ADDING MULTIPLE REPEATER CAPABILITY TO PACKET RADIO USING THE SOFTWARE APPROACH AX.25 VOL.2

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ABSTRACT:

A brief assembly language subroutine to add multiple repeater call letter decoding within the address field of a received AX.25 frame is described. If the operator's call and SSID are included in the multiple repeater segment of the address field of the received frame, the SSID has been repeated bit is set for each frame, each frame re-CRC'ed, and the entire packet then re-transmitted (forwarded) automatically by the program. Also, a short subroutine to allow the operator to input multiple repeaters' call letters into the address field of a packet to be transmitted is mentioned.

INTRODUCTION:

Since implementation of the level/layer 3 of the AX.25 packet protocol is taking somewhat longer than expected, a number of enterprising and hardy souls have promulgated the interim concept of adding multiple repeater call letters to the AX.25 address field. Theoretically, if all the stations' whose calls are in the repeater segment of each frame's address field are 'on-the-air' at the same time, have antenna systems capable of receiving one station in the repeater segment of the address field AND transmitting to another station in the repeater segment of the address field, then this interim concept may work.

We are not suggesting that this concept is theoretically unsound, but wish to point out the difficulties of making it work reliably and effectively within the real life amateur radio community. There is no question that in the laboratory it will work perfectly every time. There is no question that within the same metropolitan area it will work perfectly some of the time, Nevertheless, it is a fun and games option, so we doff our collective hats to those intrepid packeteers who created this fascinating feature. So as not to be the weird kid on the block who said "the king has no clothes on at all," we too have implemented this interesting option.

In our software approach program we have allocated 2048 bytes normal and 4096 bytes maximum, of memory for unprocessed, converted, received 8 bit parallel bytes per packet. This memory allocation allows the storage and automatic forwarding of 7 frame packets with maximum info field length (256 bytes) with up to forty four (44) repeater calls with SSIDs, also included in the extended address field of each frame.

Using the software appproach it is just as easy to check the repeater segment of the address field of each received frame for the operator's call letters for up to 44 repeaters as it is for 1 repeater, so since the name of the game is multiple repeaters, let's do it.

MODIFYING AX. 25 SOFTWARE APPROACH PROGRAM FOR FORWARDING WITH MULTIPLE REPEATERS:

Is illustrated in Figure 1's source code. Line numbers are for volume 2 of 'Packet Radio Using The Software Approach - AX.25 Protocol.' The commented source code is largely self explanatory. The only lines changed or added are: 12460 & 12470, 12505 - 12507, 12750, and 13101 - 13124. The program logic and flow follows.

TEZFOR (test forward) in line 12400 is entered after the packet had been received and decoded in real-time, and each frame passed the CRC test.

Lines 12400 -12450:
Determine the location of the frame's control byte (end of address field + 1) and store it in (RCTL).

Lines 12460 - 12470:
Modify the CAL (call letters comparison) subroutine beginning in line 13040 so that line 13070's JP,NZ is to TEZNUM (test number of repeater calls in address field),

Lines 12480 - 12506:
Add 14 decimal to the frame's beginning address in memory, which is the beginning of the repeater calls, if any, and save it in BGNRPT. CALRPT (calculate number of repeaters) in line 13311 is then called.

Lines 13111 - 13122:
Simply subtract the beginning repeater memory location address from the frame's control byte address location and if zero (no repeater calls in frame), go on to TESADR (test address) to see if the packet is addressed to vou. If there are 1 or

more repeater calls in the address field, then the amount of memory used by the repeater call(s) is divided by 7 (call letters + SSID) and the number of repeater calls stashed in NUMRPT before returning to line 12507.

Lines 12507 - 12520:
Load HL with the first repeater's call letter first byte memory location, load DE with your call letter first byte memory location, and then call CAL in line 13040.

Lines 13040 - 13110:
Scan through the frame's extended address field searching for a match between your call letters and the call letters in the repeater segment of the frame's address field. If no match is found, then line 13115 jumps off to TESADR to see if the frame was addressed to you and if so, then process it. If a match-is found, then line 13101 returns to line 12530.

Lines 12530 -12550:
First test the repeater's SSID against yours. The program assumes that your SSID byte's bit one is zero (if not, change it accordingly in line 12530). If not the same, line 12540 jumps off to TEZADR. If the same, then RECRC is called to set the 'has been repeated SSID bit' and re-CRC the frame.

Lines 12560 - 12630:
Test the P/F bit of the frame's control byte and if not set = more frames in this packet, jump off to process the next frame in line 12710. If the P/F bit is set = last frame of this packet, lines 12600 - 12610 set alternate DE with LENG1 (total length of packet + 1) and then jump off to REXIT to re-transmit (forward) the packet.

All this processing only requires a few milliseconds and is totally transparent to the operator except for the-<FORWARDING> message which is displayed on the receive mode video display.

MODIFYING AX. 25 SOFTWARE APRROACH
TO TRANSMIT MULTI-REPEATER CALLS:

Is quite simple if only single frame packets are used. It seems to us that when using the multi-repeater function it would be wise to limit the packet to the single frame variety to keep the BERP (bit error rate probability) as low as possible. Further, 2 repeaters in the address field seems adequate for most all practical purposes.

If you wish to add the multi-frame packet capability when using multiple repeaters, the software approach gives you total freedom to do so. The only limitation in our software approach is the memory set aside for assembled packets ready to be transmitted = 2048 bytes. Therefore, the program without too much modification can accomodate maximum length info fields (256 bytes) with multiple repeaters:

7 frames per packet = 2 repeaters
6 frames per packet = 8 repeaters
5 frames per packet = 18 repeaters
4 frames per packet = 35 repeaters

If you wish to add the multi-frame AND multi-repeater transmit capability to our software approach, by all means do so and we wish you well.

CONCLUSION:

Having more than one repeater in the address field of an AX.25 frame is certainly a temporary and possibly useful expedient until level/layer 3 is implemented.

IF you would like a 35 track double sided disk for the Model I or single sided disk for the Model III TRS-80 with the multi-repeater capability in receive mode and up to two (2) repeaters input in transmit mode, then send $29 in US funds to:

Richcraft Engineering Ltd.
#1 Wahmeda Industrial Park
Chautauqua, New York 14722

A short single sheet of operating instructions is sent with the AX.25 disk outlining ONLY those changes to the operating instructions in Volume 2 of the software approach. Volume 2 is required for the balance of instructions to operate the program. The disk includes the PACK/CMD program, ASCII/CMD and MODIF1 object code programs, and ASCII2 and MODIF2 uncommented source code programs.

These modified programs also include the automatic switching from keyboard input message to receive mode function when connected, that is mentioned in another paper in these proceedings. The programs are very difficult to follow as it was necessary to move the real-time receive mode decoding subroutine from ASCII2 to the end of MODIF2 to allow the program to be assembled with a standard 2 pass editor & assembler in 48K of memory. Expert assembly language programmers should have little difficulty following these changes, so be forewarned as we do not plan to re-write volume 2 for these modest improvements.

IF you are the original purchaser of an earlier version of the Richcraft Ax.25 disk program and wish it updated, return the original disk and $10 to have it updated and returned to you postpaid.

- FIGURE 1 -

```
12400 TEZFOR  LD      HL,(BGINIT)     ;BEGIN FRAME IN MEMORY
12410         LD      A,(HL)          ;LOOK FOR THE FRAME'S
12420         INC     HL              ;CONTROL BYTE MEM ADDRESS
12430         BIT     0,A             ;AFTER THE
12440         JP      Z,TEZFOR+3      ;LAST SSID EYTE
12450         LD      (RCTL),HL       ;AND SAVE IT IN RCTL
12460         LD      HL,TESADR-1     ;CHANGE JP NZ ADDRESS
12470         LD      (CAL+6),HL      ;IN CALL LETTERS TEST
12480         LD      HL,(BGINIT)     ;BEGIN FRAME MEM LOCATION
12490         LD      DE,14           ;UR CALL+HIS CALL+SSID'S
12500         ADD     HL,DE           ;REPEATER ADDRESS IF ANY
12505         LD      (BGNRPT),HL     ;REPEATER BEGIN LOCATION
12506 .       CALL    CALRPT          ;CACULATE NO. REPEATERS
12507         LD      HL,(BGNRPT)     ;REPEATER BEGIN LOCATION
12510         LD      DE,FM           ;YOUR CALL LETTERS BEGIN
12520         CALL    CAL             ;COMPARE WITH REPEATER
12530         BIT     1,(HL)          ;TEST SSID FOR YOU ?
12540         JP      NZ,TEZADR       ;IF NOT, IGNORE IT
12550         CALL    RECRC           ;SET RPTR BIT+ RE-DO CRC
12560         LD      HL,(RCTL)       ;CONTROL BYTE LOCATION
12570         BIT     4,(HL)          ;P/F BIT SET = LAST ONE
12580         JP      Z,ADDIT         ;IF NOT, DO NEXT FRAME
12590         EXX                     ;SINCE LAST ONE THEN
12600         LD      DE,(LENG1)      ;SET ALTERNATE DE TO THE
12610         INC     DE              ;TOTAL PACKET
12620         EXX                     ;LENGTH + 1 FOR SEND7
12630         JP      REXIT           ;AND RE-TRANSMIT IT
12640 ADDIT   LD      A,(FRMNUM)      ;FRAMES PER PACK COUNTER
12650         INC     A               ;PLUS ONE
12660         LD      (FRMNUM),A      ;AND SAVE IT
12670         EXX                     ;SET ALTERNATE HL
12680         LD      ML,(LENG1)      ;FOR TOTAL PACK
12690         INC     HL              ;+ 1 FOR SEND7
12700         EXX                     ;RESTORE REG. REGISTERS
12710         JP      CONT            ;GO PROCESS NEXT FRAME
12720 FRMNUM  DEFB    0               ;FRAMES/PACK COUNTER
12730         POP     AF              ;ADJUST STACK FOR CALL
12740 TESADR  LD      HL,MODE2-1      ;RESET JP,NZ ADDRESS
12750         LD      (CAL+6),HL      ;IN CALL COMPARISON
12760         LD      HL,(BGINIT)     ;BEGIN FRAME MEM LOCATION
12770         LD      DE,FM           ;YOUR CALL LETTERS BEGIN
12780         CALL    CAL             ;COMPARE WITH YOUR CALL
12790         LD      A,(RPT)         ;VIA REPEATER POINTER
12800         CP      1               ;1 = ON 2 = OFF
12810         JP      Z,TES3          ;IF SO, TEST RPTR CALL
12820         LD      DE,7            ;NOT VIA REPEATER,
12830         ADD     HL,DE           ;SO TEST OTHER STATION'S
12840         BIT     0,(HL)          ;SSID BIT ZERO TO ENSURE
12850         JP      Z,MODE2         ;IT IS DIRECT OR IGNORE.
12860 TES2    LD      A,(SIGN3)       ;AUTO MODE POINTER
12870         CP      1               ;1 = ON 0 = OFF
12880         JP      Z,TESCTL        ;IF AUTO, TEST CONTROL
12890         LD      HL,(BGINIT)     ;ELSE TEST HIS
12900         LD      DE,7            ;CALL LETTERS
12910         ADD     HL,DE           ;AGAINST THE
12920         LD      DE,TO           ;CALL TO WHICH
12930         CALL    CAL             ;YOU ARE CONNECTED.
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- FIGURE 1 CONTINUED -

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12940         JP      TESCTL          ;OK, SO TEST CONTROL
12950 TES3    INC     DE              ;VIA REPEATER
12960         PUSH    DE              ;SO TEST
12970         LD      DE,8            ;REPEATER
12980         ADD     HL,DE           ;CALL
12990         POP     DE              ;LETTERS
13000         CALL    CAL             ;AND IF OK,
13010         BIT     7,(HL)          ;THE REPEATED SSID BIT.
13020         JP      Z,MODE2         ;NOT REPEATED, SO IGNORE
13030         JP      TES2            ;NOW TEST HIS CALL LTRS
13040 CAL     LD      BC,6            ;RPTR/CALL COMPARISON
13050         LD      A,(DE)          ;FRAME MID-MEM ADDRESS
13060         CP      (HL)            ;UR CALL LETTERS ADDRESS
13070         JP      NZ,MODE2-1      ;NOT SAME ? THEN EXIT
13080         INC     DE              ;NEXT MID-MEM ADDRESS
13090         INC     HL              ;NEXT COMPARISON ADDRESS
13100         DEC     C               ;-1 CALL LETTER COUNTER
13101         RET     Z               ;ALL MATCH, SO RETURN
13102         JP      CAL+3           ;GO TEST NEXT LETTER
13103 TEZNUM  LD      A,(NUMRPT)      ;NUMBER REPEATER CALLS
13104         DEC     A               ;LESS ONE
13105         LD      (NUMRPT),A      ;AND SAVE IT IN MEMORY
13106         JP      Z,TESADR-1      ;IF ZERO GO TEST ADDRESS
13107         LD      DE,FM           ;UR CALL MEMORY LOCATION
13108         INC     HL              ;SKIP SSID FOR NOW
13109         ADD     HL,BC           ;NEXT RPTR CALL LOCATION
13110         JP      CAL             ;GO TEST NEXT RPTR CALL
13111 CALRPT  LD      HL,(RCTL)       ;END REPEATER CALLS + 1
13112         LD      DE,(BGNRPT)     ;BEGIN RPTR MEM LOCATION
13113         OR      A               ;CLEAR CARRY FLAG
13114         SBC     HL,DE           ;RTCTL MINUS BEGIN RPTR
13115         JP      Z,TESADR-1      ;IF ZERO, TEST ADDRESS
13116         EX      DE,HL           ;REPEATER BYTES TO DE
13117         LD      HL,7            ;6 CALL LETTERS + SSID
13118         CALL    2490H           ;DIVIDE HL INTO DE
13119         CALL    0A7FH           ;SINGLE PREC. TO INTEGER
13120         LD      A,L             ;NUMBER REPEATER CALLS
13121         LD      (NUMRPT),A      ;STASH THEM IN MEMORY
13122         RET                     ;GOTO LINE 12530
13123 BGNRPT  DEFW    0               ;SAVE 2 BYTES FOR ADDRESS
13124 NUMRPT  DEFB    0               ;SAVE 1 BYTE RPTR COUNT
13130 REXIT   LD      IY,37873        ;DISPLAY <FORWARDING>
13140         CALL    SHOWIT          ;MESSAGE ON VIDEO
13150         LD      DE,(ENDIT)      ;CLOSING FLAG ADDRESS
13160         LD      HL,(REX)        ;MID-MEM BEGIN ADDRESS
13170         PUSH    HL              ;SWAP HL
13180         POP     IY              ;INTO IY
13190         LD      A,(FRMNUM)      ;FRAMES/PACKET COUNTER
13200         CP      0               ;SINGLE FRAME PACKET ?
13210         CALL    Z,SFRM1         ;IF SO, SET FOR SINGLE
13220         CALL    NZ,SFRM2        ;ELSE SET MULTI-FRAME
13230         LD      A,1             ;SET THE XMIT SUBROUTINE
13240         LD      (LASONE),A      ;LAST ONE POINTER
13250         XOR     A               ;ZERO OUT TRANSMIT
13260         LD      (ZEROMK),A      ;MARK COUNTER
13270         LD      (ZEROSP),A      ;AND SPACE COUNTER
13280         LD      (FRMNUM),A      ;AND FRAME COUNTER TOO
13290         CALL    SETIT           ;SETUP FOR SEND7 XMIT
13300         JP      FLGDLY          ;FINALLY - GO SEND IT
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Appendix

The following document is reprinted by permission of the Director, CCIR. Recommendation 476-3 specifies the protocol for AMTOR (Amateur Teleprinting Over Radio) and is referenced in FCC rules section 97.69.

RECOMMENDATION 476-3 *

DIRECT-PRINTING TELEGRAPH EQUIPMENT IN THE MARITIME MOBILE SERVICE

(Question 5/8)

(1970-1974-1978-1982)

The CCIR,

CONSIDERING

a) that there is a requirement to interconnect mobile stations, or mobile stations and coast stations, equipped with start-stop apparatus employing the International Telegraph Alphabet No. 2, by means of radiotelegraph circuits;

b) that direct-printing telegraphy communications in the maritime mobile service can be listed in the following categories:

b.a telegraph service between a ship and a coast station;

b.b telegraph service between a ship and an extended station (ship's owner) via a coast station;

b.c telex service between a ship and a subscriber of the (international) telex network;

b.d broadcast telegraph service from a coast station to one or more ships;

b.e telegraph service between two ships or between one ship and a number of other ships;

* The Director, CCIR is requested to bring this Recommendation to the attention of the CCI'TT

c) that those categories are different in nature and that consequently different degrees of transmission quality may be required;

d) that the categories given in *b.a*, *b.b* and *b.c* above may require a higher transmission quality than categories *b.d* and *b.e* for the reason that data could be handled through the services in the categories *b.a*, *6.6* and *b.c*, while the messages passed through the service of category *b.d*, and via the broadcast service of category *b.e* are normally plain language, allowing a lower transmission quality than that required for coded information;

e) that the service in category *b.d* and the broadcast service in category *b.e* cannot take advantage of an ARQ method, as there is in principle no return path;

f) that for these categories of service which by their nature do not allow the use of ARQ, another mode, i.e. the forward error-correcting (FEC) mode should be used;

g) that the period for synchronization and phasing should be as short as possible and should not exceed 5 seconds;

h) that most of the ship stations do not readily permit simultaneous use of the radio transmitter and radio receiver;

j) that the equipment on board ships should be neither unduly complex nor expensive;

k) that provision is made in Appendix 38 of the Radio Regulations for direct-printing telegraph operation,

UNANIMOUSLY RECOMMENDS

1. that when an error-detecting and correcting system is used for direct-printing telegraphy in the maritime mobile service, a 7-unit ARQ system or a 7-unit forward acting, error-correcting and indicating time-diversity system, using the same code, should be employed;

2. that equipment designed in accordance with § 1 should meet the characteristics laid down in Annex I.

ANNEX I

1. General (Mode A, ARQ and Mode B, FEC)

1.1 The system is a single-channel synchronous system using the 7-unit error-detecting code as listed in § 2 of this Annex.

1.2 The modulation rate on the rad10 link is 100 bauds. The equipment clocks controlling the modulation rate should have an accuracy of better than 30 parts in 10^6.

Note. – Some existing equipments may not conform to this requirement.

1.3 The terminal input must be able to accept the 5-unit start-stop CCITT International Telegraph Alphabet No. 2 at a modulation rate of 50 bauds.

1.4 The frequency shift on the radio link is 170 Hz. When frequency shift is effected by applying audio signals to the input of a transmitter, the centre frequency of the audio spectrum offered to the transmitter should be 1700 Hz.

Note. – A number of equipments are presently in service, using a centre frequency of 1500 Hz. These may require special measures to achieve compatibility.

1.5 The radio frequency tolerance of the transmitter and the receiver should be in accordance with Appendix 38 of the Radio Regulations. It is desirable that the receiver employs the minimum practicable bandwidth (see also Report 585).

Note. – The receiver bandwidth should preferably be between 270 and 340 Hz.

2. Table of conversion

2.1 *Traffic information signals*

TABLE I

Combination No.	Letter-case	Figure-case	International Telegraph Alphabet No. 2 Code	Emitted 7-unit signal (1)
1	A	—	ZZAAA	BBBYYYB
2	B	?	ZAAZZ	YBYYBBB
3	C	:	AZZZA	BYBBBYY
4	D	⊠(3)	ZAAZA	BBYYBYB
5	E	3	ZAAAA	YBBYBYB
6	F	0 2	ZAZZA	BBYBBYY
7	G	02	AZAZZ	BYBYBBY
8	H	08	AAZAZ	BYYBYBB
9	I		AZZAA	BYBBYYB
10	J	Audible signal	ZZAZA	BBBYBYY
11	K	(	ZZZZA	YBBBBYY
12	L	)	AZAAZ	BYBYYBB
13	M	.	AAZZZ	BYYBBBY
14	N		AAZZA	BYYBBYB
15	0	4	AAAZZ	BYYYBBB
16	P	0	AZZAZ	BYBBYBY
17	Q	1	ZZZAZ	YBBBYBY
18	R	4	AZAZA	BYBYBYB
19	S	,	ZAZAA	BBYBYYB
20	T	5	AAAAZ	YYBYBBB
21	U	7	ZZZAA	YBBBYYB
22	V	=	AZZZZ	YYBBBBY
23	W	2	ZZAAZ	BBBYYBY
24	X	/	ZAZZZ	YBYBBBY
25	Y	6	ZAZAZ	BBYBYBY
26	Z	+	ZAAAZ	BBYYYBB
27	← (Carriage return)		AAAZA	YYYBBBB
28	≡ (Line feed)		AZAAA	YYBBYBB
29	↓ (Letter shift)		ZZZZZ	YBYBBYB
30	↑ (Figure shift)		ZZAZZ	YBBYBBY
31	Space		AAZAA	YYBBBYB
32	Unperforated tape		AAAAA	YBYBYBB

(1) B represents the higher emitted frequency and Y the lower.

(2) At present unassigned (see CCITT Rec. El C8). Reception of these signals, however, should not initiate a request for repetition.

(3) The pictorial representation shown is a schematic of ✠ which may also be used when equipment allows (CCITT Rec. F.1).

2.2 *Service information signals*

TABLE II

Mode A (ARQ)	Emit ted signal	Mode B (FEC)
Control signal 1 (CS1)	BYBYYBB	
Control signal 2 (CS2)	YBYBYBB	
Control signal 3 (CS3)	BYYBBYB	
Idle signal β	BBYYBBY	Phasing signal 1
Idle signal *a*	BBBBYYY	Phasing signal 2
Signal repetition	YBBYYBB	

3. Characteristics

3.1 *Mode* A *(ARQ)* (see Figs. 1 and 2)

A synchronous system, transmitting blocks of three characters from an information sending station (ISS) towards an information receiving station (IRS), which stations can, controlled by the control signal 3 (see § 2.2). interchange their functions.

3.1.1 *Master and slave arrangements*

3.1.1.1 The station that initiates the establishment of the circuit (the calling station) becomes the "master" station, and the station that has been called will be the "slave" station;

this situation remains unchanged during the entire time in which the established circuit is maintained, regardless of which station, at any given time, is the Information Sending Station (ISS) or Information Receiving Station (IRS);

3.1.1.2 the clock in the master station controls the entire circuit (see circuit timing diagram, Fig. 1);

3.1.1.3 the basic timing cycle is 450 ms, and for each station consists of a transmission period followed by a transmission pause during which reception is effected;

3.1.1.4 the master station transmitting time distributor is controlled by the clock in the master station;

3.1.1.5 the slave station receiving time distributor is controlled by the received signal;

3.1.1.6 the slave station transmitting time distributor is phase-locked to the slave station receiving time distributor; i.e. the time interval between the end of the received signal and the start of the transmitted signal (t_E in Fig. 1) is constant;

3.1.1.7 the master station receiving time distributor is controlled by the received signal.

3.1.2 *The Information Sending Station (ISS)*

3.1.2.1 Groups the information to be transmitted into blocks of three characters (3 x 7 signal elements), including, if necessary, "idle signals β" to complete or to fill blocks when no traffic information is available;

3.1.2.2 emits a "block" in 210 ms after which a transmission pause of 240 ms becomes effective, retaining the emitted block in memory until the appropriate control signal confirming correct reception by the Information Receiving Station (IRS) has been received;

3.1.2.3 numbers successive blocks alternately "Block 1" and "Block 2" by means of a local numbering device. The first block should be numbered "Block 1" or "Block 2" dependent on whether the received control signal (see § 3.1.4.5) is a control signal 1 or a control signal 2. The numbering of successive blocks is interrupted at the reception of:

- a request for repetition; or
- a mutilated signal; or
- a control signal 3 (see § 2.2);

3.1.2.4 emits the information of Block 1 on receipt of control signal 1 (see § 2.2);

3.1.2.5 emits the information of Block 2 on receipt of control signal 2 (see § 2.2);

3.1.2.6 emits a block of three "signal repetitions" on receipt of a mutilated signal (see § 2.2).

3.1.3 *The Information Receiving Station (IRS)*

3.1.3.1 Numbers the received blocks of three characters alternately "Block 1" and "Block 2" by a local numbering device, the numbering being interrupted at the reception of:

- a block in which one or more characters are mutilated; or
- a block containing at least one "signal repetition"; (3.1.2.6)

3.1.3.2 after the reception of each block, emits one of the control signals of 70 ms duration after which a transmission pause of 380 ms becomes effective;

3.1.3.3 emits the control signal 1 at the reception of:

- an unmutilated "Block 2", or
- a mutilated "Block 1", or
- Block 1" containing at least one "signal repetition";

3.1.3.4 emits the control signal 2 at reception of:

- an unmutilated "Block 1", or
- a mutilated "Block 2", or
- a "Block 2" containing at least one "signal repetition".

3.1.4 *Phasing*

3.1.4.1 When no circuit is established, both stations are in the "stand-by" position. In this stand-by position no ISS or IRS and no master or slave position is assigned to either of the stations;

3.1.4.2 the station desiring to establish the circuit emits the "call" signal. This "call" signal is formed by two blocks of three signals;

3.1.4.3 the call signal contains:

- in the first block: "signal repetition" in the second character place and any combination of information signals * in the first and third character place,
- in the second block: "signal repetition" in the third character place preceded by any combination of the 32 information signals * in the first and second character place;

3.1.4.4 on receipt of the appropriate call signal the called station changes from stand-by to the I R S position and emits the control signal 1 or the control signal 2;

3.1.4.5 on receipt of two consecutive identical control signals, the calling station changes into I S S and operates in accordance with § 3.1.2.4 and 3.1.2.5.

3.1.5 *Rephasing* **

3.1.5.1 When reception of information blocks or of control signals is continuously mutilated, the system reverts to the "stand-by" position after a predetermined time (a preferable predetermined time would be the duration of *32* cycles of 450 ms), to be decided by the user, of continuous repetition; the station that is master station at the time of interruption immediately initiates rephasing along the same lines as laid down in § 3.1.4;

3.1.5.2 if, at the time of interruption, the slave station was in the IRS position, the control signal to be returned after phasing should be the same as that last sent before the interruption to avoid the loss of an information block upon resumption of the communication. (Some existing equipments may not conform to this requirement);

3.1.5.3 however, if, at the time of interruption, the slave station was in the ISS position, it emits, after having received the appropriate call blocks, either:

- the control signal 3; or
- the control signal 1 or 2 in conformity with § 3.1.4.4, after which control signal 3 is emitted to initiate changeover to the ISS position;

3.1.5.4 if rephasing has not been accomplished within the time-out interval of § 3.1.9.1, the system reverts to the stand-by position and no further rephasing attempts are made.

3.1.6 *Change-over*

3.1.6.1 *The Information Sending Station (ISS)*

- Emits, to initiate a change in the direction of the traffic flow, the information signal sequence "Figure shift" – "Plus" ("figure case of *Z*") – "Question Mark" ("figure case of *B*") *** followed, if necessary, by one or more "Idle Signals β" to complete a block;
- emits, on receipt of a control signal 3, a block containing the signals "Idle Signal β" – "Idle Signal α" – "Idle Signal β";
- changes subsequently to IRS after the reception of a "signal repetition".

3.1.6.2 *The Information Receiving Station (IRS)*

- Emits the control signal 3:
  - (a) when the station wishes to change over to ISS,
  - (b) on receipt of a block in which the signal information sequence "Figure shift" – "Plus" – (figure-case of Z) – "Question Mark" (figure-case of B) terminates *** or upon receipt of the following block. In the latter case, the IRS shall ignore whether or not one or more characters in the last block are mutilated:
- changes subsequently to ISS after reception of a block containing the signal sequence "Idle signal β" – "Idle signal α" "Idle signal β";
- emits one "signal repetition" as a master station, or a block of three "signal repetitions" as a slave station, after being changed into ISS;

3.1.7 *Output to line*

3.1.7.1 the signal offered to the line output terminal is a 5-unit start-stop signal at a modulation rate of 50 bauds.

3.1.8 *Answerback*

3.1.8.1 The WRU (Who are you?) sequence, which consists of combination Nos. 30 and 4 in the International Telegraph Alphabet No. 2, is used to request terminal identification.

* The composition of these signals and their assignment to individual ships require international agreement (see Recommendation 491).

** Some coast stations do not provide rephasing (see also Recommendation 492).

*** In the Telex network, the signal sequence combination No. 26 - combination No. 2, sent whilst the teleprinters are in the figure case condition, is used to initiate a reversal of the flow of information. The IRS is, therefore, required to keep track of whether the traffic information flow is in the letter-case or figure-case mode to ensure proper end-to-end operation of the system.

3.1.8.2 The Information Receiver Station (IRS), on receipt of a block containing the WRU sequence, which will actuate the the teleprinter answerback code generator:

- changes the direction of traffic flow in accordance with § 3.1.6.2;
- transmits the signal information characters derived from the teleprinter answerback code generator;
- after transmission of 2 blocks of "Idle signals β" (after completion of the answerback code, or in the absence of an answerback code), changes the direction of traffic flow in accordance with § 3.1.6.1.

Note. – Some existing equipments may not conform to this requirement.

3.1.9 *End of communication*

3.1.9.1 When reception of information blocks or of control signals is continuously mutilated, the system reverts to the "stand-by" position after a predetermined time of continuous repetition, which causes the termination of the established circuit, (a preferable predetermined time would be the duration of 64 cycles of 450 ms);

3.1.9.2 the station that wishes to terminate the established circuit transmits an "end of communication signal";

3.1.9.3 the "end of communication signal" consists of a block containing three "Idle Signal *a*":

3.1.9.4 the "end of communication signal" is transmitted by the ISS;

3.1.9.5 if an IRS wishes to terminate the established circuit it has to change over to ISS in accordance with § 3.1.6.2;

3.1.9.6 the IRS that receives an "end of communication signal" emits the appropriate control signal and reverts to the "stand-by" position;

3.1.9.7 on receipt of a control signal that confirms the unmutilated reception of the "end of communication signal", the ISS reverts to the "stand-by" position;

3.1.9.8 when after a predetermined number of transmissions * of the "end of communication signal" no control signal has been received confirming the unmutilated reception of the "end of communication signal", the ISS reverts to the stand-by position and the IRS times out in accordance with § 3.1.9.1.

3.2 *Mode B, forward error correction (FEC)* (see Figs. 3 and 4)

A synchronous system, transmitting an uninterrupted stream of characters from a station sending in the collective B-mode (CBSS) to a number of stations receiving in the collective B-mode (CBRS), or from a station sending in the selective B-mode (SBSS) to one selected station receiving in the selective B-mode (SBRS).

3.2.1 *The station sending in the collective or in the selective B-mode (CBSS or SBSS)*

3.2.1.1 Emits each character twice: the first transmission (DX) of a specific character is followed by the transmission of four other characters, after which the retransmission (RX) of the first character takes place, allowing for time-diversity reception at 280 ms time space;

3.2.1.2 emits as a preamble to messages or to the call sign, **alternately** the phasing signal 1 (see § 2.2) and the phasing signal 2 (see § 2.2) whereby phasing signal 1 is transmitted in the RX, and phasing signal 2 in the DX position. At least four of these signal pairs (phasing signal 1 and phasing signal 2) should be transmitted.

3.2.2 The station sending in the collective B-mode (CBSS)

3.2.2.1 Emits during the breaks between two messages in the same transmission the phasing signals 1 and the phasing signals 2 in the RX and the DX position, respectively.

3.2.3 The station sending in the selective B-mode (SBSS)

3.2.3.1 Emits after the transmission of the required number of phasing signals (see § 3.2.1.2) the call sign of the station to be selected. This call sign is a sequence of four characters that represents the number code of the called station. This transmission takes place in the time diversity mode according to § 3.2.1.1;

3.2.3.2 emits the call sign and all further signals in a 3B/4Y ratio, i.e. inverted with respect to the signals in Table I of § 2 in the column "emitted 7-unit signal". Consequently, **all** signals, i.e. both traffic information signals and service information signals, following the phasing signals are transmitted in the 3B/4Y ratio;

3.2.3.3 emits the service information signal "Idle signal β" during the idle time between the messages consisting of traffic information signals.

* A preferable predetermined number would be four transmissions of the "end of communication signal".

3.2.4 The station(s) receiving in the collective or in the selective B-mode (CBRS or SBRS)

3.2.4.1 Checks both characters (DX and RX), printing an unmutilated DX or RX character, or printing an error symbol or space, if both are mutilated.

3.2.5 Phasing

3.2.5.1 When no reception takes place, the system is in the "stand-by" position as laid down in § 3.1.4.1;

3.2.5.2 on receipt of the sequence *"phasing signal 1" – 'phasing signal 2"*, or of the sequence *"phasing signal 2" – "phasing signal 1"*, in which phasing signal 2 determines the DX and phasing signal 1 determines the RX position, and at least one further phasing signal in the appropriate position, the system changes from "stand-by" to the CBRS position;

3.2.5.3 when started as CBRS the system changes to the SBRS (selectively called receiving station) position on receipt of the inverted characters representing its selective call number;

3.2.5.4 having been changed into the CBRS or into the SBRS position the system offers continuous stop-polarity to the line output terminal until either the signal "carriage return" or "'line feed" is received;

3.2.5.5 when started as SBRS, the decoder re-inverts all the following signals received to the 3Y/4B ratio, so that these signals are offered to the SBRS in the correct ratio, but they remain inverted for all other stations;

3.2.5.6 both the CBRS and the SBRS revert to the stand-by position if, during a predetermined time, the percentage of mutilated signals received has reached a predetermined value.

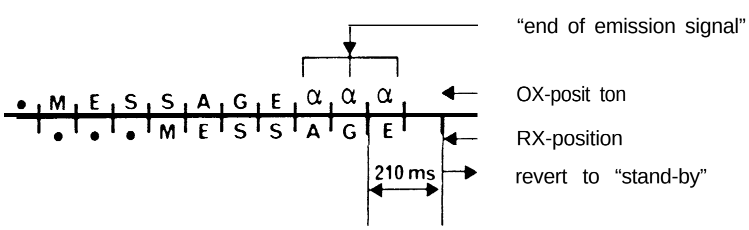
3.2.6 Output to line

3.2.6.1 The signal offered to the line output terminal is a S-unit start-stop CCITT International Telegraph Alphabet No. 2 signal at a modulation rate of 50 bauds.

3.2.7 End of emission

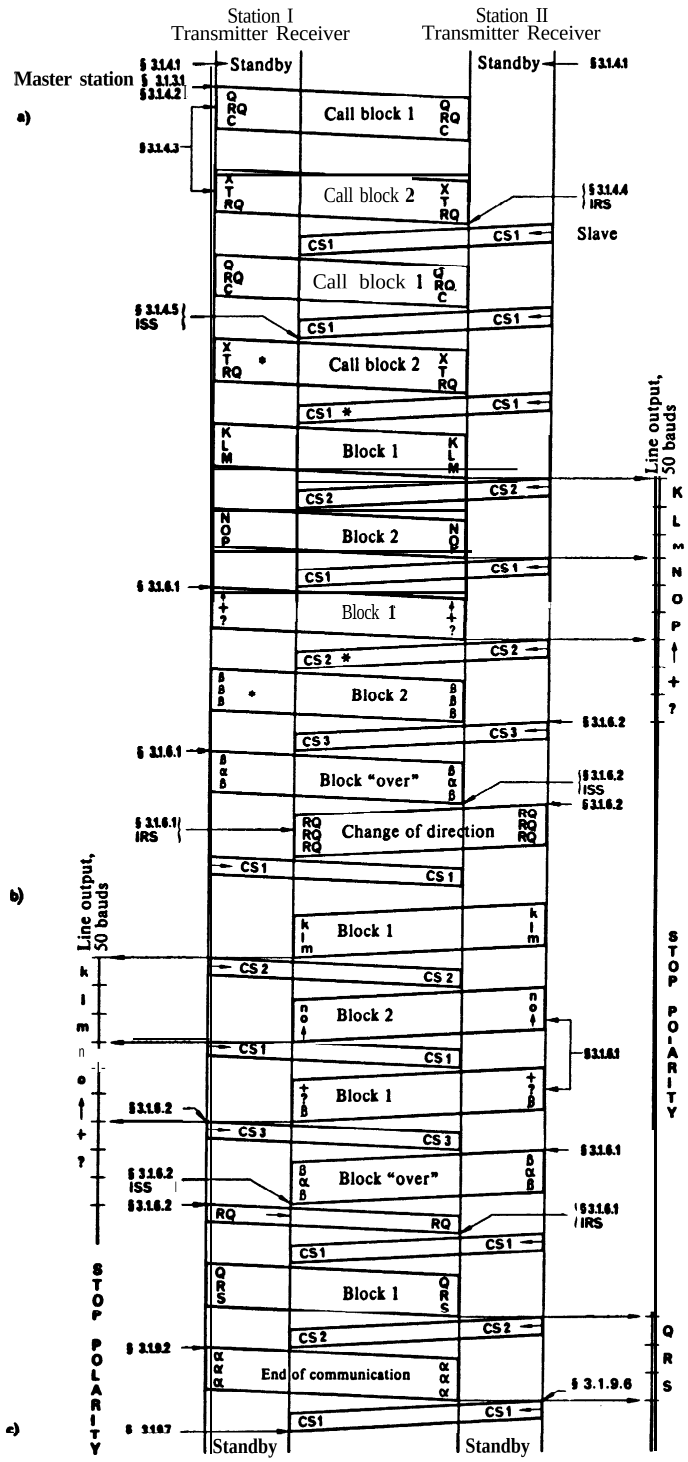
3.2.7.1 The station sending in the B-mode (CBSS or SBSS) that wishes to terminate the emission transmits the "end of emission signal";

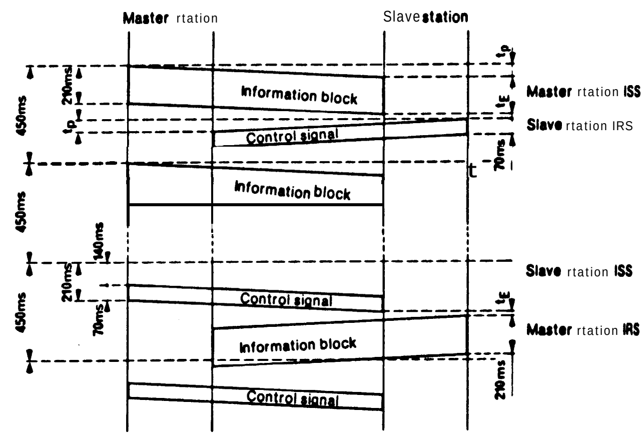
3.2.7.2 the "end of emission signal" consists of three consecutive "idle signals *a*" (see § 2.2) transmitted in the DX position only, immediately after the last transmitted traffic information signal in the DX position, after which the station terminates its emission and reverts to the "stand-by" position;



3.2.7.3 the CBRS or the SBRS reverts to the "stand-by" position not less than 210 ms after receipt of at least two consecutive "idle signals α" in the DX position.

Selective call No. 32610 transmitted as
(see Rec. 491 § 2 ,3) Q(RQ)C XT(RQ)





Basic timing cycle

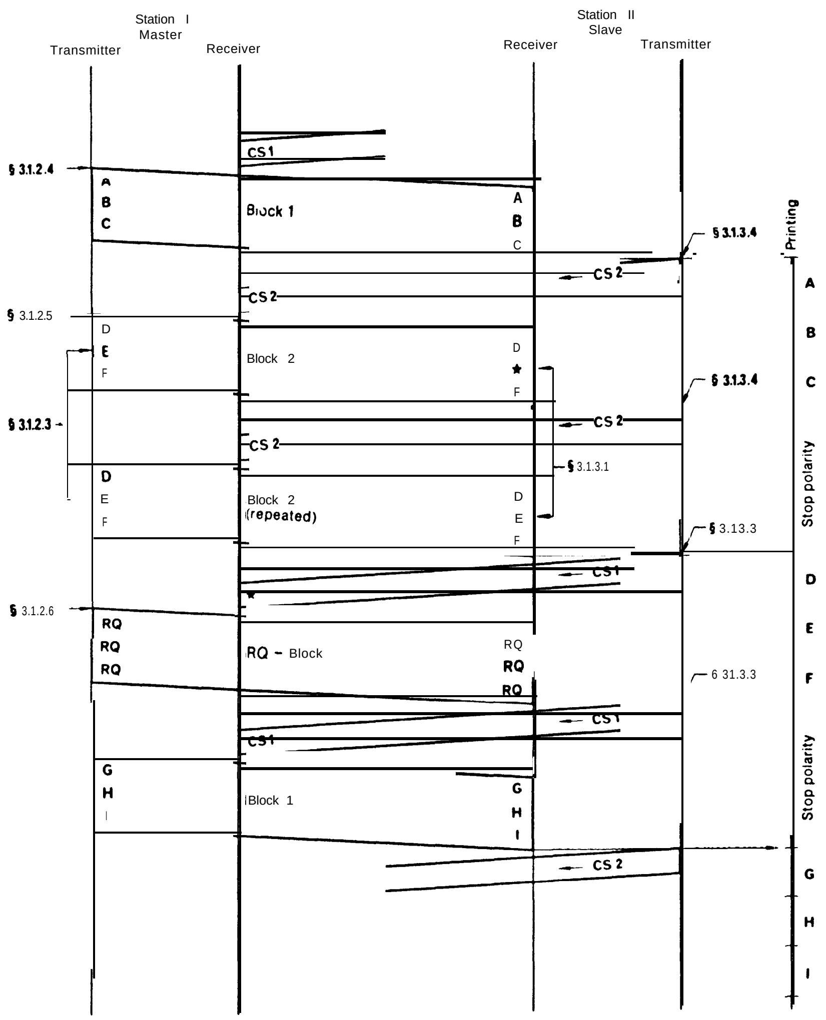
FIGURE 1 – *A-Mode operation*

a) Start of communication
b) Change of the direction of the traffic flow
c) End of communication
CS: Control signal

ISS : Information sending station
IRS : Information receiving station
RQ: Signal repetition information signal

t: Figure shift
t_p: (One way) propagation time
t_E: (Fixed) equipment delay

*The transmission of these signals may be omitted.



• Detected error Symbol.

FIGURE 2 – *Mode A under error receiving conditions*

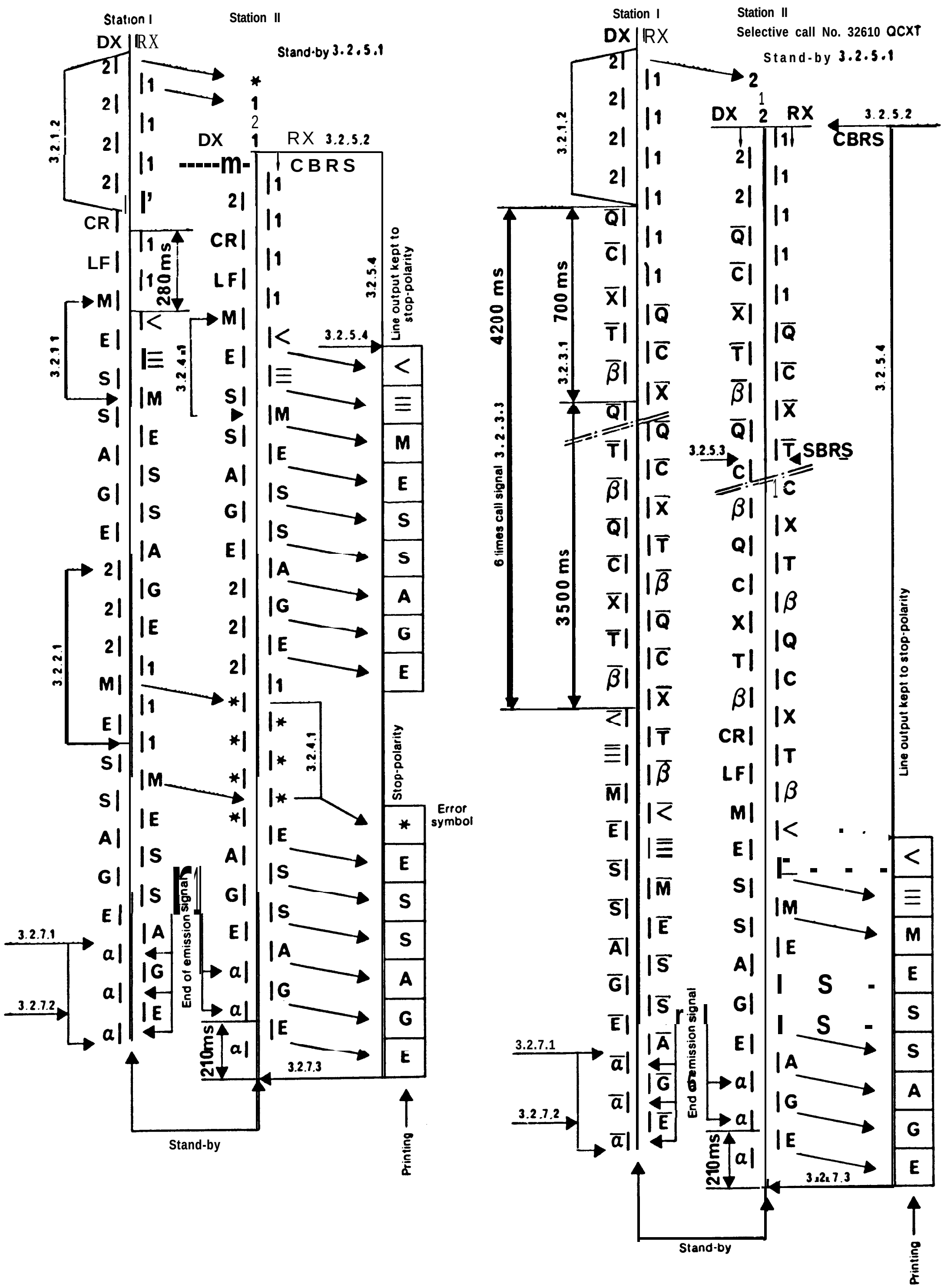


FIGURE 3 – *B-mode operation*

Collectively

1 : Phasing signal 1
2: Phasing signal 2
<: Carriage return (CR)
≡: Line feed (LF)
● : Detected error symbol

Selectively

CBSS: B-mode – Sending collectively
CBRS: B-mode – Receiving collectively
SBSS: B-mode – Sending selectively
SBRS: B-mode – Receiving selectively

Overlined symbols (e.g. $\overline{M}$) are transmitted in the 3B/4Y ratio