as an SDH access system with termination and add/drop functionality from STM-16, STM-4 and STM-1 trunks. Typical applications are the termination of VC-n traffic in linear networks (terminal multiplexer TM) and add/drop of VC-n traffic in linear or ring networks (add/drop multiplexer ADM).

The following SDH interfaces are supported:

- two interfaces STM-16 or STM-4 (SAMO3 and SAMO2):
  - STM-16 optical or
  - STM-4 optical,
- two interfaces STM-4 or STM-1 (SAMO1, SAMO5, SAMO2 and SAMO3):
  - STM-4 optical or
  - STM-1 electrical or optical,
- two interfaces STM-4 (SAMO5):
  - STM-4 optical.
- two interfaces STM-1 (SAMO1):
  - STM-1 electrical or optical.

The interfaces can be used as aggregate interfaces for the transmission of STM-16, STM-4 or STM-1 traffic into the transport network, or as tributary interfaces for the access of subtended network elements. The aggregate or tributary usage of an interface is independent of the service unit configuration.

The SAMO1, SAMO5, SAMO2 and SAMO3 units access TDM services via the PBUS. Up to 64 or 67 P12 tributary signals can directly be accessed and transported in the SDH network via any of the available SDH interfaces.

The SAMO3 unit accesses TDM services also via its E12 front interfaces. Up to 48 transparent P12 tributary signals can directly be accessed and transported in the SDH network via any of the available SDH interfaces.
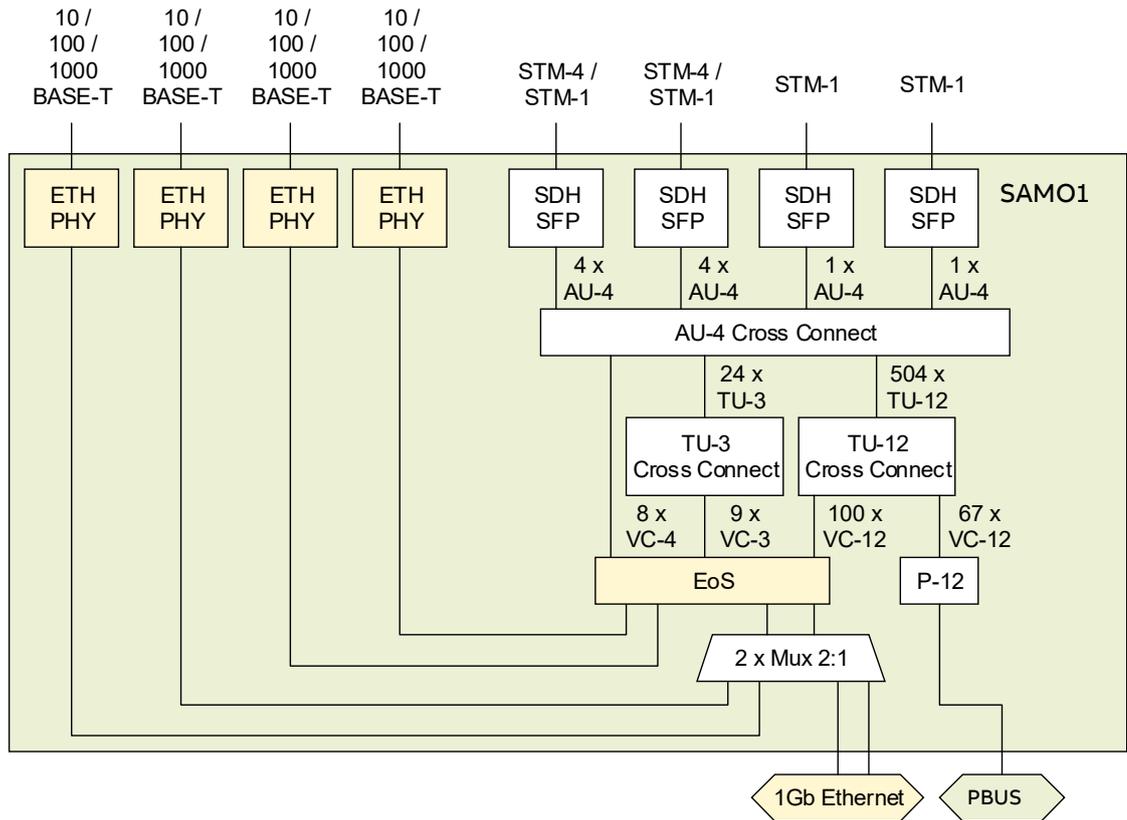
Figure 93: SAMO1 overview
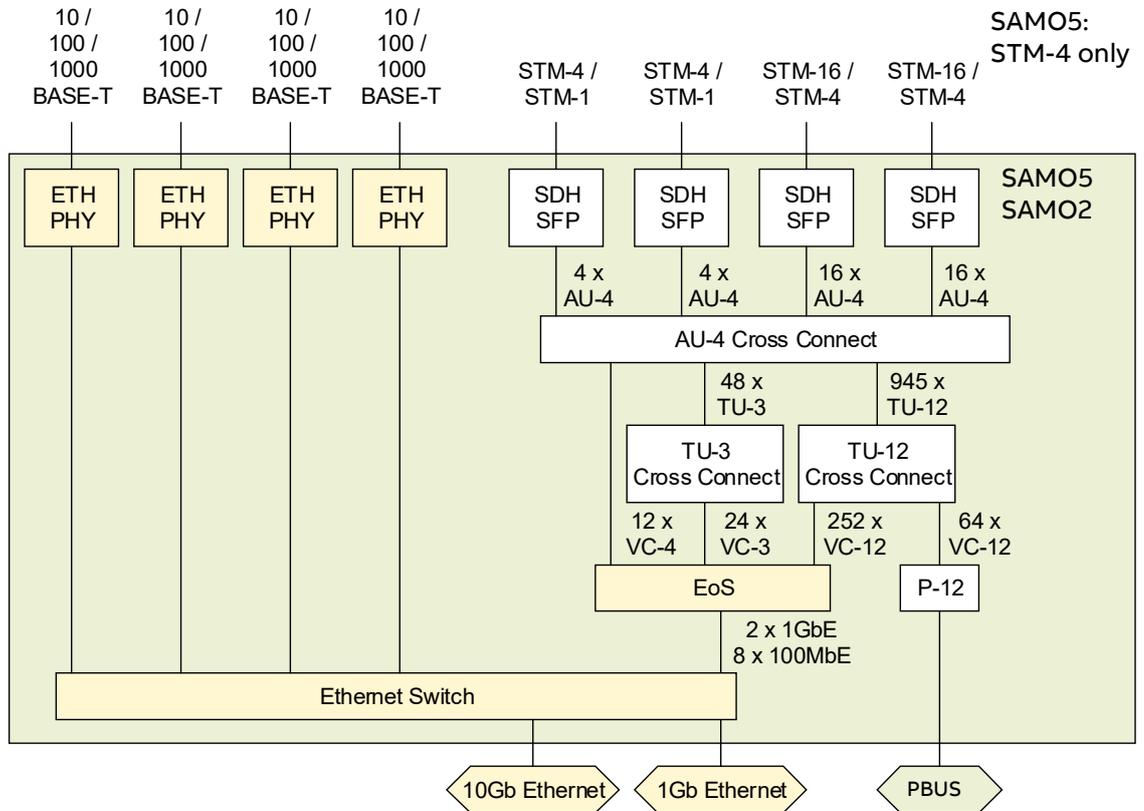
Figure 94: SAMO5 and SAMO2 overview
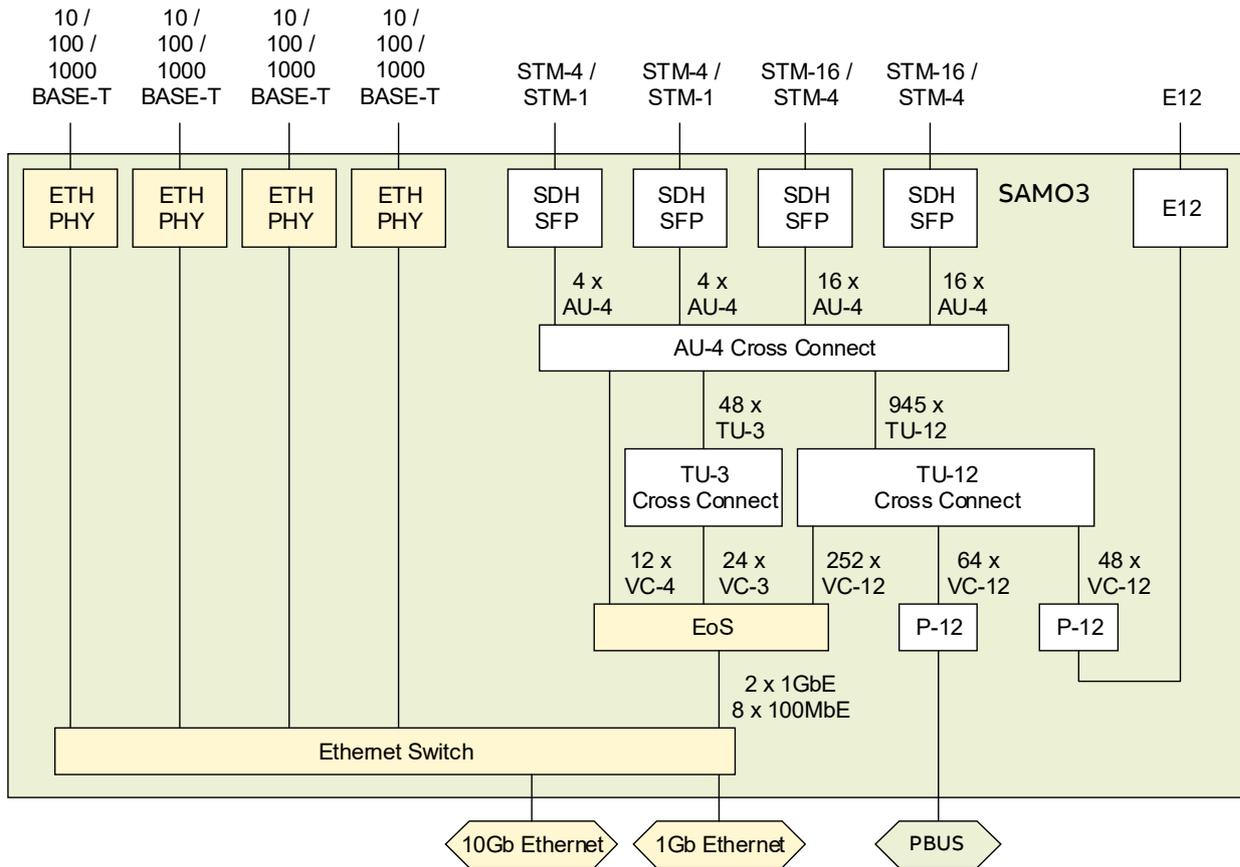
Figure 95:   SAMO3 overview

4.3.2   EoS Transport

The SAMO1, SAMO5, SAMO2 and SAMO3 units access Ethernet services via the unit's four electrical 10/100/1000BASE-T front interfaces and the Gb-Ethernet star from the core unit(s).

With the SAMO1 unit, Ethernet traffic is transported over up to four Ethernet over SDH (EoS) groups. Each EoS group consists of a number of virtual channels (VC):

- up to 8 x VC-4,
- up to 9 x VC-3,
- up to 63 x VC-12 per EoS group, up to 100 x VC-12 per SAMO1 unit.

With the SAMO5, SAMO2 and SAMO3 units, when using the unswitched mode, Ethernet traffic from the Ethernet front ports is transported over four Ethernet over SDH (EoS) groups bypassing the FOX61x Switch. In addition Ethernet traffic from the FOX61x Switch is transported over up to 28 (SAMO5: 4) EoS groups. When using the switched mode, i.e. the Ethernet front ports access the FOX61x Switch, Ethernet traffic from the FOX61x Switch is transported over up to 32 (SAMO5: 8) EoS groups.

> **i**   **Please note:**
> Using the MPLS-TP Transport function the number of EoS groups is limited to 12.

Each EoS group consists of a number of virtual channels (VC):

- up to 12 x VC-4,
- up to 24 x VC-3,
- up to 63 x VC-12 per EoS group, up to 252 x VC-12 per SAMO5, SAMO2 or SAMO3 unit.

The EoS groups use virtual concatenation of the VCs and support the link capacity adjustment scheme (LCAS).

On the SAMO1 unit two of the four EoS channels are shared with the connections to the Gb-Ethernet star. The Gb Ethernet star connects the SAMO1 unit to the working and protecting core units.

4.3.3   PDH Transport

The TDM service units SAMO1, SAMO5, SAMO2, SAMO3, LEDE1, CEPI1 and DATI1 can be used as transport units for PDH signals.

The FOX61x supports the following PDH signals:

- P12 (2048 kbit/s) without a signal structure, plesiochronous to the system clock.
- P12 (2048 kbit/s) with a signal structure according to ITU-T G.704, synchronous to the system clock,
    - with or without CRC4 in time slot 0,
    - with or without CAS in time slot 16.
- P0_nc (n x 64 kbit/s) synchronous to the system clock.
- P0 (64 kbit/s) synchronous to the system clock.

All PDH signals from the tributary side and from the transport side access the PBUS. The PBUS with its access circuits acts as a blocking free distributed cross connect system with a switching capacity of 128 x P12.

P12 signals are terminated (in point-to-point network applications) or can be transparently through connected (in linear or ring network applications).

The LEDE1 and CEPI1 units provide a transport capacity of 8 x P12 with their eight E1 (ITU-T G.703) interfaces. They connect to another E1 interface. P0 and P0_nc signals are multiplexed to P12 signals for the transport.

The LEDE1 and CEPI1 units can also act as PDH tributary units.

The DATI1 unit provides a transport capacity of up to 8 x P12 with its eight SHDSL (ITU-T G.991.2) interfaces. It connects to another SHDSL interface in trunk mode. P0 and P0_nc signals can be multiplexed to P12 signals for the transport. DATI1 supports also transport modes with a bandwidth from 1 to 32 time slots, using a minimum transport capacity corresponding to 3 time slots.

The DATI1 unit can also act as a PDH tributary unit, accessing one of the available SHDSL CPEs. The CPE then provides the E1 or data interfaces.

The SAMO1, SAMO5, SAMO2 and SAMO3 units offer a transport capacity of 64 x P12 with their STM-16, STM-4 or STM-1 interfaces. The SAMO3 unit offers in addition a transport capacity of 48 x P12 from the E12 front ports. The SDH service units use the asynchronous mapping mode of a P12 signal to a VC-12. P0 and P0_nc signals are multiplexed to P12 signals for the transport.

> ⓘ   **Please note:**
> The SAMO1 supports up to 67 x P12 access to PBUS.
> → This capacity is only usable with at least 3 x P12 unidirectional traffic.
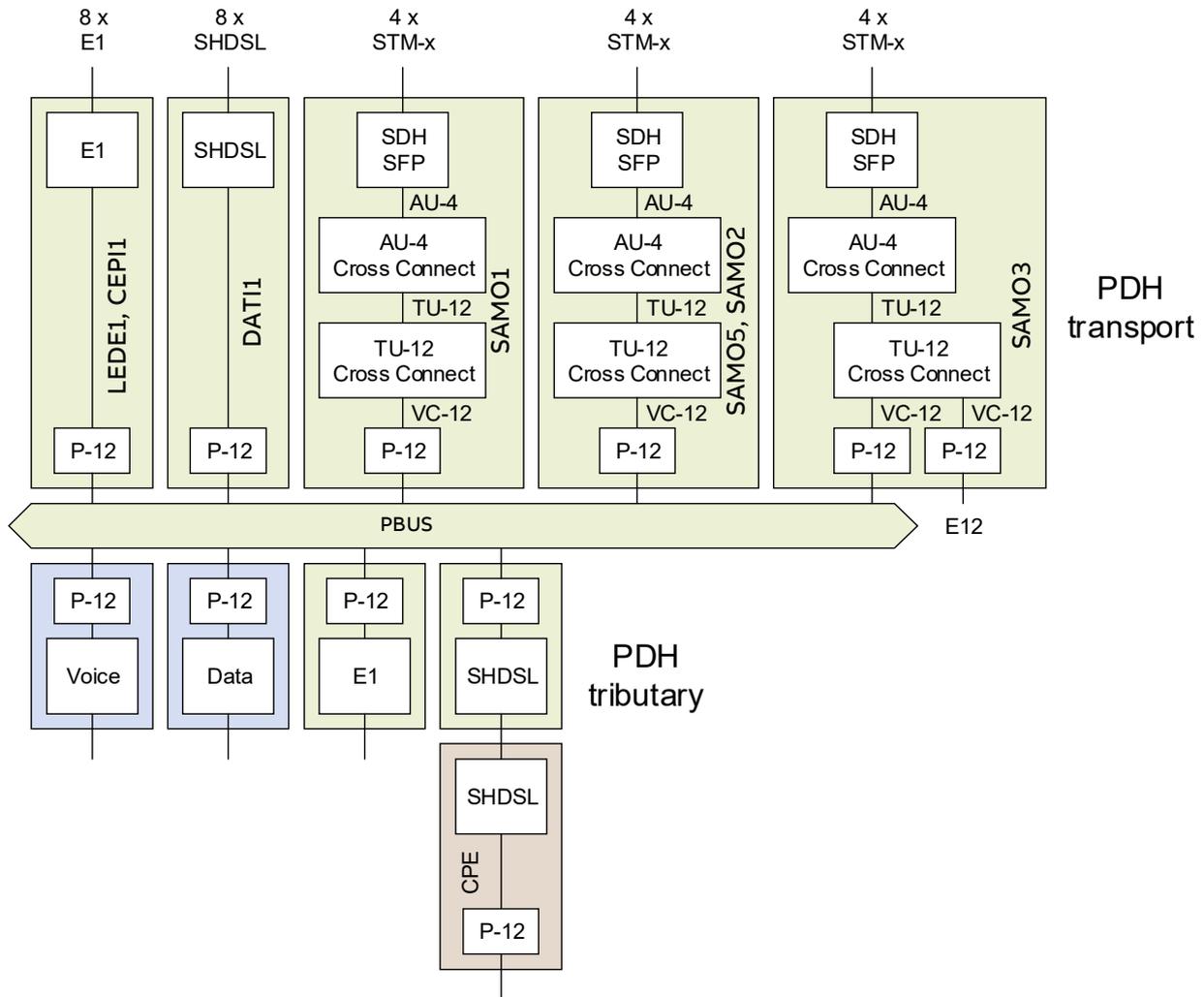
Figure 96:   PDH transport overview

4.3.4   EoP Transport

The EPSI1 unit accesses Ethernet services via the unit's four electrical 10/100BASE-TX front interfaces. The LEDS1 unit offers one 10/100BASE-TX front interface.

The EPSI1 unit supports bridging and routing applications. Routing protocols are OSPF, RIP or static routing.

With routing the IP packets are forwarded from the LAN to the PDH transport with IP over PPP or over multilink PPP.

With bridging the Ethernet frames are forwarded from the LAN to the PDH transport with one of the following bridging modes:

- MAC to HDLC,
- PPP,
- Multilink PPP.

EPSI1 supports up to 64 TDM transport interfaces with a total capacity of up to 32'764 kbit/s.

With the LEDS1 unit the Ethernet frames are forwarded from the LAN to the PDH transport with MAC to HDLC bridging. LEDS1 supports one TDM transport interface, the maximum transport capacity is 31 x 64 kbit/s.

With a SHDSL DTM-M connected to a DATI1 unit the Ethernet frames are forwarded from the LAN to the PDH transport with MAC to HDLC bridging. The SHDSL DTM-M support one

TDM transport interface for Ethernet traffic, the maximum transport capacity is 2048 kbit/s.

4.3.5 Voice Services

The FOX61x voice service units offer different analog voice interfaces:

- The LESU1 unit has 16 FXS 2-wire interfaces.

  The units connect to a subscribers telephone set. In downstream direction the interfaces generate ringing, metering and polarity reversal, and provide the line feeding. In upstream direction the interfaces detect onhook and offhook states, ground key states, pulse dialing and flash pulses. DTMF dialing is transported inband.

  Signaling information is transported via CAS.

- The LEXI1 unit has 12 FXO 2-wire interfaces.

  It connects to a local exchange. In downstream direction the interfaces detect ringing, metering and polarity reversal. In upstream direction the interfaces generate onhook and offhook states, ground key states, pulse dialing and flash pulses.

  Signaling information is transported via CAS.

- The LEDA1 unit has 8 analog 2-wire or 4-wire voice interfaces with 2 E&M signaling interfaces per voice interface.

  E&M signaling information is transported via CAS. LEDA1 supports the E&M interface types I to V.

  It connects to a subscribers telephone set which must be powered with a local battery. The LEDA1 can also be used to interconnect local exchanges using the E&M interfaces.

For the transport over a TDM network each voice channel uses one time slot (64 kbit/s) and uses CAS for the signaling information.

Figure 97 and Figure 98 show POTS and E&M voice applications with point to point network scenarios.
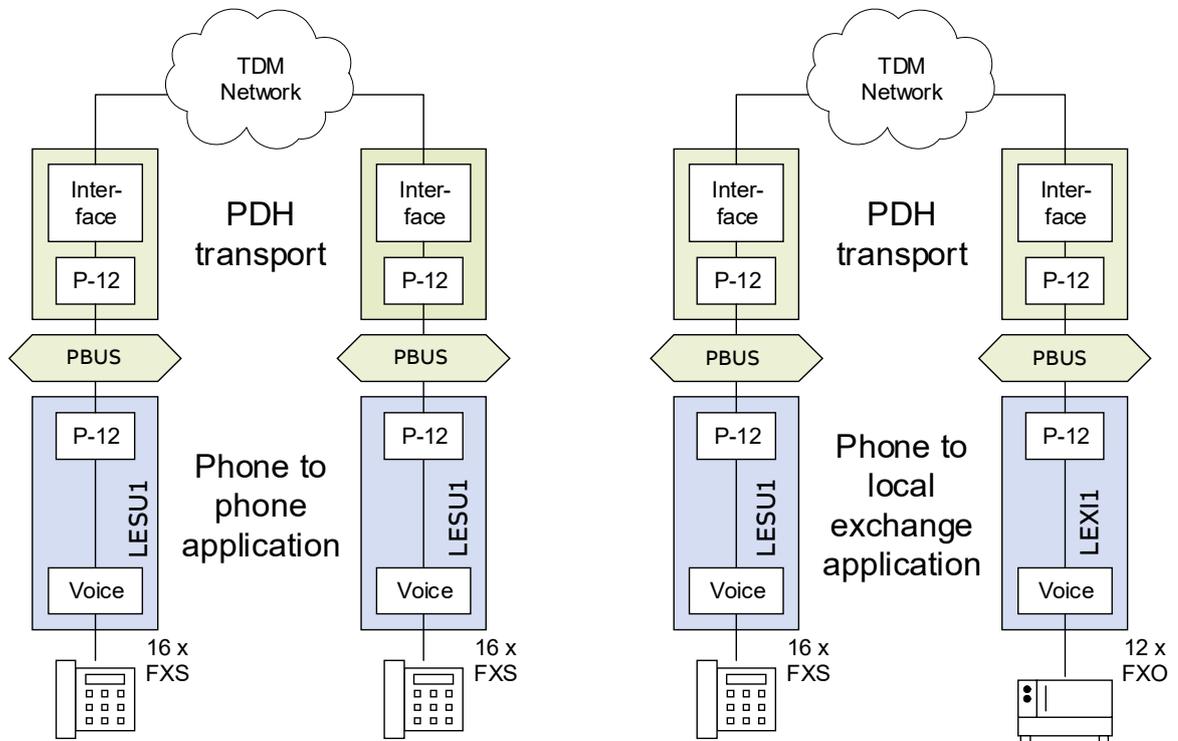
Figure 97:   POTS voice services overview
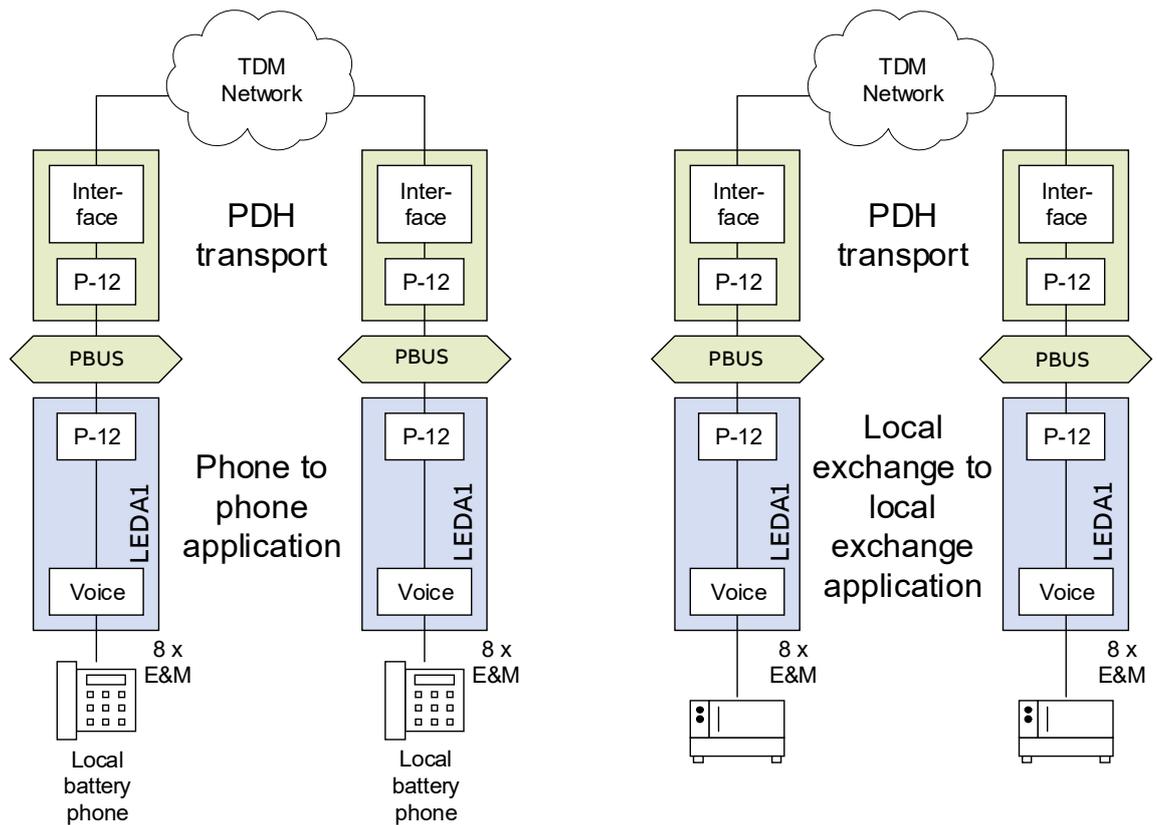
Figure 98:   E&M voice services overview

Figure 99 shows a voice application example with a multipoint to multipoint network scenario. All telephone sets connected to the voice network are interconnected. The multipoint network scenario makes use of the voice conference feature offered by the LEDA1 unit.

Since there is no local exchange involved the telephone sets must provide the call setup and tear down procedures by their own or with the support of the voice service unit:

- With the LESU1 unit operated in the phone-phone mode, as soon as one subscriber goes offhook, all telephone sets connected to the multipoint network start ringing.

- When using the LEDA1 unit the connected telephone sets must use inband signaling to address a specific other telephone set. This type of telephone sets supports also group calls. In this application the E&M signaling port is not used.

Beside the multipoint to multipoint network scenario there is also a simpler point to multipoint network scenario available. One master telephone set can access all slave telephone sets, but the slave telephone sets can only access the master telephone set.
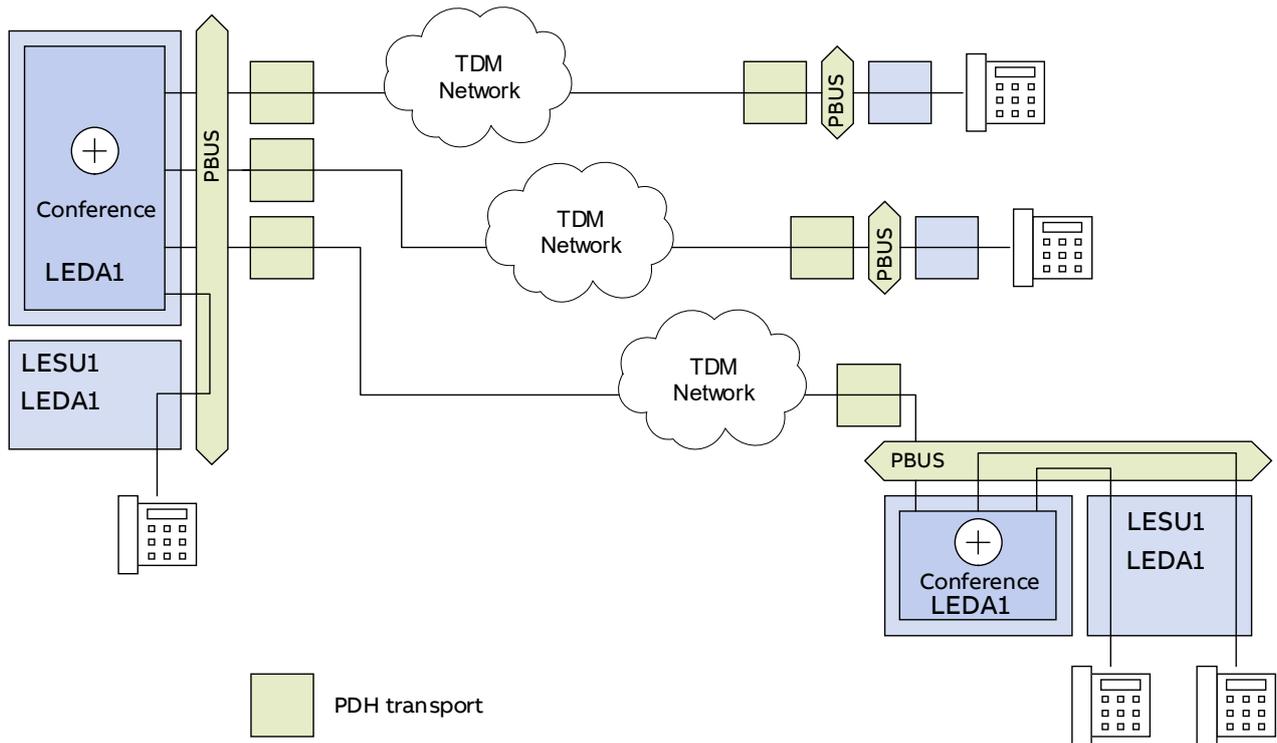
Figure 99:   Multipoint voice services overview

4.3.6   Legacy Data Services

The FOX61x legacy data service units offer different data interfaces:

- The LECO1 unit has 8 E0 (ITU-T G.703) codirectional 64 kbit/s interfaces or alternatively 2 E0 (ITU-T G.703) contradirectional 64 kbit/s interfaces.

    It connects to a subscribers DTE. The interface provides the synchronous data service.

- The LEDS1 unit has 4 data interfaces. Each data port is configurable to
    - V.24/V.28, or
    - V.35 (Appendix II), or
    - X.24/V.11, or
    - RS485 2-wire, or
    - RS485 4 wire.

    The LEDS1 plays the DCE role and connects to a subscribers DTE.

    The interface provides the asynchronous data service for subrates from 0.6 kbit/s to 38.4 kbit/s and synchronous data service for subrates from 0.6 kbit/s to 56 kbit/s.

    The interface provides the synchronous data service for nx64 data rates from 1x64 kbit/s to 32x64 kbit/s with codirectional or contradirectional timing operation.

    The LEDS1 offers several data conferences where the data signals of the connected conference participants are superimposed with a wired AND function. This implies that the idle state of a DTE must be an all-1 signal.

    CAS can be used to transport some specific interface control signals.

- The DATI1 with a connected SHDSL DTM-M offers one data interface, configurable to
    - V.24, or
    - V.35, or
    - V.36, or

146

- X.21.

The SHDSL DTM-M plays the DCE role and connects to a subscribers DTE.

The interface provides the asynchronous data service for subrates from 0.6 kbit/s to 38.4 kbit/s and synchronous data service for subrates from 0.6 kbit/s to 56 kbit/s.

The interface provides the synchronous data service for nx64 data rates from 1x64 kbit/s to 32x64 kbit/s with codirectional or contradirectional timing operation.

Figure 100 shows data applications with point to point network scenarios.
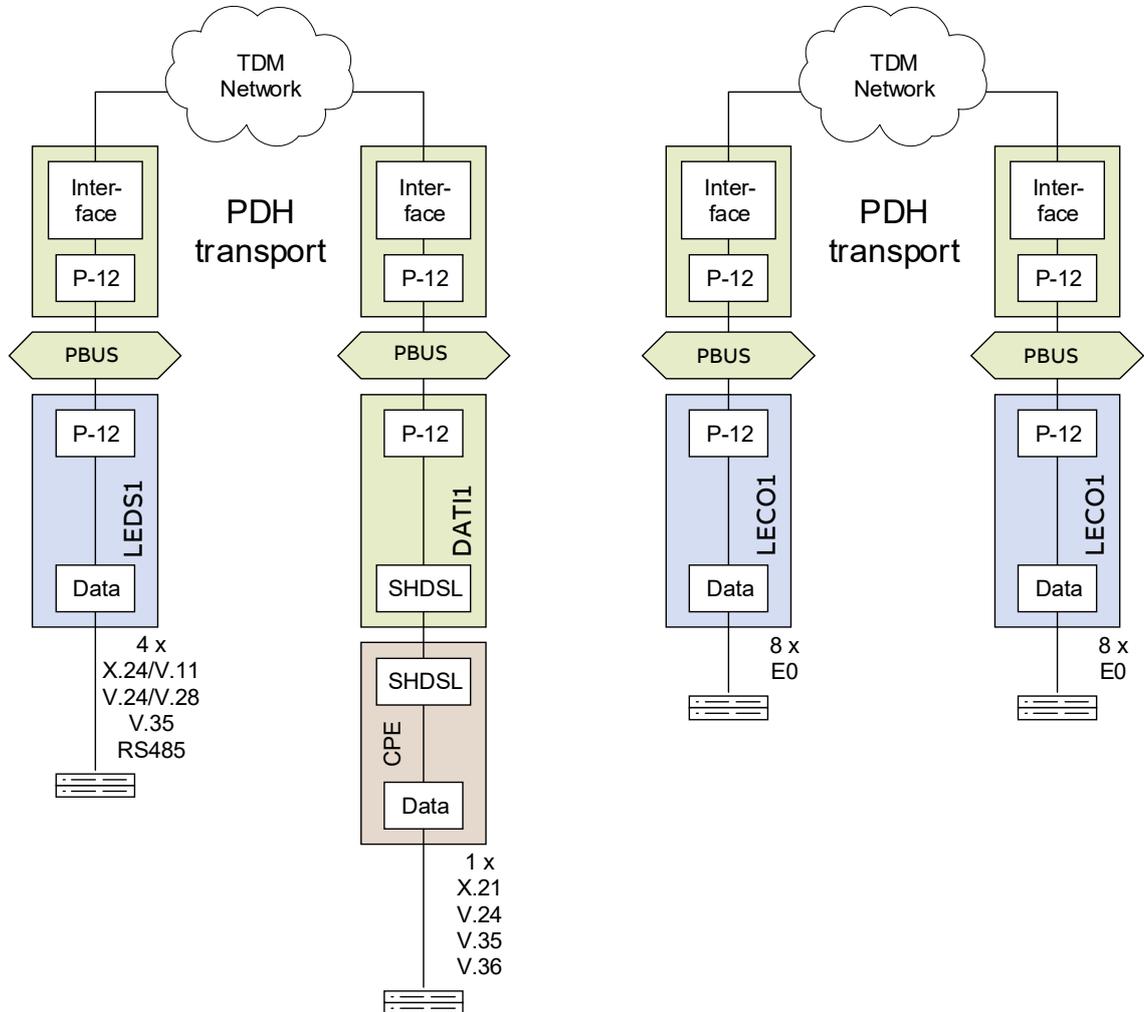
Figure 100: Data services overview

Figure 101 shows a data application example with a multipoint to multipoint network scenario. All DTEs connected to the data network are interconnected. The multipoint network scenario makes use of the data conference feature offered by the LEDS1 unit. All conference participants must be configured to the same bandwidth.

Beside the multipoint to multipoint network scenario there is also a simpler point to multipoint network scenario available. One master DTE can access all slave DTEs, but the slave DTEs can only connect to the master DTE.
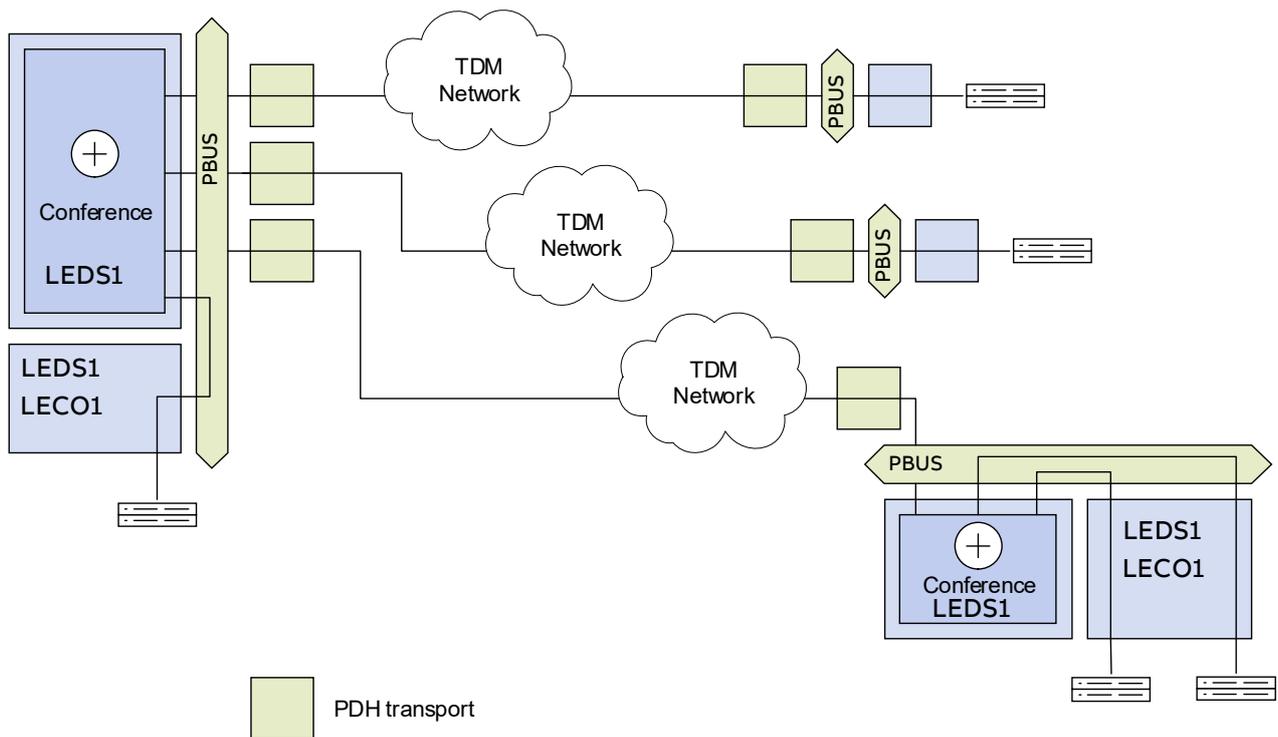
Figure 101: Multipoint data services overview

4.4 Teleprotection Services

4.4.1 Distance Protection

TEPI1 and TEPI2 teleprotection signaling supports the transmission of 4 teleprotection commands that can be transmitted in 2 directions. A maximum of 4 commands can be terminated locally.

Teleprotection command through-connections (transit) from one direction to the other as well as local drop and insert of commands is configurable.

The teleprotection interface of TEPI1 and TEPI2 complies with IEC 60834-1 allowing the following protection schemes:

- Permissive tripping (under- / overreaching)
- Intertripping (transfer tripping)
- Blocking / unblocking
- T-off (normal or inverse)

For different applications different requirements for dependability and security of the teleprotection signaling apply.

TEPI1 offers two steps to optimize the transmission either for speed or for security:

- With optimization for speed, teleprotection command status changes will be recognized when the corresponding evaluation source is validated 2 times.
- With optimization for security, teleprotection command status changes will be recognized when the corresponding evaluation source is validated 4 times.

The selected optimization influences the command pick-up time and transmission delay.

TEPI2 combines the traditionally-known modes for speed and security: Sophisticated signal processing and transmission over packet switched networks ensures security compliant values at the highest possible speed.

The transmission trail of each command can be monitored from end to end by cyclic loop tests.

The transmission protocol used for TEPI1 teleprotection signaling provides high security against the releasing of unwanted command trips in case of synchronization loss or signal inversion. The same transmission protocol as for TEBIT used in FOX51x and FOX-U is used to guarantee interoperability between TEPI1 and TEBIT for teleprotection signaling.

The transmission protocol used for TEPI2 teleprotection signaling is based on an Ethernet connection with VLAN ID and provides high dependability for the command transmission and high security against releasing of unwanted commands and uses authentication to prevent modification of tripping data by cyber security attacks on the communication link.

All events related to the teleprotection signaling application on TEPI1 and TEPI2 are stored in an event recorder. In order to have the recorded events in a fixed time relation on both sides, transmitting and receiving, the network elements can be time-synchronized. For highest accuracy TEPI1 and TEPI2 can be directly synchronized to the GPS (Global Positioning System).

For teleprotection command signaling, the following network topologies are supported:

- Point-to-point termination (in one or two directions)
- Drop-off/insert and transit over an intermediate network element
- Normal T-operation (Wired-OR Omnibus) and inverse T-operation (Wired-AND Omnibus)
- Wired-AND and Wired-OR termination of two teleprotection signals

These network topologies are supported for each single teleprotection command independently.

For a detailed description of protection schemes in general and for specific proposals for parameter setting in the particular realization refer to [1KHW002483] User Manual "TEPI1" or refer to [1KHW028634] User Manual "TEPI2".

4.4.2   Differential Protection

The OPIC1 and OPIC2 units support up to 4 optical teleprotection interfaces complying to IEEE C37.94 (IEC 62843) standard or to the proprietary FOX6plus compatible optical transmission protocol (ABB Power Grids TPE) or to the FO5 protection interface type (OPIC2 only) on every unit.

OPIC1 has an access of 4x2 Mbit/s towards the FOX61x internal cross connection backplane, PBUS, allowing for full 2 Mbit/s access per port.

The following network features help to enhance the systems availability:

- 1+1 end to end nx64 kbit/s linear trail protection with symmetrical bi-directional switching algorithm.

OPIC2 uses circuit emulation service (CESoP) for the transport of TDM differential protection signals over a packet switched network.

The following protection features of CESoP help to enhance the systems availability:

- Hitless end to end WAN protection with constant and symmetrical end to end delay for both data paths.
- Core unit redundancy to access WAN during core unit failure scenarios.

4.4.3   IEC 61850 GOOSE/SV Proxy Gateway

The TEGO1 unit supports up to 4 optical Ethernet interfaces for connection to an IEC 61850 substation bus and transport of GOOSE messages and/or SV (Sampled Values) messages between substations via up to eight WAN channels.

4.5   Binary Signal Services

TEPI1 and TEPI2 binary signal transmission supports the transmission of 16 binary signals in 2 directions. A maximum of 8 binary signals can be terminated locally.

Through-connections (transit) from one direction to the other as well as local drop and insert of binary signals are configurable.

The binary signal transmission application is intended for the transmission of:

- Control signals
- Status signals
- Metering pulses
- Slow data rate channels.

For binary signal transmission, the following network topologies are supported:

- Point-to-point termination
- Drop-off/insert and transit over an intermediate network element
- Broadcast, Wired-OR Omnibus and Wired-AND Omnibus
- Wired-OR terminations and Wired-AND terminations

These network topologies are supported for each single binary signal independently.

4.6   Protection Concept

4.6.1   Overview

FOX61x network elements are used in different topologies, such as ring, star, and linear/daisy-chain structures. In all topologies, the protection concept has to provide continuous availability of the FOX61x network in the case of link and equipment failures.

All the FOX61x network elements support rapid spanning tree protocol (RSTP) for the implementation of link protection.

The FOX61x network elements provide 1:1 traffic protection for the MPLS-TP tunnels using the VPWS and VPLS services.

The FOX61x network elements provide 1+1 traffic protection for the TDM signals on the PBUS and on the SAMO1, SAMO5, SAMO2 and SAMO3 units.

The FOX61x network elements support 1:1 equipment protection for the core unit CESM3, CESM2 and CESM1, and also for the SAMO1, SAMO5, SAMO2, SAMO3, COSI1, VFTLF, EPSI1, EROP1 [1], LEDA1 and LEDS1 service units.

> **i**   **Please note:**
> The FOX611 supports no equipment protection for the CESM1, CESM2, SAMO5, SAMO2 and SAMO3 units.

With 1:1 equipment protection, a protecting resource is provided for a single working resource.

4.6.2   Equipment Protection of the Core Unit

The FOX615 R2, FOX615 and FOX612 provide 1:1 equipment protection for the core unit.

The working unit is plugged in slot 11 of the subrack. The redundant unit is plugged in slot 13 of the subrack. Per default the working unit is the active unit, performing the subrack control functions, and the redundant unit is the standby unit.

The standby core unit is in hot (CESM3) or warm (CESM2 and CESM1) standby mode. The NE configuration and NE database stored on the standby unit are updated with every

---

1. Equipment protection with the EROP1 unit is only supported up to the ESW release r2.

"Save" operation and are thus identical to the information on the active unit. Hence, the standby unit can take over the control of the system with a cloned database.

The switch circuits on the active and the standby core unit are both part of the FOX61x Switch. This means also that all Ethernet front ports on the standby core unit, except the local management port, are active.

The switch-over can affect traffic for a short period. The switch-over due to an equipment failure is non-revertive.

The control and monitoring of the core unit equipment protection are functions on the NE level and do not require special configuration on the core unit level.

4.6.3   Equipment Protection of Service Units

The service units

- SAMO5,
- SAMO2,
- SAMO3,
- SAMO1,
- COSI1,
- VFTLF,
- EPSI1,
- EROP1, [1]
- LEDA1, and
- LEDS1

support 1:1 equipment protection.

It is possible to backup a working service unit with one backup service unit of the same HW type and running the same ESW.

On the service units the external interfaces cannot be protected.

- On the SAMO1, SAMO5 and SAMO2 units only the traffic with PBUS access can be protected.
- On the SAMO3 unit the traffic with PBUS access and traffic from the E12 front ports can be protected.
- On the LEDA1 and LEDS1 units only the conference circuits can be protected.
- On the EPSI1 units only the bridging and routing functions can be protected.
- On the EROP1 units the routing functions and the external interfaces (using an external bridge) can be protected. [1]

The switch-over can affect traffic for a short period. The switch-over due to an equipment failure is non-revertive.

A status dialog on the unit level allows you to control and monitor the service unit equipment protection.

4.6.4   Ethernet Traffic Protection

Redundancy improves the availability of the network by implementing alter-native paths. Having multiple paths for data to traverse the network allows for a single path to be disrupted without impacting the connectivity of devices on the network.

However because of multiple paths exist to a destination a protocol is needed to prevent loops in the ring.

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1. Equipment protection with the EROP1 unit is only supported up to the ESW release r2.

4.6.4.1 Linear Protection Switching (LPS) for MPLS-TP

The FOX61x supports linear protection switching (LPS) for bidirectional LSPs between two LERs. LPS makes use of the BFD continuity check (CC) for the end-to-end supervision of the working and of the protection LSP, where the LOC defect is used as signal fail (SF) condition.

LPS supports the 1:1 protection architecture type:

- Under normal conditions the user traffic is routed exclusively through the working LSP. The protection LSP remains free.
- In case of a fault condition the user traffic is switched over from the working LSP to the protection LSP at both ends of the tunnel, i.e. the LPS switching type is bidirectional. This keeps the LSP as co-routed bidirectional LSP.

The LPS operation type can be revertive or non-revertive.

4.6.4.2 Rapid spanning tree protocol (RSTP)

In switched networks where availability is important redundant paths must be created to assure connectivity. However, this type of network configuration can result in frames circulating indefinitely (broadcast storms) and consequently crashing the network. In order to avoid this problem the spanning tree protocol (STP, IEEE 802.1D) has traditionally been implemented on switches.

STP reduces the physical topology to an active tree topology that reaches all segments of the network. To achieve this, the switches/bridges exchange BPDU (bridge packet data units) protocol frames to coordinate which ports will be active (designated or root port) forwarding traffic and which will remain as backup (alternate, backup or disabled port) discarding traffic.

When a port failure is detected on a designated port then an alternate port will become designated. The election of designated, alternate and backup (second port on a switch) ports is done according to the path cost, physical topology and port priority they are assigned.

For inter-operation purposes of Ethernet LANs and MPLS-TP the FOX61x supports the R- (Reverse Layer 2 Gateway Protocol). A port configured to the R- mode acts as a pseudo root bridge with a manually configured pseudo MAC address.

The time STP requires to reconfigure the network topology (convergence time) is dependent on the network topology and number of switches. This time is relatively long in STP and therefore RSTP as an improved version of this protocol, reducing significantly the convergence time. In order to profit from RSTP all switches have to work on this mode, otherwise they will work in STP mode to keep compatibility.

The FOX61x implements RSTP 802.1D-2004 (compatible with STP).

With RSTP, the convergence time is roughly in the range of 300 ms (for the point-to-point link between 2 switches) to 5 seconds (for ring topologies with up to 19 switches).

4.6.5 TDM Traffic Protection

The SDH and PDH traffic in the FOX61x network element can be 1+1 protected.
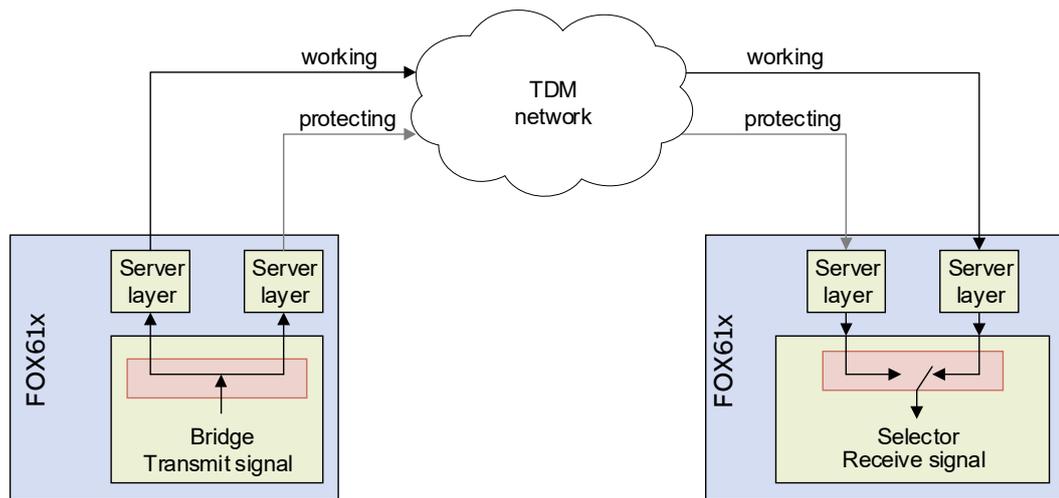
Figure 102: 1+1 protection

A signal to be protected is bridged to the working and protecting channel at the transmitting network element. At the receiving network element the working or protecting signal is selected dependent of the received signal quality.

Protection switching can be

- Unidirectional or bidirectional,
- Revertive or non revertive.

> ℹ️ **Please note:**
> The availability of protection parameters as
> - holdoff time,
> - guard time,
> - wait to restore time,
> - operation type revertive or non-revertive,
> - CAS AIS supervision,
> - switching type unidirectional or bidirectional,
>   is dependent of the unit and application.
>   → Please refer to the relevant user manuals.

FOX61x supports

- SNCP/I: Inherently monitored subnetwork connection protection.
  SNCP/I is supported for the following traffic signal types:
    - VC-4 unterminated,
    - VC-3 unterminated,
    - VC-12 unterminated,
    - P12 unstructured (transparent mode),
    - P0_nc without CAS AIS supervision.
- SNCP/N: Non-intrusively monitored subnetwork connection protection.
  SNCP/N is supported for the following traffic signal types:
    - VC-4 terminated,
    - VC-3 terminated,
    - VC-12 terminated,
    - P12 structured (monitored mode, future release).
- LTP: Linear trail protection.
  LTP is supported for the following traffic signal type:

- P0_nc with CAS AIS supervision,
- P0 with SFC multiframe supervision for fast trail switching (TEPI1),
- P0_nc with PMTS supervision for bidirectional symmetrical trail switching (OPIC1, OPIC2).

The protection mode of a connection termination point (e.g. SNCP, LTP) is given by the capabilities of the relevant unit or application respectively. The protection mode may be fixed or configurable by the application (implicit or explicit configuration). Please refer to the corresponding unit user manuals.

In addition the SAMO1, SAMO5, SAMO2 and SAMO3 units support 1+1 multiplex section protection (MSP). Please refer to the SAMO1, SAMO5, SAMO2 or SAMO3 user manual for further information.

5   Network Management System

5.1   Management Systems Overview

A single FOX61x subrack is considered as a network element (NE).

To provide economic and flexible management for all NE configurations, the FOX61x management concept is based on a layer approach, as shown in Figure 103:

- the FOXCST element manager (EM) for local and remote management activities of a single FOX61x,
- an SNMP interface provided by the FOX61x (traps and inform only in the current release, and basic configuration of the SNMP parameters),
- Syslog provides a reporting function to logging destination servers,
- the FOXMAN-UN network element manager (NEM) for remote management of a FOX-61x network from the network management center / network operation center,
- the FOXMAN-UN offers northbound interfaces (NBI) for the OSS integration,
- the DIRAC server deploys the Master Keys for the MPLS tunnel encryption to the SENC1 Crypto Engines, and forwards the encrypted MPLS tunnel configuration from FOXMAN-UN to the SENC1 Crypto Engines.

The element managers and management access for the different network element types are according to the following tables:

Table 14:   Element managers and NE types

NE type	FOXMAN-UN	FOXCST	DIRAC
FOX615 R2	yes	yes	no
FOX615	yes	yes	no
FOX612	yes	yes	no
FOX611	yes	yes	no
FOX51x	yes	no	no
SENC1 unit	no [1]	yes	yes

1. MPLS tunnel encryption configuration via DIRAC server

Table 15:   Element managers and management access

Management access		FOXMAN-UN	FOXCST	DIRAC
Direct	Proprietary with TCP/IP over Ethernet	no	yes	no
Remote	Proprietary with TCP/IP over Ethernet	yes	yes	no
Remote	Proprietary with encrypted HTTPS over Ethernet	no	no	yes
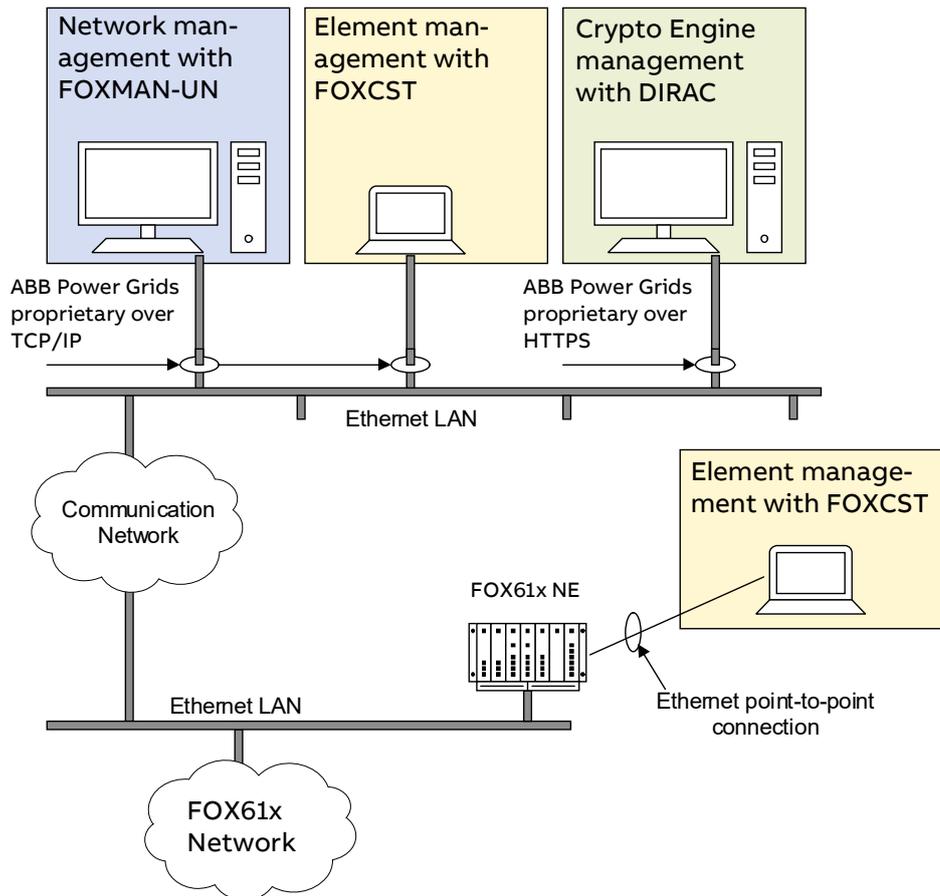
Figure 103: FOX61x management concept overview

For secure management access, the FOX61x supports SSH for the encryption of the management communication to/from the FOX61x.

Once provisioned, the FOX61x is able to run its services autonomously, without any interaction with the management system.

The FOX61x configuration is stored on the core unit, i.e. this information is used to reconfigure FOX61x units that have been restarted or replaced.

5.2   FOXCST

The FOXCST can configure and manage the FOX61x equipment. It has a graphical user interface (GUI) with shelf view and tree based view to manage an NE. The GUI provides a structured user interface with dialogs, selection boxes, graphs and mouse selection.

The FOXCST provides local or remote access to one NE at a time, either for NE configuration or for NE status and/or performance monitoring. The FOXCST can run several instances for the management of several NEs at the same time.

The FOXCST can be connected to an NE in one of the following ways:

*   Local access via the Ethernet local management port or via an Ethernet network interface on the core unit or on an Ethernet service unit.
*   Remote access via an Ethernet network, with a connection to an Ethernet interface on the core unit or on an Ethernet service unit.

The FOX61x management communication is based on TCP/IP.

With FOXCST, the configuration can be done with the FOX61x on line, i.e. units are configured if they are physically available in the subrack. The configuration is stored in the database on the NE and not interpreted by FOXCST, i.e. the parameter and resource check is done on the NE.

The configuration can be saved on the element manager for backup, and can be restored to the network element when required.

Alternatively the configuration can be done offline with a FOX61x simulation. Any unit [1] can be placed in a virtual subrack and configured. The configuration of the simulated FOX-61x has to be saved and can then be restored to the real network element later on.

The FOXCST is used for initial commissioning, NE configuration, fault management, and performance management.

The FOXCST provides the following functions for the management of NEs of small networks:

- Configuration (including the configuration of profiles),
- Fault management (alarm list),
- Performance monitoring,
- Status and diagnostic (loops etc.),
- Line testing,
- Management of user authentication and authorization by user classes,
- NE inventory (HW, SW, resource utilization),
- SW management (upgrade of ESW),

The following security features are provided by the FOXCST:

- Local user authentication via user classes and passwords, or authentication via a RADIUS server,
- Local user authentication via public/private keys,
- SSH encryption for the management communication,
- SNMPv3 for the management communication.

FOXCST can be deployed on PCs or Laptops running the Windows or Linux operating systems as listed in [1KHW028777] Release Note "FOX61x System Release R15A".

5.3   Syslog

The FOX61x provides a syslog message sender device that is able to send messages from different sources to up to ten syslog destinations. The FOX61x supports different syslog facilities, as e.g.

- Alarm logbook,
- Event logbook,
- Configuration logbook,
- Equipment logbook,
- Session logbook,
- System.

The IP addresses of the syslog destinations can be configured in the FOX61x. Each destination entity provides a message filter configuration for the System and Alarm logbook facilities that defines up to which severity syslog messages are sent to the respective destination.

5.4   SNMP

The FOX61x NEs offer a standard SNMP interface towards network management systems. With the current release of the FOX61x, the following MIBs are supported:

- Agent MIBs
    - SNMPv2-MIB (RFC 3418)

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1. The SENC1 in offline mode is not configurable

- SNMP-FRAMEWORK-MIB (RFC 3411)
- SNMP-TARGET-MIB (RFC 3413)
- SNMP-NOTIFICATION-MIB (RFC 3413)
- SNMP-VIEW-BASED-ACM-MIB (RFC 3415)
- SNMP-COMMUNITY-MIB (RFC 3584)
- SNMP-USER-BASED-SM-MIB (RFC 3414)
- SNMPv2-TC (RFC 2579)
- Other MIBs
  - RMON2-MIB (RFC 4502)
  - RMON-MIB (RFC 2819)
  - BRIDGE-MIB (RFC 4188)
  - Q-BRIDGE-MIB (RFC 4363)
  - IANAifTypeMIB
  - IF-MIB (RFC 2863)
  - ENTITY-MIB (RFC 6933)
  - INET-ADDRESS-MIB (RFC 4001)
  - ENTITY-SENSOR-MIB (RFC 3433)
  - ALARM-MIB (RFC 3877)
  - PW-TC-STD-MIB (RFC 5542)
- Private MIBs
  - FOX-SMI
  - FOX-IF-EXT-MIB
  - FOX-IANA-BFD-TC-STD-MIB
  - FOX-BFD-STD-MIB
  - FOX-MPLS-QOS-EXT-MIB
  - FOX-UNI-EVC-MIB
  - FOX-ETH-PORT-MIB
  - FOX-NE-MIB
  - FOX-ALARM-EXT-MIB
  - FOX-DIAGNOSTIC-MIB

The SNMP functionality implemented in the FOX61x provides easy activation with any of the three SNMP versions v1, v2c, or v3. In the current release, trap and inform functions are available for the above MIBs.

5.5   FOXMAN-UN

The FOXMAN-UN provides administration and simultaneous supervision and performance control for all network elements (FOX61x and FOX51x) of medium to large access networks. Depending on the type of workstation, the FOXMAN-UN can manage up to several thousand NEs.

The key to the deployment of FOXMAN-UN is its architecture, which is designed with distributed management in mind and is based on a modern hardware platform.

The FOXMAN-UN architecture consists of the following components:

- NEM desktop,
- NEM configurator,
- NEM network browser,
- Core, including database,
- North-bound interfaces,

- South-bound interfaces (agents).

The south-bound interfaces (agents) can be divided into

- ABB Power Grids proprietary agents,
- SNMP agents.
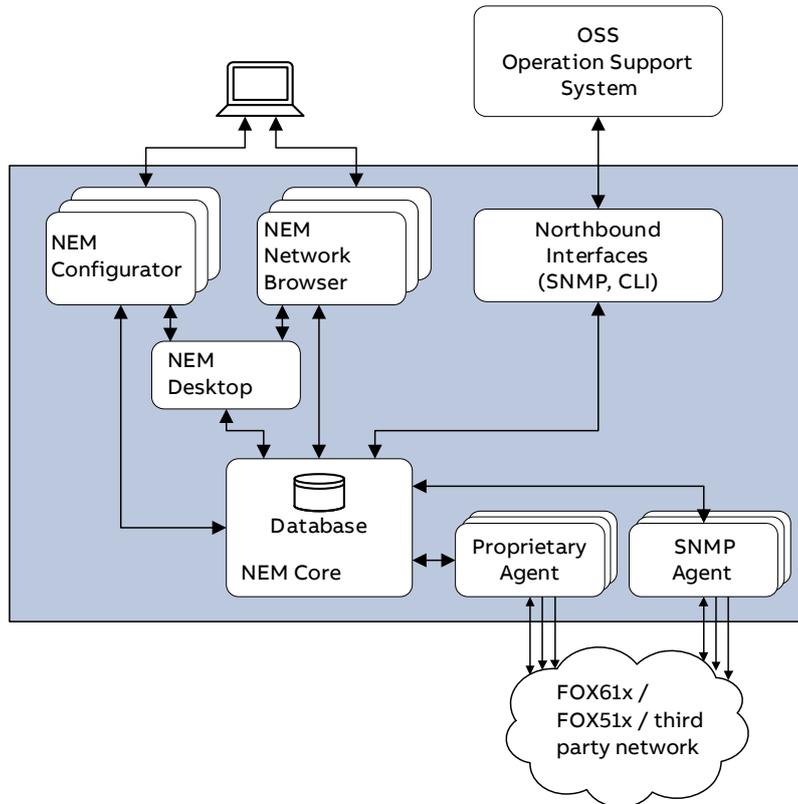
Figure 104: FOXMAN-UN architecture

An optimized multi-process implementation for the different FOXMAN-UN functions creates a high system performance.

FOXMAN-UN provides the user with two main interfaces:

- NEM configurator: This browser style interface allows setting up all the details of the management network and defining the security aspects. In addition, it provides access to the NE configuration management and limited access to the fault management.
- NEM network browser: The network browser provides the operator with a graphical view of the network in the form of maps for the supervision and the carrying out of the day-to-day management of the NEs, including full fault management.

The FOXMAN-UN accesses the NE via an Ethernet network, with a connection to an Ethernet interface on the core unit or on an Ethernet service unit.

The FOX61x management communication is based on TCP/IP.

The main functions of the FOXMAN-UN are as follows:

- Fault and performance management

    To ensure that the operator can quickly locate and analyze problems in the network and can take actions to prevent traffic disruptions, FOXMAN-UN offers the following functions:

    – Fault management,

    – Status monitoring and diagnostics,

    – Performance management, including an automatic performance data collection tool.

- Configuration management

  With the configuration management of FOXMAN-UN, the operator is able to define and configure units in the network elements. Since the configuration of the FOX61x in FOXMAN-UN is based on FOXCST, the configuration is also performed on line, i.e. the FOX-61x units are configured while they are physically available in the subrack. A network element configuration can be stored as a backup on the FOXMAN-UN, and restored to the network element if required.

  The configuration and deployment of encrypted MPLS tunnels is done via the DIRAC server.

- Security management

  The FOXMAN-UN security administration ensures that only authorized users have access to information they are responsible for.

  Apart from restricting potentially damaging functions to selected operators, FOXMAN-UN provides warning messages before they are executed.

- Inventory management

  Inventory data is collected periodically from all NEs and stored in the FOXMAN-UN database.

  It is possible to export the inventory data in XML format for integration into an OSS (operation support system) or BSS (billing support system).

- System management

  The system management of FOXMAN-UN provides the operator with the following functions:
  - Activity history,
  - NE discovery,
  - NE alarm synchronization,
  - NE inventory synchronization,
  - NE performance data collection,
  - System alarms.

The FOXMAN-UN offers the following northbound interfaces (NBI) for OSS integration:

- SNMP for fault management and basic inventory data,
- CLI for inventory data reports.

The FOXMAN-UN and FOXMAN-UN client can be deployed on workstations running a Linux operating system. The supported operating system releases are listed in [1KHW028777] Release Note "FOX61x System Release R15A".

The FOXMAN-UN client runs also on PCs / Laptops running the Windows operating systems as listed in [1KHW028777] Release Note "FOX61x System Release R15A".

5.6   DIRAC

The DIRAC server is a centralized key management system and is responsible for the generation and distribution of the Master Keys used by the SENC1 Crypto Engines. The random numbers required for the Master Keys are generated by a Quantis USB device, attached to the DIRAC server.

The DIRAC server has a command line interface (CLI) through which it is managed. In addition there is a secure interface between the network management system FOXMAN-UN and the DIRAC server in order to synchronize paired information (Crypto Engine identifiers, encrypted MPLS tunnels and tunnel endpoints, DIRAC server alarm status) between both systems.

The communication between the DIRAC server and FOXMAN-UN is done via a REST interface, based on HTTPS.

The DIRAC server also forwards the MPLS tunnels and tunnel endpoints configuration information from the FOXMAN-UN to all SENC1 Crypto Engines in the DIRAC system via

secured channels over insecure Ethernet or MPLS-TP links. The DIRAC server maintains a database with all SENC1 Crypto Engines in the FOX61x network, and with all deployed MPLS tunnels.

The DIRAC server is deployed on workstations running a Linux operating system. The supported operating system releases are listed in [1KHW028777] Release Note "FOX61x System Release R15A".

6   Specifications

6.1   Traffic Functions

6.1.1   Customer VLAN Bridge Functionality

FOX615 R2 or FOX615 or FOX612 or FOX611	
Implementation	
- Core Units	CESM3, CESM2, CESM2-F, CESM1, CESM1-F
- WAN port expansion units	EPEX1
- Service Units	ETOP1, ETOP1-F, ELET1, EPOI1, DEFM1, DEFM1-F SAMO5, SAMO5-F SAMO2, SAMO2-F SAMO3
Customer bridge functionality	Switching (Ethernet traffic) according to IEEE 802.1Q
Subscriber Ethernet Services	
- Compliance	MEF 3.0 CE (Carrier Ethernet)
- Certification	MEF 3.0 CE (Carrier Ethernet) for FOX615 with CESM3 core unit
- Service types	E-Line Release 1
	E-LAN Release 1
	E-Tree Release 1
- Referenced standards	MEF 6.2: EVC Ethernet Services Definitions Phase 3 MEF 10.3: Ethernet Services Attributes Phase 3 MEF 45: Multi-CEN L2CP MEF 45.0.1: OVC Services Requirements for L2CP
Number of bridging instances	1
Physical ports	
- Number of physical ports	245
- Interface types	10/100/1000BASE-T 100BASE-xx (SFP) [1] 1000BASE-xx (SFP) [1] 10GBASE-xx (SFP+) [1] SHDSL EFM
VLAN	
- VLAN support	according to IEEE 802.1Q (port and tag based)
- Number of VLANs supported	4089
- VLAN EtherType	0x8100 (single tagged frames) 0x8100 (Q-in-Q frames)
Ethernet switching	

FOX615 R2 or FOX615 or FOX612 or FOX611	
- Subrack switching capacity, bidirectional	Combined capacity of up to 258 Gbit/s, depending on the subrack type and utilized units. Wire speed traffic forwarding @ 84 bytes/frame
- MAC table	wire speed MAC address learning CAM table size - 16'000 addresses per service or core unit - 64'000 addresses per FOX61x network element
- Maximum frame size supported [2]	9'216 octets [3]
- Traffic prioritisation	CoS handling, according to IEEE 802.1Q: 8 queues on egress ports, 8 queues on backplane ports, each queue with selectable scheduling: - strict priority scheduling or - weighted round robin (WRR) scheduling, with assignable weight per queue. DSCP aware queuing
- Traffic classification	based on: - Port (port default priority) - Ethernet priority bits - IP DSCP field
- TDM encapsulation	Encapsulation of TDM bit streams as Pseudo Wires over packet switching networks (PSN): - SAToP (structure agnostic) - CESoPSN (structure aware) - CESoETH (structure agnostic) - CESoETH (structure aware)
Security features	Ingress storm control Ingress rate limiter per port Ingress rate limiter per VLAN Ingress rate limiter per MPLS-TP tunnel HW and SW firewall
- Maximum number of VLAN rate limiters (including the number of CVP and PWAC ports)	250 per service or core unit 2500 per network element
- Maximum number of MPLS-TP tunnel rate limiters	500 (with CESM1 and CESM2) 2000 (with CESM3)
Spanning tree	
- Number of interfaces (ports) with STP/RSTP active	64
Authentication	
- Maximum number of ports with 802.1X authentication enabled	256 [4]

1. For the recommended SFP+ and SFP module types please contact your local ABB Power Grids representative.
2. Please note that depending of the used Ethernet equipment or service unit the effectively usable maximum frame size can be smaller than the specified value.
3. Excessive jumbo frame traffic leads to high buffer resource usage and may lead to frame loss on other ports.
4. 802.1X will be available in a future release.

6.1.2   MPLS-TP Functionality

FOX615 R2 or FOX615 or FOX612 or FOX611	
MPLS-TP functionality	IETF RFC 5921 (07/2010) A Framework for MPLS in Transport Networks

FOX615 R2 or FOX615 or FOX612 or FOX611

Implementation	
- Core Units	CESM3, CESM2, CESM2-F, CESM1, CESM1-F
- WAN port expansion units	EPEX1
- Service Units	ETOP1, ETOP1-F, ELET1, EPOI1, DEFM1, DEFM1-F SAMO5, SAMO5-F SAMO2, SAMO2-F SAMO3
- Attachment Circuits	On core and service units
- MPLS-TP ports	On core units and WAN port expansion units: - Physical ports - VLAN based logical ports
Network element deployment	Label Edge Router (LER) Label Switching Router (LSR)
MPLS-TP services	Virtual Private Wire Service (VPWS) Virtual Private LAN Service (VPLS)
Capacity	
- Maximum number of MPLS-TP ports	5 physical ports per core unit 4 physical ports per WAN port expansion unit 50 logical ports per network element (VLAN based), shared with the physical ports
- Maximum number of bidirectional LSPs in LER (unprotected, 1 PW per LSP)	500 (with CESM2 or CESM1) 2000 (with CESM3)
- Maximum number of bidirectional LSPs in LSR	600 (with CESM2 or CESM1) 3500 (with CESM3)
- Maximum number of bidirectional LSP End-Points in LSR	600 per CESM2 or CESM1 unit 3500 per CESM3 unit
- Maximum number of terminated Tunnels in LER	250 (with CESM2 or CESM1) 2000 (with CESM3)
- Maximum number of bidirectional PW (shared between VPWS and VPLS)	330 (with CESM2 or CESM1) 2000 (with CESM3)
- Maximum number of VPLS instances	50 (with CESM2 or CESM1) 100 (with CESM3)
- Maximum number of member ports (CVP) per SVI VLAN	30 (with CESM2 or CESM1) 50 (with CESM3)
- Maximum number of member ports (CVP) of all SVI VLANs	500 (with CESM2 or CESM1) 1000 (with CESM3)
- Maximum number of Linear Protection Switching (LPS) groups	250
OAM	Continuity Check (CC) Remote Defect Indication (RDI) LSP Ping LSP Trace Route Delay Measurement (DM)
Protection switching	1:1
- Protection operation type	revertive non-revertive
- Protection switching type	bidirectional
- Number of protected tunnels	up to 250 (with CESM2 or CESM1) up to 1000 (with CESM3)

FOX615 R2 or FOX615 or FOX612 or FOX611	
- Number of protected tunnels with switching time < 50 ms	up to 50 (with CESM2 or CESM1) up to 250 (with CESM3)
- Number of protected tunnels with switching time < 500 ms	up to 200 (with CESM2 or CESM1) up to 750 (with CESM3)

6.1.3 Encryption Functionality

FOX615 R2 or FOX615 or FOX612 or FOX611	
Implementation	
- Encryption Units	SENC1-4, SENC1F4, SENC1-8, SENC1F8
- Unencrypted ports	Connected to an MPLS-TP port of the core unit or the WAN port expansion unit
	Connected to an MPLS-TP subinterface (VLAN based) of the core unit or the WAN port expansion unit
- Encrypted ports	Connected to the WAN
Capacity	
- Number of functional units	1 per encryption unit (SENC1-4, SENC1F4) 2 per encryption unit (SENC1-8, SENC1F8)
- Number of encryption engines	2 per functional unit
- Number of unencrypted ports	2 per functional unit
- Number of encrypted ports	2 per functional unit
- Number of random number generators	1 per encryption unit
- Traffic flows	1024 independent encrypted traffic flows (LSPs) per encryption engine and direction
	Support of 1024 encryption end points in a network
Asymmetrical encryption process	Master key encryption
- Algorithm	ECC (Elliptic Curve Cryptography), ECDH (Elliptic Curve Diffie-Hellman)
- Key length	521 bit (NIST P-521 defined in FIPS 186-4)
- Key replacement	via DIRAC server
Symmetrical encryption process	Session key and data encryption
- Algorithm	AES-GCM (Galois/Counter Mode) for encryption and authentication
- Key length	256 bit
- Key replacement	60 seconds or longer (automatic)
Authentication	X.509 certificate based
	Per traffic flow
Master key generation	Setting via CLI
	Setting via key management server (DIRAC), key change without traffic interruption
Session key generation and distribution	Based on the local random number generator
	Key is generated for the transmit direction
	Key configurable for every traffic flow (MPLS tunnel)
	Key change without traffic interruption

FOX615 R2 or FOX615 or FOX612 or FOX611	
Random number generator	HW based True Random Number Generator (TRNG)
Traffic encryption	MPLS interface based: - MPLS port - MPLS-TP subinterface (VLAN based)
	MPLS packets with an inner MPLS label of 13 and a TTL value of ≤ 127 are not encrypted
Authentication overhead	Additional tag with up to 16 bytes after the encrypted payload of all payload packets
Traffic delay	Latency between bridged ports < 4 μs (10 Gbit/s) Latency between bridged ports < 30 μs (1 Gbit/s)
	Delay compensation for PTP packets
	Delay variation for PTP packets < 50 ns
Traffic jitter and wander	Clock regenerator with through-timing capability
	Jitter requirements for 1000Base-X and 10GBase-R according to IEEE 802.3
Tamper protection	Prevents mechanical manipulation
	Tamper detection by heat sink (mechanical housing)
	Tamper proof private key storage

6.1.4 TDM Cross Connect

FOX615 R2 or FOX615 or FOX612 or FOX611	
Maximum number of TDM connections	4096
Maximum number of connection termination points (CTP)	4096
Unit placement for TDM services	A TDM unit can be placed in any slot of the FOX-61x subrack except slot 11 which is reserved for the core unit
Cross connection layers	P0_nc (n x 64 kbit/s) synchronous P12 (2048 kbit/s) plesiochronous
	VC-12 VC-3 VC-4
Protection switching times	Specification corresponding to the transfer time T_t definition in ITU-T G.808.1
- P0 LTP (based on SFC multiframe supervision, TEPI1)	≤ 5 ms
- P0_nc LTP (based on PMTS supervision, OPIC1, OPIC2)	≤ 25 ms
- P0_nc LTP (based on CAS AIS)	≤ 320 ms
- P0_nc SNCP/I - P12 SNCP/I - P12 SNCP/N	≤ 50 ms
- VC-12 SNCP/I - VC-12 SNCP/N - VC-3 SNCP/I - VC-3 SNCP/N - VC-4 SNCP/I - VC-4 SNCP/N	≤ 50 ms

FOX615 R2 or FOX615 or FOX612 or FOX611	
- STM-1 MSP unidirectional - STM-1 MSP bidirectional - STM-4 MSP unidirectional - STM-4 MSP bidirectional - STM-16 MSP unidirectional - STM-16 MSP bidirectional	≤ 50 ms
Synchronous multiplexing and connections of P12 and P0_nc traffic signals	ITU-T G.736 (03/1993) Characteristics of a synchronous digital multi-plex equipment operating at 2048 kbit/s ITU-T G.704 (10/1998) Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels ITU-T G.706 (04/1991) Frame alignment and cyclic redundancy check (CRC) procedures relating to basic frame structures defined in Recommendation G.704 ITU-T G.823 (03/2000) The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy
Primary PCM multiplexing	ITU-T G.732 (11/1988) Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s
Plesiochronous connections of P12 traffic signals	ITU-T G703 (11/2001) Physical/electrical characteristics of hierarchical digital interfaces ITU-T G.823 (03/2000) The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy
Connections of VC-12, VC-3 and VC-4 traffic signals	ITU-T G.785 (11/1996) Characteristics of a flexible multiplexer in a synchronous digital hierarchy environment ITU-T G.783 (03/2006) Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks
Protected connections	ITU-T G.808.1 (03/2006) Generic protection switching - Linear trail and subnetwork protection

FOX615 R2 or FOX615 or FOX612 or FOX611

Network element synchronization	ITU-T G.823 (03/2000) The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy ITU-T G.8262/Y.1362 (07/2010) Timing characteristics of a synchronous Ethernet equipment slave clock (option 1) ITU-T G.8264/Y.1364 (10/2008) Distribution of timing information through packet networks ITU-T G.8275.2/Y.1369.2 (06/2016) Precision time protocol telecom profile for phase/time synchronization with partial timing support from the network IEEE Std 1588-2019 (11/2019) IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
SDH network interface synchronization	ITU-T G.813 (03/2003) Timing characteristics of SDH equipment slave clocks (SEC)
TDM service synchronization in CES applications	ITU-T G.8261/Y.1361 (05/2006) Timing and synchronization aspects in packet networks

6.1.5   TDM Timing Source

FOX615 R2 or FOX615 or FOX612 or FOX611

PETS	Plesiochronous Equipment Timing Source ITU-T G.8262/Y.1362 (07/2010) Timing characteristics of a synchronous Ethernet equipment slave clock (option 1)
- Implementation	Core unit
- Frequency tolerance	± 9.2 ppm
- Free running frequency accuracy	± 4.6 ppm
- Jitter transfer minimum bandwidth	1 Hz
- Jitter transfer maximum bandwidth	10 Hz
- Jitter transfer maximum gain	0.2 dB
- Timing sources	4 PDH or Ethernet traffic sources 4 PTP traffic sources 2 synchronization inputs 1 internal oscillator
- Timing selection	Priority based Quality level based
SETS	Synchronous Equipment Timing Source ITU-T G.8262/Y.1362 (07/2010) Timing characteristics of a synchronous Ethernet equipment slave clock (option 1)
- Implementation	Service unit SAMO1 Service unit SAMO5, SAMO5-F Service unit SAMO2, SAMO2-F Service unit SAMO3
- Frequency tolerance	± 4.6 ppm

FOX615 R2 or FOX615 or FOX612 or FOX611	
- Jitter transfer maximum bandwidth	10 Hz
- Jitter transfer maximum gain	0.2 dB
- Timing sources	4 SDH traffic sources (SAMO1) 8 SDH traffic sources (SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F with EQP) 4 PDH or Ethernet traffic sources 1 synchronization input 1 internal oscillator
- Timing selection	Priority based Quality level based
PTP, Precision Time Protocol	ITU-T G.8275.2/Y.1369.2 (06/2016) Precision time protocol telecom profile for phase/time synchronization with partial timing support from the network IEEE Std 1588-2019 (11/2019) IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
PTP implementation on the core unit	- Port based - Ethernet VLAN based (layer 2) - UDP/IPv4 VLAN based (layer 3)
- Clock types	Ordinary Clock, slave ports Boundary Clock, slave and master ports Transparent Clock
- PTP messages rates per second for slave streams	Announce: 1/2, 1, 2, 4, 8 Sync: 2, 4, 8, 16, 32, 64 Delay: 2, 4, 8, 16, 32
- PTP messages rates per second for IP VLAN master streams	Announce: 1/4, 1/2, 1, 2 Sync: 1/4, 1/2, 1, 2, 4, 8, 16, 32 Delay: 1/4, 1/2, 1, 2, 4, 8, 16, 32
- PTP ports on CESM3	4 optical 1GbE or 10GbE ports 1 electrical 1GbE port
- PTP ports on CESM2	2 optical 10GbE ports 2 of 3 optical or electrical 1GbE ports
- PTP ports on CESM1	2 optical 10GbE ports 2 of 3 electrical 1GbE ports
- PTP VLANs (Ethernet or IP based)	up to 10, shared with the number of PTP ports configured to "Ordinary/Boundary Clock"
- PTP master mode, IP VLAN based	3 (CESM3 only)
- PTP slaves per PTP master, IP VLAN based	20
- PTP clock sources	4
- Timing selection	Priority based Quality level based (tree networks only)
PTP implementation on the TEGO1 unit	- Port based - VLAN based
- Clock types	Boundary Clock, master ports
- PTP ports	4 optical 1GbE ports

6.1.6　TDM Encapsulation

FOX615 R2 or FOX615 or FOX612 or FOX611
Implementation

FOX615 R2 or FOX615 or FOX612 or FOX611

- Circuit emulation unit	CEPI1, OPIC2
- TDM encapsulation	Encapsulation of TDM bit streams as Pseudo Wires over packet switching networks (PSN): CEPI1: - SAToP (structure agnostic), RFC 4553 - CESoPSN (structure aware), RFC 5086 - CESoETH (structure agnostic), MEF 8 - CESoETH (structure aware), MEF 8 OPIC2 - proprietary implementation
TDM bit rates	2048 kbit/s N x 64 kbit/s in structured 2 Mbit/s (P12)
Pseudo Wire transport capacity	CEPI1: - 8 x 2048 kbit/s, bidirectional; structured or unstructured OPIC2: - 4 x 2048 kbit/s, bidirectional; structured or unstructured
Pseudo Wire synchronization	ITU-T G.8261, adaptive and synchronous

6.1.7   NGN Voice Functionality

FOX615 R2 or FOX615 or FOX612 or FOX611

Implementation	
- Media gateway unit	COSI1
Media gateway control protocol	SIP according to IETF RFC 3261
Voice algorithm	ITU-T G.711 PCM-64 kbit/s
Fax	Voice Band Data or T.38
Modem	Voice Band Data
DTMF	Inband or RFC 2833
Echo cancellation	ITU-T G.168, up to 128 ms tail length
G.711 codec	PCM A-law companding Support of silence suppression according to G.711, Appendix II
G.729A codec	Support of silence suppression according to G.729B
PSTN user port access capacity	1216 FXS or FXO
Maximum number of simultaneous voice channels with the G.711 codec	200
Maximum number of simultaneous voice channels with the G.729A codec	80 (+120 G.711 voice channels)
Traffic handling capacity	9'750 BHCA at CCR < 99.99%
SIP requests:	
INVITE, ACK, BYE, CANCEL, NOTIFY, REGISTER	RFC 3261
UPDATE	RFC 3311
INFO	RFC 2976
REFER	RFC 3515

FOX615 R2 or FOX615 or FOX612 or FOX611

PRACK	RFC 3262
SIP responses:	
1xx, 2xx, 3xx, 4xx, 5xx, 6xx	supported
SIP compliances:	
SIP basic call flow	RFC 3665
An offer / answer model with SDP	RFC 3264
Reliability of provisional responses in SIP	RFC 3262
Privacy mechanism for SIP	RFC 3323
Private extensions to SIP for asserted identity within trusted networks	RFC 3325

6.2   Interfaces

6.2.1   Traffic Interfaces

6.2.1.1   Network Interfaces

FOX615 R2 or FOX615 or FOX612 or FOX611

Ethernet interfaces - Implementation	Core unit CESM3
- 1 x RJ45 electrical	10/100/1000BASE-T acc. to IEEE 802.3 / 802.3x auto-negotiation (half / full-duplex mode) automatic MDI/MDIx switch-over
- 4 x SFP+ cage	1000BASE-xx acc. to INF-8074i [1] (with SFP DDM support) 10GBASE-xx acc. to SFF-8431 [1]
Ethernet interfaces - Implementation	Core unit CESM2, CESM2-F
- 1 x RJ45 electrical	10/100/1000BASE-T acc. to IEEE 802.3 / 802.3x auto-negotiation (half / full-duplex mode) automatic MDI/MDIx switch-over
- 2 x SFP+ cage	1000BASE-xx acc. to INF-8074i [1] (with SFP DDM support)
- 2 x SFP+ cage	1000BASE-xx acc. to INF-8074i [1] (with SFP DDM support) 10GBASE-xx acc. to SFF-8431 [1]
Ethernet interfaces - Implementation	Core unit CESM1, CESM1-F
- 3 x RJ45 electrical	10/100/1000BASE-T acc. to IEEE 802.3 / 802.3x auto-negotiation (half / full-duplex mode) automatic MDI/MDIx switch-over
- 2 x SFP+ cage	1000BASE-xx acc. to INF-8074i [1] (with SFP DDM support) 10GBASE-xx acc. to SFF-8431 [1]
Ethernet interfaces - Implementation	WAN port expansion unit EPEX1
- 4 x SFP+ cage	10GBASE-xx acc. to SFF-8431 [1]
- 1 x QSFP+ cage	40GBASE-xxx acc. to SFF-8436 [1] (future release)

FOX615 R2 or FOX615 or FOX612 or FOX611	
Ethernet interfaces - Implementation	Encryption unit SENC1-4, SENC1F4
- 4 x SFP+ cage	1000BASE-xx acc. to INF-8074i [1] (with SFP DDM support) 10GBASE-xx acc. to SFF-8431 [1]
Ethernet interfaces - Implementation	Encryption unit SENC1-8, SENC1F8
- 8 x SFP+ cage	1000BASE-xx acc. to INF-8074i [1] (with SFP DDM support) 10GBASE-xx acc. to SFF-8431 [1]
SHDSL EFM interfaces - Implementation	SHDSL transport unit DEFM1, DEFM1-F
- 24 x SHDSL ports (EFM)	According to ITU-T, G.991.2, Annex A, B, F and G Pair bonding (up to 4 lines) Connector frame: DIN 41612
SDH interfaces - Implementation	SDH transport unit SAMO5, SAMO5-F, SAMO2, SAMO2-F, SAMO3
- 2 x SFP cage	STM-16 (optical) (SAMO2, SAMO2-F, SAMO3 only) - S-16.1, S-16.2, L-16.1, L-16.2, X-16.2, CWDM, Bidi, or STM-4 (optical) - S-4.1, S-4.2, L-4.1, L-4.2, X-4.2, CWDM, Bidi, acc. to INF-8074i
- 2 x SFP cage	STM-4 (optical) - S-4.1, S-4.2, L-4.1, L-4.2, X-4.2, CWDM, Bidi, or STM-1 (optical or electrical) - S-1.1, L-1.1, L-1.2, X-1.2, CWDM, Bidi, G.703, acc. to INF-8074i
SDH interfaces - Implementation	SDH transport unit SAMO1
- 2 x SFP cage	STM-4 (optical) - S-4.1, S-4.2, L-4.1, L-4.2, X-4.2, CWDM, Bidi, or STM-1 (optical or electrical) - S-1.1, L-1.1, L-1.2, X-1.2, CWDM, Bidi, G.703, acc. to INF-8074i
- 2 x SFP cage	STM-1 (optical or electrical) - S-1.1, L-1.1, L-1.2, X-1.2, CWDM, Bidi, G.703, acc. to INF-8074i
PDH interfaces - Implementation	PDH transport unit LEDE1
- 8 x E1 ports	According to ITU-T G.703, G.704 120 Ω symmetrical or 75 Ω asymmetrical Connector frame: DIN 41612
PDH interfaces - Implementation	PDH transport unit CEPI1
- 8 x E1 ports	According to ITU-T G.703, G.704 120 Ω symmetrical or 75 Ω asymmetrical Connector frame: DIN 41612
PDH interfaces - Implementation	PDH transport unit DATI1
- 8 x SHDSL ports (TDM)	According to ITU-T, G.991.2, Annex B Pair bonding (4 wire mode) n x 64 kbit/s duplex over 1 or 2 pairs Remote power supply for DTM-M CPE desktop Connector frame: DIN 41612

1. For the recommended QSFP+, SFP+ and SFP module types please contact your local ABB Power Grids representative.

6.2.1.2   Subscriber Interfaces

FOX615 R2 or FOX615 or FOX612 or FOX611	
Ethernet interfaces - Implementation	Service unit ETOP1, ETOP1-F
- 12 x SFP cage	12 x 100BASE-X/1000BASE-X/T EFM acc. to IEEE 802.3ah
Ethernet interfaces - Implementation	Service unit ELET1
- 24 x RJ45 electrical	24 x 10/100/1000BASE-T auto-negotiation (half / full-duplex mode) automatic MDI/MDIx switch-over EFM acc. to IEEE 802.3ah
Ethernet interfaces - Implementation	Service unit EPOI1
- 12 x RJ45 electrical	12 x 10/100/1000BASE-T auto-negotiation (half / full-duplex mode) automatic MDI/MDIx switch-over EFM acc. to IEEE 802.3ah Power over Ethernet PoE and PoE+
Ethernet interfaces - Implementation	Service unit EROP1, EROP1-F
- 12 x SFP cage	12 x 100BASE-X/1000BASE-X/T
- Routing	Static routing OSPF dynamic routing, RFC2328
Ethernet interfaces - Implementation	Service unit ESPO1
- 12 x RJ45 electrical	12 x 10/100/1000BASE-T auto-negotiation (half / full-duplex mode) automatic MDI/MDIx switch-over EFM acc. to IEEE 802.3ah Power over Ethernet PoE and PoE+
Ethernet interfaces - Implementation	Service unit ESOP1, ESOP1-F
- 12 x SFP cage	12 x 100BASE-X/1000BASE-X/T EFM acc. to IEEE 802.3ah
Ethernet interfaces - Implementation	Service unit EPSI1
- 4 x RJ45 electrical	4 x 10/100BASE-T auto-negotiation (half / full-duplex mode) automatic MDI/MDIx switch-over Ethernet over PDH (EoP) 16 x 2 Mbit/s via any P12 transport unit
- Switching	PPP, RFC1661 Multilink PPP, RFC1990 MAC/PPP, RFC1638 IP/PPP, RFC1332 MAC/HDLC encapsulation
- Routing	Static routing OSPF dynamic routing, RFC2328 RIPv2 dynamic routing, RFC2453 VRRP, RFC3768

FOX615 R2 or FOX615 or FOX612 or FOX611	
Ethernet interfaces - Implementation	Service unit SAMO1, SAMO5, SAMO5-F, SAMO2, SAMO2-F, SAMO3
- 4 x RJ45 electrical	4 x 10/100/1000BASE-T acc. to IEEE 802.3 / 802.3x auto-negotiation (half / full-duplex mode) automatic MDI/MDIx switch-over EoS via local SDH ports
Ethernet interfaces - Implementation	Service unit LEDS1
- 1 x RJ45 electrical	4 x 10/100BASE-T auto-negotiation (half / full-duplex mode) automatic MDI/MDIx switch-over
SHDSL EFM interfaces - Implementation	SHDSL transport unit DEFM1, DEFM1-F
- 24 x SHDSL ports (EFM)	According to ITU-T, G.991.2, Annex A, B, F and G Pair bonding (up to 4 lines) Connector frame: DIN 41612
SHDSL Interfaces - Implementation	Service unit DATI1
- 8 x SHDSL ports (TDM)	According to ITU-T, G.991.2, Annex B Pair bonding (4 wire mode) n x 64 kbit/s duplex over 1 or 2 pairs Remote power supply for DTM-M CPE desktop Connector frame: DIN 41612
E1 Interfaces - Implementation	Service unit LEDE1
- 8 x E1 ports	According to ITU-T G.703, G.704 120 Ω symmetrical or 75 Ω asymmetrical Connector frame: DIN 41612
E1 Interfaces - Implementation	Service unit CEPI1
- 8 x E1 ports	According to ITU-T G.703, G.704 120 Ω symmetrical or 75 Ω asymmetrical Connector frame: DIN 41612
E0 Interfaces - Implementation	Service unit LECO1 [1]
- 8 x E0 ports	According to ITU-T G.703, codirectional 120 Ω symmetrical Connector frame: DIN 41612
- 2 x E0 ports	According to ITU-T G.703, contradirectional 120 Ω symmetrical Connector frame: DIN 41612
Data Interfaces - Implementation	Service unit LEDS1
- 4 x data ports	Interface type configurable: V.24/V.28 V.35 X.24/V.11 RS485 2-wire RS485 4-wire Connector: 4 x Metral 4x6
- Line rate	Subrate asynchronous 0.6 to 38.4 kbit/s Subrate synchronous 0.6 to 56 kbit/s Synchronous 1x64 to 32x64 kbit/s

FOX615 R2 or FOX615 or FOX612 or FOX611

Data Transmission - Implementation	DTM-M CPE desktop connected to service unit DATI1
- 1 x E1 port	According to ITU-T G.703, G.704 120 Ω symmetrical (RJ45) or 75 Ω asymmetrical (BNC)
- 1 x X.21/V.11 port	DSub-15 connector
- 1 x V.35 port	MF-34 connector
- 1 x V.36 port	DSub-37 connector
PSTN FXS - Implementation	Service unit LESU1
- 16 x PSTN ports	According to ITU-T Q.552 (General transmission characteristics). The voice impedance is configurable in the element manager. Connector frame: DIN 41612
E&M voice and signaling - Implementation	Service unit LEDA1
- 8 x voice ports	2-wire or 4-wire. 600 Ω voice impedance. Connector frame: DIN 41612
- 16 x signaling ports	2 E&M signaling ports per voice port. Connector frame: DIN 41612
PSTN FXO - Implementation	Service unit LEXI1
- 12 x PSTN ports	According to ITU-T Q.552 (General transmission characteristics). The voice impedance is configurable in the element manager. Connector frame: DIN 41612
Teleprotection command tripping interfaces - Implementation	Service unit TEPI1, TEPI2
- 4 command inputs - 4 command outputs - 2 relay outputs	According to IEC 60834-1 Ed.2 (Supply voltage with battery operation). The tripping threshold is configurable in the element manager. Connector frame: DIN 41612
Binary signal interfaces - Implementation	Service unit TEPI1, TEPI2
- 8 voltage inputs (TEPI1 only) - 4 voltage inputs (TEPI2 only) - 8 current loop inputs - 8 voltage outputs - 4 relay outputs	According to IEC 60870 Connector frame: DIN 41612
Optical differential protection interfaces - Implementation	Service unit OPIC1, OPIC2
- 4 SFP cages	4 x 2 Mbit/s or 4 Mbit/s according to IEEE C37.94, or proprietary FOX6plus compatible optical transmission protocol (ABB Power Grids TPE) 2 x FO5 (OPIC2 only)
GOOSE/SV proxy gateway interfaces - Implementation	Service unit TEGO1
- 4 SFP cages	4 x 100BASE-FX/1000BASE-SX or LX, according to IEC 61850

1. The codirectional or contradirectional interfaces can only be used alternatively.

6.2.2   Management Interfaces

FOX615 R2 or FOX615 or FOX612 or FOX611	
Ethernet interfaces - Implementation	Core unit CESM3, CESM2, CESM2-F, CESM1, CESM1-F Ethernet service units
- 1 x RJ45 electrical local management port	10/100/1000BASE-T acc. to IEEE 802.3 / 802.3x (CESM3), or 10/100BASE-TX acc. to IEEE 802.3 (CESM2, CESM2-F, CESM1, CESM1-F) auto-negotiation (half / full-duplex mode), automatic MDI/MDIx switch-over, TCP/IP based, not routed
- Any RJ45 based Ethernet port of the FOX61x Switch	10/100/1000BASE-T acc. to IEEE 802.3 / 802.3x, auto-negotiation (half / full-duplex mode), automatic MDI/MDIx switch-over, TCP/IP based, VLAN tagged or untagged, routed
- Any SFP/SFP+/QSFP+ based Ethernet port of the FOX61x Switch	1000BASE-xx acc. to INF-8074i [1], 10GBASE-xx acc. to SFF-8431 [1], 40GBASE-xxx acc. to SFF-8436 [1], TCP/IP based, VLAN tagged or untagged, routed
MPLS interfaces - Implementation	Core unit CESM3, CESM2, CESM2-F, CESM1, CESM1-F WAN port expansion unit EPEX1
	Any MPLS-TP port on a core unit or WAN port expansion unit, routed, - section based - LSP based
TDM interfaces - Implementation	TDM service units
	Any P12 or P0_nc channel on a PDH or SDH service unit, routed
Ethernet interfaces - Implementation	Encryption unit SENC1-4, SENC1F4, SENC1-8, SENC1F8, local management access
- 1 x RJ45 electrical local management port	10/100/1000BASE-T acc. to IEEE 802.3, auto-negotiation (half / full-duplex mode), automatic MDI/MDIx switch-over, TCP/IP based

1. For the recommended QSFP+, SFP+ and SFP module types please contact your local ABB Power Grids representative.

6.2.3   Synchronization Interfaces

FOX615 R2 or FOX615 or FOX612 or FOX611	
2 MHz Synchronization Input / Output	According to ITU-T, G.703
- Number of inputs	2
- Input jitter tolerance	ITU-T G.813, Figure 9
- Input wander tolerance	ITU-T G.813, Table 10
- Number of outputs	1 related to the PETS clock domain 1 related to the SETS clock domain(s)
- Maximum output jitter, PETS clock domain	ITU-T G.823, Table 5, SEC requirements
- Maximum output jitter, SETS clock domain	ITU-T G.813
- Implementation	Core unit CESM3, CESM2, CESM2-F, CESM1, CESM1-F
- Synchronization system	PETS (1 input, 1 output) [1] SETS (1 input, 1 output)
- Frequency	2048 kHz ± 4.6 ppm for PETS ± 4.6 ppm for SETS
- Impedance	120 Ω or high impedance, symmetrical
PPS Output	
- Time code format	PPS 1 pulse per second, rising edge aligned with the second boundary, pulse width 1 ms.
- Implementation	CESM3 1 electrical
- Standard	ITU-T V.11 (RS-422)
- Impedance	120 Ω (active), high impedance (inactive)
IRIG-B Input	According to IRIG 200-04-TT-45
- Time code formats	IRIG-B002 IRIG-B006
- Implementation	
TEPI1	1 electrical
TEPI2	1 electrical
IRIG-B or PPS Output	
- Time code formats	IRIG-B002 IRIG-B005 (TEGO1 only) IRIG-B006 PPS
- Implementation	
TEPI2	4 electrical
OPIC2	1 optical 6 electrical
TEGO1	1 optical 6 electrical

1.   On the CESM1 and CESM2 both synchronization inputs can be used for the PETS domain.

6.2.4   Alarm Interfaces

FOX615 R2 or FOX615

For the specification of the alarm interfaces on FAMO1 or FAMO1-F, please refer to section 6.4.4 FAMO1 Fan Unit (R2) (on page 190) or section 6.4.5 FAMO1-F Alarm Unit (R1) (on page 193).

FOX612

For the specification of the alarm interfaces on FAMO2 or FAMO2-F, please refer to section 6.5.4 FAMO2 Fan Unit (R2) (on page 202) or section 6.5.5 FAMO2 Fan Unit (R3) (on page 204) or section 6.5.6 FAMO2-F Alarm Unit (R1) (on page 206).

FOX611

For the specification of the alarm interfaces on FAMO3 or FAMO3-F, please refer to section 6.6.4 FAMO3 Fan Unit (R1) (on page 213) or section 6.6.5 FAMO3 Fan Unit (R2) (on page 215) or section 6.6.6 FAMO3-F Alarm Unit (R1) (on page 217).

TEPI1, TEPI2

For the specification of the input circuits that can be used for alarm acquisition on TEPI1 or TEPI2, please refer to section 6.2.1.2 Subscriber Interfaces (on page 173)

6.2.5   Power Interfaces

FOX615 R2	
DC power interface Interface access	FOX615 R2 subrack
Power supply interface according	EN 300 132-2 V2.3.6, interface "A"
Nominal voltages - -48 V_{DC}, voltage range	-40.0 V_{DC} … -57 V_{DC} with DUPF1 or DUPF1-R -39.5 V_{DC} … -57 V_{DC} without DUPF1 or DUPF1-R
- -60 V_{DC}, voltage range	-50.5 V_{DC} … -72 V_{DC} (-75 V_{DC} for max. 5 minutes / month)
Maximum continuous current - FOX615 R2, without DUPF1 or DUPF1-R - FOX615 R2, with DUPF1 or DUPF1-R	 45 A 30 A (active cooling), 25 A (passive cooling)
Recommended fusing - FOX615 R2, without DUPF1 or DUPF1-R - FOX615 R2, with DUPF1 or DUPF1-R	 50 A slow blow 30 A slow blow
Connection points for power supply circuits - FOX615 R2 Standard - FOX615 R2 Protected (1+1 with DUPF1) - FOX615 R2 Protected (1+1 with DUPF1-R)	 2 on the cable tray 2 on DUPF1, 1 connection to the subrack 2 on DUPF1-R, 2 connections to the subrack
Power supply interface for core and service units: - nominal supply voltage:	 -48 V_{DC} or -60 V_{DC}
- normal service voltage range: The equipment function is according to the specification.	-39.5 V_{DC} … -72 V_{DC}
- abnormal service voltage range: The equipment function is not guaranteed, but equipment will not be damaged.	0 V_{DC} to -39.5 V_{DC}, and -72 V_{DC} to -75 V_{DC}

FOX615

DC power interface Interface access	FOX615 subrack
Power supply interface according	EN 300 132-2 V2.3.6, interface "A"
Nominal voltages - -48 V_{DC}, voltage range	-40.0 V_{DC} ... -57 V_{DC} with DUPF1 or DUPF1-R -39.5 V_{DC} ... -57 V_{DC} without DUPF1 or DUPF1-R
- -60 V_{DC}, voltage range	-50.5 V_{DC} ... -72 V_{DC} (-75 V_{DC} for max. 5 minutes / month)
Maximum continuous current - FOX615 subrack revisions R2A, R2B and R3B, without DUPF1 or DUPF1-R - FOX615 subrack revision R3A, without DUPF1 or DUPF1-R - FOX615, with DUPF1 or DUPF1-R	45 A 30 A 30 A (active cooling), 25 A (passive cooling)
Recommended fusing - FOX615 subrack revisions R2A, R2B and R3B, without DUPF1 or DUPF1-R - FOX615 subrack revision R3A, without DUPF1 or DUPF1-R - FOX615, with DUPF1 or DUPF1-R	50 A slow blow 30 A slow blow 30 A slow blow
Connection points for power supply circuits - FOX615 subrack revisions R2A, R2B and R3B Standard - FOX615 subrack revision R3A Standard - FOX615 Protected (1+1 with DUPF1) - FOX615 Protected (1+1 with DUPF1-R)	2 on the cable tray 1 on the cable tray 2 on DUPF1, 1 connection to the subrack 2 on DUPF1-R, 2 connections to the subrack
Power supply interface for core and service units: - nominal supply voltage:	 -48 V_{DC} or -60 V_{DC}
- normal service voltage range: The equipment function is according to the specification.	-39.5 V_{DC} ... -72 V_{DC}
- abnormal service voltage range: The equipment function is not guaranteed, but equipment will not be damaged.	0 V_{DC} to -39.5 V_{DC}, and -72 V_{DC} to -75 V_{DC}

FOX612

DC power interface - Interface access	FOX612 subrack
- Power supply interface according	EN 300 132-2 V2.3.6, interface "A"
Nominal voltages - -48 V_{DC}, voltage range	-40.0 V_{DC} ... -57 V_{DC} with DUPF2 -39.5 V_{DC} ... -57 V_{DC} without DUPF2
- -60 V_{DC}, voltage range	-50.5 V_{DC} ... -72 V_{DC} (-75 V_{DC} for max. 5 minutes / month)
Maximum continuous current	15 A
Recommended fusing	15 A slow blow
Connection points for power supply circuits	1 on the cable tray 2 with DUPF2
Power supply interface for core and service units: - nominal supply voltage:	 -48 V_{DC} or -60 V_{DC}

FOX612

- normal service voltage range: The equipment function is according to the specification.	-39.5 V_{DC} … -72 V_{DC}
- abnormal service voltage range: The equipment function is not guaranteed, but equipment will not be damaged.	0 V_{DC} to -39.5 V_{DC}, and -72 V_{DC} to -75 V_{DC}

FOX611

DC power interface - Interface access	FOX611 subrack
- Power supply interface according	EN 300 132-2 V2.3.6, interface "A"
- Nominal DC voltages	-48 V_{DC} -60 V_{DC}
- Voltage range, -48 V_{DC}	-40.0 V_{DC} … -57 V_{DC} with DUPF2 -39.5 V_{DC} … -57 V_{DC} without DUPF2
- Voltage range, -60 V_{DC}	-50.5 V_{DC} … -72 V_{DC} (-75 V_{DC} for max. 5 minutes / month)
- Maximum continuous current	8 A
- Recommended fusing	8 A slow blow
- Connection points for power supply circuits	1 on the 19-inch adapter 2 with DUPF2
AC power interface - Interface access	POAC1 AC/DC converter (part of the optional FOX611 AC power kit)
- POAC1 specification	refer to section 6.6.8.2 Specification (on page 219)
- Backup battery, optional	48V, 10 Ah … 40 Ah
- Recommended fusing for the backup battery	10 A
Power supply interface for core and service units: - nominal supply voltage:	-48 V_{DC} or -60 V_{DC}
- normal service voltage range: The equipment function is according to the specification.	-39.5 V_{DC} … -72 V_{DC}
- abnormal service voltage range: The equipment function is not guaranteed, but equipment will not be damaged.	0 V_{DC} to -39.5 V_{DC}, and -72 V_{DC} to -75 V_{DC}

TEPI1, TEPI2

Auxiliary power supply output - Implementation	Service units TEPI1, TEPI2
- Output voltage - Maximum continuous current	24 V_{DC} +5%/-20% ≤ 40 mA, short-circuit protected

6.3 Performance Control and Management Functions

6.3.1 System Level

FOX615 R2 or FOX615 or FOX612 or FOX611	
System level alarm system: - Alarm indicators	LEDs relay contacts (FOX615 R2, FOX615 and FOX612 only)
- Lists	NE fault list, logbook
- Logbooks	dedicated logbooks for alarms, events, configuration, equipment, and session management
- Inventory data	for hardware and NE software system
- Software installation status	for NE wide ESW installation and installation progress
TDM diagnostics	TDM pattern generator and analyzer: [1] - Bit error counter - Performance management data collection - Round trip delay measurement
- Bit rates	n x 64 kbit/s, n = 1 … 31 2048 kbit/s (transparent)
- Test pattern	PRBS 2^{23}-1 PRBS 2^{15}-1 PRBS 2^6-1 PRBS 2^{23}-1 inverted PRBS 2^{15}-1 inverted PRBS 2^6-1 inverted Fixed pattern (8 bit) CAS

1. On a FOX61x network element with the CESM3 core unit this feature will be supported in a future release.

6.3.2 Traffic Functions

FOX615 R2 or FOX615 or FOX612 or FOX611	
Status and Maintenance - Core unit CESM3, CESM2, CESM2-F, CESM1, CESM1-F	status of Ethernet interfaces is monitored mirroring Ethernet statistics LSP Ping LSP Trace Route
Status and Maintenance - WAN port expansion unit EPEX1	status of Ethernet interfaces is monitored mirroring Ethernet statistics LSP Ping LSP Trace Route
- ETOP1, ETOP1-F, ELET1, EPOI1	status of Ethernet interfaces is monitored mirroring Ethernet statistics
- ESPO1, ESOP1, ESOP1-F	status of Ethernet interfaces is monitored Ethernet statistics

FOX615 R2 or FOX615 or FOX612 or FOX611	
- DEFM1, DEFM1-F	status of SHDSL interfaces is monitored status of Ethernet interfaces is monitored mirroring Ethernet statistics
- EROP1, EROP1-F	status of Ethernet interfaces is monitored routing ARP tables OSPF routing status monitoring ping, traceroute
- EPSI1	status of Ethernet interfaces is monitored multilink PPP status bridge status monitoring routing ARP tables OSPF routing status monitoring RIP routing status monitoring ping, traceroute
- SAMO1, SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F	status of the SETS is monitored status of SDH interfaces is monitored status of the MSP is monitored status of the terminated VC-4, VC-3 and VC-12 is monitored status of the EoS group is monitored status of Ethernet interfaces is monitored status of CRC-4 frame alignment P12 front end and back end loops mirroring (SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F only) Ethernet statistics (SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F only)
- LEDE1	status of CRC-4 frame alignment front end and back end loops
- CEPI1	status of E1 interfaces is monitored front end and back end loops Pseudo Wire status is monitored Pseudo Wire ping, ARP table, and statistics Circuit Emulation timing is monitored TDM pattern generator and analyzer: - Bit error counter - Round trip delay measurement
- COSI1	status of the PSTN user ports is monitored IP ping request
- DATI1	status of SHDSL interfaces is monitored line restart
- LESU1	status of the PSTN user ports is monitored line testing
- LEDA1	status of the E&M signaling ports is monitored line and conference participant "out of service" line and conference participant "test signal insertion" front end and back end loops
- LEXI1	status of the PSTN user port signaling is monitored line testing back end loop
- LEDS1	status of the data ports is monitored line and conference participant "out of service" line and conference participant "test signal insertion" front end and back end loops

FOX615 R2 or FOX615 or FOX612 or FOX611	
- LECO1	status of the data ports is monitored front end and back end loops
- TEPI1	unit event recorder command event recorder command trip counters command states frame error counters channel loops command loops manual loop test command state monitoring
- TEPI2	unit event recorder command event recorder command trip counters command states VLAN statistics counters packet delay variation packet delay histogram packet loss variation packet loss histogram command loops manual loop test command state monitoring binary signal state monitoring
- OPIC1	remote status via performance monitoring TS front end loop back end loop
- OPIC2 (CESoP application)	unit event recorder CESoP TTI monitoring CESoP end-to-end delay CESoP loop test CESoP packet statistics CESoP delay statistics packet delay variation packet delay histogram packet loss variation packet loss histogram
- OPIC2 (TDM application)	remote status via performance monitoring TS front end loop back end loop
- TEGO1	unit event recorder command trip counters traffic flow monitoring packet delay variation packet delay histogram packet loss variation packet loss histogram
Performance monitoring	according to ITU-T G.826 performance calculation for 24 hours intervals (up to 8 records) and 15 minutes intervals (up to 108 records)
- DEFM1, DEFM1-F	performance measurement at the SHDSL layer, on the regenerators and on the CPE, performance measurement at the Ethernet layer.

FOX615 R2 or FOX615 or FOX612 or FOX611

- EROP1, EROP1-F	performance measurement at the Ethernet interfaces: General counters, Ethernet counters, Egress queue counters performance measurement at the loopback interfaces: MIB-2 statistics performance measurement at the virtual router interfaces: MIB-2 statistics, IF-MIB IfX statistics
- EPSI1	performance measurement at the Ethernet interfaces and the bridge instances: MIB-2 statistics, RSTP statistics, Protection switchover events.
- LEDS1	performance measurement on the data ports and on the conference participants: Protection switchover events
- LECO1	performance measurement on the E0 ports: Protection switchover events, Positive and negative octet slips
- LEDA1	performance measurement on the E&M ports and on the conference participants: Protection switchover events
- LEXI1	performance measurement on the PSTN ports: Protection switchover events
- DATI1	performance measurement at the SHDSL layer and on the remote desktop
- LEDE1	performance measurement on the E1 ports
- CEPI1	performance measurement on the E1 ports and on the Pseudo Wires
- SAMO1, SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F	SETS source switchover events, MSP switchover events, performance measurements at the SDH ports, performance measurements at the terminated VC-4, VC-3 and VC-12 layers, VC-4 pointer adjustment events, performance measurements at the P12 layer, EoS group statistics
- OPIC2	channel protection switchover events VLAN packet loss and delay exceedance

6.4   FOX615 R2 and FOX615 Characteristics

6.4.1   Architecture

System architecture	fully modular open architecture
Subrack	19-inch with 21 slots
- slot 1 … 10	service units [1]
- slot 11	core unit
- slot 12	service unit [1]

- slot 13	protecting core unit or TDM service unit [2]
- slots 14 … 21	service units [1]
- slots 9 and 15	WAN port expansion unit [3]
- slots 4 and 6	slot pair for SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F EQP
- slots 18 and 20	slot pair for SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F EQP
Implementation	configurable, according to requirements
Units	
- Core units	CESM3, CESM2, CESM2-F, CESM1, CESM1-F [4]
- Encryption units	SENC1-4, SENC1F4, SENC1-8, SENC1F8
- WAN port expansion unit	EPEX1 [3]
- Service units	ETOP1, ETOP1-F, ELET1, EPOI1 DEFM1, DEFM1-F EROP1, EROP1-F ESOP1, ESOP1-F, ESPO1 EPSI1 LEDE1 CEPI1 COSI1 VFTLF LEDS1 LESU1 LEDA1 LEXI1 LECO1 DATI1 SAMO1, SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F TEPI1 TEPI2 OPIC1 OPIC2 TEGO1
- Auxiliary units	FAMO1 FAMO1-F DUPF1 DUPF1-R
Equipment protection - Core unit CESM3, CESM2, CESM2-F, CESM1, CESM1-F	1:1 equipment protection
- SDH transport unit SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F	1:1 equipment protection
- SDH transport unit SAMO1	1:1 equipment protection (PBUS access part only)
- Media gateway unit COSI1	1:1 equipment protection
- Voice frequency processing unit VFTLF	1:1 equipment protection
- IPv4 routing unit EROP1, EROP1-F	1:1 equipment protection [5]
- Ethernet switching and routing unit EPSI1	1:1 equipment protection (bridging and routing functions only)
- Data interface unit LEDS1	1:1 equipment protection (conference part only)
- E&M voice interface unit LEDA1	1:1 equipment protection (conference part only)
Internal bus system - 1 GbE double star	interconnection of every slot with 1 Gbit/s to the core unit slot and the redundant core unit slot (including GbE point-to-point connection between the core unit slots)

- 10 GbE double star	interconnection of every slot with 10 Gbit/s to the core unit slot and the redundant core unit slot (including four 10 GbE point-to-point connections between the core unit slots)
- 40 GbE double star [6]	interconnection of slot 9 and slot 15 with 40 Gbit/s to the core unit slot and the redundant core unit slot
- PBUS	internal TDM bus for up to 128 x 2048 kbit/s (unidirectional)
- CBUS	internal bus for control, clocking, powering etc.
Unit software (ESW)	downloaded
Configuration	software based, with FOXCST and FOXMAN-UN

1. With a CESM3 core unit plugged in a FOX615 R2 subrack, the slots 1, 8 to 15 and 21 are not usable for the service units ELET1, ETOP1, EPOI1, DEFM1, EROP1, ESOP1, ESPO1, SAMO5, SAMO2, SAMO3.
2. The service units ELET1, ETOP1, EPOI1, DEFM1, EROP1, ESOP1, ESPO1, SAMO5, SAMO2, SAMO3, SAMO1, CEPI1, COSI1, EPSI1 and SENC1 are not usable in slot 13.
3. An EPEX1 WAN port expansion unit must be plugged in slot 9 or slot 15 of a FOX615 R2 subrack. The core units CESM1 and CESM2 do not support the operation with the EPEX1 unit.
4. The core units CESM1, CESM1-F, CESM2 and CESM2-F will be supported in the FOX615 R2 subrack in a future release.
5. Equipment protection with the EROP1 unit is only supported up to the ESW release r2.
6. The 40 GbE double star is not available in the FOX615 subrack.

6.4.2   System Control and Management Functions

6.4.2.1   Control System

Basic control system	distributed processor system
Central system control (core unit)	dedicated unit with master processor
Service units	local slave processors
Management Information Base (MIB) - Configuration data	Configuration data stored on core unit → storage of complete NE configuration
Equipment protection of the core unit	1:1 (slots 11 and 13)
- Type of protection	warm standby, non-revertive
- MIB of redundant unit	permanently updated
- Core unit switch-over	- automatic failure driven - on FOXCST/FOXMAN-UN command
CESM3 unit switch-over traffic signal downtime, manual switch-over via FOXCST, MPLS-TP traffic signals	
- User traffic connected to the core unit	< 50 ms [1]
- User traffic connected to a service unit, 50 services	< 50 ms [1]
- User traffic connected to a service unit, 1000 services	< 50 ms [1]
CESM3 unit switch-over traffic signal downtime, core unit removed or failed, 250 protected MPLS-TP traffic signals	
- Active core unit removed or failed, working tunnels on the active core unit	< 50 ms [1]
- Active core unit removed or failed, working tunnels on the standby active core unit	< 50 ms [1]

- Standby core unit removed or failed, working tunnels on the active core unit	no downtime
- Standby core unit removed or failed, working tunnels on the standby core unit	according to the configured MPLS-TP BFD CC interval
CESM1 or CESM2 unit switch-over traffic signal downtime, manual switch-over via FOXCST	
- with MPLS-TP, user traffic	typical 2 to 5 s, depending of the configuration [1]
- with xSTP, user traffic	typical 2 to 5 s, depending of the configuration [1]
- without xSTP, user traffic	typical 2 s, depending of the configuration [1]
CESM1 or CESM2 unit switch-over traffic signal downtime, active core unit removed	
- with MPLS-TP, user traffic	typical 2 to 5 s, depending of the configuration [1]
- with xSTP, user traffic	typical 2 to 5 s, depending of the configuration [1]
- without xSTP, user traffic	typical 1 s, depending of the configuration [1]
Timing function	
- Timing synchronization	SNTPv3 PTP GPS via IRIG-B
- Synchronization modes	unicast, broadcast
- NE Time	local time, with time zones

1. For further details please contact ABB Power Grids customer support.

6.4.2.2   NE Software System

Unit software (ESW)	stored directly in flash memory of the unit (core and service units)
SW download (for ESW)	ESW installation controlled by FOXMAN-UN / FOXCST NE wide ESW installation At least 2 ESW versions can be stored on a unit Activation of the new ESW on schedule or immediately
Feature license management	allows you to buy equipment with basic functionality (hardware and/or software) and upgrade with new feature licenses

6.4.2.3   Management Functions

Configuration management for	NE incl. ESW traffic functions
Performance management for	NE traffic signals
Fault management - Hardware failures	NE and units
- ESW configuration/operation	NE and units
- Failures and performance	traffic signals
Alarm generation and reporting - Generation and severity	programmable
- Indication	local indicators relay contacts

- Reporting	alarm lists logbooks export of table data to csv or xml files syslog (up to 10 destinations, RFC 5424) remote access SNMP
SNMP MIBs	Agent MIBs - SNMPv2-MIB (RFC 3418) - SNMP-FRAMEWORK-MIB (RFC 3411) - SNMP-TARGET-MIB (RFC 3413) - SNMP-NOTIFICATION-MIB (RFC 3413) - SNMP-VIEW-BASED-ACM-MIB (RFC 3415) - SNMP-COMMUNITY-MIB (RFC 3584) - SNMP-USER-BASED-SM-MIB (RFC 3414) - SNMPv2-TC (RFC 2579) Other MIBs - RMON2-MIB (RFC 4502) - RMON-MIB (RFC 2819) - BRIDGE-MIB (RFC 4188) - Q-BRIDGE-MIB (RFC 4363) - IANAifTypeMIB - IF-MIB (RFC 2863) - ENTITY-MIB (RFC 6933) - INET-ADDRESS-MIB (RFC 4001) - ENTITY-SENSOR-MIB (RFC 3433) - ALARM-MIB (RFC 3877) - PW-TC-STD-MIB (RFC 5542) Private MIBs - FOX-SMI - FOX-IF-EXT-MIB - FOX-IANA-BFD-TC-STD-MIB - FOX-BFD-STD-MIB - FOX-MPLS-QOS-EXT-MIB - FOX-UNI-EVC-MIB - FOX-ETH-PORT-MIB - FOX-NE-MIB - FOX-ALARM-EXT-MIB - FOX-DIAGNOSTIC-MIB
Inventory management	for hardware and software
Management tools	FOXCST FOXMAN-UN DIRAC

6.4.2.4 Management Access

Local management access	Ethernet local management port, not routed
Remote management access	- VLAN Bridge port of the FOX61x Switch, routed - MPLS-TP port of the FOX61x Switch, routed - P12 or P0_nc channels, routed
Management routing function	- Static routing - OSPF dynamic routing, RFC2328 - VRRP virtual routing, RFC3768

Management router interfaces	- 2 VLAN interfaces (CESM1 and CESM2), 2 VRRP instances per interface - 8 VLAN interfaces (CESM3), 2 VRRP instances per interface - 16 TDM interfaces, PPP encapsulation, RFC1661 (maximum TDM bandwidth is 16'384 kbit/s) - 10 MPLS-TP MCC interfaces, RFC5718 (maximum rate is 2'048 kbit/s) - 8 loopback interfaces
User authentication	- local authentication in the NE with userclass and password - local authentication in the NE with public/private keys (for FOXMAN-UN only) - remote authentication via RADIUS server, with local authentication fallback
User classes	- session manager - support - manager - maintenance - information
Management access security	Security on network layer with SSH

6.4.3   Mechanics

6.4.3.1   Construction

Card cage for FOX61x units	19-inch practice
Modularity	subrack cable tray heat deflection shield fan unit or alarm unit
Installation into racks - 19-inch	direct
- ETSI (applicable standard ETS 300 119-4)	with adapters
Basic construction	metallic
- Sides and rear	sheet metal
- Top and bottom	perforated sheet metal
- Front	front cover
Connection of signal and power cables - Power supply	integrated connector
- Shields of signal cables	grounding bars in front
- Cable installation and strain relief	matching cable tray
Degree of protection, IP code (IEC 60529)	IP20
- Solid particle protection	level 2, > 12.5 mm
- Liquid ingress protection	level 0, not protected
Pollution degree	IEC 62368-1, 2
Class of equipment	IEC 62368-1, class I

6.4.3.2   Capacity and Slots

Slots - Number of slots	21
- Slot width	20.32 mm 4 HP

Allocation of units to slots	flexible, slot 11 dedicated

6.4.3.3 Dimensions

19-inch subrack without front cover (W x H x D)	482.6 x 309.5 x 279.7 mm
19-inch subrack with front cover (W x H x D)	482.6 x 309.5 x 304.3 mm
Cable tray (W x H x D)	482.6 x 87.1 x 240 mm
Heat deflection shield 2 HU (W x H x D)	482.6 x 87.8 x 228 mm
Heat deflection shield 1 HU (W x H x D)	482.6 x 43.3 x 228 mm
Construction and layout	19-inch and ETSI mounting practice refer to Figure 13: "FOX615 R2 and FOX615 subrack design and main dimensions (side view)" (on page 38)

6.4.3.4 Weight

19-inch subrack without front cover (without units)	6.44 kg
Front cover	1.25 kg
Cable tray	0.87 kg
Heat deflection shield 2 HU	1.58 kg
Heat deflection shield 1 HU	1.00 kg
ETSI adapters 2 HU (set)	0.09 kg
ETSI adapters 9 HU (set)	0.41 kg
ETSI adapters 11 HU (set)	0.50 kg
Weight of units	refer to the unit user manuals

6.4.4 FAMO1 Fan Unit (R2)

6.4.4.1 Construction

Unit construction	19-inch practice 1 HU (44.45 mm)
Installation into racks - 19-inch - ETSI (applicable standard ETS 300 119-4)	direct with adapters
Connection of signal and power cable	front access

6.4.4.2 Specification

Number of fans	10
Operation - minimum speed - maximum speed	temperature controlled ≤ 35 °C ≥ 50 °C

Performance, average minimum speed (free blowing):	
- air velocity	1 m/s
- transported air volume	330 m^3/h
- pressure drop	25 Pa
- noise	51 dBA @ 1 m

maximum speed (free blowing):	
- air velocity	2 m/s
- transported air volume	600 m^3/h
- pressure drop	80 Pa
- noise	63 dBA @ 1 m

6.4.4.3   Alarm Interface

Alarm inputs:	
- Number	12
- User defined names for input signals	yes
- Active signal level	configurable via FOXCST/FOXMAN-UN - active ground - active open
- Thresholds for detection: - Reference - "Ground state" range - "Open state" range	 positive terminal of the DC power supply (earth) -8 V … +75 V with respect to reference -75 V … -16 V with respect to reference
- Surge immunity	1.2/50 µs surge impulses with U = ± 2000 V
Connector	Molex Mini-Fit Jr.

Optical alarm indications:	
- Unit powered	1 green LED
- Partial unit failure	1 yellow LED
- Total unit failure	1 red LED

Alarm outputs:	
- Number	2
- Type	switch over contact relays
- Use	alarm status of NE - "Service Affecting Alarm" - "Non-Service Affecting Alarm"
- Current admissible	< 200 mA

- Open contact max. voltage	80 V
- Insulation (any alarm output lead to earth)	750 V_{RMS} / 50 Hz / 60 s
Conditions at the alarm outputs in case of Power fail:	
- "Service Affecting Alarm" output	active
- "Non-Service Affecting Alarm" output	not active
Connector	Molex Mini-Fit Jr.

6.4.4.4 Power Supply

Voltage range	
- nominal	-48 V_{DC}, -60 V_{DC}
- range	-39.5 V_{DC} … -75 V_{DC}
- switch on voltage (power up)	-35 V_{DC}
- switch off voltage (power down)	-27 V_{DC}
- resistance to reverse polarity	+75 V_{DC}
Power consumption (-48 V_{DC} power supply)	
- minimum speed (with all fans operating, T < 35 °C)	≤ 29 W
- maximum speed (with all fans operating, T > 50 °C)	≤ 58 W
Connector	Molex Mini-Fit Jr.

6.4.4.5 Ambient Conditions

Specifications according to the common system specification, except the following parameters:	
Operation	
- Temperature range	-10°C … +70°C
- Minimum start up temperature	-25°C

6.4.4.6 Mechanical Parameters

Overall dimensions (W x H x D)	482.6 x 43.6 x 248.6 mm
Construction	19-inch and ETSI mounting
Weight FAMO1 without packaging	2.80 kg
Weight FAMO1 power cable	0.06 kg
Weight ETSI adapters 1 HU	0.05 kg

6.4.4.7 Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F)	
- partial failure (1 fan failed)	10.3 years
- total failure (>1 fan failed)	1176 years

> **Please note:**
>
> The FAMO1 failure prediction model shows that 10% of fan units will fail when operated at a constant ambient temperature of 50°C after 1.34 years.
>
> → Therefore, if FAMO1 is expected to be operated in high temperature environments, ABB Power Grids recommends to provision reasonable stock to minimize replacement time.

6.4.5   FAMO1-F Alarm Unit (R1)

6.4.5.1   Construction

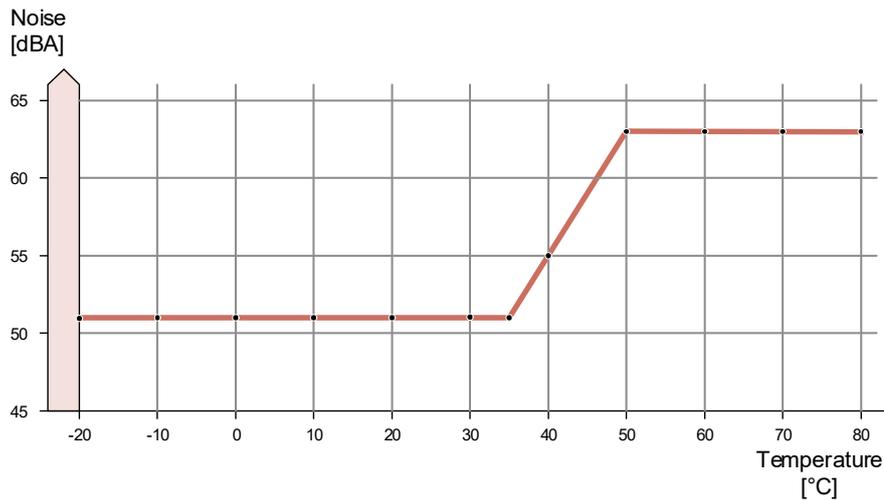|	
Unit construction	19-inch practice 1 HU (44.45 mm)
Installation into racks - 19-inch - ETSI (applicable standard ETS 300 119-4)	 direct with adapters
Connection of signal and power cable	front access

6.4.5.2   Alarm Interface

Alarm inputs: - Number	 12
- User defined names for input signals	yes
- Active signal level	configurable via FOXCST/FOXMAN-UN - active ground - active open
- Thresholds for detection: - Reference - "Ground state" range - "Open state" range	 positive terminal of the DC power supply (earth) -8 V … +75 V with respect to reference -75 V … -16 V with respect to reference
- Surge immunity	1.2/50 µs surge impulses with U = ± 2000 V
Connector	Molex Mini-Fit Jr.
Optical alarm indications: - Unit powered	 1 green LED
Alarm outputs: - Number	 2
- Type	switch over contact relays
- Use	alarm status of NE - "Service Affecting Alarm" - "Non-Service Affecting Alarm"
- Current admissible	< 200 mA
- Open contact max. voltage	80 V
- Insulation (any alarm output lead to earth)	750 V_{RMS} / 50 Hz / 60 s
Conditions at the alarm outputs in case of Power fail: - "Service Affecting Alarm" output - "Non-Service Affecting Alarm" output	 active not active
Connector	Molex Mini-Fit Jr.

6.4.5.3   Power Supply

Voltage range - nominal - range - resistance to reverse polarity	 -48 V_{DC}, -60 V_{DC} -39.5 V_{DC} … -75 V_{DC} +75 V_{DC}
Power consumption (-48 V_{DC} power supply)	≤ 1 W
Connector	Molex Mini-Fit Jr.

6.4.5.4 Ambient Conditions

Specifications according to the common system specification, except the following parameters:	
Operation - Temperature range	-25°C … +55°C

6.4.5.5 Mechanical Parameters

Overall dimensions (W x H x D)	482.6 x 43.6 x 248.8 mm
Construction	19-inch and ETSI mounting
Weight FAMO1-F without packaging	1.60 kg
Weight FAMO1-F power cable	0.06 kg
Weight ETSI adapters 1 HU	0.05 kg

6.4.5.6 Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F)	602 years

6.4.6 DUPF1 Dual Power Supply Input Unit

Power inputs	U1 U2

6.4.6.1 Interfaces

Power output to FOX61x	UTF
Alarm outputs	Supervision U1 Supervision U2

6.4.6.2 Specifications

Input voltage range	-40.0 … -75 V_{DC}
Maximum reverse polarity	+75 V_{DC}
Maximum output current	30 A
Typical power dissipation at maximum current	10 W

6.4.6.3 Alarm Interface

Alarm threshold voltage	-33 ± 3 V_{DC}
Alarm polarity	active open
Electrical contacts: - Type - Current - Voltage drop @ 10 mA - Open contact maximum voltage - Leakage current @ -75 V	solid state ≤ 10 mA ≤ 2 V -75 V ≤ 100 µA
Connector	Molex Mini-Fit Jr.

6.4.6.4 Mechanical Parameters

Installation	Mechanically integrated in the FOX615 R2 or FOX615 subrack

Overall dimensions (W x H x D)	438 x 31.7 x 52.6 mm
Weight without packaging	0.41 kg

6.4.6.5 Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F)	1610 years

6.4.7 DUPF1-R Dual Power Supply Input Unit

Power inputs	U1 U2

6.4.7.1 Interfaces

Power output to FOX61x	2 x UTF
Alarm outputs	Supervision U1 Supervision U2

6.4.7.2 Specifications

Input voltage range	-40.0 … -75 V_{DC}
Maximum reverse polarity	+75 V_{DC}
Maximum output current	30 A
Typical power dissipation at maximum current	10 W

6.4.7.3 Alarm Interface

Alarm threshold voltage	-33 ± 3 V_{DC}
Alarm polarity	active open
Electrical contacts: - Type - Current - Voltage drop @ 10 mA - Open contact maximum voltage - Leakage current @ -75 V	 solid state ≤ 10 mA ≤ 2 V -75 V ≤ 100 µA
Connector	Molex Mini-Fit Jr.

6.4.7.4 Mechanical Parameters

Installation	Separate unit installed below the cable tray of the FOX615 R2 or FOX615 subrack
Overall dimensions (W x H x D)	483 x 44 x 28 mm
Weight without packaging	0.54 kg
Weight ETSI adapters 1 HU	0.05 kg

6.4.7.5 Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F) per Power Feeding Module	2'209 years

6.4.8   Power Consumption

Maximum admissible power consumption of a FOX615 R2 or FOX615, continuous - at -48 V_{DC}	1800 W (FOX615 R2, and FOX615 subrack revision R2A and later)
- at -60 V_{DC}	1800 W (FOX615 R2, and FOX615 subrack revision R2A and later)

6.4.9   Power Dissipation

Maximum power dissipation in a FOX615 R2 or FOX615 subrack - with active cooling (with fan unit)	1800 W (FOX615 R2, and FOX615 subrack revision R2A and later)
- with passive cooling (without fan unit)	500 W

6.5   FOX612 Characteristics

6.5.1   Architecture

System architecture	fully modular open architecture
Subrack	19-inch mountable (horizontal mounting) with 8 slots (slots numbered 7 … 14)
- slot 7 … 10, 12, 14	service units
- slot 11	core unit
- slot 13	protecting core unit or TDM service unit [1]
- slots 7 and 9	slot pair for SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F EQP
Implementation	configurable, according to requirements
Units - Core units	CESM3, CESM2, CESM2-F, CESM1, CESM1-F
- Encryption units	SENC1-4, SENC1F4, SENC1-8, SENC1F8

- Service units	ETOP1, ETOP1-F, ELET1, EPOI1
	DEFM1, DEFM1-F
	EROP1, EROP1-F
	ESOP1, ESOP1-F, ESPO1
	EPSI1
	LEDE1
	CEPI1
	COSI1
	VFTLF
	LEDS1
	LESU1
	LEDA1
	LEXI1
	LECO1
	DATI1
	SAMO1, SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F
	TEPI1
	TEPI2
	OPIC1
	OPIC2
	TEGO1
- Auxiliary units	FAMO2
	FAMO2-F
	DUPF2
Equipment protection	
- Core unit CESM3, CESM2, CESM2-F, CESM1, CESM1-F	1:1 equipment protection
- SDH transport unit SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F	1:1 equipment protection
- SDH transport unit SAMO1	1:1 equipment protection (PBUS access part only)
- Media gateway unit COSI1	1:1 equipment protection
- Voice frequency processing unit VFTLF	1:1 equipment protection
- IPv4 routing unit EROP1, EROP1-F	1:1 equipment protection [2]
- Ethernet switching and routing unit EPSI1	1:1 equipment protection (bridging and routing functions only)
- Data interface unit LEDS1	1:1 equipment protection (conference part only)
- E&M voice interface unit LEDA1	1:1 equipment protection (conference part only)
Internal bus system	
- GbE double star	interconnection of every slot with 1 Gbit/s to the core unit slot and the redundant core unit slot (including GbE point-to-point connection between the core unit slots
- 10 GbE double star	interconnection of every slot with 10 Gbit/s to the core unit slot and the redundant core unit slot (including four 10 GbE point-to-point connections between the core unit slots)
- PBUS	internal TDM bus for up to 128 x 2048 kbit/s (unidirectional)
- CBUS	internal bus for control, clocking, powering etc.
Unit software (ESW)	downloaded
Configuration	software based, with FOXCST and FOXMAN-UN

1. The service units ELET1, ETOP1, EPOI1, DEFM1, ESOP1, ESPO1, EROP1, SAMO5, SAMO2, SAMO3, SAMO1, CEPI1, COSI1, EPSI1 and SENC1 are not usable in slot 13
2. Equipment protection with the EROP1 unit is only supported up to the ESW release r2.

6.5.2 System Control and Management Functions

6.5.2.1 Control System

Basic control system	distributed processor system
Central system control (core unit)	dedicated unit with master processor
Service units	local slave processors
Management Information Base (MIB) - Configuration data	Configuration data stored on core unit → storage of complete NE configuration
Equipment protection of the core unit	1:1 (slots 11 and 13)
- Type of protection	warm standby, non-revertive
- MIB of redundant unit	permanently updated
- Core unit switch-over	automatic failure driven on FOXCST/FOXMAN-UN command
CESM3 unit switch-over traffic signal downtime, manual switch-over via FOXCST, MPLS-TP traffic signals	
- User traffic connected to the core unit	< 50 ms [1]
- User traffic connected to a service unit, 50 tunnels	< 50 ms [1]
- User traffic connected to a service unit, 2000 tunnels	< 50 ms [1]
CESM3 unit switch-over traffic signal downtime, core unit removed or failed, 250 protected MPLS-TP traffic signals	
- Active core unit removed or failed, working tunnels on the active core unit	< 50 ms [1]
- Active core unit removed or failed, working tunnels on the standby active core unit	< 50 ms [1]
- Standby core unit removed or failed, working tunnels on the active core unit	no downtime
- Standby core unit removed or failed, working tunnels on the standby core unit	according to the configured MPLS-TP BFD CC interval
CESM1 or CESM2 unit switch-over traffic signal downtime, manual switch-over via FOXCST	
- with MPLS-TP, user traffic	typical 2 to 5 s, depending of the configuration [1]
- with xSTP, user traffic	typical 2 to 5 s, depending of the configuration [1]
- without xSTP, user traffic	typical 2 s, depending of the configuration [1]
CESM1 or CESM2 unit switch-over traffic signal downtime, active core unit removed	
- with MPLS-TP, user traffic	typical 2 to 5 s, depending of the configuration [1]
- with xSTP, user traffic	typical 2 to 5 s, depending of the configuration [1]
- without xSTP, user traffic	typical 1 s, depending of the configuration [1]
Timing function	
- Timing synchronization	SNTPv3 PTP GPS via IRIG-B
- Synchronization modes	unicast, broadcast
- NE Time	local time, with time zones

1. For further details please contact ABB Power Grids customer support.

6.5.2.2   NE Software System

Unit software (ESW)	stored directly in flash memory of the unit (core and service units)
SW download (for ESW)	ESW installation controlled by FOXMAN-UN / FOXCST NE wide ESW installation At least 2 ESW versions can be stored on a unit Activation of the new ESW on schedule or immediately
Feature license management	allows you to buy equipment with basic functionality (hardware and/or software) and upgrade with new feature licenses

6.5.2.3   Management Functions

Configuration management for	NE incl. ESW traffic functions
Performance management for	NE traffic signals
Fault management - Hardware failures	NE and units
- ESW configuration/operation	units
- Failures and performance	traffic signals
Alarm generation and reporting - Generation and severity	programmable
- Indication	local indicators
- Reporting	alarm lists logbooks export of table data to csv or xml files syslog (up to 10 destinations, RFC 5424) remote access SNMP

SNMP MIBs	Agent MIBs - SNMPv2-MIB (RFC 3418) - SNMP-FRAMEWORK-MIB (RFC 3411) - SNMP-TARGET-MIB (RFC 3413) - SNMP-NOTIFICATION-MIB (RFC 3413) - SNMP-VIEW-BASED-ACM-MIB (RFC 3415) - SNMP-COMMUNITY-MIB (RFC 3584) - SNMP-USER-BASED-SM-MIB (RFC 3414) - SNMPv2-TC (RFC 2579) Other MIBs - RMON2-MIB (RFC 4502) - RMON-MIB (RFC 2819) - BRIDGE-MIB (RFC 4188) - Q-BRIDGE-MIB (RFC 4363) - IANAifTypeMIB - IF-MIB (RFC 2863) - ENTITY-MIB (RFC 6933) - INET-ADDRESS-MIB (RFC 4001) - ENTITY-SENSOR-MIB (RFC 3433) - ALARM-MIB (RFC 3877) - PW-TC-STD-MIB (RFC 5542) Private MIBs - FOX-SMI - FOX-IF-EXT-MIB - FOX-IANA-BFD-TC-STD-MIB - FOX-BFD-STD-MIB - FOX-MPLS-QOS-EXT-MIB - FOX-UNI-EVC-MIB - FOX-ETH-PORT-MIB - FOX-NE-MIB - FOX-ALARM-EXT-MIB - FOX-DIAGNOSTIC-MIB
Inventory management	for hardware and software
Management tools	FOXCST FOXMAN-UN DIRAC

6.5.2.4 Management Access

Local management access	Ethernet local management port, not routed
Remote management access	- VLAN Bridge port of the FOX61x Switch, routed - MPLS-TP port of the FOX61x Switch, routed - P12 or P0_nc channels, routed
Management routing function	- Static routing - OSPF dynamic routing, RFC2328 - VRRP virtual routing, RFC3768
Management router interfaces	- 2 VLAN interfaces (CESM1 and CESM2), 2 VRRP instances per interface - 8 VLAN interfaces (CESM3), 2 VRRP instances per interface - 16 TDM interfaces, PPP encapsulation, RFC1661 (maximum TDM bandwidth is 16'384 kbit/s) - 10 MPLS-TP MCC interfaces, RFC5718 (maximum rate is 2'048 kbit/s) - 8 loopback interfaces

User authentication	- local authentication in the NE with userclass and password
	- local authentication in the NE with public/private keys (for FOXMAN-UN only)
	- remote authentication via RADIUS server, with local authentication fallback
User classes	- session manager
	- support
	- manager
	- maintenance
	- information
Management access security	Security on network layer with SSH

6.5.3 Mechanics

6.5.3.1 Construction

Card cage for FOX61x units	19-inch practice when mounted horizontally
Modularity	subrack
	cable tray
	fan unit or alarm unit
Installation into racks	
- 19-inch	with adapters
- ETSI (applicable standard ETS 300 119-4)	with adapters
Basic construction	metallic
- Sides and rear	sheet metal
- Top and bottom	perforated sheet metal
- Front	front cover
Connection of signal and power cables	
- Power supply	integrated connector
- Shields of signal cables	grounding bars in front
- Cable installation and strain relief	matching cable tray
Degree of protection, IP code (IEC 60529)	IP20
- Solid particle protection	level 2, > 12.5 mm
- Liquid ingress protection	level 0, not protected
Pollution degree	IEC 62368-1, 2
Class of equipment	IEC 62368-1, class I

6.5.3.2 Capacity and Slots

Slots	
- Number of slots	8
- Slot width	20.32 mm
	4 HP
Allocation of units to slots	flexible, slot 11 dedicated

6.5.3.3 Dimensions

| Subrack without front cover (W x H x D) | 458.45 x 176.1 x 280.3 mm |
| Subrack with front cover (W x H x D) | 458.45 x 176.1 x 303.3 mm |

19-inch mountable subrack with front cover, including 19-inch adapters (W x H x D)	482.6 x 176.1 x 303.3 mm
ETSI rack mountable subrack with front cover, including ETSI adapters (W x H x D)	532.4 x 176.1 x 303.3 mm
Cable tray (W x H x D)	138.0 x 166.5 x 49.2 mm
Construction and layout	19-inch and ETSI mounting practice refer to Figure 14: "FOX612 subrack design and main dimensions (side view)" (on page 39)

6.5.3.4 Weight

19-inch subrack without front cover (without units, without 19-inch adapter)	4.45 kg
Front cover	0.71 kg
Cable tray, included with the 19-inch adapter	0.18 kg
ETSI adapters 4 HU (set)	0.35 kg
Weight of units	refer to the unit user manuals

6.5.4 FAMO2 Fan Unit (R2)

6.5.4.1 Construction

Unit construction	special plug-in unit to FOX612 subrack, 1 HU (44.45 mm)
Installation into subrack	plug-in unit, fixed with screws
Connection of signals and power	via backplane connector
Connection of alarm inputs	front access connectors

6.5.4.2 Specification

Number of fans	4
Operation - minimum speed - maximum speed	temperature controlled ≤ 20 °C ≥ 35 °C
Performance, average: minimum speed (free blowing): - transported air volume - noise	 210 m^3/h 50 dBA @ 1 m
maximum speed (free blowing): - transported air volume - noise	 360 m^3/h 59 dBA @ 1 m

6.5.4.3 Alarm Interface

Alarm inputs:	
- Number	12
- User defined names for input signals	yes
- Active signal level	configurable via FOXCST/FOXMAN-UN - active ground - active open
Thresholds for detection:	
- Reference	positive terminal of the DC power supply (earth)
- "Ground state" range	-8 V … +75 V with respect to reference
- "Open state" range	-75 V … -16 V with respect to reference
- Surge immunity	1.2/50 µs surge impulses with U = ± 2000 V
Connector	Molex Mini-Fit Jr.

Optical alarm indications:	
- Unit powered	1 green LED
- Partial unit failure	1 yellow LED
- Total unit failure	1 red LED

6.5.4.4 Power Supply

Voltage range	
- nominal	-48 V_{DC}, -60 V_{DC}
- range	-39.5 V_{DC} … -75 V_{DC}
- switch on voltage (power up)	-35 V_{DC}
- switch off voltage (power down)	-27 V_{DC}
- resistance to reverse polarity	+75 V_{DC}
Power consumption (-48 V_{DC} power supply)	
- minimum speed (with all fans operating, T < 20 °C)	≤ 10 W
- maximum speed (with all fans operating, T > 35 °C)	≤ 24 W
Connector on the backplane	Molex Mini-Fit Jr.

6.5.4.5 Ambient Conditions

Specifications according to the common system specification, except the following parameters:

Operation	
- Temperature range	-10°C … +70°C
- Minimum start up temperature	-25°C

6.5.4.6 Mechanical Parameters

Overall dimensions (W x H x D)	165 x 40 x 235 mm
Construction	plug-in unit
Weight FAMO2 without packaging	0.650 kg

6.5.4.7 Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F)	
- partial failure (1 fan failed)	13.6 years
- total failure (>1 fan failed)	1'667 years

> **i**
>
> **Please note:**
> The FAMO2 failure prediction model shows that 10% of fan units will fail when operated at a constant ambient temperature of 50°C after 2.45 years.
>
> → Therefore, if FAMO2 is expected to be operated in high temperature environments, ABB Power Grids recommends to provision reasonable stock to minimize replacement time.

6.5.5 FAMO2 Fan Unit (R3)

6.5.5.1 Construction

Unit construction	special plug-in unit to FOX612 subrack, 1 HU (44.45 mm)
Installation into subrack	plug-in unit, fixed with screws
Connection of signals and power	via backplane connector
Connection of alarm inputs and outputs	front access connectors

6.5.5.2 Specification

Number of fans	4
Operation	temperature controlled
- minimum speed	≤ 35 °C
- maximum speed	≥ 50 °C
Performance, average:	
minimum speed (free blowing):	
- transported air volume	200 m^3/h
- noise	48 dBA @ 1 m
maximum speed (free blowing):	
- transported air volume	360 m^3/h
- noise	59 dBA @ 1 m

6.5.5.3 Alarm Interface

Alarm inputs:	
- Number	12
- User defined names for input signals	yes
- Active signal level	configurable via FOXCST/FOXMAN-UN - active ground - active open
Thresholds for detection:	
- Reference	positive terminal of the DC power supply (earth)
- "Ground state" range	-8 V … +75 V with respect to reference
- "Open state" range	-75 V … -16 V with respect to reference
- Surge immunity	1.2/50 µs surge impulses with U = ± 2000 V
Connector	Molex Mini-Fit Jr.

Optical alarm indications:	
- Unit powered	1 green LED
- Partial unit failure	1 yellow LED
- Total unit failure	1 red LED

Alarm outputs:	
- Number	2
- Type	switch over contact relays
- Use	alarm status of NE - "Service Affecting Alarm" - "Non-Service Affecting Alarm"
- Current admissible	< 200 mA
- Open contact max. voltage	80 V
- Insulation (any alarm output lead to earth)	750 V_{RMS} / 50 Hz / 60 s
Conditions at the alarm outputs in case of Power fail:	
- "Service Affecting Alarm" output	active
- "Non-Service Affecting Alarm" output	not active
Connector	Molex Mini-Fit Jr.

6.5.5.4 Power Supply

Voltage range	
- nominal	-48 V_{DC}, -60 V_{DC}
- range	-39.5 V_{DC} … -75 V_{DC}
- switch on voltage (power up)	-35 V_{DC}
- switch off voltage (power down)	-27 V_{DC}
- resistance to reverse polarity	+75 V_{DC}
Power consumption (-48 V_{DC} power supply)	
- minimum speed (with all fans operating, T < 35 °C)	≤ 10 W
- maximum speed (with all fans operating, T > 50 °C)	≤ 24 W
Connector on the backplane	Molex Mini-Fit Jr.

6.5.5.5 Ambient Conditions

Specifications according to the common system specification, except the following parameters:	
Operation	
- Temperature range	-10°C … +70°C
- Minimum start up temperature	-25°C

6.5.5.6 Mechanical Parameters

Overall dimensions (W x H x D)	165 x 40 x 235 mm
Construction	plug-in unit
Weight FAMO2 without packaging	0.650 kg

6.5.5.7 Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F)	
- partial failure (1 fan failed)	13.5 years
- total failure (>1 fan failed)	1'667 years

> **i**

> **Please note:**
> The FAMO2 failure prediction model shows that 10% of fan units will fail when operated at a constant ambient temperature of 50°C after 2.45 years.
> → Therefore, if FAMO2 is expected to be operated in high temperature environments, ABB Power Grids recommends to provision reasonable stock to minimize replacement time.
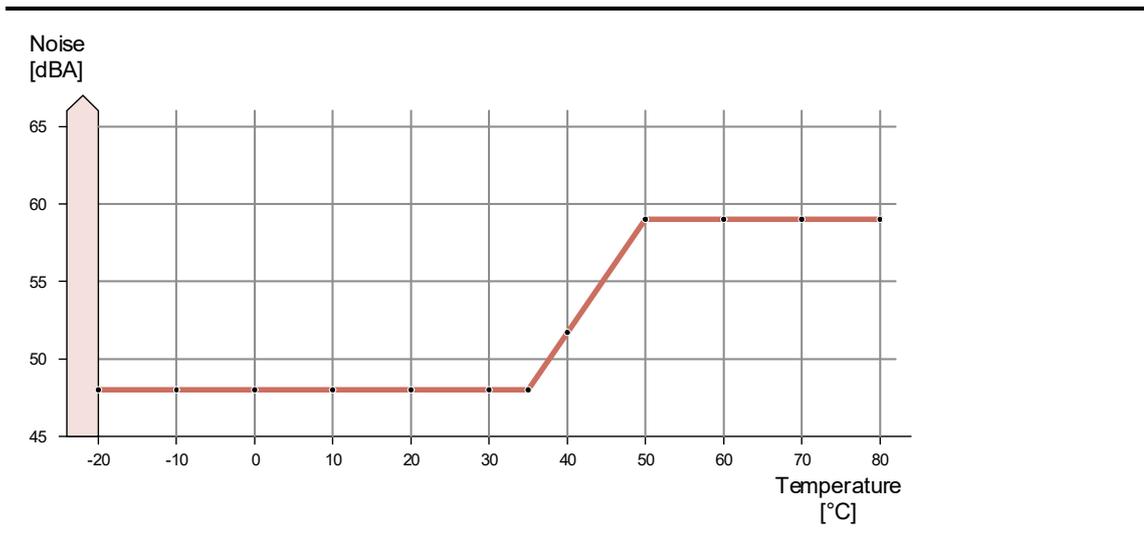
6.5.6 FAMO2-F Alarm Unit (R1)

6.5.6.1 Construction

Unit construction	special plug-in unit to FOX612 subrack, 1 HU (44.45 mm)
Installation into subrack	plug-in unit, fixed with screws
Connection of signals and power	via backplane connector
Connection of alarm inputs and outputs	front access connectors

6.5.6.2 Alarm Interface

Alarm inputs: - Number	12
- User defined names for input signals	yes
- Active signal level	configurable via FOXCST/FOXMAN-UN - active ground - active open
Thresholds for detection: - Reference - "Ground state" range - "Open state" range	positive terminal of the battery (earth) -8 V … +75 V with respect to reference -75 V … -16 V with respect to reference
- Surge immunity	1.2/50 µs surge impulses with U = ± 2000 V
Connector	Molex Mini-Fit Jr.

Optical alarm indications: - Unit powered	1 green LED

Alarm outputs: - Number	2
- Type	switch over contact relays
- Use	alarm status of NE - "Service Affecting Alarm" - "Non-Service Affecting Alarm"
- Current admissible	< 200 mA
- Open contact max. voltage	80 V
- Insulation (any alarm output lead to earth)	750 V_{RMS} / 50 Hz / 60 s
Conditions at the alarm outputs in case of Power fail: - "Service Affecting Alarm" output - "Non-Service Affecting Alarm" output	 active not active
Connector	Molex Mini-Fit Jr.

6.5.6.3 Power Supply

Voltage range - nominal - range - resistance to reverse polarity	 -48 V_{DC}, -60 V_{DC} -39.5 V_{DC} … -75 V_{DC} +75 V_{DC}
Power consumption (-48 V_{DC} battery)	≤ 1 W
Connector on the backplane	Molex Mini-Fit Jr.

6.5.6.4 Ambient Conditions

Specifications according to the common system specification, except the following parameters:	
Operation - Temperature range	-25°C … +55°C

6.5.6.5 Mechanical Parameters

Overall dimensions (W x H x D)	165 x 40 x 235 mm
Construction	plug-in unit
Weight FAMO2-F without packaging	0.30 kg

6.5.6.6 Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F)	602 years

6.5.7 DUPF2 Dual Power Supply Input Unit

Power inputs	U1
	U2

6.5.7.1 Interfaces

Power output to FOX61x	UTF
Alarm outputs	Supervision U1
	Supervision U2

6.5.7.2 Specifications

Input voltage range	-40.0 … -75 V_{DC}
Maximum reverse polarity	+75 V_{DC}
Maximum output current	15 A
Typical power dissipation at maximum current	5 W

6.5.7.3 Alarm Interface

Alarm threshold voltage	-29 … -34 V_{DC}
Alarm polarity	active open
Electrical contacts:	
- Type	solid state
- Current	≤ 10 mA
- Voltage drop @ 10 mA	≤ 2 V
- Open contact maximum voltage	-75 V
- Leakage current @ -75 V	≤ 100 µA
Connector	Molex Mini-Fit Jr.

6.5.7.4 Mechanical Parameters

Installation	Mounted on the FOX612 cable tray
Overall dimensions (W x H x D) excluding front panel overlap	32 x 42 x 143 mm
Weight without packaging, including alarm cable	0.31 kg

6.5.7.5 Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F)	1604 years

6.5.8 Power Consumption

Maximum admissible power consumption of a FOX612, continuous	
- at -48 V_{DC}	600 W
- at -60 V_{DC}	600 W

6.5.9 Power Dissipation

Maximum power dissipation in a FOX612 subrack	
- with active cooling (with fan unit)	600 W
- with passive cooling (without fan unit)	200 W

6.6 FOX611 Characteristics

6.6.1 Architecture

System architecture	fully modular open architecture
Subrack	19-inch mountable (horizontal mounting) with 4 slots (slots numbered 9 … 12)
- slot 9 … 10, 12	service units
- slot 11	core unit
Implementation	configurable, according to requirements
Units - Core units	CESM2, CESM2-F, CESM1, CESM1-F
- Encryption units	SENC1-4, SENC1F4, SENC1-8, SENC1F8
- Service units	ETOP1, ETOP1-F, ELET1, EPOI1 DEFM1, DEFM1-F EROP1, EROP1-F ESOP1, ESOP1-F, ESPO1 EPSI1 LEDE1 CEPI1 COSI1 VFTLF LEDS1 LESU1 LEDA1 LEXI1 LECO1 DATI1 SAMO1, SAMO3, SAMO2, SAMO2-F, SAMO5, SAMO5-F TEPI1 TEPI2 OPIC1 OPIC2 TEGO1
- Auxiliary units	FAMO3 FAMO3-F DUPF2 FOX611 AC power kit (includes the AC/DC converter POAC1)
Equipment protection - SDH transport unit SAMO1	1:1 equipment protection (PBUS access part only)
- Media gateway unit COSI1	1:1 equipment protection
- Voice frequency processing unit VFTLF	1:1 equipment protection
- IPv4 routing unit EROP1, EROP1-F	1:1 equipment protection [1]
- Ethernet switching and routing unit EPSI1	1:1 equipment protection (bridging and routing functions only)

- Data interface unit LEDS1	1:1 equipment protection (conference part only)
- E&M voice interface unit LEDA1	1:1 equipment protection (conference part only)
Internal bus system - GbE single star	interconnection of every slot with 1 Gbit/s to the core unit slot
- PBUS	internal TDM bus for up to 128 x 2048 kbit/s (uni-directional)
- CBUS	internal bus for control, clocking, powering etc.
Unit software (ESW)	downloaded
Configuration	software based, with FOXCST and FOXMAN-UN

1. Equipment protection with the EROP1 unit is only supported up to the ESW release r2.

6.6.2 System Control and Management Functions

6.6.2.1 Control System

Basic control system	distributed processor system
Central system control (core unit)	dedicated unit with master processor
Service units	local slave processors
Management Information Base (MIB) - Configuration data	Configuration data stored on core unit → storage of complete NE configuration
Timing function	
- Timing synchronization	SNTPv3 PTP GPS via IRIG-B
- Synchronization modes	unicast, broadcast
- NE Time	local time, with time zones

6.6.2.2 NE Software System

Unit software (ESW)	stored directly in flash memory of the unit (core and service units)
SW download (for ESW)	ESW installation controlled by FOXMAN-UN / FOXCST NE wide ESW installation At least 2 ESW versions can be stored on a unit Activation of the new ESW on schedule or immediately
Feature license management	allows you to buy equipment with basic functionality (hardware and/or software) and upgrade with new feature licenses

6.6.2.3 Management Functions

Configuration management for	NE incl. ESW traffic functions
Performance management for	NE traffic signals
Fault management - Hardware failures	NE and units
- ESW configuration/operation	units

- Failures and performance	traffic signals
Alarm generation and reporting - Generation and severity	programmable
- Indication	local indicators
- Reporting	alarm lists logbooks export of table data to csv or xml files syslog (up to 10 destinations, RFC 5424) remote access SNMP
SNMP MIBs	Agent MIBs - SNMPv2-MIB (RFC 3418) - SNMP-FRAMEWORK-MIB (RFC 3411) - SNMP-TARGET-MIB (RFC 3413) - SNMP-NOTIFICATION-MIB (RFC 3413) - SNMP-VIEW-BASED-ACM-MIB (RFC 3415) - SNMP-COMMUNITY-MIB (RFC 3584) - SNMP-USER-BASED-SM-MIB (RFC 3414) - SNMPv2-TC (RFC 2579) Other MIBs - RMON2-MIB (RFC 4502) - RMON-MIB (RFC 2819) - BRIDGE-MIB (RFC 4188) - Q-BRIDGE-MIB (RFC 4363) - IANAifTypeMIB - IF-MIB (RFC 2863) - ENTITY-MIB (RFC 6933) - INET-ADDRESS-MIB (RFC 4001) - ENTITY-SENSOR-MIB (RFC 3433) - ALARM-MIB (RFC 3877) - PW-TC-STD-MIB (RFC 5542) Private MIBs - FOX-SMI - FOX-IF-EXT-MIB - FOX-IANA-BFD-TC-STD-MIB - FOX-BFD-STD-MIB - FOX-MPLS-QOS-EXT-MIB - FOX-UNI-EVC-MIB - FOX-ETH-PORT-MIB - FOX-NE-MIB - FOX-ALARM-EXT-MIB - FOX-DIAGNOSTIC-MIB
Inventory management	for hardware and software
Management tools	FOXCST FOXMAN-UN DIRAC

6.6.2.4   Management Access

Local management access	Ethernet local management port, not routed
Remote management access	- VLAN Bridge port of the FOX61x Switch, routed - MPLS-TP port of the FOX61x Switch, routed - P12 or P0_nc channels, routed
Management routing function	- Static routing - OSPF dynamic routing, RFC2328 - VRRP virtual routing, RFC3768

Management router interfaces	- 2 VLAN interfaces (CESM1 and CESM2), 2 VRRP instances per interface - 16 TDM interfaces, PPP encapsulation, RFC1661 - (maximum TDM bandwidth is 16'384 kbit/s) - 10 MPLS-TP MCC interfaces, RFC5718 - (maximum rate is 2'048 kbit/s) - 8 loopback interfaces
User authentication	- local authentication in the NE with userclass and password - local authentication in the NE with public/private keys (for FOXMAN-UN only) - remote authentication via RADIUS server, with local authentication fallback
User classes	- session manager - support - manager - maintenance - information
Management access security	Security on network layer with SSH

6.6.3 Mechanics

6.6.3.1 Construction

Card cage for FOX61x units	19-inch practice when mounted horizontally
Modularity	subrack 19-inch adapter fan unit AC/DC converter
Installation into racks - 19-inch	with adapters
Basic construction	metallic
- Sides and rear	sheet metal
- Top and bottom	perforated sheet metal
- Front	front cover
Connection of signal and power cables - Power supply	integrated connector
- Shields of signal cables	grounding bars in front
- Cable installation and strain relief	directly on the rack
Degree of protection, IP code (IEC 60529)	IP20
- Solid particle protection	level 2, > 12.5 mm
- Liquid ingress protection	level 0, not protected
Pollution degree	IEC 62368-1, 2
Class of equipment	IEC 62368-1, class I

6.6.3.2 Capacity and Slots

Slots - Number of slots	4
- Slot width	20.32 mm 4 HP
Allocation of units to slots	flexible, slot 11 dedicated

6.6.3.3 Dimensions

Subrack without front cover (W x H x D)	458.45 x 94.9 x 280.3 mm
Subrack with front cover (W x H x D)	458.45 x 94.9 x 303.3 mm
19-inch mountable subrack with front cover, including 19-inch adapters (W x H x D)	482.6 x 94.9 x 303.3 mm
19-inch adapter (W x H x D)	85.3.0 x 90.8 x 242.5 mm
Construction and layout	19-inch mounting practice refer to Figure 15: "FOX611 subrack design and main dimensions (side view)" (on page 39)

6.6.3.4 Weight

19-inch subrack without front cover (without units, without 19-inch adapter)	2.76 kg
Front cover	0.49 kg
19-inch adapter	0.31 kg
FOX611 AC power kit (excluding POAC1)	0.08 kg
Weight of units	refer to the unit user manuals

6.6.4 FAMO3 Fan Unit (R1)

6.6.4.1 Construction

Unit construction	special plug-in unit to FOX611 subrack, 1 HU (44.45 mm)
Installation into subrack	plug-in unit, fixed with screws
Connection of signals and power	via backplane connector
Connection of alarm inputs	front access connectors

6.6.4.2 Specification

Number of fans	2
Operation - minimum speed - maximum speed	temperature controlled ≤ 35 °C ≥ 50 °C
Performance, average: minimum speed (free blowing): - transported air volume - noise	 100 m^3/h 45 dBA @ 1 m
maximum speed (free blowing): - transported air volume - noise	 180 m^3/h 58 dBA @ 1 m

6.6.4.3 Alarm Interface

Alarm inputs:	
- Number	4
- User defined names for input signals	yes
- Active signal level	configurable via FOXCST/FOXMAN-UN - active ground - active open
Thresholds for detection:	
- Reference	positive terminal of the DC power supply (earth)
- "Ground state" range	-8 V … +75 V with respect to reference
- "Open state" range	-75 V … -16 V with respect to reference
- Surge immunity	1.2/50 µs surge impulses with U = ± 2000 V
Connector	Molex Mini-Fit Jr.

Optical alarm indications:	
- Unit powered	1 green LED
- Partial unit failure	1 yellow LED
- Total unit failure	1 red LED

6.6.4.4 Power Supply

Voltage range	
- nominal	-48 V_{DC}, -60 V_{DC}
- range	-39.5 V_{DC} … -75 V_{DC}
- switch on voltage (power up)	-35 V_{DC}
- switch off voltage (power down)	-27 V_{DC}
- resistance to reverse polarity	+75 V_{DC}
Power consumption (-48 V_{DC} power supply)	
- minimum speed (with all fans operating, T < 20 °C)	≤ 4.5 W
- maximum speed (with all fans operating, T > 35 °C)	≤ 11.5 W
Connector on the backplane	Molex Mini-Fit Jr.

6.6.4.5 Ambient Conditions

Specifications according to the common system specification, except the following parameters:

Operation	
- Temperature range	-10°C … +70°C
- Minimum start up temperature	-25°C

6.6.4.6   Mechanical Parameters

Overall dimensions (W x H x D)	85 x 42 x 235 mm
Construction	plug-in unit
Weight FAMO3 without packaging	0.29 kg

6.6.4.7   Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F)	
- partial failure (1 fan failed)	17.7 years
- total failure (>1 fan failed)	1'667 years

> **i**
>
> **Please note:**
>
> The FAMO3 failure prediction model shows that 10% of fan units will fail when operated at a constant ambient temperature of 60°C after 3.2 years.
>
> → Therefore, if FAMO3 is expected to be operated in high temperature environments, ABB Power Grids recommends to provision reasonable stock to minimize replacement time.

6.6.5   FAMO3 Fan Unit (R2)

6.6.5.1   Construction

Unit construction	special plug-in unit to FOX611 subrack, 1 HU (44.45 mm)
Installation into subrack	plug-in unit, fixed with screws
Connection of signals and power	via backplane connector
Connection of alarm inputs	front access connectors

6.6.5.2   Specification

Number of fans	2
Operation	temperature controlled
- minimum speed	≤ 35 °C
- maximum speed	≥ 50 °C
Performance, average: minimum speed (free blowing):	
- transported air volume	100 m^3/h
- noise	45 dBA @ 1 m
maximum speed (free blowing):	
- transported air volume	180 m^3/h
- noise	58 dBA @ 1 m

6.6.5.3 Alarm Interface

Alarm inputs:	
- Number	4
- User defined names for input signals	yes
- Active signal level	configurable via FOXCST/FOXMAN-UN - active ground - active open
Thresholds for detection:	
- Reference	positive terminal of the DC power supply (earth)
- "Ground state" range	-8 V … +75 V with respect to reference
- "Open state" range	-75 V … -16 V with respect to reference
- Surge immunity	1.2/50 µs surge impulses with U = ± 2000 V
Connector	Molex Mini-Fit Jr.

Optical alarm indications:	
- Unit powered	1 green LED
- Partial unit failure	1 yellow LED
- Total unit failure	1 red LED

Alarm outputs:	
- Number	2
- Type	switch over contact relays
- Use	alarm status of NE - "Service Affecting Alarm" - "Non-Service Affecting Alarm"
- Current admissible	< 200 mA
- Open contact max. voltage	80 V
- Insulation (any alarm output lead to earth)	750 V_{RMS} / 50 Hz / 60 s
Conditions at the alarm outputs in case of Power fail:	
- "Service Affecting Alarm" output	active
- "Non-Service Affecting Alarm" output	not active
Connector	Molex Mini-Fit Jr.

6.6.5.4 Power Supply

Voltage range	
- nominal	-48 V_{DC}, -60 V_{DC}
- range	-39.5 V_{DC} … -75 V_{DC}
- switch on voltage (power up)	-35 V_{DC}
- switch off voltage (power down)	-27 V_{DC}
- resistance to reverse polarity	+75 V_{DC}
Power consumption (-48 V_{DC} power supply)	
- minimum speed (with all fans operating, T < 20 °C)	≤ 4.5 W
- maximum speed (with all fans operating, T > 35 °C)	≤ 11.5 W
Connector on the backplane	Molex Mini-Fit Jr.

6.6.5.5 Ambient Conditions

Specifications according to the common system specification, except the following parameters:	
Operation	
- Temperature range	-10°C … +70°C
- Minimum start up temperature	-25°C

6.6.5.6 Mechanical Parameters

Overall dimensions (W x H x D)	85 x 42 x 235 mm
Construction	plug-in unit
Weight FAMO3 without packaging	0.29 kg

6.6.5.7 Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F)	
- partial failure (1 fan failed)	17.6 years
- total failure (>1 fan failed)	1'667 years

> **i** **Please note:**
> The FAMO3 failure prediction model shows that 10% of fan units will fail when operated at a constant ambient temperature of 60°C after 3.2 years.
> → Therefore, if FAMO3 is expected to be operated in high temperature environments, ABB Power Grids recommends to provision reasonable stock to minimize replacement time.

6.6.6 FAMO3-F Alarm Unit (R1)

6.6.6.1 Construction

Unit construction	special plug-in unit to FOX611 subrack, 1 HU (44.45 mm)
Installation into subrack	plug-in unit, fixed with screws
Connection of signals and power	via backplane connector
Connection of alarm inputs and outputs	front access connectors

6.6.6.2 Alarm Interface

Alarm inputs: - Number	4
- User defined names for input signals	yes
- Active signal level	configurable via FOXCST/FOXMAN-UN - active ground - active open
Thresholds for detection: - Reference - "Ground state" range - "Open state" range	positive terminal of the battery (earth) -8 V … +75 V with respect to reference -75 V … -16 V with respect to reference
- Surge immunity	1.2/50 µs surge impulses with U = ± 2000 V
Connector	Molex Mini-Fit Jr.

Optical alarm indications: - Unit powered	1 green LED

Alarm outputs: - Number	2
- Type	switch over contact relays
- Use	alarm status of NE - "Service Affecting Alarm" - "Non-Service Affecting Alarm"
- Current admissible	< 200 mA
- Open contact max. voltage	80 V
- Insulation (any alarm output lead to earth)	750 V_{RMS} / 50 Hz / 60 s
Conditions at the alarm outputs in case of Power fail: - "Service Affecting Alarm" output - "Non-Service Affecting Alarm" output	 active not active
Connector	Molex Mini-Fit Jr.

6.6.6.3 Power Supply

Voltage range - nominal - range - resistance to reverse polarity	 -48 V_{DC}, -60 V_{DC} -39.5 V_{DC} … -75 V_{DC} +75 V_{DC}
Power consumption (-48 V_{DC} battery)	≤ 1 W
Connector on the backplane	Molex Mini-Fit Jr.

6.6.6.4 Ambient Conditions

Specifications according to the common system specification, except the following parameters:	
Operation - Temperature range	-25°C … +55°C

6.6.6.5 Mechanical Parameters

Overall dimensions (W x H x D)	85 x 42 x 235 mm
Construction	plug-in unit
Weight FAMO3-F without packaging	0.20 kg

6.6.6.6 Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F)	602 years

6.6.7 DUPF2 Dual Power Supply Input Unit

Please refer to section 6.5.7 DUPF2 Dual Power Supply Input Unit (on page 208).

6.6.8 POAC1 AC/DC Power Converter

6.6.8.1 Construction

Unit construction	special plug-in unit for the 19-inch adapter of the FOX611 subrack
Installation into subrack	plug-in unit, fixed with screws
Connection of AC and DC power	via AC/DC backplane connectors
Connection of alarm outputs	via AC/DC backplane connector to FAMO3 or FAMO3-F

6.6.8.2 Specification

Nominal input voltages	- 115 V_{AC}, - 230 V_{AC}
Input voltage range	90 V_{AC} … 264 V_{AC}
Maximum continuous input current - @ 230 V_{AC} - @ 115 V_{AC}	 2.2 A 4.5 A
External fuse	6A class B
Output voltage	-52.0 V_{DC} … -53.0 V_{DC}
Maximum continuous output current	8 A
Maximum backup battery charge current	2 A
Maximum continuous output power	350 W
Maximum usable output power for the FOX611 - without backup battery - with backup battery	 350 W 244 W

6.6.8.3 Ambient Conditions

Specifications according to the common system specification.

6.6.8.4 Mechanical Parameters

Overall dimensions (W x H x D)	105 x 41 x 199 mm
Construction	plug-in unit
Weight POAC1 unit without packaging	1.12 kg

6.6.8.5 Dependability

Calculated MTTF at 35 °C (MIL-HDBK-217F)	6.5 years

6.6.9　Power Consumption

Maximum admissible power consumption of a FOX611, continuous	
- at -48 V_{DC}	380 W
- at -60 V_{DC}	380 W

6.6.10　Power Dissipation

Maximum power dissipation in a FOX611 subrack	
- with active cooling (with fan unit)	380 W
- with passive cooling (without fan unit) [1]	80 W

1. Passive cooling is only possible without the AC/DC converter POAC1 mounted in the FOX611 subrack.

6.7　EMC/ESD and Safety

6.7.1　EMC

6.7.1.1　Product Family Standard

FOX615 R2 or FOX615 or FOX612 or FOX611	
Public Telecommunication network equipment	ETSI EN 300 386 V1.6.1
Additional EMC requirements and resistibility requirements for telecommunication equipment for enhanced availability of service	ETSI ES 201 468 V1.3.1, test level 2
Communication networks and systems for power utility automation	EN 61850-3 (2013)
Environmental and Testing Requirements for Communications Networking Devices Installed in Electric Power Substations	IEEE 1613 - 2009
Environmental and Testing Requirements for Communications Networking Devices Installed in Transmission and Distribution Facilities	IEEE 1613.1 - 2013

6.7.1.2　Emission

FOX615 R2 or FOX615 or FOX612 or FOX611	
Conducted emission 0.15 MHz … 30 MHz	EN 55032, class A
Radiated emission 30 MHz … 6000 MHz	EN 55032, class A

6.7.1.3　Immunity

FOX615 R2 or FOX615 or FOX612 or FOX611	
Electromagnetic field (IEC/EN 61000-4-3)	80 MHz … 1000 MHz, 20 V/m 1 GHz … 6 GHz, 10 V/m
Conducted common mode HF disturbance (IEC/EN 61000-4-6)	150 kHz … 80 MHz, modulated 1 kHz 80% AM, 10 V
Fast transients/bursts (IEC/EN 61000-4-4)	
- on power supply IF (CDN)	4 kV

FOX615 R2 or FOX615 or FOX612 or FOX611	
- on traffic signal interfaces (capacitive clamp)	1 kV local 2 kV field
Surge immunity (IEC/EN 61000-4-5)	ITU-T K.20 and ITU-T K.45
- Traffic and control interfaces	common mode: 2 kV 1.2/50 μs (8/20 μs) differential mode: 1 kV 1.2/50 μs (8/20 μs)
- Power supply interface	common mode: 2 kV 1.2/50 μs (8/20 μs) differential mode: 1 kV 1.2/50 μs (8/20 μs)
Damped oscillatory waves (IEC/EN 61000-4-18)	
- on traffic signal interfaces	common mode: 2.5 kV field differential mode: 1.25 kV field

6.7.2 ESD

FOX615 R2 or FOX615 or FOX612 or FOX611	
Electrostatic Discharge (IEC/EN 61000-4-2)	contact discharge: 8 kV air discharge: 15 kV

6.7.3 Safety

FOX615 R2 or FOX615 or FOX612 or FOX611	
Safety according to	IEC 62368-1:2014 Audio/video, information and communication technology equipment - Part 1: Safety requirements

6.7.4 Earthing

FOX615 R2 or FOX615 or FOX612 or FOX611	
Earthing and bonding for FOX61x	ETSI EN 300 253 V2.2.1 (2015-06), designed for integration acc. to the configuration shown in figure 2 of this EN.

6.8 Environmental Conditions and Dependability

6.8.1 Ambient Conditions

6.8.1.1 Storage

FOX615 R2 or FOX615 or FOX612 or FOX611	
Environmental class - All equipment (exclusive batteries)	ETSI EN 300 019-1-1, class 1.2 IEC 60721-3-2, class 2M1
Temperature range	-25°C … +65°C
Humidity	class 1.2
Biological and chemical active substances	not specified

6.8.1.2 Transport

FOX615 R2 or FOX615 or FOX612 or FOX611	
Environmental class - All equipment (exclusive batteries)	ETSI EN 300 019-1-2, class 2.2
Temperature ranges - ambient air for unventilated enclosures	-25°C … +70°C
- ambient air for ventilated enclosures or out- door	-25°C … +40°C
Humidity	class 2.2
Vibration random Acceleration Spectral Density - ASD @ 10-200 Hz	1.0 m^2s^{-3}
- ASD @ 200-2000 Hz	0.3 m^2s^{-3}
Biological and chemical active substances	not specified

6.8.1.3 Operation

FOX615 R2 or FOX615 or FOX612 or FOX611	
Environmental class - All equipment (exclusive batteries)	ETSI EN 300 019-1-3, class 3.3 IEC 60721-3-3, class 3M1
Temperature range (extended), with active cool- ing - Operation of FOX61x, altitude up to 2000 m - Operation of FOX61x, altitude up to 5000 m	 -25°C … +65°C [1] -25°C … +50°C
Temperature range, with passive cooling [2] - Operation of FOX61x, altitude up to 2000 m - Operation of FOX61x, altitude up to 5000 m	 -25°C … +55°C -25°C … +45°C
- Minimum start up temperature	-25°C
Humidity	0% … 95%, non-condensing
Mechanical conditions - Subrack, core unit, service units	ETSI EN 300 019-1-8, class Special (3M5)
Biological and chemical active substances	not specified
Explosive atmosphere	not allowed

1. Operation above 60°C requires optimization of the air flow around units that are equipped with SFPs. Please refer to [1KHW029122] Application Note "Extended Temperature Range Operation".
2. Passive cooling operation of the FOX612 and FOX611 subrack requires vertical mounting of the subrack.

6.8.2 Dependability

FOX615 R2 or FOX615 or FOX612 or FOX611	
Calculated MTTF at 35 °C (MIL-HDBK-217F) - FOX615 R2 subrack - FOX615 subrack	 86 years 100 years
Calculated MTTF at 35 °C (MIL-HDBK-217F) - FOX612 subrack	206 years
Calculated MTTF at 35 °C (MIL-HDBK-217F) - FOX611 subrack	491 years
Calculated MTTF at 35 °C (MIL-HDBK-217F) Plug in units	> 50 years per unit (typical)

FOX615 R2 or FOX615 or FOX612 or FOX611	
Calculated MTTF at 35 °C (MIL-HDBK-217F) Fan unit FAMO1	please refer to section 6.4.4 FAMO1 Fan Unit (R2) (on page 190)
Calculated MTTF at 35 °C (MIL-HDBK-217F) Alarm unit FAMO1-F	please refer to section 6.4.5 FAMO1-F Alarm Unit (R1) (on page 193)
Calculated MTTF at 35 °C (MIL-HDBK-217F) Fan unit FAMO2	please refer to section 6.5.4 FAMO2 Fan Unit (R2) (on page 202) and section 6.5.5 FAMO2 Fan Unit (R3) (on page 204)
Calculated MTTF at 35 °C (MIL-HDBK-217F) Alarm unit FAMO2-F	please refer to section 6.5.6 FAMO2-F Alarm Unit (R1) (on page 206)
Calculated MTTF at 35 °C (MIL-HDBK-217F) Fan unit FAMO3	please refer to section 6.6.4 FAMO3 Fan Unit (R1) (on page 213) and section 6.6.5 FAMO3 Fan Unit (R2) (on page 215)
Calculated MTTF at 35 °C (MIL-HDBK-217F) Alarm unit FAMO3-F	please refer to section 6.6.6 FAMO3-F Alarm Unit (R1) (on page 217)
Calculated MTTF at 35 °C (MIL-HDBK-217F) Dual supply input unit DUPF1 (FOX615 R2 and FOX615)	please refer to section 6.4.6 DUPF1 Dual Power Supply Input Unit (on page 194)
Calculated MTTF at 35 °C (MIL-HDBK-217F) Dual supply input unit DUPF1-R (FOX615 R2 and FOX615)	please refer to section 6.4.7 DUPF1-R Dual Power Supply Input Unit (on page 195)
Calculated MTTF at 35 °C (MIL-HDBK-217F) Dual supply input unit DUPF2 (FOX612 and FOX611)	please refer to section 6.5.7 DUPF2 Dual Power Supply Input Unit (on page 208)
Calculated MTTF at 35 °C (MIL-HDBK-217F) AC/DC converter POAC1	please refer to section 6.6.8.5 Dependability (on page 219)

7 Annex

7.1 Associated FOX61x Documents

[1KHW028777]   Release Note "FOX61x System Release R15A"

[1KHW002460]   System Description "FOX61x R15A"

[1KHW028522]   User Manual "Management Communication"

[1KHW028566]   User Manual "Ethernet Switching"

[1KHW028556]   User Manual "CEPI1"

[1KHW028559]   User Manual "COSI1"

[1KHW002483]   User Manual "TEPI1"

[1KHW028634]   User Manual "TEPI2"

[1KHW002484]   User Manual "OPIC1"

[1KHW028635]   User Manual "OPIC2"

[1KHW028776]   Product Description "Feature Licenses for FOX61x"

[1KHW029122]   Application Note "Extended Temperature Range Operation"

7.2 Feature Licenses

Part of the FOX61x functionality is subject to feature licenses. For more information on feature licenses please refer to [1KHW028776] Product Description "Feature Licenses for FOX61x".

ABB

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ABB Power Grids Switzerland Ltd
Bruggerstrasse 72
5400 Baden - Switzerland

Phone: please refer to https://www.hitachi-powergrids.com/contact-us/Customer-Connect-Center
            (Customer Contact Center)
E-Mail: communication.networks@hitachi-powergrids.com

www.hitachi-powergrids.com/communication-networks

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