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ALICE DETECTOR DATA LINK

ALICE-DDL

Physical and Signalling Interface Specification

for the Fibre Channel Implementation of the DDL

Appendix of the Interface Control Document

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1. Document Information

1.1 Abstract

This document is an appendix to the ***Interface Control Document*** (ALICE/96-43, Internal Note/DAQ, 12 December 1996). It describes the physical and signalling interface for the Fibre Channel implementation of the ALICE-DDL.

1.2 Document Status Sheet

1. Document Title: ALICE-DDL Physical and Signalling Interface Specification			
2. Document Reference Number: ALICE Detector Data Link FCS-PhI			
3. Issue	**4. Revision**	**5. Data**	**6. Reason for change**
Draft	0	2 February, 1997	Original document
Draft	1	30 April, 1997	New ordered set definition
Draft	2	4 June, 1997	Frame delimiters were introduced for all the frames
Draft	3	4 July, 1997	DIU transmitting Not_Op ord. sets in dFAIL state
Draft	4	4 September, 1997	Standard FCS ordered set are used
Final	4.1	1 March, 1998	Modification of the port state machines

Table 1 Document Status Sheet

1.3 Document Change Record

Document Change Record			**DCR No.**	
			Date	
			Originator	
			Approved by	
1. Document Title			ALICE-DDL Physical and Signalling Interface Specification	
2. Document Reference Number			ALICE Detector Data Link FCS-PhI	
3. Document Issue/Revision Number			Final/4.1	
4. Page	**5. Paragraph**	**6. Reason for Change**		

Table 2 Document Change Record (of changes made since issue ...)

1.4 Table Of Contents

1.5 List of Figures

1.6 List of Tables

2. Introduction

2.1 Purpose of the Document

This document describes the physical and signalling interface for the Fibre Channel implementation of the ALICE-DDL.

It is an appendix of the ALICE-DDL Interface Control Document (ALICE/96-43, Internal Note/DAQ, 12 December 1996).

2.2 Scope

The interface control document defines only the interface between the FEE and the SIU and the interface between the RORC and the DIU. Alternative physical and signalling interfaces can be used for different DDL implementations. Each implementation shall have its own PhI (see Figure 1).

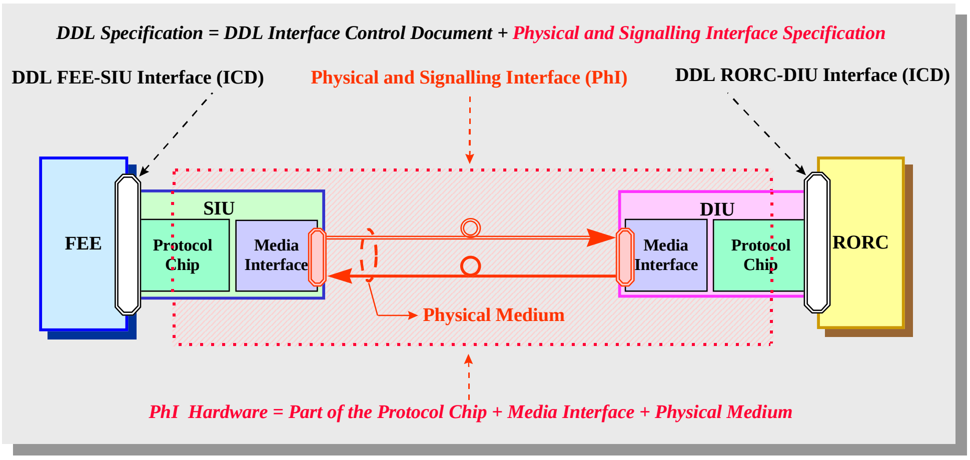

Figure 1 The DDL specifications and hardware components

2.2.1 PhI specification

The data communication protocol of the DDL consists of 4 protocol layers. The most upper layer describes the DDL interface protocol and it is defined in the ICD. The three lower layers are the object of the physical and signalling interface specification, so they are defined in this document:

- framing and signalling layer;
- coding layer;
- physical layer.

2.2.2 PhI hardware components

The physical and signalling interface is composed of three main hardware components (see Figure 1):

- part of the protocol chip of the SIU and the DIU;
- two identical media interfaces in the SIU and the DIU;
- physical medium.

In a part of the protocol chip the signalling and framing layer and the coding layer of the DDL protocol are implemented.

The media interface connects the DDL interface units to the physical medium. It consists of electrical and optical transceivers and a duplex fibre optic connector for the connection to the physical medium.

The physical medium is a full duplex physical link which connects the SIU and the DIU over a maximum distance of 200 m. It consists of two optical fibres and a duplex fibre optic connector for the connection to the DDL interface units.

The media interface and the physical medium implement the physical layer of the DDL protocol.

2.3 Definitions

SIU - DIU configuration

One of the possible configurations of the DDL, where a SIU is connected to one of the ends of the physical medium and a DIU to the other end.

DIU - DIU configuration

One of the possible configurations of the DDL, where DIUs are connected to the both ends of the physical medium.

2.4 Acronyms

C_Data	Ordered set: control data (start of frame delimiter)
End_Fr	Ordered set: end of frame delimiter for all the frames
FCS-PhI	Fibre Channel implementation of the PhI
L_Init	Ordered set: link initialisation
LRST	Interface command: link reset
LINIT	Interface command: link initialisation
MI	Media interface
Not_Op	Ordered set: not operational
N_Data	Ordered set: normal data (start of frame delimiter)
Off_Ln	Ordered set: off line
PhI	Physical and signalling interface
Rx_Rdy	Ordered set: receiver ready
Rx_Bsy	Ordered set: receiver busy
SRST	Interface command: reset source interface unit
TXLOOP	Interface command: transmitter loop-back

2.5 Abbreviations

Loss_of_Synch	Loss of synchronisation
Rx_Timeout	Time-out of the receiver
Synch_Acq	The synchronisation is acquired
Synch_Lost	The synchronisation is lost

2.6 References

[1] Fibre Channel Physical and Signalling Interface (FC-PH); ANSI X3.230-1994

[2] A. X. Widmer and P. A. Framaszek: "A DC-Ballanced, Partioned-Block, 8B/10B Transmission Code." IBM Research Journal and Development, 27, No. 5: 440-451 (September, 1983)

2.7 Overview of the document

The second chapter of this document describes:

1. the purpose of the document
2. the scope
3. the definitions
4. the acronyms
5. the abbreviations
6. the references
7. an overview of the document

The third chapter describes the different layers of the DDL:

1. the physical layer
2. the coding layer
3. the signalling and framing layer

3. General Description

3.1 Physical layer

The physical layer of the DDL protocol is defined in the FC-PH **[1]** FC-0 standard. FC-0 provides for a large variety of technology options. For the DDL applications the ***100-M5(6)-SL-I*** FC-0 option is chosen. It has the following features:

- ***100*** - 100 MB/s data transmission speed;
- ***M5(6)*** - 50 (62.5) µ multimode optical fibre;
- ***SL*** - short wave laser (850 nm) transmitter;
- ***I*** - intermediate distance (up to 500 m).

Standard duplex SC fibre optic connector is used for the connection of the interface units and the physical medium. The female connector is part of the interface units, while the male connector is part of the physical medium.

3.2 Coding layer

The transmission code of the DDL protocol is defined in the FC-PH FC-1 standard. This standard describes an 8B/10B encoding/decoding scheme **[2].**

3.3 Signalling and framing layer

3.3.1 Ordered sets

The ordered sets are specialised 32 bit wide transmission words which are used for following actions:

- bit, byte and word synchronisation;
- link initialisation;
- framing;
- flow control.

Table 3 shows the eight ordered sets which are used for the DDL protocol. In the FCS all the ordered set shall have negative beginning disparity, excepting the End of Frame delimiters. In contrast to the FCS, the IDLE (Rx_Rdy) and the Rx_Rdy (Rx_Bsy) ordered sets also can have either negative or positive beginning disparity in the DDL protocol, because they can be inserted between the data words inside the frames.

Function	DDL Acronym	FCS Acronym	Beginning RD
not operational	Not_Op	NOS	negative only
off line	Off_Ln	OLS	negative only
link initialisation	L_Init	LR	negative only
receiver ready	Rx_Rdy	IDLE	negative or positive
receiver busy	Rx_Bsy	Rx_Rdy	negative or positive
normal data	N_Data	SOFc1	negative only
control data	C_Data	SOFn1	negative only
end of frame	End_Fr	EOFt	negative or positive

Table 3 The ordered sets used in the DDL protocol

3.3.2 Receiver states

The receivers became synchronised, when they enter into the *synchronised* (SYNCH) state (see Figure 2 and Figure 3). This procedure includes the following steps:

- The receiver shall enter into RESET state:
  - after general reset (DIU);
  - after power on (SIU);
  - when input light signal was lost before and it is detected again (DIU and SIU).
- The receiver shall generate at least a 1 ms long Lock_to_Reference signal for the electrical transceiver (*LOCK* state).
- The receiver shall wait until at least 16 consecutive good Not_Op or Off_Ln ordered sets are detected (*WAIT* state).
- The receiver can stay in SYNCH state, until:
  - the Signal_Detect signal is true (the input light signal is above the limit);
  - the Loss_of_Synch state machine is staying in the Synch_Acq state.

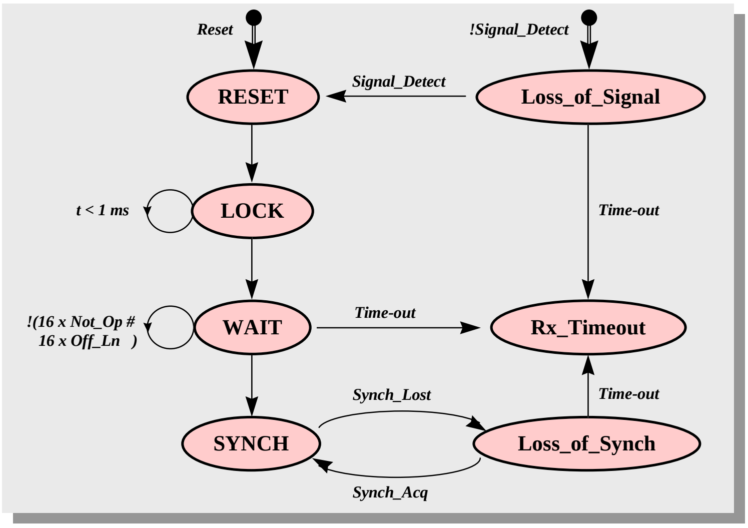

Figure 2 The state diagram of the DIU receiver

The Loss_of_Synch state machine is defined in FC-PH FC-1 in detail **[1]**. In comparison to the original definition, however, the following two changes were introduces:

- the Rx_RDY and the Rx_Bsy ordered sets can have both beginning disparities (see chapter 3.3.1);
- an invalid transmission word shall be recognised, if a not defined ordered set is detected.

The receivers of the DIU and the SIU shall have similar behaviour. The only difference is that the DIU receiver has a *receiver time-out* (Rx_Timeout) state, but the SIU receiver has not.

The DIU receiver shall enter to the Rx_Timeout state from the WAIT, the Loss_of_Signal and the *loss of synchronisation* (Loss_of_Synch) states, when it is not able to exit from these states within a pre-defined time-out period. The DIU receiver can exit from this state only, when the roRST# interface signal is activated by the RORC (reset). Thus the re-synchronisation procedure can only be initiated by the RORC. Figure 2 shows the state diagram of the DIU receiver.

The SIU receiver has not a Rx_Timeout state. It shall automatically enter to the LOCK state from the WAIT and the Loss_of_Synch states, when it is not able to exit from these states within a given time-out period. According to this procedure, the SIU shall automatically try to re-synchronise its receiver. Figure 3 shows the state diagram of the DIU receiver.

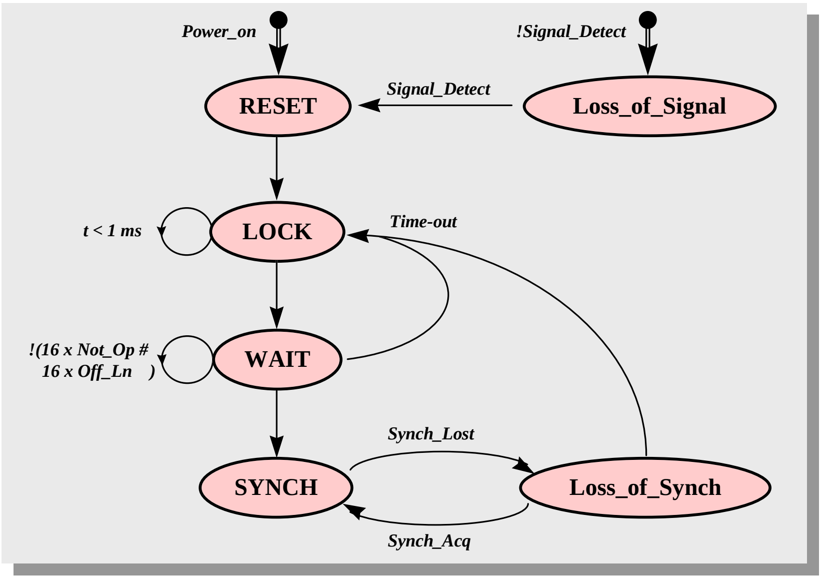

Figure 3 The state diagram of the SIU receiver

3.3.3 Transmitter states

Transmitter states of the DIU

The transmitter of the DIU has only three states: the *not operational* (NOTOP) state, the WORKING state and the *loop-back test* (LOOP) state. Figure 4 shows the bubble state diagram of the DIU transmitter.

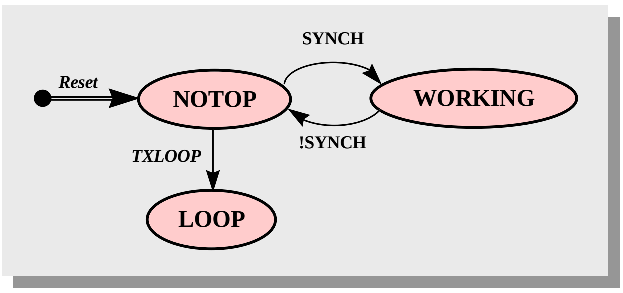

Figure 4 The bubble state diagram of the DIU transmitter

The transmitter shall enter into the NOTOP state from any other states, when the roRST# interface line is activated by the RORC. In this state the DIU shall continuously transmit Not_Op ordered sets through the physical medium. It shall enter into the LOOP state from the NOTOP state, when a TXLOOP interface command is received from the RORC. In this state the DIU can be tested in loop-back mode, while it shall not transmit any characters through the physical medium. The DIU can exit from the LOOP state only, when the roRST# interface line is activated by the RORC. The DIU transmitter shall enter into the WORKING state from the NOTOP state, when its receiver enters into the SYNCH state and it shall return to the NOTOP state again, when the DIU receiver exits from the SYNCH state. In the WORKING state the DIU will transmit frames or ordered sets according to its state (see 3.3.4).

Transmitter states of the SIU

The transmitter of the SIU has only two states: the NOTOP state and the WORKING state. Figure 5 shows the bubble state diagram of the SIU transmitter.

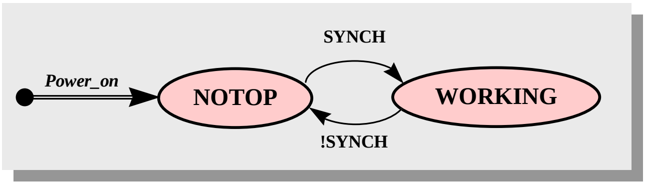

Figure 5 The bubble state diagram of the SIU transmitter

The shall enter into NOTOP state after power-on. In this state the SIU shall continuously transmit Not_Op ordered sets through the physical medium. The SIU transmitter shall enter into the WORKING state from the NOTOP state, when its receiver enters into the SYNCH state. It shall return to the NOTOP state again, when the DIU receiver exits from the SYNCH state. In WORKING state the SIU will transmit frames or ordered sets according to its state (see 3.3.4).

3.3.4 States of the interface units

The interface unit's behaviour may be viewed as a number of separate and distinct states within a unit with respect to ordered sets or other input events.

DIU states

Table 4 and Figure 6 describe the state transitions of the DIU made based on the current state and the input events received using to different representations. Table 4 shows the state transition table of the DIU, while Figure 6 the bubble state diagram.

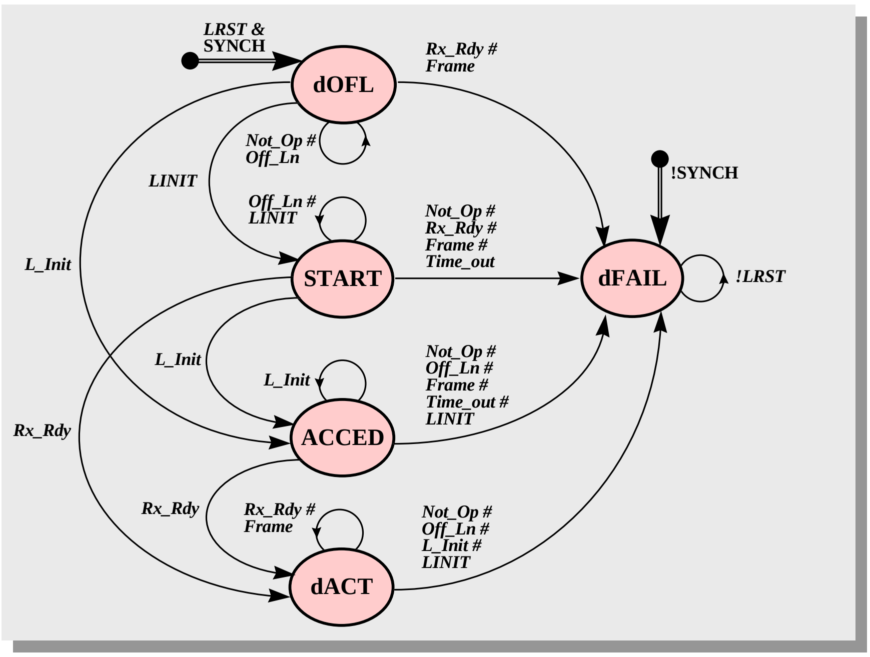

Figure 6 The bubble state diagram of the DIU

STATE	dOFL	dFAIL	START	ACCED	dACT
Transmitted ord. set →	Off_Ln	Not_Op	L_Init	Rx_Rdy	Rx_Rdy
Input event ↓					
!SYNCH[1]	dFAIL	**	dFAIL	dFAIL	dFAIL
Not_Op	**	**	dFAIL	dFAIL	dFAIL
LRST	**	dOFL	dOFL	dOFL	dOFL
Off_Ln	**	**	**	dFAIL	dFAIL
LINIT	START	**	**	dFAIL	dFAIL
L_Init	ACCED	**	ACCED	**	dFAIL
Time out	N/A	N/A	dFAIL	dFAIL	N/A
Rx_Rdy	dFAIL	**	dACT	dACT	**
Frame[2]	dFAIL	**	dFAIL	dFAIL	**

LEGEND

An ** entry means no change in state

N/A means not applicable

1) The state machine of the DIU receiver is out of the SYNCH state (it is not synchronised). All the other input events are ineffective, when the DIU receiver is out of the SYNCH state.

2) The frames formats are defined in chapter 3.3.6

Table 4 The state transition table of the DIU

The DIU enters into the *DIU failure* (dFAIL) state for following reasons:

- the DIU receiver state machine is out of the SYNCH state;
- Not_Op ordered sets are received through the physical medium;
- a protocol error has been detected;
- a time-out has been detected.

The DIU can only exit from the dFAIL state and enter into the *DIU off-line* (dOFL) state, when its receiver is in the SYNCH state and a LRST interface command is received from the RORC. The DIU shall exit from any other states and enter into the dOFL state, when a LRST interface command is received from the RORC.

The DIU can enter into the *start of link initialisation* (START) state only from the dOFL state, when a LINIT interface command is received from the RORC. The DIU shall exit from the START state and enter into the ACCED or the dACT state within a pre-defined time-out period, otherwise it shall enter into the dFAIL state.

The DIU can enter into the *link initialisation accepted* (ACCED) state only from the dOFL or the START states, when L_Init ordered sets are received through the physical medium. The DIU shall exit from the ACCED state and enter into the dACT state within a pre-defined time-out period, otherwise it shall enter into the dFAIL state.

The DIU can enter into the *DIU active* (dACT) state only from the START or the ACCED states, when Rx_Rdy ordered sets are received through the physical medium. Information (data block, command, status) in frames can be transmitted through the DDL only in this state.

SIU states

Table 5 and Figure 7 describe the state transitions of the SIU made based on the current state and the input events received. Table 5 shows the state transition table, while Figure 7 the bubble state diagram of the SIU.

STATE	sOFL	sFAIL	SRTED	sACT
Transmitted ord. set →	Off_Ln	Not_Op	L_Init	Rx_Rdy
Input event ↓				
!SYNCH[1	sFAIL	**	sFAIL	sFAIL
SYNCH	**	sOFL	**	**
Not_Op	**	**	sOFL	sOFL
Off_Ln	**	**	sOLF	sOFL
L_Init	SRTED	**	**	sOFL
Rx_Rdy	**	**	sACT	**
Frame	**	**	sOFL	**
SRST[2	N/A	N/A	N/A	sOFL

LEGEND

An ** entry means no change in state

N/A means not applicable

[1)] **The state machine of the SIU receiver is out of the SYNCH state. All the other input events are ineffective, when the SIU receiver is out of the SYNCH state.**

[2)] **The SRST interface command is transmitted as a frame through the physical medium.**

Table 5 The state transition table of the SIU

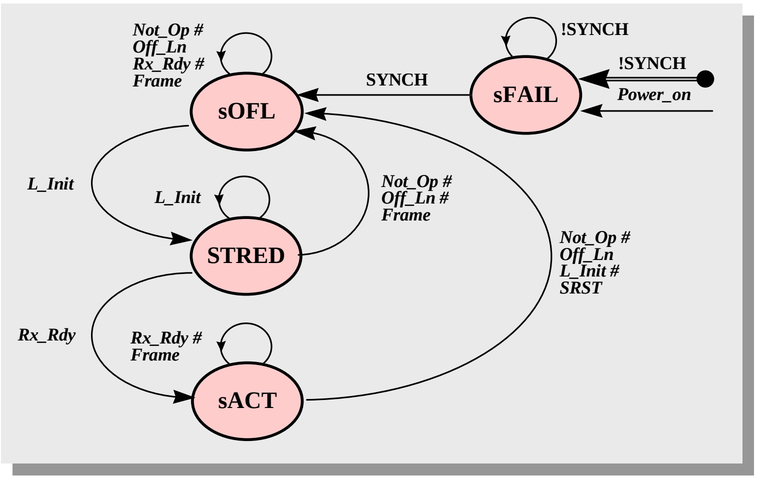

Figure 7 The bubble state diagram of the SIU

The SIU enters the *SIU failure* (sFAIL) state for following reasons:

- after the SIU powered-on;
- the SIU receiver state machine is out of the SYNCH state.

The SIU can only exit from the sFAIL state into the sOFL state, when the SIU receiver state machine enters into the SYNCH state.

The SIU enters the *SIU off-line* (sOFL) state for following reasons:

- a link protocol error has been detected;
- a SRST interface command has been received through the physical medium;
- Not_Op ordered sets have been received through the physical medium.

The SIU can enter into the *link initialisation started* (SRTED) state only from the sOFL state, when L_Init ordered sets are received through the physical medium.

The SIU can enter into the *SIU active* (sACT) state only from the SRTED state, when Rx_Rdy ordered sets are received through the physical medium.

3.3.5 Link initialisation

The DDL can be used in SIU - DIU and in DIU - DIU configurations. The link initialisation procedure is different for the two DDL configurations.

SIU - DIU configuration

Both the SIU and the DIU are controlled by the RORC. The link can only be initiated, when both the DIU and the SIU receivers are in the SYNCH state. Link initialisation can be triggered by sending a LINIT command from the RORC to the DIU. It is required after the following actions:

- the DIU has been reset by the RORC, activating the roRST# interface line;
- the link has been reset by the RORC, using a LRST interface command;
- the SIU receiver has been synchronised (after power on or any link failure);
- the SIU has been reset by the RORC, sending a SRST interface command through the physical medium.

The link initialisation is accomplished, when both interface units are in active state (dACT, sACT), so the SIU and the DIU are continuously transmitting Rx_Rdy ordered sets to each other. Information (e.g. data blocks, commands, status words) can be transmitted through the DDL only after a successful link initialisation. Figure 8 shows the state diagram of the link initialisation between a DIU and a SIU.

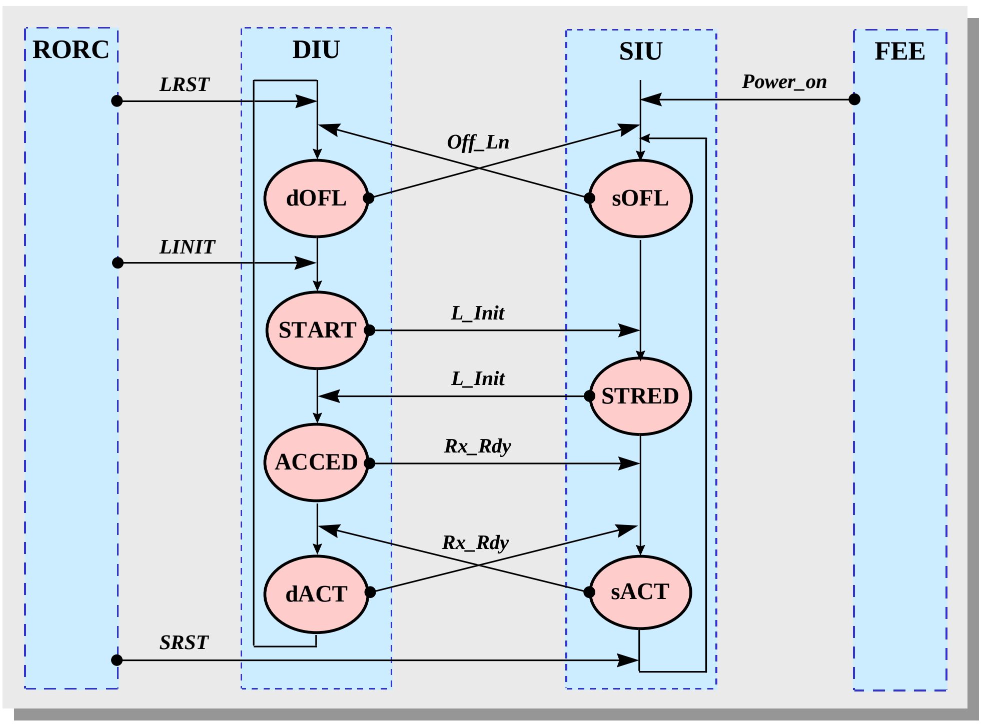

Figure 8 The state diagram of the link initialisation between a DIU and a SIU

DIU - DIU configuration

The two DIUs are controlled by different RORCs. The link can only be initiated, when both DIU receivers are in the SYNCH state. First a LRST interface command is required from the RORCs after each synchronisation of the DIU received. The link can be initiated by any of RORCs, sending a LINIT interface command to its own DIU.

The link initialisation is accomplished, when both interface units are in dACT state, so both DIUs are continuously transmitting Rx_Rdy ordered sets to each other. Information (e.g. data blocks, commands, status words) can be transmitted through the DDL only after a successful link initialisation. Figure 9 shows the state diagram of the link initialisation between two DIUs.

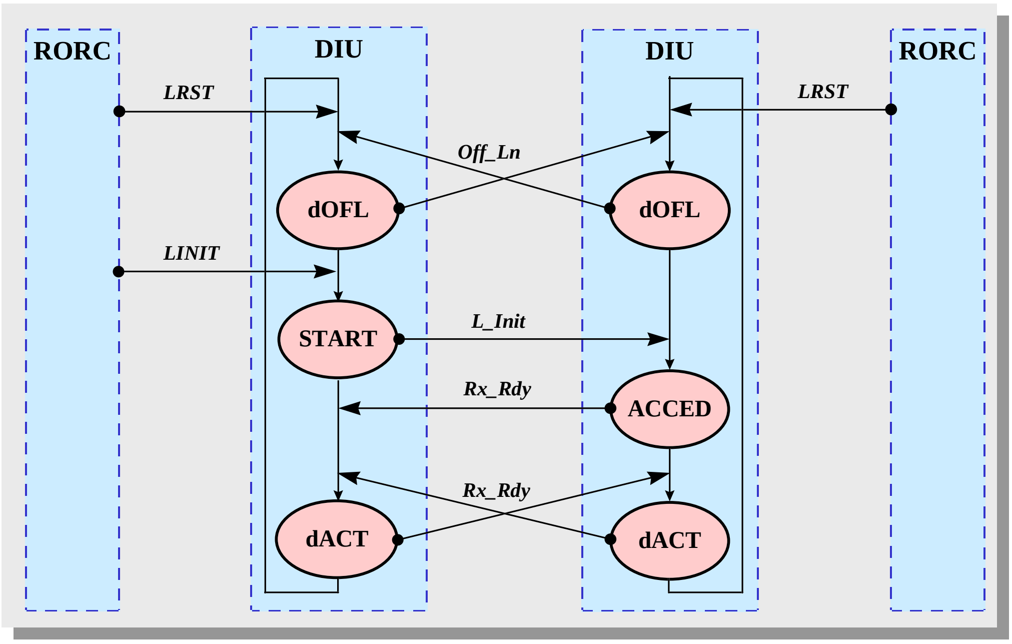

Figure 9 The state diagram of the link initialisation between two DIUs

3.3.6 Frame formats

The DDL shall transmit the data blocks in transparent way. A data block can contain Mbytes of data. In order to maintain the bit, the byte and the word synchronisation of the interface unit's receivers, some ordered sets shall be transmitted through the link at least by 5000 data bytes. For this purpose Rx_Rdy sequences are inserted between the transmitted data words, segmenting the data blocks into data frames. The probability of the non detected transmission error is decreased by generating a checksum from the data words of the frames.

All the information are transmitted in frames between the DIU and the SIU, using 32 bit words. Frame transmission shall be performed by inserting a frame immediately following a sequence of Rx_Rdy's. Rx_Rdy's shall be transmitted immediately upon a completion of the frame. The interface units shall transmit a minimum of 8 Rx_Rdy's between frames.

Two different frame formats are used in the signalling and framing layer of the DDL protocol:

- data frames for the transmission of data blocks;
- control frames for the transmission of commands and status information.

A data frame consists of 1 ÷ 256 data words (4 ÷ 1024 bytes) and a 32 bit CRC. A single N_Data ordered set is used as start of frame delimiters at the beginning of the frame and one End_Fr ordered set as end of frame delimiter at the end. Figure 10 shows the structure of the data frame with eight Rx_Rdy ordered sets between the two data frames.

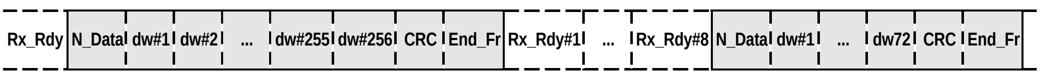

Figure 10 The data frame structure

A control frame consists of a single control word (command or status word) and a 32 bit CRC. A single C_Data ordered set is used as delimiter at the beginning of the control frame and one

End_Fr ordered set as end of frame delimiter at the end. Figure 11 shows the structure of the control frames with eight Rx_Rdy ordered sets between two frames.

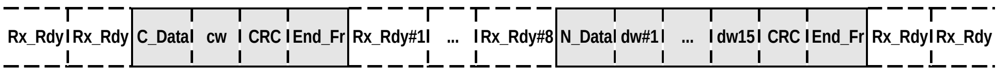

Figure 11 A control frame and a data frame and Rx_Rdy ordered sets

3.3.7 Flow control

The DDL shall provide flow control in both directions of the data transfer. The flow control shall suspend the transmission of the data words, when a data frame is open. The transmission of the new data frames can not be started until the flow control is removed. The flow control has no effect for the transmission of the control frames. The main rules are listed below:

1. The RORC shall activate the roBSY# signal, when it is not able to receive data blocks. In this case the DIU shall transmit Rx_Bsy ordered sets through the physical medium.
2. The RORC shall not activate the roBSY# signal, when it is able to receive data blocks. In this case the DIU shall transmit frames or Rx_Rdy ordered sets through the physical medium.
3. The DIU shall activate the riLF# signal, when it receives Rx_Bsy ordered sets through the physical medium. In this case the RORC can not transfer data blocks to the DIU.
4. The DIU shall not activate the riLF# signal, when it receives Rx_Rdy ordered sets through the physical medium. In this case the RORC can transfer data blocks to the DIU.
5. The FEE shall activate the foBSY# signal, when it is not able to receive data blocks. In this case the SIU shall interrupt the data frame transmission by sending Rx_Bsy ordered sets through the physical medium. The transmission of the interrupted data frame can be continued only, when Rx_Rdy ordered sets arrive to the receiver again.
6. The FEE shall not activate the foBSY# signal, when it is able to receive data blocks. In this case the SIU shall transmit frames or Rx_Rdy ordered sets through the physical medium.
7. The SIU shall activate the fiLF# signal, when it receives Rx_Bsy ordered sets through the physical medium. In this case the FEE can not transfer data blocks to the SIU.
8. The SIU shall not activate the fiLF# signal, when it receives Rx_Rdy ordered sets through the physical medium. In this case the FEE can transfer data blocks to the SIU.
9. The DIU and the SIU can only transmit data words through the physical medium, when they receive Rx_Rdy ordered sets. The transmission of the data words shall be immediately closed inserting Rx_Rdy (Rx_Bsy) ordered set, when Rx_Bsy ordered sets arrive to the receiver of the given interface unit. The transmission of the data words can be continued only, when Rx_Rdy ordered sets arrive to the receiver again (see Figure 13).

Figure 12 shows the transmission of the flow control information between the two interface units and between the external systems, connected to the DDL.

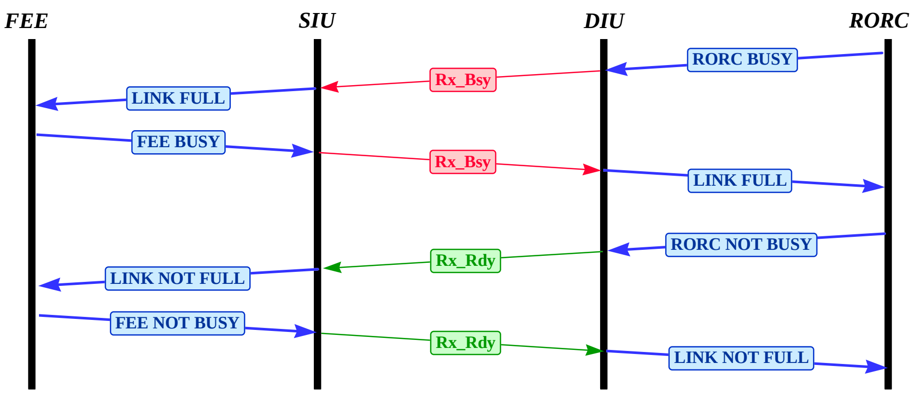

Figure 12 The transmission of the flow control information through the DDL

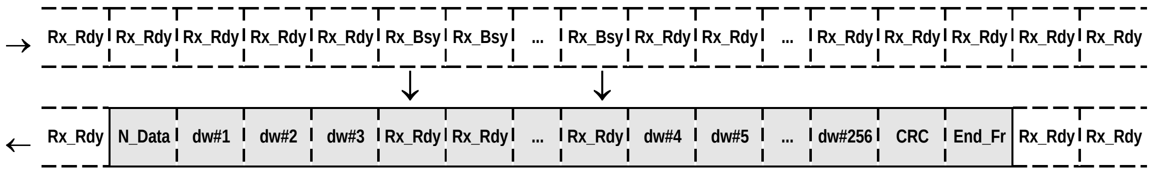

Figure 13 Flow control during the transmission of an opened data frame

4. Notes