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GROUP SPECIFICATION

Open Radio equipment Interface (ORI);
ORI interface Specification;
Part 1: Low Layers
(Release 4)

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RGS/ORI-0017

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Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) Open Radio equipment Interface (ORI).

The present document is part 1 of a multi-part deliverable covering the ORI Interface Specification, as identified below:

Part 1: "Low Layers (Release 4)";

Part 2: "Control and Management (Release 4)".

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**may not**", "**need**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document defines low layer protocols aspects of the Open Radio equipment Interface (ORI). Low layer protocols are those terminating the ORI Link (a bi-directional interface in-between two directly-connected ORI ports, on two ORI nodes).

The Layer 1/2 protocols of CPRI Specification [1] have been used as a baseline for which further requirements for protocols up to and including the Layer 2 have been defined.

See the associated specification "Requirements for Open Radio equipment Interface" [2] for more information on how the Low Layer protocols relate to other aspects of the ORI interface.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

[1] "Common Public Radio Interface (CPRI); Interface Specification V6.0".

NOTE: Available at http://www.cpri.info/spec.html.

[2] ETSI GS ORI 001: "Open Radio equipment Interface (ORI); Requirements for Open Radio equipment Interface (ORI) (Release 4)".

[3] SFF INF-8074i: "SFP (Small Formfactor Pluggable) Transceiver", Revision 1.0, May 12, 2001.

NOTE: Available at http://www.sffcommittee.com.

[4] SFF SFF-8431: "Enhanced Small Form Factor Pluggable Module SFP+", Revision 4.1, 6th of July 2009.

NOTE: Available at http://www.sffcommittee.com.

[5] ETSI TS 125 104: "Universal Mobile Telecommunications System (UMTS); Base Station (BS) radio transmission and reception (FDD) (3GPP TS 25.104)".

[6] ETSI TS 125 215: "Universal Mobile Telecommunications System (UMTS); Physical layer; Measurements (FDD) (3GPP TS 25.215)".

[7] ETSI TS 125 133: "Universal Mobile Telecommunications System (UMTS); Requirements for support of radio resource management (FDD) (3GPP TS 25.133)".

[8] ETSI TS 136 104: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (3GPP TS 36.104)".

[9] ETSI GS ORI 002-2: "Open Radio equipment Interface (ORI); ORI interface specification, Part 2: Control and Management (Release 4)".

[10] ETSI TS 145 001: "Digital cellular telecommunications system (Phase 2+); Physical layer on the radio path; General description (3GPP TS 45.001)".

[11] ETSI TS 145 004: "Digital cellular telecommunications system (Phase 2+); Modulation (3GPP TS 45.004)".

[12] ETSI TS 145 005: "Digital cellular telecommunications system (Phase 2+); Radio transmission and reception (3GPP TS 45.005)".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

Not applicable.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in GS ORI 001 [2] and the following apply:

NOTE: For any terms used in the present document that are not defined either here or directly in the clause in which they are used, refer to CPRI specification [1].

active link: See clause 3.1 in GS ORI 001 [2].

Antenna-Carrier (AxC): See section 2.1 in [1].

AxC container: See section 2.1 in [1].

AxC container block: See section 2.1 in [1].

AxC group: See section 2.1 in [1].

GSM time slot: time slot of GSM radio access technology, as defined in TS 145 001 [10]

Master port: See section 2.1 in [1].

ORI port: See clause 3.1 in GS ORI 001 [2].

ORI-specific negotiation: subset of negotiations between master port and slave port that are defined in section 4.5.3.5 of [1] to be "vendor-specific", but for which behaviour is explicitly defined within the ORI specification

ORI vendor-specific negotiation: subset of negotiations between master port and slave port that are defined in section 4.5.3.5 of [1] to be "vendor-specific", and not defined within the ORI specification to be "ORI-specific negotiations"

passive link: See clause 3.1 of GS ORI 001 [2].

RE antenna port: for Rx and Tx antenna ports, this corresponds to the Tx and Rx BS antenna connector as defined as Test Port A in [5] for UTRA-FDD, and [8] for E-UTRA

slave port: See section 2.1 in [1].

stuffing bits: See section 2.1 in [1].

stuffing samples: See section 2.1 in [1].

subchannel: See section 4.2.7.4 in [1].

Uplink Automatic Gain Control (UL AGC): function that controls the gain of the RE UL signal path of an UTRA UL AxC with the target to keep the RMS level of the UL IQ signal at the ORI port at a target value (see clause 7.1.2)

3.2 Symbols

For the purposes of the present document, the following symbols apply:

AxC Antenna-carrier

N_A Number of Antenna-Carrier (AxC) in one AxC Group

NOTE: See section 4.2.7.2.7 in [1].

N_C Number of AxC Containers of one AxC Container Group per basic frame

NOTE: See section 4.2.7.2.7 in [1].

N_V Number of stuffing samples per AxC Container Block

NOTE: See section 4.2.7.2.7 in [1].

V_{RMS} Target RMS level
$\lceil x \rceil$ Ceiling function: the largest integer y where y < x + 1,0
μ Parameter used within the IQ data compression/decompression process
σ Parameter used within the IQ data compression/decompression process

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3GPP 3rd Generation Partner Project
AGC Automatic Gain Control
ARFCN Absolute Radio Frequency Channel Number
BCI BFN Cycle Index
BFN Node B Frame Number
BS Base Station
C&M Control and Management
CPRI Common Public Radio Interface
dec Decimal
DL DownLink
E-UTRA Evolved UMTS Terrestrial Radio Access
FDD Frequency Division Duplex
GSM Global System for Mobile communications (Group Special Mobile)
HFN Hyper-Frame Number
IQ In-phase data and Quadrature data
L1 Layer 1
L2 Layer 2
LOF Loss Of Frame

NOTE: As defined in [1].

LOS Loss Of Signal

NOTE: As defined in [1].

LSB Least Significant Bit
MAC Media Access Control
MSB Most Significant Bit
ORI Open Radio equipment Interface
RAI Remote Alarm Indication

NOTE: As defined in [1].

RE Radio Equipment
REC Radio Equipment Control

RMS	Root Mean Square
RTWP	Received Total Wideband Power
Rx	Receiver
SAP	Service Access Point
SDI	SAP Defect Indication

NOTE: As defined in [1].

SFP	Small Form-factor Pluggable
Tx	Transmitter
UL	UpLink
UTRA	UMTS Terrestrial Radio Access

4 ORI Low Layers specification compliance

The RE/REC compliant to the ORI Low Layers specification shall:

- be fully compliant to CPRI Specification, as defined in section 5.2 of [1];
- support mandatory requirements defined within ORI that are defined as options within CPRI Specifications;
- support mandatory requirements defined within ORI that do not refer to functionality in CPRI Specifications.

5 Layer 1 configuration

5.1 General

Requirements for the L1 characteristics are defined below. For each of the defined characteristics, the level of support shall be declared for each port of the RE/REC.

Line bit rate

At least one of the CPRI line bit rate options specified in [1], section 4.2.1 shall be supported by the RE and REC, with the exception of 614,4 Mbit/s line bit rate.

Physical Interface

At least one of the following interfaces shall be supported:

- Optical interface parameters defined in clause 5.2.
- Electrical interface parameters defined in clause 5.3.

5.2 Optical interface

Connector type

At least one of the following connector types shall be supported by the RE and REC: LC-type, SC-type.

Simplex/Duplex operation mode

At least one of the following operation modes shall be supported by the RE and REC: Simplex (one fibre per direction), Duplex (one fibre for both transmission and reception).

Optical Fibre Type

The ORI recommendation for optical cabling follows section 4.2.4.1 of [1].

Wave length

The wave lengths to be supported by RE and REC are not specified.

Optical output power

Optical output power to be supported by RE and REC is not specified.

Sensitivity

The optical sensitivity to be supported by RE and REC is not specified.

Signal condition capabilities

The maximum fibre length and attenuation to be supported by RE and REC are not specified.

5.3 Electrical interface

Electrical Connector type

At least one of the following connector types shall be supported by the RE and REC:

- SFP [3], SFP+ [4], those defined in section 4.2.3.2 of the CPRI Specification [1].

Electrical Cable Type

The Electrical Cable Type for the ORI link follows section 4.2.3.1 in the CPRI Specification [1].

Electrical Interface Characteristics

No specific Electrical Interface Characteristics are specified by ORI. It is recommended to follow section 6.2 of the CPRI Specification [1].

6 Control plane

6.1 Mapping to CPRI protocol structure

ORI compliant nodes shall apply the usage of subchannels defined in CPRI control words (see [1]), as described in Table 6.1.1.

Table 6.1.1: Subchannel allocation within ORI

Subchannel Ns	Area	Usage
0 to 15	CPRI reserved control words	Refer to CPRI [1] for usage.
16 to 40	Vendor specific area	This area is open for vendor specific use; general ORI rules for vendor specific extensions apply (see GS ORI 001 [2]).
41 to 52	ORI reserved area	This area shall be reserved for specification by ORI. See clause 6.3 for further definition.
53 to 63	Fast C&M channel	This area carries the ORI C&M messaging (for active links only). (min. 10,56 Mbit/s @ 1 228,8 Mbit/s link speed).

NOTE: As the minimum CPRI link rate supported by ORI is 1 228,8 Mbit/s, control words have a minimum width of 16 bits.

The listed allocation leads to the map of CPRI control words, which shall be mapped for active links as described in Figure 6.1.1.

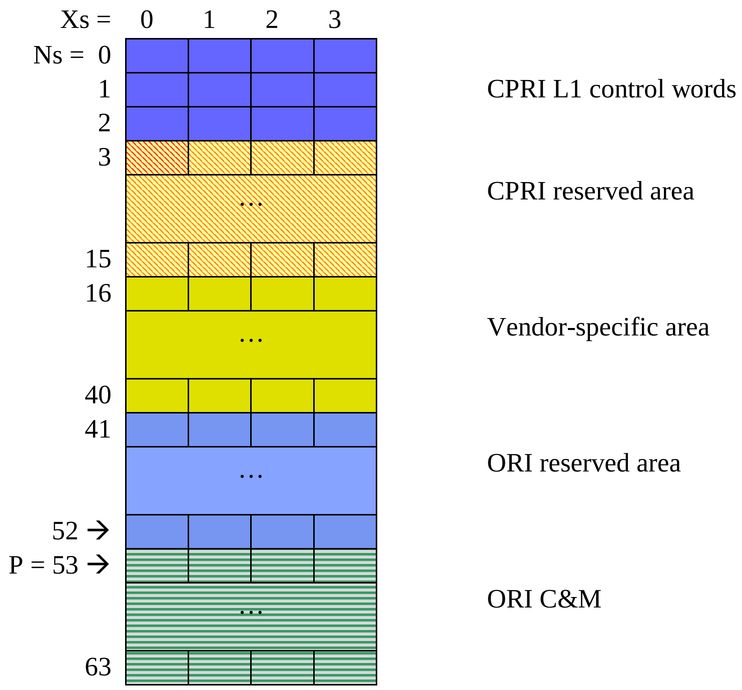

Figure 6.1.1: Control word mapping to subchannel allocation

6.2 C&M resource allocation

The Fast C&M channel, as described in [1] shall be supported by REC and RE for both Downlink and Uplink C&M communication.

The C&M pointer p is defined at byte Z.194.0 in [1].

The master port shall set byte Z.194.0 with p = 53 [dec] for active links, and p = 0 for passive links.

6.3 ORI reserved area

The Control Words in the "ORI reserved area" shall be reserved for specification within ETSI ORI, and shall not be used for other purposes.

The control words within the ORI reserved area shall be allocated as described in Table 6.3.1.

Control words not defined in Table 6.3.1 are reserved for future definition, shall be set to 0 in the present Release of this multi-part deliverable, and shall not be interpreted by the receiving ORI node.

Table 6.3.1: Control word definition within ORI reserved field

Subchannel index Ns	Allocation	Data content	Comment
52	PORT_ID	See clause 6.3.1	
50 and 51	RTWP measurement report	See clause 6.3.2	
49	BFN cycle index	See clause 6.3.3	Only Y = 0 shall be reserved for this control word.

6.3.1 PORT_ID

The PORT_ID uniquely identifies an ORI port of an ORI node (RE or REC). It is defined as follows:

<PORT_ID> = <MAC address><ORI port number><reserved byte>

MAC address: Ethernet MAC address of the node (size: 6 bytes).

ORI port number: one byte indicating the port number (from 1 to 255) per node. The port number 0 shall not be used but is reserved for possible future purposes (e.g. testing); therefore up to 255 ports per node can be addressed.

Reserved byte: The transmitter shall send zero for the reserved byte and the receiver shall not interpret this byte.

The size of the PORT_ID is 8 bytes in total such that the information completely fills two bytes (Y = 0, Y = 1) of the subchannel. For line rates higher than 1,228 Gbps, the additional bytes (Y > 1) of the subchannel shall be treated as reserved.

The exact bitwise mapping of the PORT_ID shall be as shown in Table 6.3.1.1.

Table 6.3.1.1: Allocation of PORT_ID within subchannel

Byte number	Bit number	Z.52.Y	Z.116.Y	Z.180.Y	Z.244.Y
Y = 0	B = 0 : : B = 7	LSB of reserved byte : : MSB of reserved byte	LSB of MAC byte#0 : : MSB of MAC byte#0	LSB of MAC byte#2 : : MSB of MAC byte#2	LSB of MAC byte#4 : : MSB of MAC byte#4
Y = 1	B = 8 : : B = 15	LSB of Port number : : MSB of Port number	LSB of MAC byte#1 : : MSB of MAC byte#1	LSB of MAC byte#3 : : MSB of MAC byte#3	LSB of MAC byte#5 : : MSB of MAC byte#5

The PORT_ID shall be sent by the ORI node in each hyperframe upon achieving L1/L2 synchronization of the ORI link.

An example for topology detection based on the PORT_ID is given in Annex A.

6.3.2 UTRA RTWP measurement report

For UTRA-FDD operation, the Received Total Wideband Power (RTWP) shall be measured and reported from the RE on the ORI link as defined below:

1) RTWP measurement definition:

   The received total wide band power, including noise generated in the receiver, within the bandwidth defined by the receiver pulse shaping filter. The reference point for the measurement shall be the RE (Rx) antenna port, including in the case that receiver diversity is in use by the RE. It is the responsibility of the REC to use the corresponding RTWP reported values to derive the RTWP measurement defined by TS 125 215 [6].

2) RTWP measurement period in the RE:

   The RTWP measurement period shall be 2 ms.

3) RTWP measurement accuracy minimum performance requirement:

   The RTWP measurement performed by RE shall have an accuracy such that the reported value received by the REC allows the REC to meet the RTWP minimum performance requirements defined in TS 125 133 [7] corresponding to the Base Station class supported by the RE.

4) RTWP measurement reporting by the RE performing the RTWP measurement:

   - Reporting conditions:

     ▪ The Received Total Wideband Power measurement shall be reported per AxC of type "UTRA-FDD". Reporting is required for all AxCs of type "UTRA-FDD" that are configured and reporting shall be performed autonomously by the RE. For each AxC, a RTWP reported value shall be reported from the RE in the RTWP measurement report control word on the ORI link (the mapping to the ORI link is defined in GS ORI 002-2 [9]) in every hyperframe, and shall be updated for each AxC by the RE every 2 ms, in hyperframe number 0, 30, 60, 90, 120 (HFN#0, 30, 60, 90, 120).

NOTE: An AxC is configured by higher layers as defined in GS ORI 002-2 [9].

- Mapping of RTWP measured values to RTWP reported values:
    - The RTWP measured value is adjusted according to the value of "Uplink feeder adjustment" prior to reporting, as defined and indicated to the RE in GS ORI 002-2 [9].
    - In Table 6.3.2.1 the mapping of the RTWP measured value (after feeder adjustment) to the RTWP reported value is defined. The reporting range for RTWP is from -112 dBm to -50 dBm.
    - The range in the signalling may be larger than the guaranteed accuracy range. The reported value shall be expressed in 0,1 dB steps.

Table 6.3.2.1: RTWP reported value mapping

Reported value	RTWP Measured value after feeder adjustment	Unit
0x0000	RTWP < -112,0	dBm
0x0001	-112,0 ≤ RTWP < -111,9	dBm
0x0002	-111,9 ≤ RTWP < -111,8	dBm
…	…	…
0x026B	-50,2 ≤ RTWP < -50,1	dBm
0x026C	-50,1 ≤ RTWP < -50,0	dBm
0x026D	-50,0 ≤ RTWP	dBm

5) Mapping of RTWP measurement report to the RTWP measurement report control word:

For the mapping of the RTWP reported value to the RTWP measurement report control word, a unique AxC RTWP group shall be defined in the RE performing the RTWP measurement, for each AxC for which RTWP reporting is required. The mapping of AxC to AxC RTWP group is defined in GS ORI 002-2 [9].

Based on the frame structure described in [1], the mapping of each AxC RTWP group *n* within the location, defined by Y and Xs, of the RTWP measurement report control word within subchannels 50 and 51 shall be derived using the following formula:

AxC RTWP group *n* = (Y*4) + Xs

Table 6.3.2.2 provides an example of the mapping of each AxC RTWP group for Y = 0…(T/8)-1, where the parameter T is defined in the CPRI specification [1].

Table 6.3.2.2: Allocation of RTWP reported value to subchannels

Y values	Subchannel number Ns	Xs=0	Xs=1	Xs=2	Xs=3
0…(T/8)-1	**50**	AxC RTWP group *(Y*4)*	AxC RTWP group *(Y*4)+1*	AxC RTWP group *(Y*4)+2*	AxC RTWP group *(Y*4)+3*
	51				

The mapping of each bit (0…15) of the RTWP reported value to the value of B and the subchannels 50 and 51 shall be as defined in Figure 6.3.2.1 where the bit 0 is the LSB of the RTWP reported value and the bit 15 is the MSB of the RTWP reported value.

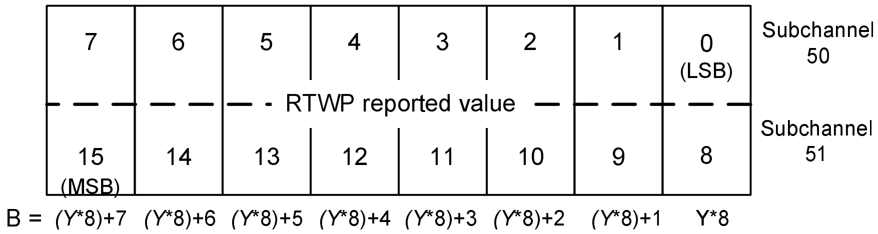

Figure 6.3.2.1: Bit allocation of RTWP reported value

6.3.3 BFN cycle index

The BFN Cycle Index (BCI) identifies the BFN cycle within a contiguous number of 3 BFN cycles.

For an arbitrary sequence of BFN cycles of n = 0…∞, the BFN cycle index shall be calculated as BCI = n (mod 3).

The indicated value of the BCI shall not change within the BFN cycle of 0…4 095.

Further rules for mapping of the BCI to the BFN cycle are defined in clause 7A.1.

A single instance of the BCI is mapped to each of the following locations: Z.49.0, Z.113.0, Z177.0, and Z241.0 using B1 and B0, where B1 is MSB and B0 is LSB, and B7 – B2 are reserved and shall be set to 0 in the present release of the specification.

6.4 Additional requirements for CPRI-defined control words

6.4.1 ORI low layer reset

Upon receiving a valid reset in Z.130.0 as defined in the CPRI Specification [1] the RE shall perform an equivalent to a power-up reset of the RE. The ORI Low Layer Reset may be used when there is no C&M layer established to reset the RE.

6.4.2 LOF

On detecting or receiving LOF (as defined in the CPRI Specification [1]) on a slave ORI port, for all AxCs mapped to that ORI link in the downlink direction, the RE shall immediately stop radio interface transmission. When the ORI link re-enters state F or G, if still configured to do so by the C&M layer, the RE shall resume radio interface transmission for those AxCs.

On detecting or receiving LOF on a master port, the RE shall report this immediately to the C&M layer. Subsequent actions are described in GS ORI 002-2 [9].

6.4.3 LOS

On detecting or receiving LOS (as defined in the CPRI Specification [1]) on a slave ORI port, for all AxCs mapped to that ORI link in the downlink direction, the RE shall immediately stop radio interface transmission. When the link re-enters state F or G, if still configured to do so by the C&M layer, the RE shall resume radio interface transmission for those AxCs.

On detecting or receiving LOS on a master port, the RE shall report this immediately to the C&M layer. Subsequent actions are described in GS ORI 002-2 [9].

6.4.4 SDI

On detecting or receiving SDI (as defined in the CPRI Specification [1]) on a slave ORI port, for all AxCs mapped to that ORI link in the downlink direction, the RE shall immediately stop radio interface transmission. When the SDI is cleared, if still configured to do so by the C&M layer the RE shall resume radio interface transmission for those AxCs.

On detecting or receiving SDI on a master port, the RE shall report this immediately to the C&M layer. Subsequent actions are described in GS ORI 002-2 [9].

6.4.5 RAI

On detecting or receiving RAI (as defined in the CPRI Specification [1]) on a slave ORI port, for all AxCs mapped to that ORI link in the downlink direction, the RE shall immediately stop radio interface transmission. When the link re-enters state F or G, if still configured to do so by the C&M layer, the RE shall resume radio interface transmission for those AxCs.

On detecting or receiving RAI on a master port, the RE shall report this immediately to the C&M layer. Subsequent actions are described in GS ORI 002-2 [9].

6.5 Data link layer for Fast C&M channel

The Data Link Layer for Fast C&M shall be as defined in section 4.4 of [1]. Additional requirements for Ethernet frames are defined in GS ORI 002-2 [9].

7 User plane

7.1 Mapping and format of IQ data

The ORI user plane may be configured to transport IQ sampled data of AxCs for E-UTRA, UTRA-FDD, GSM, compressed E-UTRA, or any combination of E-UTRA, UTRA-FDD, GSM and compressed E-UTRA simultaneously. The RE and REC shall support at least the following configuration of the user plane for the respective scenarios. The parameters are defined in [1].

NOTE: Section 4.2.7.2 of [1] is the basis on which the requirements below have been derived, and further definition of parameters and terms is found in that specification.

7.1.1 E-UTRA

- CPRI mapping method 3 ("backward compatible") shall be used as defined in section 4.2.7.2.7 of [1] and applying the values according to Table 7.1.1.1 that correspond to the different E-UTRA channel bandwidths supported. E-UTRA channel bandwidths are also listed in TS 136 104 [8].
- No AxC grouping (i.e. N_A =1).
- No stuffing samples, i.e. N_V = 0 (N_C = S) for all sampling rates - except 1,92 MHz - as shown in Table 7.1.1.1.
- All S AxC containers of the same AxC Container Block mapped in "packed position". Further mapping is specified in GS ORI 002-2 [9].
- 2's complement code numbers for I and Q data in UL and DL (MSB = sign bit).
- DL and UL sample width M = M' = 15.
- For DL, the maximum transmission power (dBm) per AxC at the RE (Tx) antenna port shall be defined as 100 % when the effective voltage amplitude value V_{RMS} (= sqrt (I^2+Q^2)) = 3 277 [dec].
- For UL, the reception power per AxC at the RE (Rx) antenna port is defined as Pr(= reference sensitivity +67,1 dB) when the effective voltage amplitude value V_{RMS} (= sqrt (I^2+Q^2)) = 16 383 [dec].
- The content of stuffing bits/samples is not specified in ORI specifications.

Table 7.1.1.1: Number N_V of stuffing samples for N_A = 1 (E-UTRA)

E-UTRA channel bandwidth [MHz]	f_S [MHz]	N_A	S	K	N_C	$N_V = N_C \cdot K - N_A \cdot S$
1,4	1,92	1	1	2	1	1
3	3,84	1	1	1	1	0
5	7,68	1	2	1	2	0
10	15,36	1	4	1	4	0
15	23,04	1	6	1	6	0
20	30,72	1	8	1	8	0

7.1.1A Compressed E-UTRA

Section 7.2.1 defines when the requirements for "compressed E-UTRA" shall apply:

- CPRI mapping method 1 ("IQ sample based") shall be used as defined in section 4.2.7.2.5 of [1] and applying the values according to Table 7.1.1A.1 that correspond to each E-UTRA channel bandwidth.
- Number of stuffing bits, i.e. N_{ST} = 0 for all sampling rates - as shown in Table 7.1.1A.1.
- All S AxC containers of the same AxC Container Block mapped in "packed position". Further mapping is specified in GS ORI 002-2 [9].
- 2's complement code numbers for I and Q data in UL and DL (MSB = sign bit).
- DL and UL sample width M = M' = 10.

Table 7.1.1A.1: AxC container size (N_{AxC}) and number N_{ST} of stuffing bits (compressed E-UTRA)

E-UTRA channel bandwidth [MHz]	f_S [MHz]	*S*	*K*	N_{AxC}	N_{ST}
10	11,52	3	1	60	0
15	17,28	9	2	90	0
20	23,04	6	1	120	0

7.1.2 UTRA-FDD

- The mapping shall be according to [1], section 4.2.7.2.
- 2's complement code numbers for I and Q data in UL and DL (MSB = sign bit).
- Downlink (DL) sample width M = 15.
- The maximum transmission power per AxC at the RE (Tx) antenna port shall be defined as 100 % when the effective voltage amplitude value V_{RMS} (= sqrt (I^2+Q^2)) = 3 277 [dec].
- Downlink Oversampling Ratio n = 1.
- Downlink Mapping of AxC Container within one Basic Frame: Option 1 (packed position). Further mapping is specified in GS ORI 002-2 [9].
- Uplink (UL) sample width M' = 7.
- Uplink Oversampling Ratio n = 2.
- IQ data shall express the linear value of voltage amplitude. The RE shall clip the IQ sample data to the limit of the interface format when the linear value would otherwise exceed the range of the interface format.
- Uplink Mapping of AxC Container within one Basic Frame: Option 2 (flexible position) with 2 reserved bits following each UTRA-FDD UL AxC Container - in order to allow the same effective positioning of AxC Containers in UL as in DL (see note). Further mapping is specified in GS ORI 002-2 [9].

NOTE: 1 UL AxC(M' = 7) + 2 reserved bits is in total the same number of bits (30 bits) as 1 DL AxC(M = 15).

- **UL AGC:** The following UL AGC configuration shall be supported:
  - Target RMS level (V_{RMS}):
    - This is configured in the RE via C&M, as defined in GS ORI 002-2 [9].
    - Value range for V_{RMS} (= sqrt (I^2+Q^2)) = 6 to 32[dec], in steps of 1[dec].

- Settling Time:

  Time interval for the RMS level to settle to the configured target RMS level for any RX input power step with a maximum residual error of 1 dB.

  - value range: 66,7 µs x 2^N with N = 0, …, 12

    The N value to be used is configured in the RE via C&M. Capability concerning supported N values are signalled from the RE via C&M. This is further defined in GS ORI 002-2 [9].

  - settling time accuracy: ±20 %

- The maximum power error in AGC settlement for any Rx input power change: ±1 dB.

7.1.3 GSM

7.1.3.1 General

- CPRI mapping method 1 (IQ sample based) shall be used, as defined in clause 4.2.7.2.5 of [1].
- The GSM symbol rate shall be 1 625 / 6 ksymb/s, see clause 2.1 of TS 145 004 [11]. The corresponding sampling rate shall be according to Table 7.1.3.1.1 for downlink and uplink respectively.
- DL sample width M = 14.
- For DL, the maximum transmission power (dBm) per AxC at the RE (Tx) antenna port shall be defined as 100 % when the effective voltage amplitude value V_{RMS} (= sqrt (I^2+Q^2)) = 1 834 [dec].
- UL samples shall be coded in Mantissa exponent format as described in clause 4.2.7.2.1 of [1]. The following parameters shall be used:
  - M' = 14
  - L = 12

NOTE: This leads to an exponent with a length of 4 bits.

- Downlink and uplink mapping of AxC Container within one Basic Frame: Option 2 "flexible position". In addition the following rule shall be satisfied for the start position of each AxC container within the basic frame:

  [T*(W-1) + B] (mod 5) = 0, where T, W, and B are defined in [1].

Table 7.1.3.1.1: Sampling rates for GSM in downlink and uplink

Direction	Sampling rate (kHz)
Downlink	3250/3
Uplink	1625/3

IQ sampling shall be performed by the REC/RE independently of the GSM time slot timing, i.e. there is no requirement for the ORI node performing the sampling to take into account GSM time slot boundaries.

7.1.3.2 Usage of AxC container block stuffing bits

The stuffing bits 0…N_{ST}-1 of each AxC container block, transported in downlink and uplink direction respectively, shall be used as follows:

- Downlink direction:
  - Bits 10… N_{ST}-1: reserved for future use by ORI.
  - Bits 0…9: used to transport the information described in clause 7.1.3.2.1.

- Uplink direction:
  - Bits 0… N_{ST}-1: reserved for future use by ORI.

NOTE: N_{ST} is defined in [1].

7.1.3.2.1 Frequency hopping information (downlink stuffing bits 0… 9)

Definition

Frequency hopping information consists of a single "n" value, as specified in Table 2-2 of [12], that is used to derive the downlink and uplink ARFCN within the frequency band configured by the C&M layer in GS ORI 002-2 [9] that the RE, terminating this downlink AxC, shall use to transmit/receive over the radio interface during a specific GSM time slot for this downlink AxC, and the uplink AxC, to which it is associated, where association is configured by C&M in GS ORI 002-2 [9].

AxC container block mapping

Frequency hopping information shall be transported in the stuffing bit locations 0...9 of every AxC container block that is transported for each GSM AxC configured in downlink direction.

For AxC container blocks 0…*i* of a GSM AxC fully or partially containing IQ data for a single downlink GSM time slot N, where AxC container block 0 is sent first, the REC shall include the "frequency hopping information" for downlink and uplink GSM time slot N in each of the container blocks 0…*i-1*.

NOTE: This means that AxC container blocks containing IQ data for more than one GSM time slot will always have available the frequency hopping information for the latest GSM time slot to be transmitted/received.

The RE terminating this downlink AxC (and any corresponding uplink GSM AxC) shall therefore be able to apply the frequency hopping information for the downlink and uplink GSM time slots before corresponding transmission/reception of those GSM time slots by the RE on the radio interface (i.e. within T2a + $DLCal_{RE}$ defined in GS ORI 002-2 [9]).

Coding and value range

The bits 0..9 shall be expressed with B0 = LSB and B9 = MSB to express a single value of "n".

The value range of n = 0…1023. Only valid values for the frequency band shall be used.

7.1.4 E-UTRA, UTRA-FDD and GSM in combination

For any combination involving at least 2 of E-UTRA, UTRA-FDD and GSM, mapping and format of IQ data for each of the used radio standards shall apply at the same time.

7.2 IQ data compression/decompression

7.2.1 General

IQ data compression/decompression shall only be applied to IQ data, and shall be restricted to E-UTRA channels with channel bandwidth of 10 MHz, 15 MHz, or 20 MHz .

An ORI node applying IQ data compression to an E-UTRA AxC shall carry out the following steps in order:

1) Assume input I/Q data samples to the compression process inline with the requirements in clause 7.1.1.

2) Compress each I/Q data sample such that the output of the compression process is a corresponding I data sample or Q data sample that follows the requirements for "compressed E-UTRA" IQ data in clause 7.1.1A.

3) Send the "compressed E-UTRA"IQ data via the master ORI port in downlink direction, or via the slave ORI port in uplink direction.

An ORI node applying IQ data decompression to an E-UTRA AxC shall carry out the following steps in order:

1) Assume input compressed I/Q data samples that were received via the slave ORI port in downlink direction, or via the master ORI port in uplink direction are inline with the requirements for "compressed E-UTRA" IQ data in clause 7.1.1A.

2) Attempt to decompress each input I data sample and Q data sample such that the output of the decompression process is a corresponding I data sample or Q data sample that follows the requirements for "E-UTRA" IQ data in clause 7.1.1.

Compression/decompression shall only be applied by ORI nodes explicitly configured by higher layers to terminate the AxC.

7.2.2 Compression process

The compression process consists of the down-sampling process and non-linear quantization process.

7.2.2.1 Down-sampling

In this process, the sampling rate shall be reduced (down-sampled). The ratio of the output sampling rate to the original input sampling rate shall be 3/4.

7.2.2.2 Non-linear quantization

The non-linear quantization consists in applying a surjective function to the I and Q sample values. This function and the non-linear quantization process is described in more detail in clause 7.2.4.

7.2.3 Decompression process

The decompression process consists of the inversed non-linear quantization process and up-sampling process.

7.2.3.1 Inversed non-linear quantization process

The inversed non-linear quantization process consists in applying one inverse function of the function used for the non-linear quantization described in more detail in clause 7.2.4.

7.2.3.2 Up-sampling

In this process, the sampling rate shall be increased (up-sampled).

7.2.4 Non-linear quantization process

Commonly the baseband signal transmitted/received for an LTE carrier may be regarded as following a normal distribution.

Therefore, the amplitude distribution of the signal can be described using standard deviation (σ) and mean (μ).

The non-linear quantization process utilizes the frequency of occurrence of the different amplitudes of the baseband signal, with the aim that amplitudes that occur more frequently are more accurately represented in the compressed signal than amplitudes that occur less frequently.

The estimated CDF function of the baseband signal is therefore intended as the method to determine how the different amplitudes in I and Q domain of the I/Q sampled LTE baseband signal are mapped to compressed I and Q sample values. The CDF function is characterized by the parameters "σ" and "μ", where μ is assumed to be 0 for the process.

The above approach allows a fine granularity of decision levels to be used for I and Q samples of LTE baseband signal waveforms of small amplitude, and a coarse granularity to be used for I and Q samples of signal waveforms of large amplitude, as schematically shown in Figure 7.2.4.1.

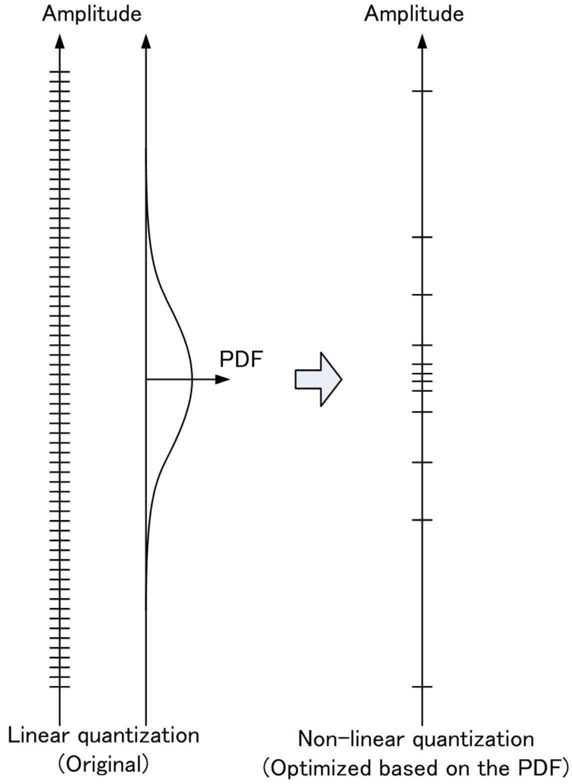

Figure 7.2.4.1: Non-linear quantization based on the probability density function (PDF) of the I/Q amplitude

Firstly, the compression function in the ORI node shall model the I/Q amplitude distribution of the sampled data for I samples and Q samples separately, and shall derive it by using the cumulative distribution function (CDF) *g(x)* (see equation 2) of the normal distribution function *f(x)* (see equation 1).

For both equations, the following definitions and values apply:

- *x* shall be the integer value of the original I or Q sample~~d~~ to be compressed. The value of *x* shall be within the I/Q amplitude range $[-2^{N-1}...2^{N-1}-1]$, and the sample width, N = 15 (bits).
- σ is the compression parameter, where the value of σ shall be configured by higher layers as defined in GS ORI 002-2 [9].

$$f(x) = \frac{1}{\sqrt{2\pi}\cdot\sigma} exp\left(\frac{-x^2}{2\sigma^2}\right) \quad (1)$$

$$g(x) = \frac{1}{2}\left(1 + erf\left(\frac{x}{\sqrt{2}\cdot\sigma}\right)\right) \quad (2)$$

Then, the function *g(x)* shall be mapped to *h(x)* to generate the "compressed" I and Q samples respectively, by using equation (3) where:

- *h(x)* is the integer value of the "compressed" I or Q sample to be generated as the result of the non-linearization process, where the integer value of *h(x)* shall be within the range $[0...2^M -1]$.
- M = 10, where M shall be the width (in bits) of the "compressed" I or Q sample.

$$h(x) = \lceil g(x) * (2^M - 1) \rceil \quad (3)$$

Figure 7.2.4.2 provides a graphic representation of the non-linear quantization process for further understanding.

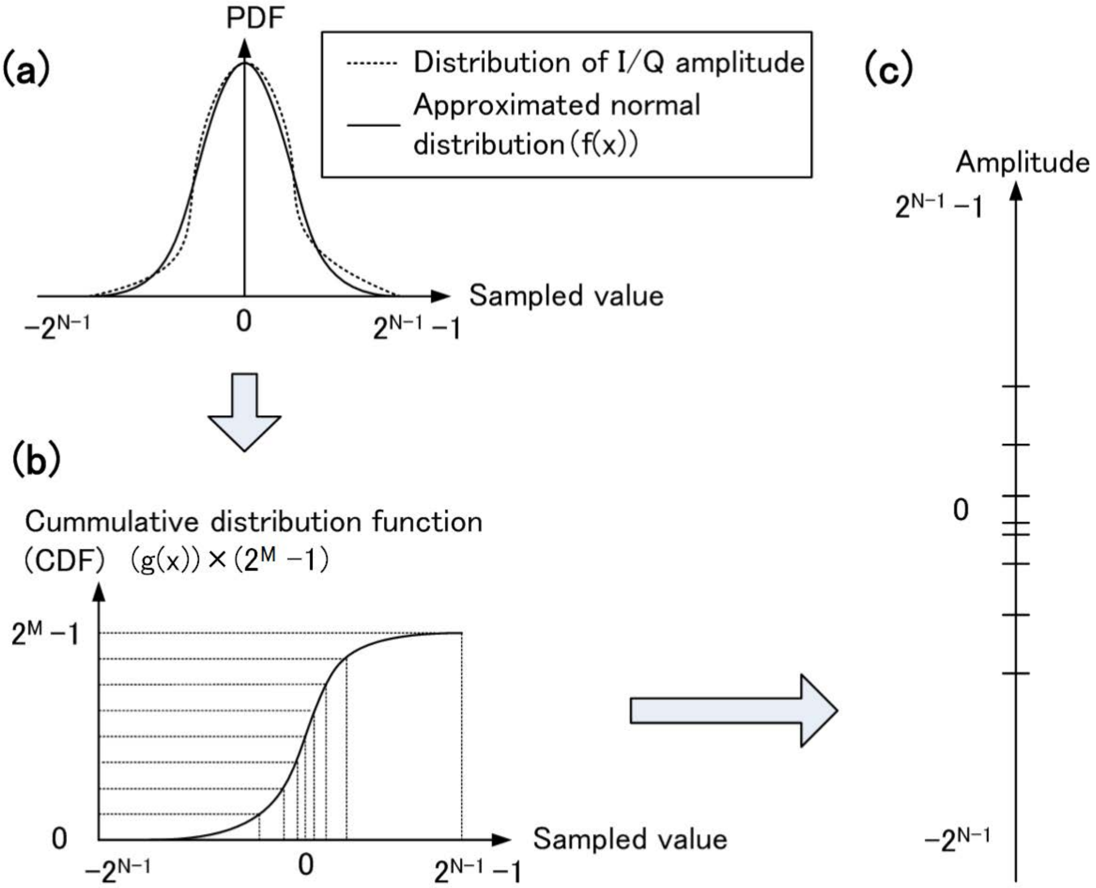

Figure 7.2.4.2: Optimizing process of non-linear quantizer based on the probability density function (PDF) of the I/Q amplitude

7A Synchronization and timing

7A.1 GSM frame timing aspects

In order to support requirements in [1] for GSM frame timing, the BFN Cycle Index control word specified in clause 6.3.3 shall be supported by REC and RE for transmission and reception on both master ports and slave ports.

Furthermore, the REC shall index each downlink cycle of BFN# 0…4 095 using the BFN Cycle Index (BCI). The BFN Cycle Index (BCI) identifies the BFN cycle within a contiguous number of 3 BFN cycles. For an arbitrary sequence of BFN cycles of n = 0…∞, the BFN cycle index shall be calculated as BCI = (n)mod(3). The value of the BCI shall not change within the BFN cycle of 0…4 095.

The REC and RE shall support requirements defined in section 4.2.8.3 of [1] for downlink operation. The "GSM frame offset" shall be equal to 0 when both the BCI = 0, and CPRI frame "m" = BFN#0. Given that 60 ms is a factor of 3 × 4 096 × 10 ms, this means that this same GSM frame offset shall only apply at the start of every BFN cycle with value BCI = 0.

The above mapping shall be fixed and apply for all GSM AxCs on the same ORI link.

Figure 7A.1.1 further illustrates how the BCI, BFN cycle, 60 ms cycles, are related, as well as the mapping of AxC container blocks of GSM AxCs.

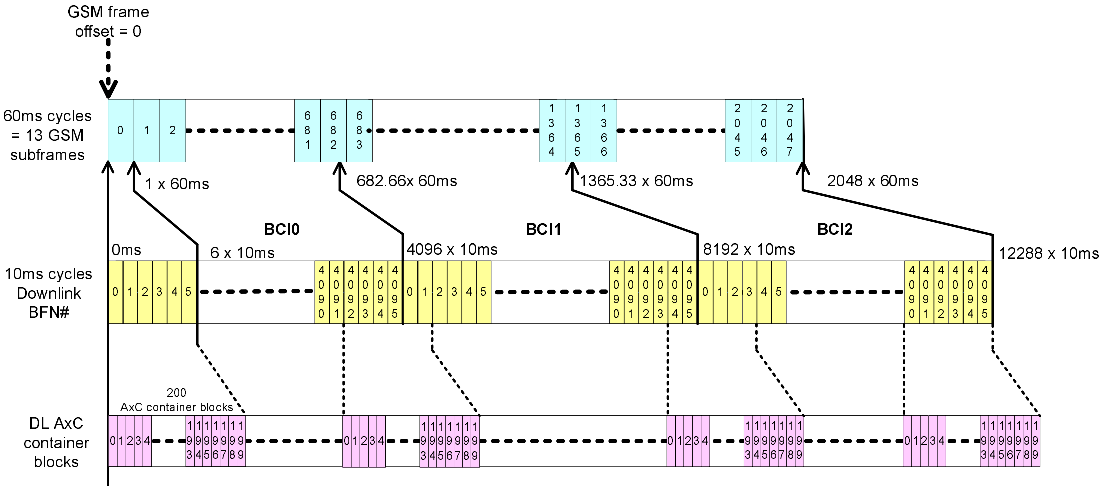

Figure 7A.1.1: Timing relationship and mapping between downlink GSM AxC container blocksand BFN/BFN cycle

8 ORI start-up sequence

8.1 General

The start-up sequence shall follow section 4.5 of [1] with the following additions and/or exceptions.

8.2 Optical interface

For optical interface, the additional actions shall be followed:

In CPRI State A:

- Master port: the output shall be off.
- Slave port: the output shall be off.

In CPRI State B:

- Master port: the optical output shall be switched "from off to on" upon entering state B of the start-up sequence.
- Slave port: the optical output shall be off until the slave port has detected optical light from the master port on the other side of the link and has reached synchronization state HFNSYNC in State B.

In CPRI States C through G:

- Master port: the output shall be on.
- Slave port: the output shall be on.

8.3 CPRI Transition 6 in ORI

Trigger:

- All of the ORI specific negotiations and vendor specific negotiations have been successfully completed.
- Note that, if neither ORI specific negotiation nor vendor specific negotiation is defined, the transition 4 (state D to E) directly causes the transition 6.

NOTE: The definition of any vendor specific negotiation is not specified in the ORI specifications.

Actions:

- The "layer 1 start-up timer" is cleared.

8.4 Layer 1 start-up timer value

The L1 start-up timer is defined in section 4.5.2 of the CPRI Specification [1]. The master port and the slave port shall use the following value as the L1 start-up timer expiry value, with the exception when "vendor specific" negotiation is involved and for which case the timer value can be extended accordingly.

Master port: 9,9 seconds to 10,1 seconds.

Slave port: 9,9 seconds to 10,1 seconds.

NOTE: If ORI vendor specific negotiation in state E is involved, this value has to be reconsidered.

8.5 CPRI State B duration in ORI

In state B, the slave port shall attempt to reach synchronization state HFNSYNC for at least the duration of 10 minutes.

Annex A (informative): Example for topology detection based on PORT_ID

PORT_IDs are sent via a L1 control word upon achieving L1/L2 synchronization on a CPRI link (see clause 6.3.1). Figure A.1 shows the PORT_IDs of an exemplary topology.

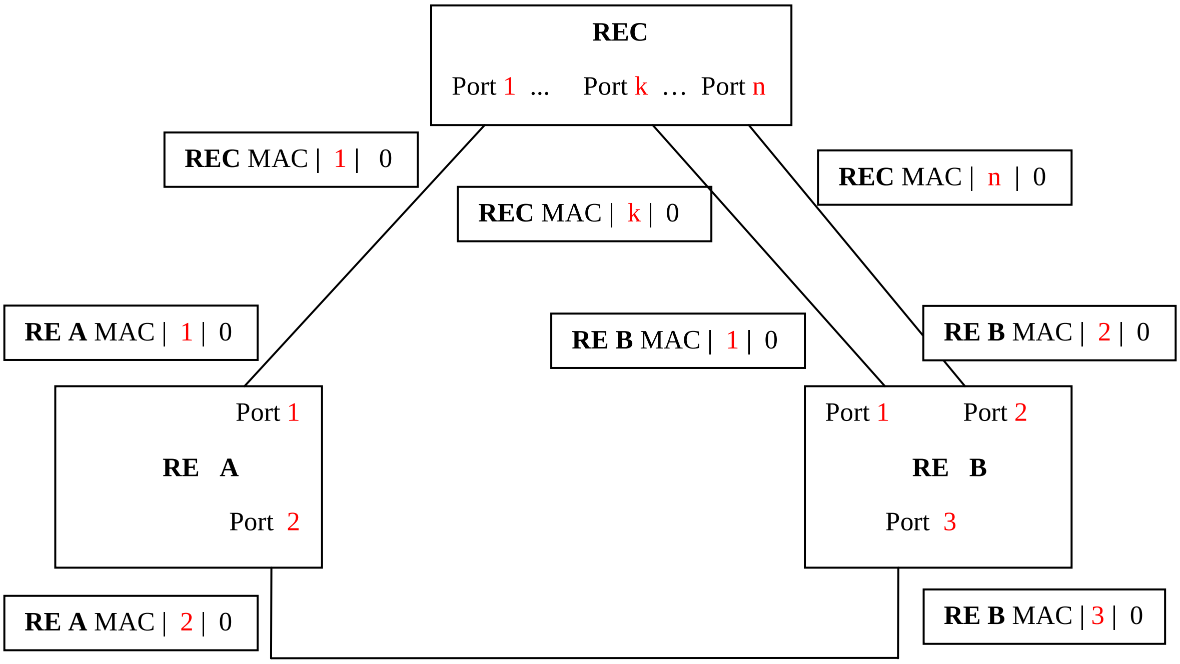

Figure A.1: Topology example

In single hop topologies, a REC is directly connected to all REs. Therefore, the REC can derive the complete topology directly from the L1 control word containing the PORT_ID.

For multi-hop topologies, the REC can derive neighbour relations based on L3 PORT_ID reports as exemplarily shown in Table A.1.

Table A.1: PORT_ID reports for the example given in Figure A.1

Node	Transmitted PORT_ID	Received PORT_ID
Known in REC:	REC MAC | 1 | 0	RE A MAC | 1 | 0
	…	…
	REC MAC | k | 0	RE B MAC | 1 | 0
	…	…
	REC MAC | n | 0	RE B MAC | 2 | 0
Reported by RE A:	RE A MAC | 1 | 0	REC MAC | 1 | 0
	RE A MAC | 2 | 0	RE B MAC | 3 | 0
Reported by RE B:	RE B MAC | 1 | 0	REC MAC | k | 0
	RE B MAC | 2 | 0	REC MAC | n | 0
	RE B MAC | 3 | 0	RE A MAC | 2 | 0

History

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