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		Reference	

Ethernet Switching in GEM

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1 General Information

1.1 Revision Information

Rev A: First revision of the document.

1.2 Introduction

This document specifies the most important functions that are available in the Ethernet switches designed for placement in the GEM subrack. Ethernet switching in DCP2 (GDDM subrack) or DCP202 (BYB202 subrack) is not included in this release of the document. In the OSI reference model the specified functions reside in the Transmission media layer, the Physical layer (layer 1) and the Data Link layer (layer 2) as well as in the Management layer.

Ethernet switching in GEM is an RPS platform function for distributing user data encapsulated in MAC Frames from one end station to one or several other end stations. It is implemented in function blocks SCBHW (including the SCB-RP plug-in units) and GESBHW (including the GESB plug-in unit). The most closely users of the specified functions are the Regional Processor Bus of Ethernet type (RPB-E) and the Regional Processor Interprocessor Communication (RPIC). The platform function is also open for use by other applications.

1.3 References

25/155 19-ANZ 212 08, RP Interprocessor Communication.

102 62-BFD 508 002/1, Generic Ericsson Magazine (GEM)..

ANSI/IEEE Std 802, 2001 Edition IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture.

ANSI/IEEE Std 802.1D, 1998 Edition (Adopted by the ISO/IEC and redesignated as ISO/IEC 15802-3:1998) Part 3: Media Access Control (MAC) Bridges.

ANSI/IEEE Std 802.1Q, 2003 Edition IEEE Standard for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks.

IEEE Std 802.2, 1998 Edition (Adopted by the ISO/IEC and redesignated as ISO/IEC 8802-2) Part 2: Logical link control.

IEEE Std 802.3, 2000 Edition (Adopted by the ISO/IEC and redesignated as ISO/IEC 8802-3:2000(E)) Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.

ANSI/TIA/EIA-568-A, Commercial Building Telecommunications Cabling Standard.

Ethernet: The Definitive Guide by Charles E. Spurgeon. Published by O'Reilly & Associates, First Edition February 2000, ISBN 1-56592-660-9.

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1.4 Concepts

0x18-C2	Example of a hexadecimal representation of a two Byte number.
10Base-T	IEEE 802.3 Physical Layer specification for a 10 Mb/s LAN over two pairs.
100Base-Tx	IEEE 802.3 Physical Layer specification for a 100 Mb/s LAN over two pairs of Cat5 cable.
1000Base-T	IEEE 802.3 Physical Layer specification for a 1000 Mb/s LAN over four pairs of Cat5E cable.
ANSI	American National Standards Institute.
BI_DA+	Positive Bidirect #A
BT	Bit Time, the reciprocal of the bit rate.
BYB202	Hardware equipment practice used in AXE with parallel RP bus.
BYB501	Hardware equipment practice used in AXE with serial RP bus.
Byte	A group of 8 bits, also known as an octet.
Cat5	A 100 ohm balanced cable with four twisted pairs specified up to 100 MHz. Can be used for 10BaseT and 100BaseTx.
Cat5E	A 100 ohm balanced cable with four twisted pairs specified up to 100 MHz, with extra requirements compared to Cat5. Can be used for 10BaseT, 100BaseTx and 1000BaseT
CE	Cabling Element, a twisted pair of wires.
CSMA/CD	Carrier Sense Multiple Access/Collision Detect, principle used for Ethernet half duplex.
DCP2	Data Communication Platform, with RPB-S for BYB501.
DCP202	Data Communication Platform, with RPB-P for BYB202.
DHCP	Dynamic Host Configuration Protocol, an open standard for automated allocation, configuration and management of IP addresses and TCP/IP protocol stack parameters.
DIX	Digital, Intel, Xerox. DIX is used as a name for the version of Ethernet that these three companies developed, also called Ethernet II.

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EIA/TIA	Electronic Industries Associated / Telecommunications Industry Association of America.
End station	A system attached to a LAN that is an initial source or a final destination of MAC frames transmitted across that LAN.
Ethernet II	See DIX
EthernetDIX	See DIX
Fast Ethernet	The same as 100BaseTx
FCS	Frame Check Sequence
GDDM-H	Generic Datacom Device Magazine for Half height boards (115 mm height), used in DCP2
GEM	Generic Ericsson Magazine, used in BYB501.
GESB	Gigabit Ethernet Switch Board, used in GEM
Giga Ethernet	The same as 1000BaseT
HOL	Head of Line Blocking
I/G address	Individual/Group address
IEEE	Institute of Electrical and Electronic Engineers.
IEEE802.3	In this document used for the packet format described in the first IEEE802.3 standard released in 1985. Nowadays the EthernetDIX version is also included in the IEEE802.3 standard.
IETF	Internet Engineering Task Force.
IP	Internet Protocol, a standard protocol in the Network layer in OSI
IP stack	Software for IP
KiB	Kilo-binary Byte, 1 024 Bytes
LAN	Local Area Network
LED	Light Emitting Diode
Linkhandler	Provides transparent communication across CPU or system boundaries. It also provides client supervision and creation and removal of logical channels.

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LLC	Logical Link Control, sublayer in the Data Link layer in OSI.
LSB	Least Significant Bit
MAC	Media Access Control, sublayer in the Data Link layer in OSI.
Mb/s	Million bits per second, bit rate
MDI	Medium Dependent Interface
MDI-X	Medium Dependent Interface with cross over
MiB	Mega-binary Byte, 1 048 576 Bytes
MSB	Most Significant Bit
OSI	Open Systems Interconnection, reference model specified by ISO/IEC
PAD	Extra Bytes of no value, used to fill up a too small MAC frame.
PAUSE operation	A mechanism for full duplex flow control.
QoS	Quality of Service, also called User Priority
REOS	REgional Operating System, API
RFC xxx	Request For Comments number xxx, issued by Internet Engineering Task Force (IETF).
RJ45	Registered Jack # 45, an eight-pin Modular connector of ISO/IEC 8877:1992, a standard connector used for Ethernet.
RPI	Regional Processor Integrated
RPIC	Regional Processor Interprocessor Communication
RPB-P	Regional Processor Bus, Parallel version
RPB-S	Regional Processor Bus, Serial version
RPS	Regional Processor Subsystem
SCB-RP	Support and Connection Board with an RP, used in GEM
SFD	Start Frame Delimiter
SNAP	Subnetwork Access Protocol

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Switch	A layer 2 interconnection device that conforms to the ISO/IEC 10038 (ANSI/IEEE 802.1D-1990) International Standard.
TCI	Tag Control Information
TCP	Transmission Control Protocol on level 4 in OSI
TP	Twisted Pair, two wires twisted together in a cable.
TPID	Tag Protocol Identifier
U/L address	Universal/Local address
UDP	User Datagram Protocol on level 4 in OSI
VLAN	Virtual Bridged Local Area Network

2 Function

2.1 General

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2.2 Layer architecture

In this document the intention is to describe the functions associated to different layers in the following order: Transmission Media, Management layer, Physical layer, MAC sublayer, Bridging sublayer and Higher layers. For each layer the functions are described in the order they are executed. The Management layer is a common layer for both the Physical layer and the Data Link layer.

Table 1 Layer Architecture for Ethernet switches.

Management layer	Bridging (Relay) sublayer in Data Link layer
	MAC sublayer in Data Link layer
	Physical layer
	Transmission Media

2.3 Switch Management

Both the SCB-RP and the GESB have a built-in RP, including FW, for management of the switches (change configuration parameters, read out statistics, etc.), but at present no loadable SW has been released for that. Some of the functions that are supported in the HW and therefor are possible to reconfigure with a future SW release are: VLAN, User Priority, Head of

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Line Blocking, Spanning Tree, Mirroring (Port monitoring, sniffer) Test port, MAC_Adress register size and aging time, Link Aggregation.

In the GESB, its built-in processor and its from factory loaded FW are used for one part of the initial default configuration of the switch. This is done automatically but has the drawback that if the processor by some reason make a cold or warm restart (HW or SW reset), the switch will be configured once again and during that time the data transmission through the switch can be disturbed.

2.4 Hardware implementation

The function, Ethernet switching in GEM, is split into two different HW implementations, SCB-RP and GESB. GESB is purely dedicated to Ethernet switching. The SCB-RP has also other functions besides Ethernet switching. The SCB-RP handles Ethernet switching internal in the GEM subrack and presents also Ethernet interfaces for cable connections to the outside world. GESB has only cable connected Ethernet switch ports and is intended for connecting several subracks together.

2.5 Transmission Media

2.5.1 General

The function of the Transmission Media is to connect pairs of signalling pins in one switch port to pairs of signalling pins in a port in an other switch or end station, via balanced signalling lines in a cable or a backplane.

2.5.2 Cables

There exists two different wiring standards for Ethernet cables, the EIA/TIA T568A and the T568B wiring sequence standard, pin/cable pair configuration. For Ethernet switching in GEM the EIA/TIA T568A wiring sequence standard is chosen. For each of the wiring standards, the wires in the cable can be configured to the pins of the connector in two ways, normal or cross-over. A straight cable has the Normal Wiring Sequence in both ends. A cross-over cable has the Normal Wiring Sequence in one end and the Cross-over Wiring Sequence in the other. Two different connectors are used in the switches and end stations, the standardized RJ45 connector and the Ericsson unique Concept connector, which has better properties. Article numbers for the cables to use together with the switches SCB-RP and GESB can be found in the Cable Information document for each board.

Table 2 Normal Wiring Sequence in the connectors.

Cabling Element / wire	Wire color	Concept pin number	RJ45 pin number, T568A
CE1 / b	blue	B2	4
CE1 / a	white with blue	A1	5
CE2 / b	orange	B1	6

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CE2 / a	white with orange	A2	3
CE3 / b	green	B4	2
CE3 / a	white with green	A3	1
CE4 / b	brown	B3	8
CE4 / a	white with brown	A4	7

Table 3 Cross-over Wiring Sequence in the connectors.

Cabling Element / wire	Wire color	Concept pin number	RJ45 pin number, T568A
CE1 / b	blue	A4	7
CE1 / a	white with blue	B3	8
CE2 / b	orange	B4	2
CE2 / a	white with orange	A3	1
CE3 / b	green	B1	6
CE3 / a	white with green	A2	3
CE4 / b	brown	A1	5
CE4 / a	white with brown	B2	4

2.5.3

Backplane

The end station ports have the same pin numbering independent of which switch port they are connected to. All switch ports have similar pin numbering as the port 0, but 2 pins below for each higher port.

Table 4 Backplane pin connections between switch and end station slots (switch only shown for port #0).

Pin number for switch, A- or B-side port 0	Pin number for end station, A-side	Pin number for end station, B-side
X06_A01	X10_A01	X10_E01
X06_A02	X10_A02	X10_E02
X06_B01	X10_B01	X10_D01
X06_B02	X10_B02	X10_D02
X06_D01	X10_A03	X10_E03
X06_D02	X10_A04	X10_E04
X06_E01	X10_B03	X10_D03
X06_E02	X10_B04	X10_D04

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2.6 Automatic Wire Map detection and correction

This function in the Physical layer is used for detection and correction of faults in the link between two ports. One possible fault that can be detected and corrected is a polarity error within an individual pair. An other possible fault is a swapping between different pairs. Detection and correction is only done on the receiving part of the ports. The fault where a signal is sent on wires belonging to different pairs is not detected or corrected by this function. The function is closely related to, and active during the Automatic MDI/MDI-X Configuration function and before the Auto-negotiation and Parallel Detection functions. The default configuration in all ports in the SCB-RP and GESB switches is to support the Automatic Wire Map detection and correction function.

2.7 Automatic MDI/MDI-X Configuration

This is a function to guarantee that there is always an odd number of cross-overs between two ports so that a transmitter will be connected to a receiver. The function is placed in the Physical layer and is performed before any Auto-Negotiation or Parallel detection. All ports in the switches SCB-RP and GESB have this internal automatic MDI/MDI-X Configuration function. Nevertheless the recommendation is to use either straight or full cross-over cables depending on what type of ports that are to be connected and not rely upon this automatic crossover function inside the ports. Therefor, to connect an end station port to a switch port a straight cable shall be used and to connect two switch ports together or two end station ports together, a full crossover cable shall be used (Note, there are cables on the market that are called cross-over but only has the cross over function for two of the four pairs and therefor can not be used for 1000BaseT). The tables below show how the signals will be configured to different connector pins in the case that no Wire Map correction is done.

Table 5 Concept cable connector pin-outs

Concept pin number	MDI	MDI-X
A1	BI_DC-	BI_DD-
A2	BI_DB+ or RD+	BI_DA+ or TD+
A3	BI_DA+ or TD+	BI_DB+ or RD+
A4	BI_DD+	BI_DC+
B1	BI_DB- or RD-	BI_DA- or TD-
B2	BI_DC+	BI_DD+
B3	BI_DD-	BI_DC-
B4	BI_DA- or TD-	BI_DB- or RD-

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Table 6 RJ45 Cable connector pin-outs

RJ45 pin number	MDI	MDI-X
1	BI_DA+ or TD+	BI_DB+ or RD+
2	BI_DA- or TD-	BI_DB- or RD-
3	BI_DB+ or RD+	BI_DA+ or TD+
4	BI_DC+	BI_DD+
5	BI_DC-	BI_DD-
6	BI_DB- or RD-	BI_DA- or TD-
7	BI_DD+	BI_DC+
8	BI_DD-	BI_DC-

Table 7 Backplane pin-outs for switch slot (only shown for port #0).

Backplane pin number	MDI	MDI-X	GEM designation
X06_A01	BI_DA+ or TD+	BI_DB+ or RD+	10BaseT_TXP_0
X06_A02	BI_DB+ or RD+	BI_DA+ or TD+	10BaseT_RXP_0
X06_B01	BI_DA- or TD-	BI_DB- or RD-	10BaseT_TXN_0
X06_B02	BI_DB- or RD-	BI_DA- or TD-	10BaseT_RXN_0
X06_D01	BI_DC+	BI_DD+	1000BaseT_TXP_0
X06_D02	BI_DD+	BI_DC+	1000BaseT_RXP_0
X06_E01	BI_DC-	BI_DD-	1000BaseT_TXN_0
X06_E02	BI_DD-	BI_DC-	1000BaseT_RXN_0

2.8 Automatic configuration of Ethernet Medium Access and PAUSE flow control

2.8.1 General

There exists many different versions of the Ethernet Medium Access, for example 10BaseT, 100Base-T2, 100Base-T4, 100BaseTx, 1000BaseCX, 1000BaseT and some in either half or full duplex mode. A port in half duplex mode use the CSMA/CD MAC procedure and can not receive and transmit data at the same time. All ports in the switches SCB-RP and GESB are capable of working at 10BaseT_HalfDuplex, 10BaseT_FullDuplex, 100BaseTx_HalfDuplex and 100BaseTx_FullDuplex. One front port on SCB-RP and all ports on GESB can also work at 1000BaseT_HalfDuplex and 1000BaseT_FullDuplex. The corresponding wire speed is 10Mbit/s in 10BaseT, 100Mbit/s in 100BaseTx and 1000Mbit/s in 1000BaseT.

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Four different PAUSE modes can then be chosen for each port depending on the capability of the own port and of the connected port, disable PAUSE transmit and disable PAUSE receive, disable PAUSE transmit and enable PAUSE receive, enable PAUSE transmit and disable PAUSE receive or enable PAUSE transmit and enable PAUSE receive.

2.8.2 Auto-Negotiation

The Auto-Negotiation function in the Physical layer is used during start-up between two connected Ethernet ports for an automatic configuration of the link's Ethernet Medium Access (speed and duplex mode) and flow control. The function uses Fast Link Pulses (FLP) between the two connected ports to transmit each capability. After the negotiation has finished no more FLP are sent unless the link goes down again. All switch ports on SCB-RP and GESB is configured to support Auto-Negotiation as default.

The default configuration in the switches SCB-RP and GESB is to advertise all of their Ethernet Medium Access capabilities for each port. Which Ethernet Medium Access that will be chosen after the Auto-Negotiation process can be seen in the table below.

Table 8 Prioritization scheme for Ethernet Medium access

Prioritization high to low
1000BaseT full duplex
1000BaseT
100BaseTx full duplex
100BaseTx
10BaseT full duplex
10BaseT

Four capability alternatives for flow control can be advertised to an other connected port, No PAUSE (can neither transmit or receive PAUSE frames), Asymmetric PAUSE toward other port (can transmit but not receive PAUSE frames), Symmetric PAUSE (can receive and transmit PAUSE frames, but only if the link partner also can do both) or Both Symmetric PAUSE and Asymmetric PAUSE toward own port (can receive and transmit PAUSE frames as well as only receive and not transmit PAUSE frames). The default configuration in the switch GESB is to advertise Symmetric PAUSE. The switch SCB-RP advertise Symmetric PAUSE for the port capable of 10/100/1000BaseT and No PAUSE for all other ports only capable of 10/100BaseT. Which PAUSE flow control configuration that will be chosen after the Auto-Negotiation process can be seen in the table below.

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Table 9 PAUSE Resolution

PAUSE configuration chosen for own port	Own port capability	Connected port capability
Disable transmit Disable receive	No PAUSE	Don't care
Disable transmit Disable receive	Asymmetric PAUSE toward connected port	No PAUSE or Asymmetric PAUSE toward connected port or Symmetric PAUSE
Disable transmit Disable receive	Symmetric PAUSE	Anything else than Symmetric PAUSE
Disable transmit Disable receive	Both Symmetric PAUSE and Asymmetric PAUSE toward own port	No PAUSE
Disable transmit Enable receive	Both Symmetric PAUSE and Asymmetric PAUSE toward own port	Asymmetric PAUSE toward connected port
Enable transmit Disable receive	Asymmetric PAUSE toward connected port	Both Symmetric PAUSE and Asymmetric PAUSE toward own port
Enable transmit Enable receive	Symmetric PAUSE or Both Symmetric PAUSE and Asymmetric PAUSE toward own port	Symmetric PAUSE or Both Symmetric PAUSE and Asymmetric PAUSE toward own port

2.8.3

Parallel Detection

If Ethernet ports not capable of Auto-Negotiation is connected to the switches, the default configuration in the switches are to use the Parallel Detection function in the Physical layer instead. By this function the switches can detect the speed (10BaseT, 100BaseTx or 1000BaseT) but not the duplex mode from an external port. The switch port will then be configured to the same speed and to half duplex mode. It is therefor not possible to connect ports with full duplex mode that is not capable of Auto-Negotiation to the switches SCB-RP or GESB.

Because of the half duplex mode, PAUSE flow control can not be used.

2.9

Link Monitoring

This function in the Physical layer can be used for detection of faults in the communication between ports in two different switches. Alarms can be given either through a LED or a Management SW. The switches in SCB-RP and GESB is not equipped with LEDs visible during normal use. For test purposes

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the SCB-RP can be equipped with an extra test board with LEDs. The GESB has the lay-out prepared so that LEDs can be soldered in for test purposes. At present no Management SW is released for SCB-RP or GESB.

2.10 MAC frame format, interframe gap and frame bursting

2.10.1 General

There exist two standardized versions of the MAC frame format, the Basic MAC frame format and the Tagged MAC frame format, which is an extended version of the Basic MAC format. Beside these there is also a Jumbo frame format that is not standardized and therefor has no guarantee for interoperability between different component manufactures. The switches in the AXE GEM subrack, SCB-RP and GESB, support both Basic and Tagged MAC frame formats, but do not support Jumboframes. If the switches receive ill-framed data, for example a MAC frame that is too long, too short or has an incorrect FCS, then the switches will discard and not forward this data.

2.10.2 Basic MAC frame

The basic MAC frame format consists of 0–1500 Bytes of MAC client data, 26 Bytes overhead and if needed a Pad to fill up the frame size to the requirement of minimum 64 Bytes length. An Extension might also be needed in some cases. When the Length/Type is used as a Length value it is equal to the length of the MAC Client Data. The Preamble, SFD, PAD, FCS and Extension are added and removed in the MAC sublayer with one exception. In EthernetDIX the PAD is not removed when the user data is delivered to the next higher layer.

Table 10 Basic MAC frame format

Preamble	7 Bytes
Start Frame Delimiter (SFD)	1 Byte
MAC Destination Address	6 Bytes
MAC Source Address	6 Bytes
Length/Type	2 Bytes
MAC Client Data	0 – 1500 Bytes
PAD	0 — 46 Bytes
Frame Check Sequence (FCS)	4 Bytes
Extension	(only in 1000BaseT half duplex to fill up frame size to 512 Byte)
Total size of a Basic MAC frame	64 – 1518 Bytes, (72 – 1526 Bytes with Preamble and SFD)

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2.10.3 Tagged MAC frame

The tagged MAC frame format consists of 0–1500 Bytes of MAC client data and 30 Bytes overhead and if needed a Pad to fill up the frame size to the requirement of minimum 64 Bytes length. An Extension might also be needed in some cases. When the Length/Type is used as a Length value it is equal to the length of the MAC Client Data. The Preamble, SFD, PAD, FCS and Extension are added and removed in the MAC sublayer with one exception. In EthernetDIX the PAD is not removed when the user data is delivered to the next higher layer.

Tagged MAC frame format is used in systems with VLANs and/or User Priority. Both SCB-RP and GESB can forward tagged MAC frames, but with the default configuration they are not able to prioritize or filter out frames on different ports depending on the QTag Prefix for that frame. As default the SCB-RP and GESB switches will not add a Tag to an incoming frame nor will they remove a Tag from an outgoing frame. The QTag Prefix is the Tag Protocol Identifier (802.1QTagType constant = 0x81–00) together with the Tag Control Information.

Table 11 Tagged MAC frame format

Preamble	7 Bytes
Start Frame Delimiter (SFD)	1 Byte
MAC Destination Address	6 Bytes
MAC Source Address	6 Bytes
Tag Protocol Identifier (TPID)	802.1QTagType, 0x81–00, 2 Bytes
Tag Control Information (TCI)	2 Bytes
Length/Type	2 Bytes
MAC Client Data	42 – 1500 Bytes
PAD	0 — 42 Bytes
Frame Check Sequence (FCS)	4 Bytes
Extension	(only in 1000BaseT half duplex to fill up frame size to 512 Byte)
Total size of a Tagged MAC frame	64–1522 Bytes, (72 – 1530 Bytes with Preamble and SFD)

2.10.4 Jumboframes

In Jumboframes the MAC Client Data field is expanded from 1500 up to 9000 Bytes. Jumboframes can only be used in full duplex mode. They are not supported in SCB-RP or GESB.

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2.10.5 Interframe gap

Between each MAC frame an interframe gap of at least 96 bit times (BT) is inserted.

Table 12 Inter Frame Gap (flow)

MAC frame	Inter frame gap	MAC frame	Inter frame gap	MAC frame
576 – 12240 BT	>= 96 BT	576 – 12240 BT	>= 96 BT	576 – 12240 BT

2.10.6 Frame bursting

Frame bursting is a function in the MAC sublayer to improve performance for short frames. It can only be used in 1000BaseT half duplex mode. With Frame bursting several frames are sent directly after one another separated by an Inter frame gap with non-data symbols. Only the first frame need an extension. The total length of the burst must not exceed 65 536 bit times. The switches in SCB-RP and GESB support Frame bursting, both for receiving and for sending.

Table 13 Frame bursting (flow)

MAC frame with extension	Inter frame gap with non-data symbols	MAC frame without extension	Inter frame gap with non-data symbols	MAC frame without extension
>=4160 BT	>=96 BT	>=576 BT	>=96 BT	>=576 BT

2.11 Packet formats and Protocol discrimination

2.11.1 General

Seen from the higher layers there exists two different Packet formats, the EthernetDIX (also called Ethernet II or just Ethernet) and the IEEE802.3. The difference between the two Packet formats is in the handling of higher layer protocols. EthernetDIX interfaces directly from the MAC sublayer to different high-level network protocols and uses a 2 Byte Type address to distinguish between them, while the IEEE802.3 uses an LLC protocol in the Data link layer for that. This difference can also be seen in the Length/Type part of the MAC frame format, where EthernetDIX use a Type value of 1536 or higher and IEEE802.3 use a Length value below 1536. Both versions can co-exist in the switches SCB-RP and GESB. The switches can also distinguish between the two Ethernet versions and will for IEEE802.3 frames discard incoming frames if the length value is not in accordance with the length of the frame.

The transmit data encapsulation in the MAC sublayer is the same for both versions and consists of adding Preamble, SFD, PAD, FCS and if needed Extension. The MAC sublayer can distinguish between Length and Type values

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in the received MAC frame and use different receive data decapsulation for the two versions.

2.11.2 EthernetDIX

Because no data length value is used in EthernetDIX it is not possible to see at the Data link or Physical layers what part of a MAC frame that is actually real user data and what is just an added PAD. Both will therefor be delivered up to the higher level network protocol, which is required to have some function to filter out the User Data from the PAD added by the MAC sublayer.

Table 14 Untagged EthernetDIX MAC frame format

Preamble	
Start Frame Delimiter (SFD)	
MAC Destination Address	
MAC Source Address	
Length/Type	A Type value is used (≥ 1536)
User Data (at least 46 Bytes)	
PAD	
Frame Check Sequence (FCS)	
Extension	

2.11.3 IEEE802.3

IEEE802.3 use the LLC sublayer from IEEE Std 802.2 as an upper part in the Data Link layer. The PAD is removed during the receive data decapsulation in the MAC sublayer before delivering to the LLC sublayer.

Table 15 Untagged IEEE802.3 MAC frame format

Preamble	
Start Frame Delimiter (SFD)	
MAC Destination Address	
MAC Source Address	
Length/Type	A Length value is used (< 1536)
Destination Service Access Point (DSAP)	1 Byte
Source Service Access Point (SSAP)	1 Byte
Control	1 or 2 Bytes
User Data	

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PAD	
Frame Check Sequence (FCS)	
Extension	

2.12 MAC_Address filtering

2.12.1 Uni-/Multi-/Broad-cast MAC address support

The MAC addresses are 48-bit long. The LSB of the first Byte is the Individual/Group (I/G) address bit and the next bit is the Universal/Local (U/L) address bit. The MAC address is sent with LSB of Byte 0 first. The MAC address example in the table below will be sent out as YX11 0101 0111 1011 0001 0010 0000 0000 0000 0000 0001. This corresponds to the hexadecimal address 0xAC-DE-48-00-00-80 if the U/L address bit X=0 and the I/G address bit Y=0. For Group addresses (used for Broadcast and Multicast) the I/G bit is set to 1 and for Individual addresses (used for Unicast) to 0. For Universal addresses (addresses that are globally administered and therefor unique in the whole world) the U/L bit is set to 0 and for Local addresses (addresses that are locally administered and therefor maybe only unique within one network) to 1. The Broadcast address is 0xFF-FF-FF-FF-FF-FF. The default configuration in the switches SCB-RP and GESB is to support all different MAC addresses, but MAC frames with Multicast addresses are handled as a Broadcast except for the special Multicast address 0x01-80-C2-00-00-01 used for PAUSE frames.

Table 16 MAC address example

	MSB.....LSB
Byte 0	101011XY
Byte 1	11011110
Byte 2	01001000
Byte 3	00000000
Byte 4	00000000
Byte 5	10000000

2.12.2 Frame flooding

If a switch receives a MAC frame with a MAC address it do not recognize (not in any of its address tables), it will send out the frame on all of its ports, frame flooding.

2.12.3 Address filtering, Register size, address self-learning

Each switch port has its own MAC address register (address table) . The set-up of the address table can be either self-learning or via management. Self-learning is only possible for individual addresses. If a MAC address is set

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in the address table for one port, incoming frames with this destination address will only be sent out on this port. The size of the address register on each port is 8k addresses in both SCB-RP and GESB. The default configuration in both SCB-RP and GESB is to discard frames with multicast addresses.

2.12.4 Aging time or unlearning

If a switch input port not has received MAC frames with a specific MAC address for a specified time (called Aging time), that address shall be removed from the switch ports address table, so that the address can be reused somewhere else instead. This is for example what happens if a board or a cable is moved to some other place in the system. In IEEE802.1D table 7–4 it is stated that any Aging time between 10.0 to 1 000 000.0 seconds can be used in a switch, but the recommended default value is 300.0 s. The switch in SCB-RP has 103 — 206 s as default and the switch in GESB has 300 s as default. This means that it can take up to 5 minutes before a board, that is moved from one place to another, will get all frames that are addressed to its MAC address.

2.12.5 Mirroring (Port monitoring, sniffer), Test port

The HW in both SCB-RP and GESB support the configuration of one port as a sniffer for port monitoring but at present no SW is released for this purpose.

SCB-RP is equipped with a special 100BaseT port with a standard RJ45 connector to be used only for test purposes.

2.13 Switch Architecture

Several Switch architectures are in use. One is “Cut through”, where the switch starts to forward the frame as soon as the MAC destination address has been received. An other is “Store and forward”, where the switch stores the whole frame before it start forwarding. The switches in both SCB-RP and GESB runs in the store and forward mode, which allow transfer of data frames between ports which have been set up to different speed and duplex modes and also to discard incorrect frames.

2.14 Ethernet Flow Control, Back pressure

2.14.1 General

The function Flow Control is done in totally different ways for the two duplex modes. In half duplex mode back pressure can be used. Back pressure use the Collision Detection function and require no set up between the two ports. In full duplex mode the PAUSE operation in the MAC Control protocol can be used which requires a set up to start to function, either automatically during Auto-Negotiation or manually. The default configuration in the switches SCB-RP and GESB is to use Back pressure and to advertise PAUSE capability with Auto-Negotiation. At present no SW is released to reconfigure the default values.

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2.14.2 Half Duplex

In half duplex mode the back pressure function in the MAC sublayer can be used to slow down data flow to an incoming port. This means that the port sends out a jamming signal based on the CSMA/CD algorithm for a specified time if the data in the input buffer exceeds its upper threshold. If the buffer is still full after that time a new jamming signal is sent out. The default configuration for the jamming length is 4 kBT for SCB-RP (which equals 0.4 ms, 0.04 ms and 0.004 ms for a bitrate of 10 Mbit/s, 100 Mbit/s and 1000 Mbit/s respective) and 1,6 ms for GESB (independent of the bitrate).

2.14.3 Full Duplex

Flow control by use of the PAUSE function in the MAC sublayer can be automatically configured during auto-negotiation.

Pause time requests are sent from the Data Link layer as untagged EthernetDIX frames to a specific multicast MAC destination address, 01-08-C2-00-00-01, that is used only for this purpose. A frame with this specific address is terminated in the receiving port and is not forwarded. The PAUSE frame is of type MAC Control (type value 0x8808) and contains the PAUSE Opcode (0x0001) together with the requested number of pause units. 0 through 65 535 pause units can be ordered in a pause time request. Each pause unit is equal to 512 bit times. PAUSE frames can be sent to ports even when they are in a pause state. If a new PAUSE frame is received before the current frame's pause time has expired, the pause function will be restarted using the new pause value. The default configuration in the switches SCB-RP and GESB is to send a pause time request of 65 535 pause units when the input buffer exceeds its upper threshold. After a specified time a new check is done and if the buffer is still full a new pause time request of 65 535 pause units will be sent, in other case a pause time request of 0 pause units will be sent. The default configuration for the time between each check is 4 kBT for SCB-RP and 1,6 ms for GESB.

Table 17 PAUSE frame format

Preamble	
Start Frame Delimiter (SFD)	
MAC Destination Address	PAUSE address, 0x01-80-C2-00-00-01
MAC Source Address	
Length/Type	MAC Control Type, 0x88-08
MAC Control Opcode	PAUSE Opcode, 0x00-01
MAC Control parameters	Number of pause units, 2 Bytes
PAD	42 Bytes of zeroes

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Frame Check Sequence (FCS)	
Extension	

2.15 Head of Line Blocking Prevention

Each port in a switch have one input buffer and one output buffer. Internal in the switch frames are transferred from the input buffer of one port to the output buffer of an other port. If a frame in an input buffer is temporary blocked from being delivered to the output buffer and therefor block the next frame in the input buffer from being delivered to another output buffer, the input buffer is said to be in Head of Line Blocking state (HOL). The cause of the blocking of the first output buffer can either be that it is full or that some other input buffers are transferring frames to it. By using the function "Head of Line Blocking Prevention" for an output buffer the input buffer is allowed to discard frames to this output buffer in case it is blocked.

The default configuration in the SCB-RP and GESB switches is to not use Head of Line Blocking Prevention. This puts a requirement on all end stations (including their protocols) connected to the network, that they are not allowed to send so many frames without response, that some switch port can get into Head of Line Blocking state.

2.16 Virtual LANs

The VLAN function in the MAC sublayer uses tagged MAC frames. The VLAN value 0 in the QTag Prefix indicates that only User Priority and no VLAN is used. VLAN value 1 and 4095 (0xFFFF) are reserved for special use. VLAN value 1 is used internally in the switches GESB and SCB-RP as default VLAN. All other 4093 VLAN values is possible to use as VLAN identifiers. SCB-RP can handle all VLANs. GESB can handle 32 port-based VLANs and 64 Tagged VLANs.

Both the GESB and SCB-RP HW has support for VLAN, but at present no SW is released to configure the switch ports for different VLANs. The default configuration in the switches give the following behavior: No tag will be added to a received MAC frame without a tag. An incoming MAC frame with a tag will be forwarded with the same tagging. No filtering depending on the VLAN tag will be done in the switches.

2.17 User Priority (Quality of Service, QoS)

The User Priority function in the MAC sublayer uses tagged MAC frames. The QTag Prefix give room for 8 User Priority levels, 0 — 7.

Both the GESB and SCB-RP HW has support for User Priority, but at present no SW is released to reconfigure the switch ports. The default configuration in the switches give the following behavior: No User Priority tag will be added to a received MAC frame without a tag. Incoming MAC frames with User Priority tagging will be forwarded with the same tagging. No prioritization depending on the User Priority tag will be done in the switches.

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2.18 Spanning Tree

The Spanning Tree function in the Bridging (Relay) sublayer is used for eliminating data loops in the network and see to that there is at most one data route between any two end stations. It can also be used to achieve fault tolerance by automatic reconfiguration in case of a failure in the network. The Spanning Tree function uses IEEE802.3 packets.

The HW in both GESB and SCB-RP has support for the Spanning Tree function, but it is disabled in their default configuration. At present no SW is released to reconfigure the switches.

2.19 Link Aggregation, Port trunking

Link Aggregation (also called port trunking) is a method to configure two or more Ethernet ports together in such a way that they can be treated as if they were a single port but with a higher bandwidth. Link Aggregation can also be used to achieve increased availability. With Link Aggregation the failure of a single port need not cause a total link failure, only a reduced bandwidth on the aggregated port. Link Aggregation can only be used in full duplex mode. Both the SCB-RP and the GESB HW has support for Link Aggregation, but at present no SW is released to configure the switches for Link Aggregation. No Automatic configuration of Link Aggregation is possible with the default configuration in SCB-RP or GESB.

3 Operational Conditions

3.1 External Conditions

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3.2 Application Parameters

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3.3 Commands

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3.4 Printouts

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3.5 Subscriber Procedures

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3.6 Subscriber Categories

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3.7 Charging

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3.8 Capabilities

3.8.1 Frame loss and error rates

The switches and the Ethernet MAC protocol do not guarantee delivery of a MAC frame. They make a “best effort” to deliver the frame without errors, but if congesting occurs a frame can be discarded.

The probability for a fault in a MAC frame transmitted between two ports is less than 8×10^{-8} per Byte of the MAC frame length. If a fault is detected in a receiving port the frame is discarded. The probability for an undetected error in the user data encapsulated in a MAC frame transmitted between two ports is less than 5×10^{-14} per Byte of user data length.

3.8.2 Frame misordering

The switches SCB-RP or GESB are designed to guarantee that all frames sent from one end station to one other end station will be delivered in the same order as they were sent out.

3.8.3 Frame duplication

The switches SCB-RP or GESB are designed to guarantee that no duplicated frames are delivered to a receiving end station.

3.8.4 Transit delay, frame lifetime and Maximum Seven Hop Network size

The IEEE standard requires that the absolute maximum transit delay through one switch shall be 4.0 seconds. Frames that would exceed this limit shall be discarded. The default configuration in SCB-RP is and GESB is infinity.

The standard IEEE802.1D requires that a frame between two end stations must not pass through more than 7 switches. This puts restrictions on the design of the Ethernet network structure.

3.8.5 Throughput

The switches in both SCB-RP and GESB are of a non-blocking design. This means that they can transmit and receive frames of minimum size on all ports at maximum bandwidth simultaneously without any loss.

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3.8.6 Useful bandwidth

To each MAC Client Data packet an overhead of at least 26 Bytes is added and between each MAC frame an interframe gap of at least 96 bit times (BT) is inserted. This means for example that when sending MAC Client Data packets with a length of 50 Bytes in each Basic MAC frame, only maximum 57% of the available bandwidth can be used for user data.