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Title: RATE ADAPTATION ON THE MS-BS INTERFACE

Editor: S. THOMAS UK

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List of Contents:

- 0 Scope
 - 1 General Approach
 - 2 The RAO Function
 - 3 The RA1 Function
 - 4 The RA2 Function
 - 5 The RA1/RA1' Function
 - 6 The RA1' Function
 - 7 Support of Non-Transparent Bearer Applications
- Figures

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0 Scope

This recommendation defines the rate adaptation functions to be used in GSM PLMN Mobile Stations for adapting terminal interface data rates to the MS-BS interface data rates in accordance with GSM recommendation 03.10.

The provision of these functions will depend on the services a particular station is designed to support.

Note: This recommendation should be considered together with GSM Recommendation 08.20 (Rate Adaptation on the BS-MSC Interface) to give a complete description of PLMN rate adaptation.

1 General Approach

GSM recommendation 03.10 (section 4) defines the PLMN connection types necessary to support the GSM PLMN data and telematic services.

Within the MS there are several different data rate adaptation functions which are combined as shown in GSM 03.10 as part of the connection type.

These functions are RAO, RA1, RA2, RA1' and RA1/RA1'. The RAO, RA1 and RA2 are ^{identical} ~~equivalent~~ to those functions described in CCITT recommendation V.110.

The RA1' function is similar to RA1 but has a reduced bit rate output compatible with the coding scheme proposed for data services on the radio interface.

The RA1/RA1' is a relay function, used as indicated in GSM 03.10.

2 The RAO Function

2.1 Asynchronous-to-Synchronous Conversion (RAO)

The RAO Function is only used with asynchronous interfaces. Incoming asynchronous data is padded by the addition of stop elements to fit the nearest channel defined by $(2 \text{ to the power } n) \text{ times } 600 \text{ bit/s}$. Thus both 75 bit/s and 300 bit/s user data signalling rates shall be adapted to a synchronous 600 bit/s stream. The resultant synchronous stream is fed to RA1 or RA1'.

2.2 Break Signal

The RAO shall detect and transmit the break signal in the following fashion;

If the converter detects M to $2M+3$ bits, all of start polarity, where M is the number of bits per character in the selected format including start and stops bits, the converter shall transmit $2M+3$ bits of start polarity.

If the converter detects more than $2M+3$ bits all of start polarity, the converter shall transmit all these bits as start polarity.

The $2M+3$ or more bits of start polarity received from the transmitting sides shall be output to the receiving terminal.

The terminal must transmit on circuit 103 at least $2M$ bits stop polarity after the start polarity break signal before sending further data character. The converter shall then regain character synchronism from the following stop to start transition.

2.3 Overspeed/Underspeed

A RAO shall insert additional stop elements when its associated terminal is transmitting with a lower than nominal character rate. If the terminal is transmitting characters with an overspeed of up to 1% (or 2.5% in the case of nominal speeds lower than 600 bit/s), the asynchronous-to-synchronous converter may delete stop elements as often as is necessary to a maximum of one for every eight characters at 1% overspeed. The converter on the receiving side shall detect the deleted stop elements and reinsert them in the received data stream (circuit 104).

The nominal length of the start and data elements shall be the same for all characters. The length of the stop elements may be reduced by as much as 12.5% for nominal speeds exceeding 300 bit/s to allow for overspeed in the transmitting terminal. For nominal speeds less than or equal to 300 bit/s a 25% reduction in stop element is allowed.

2.4 Parity Bits

Possible parity bits included in the user data are considered as data bits by the RAO function (and RA1 function).

2.5 Flow Control

Where applicable, this function is as specified in the relevant terminal adapter function recommendation (GSM 07 series).

3 The RA1 Function

This function is used to adapt between the synchronous user rates, or the output of the RAO function and the intermediate rate of 8 or 16 kbit/s.

The CCITT V.110 80 bit frame shown in Figure 1 is used. The D bits are used to convey the user data and the S and X bits are used to convey channel control information according to the relevant terminal adapter function recommendation.

The E bits are used to convey the following information:

- i) User Data Rate - E1, E2 , E3 , - see Figure 2
- ii) Network Independent Clocking E4 , E5 , E6 ,
- iii) Multiframe Synchronisation - E7 .

Note: The use of multiframe synchronisation and network independent clocking is for further study.

The order of transmission of the 80 bit frame is from left to right and top to bottom.

4 RA2 Function

This procedure is based on the RA2 function as specified in CCITT V.110. It is used to rate adapt to/from the intermediate rates of 8 or 16 kbit/s from/to the 64 kbit/s rate used at the S interface.

It considers the 64 kbit/s stream to consist of octets, bits 1 through 8, with bit 1 being transmitted first.

The procedure requires that:

- i) The 8 kbit/s stream occupies bit position 1;
- ii) The 16 kbit/s bitstream occupies bit positions (1,2);
- iii) The order of transmission of the bits of the subrate stream is identical before and after rate adaptation.
- iv) All unused bits in the 64 kbit/s stream are set to binary "1".

5 The RA1/RA1' Function

The RA1/RA1' function is used to convert between the CCITT V.110 80 bit frames produced at the 8 and 16 kbit/s intermediate rates and the input rate to the FEC function for transmission on the radio interface in radio interface frames.

There are three data rates used for data transfer over the radio interface. These are 12 kbit/s, 6 kbit/s and 3.6 kbit/s. In order to adapt the 8 and 16 kbit/s intermediate rates to these radio interface data rates, three processes are used. Firstly the 17 synchronisation bits are removed. Secondly the E1, E2 and E3 bits are removed. Thirdly, in the 3.6 kbit/s case, half the data bits are discarded. These processes result in modified CCITT V.110 frames of sizes 60, 60 and 36 bits for the 12, 6 and 3.6 kbit/s data rates respectively. The resultant modified CCITT V.110 frames for the various user data rates are shown in figures 3-7. These functions are described below (note that the designations "tb" and "rb" are used to designate bits sent/received on the RA1 and RA1' side of the RA1/RA1' function respectively).

5.1 Radio Interface rate of 12 kbit/s

In this case 200 modified CCITT V.110 60 bit frames are received/sent over the radio interface every second. Each radio interface frame is used to transport a sequence of 4 modified CCITT V.110 60 bit frames. The RA1/RA1' function will add/subtract the 17 bit synchronisation pattern and the E1, E2 and E3 bits to/from each CCITT V.110 80 bit frame as follows:

Modified CCITT V.110 60 bit frame:

```

rb1,2,3...rb7
rb8.....rb14
rb15.....rb21
rb22.....rb28
rb29.....rb35      = 60 bits/frame or 12 kbit/s
rb36.....rb42
rb43.....rb49
rb50.....rb56
rb57.....rb60

```

CCITT V.110 80 bit frame:

```

0 0 0 0 0 0 0 0
1 tb1,2,3...tb7
1 tb8.....tb14
1 tb15.....tb21
1 tb22.....tb28
1 tb29.....tb35
1 tb36.....tb42      = 80 bits/frame or 16 kbit/s
1 tb43.....tb49
1 tb50.....tb56
1 tb57.....tb63

```

For modified CCITT V.110 60 bit frames received from the radio interface, the bits tb1 - tb28 are set to the same value as bits rb1 - rb28. Bits tb29 - tb31 are set according to the user data rate as shown in Figure 2. Bits tb32 - tb63 are set to the same value as rb29 - rb60.

For modified CCITT V.110 60 bit frames transmitted over the radio interface, the bits rb1 - rb28 are set to the same value as tb1 - tb28. Bits tb29 - tb31 are discarded. Bits rb29 - rb60 are set to the same value as bits tb32 - tb63.

5.2 Radio Interface rate of 6 kbit/s

In this case 100 modified CCITT V.110 60 bit frames are received/sent over radio interface every second. Each radio interface frame is used to transport a sequence of 4 modified CCITT V.110 60 bit frames. The RA1/RA1' function will add/subtract the 17 bit synchronisation pattern and the E1,E2 and E3 bits to/from each CCITT V.110 80 bit frame as follows:

Modified CCITT V.110 60 bit frame:

```

rb1,2,3...rb7
rb8.....rb14
rb15.....rb21
rb22.....rb28
rb29.....rb35          = 60 bits/frame or 6 kbit/s
rb36.....rb42
rb43.....rb49
rb50.....rb56
rb57.....rb60

```

CCITT V.110 80 bit frame:

```

0 0 0 0 0 0 0 0
1 tb1,2,3...tb7
1 tb8.....tb14
1 tb15.....tb21
1 tb22.....tb28
1 tb29.....tb35
1 tb36.....tb42          = 80 bits/frame or 8 kbit/s
1 tb43.....tb49
1 tb50.....tb56
1 tb57.....tb63

```

For modified CCITT V.110 60 bit frames received from the radio interface, the bits tb1 - tb28 are set to the same value as the bits rb1 - rb28. Bits tb29 - tb31 are set according to Figure 2. Bits tb32 - tb63 are set to the same value as rb29 - rb60.

For modified CCITT V.110 60 bit frames transmitted over the radio interface, the bits rb1 - rb28 are set to the same value as bits tb1 - tb28. Bits tb29 - tb31 are discarded. Bits rb29 -rb60 are set to the same value as bits tb32 - tb63.

It should be noted that this process is identical to that used for the 12 kbit/s case except that the frame repetition rates are halved.

5.3 Radio Interface rate of 3.6 kbit/s

In this case 100 modified CCITT V.110 36 bit frames are received/sent over the radio interface every second. Each radio interface frame is used to transport a sequence of 4 modified CCITT V.110 36 bit frames. The RA1/RA1' function will add/subtract the 17 bit synchronisation pattern and the E1,E2 and E3 bits to/from each CCITT V.110 80 bit frame as follows:

Modified CCITT V.110 36 bit frame:

```

rb1,2,3...rb7
rb8.....rb14
rb15.....rb21
rb22.....rb28
rb29.....rb35
tb36.....rb36

```

= 36 bits/frame or 3.6 kbit/s

CCITT V.110 80 bit frame:

```

0 0 0 0 0 0 0 0
1 tb1,2,3...tb7
1 tb8.....tb14
1 tb15.....tb21
1 tb22.....tb28
1 tb29.....tb35
1 tb36.....tb42
1 tb43.....tb49
1 tb50.....tb56
1 tb57.....tb63

```

= 80 bits/frame or 8 kbit/s

In this case, the mapping between the bits is as follows:

```

rb1 = tb1 = tb2
rb2 = tb3 = tb4
rb3 = tb5 = tb6
rb4 = tb7
rb5 = tb8 = tb9
rb6 = tb10 = tb11
rb7 = tb12 = tb13
rb8 = tb14
rb9 = tb15 = tb16
rb10 = tb17 = tb18
rb11 = tb19 = tb20
rb12 = tb21
rb13 = tb22 = tb23
rb14 = tb24 = tb25
rb15 = tb26 = tb27
tb16 = tb28
rb17 = tb32
rb18 = tb33
rb19 = tb34
rb20 = tb35
rb21 = tb36 = tb37
rb22 = tb38 = tb39
rb23 = tb40 = tb41
rb24 = tb42
rb25 = tb43 = tb44
rb26 = tb45 = tb46
rb27 = tb47 = tb48
rb28 = tb49
rb29 = tb50 = tb51
rb30 = tb52 = tb53
rb31 = tb54 = tb55
rb32 = tb56

```


rb33 = tb57 = tb58
rb34 = tb59 = tb60
rb35 = tb61 = tb62
rb36 = tb63

For modified CCITT V.110 36 bit frames transmitted over the radio interface, tb29 -tb31 are discarded. For modified CCITT V.110 36 bit frames received from the radio interface, tb29 - tb31 are set as shown in Figure 2.

Note: The action to be taken in the case where two bits which should have the same value (e.g. tb1 and tb2 or tb61 and tb62) are received with different values is for further study.

5.4 Synchronisation

Action to be taken on loss of frame alignment at the RA1/RA1' function is for further study.

6 The RA1' Function

This function is used to adapt between the synchronous user data rates, or the output of the RAO function and the radio interface data rates of 3.6, 6 or 12 kbit/s.

The modified CCITT V.110 36 or 60 bit frame structures for each of the user rates is shown in figures 3-7. The meaning of the bits is described in section 3.

7 Support of Non-Transparent Bearer Applications

In the case of non-transparent services, the RA1' function provides direct access to the 12 and 6 kbit/s radio interface data rates. This direct access results in the use of a modified CCITT V.110 60 bit frame for non-transparent services (figure 8). In this case the RA1' function also provides for the alignment of sequences of 4 modified CCITT V.110 60 bit frames to/from radio interface frames. This allows 240 bit Radio Link Protocol (RLP) frames to be aligned with radio interface frames.

The first bit of each RLP frame to be transmitted will correspond to the first bit of each radio interface frame to be transmitted, etc to the last bit of each RLP frame which will correspond to the last bit of the radio interface frame to be transmitted.

The radio interface provides for the synchronous transmission and reception of 240 bit RLP frames every 20 or 40 ms for full and half rate TCHs respectively. Occasions may arise when there is no RLP frame to transmit in a

particular radio interface frame. In this case a frame of 240 zeroes will be transmitted. This frame will be discarded by the distant RLP function, due to FCS failure, but will allow physical link synchronisation to be maintained between the MS and the MSC/IWF.

OCTET:		BIT NUMBER							
No.	:	1	2	3	4	5	6	7	8
0	:	0	0	0	0	0	0	0	0
1	:	1	D1	D2	D3	D4	D5	D6	S1
2	:	1	D7	D8	D9	D10	D11	D12	X
3	:	1	D13	D14	D15	D16	D17	D18	S3
4	:	1	D19	D20	D21	D22	D23	D24	S4
5	:	1	E1	E2	E3	E4	E5	E6	E7
6	:	1	D25	D26	D27	D28	D29	D30	S6
7	:	1	D31	D32	D33	D34	D35	D36	X
8	:	1	D37	D38	D39	D40	D41	D42	S8
9	:	1	D43	D44	D45	D46	D47	D48	S9

Figure 1 The CCITT V.110 80 bit RA1 frame structure

Intermediate Data Rate		E1	E2	E3	
8 kbit/s	16 kbit/s				
600		1	0	0	Note
1200		0	1	0	
2400		1	1	0	
4800	9600	0	1	1	

Note: The 300 bit/s user data rate is carried on the 600 bit/s synchronous stream by adding stop elements, see section 2.1.

Figure 2 Coding of data rates

D1	D2	D3	D4	D5	D6	S1
D7	D8	D9	D10	D11	D12	X
D13	D14	D15	D16	D17	D18	S3
D19	D20	D21	D22	D23	D24	S4
E4	E5	E6	E7	D25	D26	D27
D28	D29	D30	S6	D31	D32	D33
D34	D35	D36	X	D37	D38	D39
D40	D41	D42	S8	D43	D44	D45
D46	D47	D48	S9			

Figure 3: Modified CCITT V.110 60 bit frame for 9.6. kbit/s transparent data

D1	D2	D3	D4	D5	D6	S1
D7	D8	D9	D10	D11	D12	X
D13	D14	D15	D16	D17	D18	S3
D19	D20	D21	D22	D23	D24	S4
E4	E5	E6	E7	D25	D26	D27
D28	D29	D30	S6	D31	D32	D33
D34	D35	D36	X	D37	D38	D39
D40	D41	D42	S8	D43	D44	D45
D46	D47	D48	S9			

Figure 4: Modified CCITT V.110 60 bit frame for 4.8. kbit/s transparent data



D1	D2	D3	S1	D4	D5	D6	X
D7	D8	D9	S3	D10	D11	D12	S4
E4	E5	E6	E7	D13	D14	D15	S6
D16	D17	D18	X	D19	D20	D21	S8
D22	D23	D24	S9				

Figure 5: Modified CCITT V.110 60 bit frame for 2.4 kbit/s transparent data

D1	D1	D2	S1	D2	D3	D3	X
D4	D4	D5	S3	D5	D6	D6	S4
E4	E5	E6	E7	D7	D7	D8	S6
D8	D9	D9	X	D10	D10	D11	S8
D11	D12	D12	S9				

Figure 6: Modified CCITT V.110 60 bit frame for 1.2 kbit/s transparent data

D1	D1	D1	S1	D1	D2	D2	X
D2	D2	D3	S3	D3	D3	D3	S4
E4	E5	E6	E7	D4	D4	D4	S6
D4	D5	D5	X	D5	D5	D6	S8
D6	D6	D6	S9				

Note: The 300 bit/s user data rate is carried on the 600 bit/s synchronous stream by adding stop elements, see section 2.1.

Figure 7: Modified CCITT V.110 60 bit frame for 600 bit/s transparent data

D1	D2	D3	D4	D5	D6	D'1
D7	D8	D9	D10	D11	D12	D'2
D13	D14	D15	D16	D17	D18	D'3
D19	D20	D21	D22	D23	D24	D'4
D'5	D'6	D'7	D'8	D25	D26	D27
D28	D29	D30	D'9	D31	D32	D33
D34	D35	D36	D'10	D37	D38	D39
D40	D41	D42	D'11	D43	D44	D45
D46	D47	D48	D'12			

Figure 8: Modified CCITT V.110 60 bit frame for non- transparent data

