INTERNATIONAL STANDARD

IEC 60870-5-101

1995

AMENDMENT 2
2001-10

Amendment 2

Telecontrol equipment and systems –

Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks

International Electrotechnical Commission 3, rue de Varembé Geneva, Switzerland
Telefax: +41 22 919 0300 e-mail: inmail@iec.ch IEC web site http://www.iec.ch

Commission Electrotechnique Internationale
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FOREWORD

This amendment has been prepared by IEC technical committee 57: Power system control and associated communications.

The text of this amendment is based on the following documents:

FDIS	Report on voting
57/535/FDIS	57/551/RVD

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until 2003. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

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1 Scope and object

Add, after the third paragraph, the following new text:

Although this companion standard defines the most important user functions, other than the actual communication functions, it cannot guarantee complete compatibility and interoperability between equipment of different vendors. An additional mutual agreement is normally required between concerned parties regarding the methods of use of the defined communication functions, taking into account the operation of the entire telecontrol equipment.

2 Normative references

Insert, in the list, the titles of the following standards:

IEC 60870-5-103:1997, *Telecontrol equipment and systems – Part 5-103: Transmission protocols – Companion standard for the informative interface of protection equipment*

ISO/IEC 8824-1:2000, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*

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5 Physical layer

5.1 Selections from ISO and ITU-T standards

Add, on page 19, after 5.1.3, the following new subclause:

5.1.4 Other compatible interfaces

Physical interfaces other than those which are recommended in the IEC 60870-5 series may be used, according to agreement between user and vendor. However, if other interfaces are used, it is the responsibility of the user and the vendor to prove their functionality and interoperability.

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6 Link layer

6.1 Selections from IEC 60870-5-1: Transmission frame formats

Add, after the notes, the following new text:

Transmission rule R3 states that no idle line intervals are admitted between characters. This may not be possible to achieve in some practical implementations, particularly with high bit rate transmission, because of unavoidable hardware or software delays.

However, annex B demonstrates that a line idle interval between characters that has a duration not longer than one transmitted bit time does not reduce the frame integrity. Therefore, transmission rule R3 may be relaxed to allow line idle intervals of up to one transmitted bit time duration between characters. The line idle intervals between characters extend the transmission time of time critical information (for example, clock synchronization) which may reduce the accuracy of clocks in controlled stations.

There is no requirement for the receiver to measure line idle intervals between characters. For example, the receiver may be implemented using an industry standard UART circuit alone, without any special hardware or software concerned with the duration of gaps between characters in a received frame.

6.2 Selections from IEC 60870-5-2: Link transmission procedures

Add, after the third paragraph, the following new subclause:

6.2.1 State transition diagrams

This subclause adds more detail to the base definitions of link transmission procedures given in IEC 60870-5-2. State transition diagrams are used to define the procedures more exactly so that link layers implemented by different manufacturers can be made fully interoperable. State transition diagrams represent the states (in this case of the link layer defined in IEC 60870-5-2) and the transitions from one state into another. The actions (send Tx and receive Rx) are included. In addition to the states, important internal processes are described.

The state transition diagrams are presented in the format defined by Grady Booch/Harel. The explanation of the particular elements is shown in figure 75.

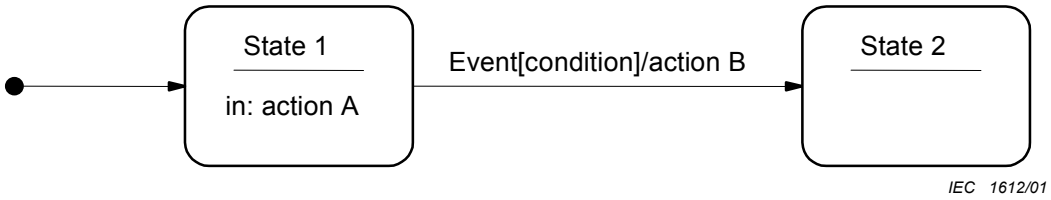

Figure 75 – State transition diagram by Grady Booch/Harel

The word "in" describes an action which is triggered when a transition into a new state occurs. The transition to the next state may be triggered by the termination of the current state, in the case where there is no defined event to cause the transition.

The notation used in the following state transition diagrams is:

FC0 to FC15 = function code number 0 to 15, see tables 1 to 4 of IEC 60870-5-2

FCB = frame count bit

FCV = frame count bit valid

DFC = data flow control

ACD = access demand

PRM = primary message

SC = single character

Replace the heading "UNBALANCED TRANSMISSION" *by:*

6.2.1.1 Unbalanced transmission procedures

Add, after the fourth paragraph of 6.2.1.1, the following new text:

The SEND/NO REPLY service is used when issuing a user data message to all stations (broadcast address).

Add, after the second sentence of the sixth paragraph, the following new text:

The assignment of the causes of transmission to the two classes is defined in 7.4.2.

Add, after the sixth paragraph, the following new text:

Table 10 shows the permissible combinations of the unbalanced link layer procedures.

Table 10 – Permissible combinations of unbalanced link layer services

Function codes and services in the primary direction	Permitted function codes and services in the secondary direction
<0> Reset of remote link	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<1> Reset of user process	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<3> SEND/CONF user data	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<4> SEND/NO REPLY user data	No reply
<8> REQUEST for access demand	<11> RESPOND: status of link
<9> REQUEST/RESP request status of link	<11> RESPOND: status of link
<10> REQUEST/RESP request user data class 1	<8> RESPOND: user data or <9> RESPOND: requested data not available
<11> REQUEST/RESP request user data class 2	<8> RESPOND: user data or <9> RESPOND: requested data not available

Responses <14> Link service not functioning or <15> Link service not implemented are also permitted. The single control character E5 may be used instead of a fixed length CONFIRM ACK (secondary function code <0>) or fixed length RESPOND NACK (secondary function code <9>) except when there is an access demand for class 1 data (ACD = 1) or further messages may cause an overflow (DFC = 1). This is shown in figures 77 and 78. The single character A2 must not be used.

For unbalanced transmission procedures: The primary station contains only a primary link layer and the secondary station contains only a secondary link layer (see figure 76). More than one secondary station may be connected to one primary station. Compatible communication between the primary station and a particular secondary station relies on these two stations alone. The polling procedure for requesting data from multiple secondary stations is a local internal function of the primary station and need not be shown in figures 76 to 78. Consequently, these diagrams only show the primary station and a single secondary station. In the case of more than one secondary station, the primary station has to remember the current state of each secondary station.

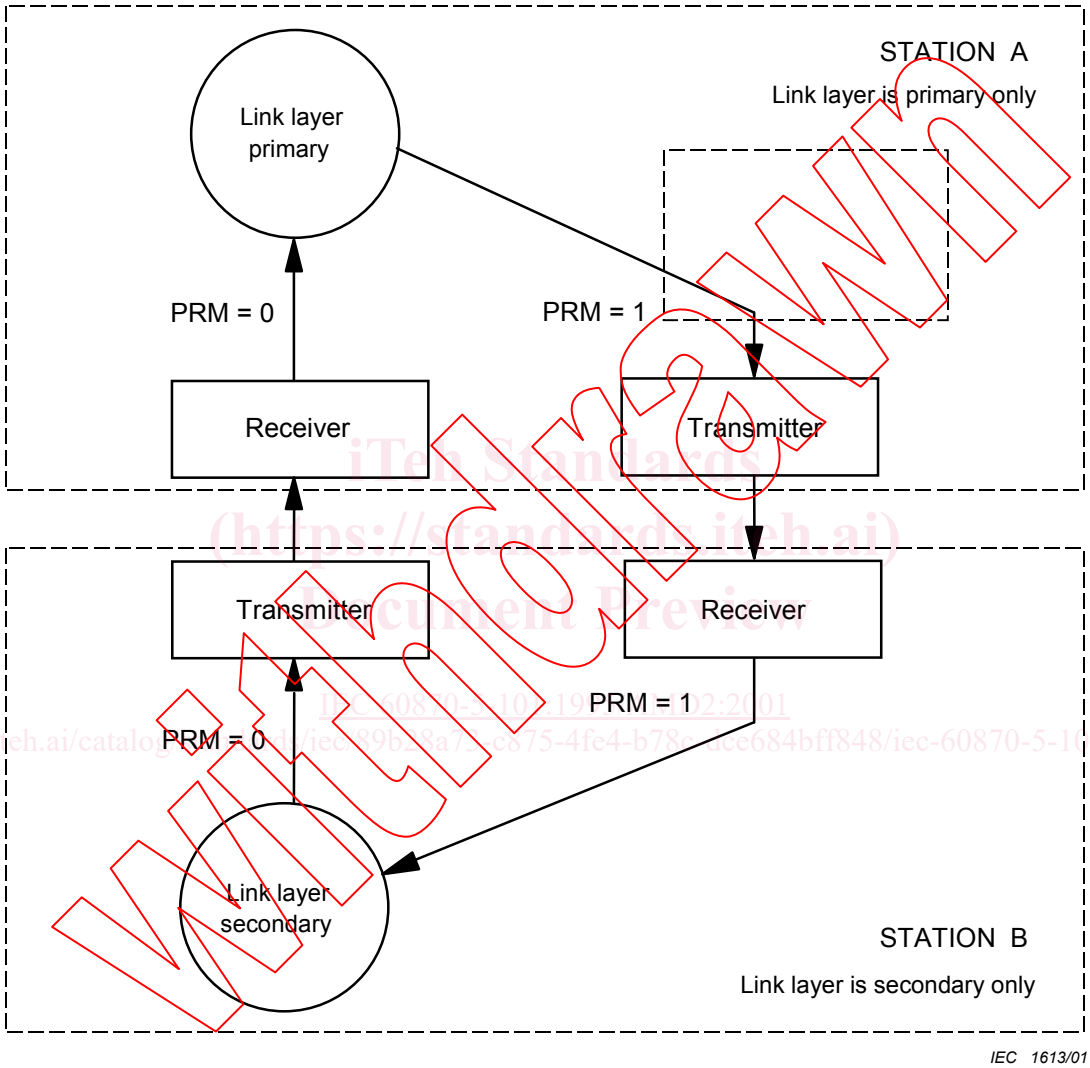

Figure 76 – Unbalanced transmission procedures, primary and secondary stations

Figure 77 shows the state transition diagram of the primary station, figure 78 that of the secondary station.

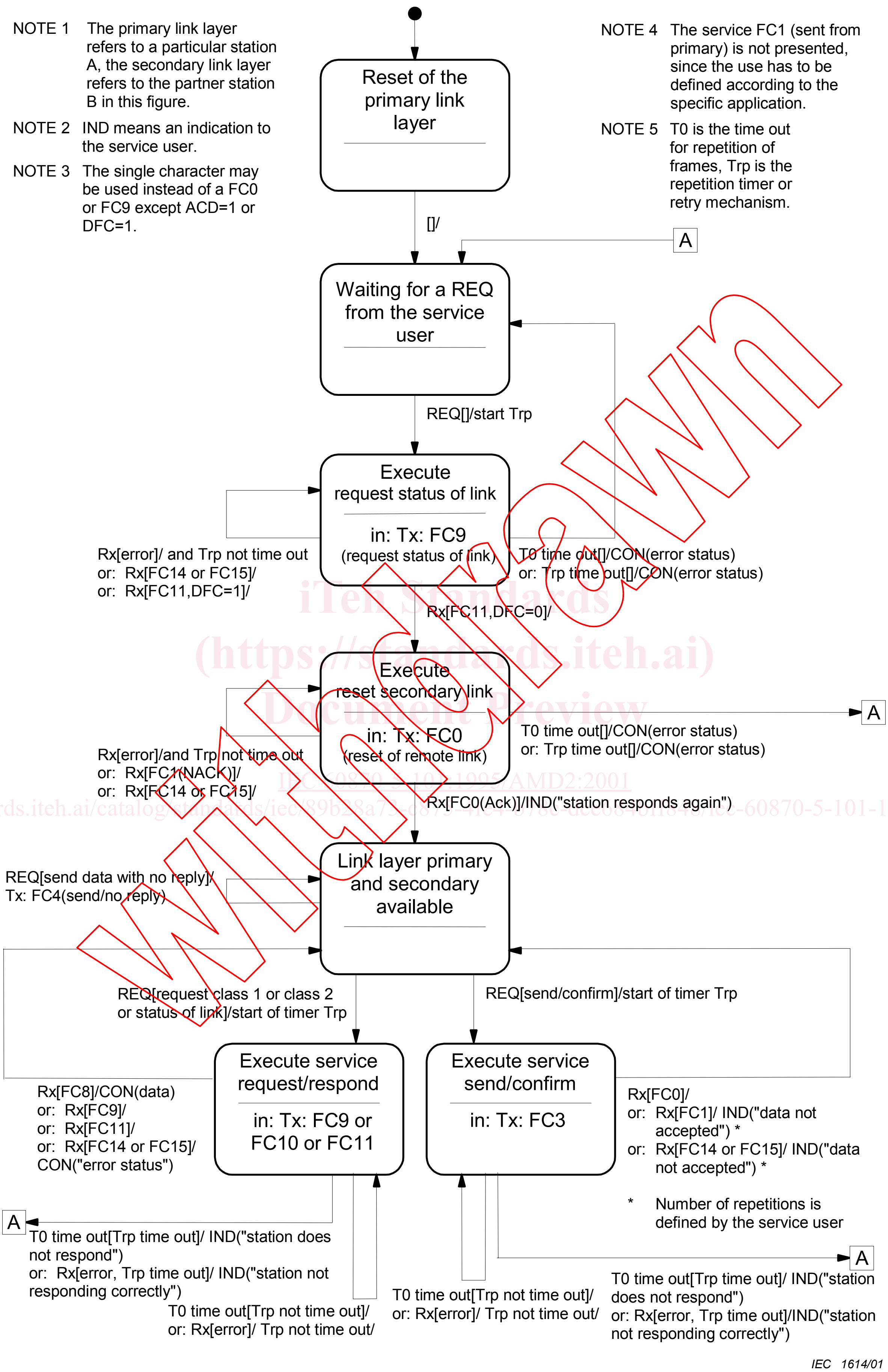
NOTE 1 The primary link layer refers to a particular station A, the secondary link layer refers to the partner station B in this figure.
NOTE 2 IND means an indication to the service user.
NOTE 3 The single character may be used instead of a FC0 or FC9 except ACD=1 or DFC=1.
NOTE 4 The service FC1 (sent from primary) is not presented, since the use has to be defined according to the specific application.
NOTE 5 T0 is the time out for repetition of frames, Trp is the repetition timer or retry mechanism.
Reset of the primary link layer
[]/
A
Waiting for a REQ from the service user
REQ[]/start Trp
Execute request status of link
in: Tx: FC9 (request status of link)
Rx[error]/ and Trp not time out
or: Rx[FC14 or FC15]/
or: Rx[FC11,DFC=1]/
T0 time out[]/CON(error status)
or: Trp time out[]/CON(error status)
Rx[FC11,DFC=0]/
Execute reset secondary link
in: Tx: FC0 (reset of remote link)
A
T0 time out[]/CON(error status)
or: Trp time out[]/CON(error status)
Rx[error]/and Trp not time out
or: Rx[FC1(NACK)]/
or: Rx[FC14 or FC15]/
Rx[FC0(Ack)]/IND("station responds again")
Link layer primary and secondary available
REQ[send data with no reply]/
Tx: FC4(send/no reply)
REQ[request class 1 or class 2 or status of link]/start of timer Trp
REQ[send/confirm]/start of timer Trp
Execute service request/respond
in: Tx: FC9 or FC10 or FC11
Execute service send/confirm
in: Tx: FC3
Rx[FC8]/CON(data)
or: Rx[FC9]/
or: Rx[FC11]/
or: Rx[FC14 or FC15]/
CON("error status")
Rx[FC0]/
or: Rx[FC1]/ IND("data not accepted") *
or: Rx[FC14 or FC15]/ IND("data not accepted") *
* Number of repetitions is defined by the service user
A
T0 time out[Trp time out]/ IND("station does not respond")
or: Rx[error, Trp time out]/ IND("station not responding correctly")
T0 time out[Trp not time out]/
or: Rx[error]/ Trp not time out/
T0 time out[Trp not time out]/
or: Rx[error]/ Trp not time out/
A
T0 time out[Trp time out]/ IND("station does not respond")
or: Rx[error, Trp time out]/IND("station not responding correctly")
IEC 1614/01

Figure 77 – State transition diagram for unbalanced transmission primary to secondary

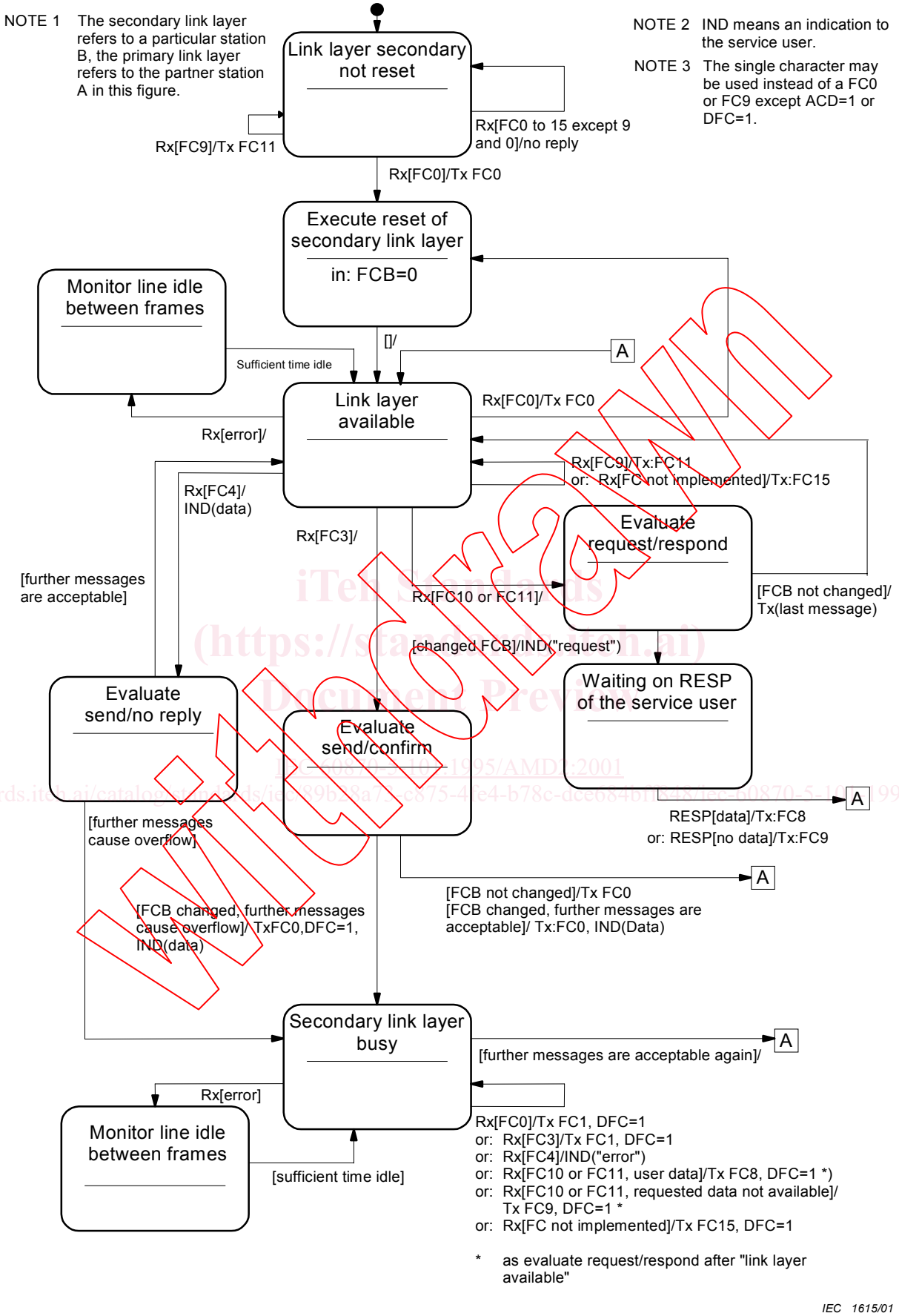

Figure 78 – State transition diagram for unbalanced transmission secondary to primary

Replace the heading "BALANCED TRANSMISSION" *by:*

6.2.1.2 Balanced transmission procedures

Add, after the first paragraph of 6.2.1.2, the following:

The following table shows the permissible combinations of the balanced link layer procedures

Table 11 – Permissible combinations of balanced link layer services

Function codes and services in the primary direction	Permitted function codes and services in the secondary direction
<0> Reset of remote link	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<1> Reset of user process	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<2>SEND/CONF test function for link	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<3> SEND/CONF user data	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<4> SEND/NO REPLY user data	No reply
<9> REQUEST/RESP request status of link	<11> RESPOND: status of link

Responses <14> link service not functioning or <15> link service not implemented are also permitted. The single control character E5 may be used instead of a fixed length CONFIRM ACK (secondary function code <0>) except when further messages may cause an overflow (DFC = 1).

Add, after the second paragraph, the following new text:

The link layers for balanced transmission procedures consist of two decoupled logical processes, one logical process represents station A as the primary station and station B as the secondary station and the other logical process represents station B as the primary station and station A as the secondary station (each station is a combined station). Thus, two independent processes exist in each station to control the link layer in the logical primary and in the secondary direction. Figure 79 shows the typical arrangement of the link layer using balanced transmission procedures.

NOTE The physical transmission direction is fixed defined by the bit DIR. The logical processes primary or secondary may change from station A to B and vice versa. The primary message is defined by the bit PRM = 1, the secondary message by the bit PRM = 0 (see 6.1.2 of IEC 60870-5-2).

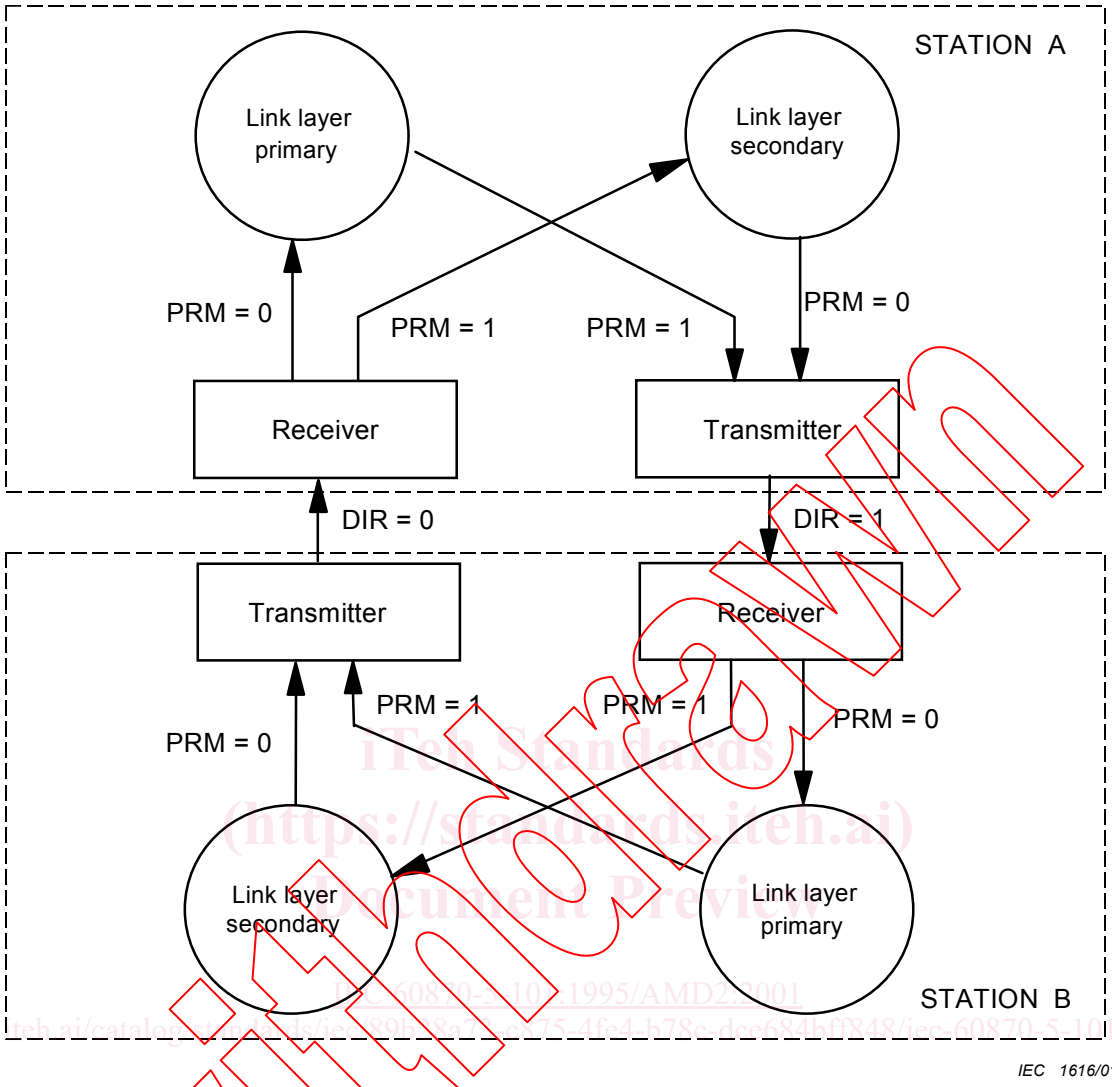

Figure 79 – Balanced transmission procedures, primary and secondary link layers

Figures 80 and 81 do not show the reactions of the link layer in the case of receiving corrupted frames. These frames are already rejected by a process which is not shown in the following. This process is also responsible for the control of the time out interval. Figure 80 shows the state transition diagram of the primary link layer using balanced transmission procedures. Figure 81 shows the secondary link layer.

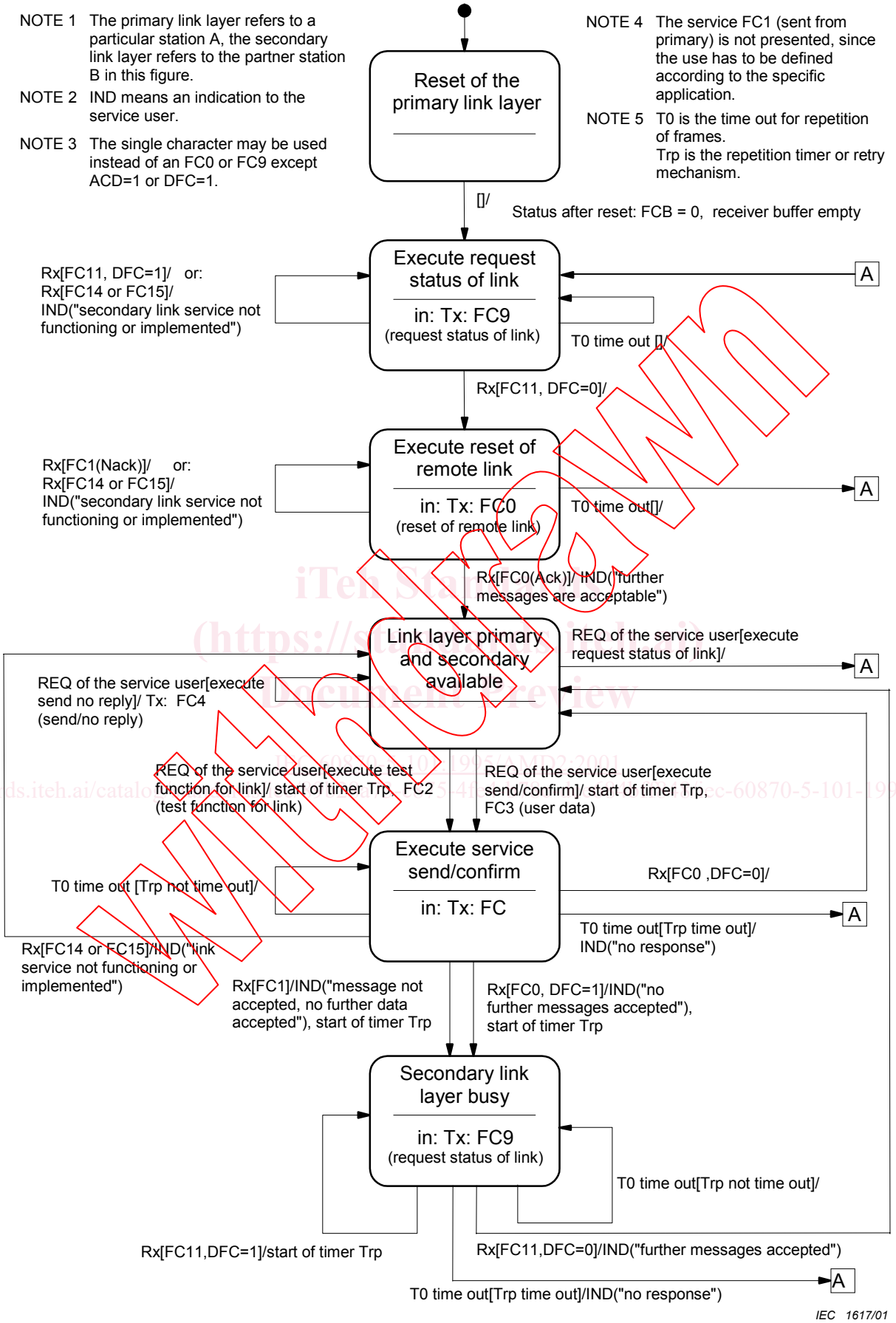

Figure 80 – State transition diagram for balanced transmission primary to secondary

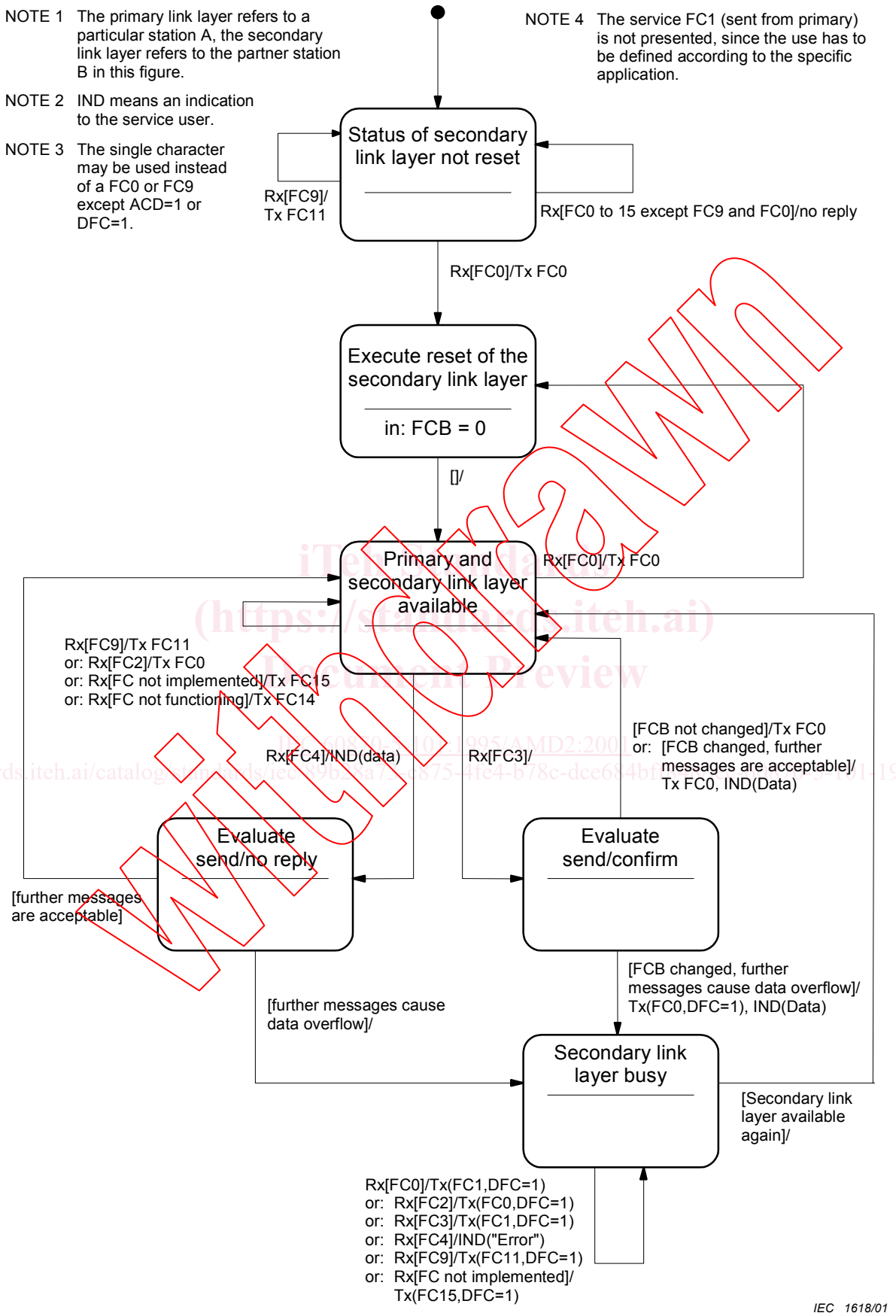

Figure 81 – State transition diagram for balanced transmission secondary to primary

Add, at the end of the last paragraph, the following new text:

DIR defines the physical transmission direction (see 6.1.2 of IEC 60870-5-2):

1 = station A (controlling station) to station B (controlled station)

0 = station B (controlled station) to station A (controlling station)

All messages sent by the controlling station will have the data link control field DIR bit set to 1. All messages sent by the controlled station will have the data link control field DIR bit set to 0.

In the case of two equivalent stations (for example, two control centres) the DIR is defined by agreement.

If defined, the balanced mode address field will contain the destination address for both primary and secondary messages.

Replace the heading "TIME OUT INTERVAL FOR REPEATED FRAME TRANSMISSION" *by*:

6.2.2 Definitions of time out interval for repeated frame transmission

Add, at the beginning of the first paragraph, the following new text:

Formulae are given in annex A of IEC 60870-5-2 for calculating the time out interval for repeated transmissions, assuming two cases and a variety of project-specific parameters.

Add, after the first paragraph, the following new text:

This present subclause clarifies the use of the formulae by calculating two tables which give examples of time out intervals for a number of typical conditions for both balanced and unbalanced transmission.

Reference: IEC 60870-5-2, annex A – figure A.2, case 1 (unbalanced transmission procedures);
IEC 60870-5-2, annex A – figure A.4, case 1 (balanced transmission procedures).

Abbreviations not defined in IEC 60870-5-2:

BAB transmission speed from station A to station B

BBA transmission speed from station B to station A

LBAmax number of octets of the longest frame from B to A

LADDR length of the link address field

BAB, BBA, LBAmax, LADDR, t_R and t_{RB} are project-specific parameters.

6.2.2.1 Unbalanced transmission

The following condition is valid for the time out interval T_O:

$$T_O > t_{LD} + T_{LBA}$$

where $t_{LD} = t_{DAB} + t_R + t_{DBA}$

and t_R is the reaction time of station B (specific per equipment)

t_{DAB} = 0,5/BAB (see note below)

t_{DBA} = 0,5/BBA (see note below)

T_{LBA} = 11 × LBAmax/BBA

Examples for the specification of the time out interval

Definitions: station B = controlled station,

equal transmission speed in both directions,

reaction time of station B t_R = 50 ms.

NOTE The signal delays t_{DAB} and t_{DBA} (see IEC 60870-5-2, annex A) are assumed to be half the transmission time of a data bit.

Table 12 – Time out intervals (T_O) depending on frame length, transmission speed and project specific parameters (examples)

LBAmax	Transmission speed bit/s	t_{LD} ms	T_{LBA} ms	T_O ms
20	100	60,0	2 200,0	2 260,0
	600	51,7	366,7	418,4
	1 200	50,8	183,3	234,1
	9 600	50,1	22,9	73,0
	19 200	50,0	11,4	61,4
	64 000	50,0	3,4	53,4
240	100	60,0	26 400,0	26 460,0
	600	51,7	4 400,0	4 451,7
	1 200	50,8	2 200,0	2 250,8
	9 600	50,1	275,0	325,1
	19 200	50,0	137,5	187,5
	64 000	50,0	41,3	91,3

6.2.2.2 Balanced transmission

The following condition is valid for the time out interval T_O:

$$T_O > t_{LDA} + T_{LSPBA} + t_{GB} + T_{LPSBA}$$

where $t_{LDA} = t_{DAB} + t_{RB} + t_{DBA}$

and t_{RB} is the reaction time of station B (specific per equipment)

t_{DAB} = 0,5/BAB (see note below)

t_{DBA} = 0,5/BBA (see note below)

t_{GB} = 33/BBA [1)]

T_{LPSBA} = 11 × LBAmax/BBA

T_{LSPBA} = 11(LADDR + 4)/BBA

NOTE The signal delays t_{DAB} and t_{DBA} (see IEC 60870-5-2, annex A) are assumed to be half the transmission time of a data bit.

[1)] t_{GB} = 33 bit is the critical case for the definition of T_O.
t_{GB} is a system specific parameter which may be significantly less than 33 bit (for example, 0,5 bit).

Examples for the specification of the time out interval

Definitions: station B = controlled station,
equal transmission speed in both directions,
reaction time of station B t_R = 50 ms
length of address field LADDR = 1

Table 13 – Time out intervals (T_O) depending on frame length, transmission speed and project specific parameters (examples)

LBAmax	Transmission speed bit/s	t_{LDA} ms	t_{GB} ms	T_{LSPBA} ms	T_{LPSBA} ms	T_O ms
20	100	60,0	330,0	550,0	2 200,0	3 140,0
	600	51,7	55,0	91,7	366,7	565,1
	1 200	50,8	27,5	45,8	183,3	307,4
	9 600	50,1	3,4	5,7	22,9	82,1
	19 200	50,0	1,7	2,9	11,4	66,0
	64 000	50,0	0,5	0,9	3,4	54,8
240	100	60,0	330,0	550,0	26 400,0	27 340,0
	600	51,7	55,0	91,7	4 400,0	4 598,4
	1200	50,8	27,5	45,8	2 200,0	2 324,1
	9 600	50,1	3,4	5,7	275,0	334,2
	19 200	50,0	1,7	2,9	137,5	192,1
	64 000	50,0	0,5	0,9	41,3	92,7

6.2.3 The use of the different resets

IEC 60870-5-2 defines the services FC0 reset of remote link and FC1 reset of user process. Additionally, IEC 60870-5-5 and this standard define the remote initialization procedure which uses the reset process command C_RP_NA_1 type identification number <105>.

The use of the different resets is specified in table 14.

Table 14 – Effects of the different resets

Controlling station layer 7 and user	Primary link	Secondary link	Controlled station layer 7 and user
	Reset of remote link (FC0)	Secondary link reset	–
	Reset of user process (FC1)	Reset	Reset
Reset process command	–	–	Reset

Reset of remote link is used when the secondary link is reset independently from the layers above the link. In this case, the frame count bit of the control field is always set to zero. A pending secondary link layer message is deleted.

Reset of user process as a link function is used if the link layer is still working but the process functions of the controlled station are not available. In this case, a reset of the user process via a link service might put the user process into operation. This service can only be used if the link layer is able to reset the user process via a separate signal.