Technical Description

Harmony Trunk

DragonWave

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INTRODUCTION

The Harmony Trunk is a hybrid microwave solution with the capability to smoothly migrate from full-TDM, to Hybrid, to full-IP via a simple software configuration. Operators can transport TDM and IP signals natively over the air without any encapsulation or mapping. The Harmony trunk's outage-less expansion and upgrade process ensure a rapid and simple installation and fast network roll-out. With its advanced features and performance, the Harmony Trunk can significantly enhance existing copper and fibre optic core transport systems.

SOLUTION HIGHLIGHTS:

- Smooth migration from legacy SDH to SDH/IP to full-IP via software configuration
- Best in class density (16 channels in one ETSI rack)
- Double terminal single-rack (up to 8xWG node in a rack)
- Full digital self-commissioning
- Adaptive modulation from 4QAM to 512QAM with LDPC coding
- Upgradable to XPIC and asynchronous operation
- High power up to +35dBm
- ATPC and RTPC/MTPC 20dB range
- Diversity available: FD, RX SD, TX+RX SD, Hybrid SD
- 2x(1+1) HSBY co-channel supported in same shelf
- Multi-baseband interface: STM-1 electrical, STM-1 optical , STM-4 and Gigabit Ethernet can co-exist in the same terminal
- Gigabit Ethernet interface supported with Nx RF carriers mapping and adaptive load balancing
- Fully outdoor version available up to 7+1 / 8+0 for site cost optimization

1. GENERAL CHARACTERISTICS

Baseband Interfaces

Native SDH	STM-1 electrical (Rec.ITU-T G.703) STM-1 optical (Rec.ITU-T G.957, S-1.1, L-1.1) STM-4 optical (Rec.ITU-T G.957, S-4.1, L-4.1)
Native IP	GE 1000base-T (IEEE 802.3ab) GE 1000base-SX (IEEE 802.3z) GE 1000base-LX (IEEE 802.3z)

Equipment Traffic capacity in Native SDH mode

Main Baseband	STM-1 electrical or optical, STM-4
Gross bit rate	192.384 Mbps (64QAM @ 40MHz) per each carrier
	169.344 Mbps (128QAM @ 28-30MHz) per each carrier

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Equipment Traffic capacity in Native IP mode

Main Baseband	GigaEthernet (electrical or optical via SFP)
Gross bit rate (40MHz)	64.128 Mbps @ 4QAM per each carrier
	96.192 Mbps @ 8QAM per each carrier
	128.256 Mbps @ 16QAM per each carrier
	160.320 Mbps @ 32QAM per each carrier
	192.384 Mbps @ 64QAM per each carrier
	224.448 Mbps @ 128QAM per each carrier
	256.512 Mbps @ 256QAM per each carrier
	288.576 Mbps @ 512QAM per each carrier
Gross bit rate (28-30MHz)	48.384 Mbps @ 4QAM per each carrier
	72.576 Mbps @ 8AM per each carrier
	96.768 Mbps @ 16QAM per each carrier
	120.960 Mbps @ 32QAM per each carrier
	145.152 Mbps @ 64QAM per each carrier
	169.344 Mbps @ 128QAM per each carrier
	193.536 Mbps @ 256QAM per each carrier
	217.728 Mbps @ 512QAM per each carrier

Radio Throughput in Native IP mode

Net Radio Throughput (40MHz)	43.01 Mbps (4QAM) per each carrier
	75.26 Mbps (8QAM) per each carrier
	107.01 Mbps (16QAM) per each carrier
	138.75 Mbps (32QAM) per each carrier
	170.50 Mbps (64QAM) per each carrier
	202.75 Mbps (128QAM) per each carrier
	233.47 Mbps (256QAM) per each carrier
	265.73 Mbps (512QAM) per each carrier
	281.60 Mbps (512QAM+) per each carrier
Net Radio Throughput (28-30MHz)	30.66 Mbps (4QAM) per each carrier
	54.56 Mbps (8QAM) per each carrier
	78.45 Mbps (16QAM) per each carrier
	102.74 Mbps (32QAM) per each carrier
	126.63 Mbps (64QAM) per each carrier
	150.53 Mbps (128QAM) per each carrier
	174.82 Mbps (256QAM) per each carrier
	198.71 Mbps (512QAM) per each carrier
	211.06 Mbps (512QAM+) per each carrier

Throughput means effective data speed excluding overhead bits: in accordance with RFC1242, throughput is “the maximum rate at which none of the offered frames are dropped by the device”. In the

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following table, such throughput is intended as net radio capacity and not L1 port load, which is higher and dependant on the frame size, thanks to the gap compression mechanism. 512QAM+ (future availability) means a special version of 512QAM format having lighter LDPC FEC, in order to optimize throughput.

Digital service channels

Auxiliary channels available as default:

- 2x2.048 Mbit/s wayside per each STM-1 as default
- 1x64kbps Basic EOW terminal to terminal (no selective/express and omnibus calling)
- 1x192kbps DCC for management purposes

Additional optional auxiliary channels available via AUX card:

- 1x64kbps EOW voice channel for selective/express and omnibus calling
- Up to 3x64kbit/s Radio User Channels (RUC) per each direction

The optional RUC channels can be chosen digital (G.703 or V.11) or analogue VF by means of proper HW sub-module mounted on AUX card.

Operating Frequency Bands

40MHz Frequency spacing

4	GHz	3.6-4.2	ITU-R Rec. F.635 Annex 1
5	GHz	4.4-5.0	ITU-R Rec. F.1099 Annex 1
6U	GHz	6.4 - 7.1	ITU-R Rec. F.384
		6.4 - 7.1	ITU-R Rec. F.384 INTERLEAVED
11	GHz	10.7 - 11.7	ITU-R Rec. F.387
		10.7 - 11.7	ITU-R Rec. F.387 Annex 2

28-30MHz Frequency spacing

U4	GHz	3.8 - 4.2	ITU-R Rec. F.382
L6	GHz	5.9 - 6.4	ITU-R Rec. F.383
L7	GHz	7.1 – 7.4	ITU-R Rec. F.385
U7	GHz	7.4 – 7.7	ITU-R Rec. F.385
		7.4 – 7.7	ITU-R Rec. F.385 Annex 1
L7/U7	GHz	7.11 – 7.75	ITU-R Rec. F.385 Annex 3
8	GHz	7.7 - 8.2	ITU-R Rec. F.386-8 Annex 6
		7.9 - 8.4	ITU-R Rec. F.386-8 Annex 3, OIRT
		7.9 - 8.5	CEPT ECC/REC/(02)06
11	GHz	10.0- 10.7	CEPT/ERC 12 05 Annex A
13	GHz	12.7- 13.2	ITU-R Rec. F.497

IF frequencies

Tx side:	First IF : 140 MHz; second IF: 844 MHz
Rx side:	First IF : 844 MHz; second IF: 140 MHz

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RF oscillator

Type of RF local oscillator:	PLL Synthesizer
Frequency agility / tunability:	Half band (4-8 GHz) Quarter band (11-13 GHz)

Adaptive Time Domain Equalizer (ATDE)

Type of ATDE equalizer:	11 taps linear transversal equalizer (LTE) with 10 taps decision feedback equalizer (DFE)

Cross-Polar Interference Canceller (XPIC)

Type of XPIC canceller:	10 taps full digital LTE XPIC equalizer
XPIC gain (XPIF)	20dB
XPIC Delay Equalization	Automatic up to 150ns
Synch cable between CC carriers	Not required (asynchronous XPIC equalization)

SD Combiner

Type of combiner	3dB gain combiner at BaseBand
Combiner operation	In-Phase Max Power (MaP) / Minimum Dispersion (MiD)
Phase shifter	EPS 3500 deg/s
SD Delay Equalization	Automatic up to 150ns

Protection switching

Native SDH mode:

1:N Radio Protection Switching	Errorless Hitless Unipolar Switch (USW) at BaseBand
1:1 Line Protection Switching	Redundancy of BB cards via proper MSP subrack

Native IP mode:

Nx Load sharing	Adaptive load balancing (L1 radio trunking byte-by-byte)
1:1 Line Protection	Line LAG and RSTP at BB GE card level

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Background BER

Equipment Background BER	10^{-12}

ATPC and RTPC/MTPC

ATPC Range (Typical)	20 dB
ATPC operation	continuous
ATPC response time (full range)	200 ms
ATPC speed	100 dB/s
ATPC threshold initiator	-45 / -55 / -65dBm (default) SW selectable
ATPC feedback channel	6 bits in RFCOH
RTPC/MTPC Range (Typical)	20 dB
RTPC/MTPC step	1 dB
RTPC/MTPC speed	100 dB/s

2. TRANSCEIVER CHARACTERISTICS

2.1 GENERAL CHARACTERISTICS

RF frequency stability ± 10 ppm

RF flange

- Type of wave guide flange (reference points C, C', Cd)

U4, 4G	5G	6L, 6U	7G, 8G	11G	13G
UDR40	UDR48	UDR70	UDR84	UDR100	UDR120

RF input/output connectors

- Receiver input (@ reference points A / Ad): SMA 50 Ohm
- Transmitter output (@ reference points A'): SMA 50 Ohm

RF Connector for L.O. monitoring point

Type	SMA

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2.2 TRANSMITTER

Transmitted Nominal Power (dBm) @ point A'

4GHz to 8GHz @ 40MHz bandwidth

Modulation	Normal Power (default)	High Power	+2dB Extra boost
4QAM	+30 dBm	+33 dBm	+35 dBm
8QAM	+30 dBm	+33 dBm	+35 dBm
16QAM	+30 dBm	+33 dBm	+35 dBm
32QAM	+30 dBm	+33 dBm	+35 dBm
64QAM	+30 dBm	+33 dBm	+35 dBm
128QAM	+29 dBm	+32 dBm	+34 dBm
256QAM	+28 dBm	+31 dBm	+33 dBm
512QAM	+27 dBm	+30 dBm	+32 dBm

4GHz to 8GHz @ 28-30MHz bandwidth

Modulation	Normal Power (default)	High Power	+2dB Extra boost
4QAM	+29 dBm	+32 dBm	+34 dBm
8QAM	+29 dBm	+32 dBm	+34 dBm
16QAM	+29 dBm	+32 dBm	+34 dBm
32QAM	+29 dBm	+32 dBm	+34 dBm
64QAM	+29 dBm	+32 dBm	+34 dBm
128QAM	+29 dBm	+32 dBm	+34 dBm
256QAM	+28 dBm	+31 dBm	+33 dBm
512QAM	+27 dBm	+30 dBm	+32 dBm

11GHz (40MHz)

Modulation	Normal Power (default)	+2dB Extra boost
4QAM	+30 dBm	+32 dBm
8QAM	+30 dBm	+32 dBm
16QAM	+30 dBm	+32 dBm
32QAM	+30 dBm	+32 dBm
64QAM	+30 dBm	+32 dBm
128QAM	+29 dBm	+31 dBm
256QAM	+28 dBm	+30 dBm
512QAM	+27 dBm	+29 dBm

13GHz (28MHz)

Modulation	Normal Power (default)	+2dB Extra boost
4QAM	+28 dBm	+30 dBm
8QAM	+28 dBm	+30 dBm
16QAM	+28 dBm	+30 dBm
32QAM	+28 dBm	+30 dBm
64QAM	+28 dBm	+30 dBm
128QAM	+27 dBm	+29 dBm
256QAM	+26 dBm	+28 dBm
512QAM	+25 dBm	+27 dBm

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Transmit tolerance and backoff

Tolerance on transmitted power (dB)	± 1 dB
IF linearizer	Pre-distortion type, adaptive and digital
Back-off (64 QAM)	8 dB
Back-off (128 QAM)	9 dB
Back-off (256 QAM)	10 dB
Back-off (512 QAM)	11 dB

Band width at 99% of emitted power for STM-1 signals

	40 MHz spacing	**28-30 MHz spacing**
Necessary and occupied bandwidth (ITU-R Rec. F.1191)	≤ 35.40 MHz	≤ 25.98 MHz
Designation of Emission (ITU Radio Reg. Art 4 and Appendix 6)	35M4 D7W ET	26M0 D7W ET

2.3 RECEIVER

Noise figure @ reference point A (dB)

4 to 8GHz	**11GHz**	**13GHz**
2.0	3.0	4.0

Typical Receiver Threshold (dBm) @ point A for SDH traffic:

STM-1 @ 64QAM/40MHz

Band	**4 to 8GHz**	**11GHz**	**13GHz**
Threshold for BER $\leq 10^{-3}$	-76.5	-75.5	-74.5
Threshold for BER $\leq 10^{-6}$	-75.5	-74.5	-73.5
Threshold for BER $\leq 10^{-10}$	-74.5	-73.5	-72.5

STM-1 @ 128QAM/28-30MHz

Band	**4 to 8GHz**	**11GHz**	**13GHz**
Threshold for BER $\leq 10^{-3}$	-73	-72	-71
Threshold for BER $\leq 10^{-6}$	-72	-71	-70
Threshold for BER $\leq 10^{-10}$	-71	-70	-69

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Typical Receiver Threshold (dBm) @ point A for IP traffic @ 28-30MHz:

4QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-92.5	-91.5	-90.5
Threshold for BER ≤ 10^{-6}	-91.5	-90.5	-89.5
Threshold for BER ≤ 10^{-10}	-90.5	-89.5	-88.5

8QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-88	-87	-86
Threshold for BER ≤ 10^{-6}	-87	-86	-85
Threshold for BER ≤ 10^{-10}	-86	-85	-84

16QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-85	-84	-83
Threshold for BER ≤ 10^{-6}	-84	-83	-82
Threshold for BER ≤ 10^{-10}	-83	-82	-81

32QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-81.5	-80.5	-79.5
Threshold for BER ≤ 10^{-6}	-80.5	-79.5	-78.5
Threshold for BER ≤ 10^{-10}	-79.5	-78.5	-77.5

64QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-78.5	-77.5	-76.5
Threshold for BER ≤ 10^{-6}	-77.5	-76.5	-75.5
Threshold for BER ≤ 10^{-10}	-76.5	-75.5	-74.5

128QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-75.5	-74.5	-73.5
Threshold for BER ≤ 10^{-6}	-74.5	-73.5	-72.5
Threshold for BER ≤ 10^{-10}	-73.5	-72.5	-71.5

256QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-72.5	-71.5	-70.5
Threshold for BER ≤ 10^{-6}	-71.5	-70.5	-69.5
Threshold for BER ≤ 10^{-10}	-70.5	-69.5	-68.5

512QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-69.5	-68.5	-67.5
Threshold for BER ≤ 10^{-6}	-68.5	-67.5	-66.5
Threshold for BER ≤ 10^{-10}	-67.5	-66.5	-65.5

512QAM+ (special 512QAM mode with lighter LDPC to maximize throughput)

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-66.5	-65.5	-64.5
Threshold for BER ≤ 10^{-6}	-65.5	-64.5	-63.5
Threshold for BER ≤ 10^{-10}	-62.5	-61.5	-60.5

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Typical Receiver Threshold (dBm) @ point A for IP traffic @ 40MHz:

4QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-91	-90	-89
Threshold for BER ≤ 10^{-6}	-90	-89	-88
Threshold for BER ≤ 10^{-10}	-89	-88	-87

8QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-87	-86	-85
Threshold for BER ≤ 10^{-6}	-86	-85	-84
Threshold for BER ≤ 10^{-10}	-85	-84	-83

16QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-84	-83	-82
Threshold for BER ≤ 10^{-6}	-83	-82	-81
Threshold for BER ≤ 10^{-10}	-82	-81	-80

32QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-80.5	-79.5	-78.5
Threshold for BER ≤ 10^{-6}	-79.5	-78.5	-77.5
Threshold for BER ≤ 10^{-10}	-78.5	-77.5	-76.5

64QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-77.5	-76.5	-75.5
Threshold for BER ≤ 10^{-6}	-76.5	-75.5	-74.5
Threshold for BER ≤ 10^{-10}	-75.5	-74.5	-73.5

128QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-74.5	-73.5	-72.5
Threshold for BER ≤ 10^{-6}	-73.5	-72.5	-71.5
Threshold for BER ≤ 10^{-10}	-72.5	-71.5	-70.5

256QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-71	-70	-69
Threshold for BER ≤ 10^{-6}	-70	-69	-68
Threshold for BER ≤ 10^{-10}	-69	-68	-67

512QAM

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-69	-68	-67
Threshold for BER ≤ 10^{-6}	-68	-67	-66
Threshold for BER ≤ 10^{-10}	-66	-65	-64

512QAM+ (special 512QAM mode with lighter LDPC to maximize throughput)

Band	4 to 8GHz	11GHz	13GHz
Threshold for BER ≤ 10^{-3}	-65	-64	-63
Threshold for BER ≤ 10^{-6}	-64	-63	-62
Threshold for BER ≤ 10^{-10}	-61	-60	-59

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3. MODEMODULATOR

3.1 GENERAL CHARACTERISTICS

Bandwidth	**28/29/29.65/30 MHz**	**40 MHz**
Type of modulation	4QAM to 512QAM	4QAM to 512QAM
FEC type	LDPC	LDPC
IF	140 MHz	140 MHz
Spectrum Shaping	Square Root Nyquist	Square Root Nyquist
ISI cancellation method	Raised Cosine	Raised Cosine
Roll-off factor	20%	25%
Symbol rate	24.192 Mbit/s	32.064 Mbit/s

3.2 SIGNAL TO NOISE RATIO (C/N, S/N, SNR, RF LOOP) FOR STM-1 SIGNAL (DB)

Modulation format	**64 QAM**	**128 QAM**
BER = 10^{-3}	20.0	24.5
BER = 10^{-6}	21.0	25.5
BER = 10^{-10}	22.0	26.5

4. BRANCHING

4.1 GENERAL CHARACTERISTICS

Return loss 26 dB

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4.2 BRANCHING LOSSES

Branching losses depend on the number of channels equipped in the branching in the same polarization. In the following table Np is the maximum between the number of channels equipped in V polarization and the number of channels equipped in H polarization. Typical average branching losses (Tx + Rx) are evaluated from points A and A' including, TX filter, RX filter, filter circulators and antenna circulators, and are reported in the following table.

Np	4G	U4G	5G	L6, U6G	7G	L8G	11G	13G
1	4.4	4.4	4.6	5.0	6.0	6.0	6.8	7.9
2	5.0	5.0	5.2	5.7	6.8	6.8	7.6	8.7
3	5.6	5.6	5.8	6.4	7.5	7.5	8.3	9.5
4	6.1	6.1	6.3	6.9	8.0	8.0	8.9	10.1
5	6.7	6.7	6.9	7.6	8.7	8.7	9.7	10.9
6	7.2	7.2	7.5	8.2	9.3	9.3	10.3	11.5
7	7.6	-	8.1	8.8	10.0	10.0	11.0	12.3
8	-	-	-	9.4	10.5	10.5	11.6	12.9
9	-	-	-	-	11.0	-	12.4	-
10	-	-	-	-	11.6	-	13.0	-
11	-	-	-	-	-	-	13.7	-
12	-	-	-	-	-	-	14.3	-

5. ENVIRONMENTAL CHARACTERISTICS

5.1 OPERATING CONDITIONS

The equipment meets the environmental conditions standardized in ETSI 300-019-1-3, Class 3.2.

Temperature limits: -5 to 45 °C

Humidity limits: 5% to 95%

Altitude: Up to 4500 m

Maximum recommended temperature limit: up to 60 °C

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5.2 TRANSPORT AND STORAGE

Transport	The equipment meets the environmental conditions standardized in ETSI 300-019-1-2 Class 2.3
Storage	The equipment meets the environmental conditions standardized in ETSI 300-019-1-1 Class 1.3

5.3 WASTE

The system is compliant with European Union's RoHS and WEEE directives.

RoHS:	Restriction of the use of certain Hazardous Substances in electrical and electronic equipment
WEEE:	Waste from Electrical and Electronic Equipment

6. MECHANICAL CHARACTERISTICS

All the modules are housed inside the subrack, mounted inside ETSI standard rack.

Rack dimensions are following:

Height	1800 mm or 2200mm
Width	600 mm
Depth	300 mm

The rack can be chosen 1800mm or 2200mm, as preferred by customer. Following picture shows layout of subrack mounted inside 2200mm rack, with front cover (top view, frontal view and side view).

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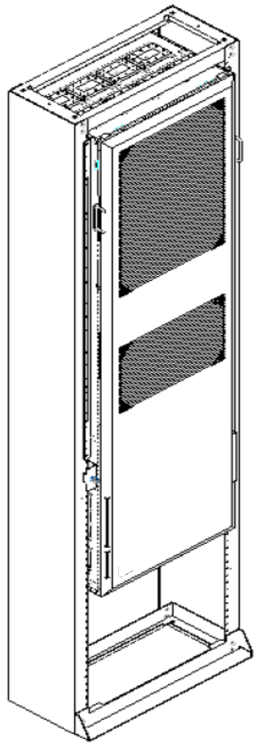
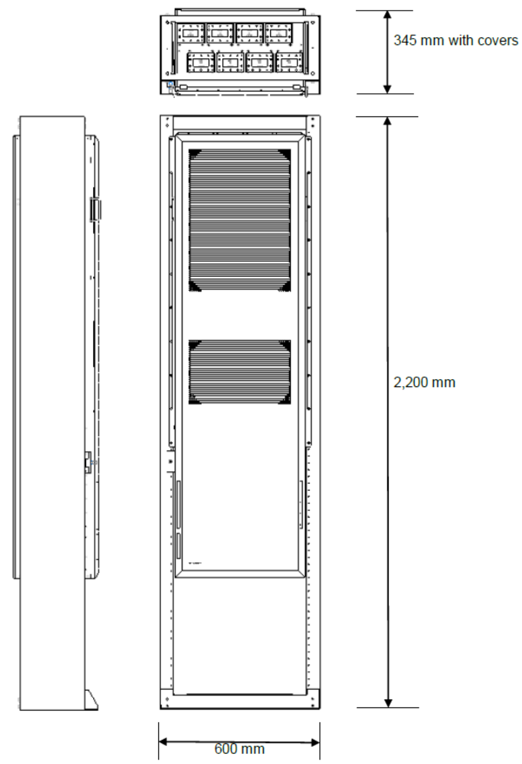
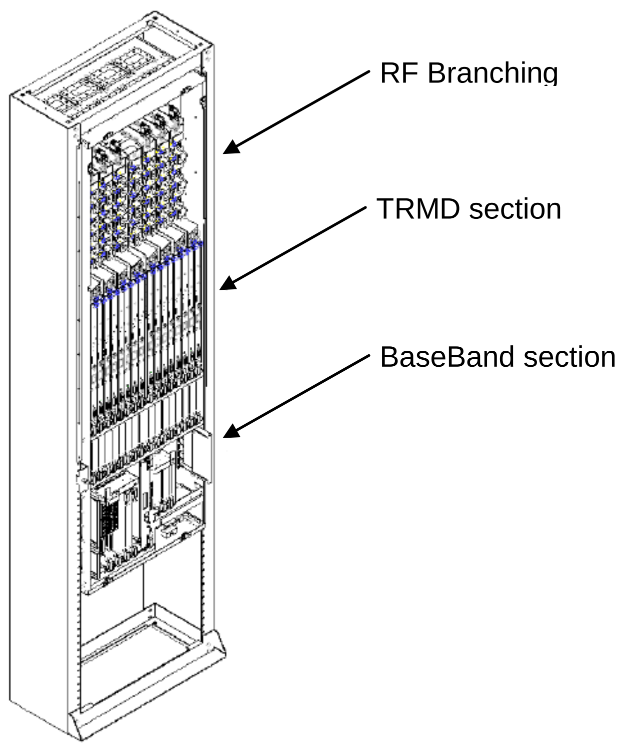




The following picture shows the Harmony Trunk without front cover. All the cards are already mounted when rack is delivered, no intra-rack cabling is needed during installation and commissioning.



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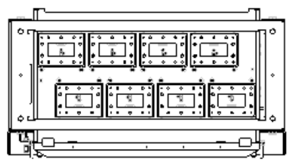
Waveguide connection is generally done by means of flexible and twistable waveguide. Following figure shows the flanges available on the top of the rack (up to 8 flanges are available to allow two directions with two polarizations each and SD each, in the same rack).



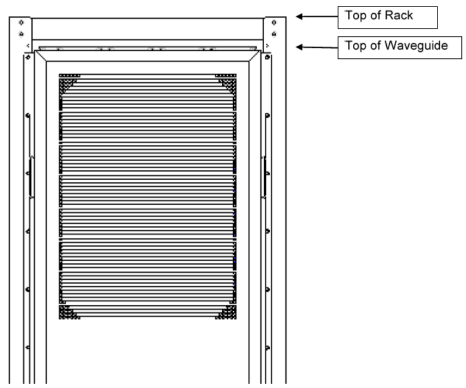
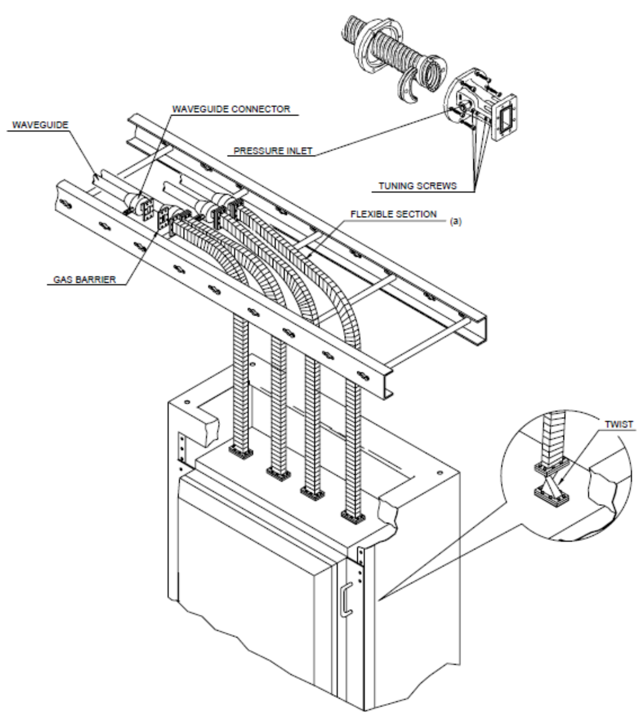


Figure below shows the waveguide connections to the equipment antenna port in the particular case of use of connection by means of flex+twist as recommended.



Example of Feeder Connection for 4 wg runs in a rack

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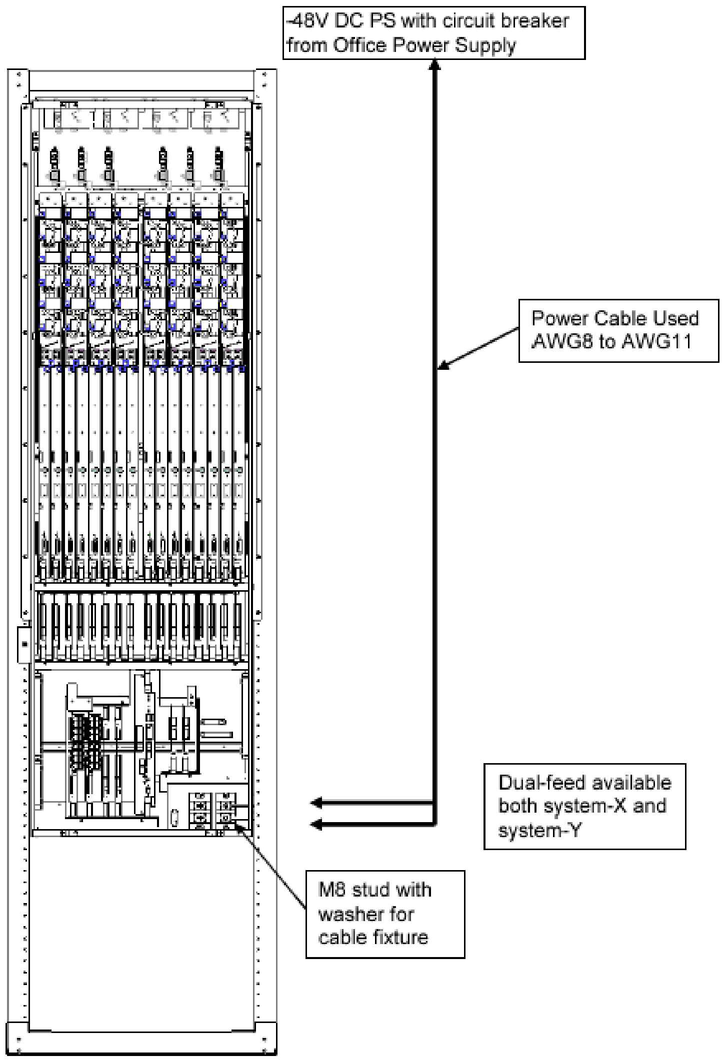
The following picture shows the reference for the 1:1 protected power feed connection.



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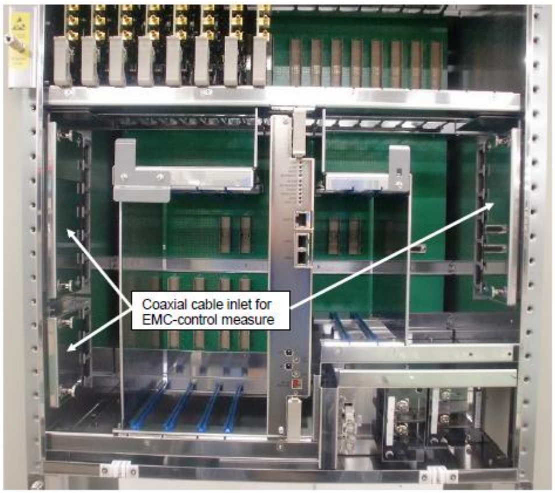
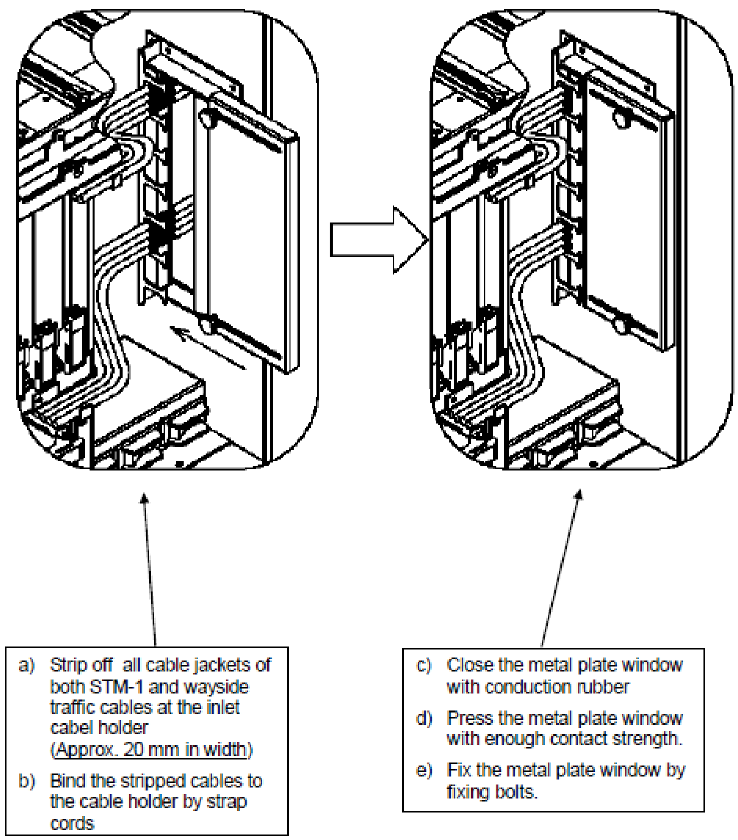
Last step of installation is the preparation and connection of tributary cables. It is interesting to note that the subrack has got very useful inlets for EMC control as shown in the following picture.



The instructions how to use such inlet is reported in following picture.



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7. POWER CONSUMPTION

7.1 NOMINAL FEEDING VOLTAGE

Nominal Voltage (V)	-48 V
Allowed feeding voltage (V)	±20% (-36 to -72 V)
Power feed mains	Single access feed with 1:1 redundancy
Power supply distribution	Via backplane

7.2 POWER CONSUMPTION

Transceiver Unit includes MODEM, TX/RX and RX SD.

Typical values of Power consumption for Harmony Trunk units are reported in the following table.

Unit	**Power consumption (W)**
Transceiver Unit TRMD 4-8GHz (+35dBm Tx power, XPIC, SD)	88 (60 with ATPC)
Transceiver Unit TRMD 11GHz (+32dBm Tx power, XPIC, SD)	80 (60 with ATPC)
Transceiver Unit TRMD 13GHz (+29dBm Tx power, XPIC, SD)	80 (60 with ATPC)
Fan Unit	5
MCF/Controller SV card	10
BB STM-1	6
BB STM-4	20
BB GE ML v1 (GE SW v1, 2xGE + 1xFE)	16
BB GE ML v2 (GE SW v2, 4xGE))	26
BB GE Adapter	1
SPC card (Shared Protection Channel SDH/IP)	6
SFP Module	1
AUX card (optional unit)	13

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8. SYSTEM DESCRIPTION

8.1 GENERAL DESCRIPTION

Harmony Trunk is a digital microwave communication system based on the IP and SDH specifications conforming to international communications standards such as ITU-T, ITU-R and ETSI. It is the suitable choice for trunk communication network in combination with fiber optical transmission system. For the operation, maintenance and monitoring of the whole system, a web-based local craft terminal, element manager and network manager are connected on customer's requirement.

Harmony Trunk system processes native TDM and native IP signals transporting them over the air without any type of ETHoverTDM nor TDMoverETH mapping. The same HW transceiver can be selected by SW as native TDM or native IP device, and applies flexible QAM modulation technology (4QAM to 512QAM with adaptive modulation) with LDPC coding to get best throughput and optimum performances and efficiency.

The system supports, with same HW transceiver SW upgradeable, both alternated pattern and co-channel operation with XPIC equalization, thus doubling spectrum efficiency, eventually with Space Diversity.

ACAP, ACCP and CCDP channeling schemes are supported at all frequency bands without any need of hybrid couplers, thanks to the universal narrow band RF filters implemented.

Also, power boost can be upgraded via SW on the transceiver to increase up to +35 dBm TX power. 20 dB range continuous ATPC and 1 dB step RTPC/MTPC are available to fine-tune TX power to minimize the power consumption down to average 80W/carrier

With different combinations of RF transmit/receive units, RF branching network unit and modulator/ demodulator units, this system can support the full range of radio frequency bands recommended by ITU-R (4G, 5G, L6G, U6G, 7G, L8G, 11G, 13G) and frequency spacing of 28MHz, 29MHz, 29.65MHz, 30MHz, 40MHz and also 56-58-59.3-60MHz.

N+1 up to 15+1 Radio Protection Switching (RPS) is implemented on the radio side using single controller card. Also 2x(N+1) protection scheme can be implemented in the same subrack, as both 2x(N+1) single direction or double direction (add/drop E/W repeater), using same universal MCF/controller card. Hitless switching with very early warning detection and multiple switching criteria is implemented against propagation impairments such as multipath fading. The RPS ensures redundancy of the main signals, Wayside and auxiliary channels, including EOW.

Line side, (1+1) multiplex section protection is implemented for the STM-1 interface as option, while dual line interface with RSTP, MSTP protection and line LAG is available for GigaEthernet interface.

The traffic interface can be chosen STM-1 electrical, optical (SFP module), STM-4 or GigaEthernet (SFP module). Also any mix of such BB interfaces is supported in the same terminal. Following pictures show Block Diagram for the cases of TDM interfaces, IP interfaces, mixed TDM+IP interfaces.

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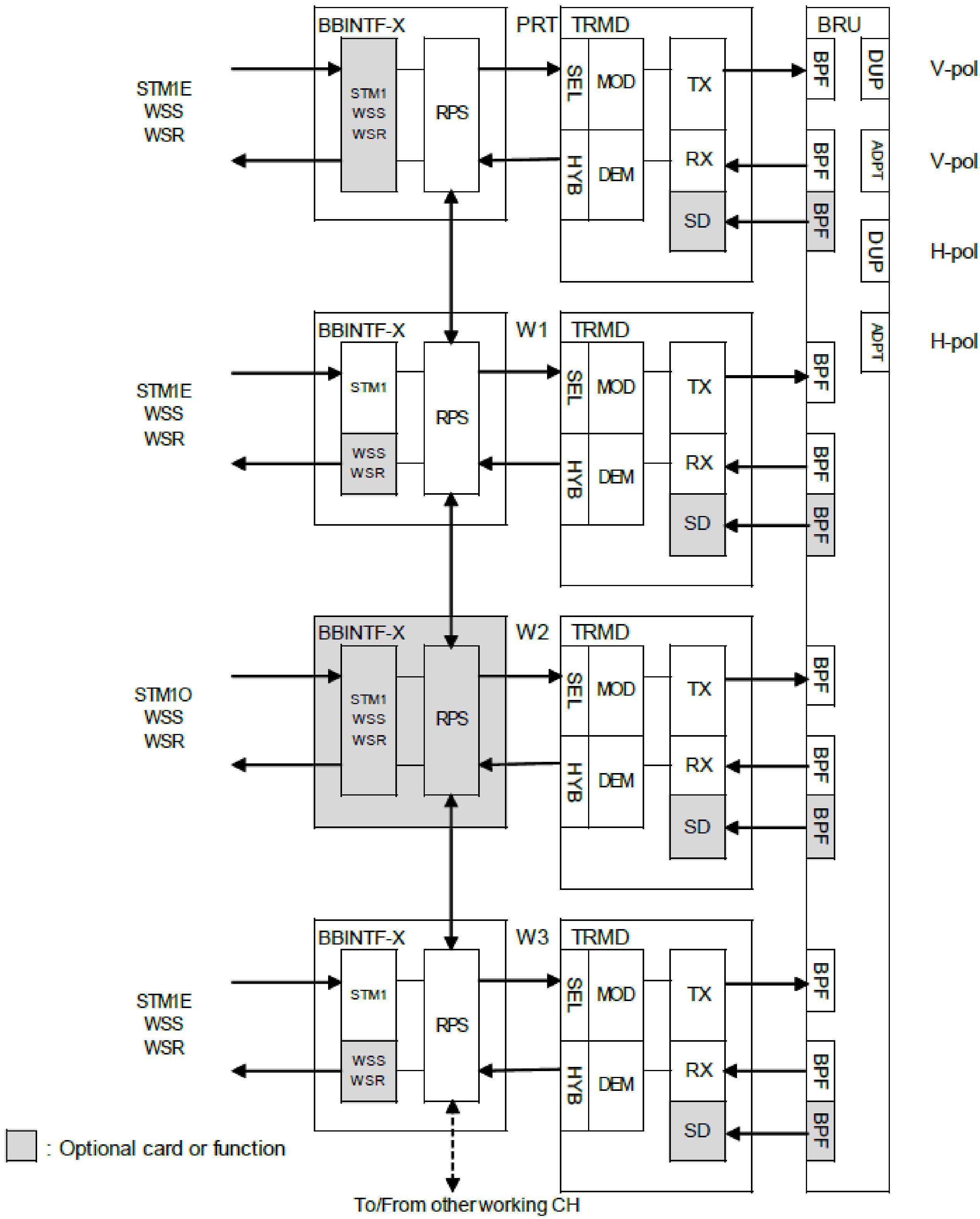

Radio block diagram for TDM STM-1 interface

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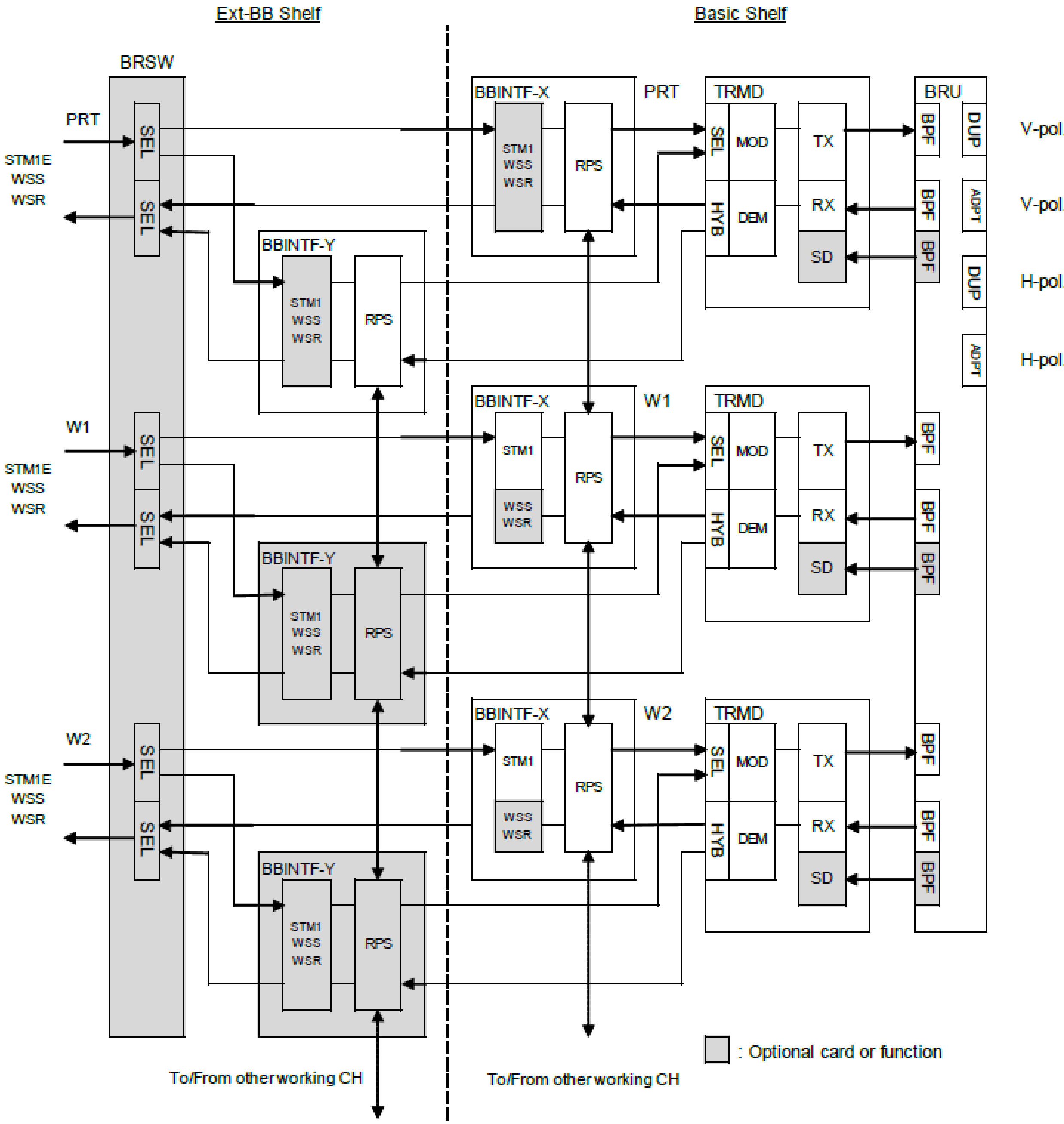

Radio block diagram for TDM STM-1 electrical with redundant DTI interface

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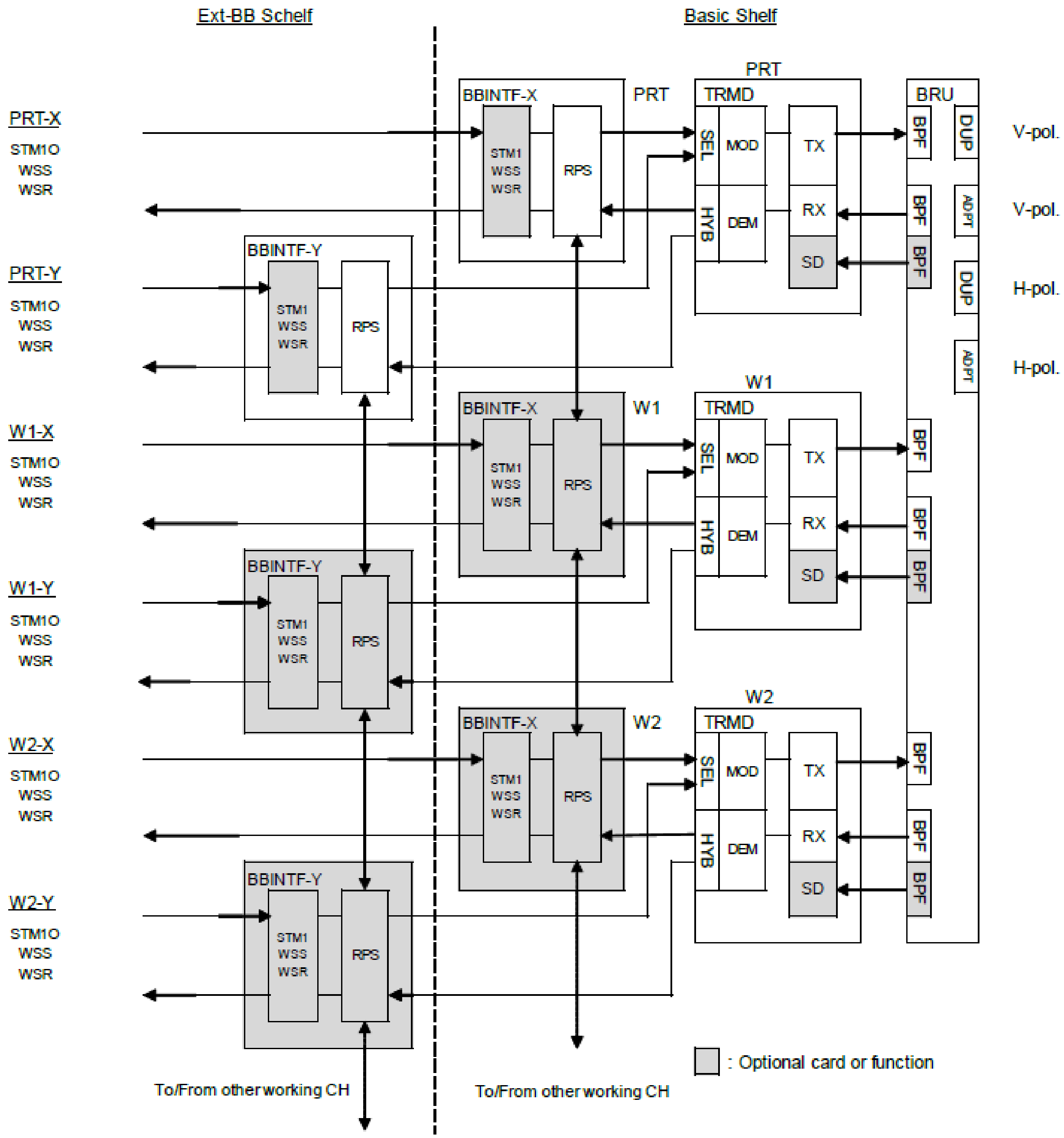

Radio block diagram for TDM STM-1 optical with redundant DTI interface

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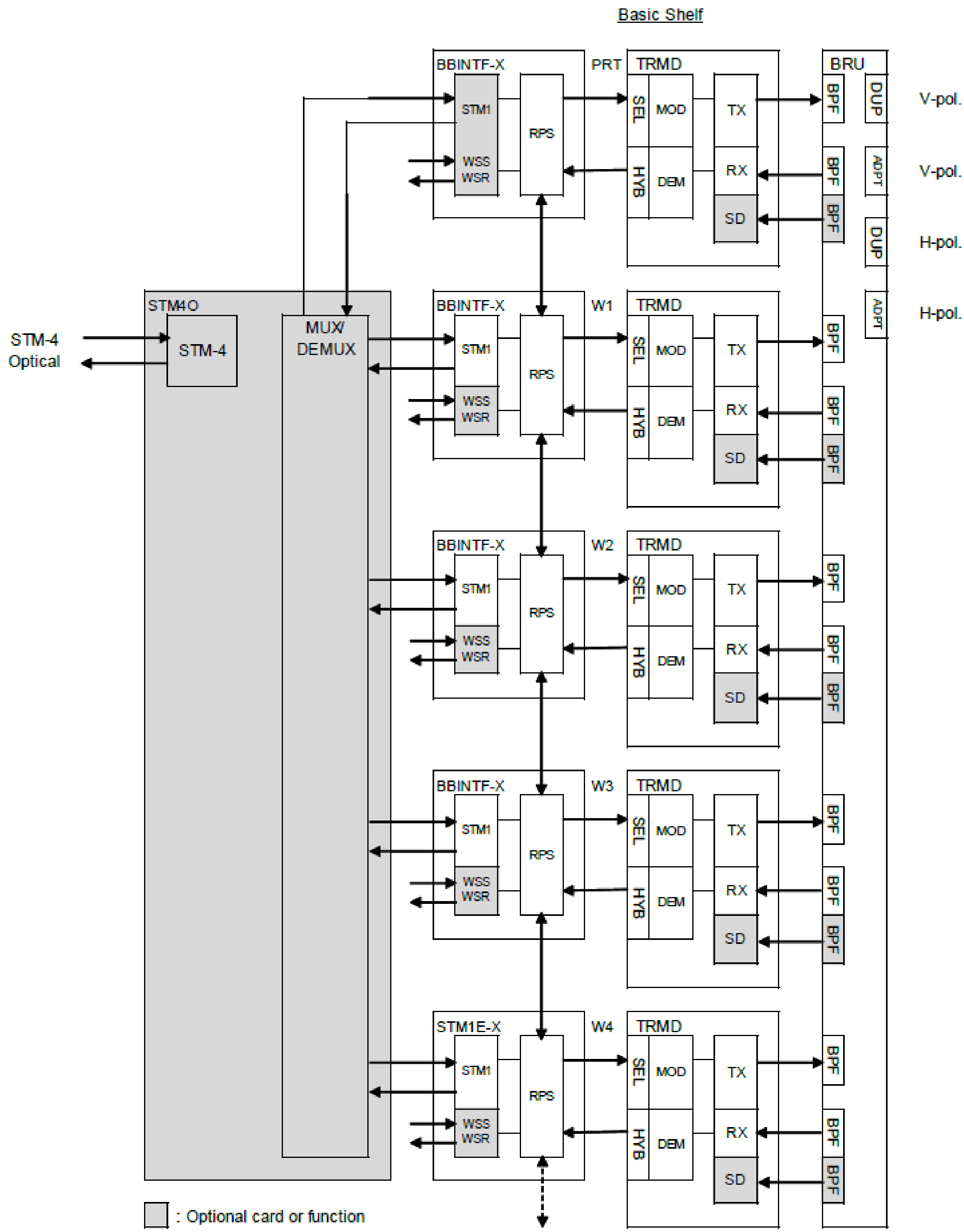

Radio block diagram for TDM STM-4 interface

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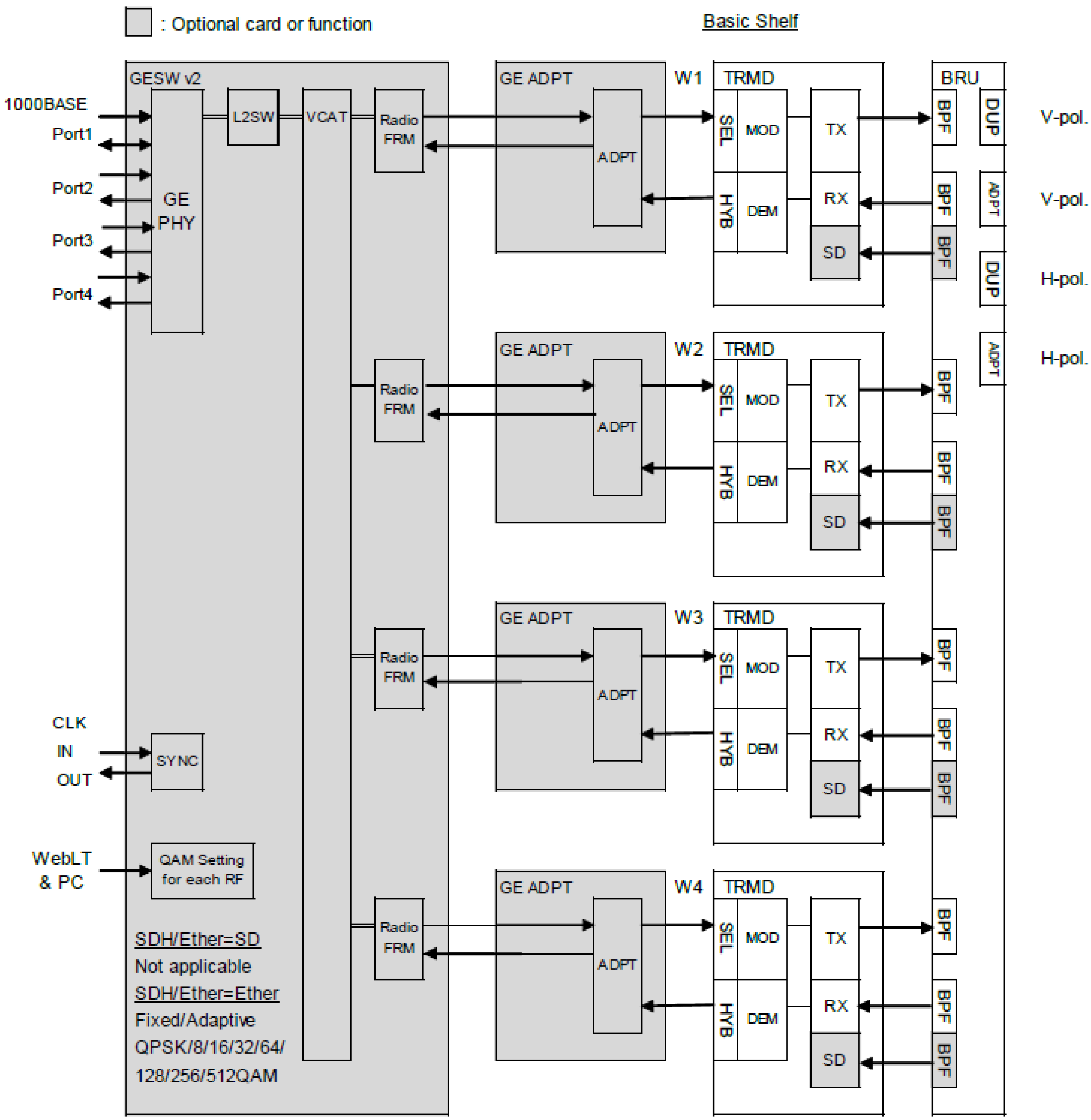

Radio block diagram for GE native IP interface

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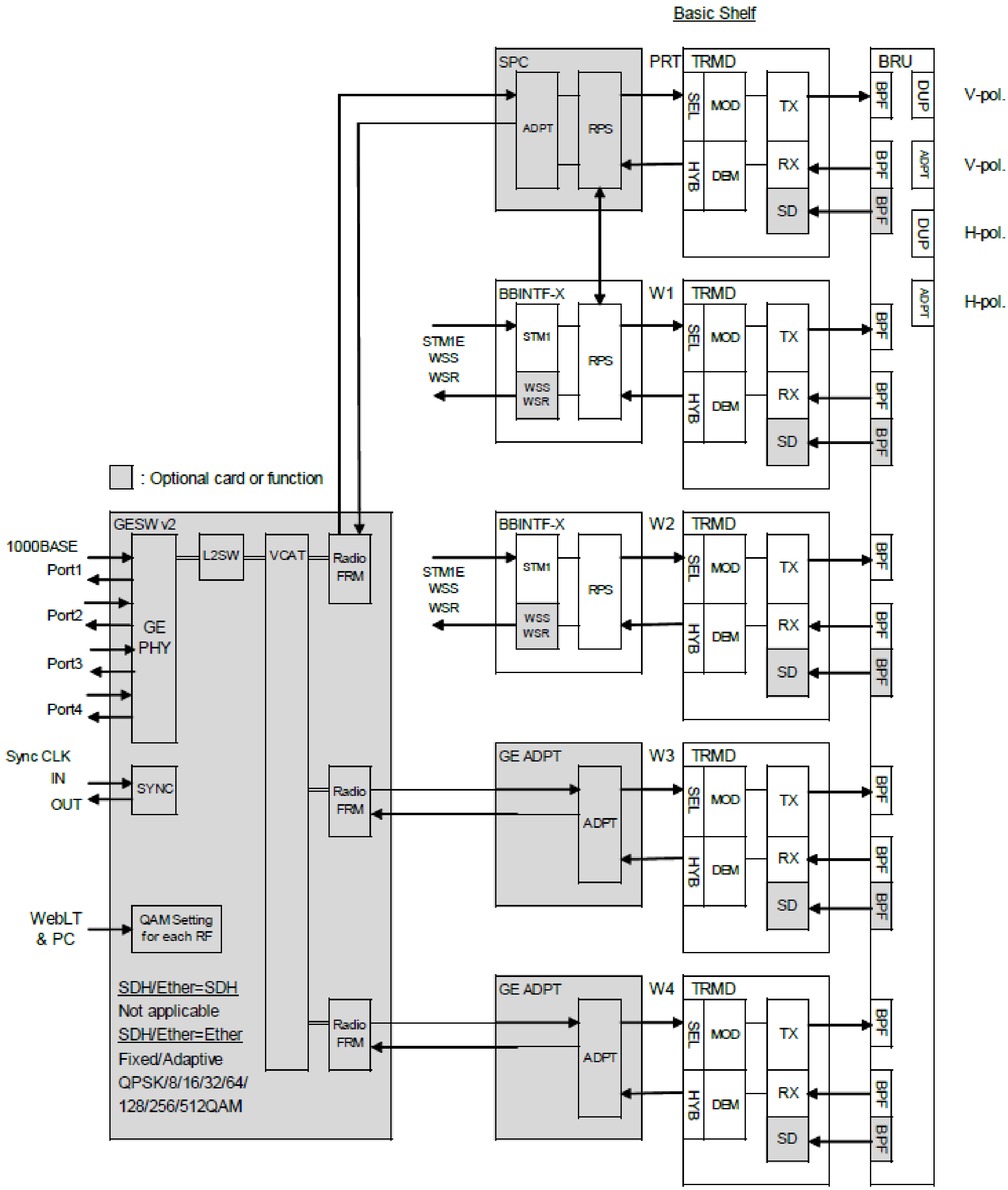

Note: When N+1 RPS for SDH system is activated, Native IP system using protection channel is switched off as low priority traffic.

Radio block diagram for native TDM + native IP interface

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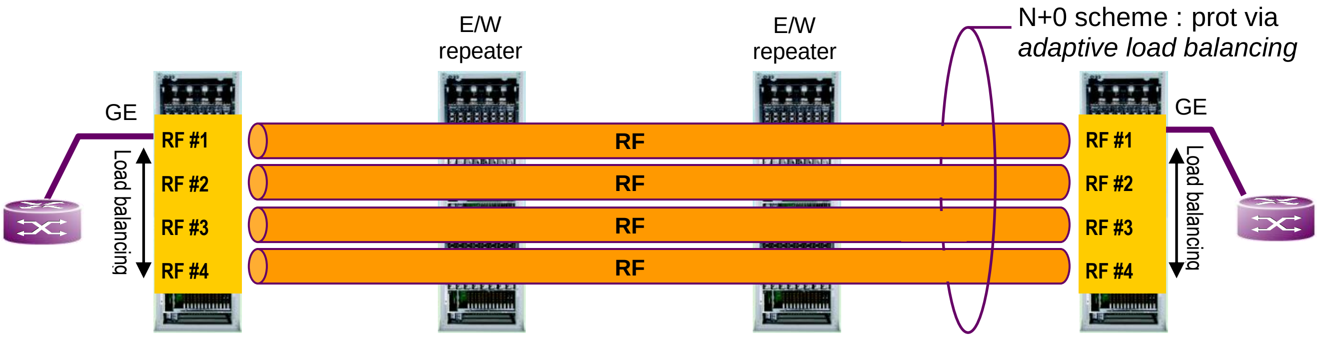
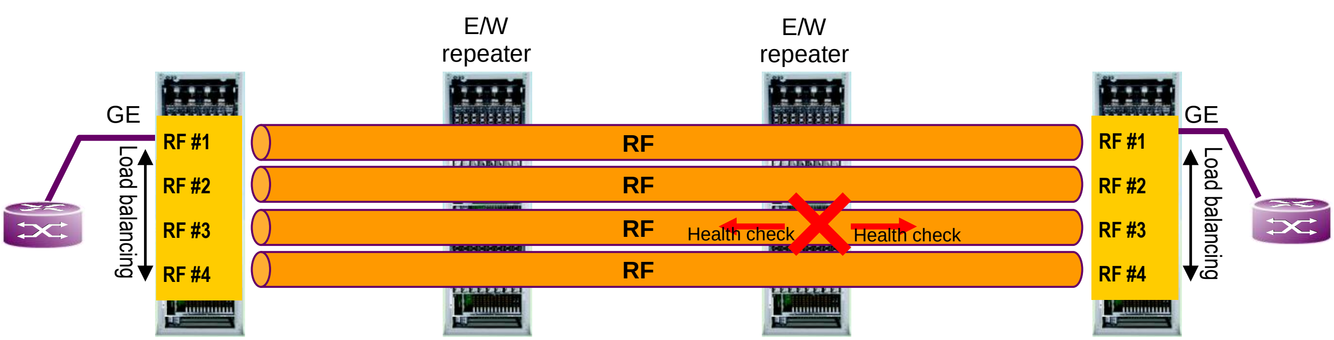
8.2 ETHERNET FEATURES

The GigaEthernet interface is implemented as GE ML (Multi-Link) interface integrating a L2-switch Ethernet device and a digital mapper capable of mapping MxLAN GigaEthernet into Nx RF carriers with layer 1 byte-by-byte adaptive load balancing mechanism (radio bonding).



Mapping of MxGE via 1x GE ML L2 in a 3-hops Trunk chain in 4+0 radio configuration

The main advantage of the GE ML card is the adaptive load balancing among the Nx RF carriers capacity. This function gives the maximum spectral efficiency possible, because there is no need to have a dedicated protection channel which is unused for most of time, but simply the protection is intrinsic, because the faulty channel is simply forbidden to transmit until restored. Basically, the Harmony Trunk equipped with GE ML handles dedicated health check packets, which provide the information about the faulty status of an RF carrier. When a failure is detected, that carrier is not used and the Ethernet traffic is distributed among the (N-1) available RF carriers, until the faulty carrier is restored. Thus, instead of having a standby channel used only in case of failure (which is approximately 1-to-10% of time), the entire reserved spectrum is used fully in the normal propagation conditions (which is approximately 90-to-99% of time), and reduced (QoS-driven) only during the abnormal condition (failure or fading). This concept is depicted in following picture.



Failure detected in a Trunk repeater site: health check packet signalling

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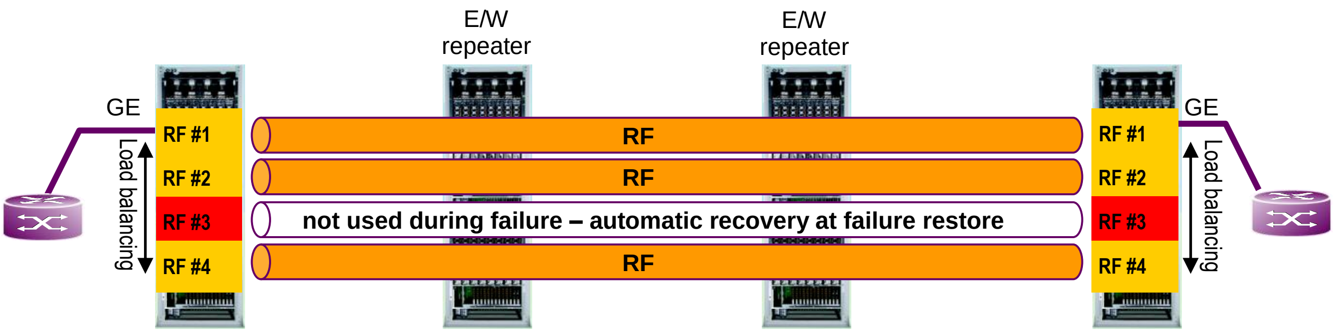
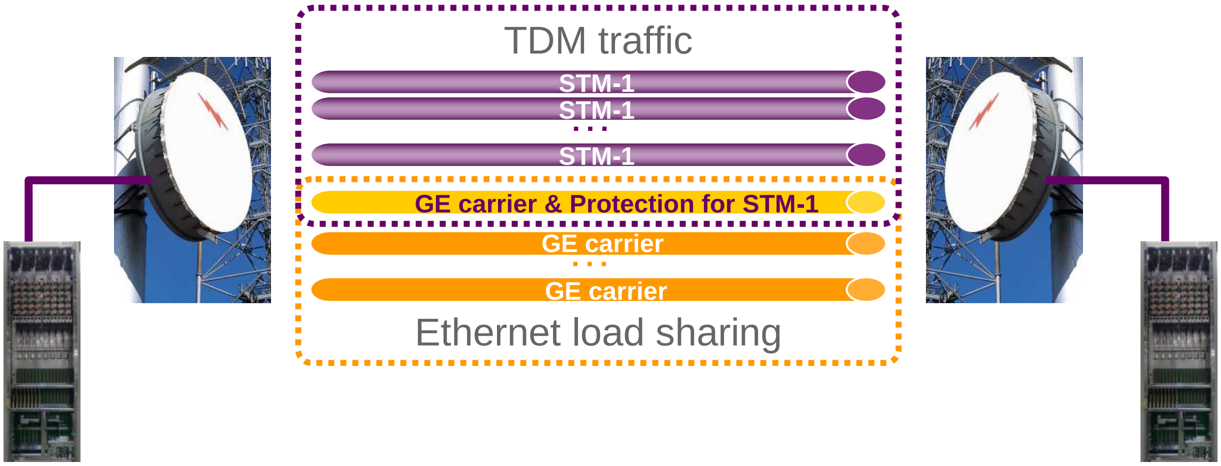


After health check packet signalling, the faulty carrier is inhibited from mapping

This mechanism is even more interesting in case of mixed TDM + Ethernet interfaces scenario, because during normal operation (no failures), the protection channel dedicated to the TDM section can be exploited as container for the GigaEthernet load balancing function, thus using 100% of the available spectrum.



TDM traffic is protected by Ethernet RF carriers: 100% spectrum use for 100% of time!

The GigaEthernet interface implements a SynchE device supporting external E1 clock, line and radio side clock extraction, holdover and free-running modes. 1000BaseT, 1000Base-SX and 1000Base-LX interfaces are interchangeable via SFP module. Half/Full Duplex speed with auto-negotiation is supported for the electrical 1000BaseT interface.

If needed, some TDM channels can be added to an Ethernet traffic group: up to 3x64kbps user channels (G.703 and/or V-11 and/or VF) can be added as option, and also one EOW channel.

The GE ML card of Harmony Trunk is also SW upgradeable via WebLCT to allow Eth features enrichment (VLAN handling, QinQ handling, rate limiting, multicast and broadcast packets handling, storm protection, QoS, RSTP, MSTP, Line LAG for interface protection), in full compliance with IP/MPLS scenarios (.1p, DSCP/DiffServ, MPLS EXP supported). Strict priority and Weighted Round Robin scheduling methods are both supported. Any frame size up to 9.6kbyte Jumbo frames are supported. 128kByte buffer dimension per each port is available to prevent any undesired packet drop.

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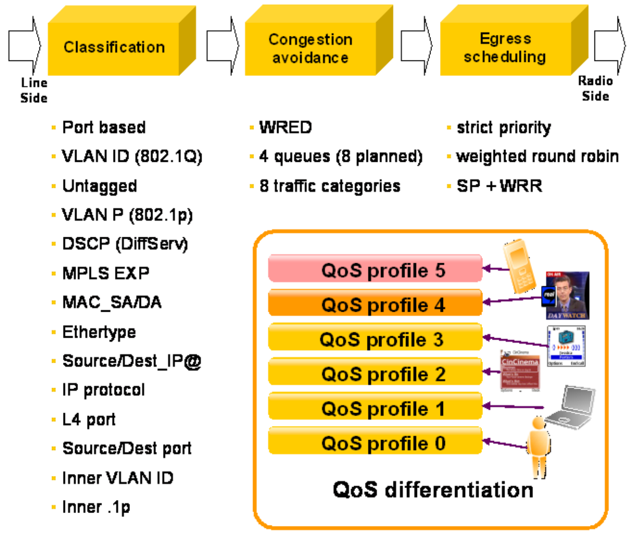
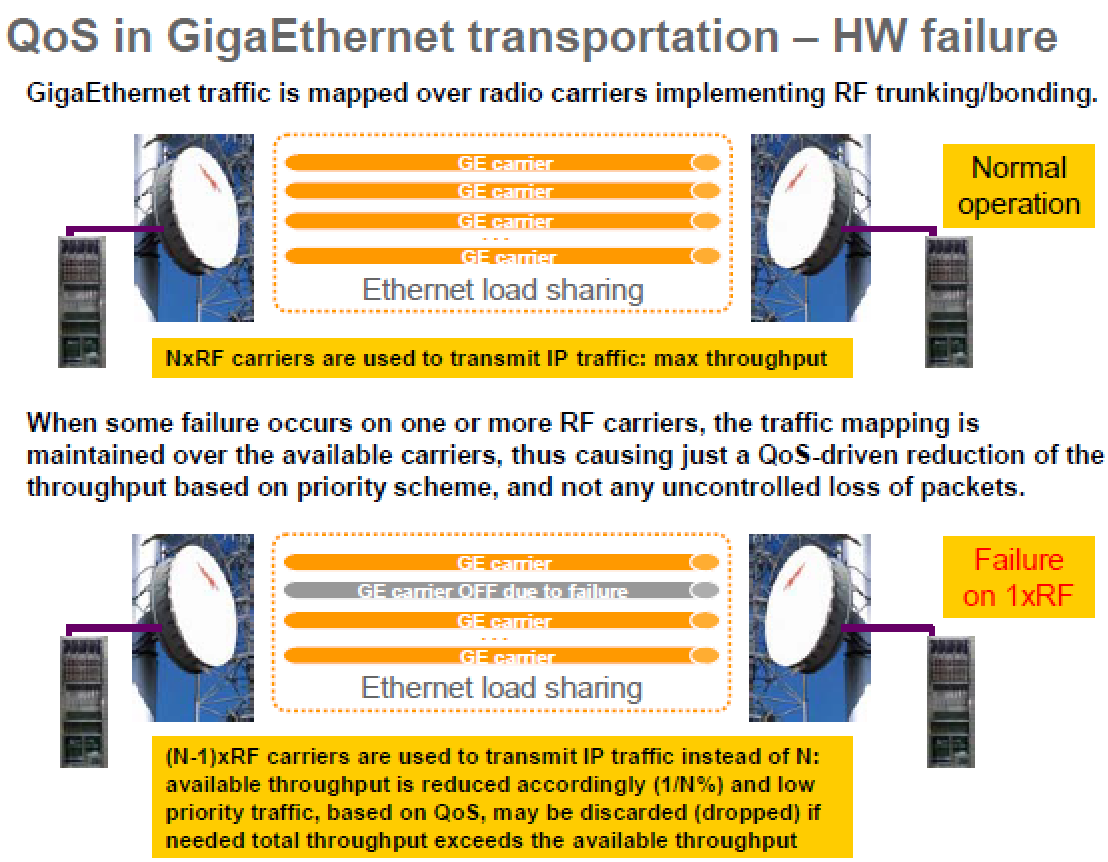


QoS features of Harmony Trunk

Once QoS is activated in the GE ML card, the adaptive load balancing mechanism is implemented in a carrier-grade mode, dropping, if needed in case of failure on one or more RF carriers, just the low priority packets and not the high priority ones.



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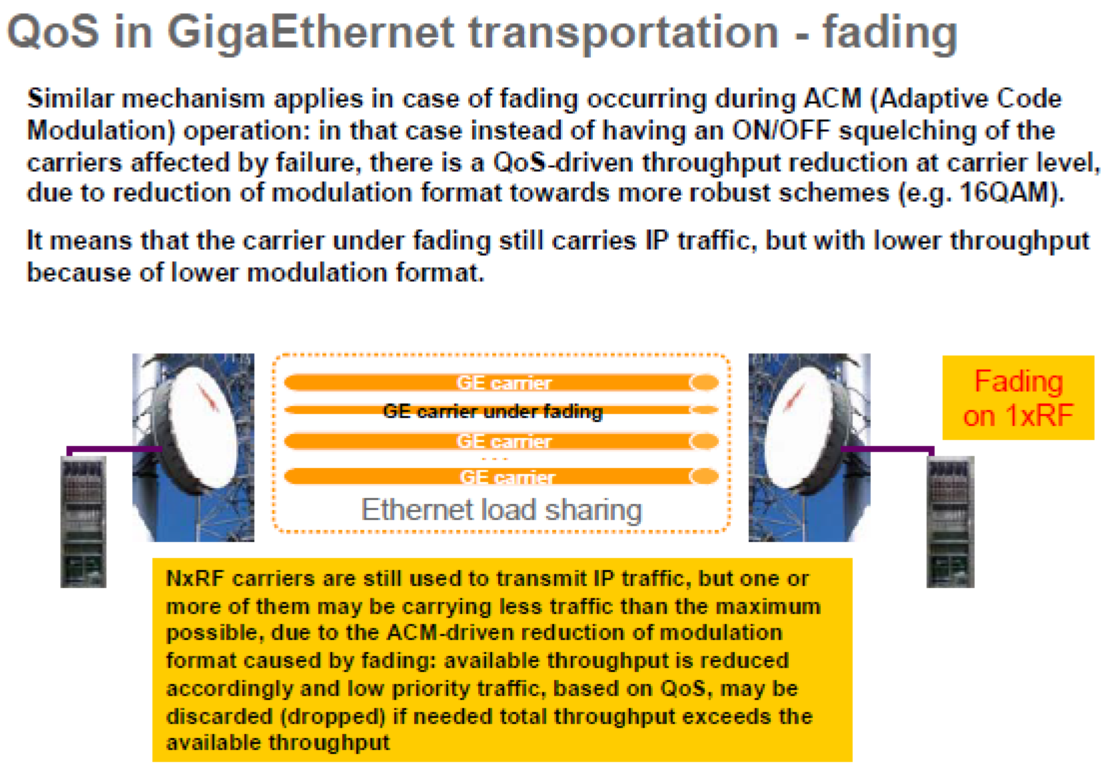
Similar concept applies in case of adaptive modulation activated: capacity of each single RF carrier is increased or decreased based on the current level of fading according to a QoS-driven approach.



8.3 TRANSCEIVER UNIT

The Transceiver Unit is an all-in-one unit that receives the base band (BB) signals and, after processing, it outputs the converted signals to the antenna port via RF Branching section at the required Radio Frequency.

All the functions required for the signal processing are enclosed in this unit: it implements QAM (4/8/16/32/64/128/256/512) modulation with LDPC FEC and the corresponding demodulation; it converts signals into 1st IF (140MHz), then (via synthesizer) to RF through 2nd IF (844MHz).

The STM-1 electrical signals are output from the Transceiver to the outside via the BB interfaces for N+1 RPS switchover (bipolar switchover) in the event of a Transceiver failure. Moreover, to reduce random errors in transmission paths, the LDPC forward error correction method is used. In addition to the main signals, the Transceiver also processes the input and output signals of the 2x2Mb/s Way Side traffic (one on SOH and one on RFCOH, applicable only to native SDH signals) and of the optional user channels. These signals are accessed through the baseband interface unit in the same way as the main signals. RPS DADEing function, together with Space Diversity DADEing, XPIC DADEing, group delay and amplitude of IF-IF response are all implemented in the transceiver unit in digital and automatic mode via powerful SW embedded in the system.

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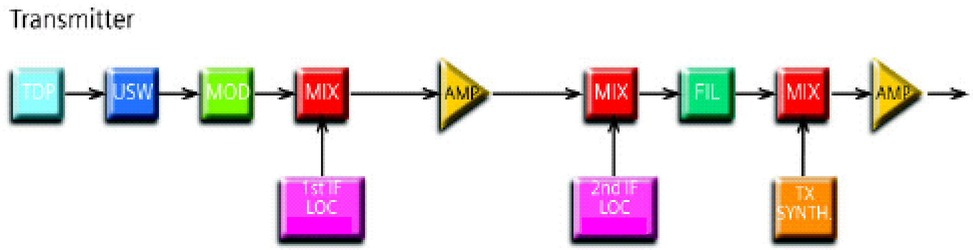
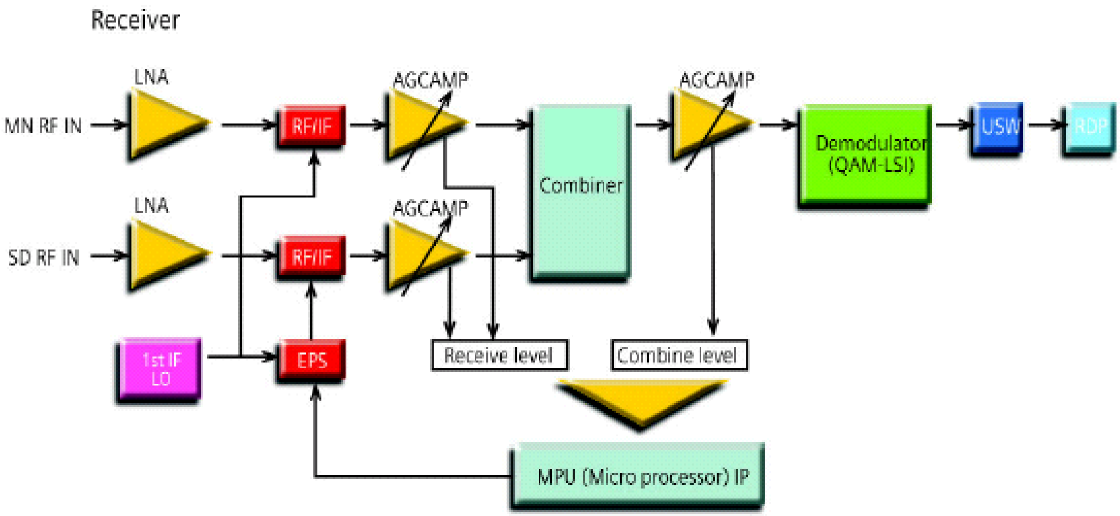


Transmitter block diagram



Receiver block diagram

Additional functions of the Unit are described below:

8.4 SPACE DIVERSITY

As a counter measure to severe propagation path conditions, Space Diversity (SD) reception is available, provided that the branching network section is equipped with the necessary adaptors and filters for Space Diversity part. Also in field upgrade from "without SD" to "with SD" is possible without any HW change, just equipping the missing items in the Branching network section. Enable or disable the SD function is possible via SW. Each transceiver unit includes two sets of receiver. One receiver (Main receiver) is connected to the Main antenna (upper) and the other one (SD receiver) is connected to the SD antenna (lower). Two receiver outputs are combined together after phase synchronization. Such phase synchronization is achieved at baseband level, just before the demodulation stage. The combining ratio of two receiver outputs is controlled through patented algorithms to optimize transmission performance. The SD system can improve the Carrier to Noise Ratio (C/N) up to 3dB during the stable propagation condition period, and remarkably reduce the possibility of outage due to multi-path fading.

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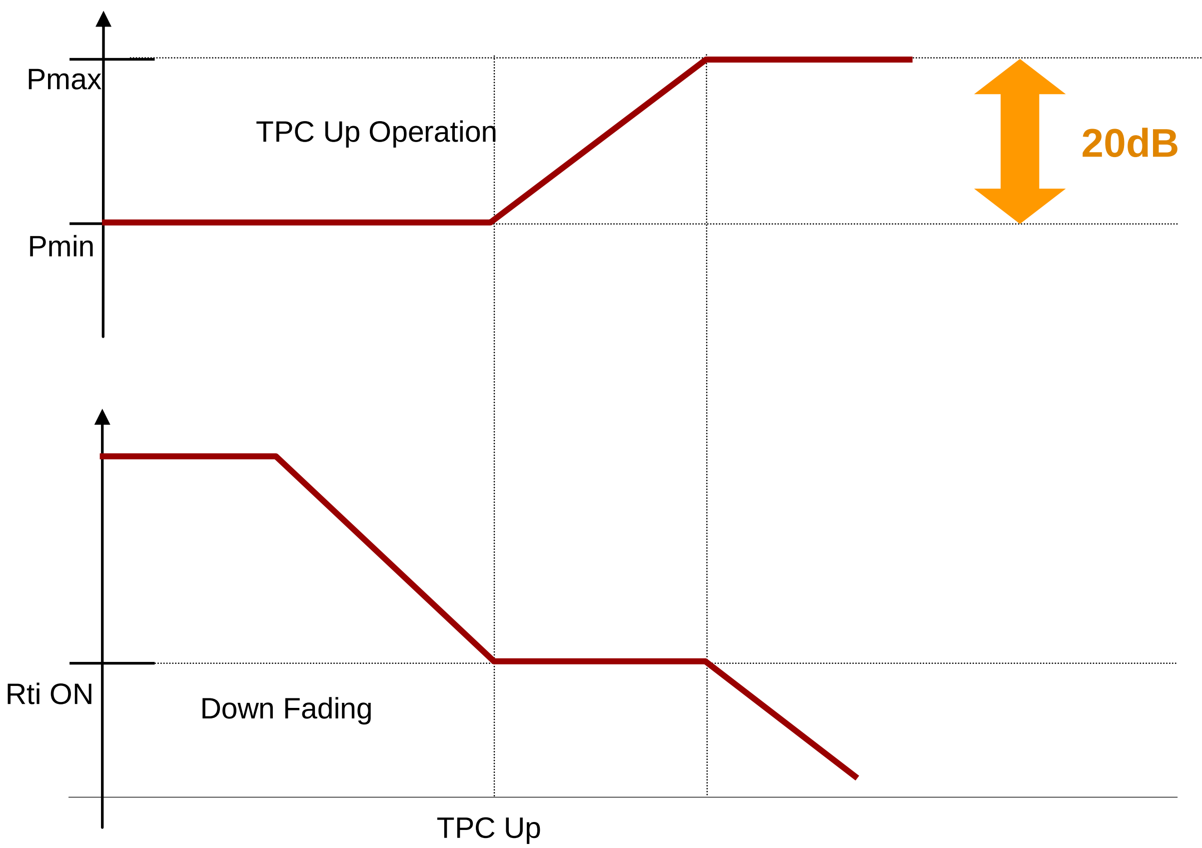
8.5 ATPC

The Automatic Transmit Power Control is designed to make the microwave transmitter operating with variable output power in a range from a maximum value Pmax to a minimum value Pmin, at which the transmitter works for most of the time.The maximum value is achieved only during strong fading conditions over the hop, as detected by the far-end receivers, experiencing low receive signal levels.
The ATPC technique, used to improve systems performance, is thought as a standard built-in equipment feature that can be optionally disabled. The main benefits obtained by the ATPC introduction derive from:
• Reduction of upfade problems in the receivers.
• Improvement in outage performance due to reduced influence of adjacent channel interference.
• Solution for frequency interference problem in crowded nodal stations by reducing nominal receive level.



ATPC Curve

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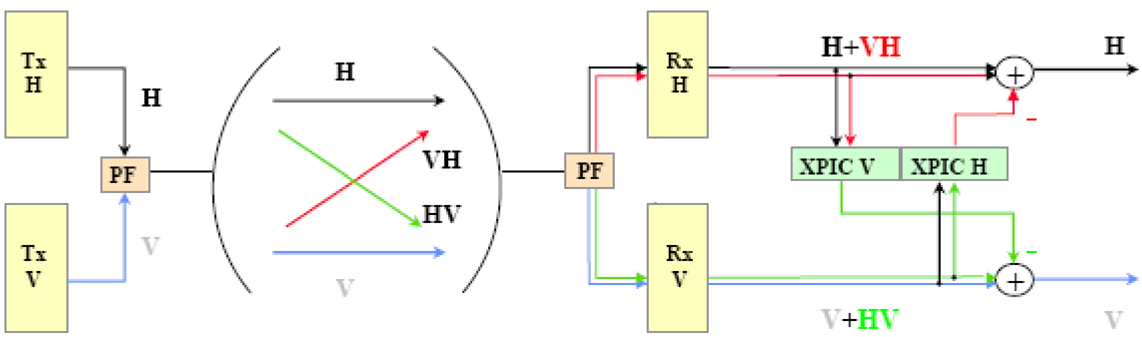
8.6 XPIC EQUALIZER

A powerful XPIC module with 20dB gain (XPIF) is integrated on Transceiver unit board and consists in an adaptive transversal LTE filter, providing effective countermeasure and superior cancellation performance also in presence of non-nominal propagation conditions.
Co-channel operation with high level modulation schemes requires very high cross-polarization discrimination (XPD). Modern radio relay antennas meet the XPD requirements at least under ideal propagation conditions; nevertheless cross-polarization interference (XPI) between orthogonally arranged channels may increase under particular conditions such as rainfall or multipath propagation.
As additional means to counteract these phenomena, a powerful cross-polarization interference canceller device has been fit into the demodulator of Harmony Trunk system, and can be activated by SW in case of CCDP operation. Since the interference effects are time variable, the XPIC device structure is adaptive, consisting of a 10-taps transversal LTE filter.
Due to the chosen XPIC concept, no common use or synchronization of the L.O. of vertical and horizontal channels is required at transmit side, nor at receive side (asynchronous XPIC equalization). At receive side, just the exchange of the received data signals at IF level is necessary. Big advantage of this concept is the independence of the XPIC operation from the lock-in state of the carrier recovery being the carrier frequencies of the interfering signal and the compensation signal identical at the adder point. This greatly improves performances after strong XPI events since the XPIC can first remove the XPI on the main signal, thus facilitating the subsequent lock-in procedure.



XPIC concept, functional diagram

8.7 ADAPTIVE EQUALIZATION

As the number of modulation states increases, the radio systems become more vulnerable to multipath fading.
The Adaptive Time Domain Equalizer (ATDE) represents a powerful solution which shows a better performance vs. complexity ratio, together with a lower sensitivity to the timing phase.
Harmony Trunk ATDE is implemented as a combination of an 11-tap linear Transversal Equalizer (LTE) and a 10-tap Decision Feedback Equaliser (DFE) and integrated in the fully digital modem LSI that incorporates all the MODEM and Transceiver functions.

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8.8 BASE BAND SECTION

The BB section provides supervisory and control function, including alarm/event information management and provisioning data setting. It consists of the following units: MCF/Controller, BB unit and/or GE ML or STM-4 card, AUX card.

- **MCF/Controller:** it implements the supervisory and control functions for Transceiver Unit; manages and controls hitless RPS; terminates the DCC line; handles station alarms (16 digital inputs and 8 remote commands to control external equipment by DragonView); handles the equipment alarms (general alarms plus severities CRITICAL/MAJOR/MINOR/WARNING); sets security levels of operators; manages bit error performance, analogue monitoring and event monitoring.
- **STM-4 BB Interface**: it is the STM-4 interface integrating 4xSTM-1 mux-demux function. The STM-4 interface can be Optical S-4.1 or L-4.1 via SFP optical module. Up to two cards STM-4 can be equipped per each subrack. The connection to the 4xSTM-1 BB interfaces is done via backplane. The STM-4 interface can be protected by 4+1 configuration using 5 carriers.
- **GE ML (Multi-Link)**: it is the GigaEthernet interface integrating L2-switch and SynchE, and provides intrinsic radio protection via adaptive load balancing among the available channels in the Nx RF carriers. 1+1 DTI redundancy is provided by means of availability of two GigaEthernet interfaces on two SFP modules for protection of the data via RSTP (Rapid Spanning Tree Protocol) and eventually Link Aggregation line side. It provides 4xGE interfaces in total.
- **STM-1 BB Interface:** it is the Base Band physical interface for STM-1 signals. It implements a hitless switchover in the unipolar stage in case of failure or fading. In case of STM-4 interface, it is connected via backplane to the STM-4 card. The required number of BB interfaces is the same as the number of RF working channels, plus the protection channel (Occasional STM-1). Each card includes two wayside channels 2Mbps, 75Ohm. The STM-1 interface can be Electrical or Optical (S-1.1 or L-1.1 via SFP optical module). Also DTI (Double Tributary Interface) operation with card redundancy is available via equipping the optional MSP subrack at rack bottom.
- **GE ADPT Interface:** it is the Base Band adapter interface for each GigaEthernet container pertaining to each RF carrier. It is connected via backplane to the GE ML card. The required number of GE ADPT interfaces is the same as the number of RF working channels involved in the load balancing function. A high-end HW version of this card is planned, which includes one wayside channel 2Mbps, 75Ohm.
- **SPC card:** it is optional module equipped as a BB interface and acting as an occasional Ethernet container for the protection channel of the SDH section in a hybrid system having some native SDH traffic and some native IP traffic in the same system.
- **AUX card:** it is optional module equipped in the BaseBand section to enable EOW branching and up to 3x64kbps user channels (G.703 and/or V.11 and/or VF analogue) via proper, dedicated sub-modules.

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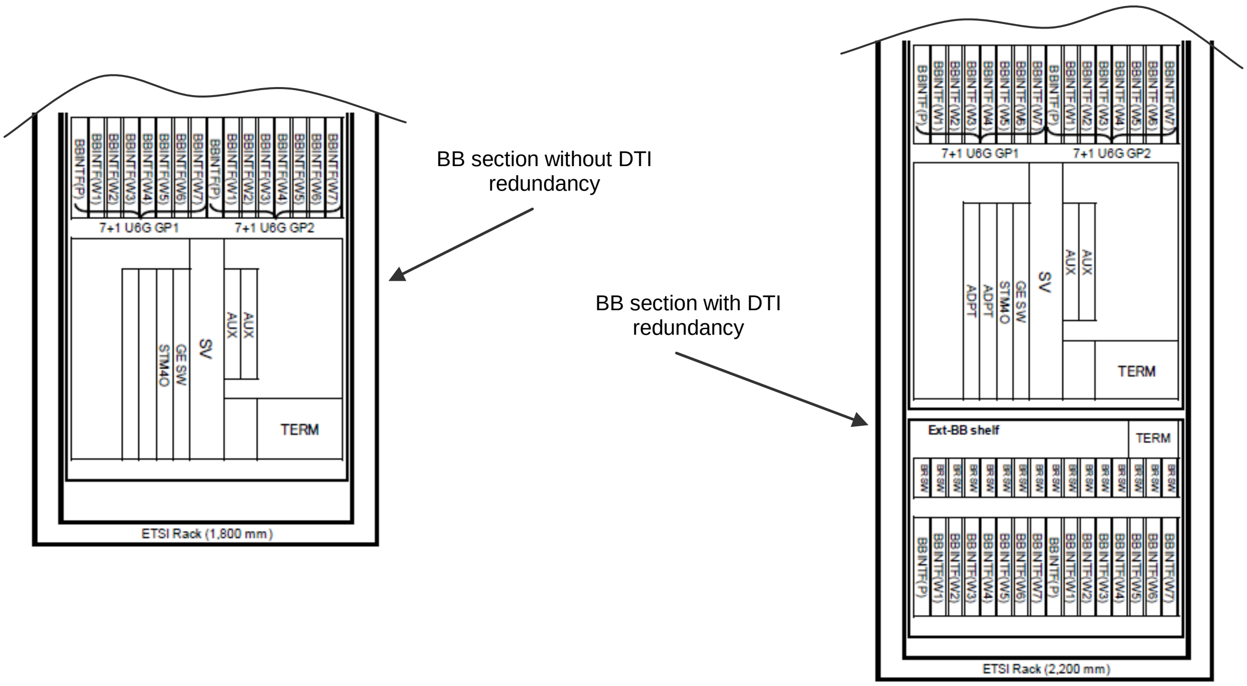

GigaEthernet optical interface

Reference Recommendation:	IEEE 802.3z Gigabit Ethernet (1.25GBd)
Mechanics:	Hot-pluggable SFP module

General characteristics	**1000Base-SX**	**1000Base-LX**
Bit Rate	1.25 Gb/s	1.25 Gb/s
Operating wavelength range	830-860	1270-1335
Transmitter source	MLM	SLM
Max RMS spectral width	0.85 nm	4.0 nm
Mean launched power (point S) :		
• Maximum	-3 dBm	-3 dBm
• Minimum	-9.5 dBm	-9.5 dBm
Minimum extinction ratio	9 dB	9 dB
Minimum sensitivity (point R)	-21 dBm	-19 dBm
Minimum overload	0 dBm	-3 dBm
Connector type (hot-swap SFP)	LC (duplex)	LC (duplex)

GigaEthernet electrical interface

Reference Recommendation:	IEEE 802.3ab Gigabit Ethernet (1.25GBd)
Mechanics:	Hot-pluggable SFP module

General characteristics	**1000Base-T**
Bit Rate	1.25 Gb/s
Cable type	Shielded or unshielded twisted pair cat. 5
Connector type (hot-swap SFP)	RJ45 with autocrossover
Mode of operation	Half Duplex / Full Duplex (autonegotiation)

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STM-1 optical interface

Reference Recommendation	ITU-T G.957 (Table 2)	
General characteristics	**S-1.1 type**	**L-1.1 type**
Bit Rate	155.52 Mb/s	155.52 Mb/s
Operating wavelength range	1260-1360	1280-1335
Transmitter source BSW Optical (SFP)	SLM	SLM
Transmitter source OPT MSP shelf	MLM	MLM
RMS spectral width	7.7 nm	4.0 nm
Mean launched power (point S) :		
• Maximum	-8 dBm	0
• Minimum	-15 dBm	-5 dBm
Minimum extinction ratio	8.2 dB	10 dB
Minimum sensitivity (point R)	-28 dBm	-34 dBm
Minimum overload	-8 dBm	-10 dBm
Connector type BSW Optical (SFP)	LC (duplex)	LC (duplex)
Connector type OPT MSP shelf	SC or FC (duplex)	SC or FC (duplex)

STM-1 electrical interface

Reference Recommendation	ITU-T G.703
General characteristics	
Bit Rate	155.52 Mbit/s ± 20 ppm.
Code	CMI
Input Equalizer	0-12.7 dB
Connector type BSW Electrical	1.0/2.3

Jitter performances

- **Output jitter and wander generation**[1]

  Recommendation ITU-T G.825

- **Jitter and wander transfer characteristics**

  Recommendation ITU-T G.958

- **Jitter tolerance**

  Recommendation ITU-T G.825

[1] With no jitter at the input port

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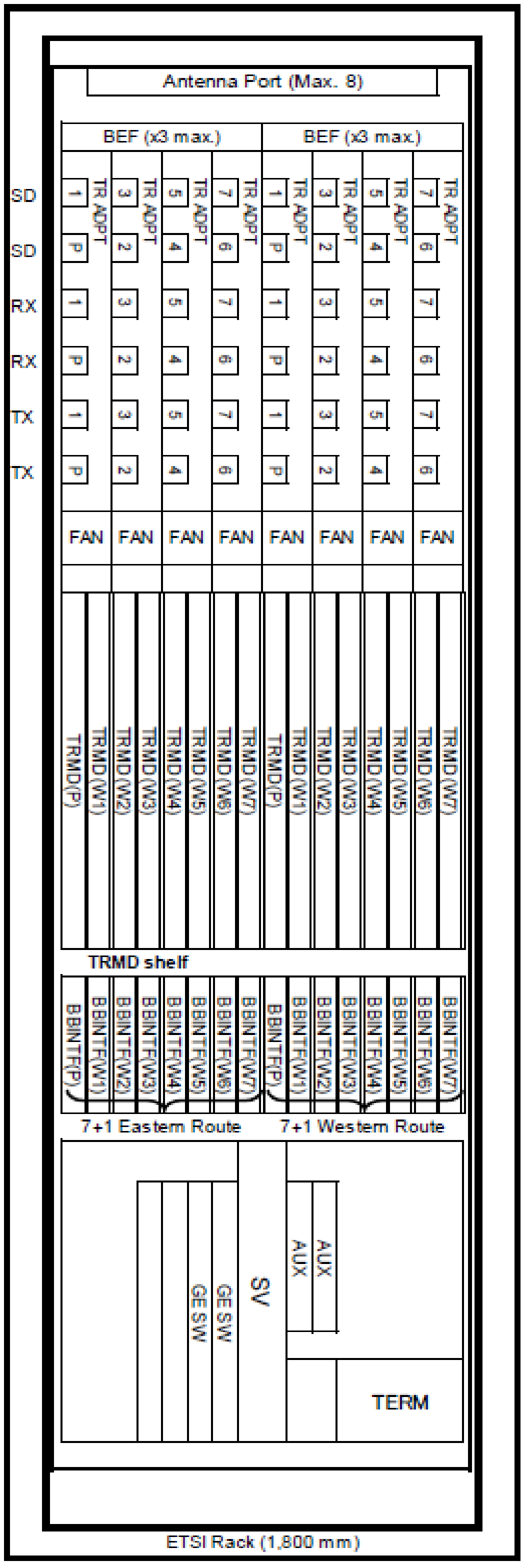

Layout of the subrack in case of GE ML repeater 8+0

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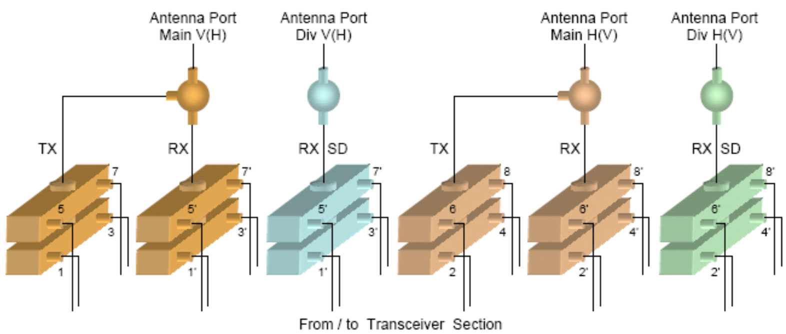
8.9 BRANCHING SECTION

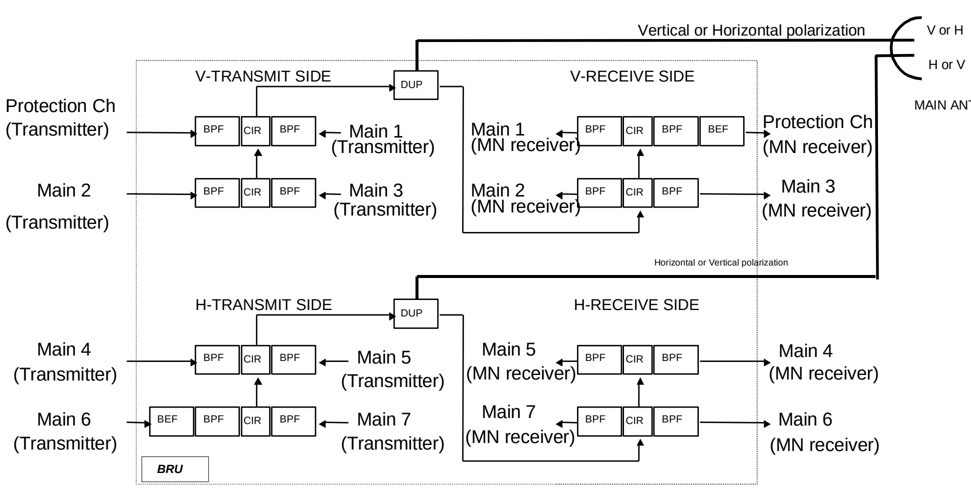
The Branching section consists of a transmitting and receiving antenna duplexer, a Space Diversity antenna transducer and a plug-in branching filter for each RF channel, integrating the channel circulator.
The Branching section is completely accessible from the front part of the rack.
The Horizontal and Vertical polarization branching paths are independent and accessible as separate items, so that any operation on a branching path on one polarization cannot affect the traffic of the opposite polarization path.
The SD receive branching path is independent from main TX+RX path and is accessible as separate item, so that any operation on the SD branching path (e.g. SD upgrade) can be done without affecting the traffic circulating on the main TX+RX path.



Branching layout for alternated operation

8.10 7+1 ALTERNATED OPERATION

The high compactness of the system enables to locate the branching for 16 channels together with the branching for SD receiver in the same subrack, inside a single rack.
It allows mixed polarization (H and V) inside the same shelf, and the choice of frequency and polarization of stand-by channel.



Branching scheme for 7+1 AP configuration

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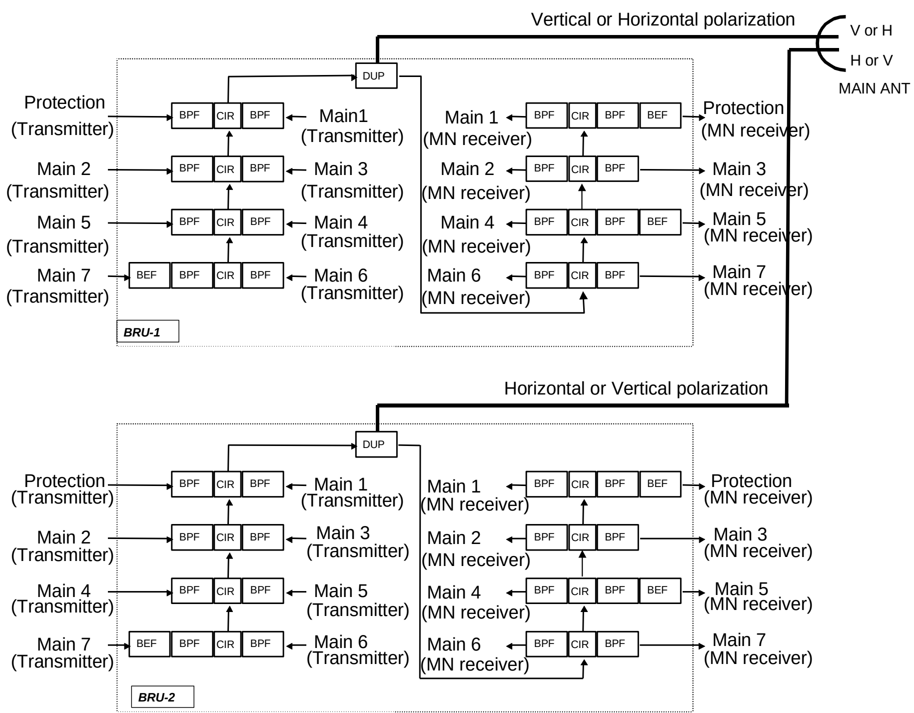
Expansion inside the same shelf can be obtained, even from 1+0 Terminal to 15+1 Terminal, without removing the Transceiver Units already located in the rack.

8.11 2X(7+1) CO-CHANNEL OPERATION

The use of narrow-band RF filters allows the connection of all the channels of one polarization in the same branching system without any need of any additional 3dB-loss coupler for the separation of odd and even channels. This enables to keep the system performance for Co-channel systems at the same level of Alternate Pattern (ACAP) ones.
Up to 16 channels on the same polarization can be mounted in the same subrack. Also complete 2x(7+1)CCDP system can be mounted in the same subrack.



Branching scheme for 2x(7+1) co-channel configuration

9. EQUIPMENT MANAGEMENT

The Harmony Trunk management platform bases upon the presence of the MCF/Controller unit with the following tasks:

- receiving and transmitting from/to the controlled units all the information required for system management
- transmitting to Local Craft Terminal (WebLCT) and the Element Manager (EM) the alarms and measures coming from the units
- receiving controls / settings from LCT / EM.

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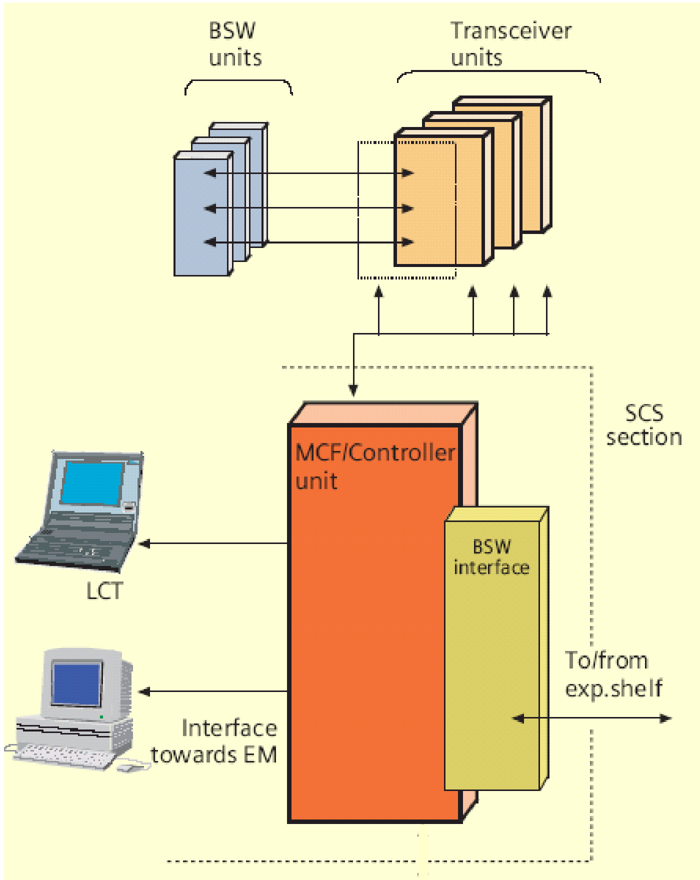

Management architecture

A powerful local control is managed by a Windows PC as craft-terminal via LAN port. The LCT handles units' status and configuration, provides alarms and performance monitoring and reports analogue measures. In addition, Security and Inventory facilities are available. Also the remote control can be done via LCT through the DCN connection. Web LCT via HTTP server integrated inside SNMP/IP type MCF/Controller is available (no need of separate dedicated SW, nor for dedicated license for LCT operation).

The information stored and processed by MCF/Controller unit (configuration, events, performance monitoring) are made externally available in different ways in order to allow the radio to be considered as a Network Element of the Telecommunication Management Network.
The remote control can be performed via DragonView with the connection to the equipment done via DCN, using the same LAN port as the Web LCT one. For this purpose, 2 LAN ports are available in each MCF/Controller card to allow easy daisy chain DCN connection for co-located terminals, and also simultaneous connection of Web LCT and DragonView: even if main TMN is connected to the network, the link reconfiguration can be done via LCT at any based network point.

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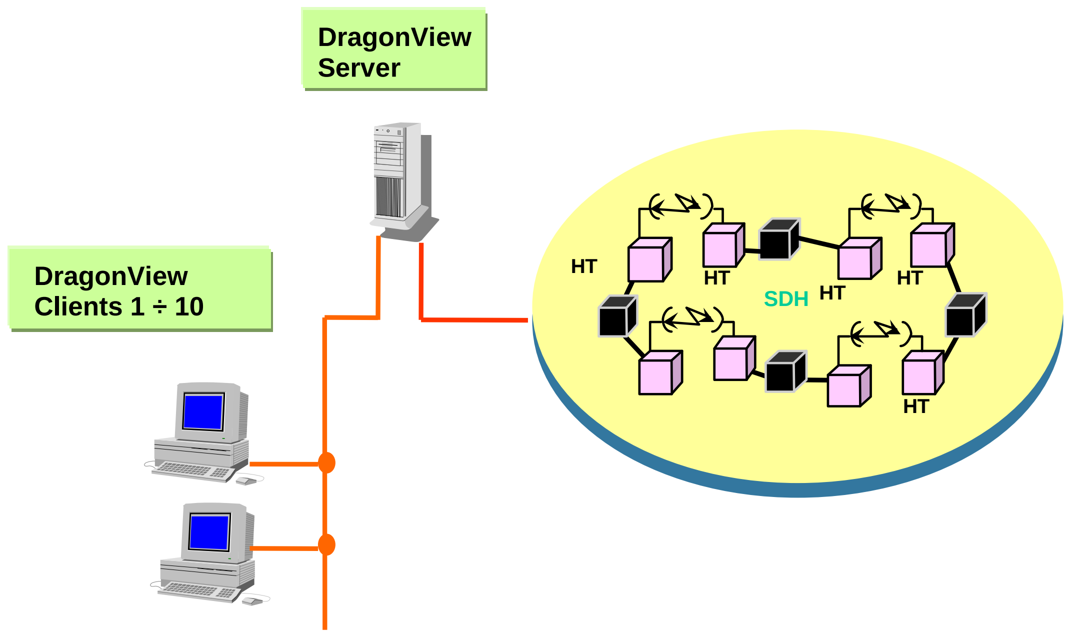

MW Radio TMN

Security Management, Fault management, Configuration Set-up, Performance Management, Metering are performed by DragonView, pointing to each of the Radio Systems connected to the network.

Performance monitoring collection via on-click XML file and relevant storing into the DragonView database is supported, together with alarms and log events.

The TMN-NE interface uses SNMP (Simple Network Management Protocol) via the MCF/Controller SV card, thus allowing a direct integration in any 3rd party SNMP manager TMN. However, the solution recommended by DragonWave consists in using DragonView to monitor Harmony Trunk and integrating DragonView in the 3rd party TMN by using any of the many NorthBound interfaces available in the DragonView portfolio.

All synchronous systems in DragonWave's portfolio have a common platform as Network Manager to provide ITU-T Rec. M.3010 functions applied to transport network. Information about the Element Manager Features and characteristics are available under separate product descriptions.

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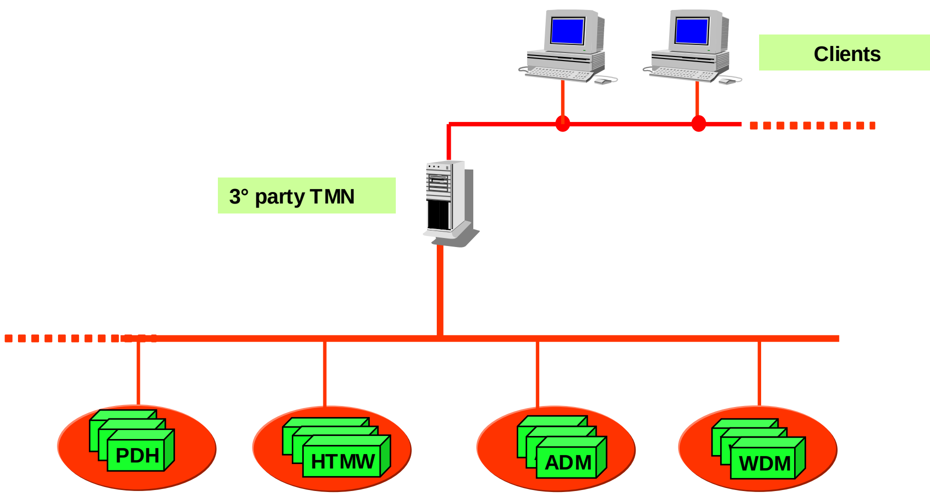

Integration in 3rd party TMN

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