RECOMMENDATION ITU-R F.342-2*

AUTOMATIC ERROR-CORRECTING SYSTEM FOR TELEGRAPH SIGNALS TRANSMITTED OVER RADIO CIRCUITS

(1951-1953-1956-1959-1963-1966-1970)

The ITU Radiocommunication Assembly,

considering

(a) that it is essential to be able to interconnect terminal start-stop apparatus employing the International Telegraph Alphabet No. 2 by means of radiotelegraph circuits;

(b) that radiotelegraph circuits are required to operate under varying conditions of radio propagation, atmospheric noise and interference, which introduce varying degrees of distortion which may at times exceed the margin of the receiving apparatus;

(c) that, in consequence, the transmission of 5-unit code signals over radio circuits is liable to errors and that such errors are not automatically detectable by the receiving apparatus;

(d) that an effective means of reducing the number of wrongly printed characters is the use of codes, permitting the correction of errors by detecting the errors and automatically causing repetition;

(e) that the method using synchronous transmission and automatic repetition (ARQ), is now well proven;

(f) that it is desirable to permit the correct phase to be established automatically on setting up a circuit;

(g) that certain circumstances can occur which result in a loss of the correct phase relationship between a received signal and the receiving apparatus;

(h) that it is desirable to permit the correct phase relationship to be re-established automatically after such a loss, without causing errors;

(j) that, to avoid mis-routing traffic, it is essential to prevent phasing to a signal which has been unintentionally inverted;

(k) that there is sometimes a need to subdivide one or more channels, to provide a number of sub-channels at a proportionately reduced character rate;

(l) that the method of automatically achieving the correct phase relationship between the received signal and the sub-channelling apparatus should be an integral part of the phasing process;

(m) that compatibility with existing equipment, designed in accordance with Recommendation 242, Los Angeles, 1959, is a requirement,

recommends

1. that, when the direct use of a 5-unit code on a radio circuit gives an intolerable error rate and there is a return circuit, a 7-unit ARQ system be employed;

2. when automatic phasing of such a system is required, the 7-unit system, described in Annex I, should be adopted as a preferred system;

3. that equipment, designed in accordance with § 2, should be provided with switching, to permit operation with equipment designed in accordance with Recommendation 242, Los Angeles, 1959.

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* Radiocommunication Study Group 9 made editorial amendments to this Recommendation in 2000 in accordance with Resolution ITU-R 44.

ANNEX I

1. Table of conversion

TABLE I

	International code No. 2	International code No. 3
A	ZZAAA	AAZZAZA
B	ZAAZZ	AAZZAAZ
C	AZZZA	ZAAZZAA
D	ZAAZA	AAZZZAA
E	ZAAAA	AZZZAAA
F	ZAZZA	AAZAAZZ
G	AZAZZ	ZZAAAAZ
H	AAZAZ	ZAZAAZA
I	AZZAA	ZZZAAAA
J	ZZAZA	AZAAAZZ
K	ZZZZA	AAAZAZZ
L	AZAAZ	ZZAAAZA
M	AAZZZ	ZAZAAAZ
N	AAZZA	ZAZAZAA
O	AAAZZ	ZAAAZZA
P	AZZAZ	ZAAZAZA
Q	ZZZAZ	AAAZZAZ
R	AZAZA	ZZAAZAA
S	ZAZAA	AZAZAZA
T	AAAAZ	ZAAAZAZ
U	ZZZAA	AZZAAZA
V	AZZZZ	ZAAZAAZ
W	ZZAAZ	AZAAZAZ
X	ZAZZZ	AAZAZZA
Y	ZAZAZ	AAZAZAZ
Z	ZAAAZ	AZZAAAZ
Carriage return	AAAZA	ZAAAAZZ
Line feed	AZAAA	ZAZZAAA
Figures	ZZAZZ	AZAAZZA
Letters	ZZZZZ	AAAZZZA
Space	AAZAA	ZZAZAAA
Unperforated tape	AAAAA	AAAAZZZ
Signal repetition		AZZAZAA
Signal α		AZAZAAZ
Signal β		AZAZZAA

2. Repetition cycles

2.1 Four characters for normal circuits, which are not subject to excessive propagation time. The cycle should comprise one “signal repetition” and three stored characters.

2.2 Eight characters on circuits for which the four-character repetition cycle is inadequate. The cycle should comprise one “signal repetition”, three signals β and four stored characters, or one “signal repetition” and seven stored characters.

3. Channel arrangement

3.1 *Channel A*

3.1.1 For equipment employing a four-character repetition cycle: one character inverted followed by three characters erect (see Fig. 1a).

3.1.2 For equipment employing an eight-character repetition cycle: one character inverted followed by seven characters erect (see Fig. 2a).

3.2 *Channel B*

3.2.1 For equipment employing a four-character repetition cycle: one character erect followed by three characters inverted (see Fig. 1b).

3.2.2 For equipment employing an eight-character repetition cycle: one character erect followed by seven characters inverted (see Fig. 2b).

3.3 *Channel C*

As for Channel B (see Figs. 1c and 2c).

3.4 *Channel D*

As for Channel A (see Figs. 1d and 2d).

3.5 *Order of transmission*

3.5.1 Characters of Channels A and B are transmitted consecutively (see Figs. 1e and 2e).

3.5.2 Elements of Channel C are interleaved with those of Channel A (see Figs. 1g and 2g).

3.5.3 Elements of Channel D are interleaved with those of Channel B (see Figs. 1g and 2g).

3.5.4 In the aggregate signal, A elements precede those of C, and B elements precede those of D (see Figs. 1g and 2g).

3.5.5 The first erect character on A, transmitted after the inverted character on A, is followed by the erect character on B (see Figs. 1e and 2e).

3.5.6 The erect character on C is followed by the inverted character on D (see Figs. 1f and 2f).

3.5.7 The inverted character on A is element-interleaved with the erect character on C (see Figs. 1g and 2g).

4. Sub-channel arrangement

4.1 The character transmission rate of the fundamental sub-channel should be a quarter of the standard character rate.

4.2 Sub-channels should be numbered 1, 2, 3 and 4 consecutively.

4.3 Where a four-character repetition cycle is used, sub-channel 1 should be that sub-channel which has opposite keying polarity to the other three sub-channels of the same main channel (see Figs. 3a-d).

Where an eight-character repetition cycle is used, sub-channel 1 should be that sub-channel which has alternately erect and inverted keying polarity (see Figs. 3e-h).

4.4 When sub-channels of half-character rate, or three-quarter-character rate are required, combinations of the fundamental sub-channels should be arranged as shown in Table II.

TABLE II

Proportion of full-channel character rate	Combination of fundamental sub-channels
(1) quarter (2) quarter (3) half	No. 1 No. 3 Nos. 2 and 4
(1) half (2) half	Nos. 1 and 3 Nos. 2 and 4
(1) quarter (2) threes quarters	No. 1 Nos. 2, 3 and 4

5. Designation of aggregate signal

To assist in identifying the signal condition when applying the aggregate telegraph signal to modulate the radio channel, the following designation for the aggregate signal should be used:

TABLE III

Seven-unit code condition	Aggregate signal condition	
	Erect character	Inverted character
A Z	B Y	Y B

6. Diagrams

As a result of the characteristics specified in §§ 2, 3 and 4 of this Annex, the transmission of characters will be as shown in Figs. 1, 2 and 3.

7. Automatic phasing

7.1 Automatic phasing should normally be used. It should be initiated either:

7.1.1 after a waiting period during which cycling due to the receipt of errors has occurred continuously on both channels of a 2-channel system, or on at least two main channels of a 4-channel system;

7.1.2 after equal counts of A and Z elements have been made over at least two consecutive system cycles whilst continuous cycling due to the receipt of errors is occurring on all main channels;

7.2 when the slave station is phasing, it should transmit in each channel, in place of the "signal repetition", a 7-element signal in which all 7 elements are of the same polarity, all other characters in the repetition cycle being transmitted unchanged. (Existing systems without this facility need not be modified because compatibility is assured.)

8. ITU-T Recommendation S.12 (Fascicle VII.2) recommends that the interval between the beginning of successive start elements of the signals transmitted into the landline network be 145 5/6 ms. Therefore, the duration of the transmission cycle on the radio circuit and also the modulation rate must be chosen correspondingly, if connection to the network is required.

Practical values for the modulation rate in bauds and the duration of the transmission cycle, which enable synchronization to be effected by using a single oscillator for three cases, are shown in Table IV.

TABLE IV

Transmission cycle (ms)	Modulation rate (bauds)	
	2-channel operation	4-channel operation
145 5/6	96	192
This is the preferred standard. See ITU-T Recommendations S.12 and S.13		
163 1/3 140	85 5/7 100	171 3/7 200

The transmission cycle of 145 5/6 ms is the preferred standard for connection to 50-baud networks.

The transmission cycle of 163 1/3 ms is suitable for connecting to 45-baud networks.

The transmission cycle of 140 ms is suitable for radio circuits without direct connection to a landline network.

The tolerance on the frequency of the master oscillator, controlling the timing of each terminal equipment, should be $\pm 1 \times 10^{-6}$.

9. ITU-T Recommendation U.20 (Fascicle VII.1) gives the signalling conditions to be used when telex communication is to be established by means of such radio circuits:

9.1 for circuits on switched telegraph networks, the conditions of ITU-T Recommendation U.20 should apply;

9.2 for point-to-point circuits, Administrations may adopt, at the terminal equipment under their jurisdiction, their own method of stopping and starting the motors of the receiving machines, based on ITU-T Recommendation S.7 (Fascicle VII.2);

9.3 signal β should normally be transmitted to indicate the idle circuit condition. However, for signalling purposes, the signals α and β may be employed.

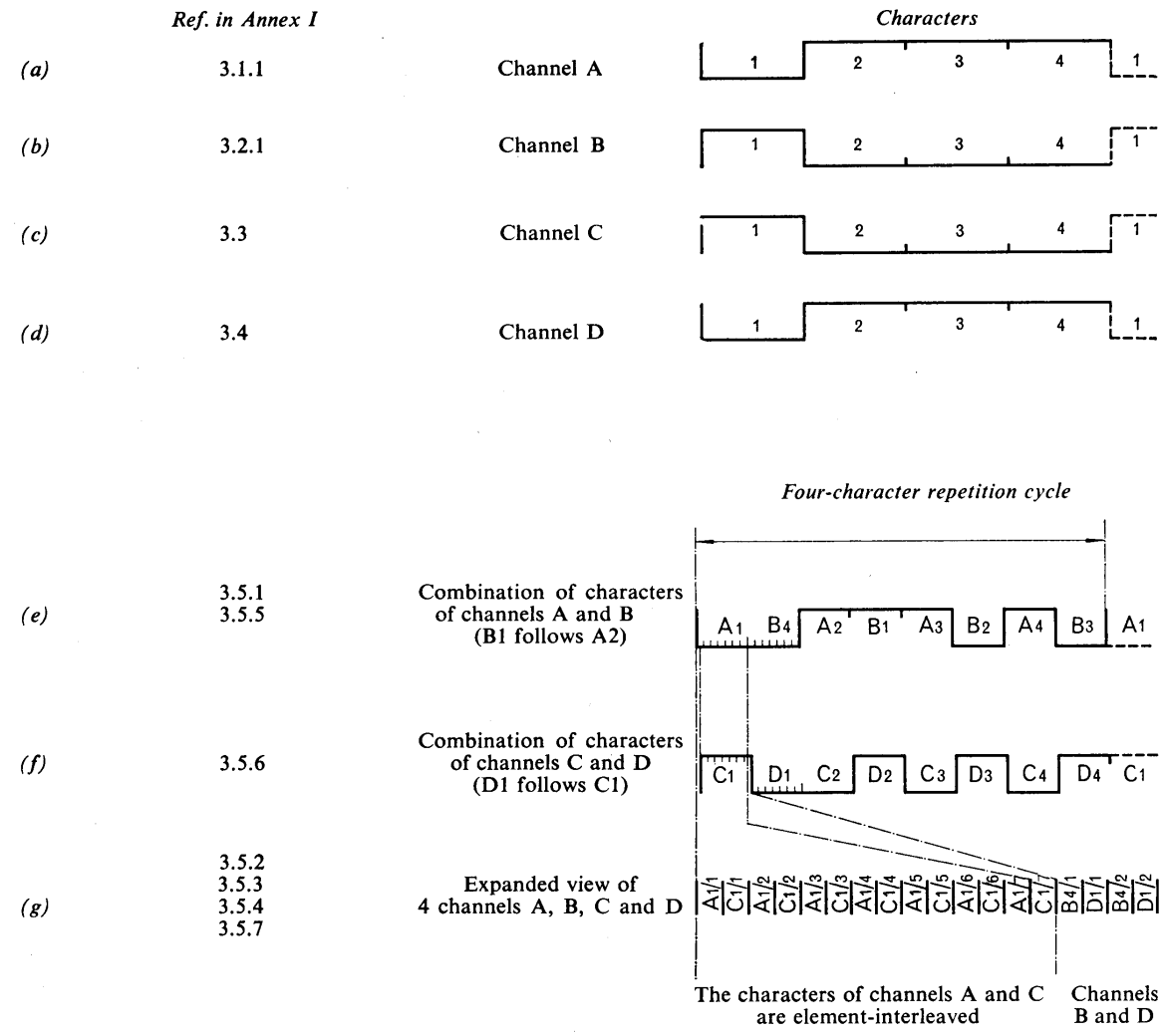

FIGURE 1 – *Channel arrangement for a four-character repetition cycle*

D01-sc

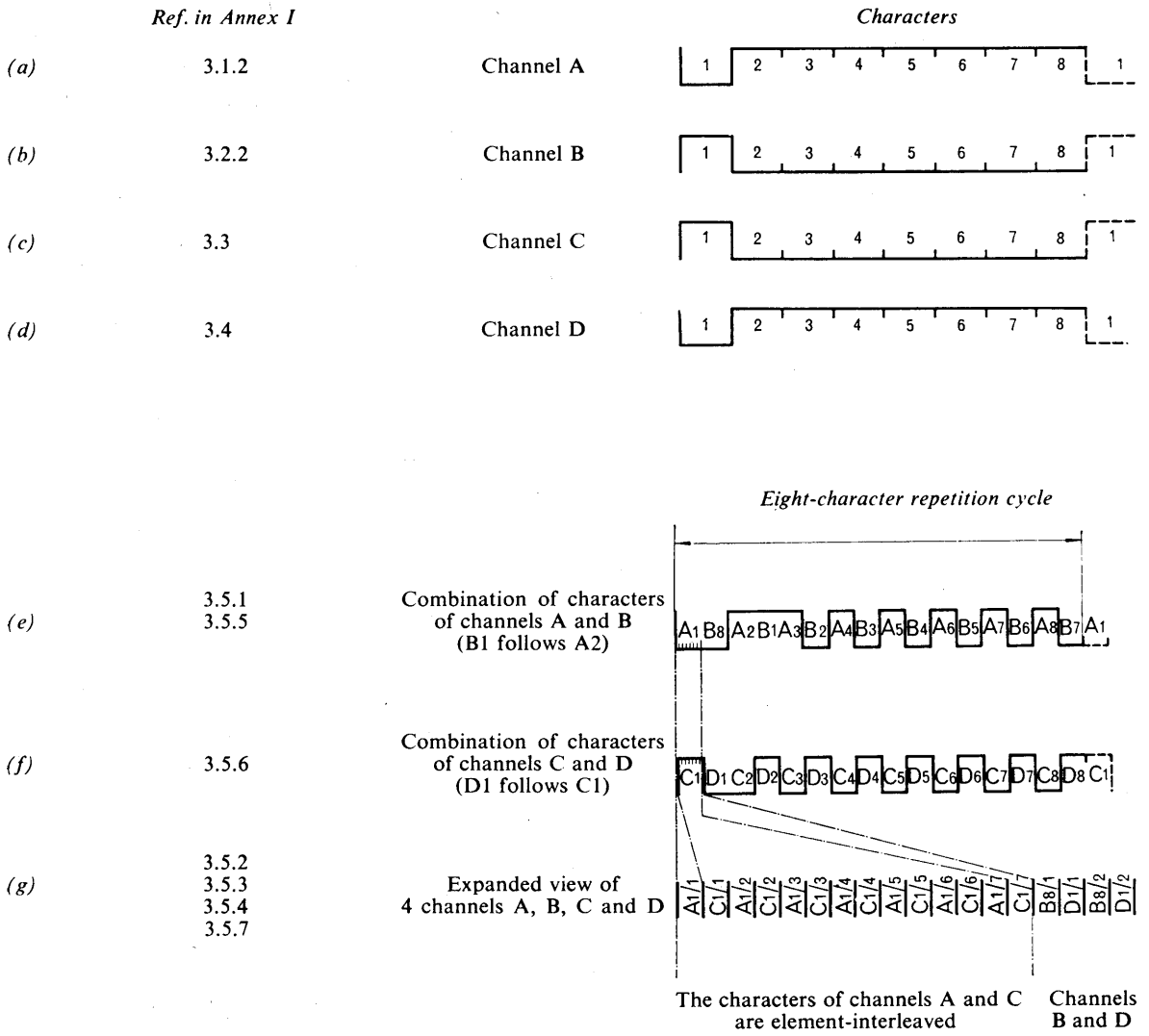

FIGURE 2 – *Channel arrangement for an eight-character repetition cycle*

D02-sc

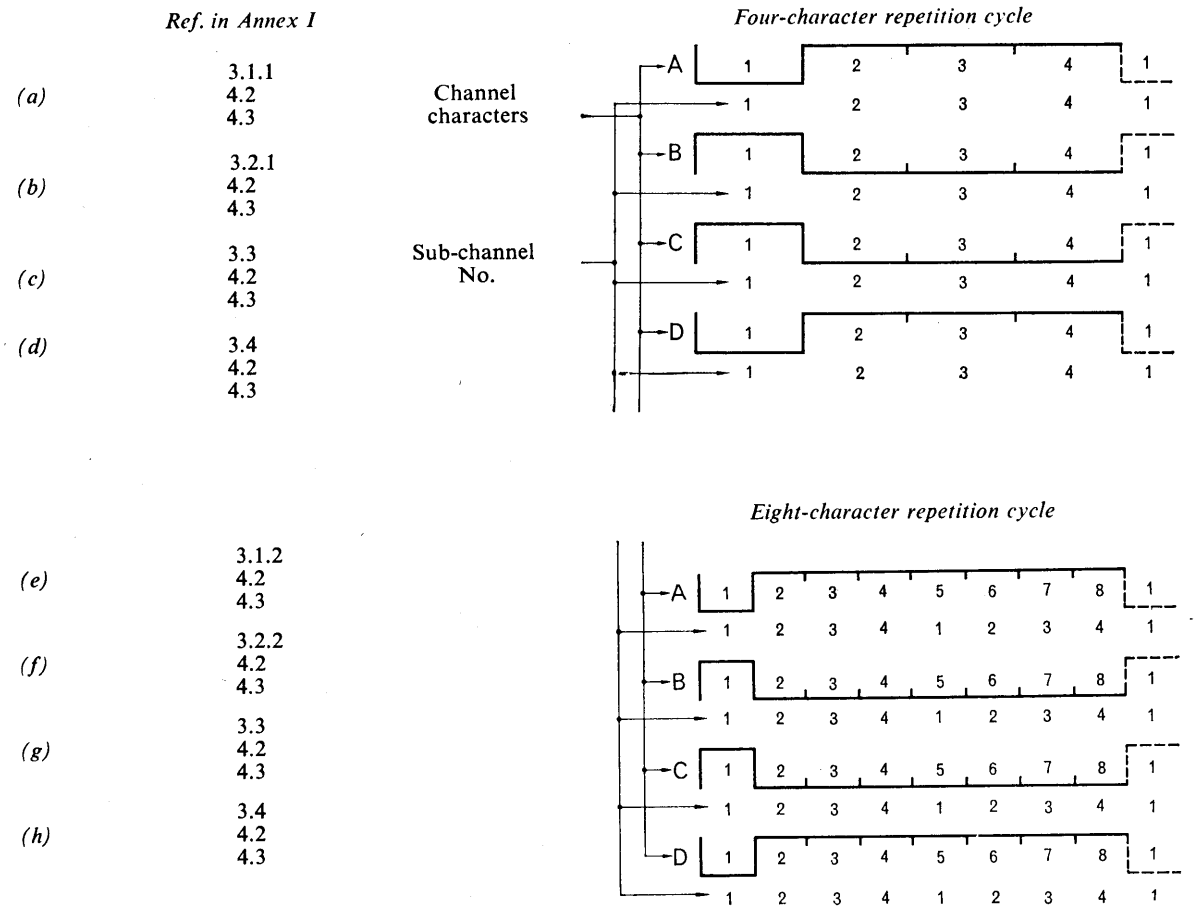

FIGURE 3 – *Sub-channelling arrangements for a four- and an eight-character repetition cycle*

D03-sc

ANNEX II

TERMS RELATED TO ARQ-SYSTEMS

Part 1

1. Signal repetition
RQ-signal

Signal Roman one – the seven unit combination (AZZAZAA) which is used to request a repetition (RQ-signal) or to precede a re-transmission (BQ-signal);

2. Repetition cyclee – the sequence of characters, the number of which is determined by the *loop time-delay of the system*, to provide automatic repetition of information;

3. RQ-cycle

Request cycle – the *repetition cycle* transmitted by ARQ-apparatus at the detection of a mutilation;

4. BQ-cycle

Response cycle – the *repetition cycle* transmitted by ARQ-apparatus at a request for repetition;

5. Non-print cycle – the interval at the ARQ-receiver, initiated by the detection of a mutilation or a *signal repetition*, that has the same duration as a *repetition cycle* and during which all signals received are prevented from being printed;

6. Gated RQ – a procedure in which a check is made for the presence of a signal repetition during a *non-print* cycle;

7. Tested RQ – a procedure in which a check is made for the presence of a *signal repetition* and a check is made for the ratio A/Z on all characters received after the *signal repetition* within the *non-print cycle*;

8. Tested repetition cycle – a *non-print cycle* in which a check is made for the presence of a *signal repetition* and for the correct ratio A/Z of all the characters received;

9. Cycling – the condition that a repetition procedures is in progress;

10. Marking pattern – a specific pattern of polarity inversions applied to characters in an *aggregate signal*;

11. Marked cycle
System cycle – a cycle consisting of a specific character *marking pattern*, that is continuously repeated and has the duration of a *repetition cycle*;

12. System phase
Marked cycle phase – the condition in which the *marking pattern* of the local timing coincides with the *marked cycle* of the received signal;

13. Phasing
Phase hunting – the condition in which a station is hunting for *character phase* or *system phase*;

14. Manual phasing – *phasing* by manual action only;

15. Semi-automatic phasing – *phasing* completed automatically after manual initiation;

16. Automatic phasing – *phasing*, initiated and completed automatically after automatic detection of “out-of-phase”;

17. Master station – the station, the transmitting equipment of which is directly driven by a master oscillator but the receiver timing of which is normally synchronized to the incoming signal;

18. Slave station – the station, receiver and transmitter timing of which are both synchronized to the received signal;

19. End-to-end time delay – the delay between the output terminals of an ARQ-transmitter and the input terminals of the ARQ-receiver at the other end (this is the sum of radio and line circuit delays in one direction of a route);

20. Loop time-delay of a route – the sum of the end-to-end delays in the send and return directions of a route;

21. Master station delay – the period between the beginning of reception of a *signal repetition* at the ARQ-input terminals at the *Master station* and the beginning of transmission of the replying *signal repetition* at that station.

Note. – This comprises the “scanning” and equipment delays and a further delay which, when added to the *loop time-delay of the system*, produces an integral multiple of the *character cycle* duration;

22. Slave station delay – the period between the beginning of reception of a *signal repetition* at the ARQ-input terminals at the *slave station* and the beginning of transmission of the replying *signal repetition* at that station.

Note. – This comprises "scanning" and equipment delays and a "pre-set" delay between the receiver and the transmitter;

23. Loop time-delay of a system (as seen from the master station) – the sum of the *loop time-delay*, measured under working conditions.

Part 2

(a) Aggregate signal – the synchronous signal produced by combining the channel signals;

(b) Balanced aggregate signal – an aggregate signal containing equal numbers of elements of each polarity;

(c) Character cycle – the period in which each channel of a time-division multiplex transmission has completed one character in the synchronous path;

(d) Element synchronism – in synchronous systems:
the condition in which an element of the local timing coincides completely with an element of the received signal;

(e) Synchronizing – the action of adjustment of element synchronism;

(f) Phase relationship – in synchronous systems:
the relative phase of receiving apparatus and incoming signals, or receiving and sending apparatus;

(g) Character phase – the condition in which a *character cycle* of the local timing coincides completely with a character cycle of the received signal.

Note. – Under these conditions, a character of the aggregate signal transmitted on a particular channel is received on the correct channel;

(h) Sub-channel – a teleprinter channel which is allocated a quarter rate of a normal channel, or multiples thereof;

(j) Sub-channel phase – the condition in which a character transmitted on a particular sub-channel is received on the correct sub-channel;

(k) Transposition – Add to definition 33.25 of the ITU "List of Definitions..." (Part I):
"Transpositions may be regarded as of first or higher order according to the number of interchanges occurring within a character."