Harmony Eband

Product Description v1.0

Table of content

1. E-BAND SYSTEM

- This document describes the product Harmony Eband in its software release 1.0.

2. SYSTEM TYPES

- Harmony Eband is an outdoor radio
- Its transmission capacity is licensed at
  - 100 Mbps (licence included with the outdoor radio)
  - 500 Mbps (upgrade licence from 100 to 500 Mbps, full duplex)
  - 1 Gbps (upgrade licence from 500 Mbps to 1 Gbps, full duplex)
  - 1.5 Gbps (upgrade licence from 1 to 1.5 Gbps, full duplex)
  - 2.5 Gbps (upgrade licence from 1.5 to 2.5 Gbps, full duplex)
- Harmony Eband supports
  - Adaptive Modulation
  - 1+1 Hot Stand-By operation
  - 2+0 operation (The two radios are connected through a dedicated, high-speed interface. Local traffic goes to one of the radios, the Master. Nx Giga-Ethernet and LAG is used for this. The Master radio shares the traffic load between the two radios.)

3. RADIO

- Harmony Eband complies with
  - ETSI EN 302 217
  - FCC Part 101 (2004)
- Its frequency band is 71-76 GHz paired with 81-86 GHz and operates in Frequency Division Duplex transmission with duplex spacing of 10 GHz
- A single radio transmits over the complete 71-76 GHz sub-band and receives over the complete 81-86 GHz sub-band. The corresponding radio transmits over the complete 81-86 GHz sub-band and receives over the complete 71-76 GHz sub-band.
- A different hardware variant supports transmission with 2.5 GHz duplex spacing
- Harmony Eband supports channel spacing of 250 MHz and 500 MHz
- It has the capability to operate 2+0 links with the ACAP, ACCP and CCDP channel arrangements

3.1 Physical modes

- Table of physical modes
- The minimum as well as the maximum physical modes are configurable
- Table of FEC types and redundancy
- Table of symbol rate and roll-off factor
- Both 250 and 500 MHz channels can scale a hitless, adaptive way to 25 MHz channel that can also work in hitless adaptive modulation between BPSK and 64QAM
- The scrambler is a PRBS sequence of order 2^25 generated with an LFSR(25,22)

3.2 Transmitter Characteristics with static modulation

- Radio frequency tolerance of less than 50 ppm
- 20 dBm of output power at the 1 dB compression point
- Table of Nominal Output Power
- Table of Guaranteed Output Power
- Transmitter power tolerance of +/- 1 dB
- Table of ETSI Spectral Efficiency Class for each Physical Mode
- Compliant with ETSI power density mask
- Table of Compliance to ETSI RF Spectrum Masks for each Physical Mode
- Table of Output Power Range and Step
- The ATPC engine involves the remote receiver, change commands are requested by the remote side. The ATPC changes are triggered in a configurable way by quality criteria (S/MSE) or received power against a defined configurable threshold, which is set in the SW build to the recommended value for hitless behaviour up to 100dB/s fading speed. Change commands are inserted by the remote ODU in a dedicated field of the baseband frame and are extracted by the local ODU to apply the requested change to the transmission power.

3.3 Receiver characteristics with static modulation

- Table of Carrier to Noise Ratio
- Table of Nominal Receive Signal Level
- Table of Guaranteed Receive Signal Level
- Residual BER less than 10E-12
- Radio BER vs Frame Error Rate : Errors will appear in clusters of more than forty error bits, when the error rate is less than 10E-8 it is safe to say that every packet will have at most one error event. When the packet size is N = 512 bytes (n=4096 bits) the packet rate equals the throughput divided by 4096. The Packet Error Rate equals BER divided by 40

$$PER = (BER/40) / (Throughput/4096) \sim BER * 100$$

- Similarly if the packet size is 64 bytes then : PER = BER * 12.8.
- Maximum RSL level without distortion : -22 dBm (BPSK, QPSK), -24 dBm (16-64QAM)
- Maximum RSL level without damage : -10 dBm
- Table of Co-Channel Interference at 1dB / 3dB Degradation
- Table of Adjacent Channel Interference at 1dB / 3dB Degradation
- Table of Net Filter Discrimination, First Adjacent Channel
- Table of Net Filter Discrimination, Second Adjacent Channel
- Table of Net Filter Discrimination for Cross Impacts on Different Physical Modes

3.4 Adaptive modulation

- Adaptive Modulation changes are hitless, uni-directional and cope with fading speed of 100 dB/sec
- The Adaptive Modulation engine involves the remote receiver. Change commands are by the remote side. Two independent engines work in the two radio directions. Adaptive Modulation changes are triggered by quality criteria (S/MSE) against defined thresholds. Thresholds are in principle configurable, but the product is released with recommended configured thresholds that ensure proper hysteresis to counteract in hitless way up to 100dB/s of fading speed. Change commands are inserted by the remote ODU in a dedicated field of the baseband frame and are extracted by the local ODU to apply the requested change to the transmission mode.
- Improvements in transmit output power when using Adaptive Modulation : 16, 64 QAM are backed off to QPSK value
- Transmit output power can be limited (RTPC) to a configurable static value, it can also be limited as an offset with respect to the reference mode
- Adaptive Modulation, bandwidth and Automatic Transmission Power Control comply with EN 302-217-2-2 Annex I

3.5 Throughput

- Table of Net Radio Throughput without FEC Redundancy (no gross bit rate)
- Table of Ethernet Throughput without Packet Compression Techniques
- Header compression is a proprietary algorithm able to compress any combination of the first 128 bytes of the frame into a 2 byte label. Header compression does not introduce any delay. Performances depend on many factors, such as service type and average packet length.
- Packet compression technique : Bulk data compression performs lossless data compression on an entire Ethernet packet, or group of Ethernet packets. Bulk data compression introduces some packet delay variation where the variation depends on the size of the "block" of data being compressed; this is user-configurable. Performance depends on many factors, such as service type and block size. Compression is configurable on a per queue basis.

3.6 Advanced radio channel configurations

- 2+0 load balancing: Load sharing is a proprietary algorithm that uses a byte by byte strategy. Traffic is split between the two ODUs according to the individual throughput capability (current adaptive transmission mode aware) without adding delay or overhead.
- 2+0 CCDP with / without XPIC: the ODUs are interconnected by the CPRI interface. Load balancing is performed by the master ODU of the link, which also receives the local traffic from the IDU. Hardware protection uses the same protocols of the 1+1 Hot Stand-By system type.
- 2+0 with MIMO (2 antennas): Same interconnection, load sharing and hardware protection algorithms as for the 2+0 XPIC system type.
- The product provides CPRI interface with maximum capability of 6.144 Gbps

4. EQUIPMENT INTERFACES

- Two SFP optical / electrical and two RJ45 electrical Giga-Ethernet ports are available.
- Maximum length of the cable for the Giga-Ethernet electrical interface without boosters or repeaters : 100 m
- Maximum length of the cable for the Giga-Ethernet electrical interface with Power-over-Ethernet : 100 m
- Maximum length of the fibre for the Giga-Ethernet optical interface : 500 m
- Maximum length for power supply cable : 300 m

5. PROTECTION AND RESILIENCY

5.1 Protection of the radio link

- 1+1 Hot Stand-By protection is supported
- Single-cable 1+1 protection is supported: The two ODUs are interconnected through an high-speed interface. Normally the active node would use its radio to forward the data. In the event of failure of this radio, the active node will use the interconnection between the nodes to forward the data to the radio of the stand-by partner.
- Double-cable 1+1 protection is supported : three protection protocols based on proprietary CCM sections are implemented
  - Mode 1: No interconnection between the two ODUs and the IDU support is required. Three CCM sections are active at the same time, one between the two ODUs and two between each ODU and the IDU. These CCM sections drive a state machine to determine which ODU is transmitting and which is in standby.
  - Mode 2: Hot Stand-By is piloted by the ODU only and the interconnection of the ODUs is required. Two CCM sections are active in parallel from ODU to ODU, one through the direct interconnection through the cable and one through the IDU. Again, the CCM sections drive the state machine to determine which ODU is active and which one is in stand-by.
  - Mode 3: for generic indoor devices, Mode3 works as Mode 2 for the ODU communication and requires the support of the IDU in changing data path from one ODU to one other. The change is triggered or by shut down of the Ethernet port or by CCMs (specifically EOAM VSM) sent to the IDU. The IDU uses its own protocol to switch path once triggered.
- Asymmetric hybrid (splitter) losses : 1 / 6 dB
- Symmetric hybrid (splitter) loss : 3 dB
- 1+1 HSBY performances - switching time : less than 100 ms for wireless link fast fail, radio transmitter failure, user data port failure, and node failure
- 2+0 load balancing - connection options towards antenna : the system can use frequency diversity, XPIC and MIMO. Single / dual polarization integrated and non-integrated are connection options to the antenna.

- 2+0 load balancing - connection options towards L2/L3 switch : Nx GE interface in LAG

5.2 Software Resiliency

- The system functions are independent of the management system (NMS) once proper configuration is applied by the user.

- Storage of configuration data in the NMS, and configuring from the NMS data base is supported.

6. MECHANICAL, ELECTRICAL AND ENVIRONMENTAL FEATURES

6.1 Mechanical dimensions

6.2 Weight

- Equipment weight : 3.4 kg

6.3 Power consumption

- Typical and worst-case power consumption, 1+0, 1 Gbps: 30 W, 33 W
- Typical and worst-case power consumption, 1+0, 2.5 Gbps: 32 W, 35 W
- Typical and worst-case power consumption, 1+1, 1 Gbps: 60 W, 66 W

6.4 Power supply

- Power supply of -48 V DC according to ETSI ETS 300-132-2
- Power supply variation : +/-20%
- Outdoor power injectors (IP65):
    - AC P+E Outdoor Midspan Injector (1 port)
    - DC P+E Outdoor Midspan Injector (1 port)

6.5 Environmental requirements

- Compliant with ETSI ETS 300-019-1-1 Class 1.2 for equipment storage
- Compliant with ETSI ETS 300-019-1-2 Class 2.3 for equipment transportation
- Operating temperature range of -40 °C to +60 °C
- Cold start temperature at -20° C
- Relative humidity from 0% to 100%
- Maximum operational altitude: 4500 m
- IP65 compliance with IEC 60529 for waterproof resiliency

7. LEVEL-2 FUNCTIONALITIES

7.1 Ethernet switching

- Switch capacity: 20 Gbps non-blocking
- Frames up to 9600 bytes are supported
- MTU is configurable
- Buffer size (queue depth) is configurable
- Link Loss Forwarding (LLF) is supported
- Support of Ethernet Version II-frames (IEEE 802.3) according to RFC-2878: Multicast/ Unicast /Broadcast

7.2 VLAN

- VLAN tagging 802.1Q is supported
- VLAN IDs 0 – 4095 are managed
- VLAN stacking (QinQ) according to IEEE802.1ad is supported
- Each port is able to managed more than one S-VLAN
- QinQ supports PCP (p-bits) copy from C-VLAN to S-VLAN

7.3 Quality of Service

- Eight queues are supported
- Tail dropping when queue is overflowing is supported
- Frame dropping when aging threshold is reached is supported
- Color dropping for discarding first "Yellow" colored frames is supported
- Strict Priority (SP) scheduling and WFQ / WRR is supported
- 802.1P, DSCP is supported
- MPLS EXP bits are supported

7.4 Traffic shaping and policing

- Ingress traffic policing and egress traffic shaping are supported at the Giga-Ethernet interfaces
- Policing implementation according to MEF10.1 (TrTCM)

8. SYNCHRONIZATION

8.1 Frequency synchronization

- Synchronous Ethernet (SyncE) according to ITU-T G.8261, 8262, 8264
- SynchE is available on electrical and optical interfaces
- Multiple sources of synchronization can be configured, different sources can be assigned different priorities
- Holdover and reference switching requirements of G.8262 Section 11 met are supported

8.2 Phase timing and frequency synchronization

- 1588v2 Precision Timing Protocol (PTP) transparent clock (TC) is supported : packets are stamped upon arrival in the physical device. Delta is calculated and added to the outbound packet at the far end of the link in the physical device. A proprietary air protocol is used to maintain delta clock synchronization at both ends of the link

9. OPERATION ADMINISTRATION MAINTENANCE AND PERFORMANCE MONITORING

9.1 Ethernet Fault Management (FM)

- Link Monitoring, Loopback and RDI supported according to IEEE 802.3ah
- E2E monitoring supported according to 802.3ag
- Loopback, Link Trace, AIS and RDI according to 802.3ag will be supported in a following release

9.2 Ethernet measurements

- Test and turn-up with RFC 2544 LBM/LBR loopback features is supported
- Test and turn-up with ITU-T Y.1564 loopback features is supported
- Operational Performance Monitoring with ITU-T Y.1731 DMM/DMR loopback features is supported

9.3 RMON

- RMON according to RFC 2819
- RMON statistics are available per port, radio port included
- RMON statistics are also available per VLAN

9.4 Radio performance monitoring

- Counters statistics are available on 15 m and 24 hour basis
- Adaptive Modulation counters are available
- Radio link G.826 / G.828 counters are available
- Radio link threshold counters are available

9.5 Counters collection capabilities

- The product can store the last sixteen 15-minute counters
- The product can store the last four 24-hour counters
- The statistics collection method used by the NMS (NetViewer) in order to upload information from the Network Element (the product) are xml files containing historical performance data retrieved by FTP or sFTP

9.6 Other OAM features

- SNMPv3 with full CLI configuration equivalent
- The product supports both out-of-band and in-band management over the radio channel
- The product notifies to external L2 switches, via standard Ethernet OAM messages, the status of the available radio capacity; the available radio capacity can change because of Adaptive Modulation

DragonWave

10. TECHNICAL DATA

10.1 Nominal Tx power

	Maximum transmitter power [dBm]	
Modulation	Typical	Guaranteed
QPSK	15	14
16QAM	13	12
32QAM	13	12
64QAM	13	12
128QAM	12	11
256QAM	12	11

Table 1: Maximum Transmitter Power

10.2 Spectrum efficiency class

Modulation	Spectrum efficiency class	Spectrum efficiency sub-class	Radio interface capacity [Mbit/s]
QPSK/4QAM	2	2	402
16QAM	4L	4	804
32QAM	4H	5	1005
64QAM	5LB	6	1206
128QAM	5HB	7	1408
256QAM	6LB	8	1609

Table 2: Spectrum Efficiency (250MHz)

Modulation	Spectrum efficiency class	Spectrum efficiency sub-class	Radio interface capacity[Mbit/s]
QPSK/4QAM	2	2	804
16QAM	4L	4	1609
32QAM	4H	5	2011
64QAM	5LB	6	2413
128QAM	5HB	7	2816
256QAM	6LB	8	3218

Table 3: Spectrum Efficiency (500MHz)

10.3 Receiver sensitivity

250MHz	Minimum receive level for BER≤10e-6	
Modulation	Typical [dBm]	Guaranteed [dBm]
QPSK	-69.5/-78.5(BPSK)	-69.6/-78.5(BPSK)
16QAM	-63.5	-63.5
32QAM	-60.5	-60.5
64QAM	-57.5	-57.5
128QAM	-54.5	-54.5
256QAM	-51.5	-51.5

Table 4: Minimum Receive Levels for 250MHz Channels

500MHz	Minimum receive level for BER≤10e-6	
Modulation	Typical [dBm]	Guaranteed [dBm]
QPSK	-66.5/-75.5(BPSK)	-66.5/-75.5(BPSK)
16QAM	-60.5	-60.5
32QAM	-57.5	-57.5
64QAM	-54.5	-54.5
128QAM	-51.5	-51.5
256QAM	-48.5	-48.5

Table 5: Minimum Receive Levels for 500MHz Channels

10.4 Ethernet throughput

Channel	Frame size	Modulation	Maximum frame rate [frames/s]
250MHz	64Byte	QPSK	380952.4
		16QAM	761904.8
		32QAM	1523809.5
		64QAM	1904761.9
		128QAM	2285714.3
		256QAM	2666666.7
	1518Byte	QPSK	16541.4
		16QAM	33082.7
		32QAM	66165.4
		64QAM	82706.8
		128QAM	99248.1

		256QAM	115789.5
500MHz	64Byte	QPSK	761904.8
		16QAM	1523809.5
		32QAM	3047619.0
		64QAM	3809523.8
		128QAM	4571428.6
		256QAM	5333333.3
	1518Byte	QPSK	33082.7
		16QAM	66165.4
		32QAM	132330.8
		64QAM	165413.5
		128QAM	198496.2
		256QAM	231578.9

Table 6: Frame rates

10.5 C/I performances

250MHz	**Carrier-to-interference ratios [dB]**		
Modulation	Co-Channel	1st adjacent	2nd adjacent
QPSK	23	0	-10
16QAM	27	0	-10
32QAM	30	-2	-12
64QAM	33.5	-6	-16
128QAM	37	-3	-13
256QAM	40.5	0	-10

Table 7: Carrier-to-Interference Ratios for 250MHz Channels

500MHz	**Carrier-to-interference ratios [dB]**		
Modulation	Co-Channel	1st adjacent	2nd adjacent
QPSK	23	0	-10
16QAM	27	0	-10
32QAM	30	-2	-12
64QAM	33.5	-6	-16
128QAM	37	-3	-13

256QAM	40.5	0	-10

Table 8: Carrier-to-Interference Ratios for 500MHz Channels

10.6 NFD

250MHz	**Receiver net filter discrimination [dB]**	
Modulation	1st adjacent	2nd adjacent
QPSK	-25	-35
16QAM	-25	-35
32QAM	-25	-35
64QAM	-25	-35
128QAM	-25	-35
256QAM	-25	-35

Table 9: Receiver Net Filter Discrimination for 250MHz Channels

500MHz	**Receiver net filter discrimination [dB]**	
Modulation	1st adjacent	2nd adjacent
QPSK	-25	-35
16QAM	-25	-35
32QAM	-25	-35
64QAM	-25	-35
128QAM	-25	-35
256QAM	-25	-35

Table 10: Receiver Net Filter Discrimination for 500MHz Channels

10.7 MTBF

Configuration	**Calculated [Yrs]**	**Guaranteed [Yrs]**
1+0	50	50

1+1 HSB	75	75
2+0	22.5	22.5

Table 11: Mean time between failures- Values

10.8 Maximum power consumption

Configuration	Maximum power consumption [W]
1+0	37
1+1 HSB	74
2+0	74

Table 12: Maximum Power Consumption

10.9 Dimensions and weight

Height	22.1cm
Width	19.0cm
Depth	8.7cm
Weight	3.4kg

Table 13: Dimensions and Weight

10.10 Antenna details and dimensions

Item Code	Name	Diameter [cm]	Flange type	Manufacturer
T559DA300.SP	30 cm external antenna (SP); includes adapter	30	Custom flange	CommScope
T559DA600.SP	60 cm external antenna (SP); includes adapter	60	Custom flange	CommScope
T559IN100.SP	10 cm integrated flat-panel antenna (SP)	10	Custom flange	Huhber and Schuner
T559IN280.SP	28 cm integrated flat-panel antenna (SP)	28	Custom Flange	Huhber and Schuner

Table 14: Antenna Detail and Dimensions

10.11 Antenna performances

Name	Gain [dBi]	3dB bean width [deg]	Cross polar discrimination [dB]	Front to back [dB]
30 cm external antenna (SP); includes adapter	43.5	0.9	25	61
60 cm external antenna (SP); includes adapter	50.5	0.5	25	68
10 cm integrated flat-panel antenna (SP)	38	2.8	40	60
28 cm integrated flat-panel antenna (SP)	43	1	40	60

Table 15: Antenna Performance Characteristics

10.12 Antenna class

Name	Type & Class

30 cm external antenna (SP); includes adapter	Parabolic Class 3
60 cm external antenna (SP); includes adapter	Parabolic Class 3
10 cm integrated flat-panel antenna (SP)	2
28 cm integrated flat-panel antenna (SP)	2

Table 16: Type and Class according to ETSI EN 300 833

11. SYSTEM COMPONENTS

11.1 Hardware

Unique item code	Item name	Description
T559HESAN.00	Harmony Eband Low radio (71-86GHz), 100Mbps licensed capacity, 2 x 10/100/1000bT + 2 x SFP; No antenna	Harmony Eband Low Tx transmitter
T559HESAN.50	Harmony Eband High radio (71-86GHz), 100Mbps licensed capacity, 2 x 10/100/1000bT + 2 x SFP; No antenna	Harmony Eband High Tx transmitter
T555ETRJ.08	RJ45 connector for Ethernet cable	Connector for GE electrical interface
CS73320.08	Cable tie 7,6*390 black (100 pcs)	Ties to be used to fix cables when pole diameter is up to 100 mm
CS73320.04	Cable tie 4,6*200 black (100 pcs)	Ties to be used to fix cables when pole diameter is up to 50 mm
T555PSAM.02	FP MR connector for Power cable	Connector to terminate power supplier cable ODU side
T555SFSM0.10	SFP opt. 1000Base-LX - 10Km	SFP module to be used when local traffic is with GE optical interface

T559MKHEALL.00	Harmony Eband and external antenna mounting kit (for spare)	Mounting kit for Harmony Eband radio and antenna
T555GDOU.06	Grounding cable for FlexiPacket Radio	Grounding cable for Harmony radio
T555GDCB.10	Grounding cable for Eth and PS	Grounding cable for either Ethernet cable or power supply cable
T555PSCB.13	Power Supply cable reel 500m (30m proportional value)	Power supplier cable reel, 500m length
T559CBLCSM.50	Outdoor 50m SM fibre cable with separable LC connectors	50m single mode fibre cable with connectors
T559CBLCMM.50	Outdoor 50m MM fibre cable with separable LC connectors	50m multi-mode fibre cable with connectors
T559CBODU.02	ODU to ODU interconnection cable, 1.5m	Interconnection cable between two Harmony radio to be used in 2+0/1+1 system types
T559IN100.SP	10 cm integrated flat-panel antenna (SP)	10cm antenna
T559IN280.SP	28 cm integrated flat-panel antenna (SP)	28cm antenna
T559IN280.MM	28 cm integrated flat-panel MIMO antenna (SP)	Integrated dual antenna for MIMO configuration

T559DA300.SP	30 cm external antenna (SP); includes adapter	30cm antenna
T559DA600.SP	60 cm external antenna (SP); includes adapter	60cm antenna
T559MTUNB.00	1+1 asymmetric splitter (including supporting frame)	Unbalanced 1+1 frame and mounting
T559MTBAL.00	1+1 symmetric splitter (including supporting frame)	Balanced 1+1 frame and mounting
T559MTOMT.00	2+0 OMT splitter (including supporting frame)	OMT splitter and mounting
T559CBWG.01	Flexible waveguide (1m)	Flexible wave guide for separate mounting.

Table 17: System Components (HW)

11.2 Software

License code	Brief description
T559LKFEAAM.00	Adaptive modulation
T559LKFEUNI.00	Ethernet UNI (ELINE/ELAN MEF service)
T559LKFEOAM.00	802.1ag, 802.3ah, Y.1731
T559LKFEEPM.00	Enhanced Performance Monitoring
T559LKFESYN.00	1588v2 Transparent Clock
T559LKFEHSB.00	Hot-standby
T559LKFEMIM.00	MIMO for extended reach
T559LKFEBAC.00	Bandwidth Accelerator

T559LKFESEC.00	Security Package
T559LKFE2BW.00	2+0 Support
T559LKFEPKF.00	Packet Fragmentation
T559LKCP0500.00	100Mbps to 500Mbps capacity upgrade (full duplex)
T559LKCP1000.00	500Mbps to 1Gbps capacity upgrade (full duplex)
T559LKCP1500.00	1Gbps to 1.5Gbps capacity upgrade (full duplex)
T559LKCP2500.00	1.5Gbps to 2.6Gbps capacity upgrade (full duplex)
T559LKCPFULL.00	100 Mbps to 2.6 Gbps capacity upgrade (full duplex)
T559SWB010.00	Basic Software R1.0

Table 18: System Components (SW)

12. GLOSSARY