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SERIES V: DATA COMMUNICATION OVER THE TELEPHONE NETWORK

Simultaneous transmission of data and other signals

Enhancements to Recommendation V.90

ITU-T Recommendation V.92

(Formerly CCITT Recommendation)

ITU-T V-SERIES RECOMMENDATIONS

DATA COMMUNICATION OVER THE TELEPHONE NETWORK

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation V.92

Enhancements to Recommendation V.90

Summary

Digital and analogue modems for use on the Public Switched Telephone Network (PSTN) at data signalling rates up to 56 000 bit/s downstream and up to 48 000 bit/s upstream, with reduced start-up time on recognized connections, and procedures to support modem-on-hold in response to call-waiting events or outgoing call requests.

Source

ITU-T Recommendation V.92 was prepared by ITU-T Study Group 16 (2001-2004) and approved under the WTSA Resolution 1 procedure on 17 November 2000.

FOREWORD

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NOTE

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1 Scope

This Recommendation specifies the operation between two different modems, one a digital modem and the other an analogue modem, both as defined in clause 3. The two modems are specified herein in terms of coding, start-up signals and sequences, operating procedures and DTE-DCE interface functionality. The network interface of the digital modem and the signalling rate that is used to connect the digital modem locally to a digital switched network are considered to be national matters and are hence not specified herein. The principal characteristics of these modems are as follows:

a) duplex mode of operation on the PSTN;

b) channel separation by echo cancellation techniques;

c) PCM modulation in both directions at a symbol rate of 8000;

d) synchronous channel data signalling rates in the downstream direction from 28 000 bit/s to 56 000 bit/s in increments of 8000/6 bit/s;

e) synchronous channel data signalling rates in the upstream direction from 24 000 bit/s to 48 000 bit/s in increments of 8000/6 bit/s;

f) adaptive techniques that enable the modems to achieve close to the maximum data signalling rates the channel can support on each connection;

g) negotiate V.34 modulation upstream (downstream) if a connection will not support PCM modulation upstream (downstream);

h) exchange of rate sequences during start-up to establish the data signalling rate;

i) use of V.8, and optionally V.8 *bis*, procedures during modem start-up or selection;

j) reduced start-up time on recognized connections; and

k) support of modem-on-hold procedures in response to call-waiting events or outgoing call requests.

2 References

The following ITU-T Recommendations and other references contain provisions, which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

– ITU-T G.711 (1988), *Pulse code modulation (PCM) of voice frequencies.*

– ITU-T V.8 (2000), *Procedures for starting sessions of data transmission over the public switched telephone network.*

– ITU-T V.8 *bis* (2000), *Procedures for the identification and selection of common modes of operation between data circuit-terminating equipment (DCEs) and between data terminal equipment (DTEs) over the public switched telephone network and on leased point-to-point telephone-type circuits.*

- ITU-T V.14 (1993), *Transmission of start-stop characters over synchronous bearer channels.*
- ITU-T V.21 (1988), *300 bits per second duplex modem standardized for use in the general switched telephone network.*
- ITU-T V.24 (2000), *List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE).*
- ITU-T V.25 (1996), *Automatic answering equipment and general procedures for automatic calling equipment on the general switched telephone network including procedures for disabling of echo control devices for both manually and automatically established calls.*
- ITU-T V.34 (1998), *A modem operating at data signalling rates of up to 33 600 bit/s for use on the general switched telephone network and on leased point-to-point 2-wire telephone-type circuits.*
- ITU-T V.42 (1996), *Error-correcting procedures for DCEs using asynchronous-to-synchronous conversion.*
- ITU-T V.43 (1998), *Data flow control.*
- ITU-T V.80 (1996), *In-band DCE control and synchronous data modes for asynchronous DTE.*
- ITU-T V.90 (1998), *A digital modem and analogue modem pair for use on the public switched telephone network (PSTN) at data signalling rates of up to 56 000 bit/s downstream and up to 33 600 bit/s upstream.*

3 Definitions

This Recommendation defines the following terms:

3.1 analogue modem: The analogue modem is the modem of the pair that, when in data mode, receives G.711 signals that have been passed through a G.711 decoder. The modem is typically connected to the PSTN.

3.2 digital modem: The digital modem is the modem of the pair that, when in data mode, generates G.711 signals. The modem is connected to a digital switched network through a digital interface, e.g. a Basic Rate Interface (BRI) or a Primary Rate Interface (PRI).

3.3 downstream: Transmission in the direction from the digital modem towards the analogue modem.

3.4 nominal transmit power: Reference transmit power that is configured by the user.

3.5 Qa.b format: Numbers denoted as signed Qa.b are represented in (a + b + 1)-bit two's-complement format with b bits after the binary point, and assume values in the half-open interval $[-2^a, 2^a[$. Numbers denoted as unsigned Qa.b are represented in (a + b)-bit format with b bits after the binary point, and assume values in the half-open interval $[0, 2^{a+1}[$.

3.6 Ucode: As defined in clause 3/V.90.

3.7 upstream: Transmission in the direction from the analogue modem towards the digital modem.

3.8 L_U: The value of L_U is set such that TRN_{1U} is transmitted at the desired data mode transmit power.

4 Abbreviations

This Recommendation uses the following abbreviations:

BRI	Basic Rate Interface
DCE	Data Circuit-Terminating Equipment
DIL	Digital Impairment Learning sequence
DTE	Data Terminal Equipment
PRI	Primary Rate Interface
PSTN	Public Switched Telephone Network
RTDEd	Round-Trip Delay Estimate – digital modem

5 Digital modem

The data signalling rates, symbol rate, scrambler and encoder for the digital modem shall be the same as those given in clause 5/V.90.

6 Analogue modem

6.1 Data signalling rates

The modem shall transmit synchronously at data signalling rates of 24 000 bit/s to 48 000 bit/s in increments of 8000/6 bit/s. The data signalling rate shall be determined during Phase 4 of modem start-up according to the procedures described in 9.6.

6.2 Symbol rate

The upstream symbol rate shall be 8000 symbol/s derived from the digital network.

6.3 Scrambler

The analogue modem shall include a self-synchronizing scrambler as specified in clause 7/V.34, using the generating polynomial, GPA, in equation 7-2/V.34.

6.4 Transmitter

The framing of the transmitter shall be based upon Figure 1.

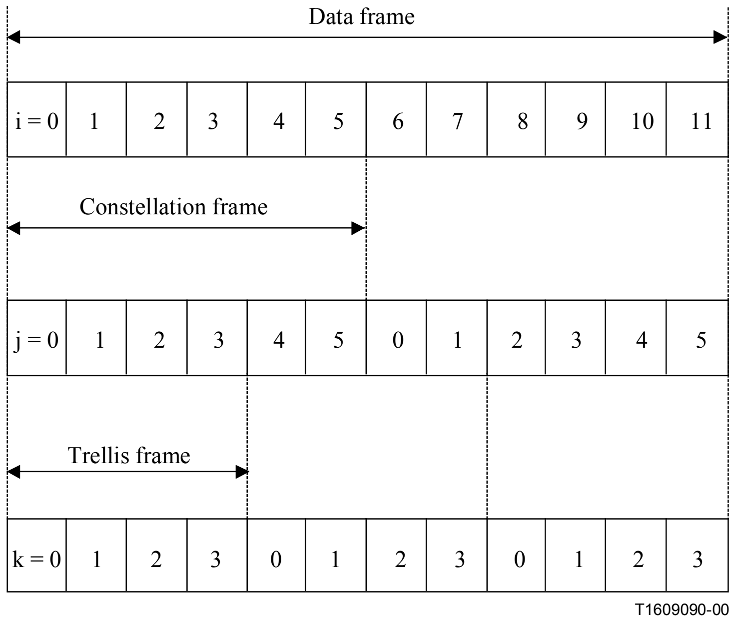

Figure 1/V.92 – Framing structure for the analogue modem

Figure 2 is a block diagram of the major elements of the analogue modem transmitter, which are described in detail in 6.4.1 to 6.4.4.

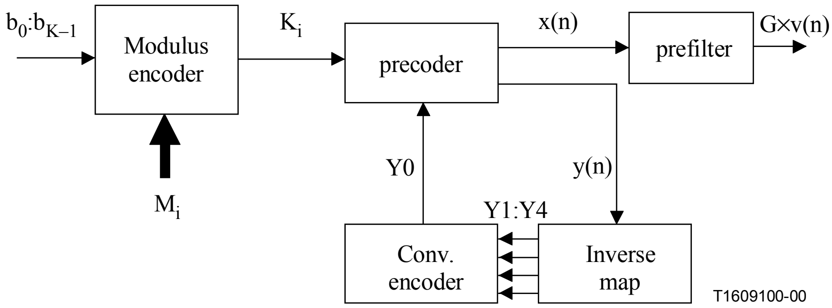

Figure 2/V.92 – Analogue modem transmitter block diagram

6.4.1 Modulus encoder

For each data frame, K scrambled bits, denoted by bits b_0 to b_{K-1}, where b_0 is first in time, enter the modulus encoder. Parameters M_0 to M_{11} also enter the modulus encoder.

The values of M_i and K shall satisfy the inequality $2^K \leq M = \prod_{i=0}^{11} M_i$

The modulus encoder converts the K bits into twelve numbers, K_0 to K_{11}, using the following algorithm.

NOTE – Other implementations are possible but the mapping function must be identical to that given in the algorithm described below.

1) Represent the incoming K bits as an integer, R:

$$R = b_0 + b_1 \times 2^1 + ... + b_{K-1} \times 2^{K-1}$$

2) Determine the 'sign' of R:

$$s(f) = 0 \text{ if } R \le (M-1)/2;\ s(f) = 1 \text{ if } R > (M-1)/2$$

3) Differentially encode the 'sign':

$$d(f) = s(f) \oplus d(f-1), \text{ where } \oplus \text{ represents modulo 2 addition}$$

4) Form R_0:

$$R_0 = R \text{ if } d(f-1) = 0;\ R_0 = M - 1 - R \text{ if } d(f-1) = 1$$

5) Divide R_0 by M_0. The remainder of this division gives K_0, the quotient becomes R_1 for use in the calculation for the next data frame interval. Continue for the remaining eleven data frame intervals. This gives K_0 to K_{11} as:

$$K_i = R_i \text{ modulo } M_i, \text{ where } 0 \le K_i < M_i;\ R_{i+1} = (R_i - K_i)/M_i$$

6) The numbers K_0 to K_{11} are the outputs of the modulus encoder, where K_0 corresponds to data frame interval 0 and K_{11} corresponds to data frame interval 11.

6.4.2 Precoder and prefilter

The precoder has inputs from the modulus encoder and the convolutional encoder. For each K_i received from the modulus encoder, the precoder identifies K_i with an equivalence class $E(K_i)$. The precoder selects a point u(n) from the equivalence class $E(K_i)$. The index of the constellation point u(n) is denoted by y(n).

The equivalence classes are chosen as follows. Let the N constellation points be denoted by $a(\eta)$, $-N/2 \le \eta < N/2$, where the indices are in the same order as the levels. (N is the appropriate constellation length taken from the CP_d sequence, i.e. one of $2*LC_1$ through $2*LC_6$ in Table 30). Thus negative points have negative indices, and positive points have non-negative indices. The modulus encoder output K_i has M_i possible values $0 \le K_i < M_i$. The equivalence class $E(K_i)$ corresponding to K_i is then defined as:

$$E(K_i) = \{a(\eta_k) \mid \eta_k = K_i + z_k M_i,\ z_k \text{ an integer}\} \text{ for } k = 0, 1, 2;$$

$$\{a(\eta_k) \mid \eta_k = 2K_i + 2z_k M_i + (\eta_0 + \eta_1 + \eta_2 + Y0)\text{mod}2,\ z_k \text{ an integer}\} \text{ for } k = 3.$$

The precoder filter output is then:

$$x(n) = u(n) + \sum_{\kappa=1}^{LZ_1} u(n-\kappa) z_1(\kappa) + \sum_{\kappa=1}^{LP_1} x(n-\kappa) p_1(\kappa)$$

The prefilter takes the output of the precoder filter and produces v(n), defined as:

$$v(n) = \sum_{\kappa=0}^{LZ_2 - 1} x(n-\kappa) z_2(\kappa) + \sum_{\kappa=1}^{LP_2} v(n-\kappa) p_2(\kappa)$$

Finally the output v(n) is multiplied by a gain, G.

6.4.3 Inverse map

For each trellis frame the inverse map takes the two pairs (y(0),y(1)) and (y(2),y(3)) and produces Y1, Y2, Y3 and Y4. It is identical to the symbol-to-bit converter described in 9.6.3.1/V.34. The odd-integer coordinates used in 9.6.3.1/V.34 are calculated as $2 \times y(k) + 1$.

6.4.4 Convolutional encoder

The convolutional encoders from ITU-T V.34 shall be used. The convolutional encoder takes the outputs Y1, Y2, Y3 and Y4 from the inverse map and produces Y0, as described in 9.6.3.2/V.34, except that the 2T delays are replaced by 4T delays.

7 Interchange circuits

The requirements of this clause apply to both modems.

7.1 List of interchange circuits

References in this Recommendation to V.24 interchange circuit numbers are intended to refer to the functional equivalent of such circuits and are not intended to imply the physical implementation of such circuits. For example, references to circuit 103 should be understood to refer to the functional equivalent of circuit 103 (see Table 1).

Table 1/V.92 – Interchange circuits

Interchange circuit		Notes
No.	**Description**	
102 103 104 105 106	Signal ground or common return Transmitted data Received data Request to send Ready for sending	
107 108/1 or 108/2 109	Data set ready Connect data set to line Data terminal ready Data channel received line signal detector	1
125 133	Calling indicator Ready for receiving	2
NOTE 1 – Thresholds and response times are not applicable because a line signal detector cannot be expected to distinguish received signals from talker echoes. NOTE 2 – Operation of circuit 133 shall be in accordance with 4.2.1.1/V.43.		

7.2 Asynchronous character-mode interfacing

The modem may include an asynchronous-to-synchronous converter interfacing to the DTE in an asynchronous (or start-stop character) mode. The protocol for the conversion shall be in accordance with ITU-T V.14, ITU-T V.42 or ITU-T V.80. Data compression may also be employed.

8 Signals and sequences

All PCM codewords transferred in training sequences are described using the universal codes as specified in Table 1/V.90. In Tables 2 to 5, 11 to 24, 27 and 30 to 33, unless stated otherwise, values given as bit patterns are transmitted leftmost bit first in time and values given as integers are transmitted least-significant bit first in time.

8.1 Full Phase 1

All full Phase 1 signals and sequences are defined in ITU-T V.25, ITU-T V.8 or ITU-T V.8 *bis*.

8.2 Short Phase 1 signals and sequences for the analogue modem

Signals QC1a and QCA1a are intended for use when the connection is initiated according to ITU-T V.8. Signals QC2a and QCA2a are intended for use when the connection is initiated according to ITU-T V.8 *bis*.

Short Phase 1 information bits are transmitted at 300 bits/s modulating either V.21(L), the low-band channel defined in ITU-T V.21, or ITU-T V.21(H), the high-band channel defined in ITU-T V.21.

8.2.1 QC1a

Signal QC1a is a sequence of bits transmitted using V.21(L) modulation. The sequence consists of 10-bit frames using V.8-type formatting as defined in Table 2. QC1a is transmitted once, and is followed immediately by CM.

Table 2/V.92 – Definition of QC1a

Bit position	Content	Definition	
0:9	1111111111	Ten ONEs	
10:19	0101010101	Synchronization sequence	
20	0	Start bit	
21	0	Indication for analogue modem	
22	0	Indication for QC	
23	P	Set to 1 calls for LAPM protocol according to ITU-T V.42 (see 9.2.5)	
24:29	W0XYZ1	WXYZ	U_{QTS}: Ucode of the PCM codeword to be used for QTS
		0000	61
		0001	62
		0010	63
		0011	66
		0100	67
		0101	70
		0110	71
		0111	74
		1000	75
		1001	78
		1010	79
		1011	82
		1100	83
		1101	86
		1110	87
		1111	Cleardown from on-hold state
30:39	1111111111	Ten ONEs	
40:49	0101010101	Bits 10:19 repeated	
50:59	000PW0XYZ1	Bits 20:29 repeated	

8.2.2 QC2a

Signal QC2a is a sequence of bits transmitted using V.21(H) modulation. The bits are transmitted using the signal structure defined in clause 7/V.8 *bis* and the information field structure defined in clause 8/V.8 *bis*. The analogue modem shall encode the identification field as defined in Table 3.

Table 3/V.92 – Definition of identification field in QC2a

Bit position	Content	Definition
0:3	1011	Message type
4:7	VVVV	V.8 *bis* revision number (Note)
8:11	WXYZ	U_{QTS} from Table 2
12	0	Reserved for ITU
13	P	Set to 1 calls for LAPM protocol according to ITU-T V.42 (see 9.2.5)
14	0	QC identifier
15	0	Analogue modem
NOTE – At the time of publication the V.8 *bis* revision number is 0100. The receiving modem shall ignore this field.		

8.2.3 QCA1a

Signal QCA1a is a sequence of bits transmitted using V.21(H) modulation. The sequence consists of 10-bit frames using V.8-type formatting as defined in Table 4. QCA1a is transmitted once.

Table 4/V.92 – Definition of QCA1a

Bit position	Content	Definition
0:9	1111111111	Ten ONEs
10:19	0101010101	Synchronization sequence
20	0	Start bit
21	0	Indication for analogue modem
22	1	Indication for QCA
23	P	Set to 1 calls for LAPM protocol according to ITU-T V.42 (see 9.2.5)
24:29	W0XYZ1	U_{QTS}: WXYZ from Table 2
30:39	1111111111	Ten ONEs
40:49	0101010101	Bits 10:19 repeated
50:59	001PW0XYZ1	Bits 20:29 repeated
60:69	1111111111	Ten ONEs

8.2.4 QCA2a

Signal QCA2a is a sequence of bits transmitted using V.21(L) modulation. The bits are transmitted using the signal structure defined in clause 7/V.8 *bis* and the information field structure defined in clause 8/V.8 *bis*. The analogue modem shall encode the identification field as defined in Table 5.

Table 5/V.92 – Definition of identification field in QCA2a

Bit position	Content	Definition
0:3	`1011`	Message type
4:7	`VVVV`	V.8 *bis* revision number (Note)
8:11	`WXYZ`	U_{QTS} from Table 2
12	`0`	Reserved for ITU
13	`P`	Set to 1 calls for LAPM protocol according to ITU-T V.42 (see 9.2.5)
14	`1`	QCA identifier
15	`0`	Analogue modem
NOTE – At the time of publication the V.8 *bis* revision number is 0100. The receiving modem shall ignore this field.		

8.2.5 TONEq

Signal TONEq is a 980 Hz tone.

8.3 Short Phase 1 signals and sequences for the digital modem

Signals QC1d and QCA1d are intended for use when the connection is initiated according to ITU-T V.8. Signals QC2d and QCA2d are intended for use when the connection is initiated according to ITU-T V.8 *bis*.

8.3.1 ANSpcm

Signal ANSpcm is a repetitive sequence of PCM codewords that produces a tone at approximately 2100 Hz. The sequence repeats every 301 symbols and has a phase reversal added to it every 3612 symbols. The codeword sequence may be used to verify that assumed channel characteristics are correct, and shall be transmitted at one of four transmit levels as defined in Table 6.

Table 6/V.92 – ANSpcm generation parameters

Transmit level	scl		ϑ
	μ-law	A-law	
−9.5 dBm0	1334	667	$0.25 \times \pi / 301$
−12 dBm0	1000	500	$0.25 \times \pi / 301$
−15 dBm0	708	354	$0.25 \times \pi / 301$
−18 dBm0	500	250	$0.25 \times \pi / 301$

The 301 symbol Ucode sequence may be generated using the following equation:

$$x = \lfloor scl \times \sqrt{2} \times \cos(2\pi k \times 79 / 301 + \vartheta) + 0.5 \rfloor \text{ for } k = 0, 1, 2, \ldots, 300$$

and quantizing x to a linear PCM value according to ITU-T G.711 where scl and ϑ are defined in Table 6. The resulting output shall equal the output defined in Tables 7 to Table 10 depending on the value of scl.

NOTE – Some network equipment are known to alter the characteristics of the channel in response to ANSpcm.

Table 7/V.92 – −9.5 dBm0 ANSpcm sequence

	μ	A		μ	A		μ	A		μ	A		μ	A		μ	A		μ	A
0	A1	88	43	43	6F	86	24	0F	129	AD	87	172	AD	87	215	24	0F	258	43	6C
1	58	76	44	23	09	87	B1	98	130	A9	80	173	27	0D	216	39	10	259	A2	88
2	22	08	45	B8	93	88	A7	8D	131	29	00	174	31	18	217	A3	89	260	DC	CB
3	C2	EE	46	A5	8F	89	2C	07	132	2D	07	175	A4	8F	218	C5	ED	261	22	08
4	A3	89	47	30	1B	90	2A	00	133	A6	8D	176	BA	91	219	22	08	262	D6	F0
5	38	13	48	27	0D	91	A9	83	134	B2	99	177	23	09	220	5E	4F	263	A2	88
6	25	0F	49	AC	87	92	AD	84	135	24	0F	178	46	62	221	A2	88	264	40	69
7	B0	9B	50	AA	80	93	26	0D	136	3A	11	179	A2	88	222	53	7D	265	23	0E
8	A7	82	51	29	03	94	33	1E	137	A3	89	180	E2	C0	223	22	08	266	B7	92
9	2C	06	52	2D	04	95	A4	8F	138	C7	E3	181	22	08	224	BF	EB	267	A5	8F
10	2A	01	53	A6	8D	96	BB	96	139	22	08	182	D1	FF	225	A3	8E	268	2F	1A
11	A9	83	54	B3	9E	97	22	09	140	67	45	183	A2	89	226	37	12	269	27	02
12	AE	84	55	24	0E	98	48	60	141	A2	88	184	3F	6A	227	25	0C	270	AC	86
13	26	0C	56	3C	17	99	A2	88	142	4F	79	185	23	0E	228	AF	9A	271	AA	81
14	34	1F	57	A2	89	100	EC	DE	143	22	09	186	B6	9D	229	A8	82	272	28	03
15	A4	8E	58	CA	E6	101	22	08	144	BE	95	187	A5	8C	230	2B	06	273	2E	04
16	BC	97	59	22	08	102	CE	FA	145	A3	8E	188	2F	05	231	2B	01	274	A6	8C
17	22	09	60	72	53	103	A2	89	146	36	1D	189	28	02	232	A8	83	275	B4	9F
18	4B	67	61	A2	88	104	3E	15	147	25	0C	190	AB	86	233	AE	85	276	24	0E
19	A2	88	62	4D	65	105	23	0E	148	AF	85	191	AB	81	234	26	0C	277	3D	14
20	FC	D4	63	22	09	106	B5	9C	149	A8	82	192	28	02	235	35	1C	278	A2	89
21	22	08	64	BD	94	107	A5	8C	150	2B	01	193	2E	05	236	A4	8E	279	CC	E4
22	CB	E7	65	A4	8E	108	2E	05	151	2B	06	194	A5	8C	237	BD	94	280	22	08
23	A2	89	66	34	1F	109	28	03	152	A8	82	195	B5	9C	238	22	09	281	F7	D6
24	3C	17	67	26	0C	110	AB	81	153	AF	85	196	23	0E	239	4D	65	282	A2	88
25	24	0E	68	AE	85	111	AB	86	154	25	0C	197	3E	15	240	A2	88	283	4A	66
26	B4	9F	69	A8	83	112	28	02	155	36	1D	198	A2	89	241	6F	5D	284	22	09
27	A6	8C	70	2A	01	113	2F	05	156	A3	8E	199	CE	FB	242	22	08	285	BC	97
28	2E	04	71	2B	06	114	A5	8C	157	BF	EA	200	22	08	243	C9	E1	286	A4	8E
29	28	03	72	A7	82	115	B6	9D	158	22	09	201	EA	D8	244	A2	89	287	33	1E
30	AA	81	73	AF	9A	116	23	0E	159	50	7E	202	A2	88	245	3B	16	288	26	0C
31	AC	86	74	25	0F	117	3F	6B	160	A2	88	203	48	60	246	24	0E	289	AE	84
32	27	02	75	37	12	118	A2	89	161	65	47	204	23	09	247	B3	9E	290	A9	83
33	2F	1A	76	A3	8E	119	D2	FC	162	22	08	205	BB	96	248	A6	8D	291	2A	01
34	A5	8F	77	C0	E8	120	22	08	163	C6	E3	206	A4	8F	249	2D	04	292	2C	06
35	B8	93	78	22	08	121	E0	C2	164	A3	89	207	32	19	250	29	03	293	A7	82
36	23	0E	79	55	73	122	A2	88	165	3A	11	208	26	0D	251	AA	80	294	B0	9B
37	41	69	80	A2	88	123	45	6D	166	24	0F	209	AD	84	252	AC	87	295	25	0F
38	A2	88	81	5D	49	124	23	09	167	B2	99	210	A9	80	253	27	0D	296	38	13
39	D7	F1	82	22	8	125	BA	91	168	A6	8D	211	2A	00	254	30	1B	297	A3	89
40	21	08	83	C4	EC	126	A4	8F	169	2D	07	212	2C	07	255	A5	8F	298	C2	EE
41	DB	F5	84	A3	89	127	31	18	170	29	00	213	A7	8D	256	B9	90	299	22	08
42	A2	88	85	39	10	128	27	0D	171	A9	80	214	B1	98	257	23	09	300	59	74

Table 8/V.92 – −12 dBm0 ANSpcm sequence

	μ	A		μ	A		μ	A		μ	A		μ	A		μ	A		μ	A
0	A9	83	43	4A	66	86	2B	06	129	B3	9E	172	B3	9E	215	2B	06	258	4A	66
1	5D	49	44	2A	00	87	B8	93	130	AF	85	173	2D	07	216	3F	6A	259	A9	80
2	29	00	45	BE	95	88	AD	87	131	2F	05	174	39	10	217	AA	80	260	E0	C2
3	C9	E1	46	AB	86	89	32	19	132	33	1E	175	AB	81	218	CB	E7	261	29	03
4	AA	80	47	38	13	90	2F	1A	133	AD	87	176	BF	EB	219	29	00	262	DB	F5
5	3D	15	48	2D	07	91	AE	85	134	B9	90	177	2A	00	220	64	46	263	A9	80
6	2B	06	49	B2	99	92	B4	9F	135	2B	01	178	4C	64	221	A9	83	264	48	60
7	B7	92	50	AF	9A	93	2C	07	136	3F	6B	179	A9	80	222	59	77	265	2A	01
8	AD	84	51	2E	05	94	3A	11	137	AA	80	180	E7	DA	223	29	00	266	BD	94
9	32	19	52	34	1F	95	AB	81	138	CD	E5	181	29	03	224	C7	E3	267	AB	86
10	2F	1A	53	AC	87	96	C0	E8	139	29	00	182	D8	F6	225	AA	81	268	37	12
11	AE	85	54	BA	91	97	2A	00	140	6B	59	183	A9	80	226	3D	14	269	2D	04
12	B4	9F	55	2B	01	98	4E	7A	141	A9	83	184	46	62	227	2C	06	270	B1	98
13	2C	07	56	41	69	99	A9	80	142	56	70	185	2A	01	228	B7	92	271	B0	9B
14	3A	11	57	AA	80	100	EF	DD	143	29	00	186	BC	97	229	AD	84	272	2E	05
15	AB	81	58	CE	F8	101	29	03	144	C5	ED	187	AC	86	230	31	18	273	35	1C
16	C2	EE	59	29	03	102	D4	F2	145	AA	81	188	36	1D	231	30	1B	274	AC	87
17	29	00	60	76	51	103	A9	80	146	3C	17	189	2E	04	232	AE	84	275	BB	96
18	4F	79	61	A9	83	104	44	6C	147	2C	06	190	B1	98	233	B5	9C	276	2A	01
19	A9	83	62	52	7C	105	2A	01	148	B6	9D	191	B0	9B	234	2C	06	277	43	6F
20	FD	D4	63	29	00	106	BB	96	149	AE	84	192	2E	04	235	3B	16	278	A9	80
21	29	03	64	C3	EF	107	AC	86	150	30	1B	193	36	1D	236	AA	81	279	D1	FF
22	D0	FE	65	AA	81	108	35	1C	151	31	18	194	AC	86	237	C4	EC	280	29	03
23	A9	80	66	3B	16	109	2E	04	152	AE	84	195	BC	97	238	29	00	281	F9	D6
24	42	6E	67	2C	06	110	B0	9B	153	B6	9D	196	2A	01	239	53	7D	282	A9	83
25	2B	01	68	B5	9C	111	B1	98	154	2C	06	197	45	6D	240	A9	83	283	4F	78
26	BB	96	69	AE	84	112	2D	04	155	3C	17	198	A9	80	241	72	53	284	2A	00
27	AC	87	70	30	1B	113	36	1D	156	AA	81	199	D5	F3	242	29	03	285	C2	EE
28	35	1C	71	31	18	114	AC	86	157	C5	E2	200	29	03	243	CE	FB	286	AB	81
29	2E	05	72	AD	84	115	BC	97	158	29	00	201	ED	DF	244	AA	80	287	3A	11
30	AF	9A	73	B7	92	116	2A	01	159	57	71	202	A9	80	245	41	69	288	2C	07
31	B2	99	74	2B	06	117	46	62	160	A9	83	203	4D	65	246	2B	01	289	B4	9F
32	2D	04	75	3D	14	118	A9	80	161	69	5B	204	2A	00	247	BA	91	290	AE	85
33	37	12	76	AA	81	119	D8	F6	162	29	00	205	C0	E8	248	AC	87	291	2F	1A
34	AB	86	77	C7	E3	120	29	03	163	CC	E4	206	AB	81	249	34	1F	292	32	19
35	BD	94	78	29	00	121	E6	C4	164	AA	80	207	39	10	250	2E	05	293	AD	84
36	2A	01	79	5A	74	122	A9	80	165	3F	6B	208	2C	07	251	AF	9A	294	B8	93
37	48	60	80	A9	83	123	4B	67	166	2B	01	209	B4	9F	252	B2	99	295	2B	06
38	A9	80	81	62	40	124	2A	00	167	B9	90	210	AF	85	253	2D	07	296	3E	15
39	DC	CB	82	29	00	125	BF	EA	168	AD	87	211	2F	05	254	38	13	297	AA	80
40	29	03	83	CA	E6	126	AB	86	169	33	1E	212	33	1E	255	AB	86	298	C9	E1
41	DF	CC	84	AA	80	127	39	10	170	2F	05	213	AD	87	256	BE	95	299	29	00
42	A9	80	85	3E	15	128	2D	07	171	AF	85	214	B8	93	257	2A	00	300	5E	4F

Table 9/V.92 – −15 dBm0 ANSpcm sequence

	μ	A		μ	A		μ	A		μ	A		μ	A		μ	A		μ	A
0	AF	9A	43	4F	79	86	32	19	129	BB	96	172	BB	96	215	32	19	258	50	7E
1	63	41	44	31	18	87	BF	EA	130	B8	93	173	34	1C	216	47	63	259	AF	9B
2	30	1B	45	C6	E2	88	B5	9C	131	37	12	174	3F	6B	217	B0	9B	260	E7	C5
3	CF	F8	46	B2	99	89	3B	16	132	3B	16	175	B2	99	218	D1	FF	261	2F	1A
4	B1	98	47	3E	15	90	38	13	133	B4	9F	176	C8	E0	219	2F	1A	262	E0	C2
5	45	6D	48	35	1C	91	B7	92	134	BF	EB	177	30	1B	220	69	58	263	B0	9B
6	33	1E	49	BA	91	92	BC	97	135	32	19	178	52	7C	221	AF	9A	264	4E	7B
7	BE	95	50	B8	93	93	34	1F	136	48	60	179	AF	9A	222	5F	4C	265	31	18
8	B5	9C	51	37	12	94	40	68	137	B0	9B	180	EC	DE	223	30	1B	266	C5	ED
9	3A	11	52	3C	17	95	B2	99	138	D4	F2	181	2F	1A	224	CD	E5	267	B3	9E
10	38	13	53	B4	9F	96	C9	E1	139	2F	1A	182	DD	C9	225	B1	98	268	3E	15
11	B7	92	54	C0	E8	97	30	1B	140	6F	5D	183	B0	9B	226	44	6C	269	35	1C
12	BC	97	55	32	19	98	55	73	141	AF	9A	184	4D	65	227	33	1E	270	BA	91
13	34	1F	56	49	61	99	AF	9A	142	5C	4B	185	31	18	228	BE	95	271	B9	90
14	41	69	57	B0	9B	100	F3	D3	143	30	1B	186	C4	EC	229	B6	9D	272	36	1D
15	B2	99	58	D6	F0	101	2F	1A	144	CC	E4	187	B3	9E	230	3A	11	273	3C	17
16	CA	E6	59	2F	1A	102	DB	F5	145	B1	98	188	3D	14	231	39	10	274	B4	9F
17	30	1B	60	78	56	103	B0	9B	146	43	6F	189	36	1D	232	B6	9D	275	C2	EE
18	57	76	61	AF	9A	104	4C	64	147	33	1E	190	B9	90	233	BD	94	276	31	18
19	AF	9A	62	59	77	105	31	18	148	BD	94	191	B9	90	234	33	1E	277	4B	67
20	FD	D5	63	30	1B	106	C2	EE	149	B6	9D	192	36	1D	235	42	6E	278	B0	9B
21	2F	1A	64	CB	E7	107	B3	9E	150	39	10	193	3D	14	236	B1	98	279	D9	F7
22	D8	F6	65	B1	98	108	3D	14	151	39	10	194	B3	9E	237	CB	E7	280	2F	1A
23	B0	9B	66	42	6E	109	36	1D	152	B6	9D	195	C3	EF	238	30	1B	281	FB	D7
24	4A	66	67	34	1F	110	B9	90	153	BD	94	196	31	18	239	5A	74	282	AF	9A
25	31	19	68	BC	97	111	BA	91	154	33	1E	197	4C	64	240	AF	9A	283	57	71
26	C1	E9	69	B6	9D	112	36	1D	155	43	6F	198	B0	9B	241	76	51	284	30	1B
27	B4	9F	70	39	10	113	3D	14	156	B1	98	199	DB	F5	242	2F	1A	285	CA	E6
28	3C	17	71	3A	11	114	B3	9E	157	CC	E5	200	2F	1A	243	D6	F0	286	B2	99
29	37	12	72	B5	9C	115	C4	EC	158	30	1B	201	F0	D2	244	B0	9B	287	41	69
30	B8	93	73	BE	95	116	31	18	159	5D	48	202	AF	9A	245	49	61	288	34	1F
31	BA	91	74	33	1E	117	4D	65	160	AF	9A	203	54	72	246	32	19	289	BC	97
32	35	1C	75	44	6D	118	B0	9B	161	6D	5F	204	30	1B	247	C0	E8	290	B7	92
33	3E	15	76	B1	98	119	DE	CF	162	2F	1A	205	C8	E0	248	B4	9F	291	38	13
34	B3	9E	77	CE	FA	120	2F	1A	163	D3	FD	206	B2	99	249	3C	17	292	3A	11
35	C5	ED	78	30	1B	121	EB	D9	164	B0	9B	207	3F	68	250	37	12	293	B5	9C
36	31	18	79	5F	4D	122	AF	9A	165	48	60	208	34	1F	251	B8	93	294	BE	95
37	4E	7B	80	AF	9A	123	52	7C	166	32	19	209	BB	96	252	BB	96	295	33	1E
38	B0	9B	81	68	5A	124	30	1B	167	BF	EB	210	B7	92	253	35	1C	296	46	62
39	E2	C0	82	2F	1A	125	C7	E3	168	B4	9F	211	38	13	254	3F	6A	297	B1	98
40	2F	1A	83	D0	FE	126	B2	99	169	3B	16	212	3B	16	255	B2	99	298	CF	F9
41	E6	C4	84	B1	98	127	3F	6A	170	37	12	213	B5	9C	256	C6	E2	299	30	1B
42	B0	9B	85	47	63	128	35	1C	171	B8	93	214	BF	EA	257	31	18	300	64	46

Table 10/V.92 – −18 dBm0 ANSpcm sequence

	μ	A		μ	A		μ	A		μ	A		μ	A		μ	A		μ	A
0	B8	93	43	57	71	86	3B	16	129	C2	EE	172	C2	EE	215	3B	16	258	58	76
1	69	5B	44	39	10	87	C7	E3	130	BE	95	173	3C	17	216	4E	7A	259	B9	90
2	39	10	45	CD	E5	88	BC	97	131	3E	15	174	48	60	217	B9	90	260	EC	DE
3	D7	F1	46	BB	96	89	41	69	132	42	6E	175	BA	91	218	D9	F7	261	38	13
4	B9	90	47	47	63	90	3F	6A	133	BC	97	176	CE	FA	219	39	10	262	E7	C5
5	4C	64	48	3C	17	91	BE	95	134	C8	E0	177	39	10	220	6D	5C	263	B9	90
6	3B	16	49	C1	E9	92	C3	EF	135	3A	11	178	5A	74	221	B8	93	264	56	70
7	C6	E2	50	BF	EA	93	3C	17	136	4E	7B	179	B9	90	222	65	47	265	3A	11
8	BD	94	51	3E	15	94	48	61	137	B9	90	180	EF	DD	223	39	10	266	CC	E4
9	41	69	52	43	6F	95	BA	91	138	DB	F5	181	38	13	224	D5	F3	267	BB	96
10	3F	6A	53	BC	97	96	CF	F8	139	38	10	182	E3	C1	225	BA	91	268	46	62
11	BE	95	54	C9	E1	97	39	10	140	73	53	183	B9	90	226	4C	64	269	3D	14
12	C3	EF	55	3A	11	98	5B	4A	141	B8	93	184	54	72	227	3B	16	270	C0	E8
13	3C	17	56	4F	79	99	B8	93	142	61	40	185	3A	11	228	C6	E2	271	BF	EB
14	49	61	57	B9	90	100	F6	D1	143	39	10	186	CB	E7	229	BD	94	272	3E	15
15	BA	91	58	DC	CB	101	38	13	144	D3	FD	187	BB	96	230	40	68	273	44	6C
16	D0	FE	59	38	13	102	E0	C2	145	BA	91	188	45	6D	231	3F	6B	274	BC	97
17	39	10	60	7A	57	103	B9	90	146	4B	67	189	3D	14	232	BD	94	275	CA	E6
18	5D	49	61	B8	93	104	52	7C	147	3B	16	190	C0	E8	233	C4	EC	276	3A	11
19	B8	93	62	5F	4C	105	3A	11	148	C5	ED	191	BF	EB	234	3B	16	277	51	7F
20	FE	D5	63	39	10	106	CA	E6	149	BD	94	192	3D	14	235	4A	66	278	B9	90
21	38	13	64	D1	FF	107	BB	96	150	3F	6B	193	45	6D	236	BA	91	279	DE	CF
22	DE	CE	65	BA	91	108	44	6C	151	3F	68	194	BB	96	237	D2	FC	280	38	13
23	B9	90	66	4A	66	109	3D	14	152	BD	94	195	CB	E7	238	39	10	281	FC	D4
24	50	7E	67	3B	16	110	BF	EB	153	C5	ED	196	3A	11	239	5F	4D	282	B8	93
25	3A	11	68	C4	EC	111	C0	E8	154	3B	16	197	53	7D	240	B8	93	283	5D	48
26	CA	E6	69	BD	94	112	3D	14	155	4B	67	198	B9	90	241	78	56	284	39	10
27	BC	97	70	3F	6B	113	45	6D	156	BA	91	199	E1	C3	242	38	13	285	CF	F9
28	44	6C	71	40	68	114	BB	96	157	D3	FD	200	38	13	243	DC	CB	286	BA	91
29	3E	15	72	BD	94	115	CB	E7	158	39	10	201	F5	D0	244	B9	90	287	49	61
30	BF	EA	73	C6	E2	116	3A	11	159	62	41	202	B8	93	245	4F	79	288	3C	17
31	C1	E9	74	3B	16	117	54	72	160	B8	93	203	5B	75	246	3A	11	289	C3	EF
32	3D	14	75	4C	64	118	B9	90	161	71	52	204	39	10	247	C9	E1	290	BE	95
33	46	62	76	BA	91	119	E4	C6	162	39	10	205	CF	F8	248	BC	97	291	3F	6A
34	BB	96	77	D5	F3	120	38	13	163	DA	F4	206	BA	91	249	43	6F	292	41	69
35	CC	E4	78	39	10	121	EE	DC	164	B9	90	207	48	60	250	3E	15	293	BD	94
36	39	10	79	66	44	122	B9	90	165	4E	7B	208	3C	17	251	BF	EA	294	C6	E3
37	56	70	80	B8	93	123	59	77	166	3A	11	209	C2	EF	252	C1	E9	295	3B	16
38	B9	90	81	6D	5F	124	39	10	167	C8	E0	210	BE	95	253	3C	17	296	4D	65
39	E8	DA	82	39	10	125	CE	FA	168	BC	97	211	3E	15	254	47	63	297	B9	90
40	38	13	83	D8	F6	126	BA	91	169	42	6E	212	42	6E	255	BB	96	298	D7	F1
41	EB	D9	84	B9	90	127	47	60	170	3E	15	213	BC	97	256	CD	E5	299	39	10
42	B9	90	85	4D	65	128	3C	17	171	BE	95	214	C7	E3	257	39	10	300	6A	58

8.3.2 QC1d

Signal QC1d is a sequence of bits transmitted using V.21(L) modulation. The sequence consists of 10-bit frames using V.8-type formatting as defined in Table 11. QC1d is transmitted once, and is followed immediately by CM.

Table 11/V.92 – Definition of QC1d

<table>
<tr><th>Bit position</th><th>Content</th><th colspan="2">Definition</th></tr>
<tr><td>0:9</td><td>1111111111</td><td colspan="2">Ten ONEs</td></tr>
<tr><td>10:19</td><td>0101010101</td><td colspan="2">Synchronization sequence</td></tr>
<tr><td>20</td><td>0</td><td colspan="2">Start bit</td></tr>
<tr><td>21</td><td>1</td><td colspan="2">Indication for digital modem</td></tr>
<tr><td>22</td><td>0</td><td colspan="2">Indication for QC</td></tr>
<tr><td>23</td><td>P</td><td colspan="2">Set to 1 calls for LAPM protocol according to ITU-T V.42 (see 9.2.5)</td></tr>
<tr><td rowspan="5">24:29</td><td rowspan="5">000LM1</td><td>LM</td><td>Level of ANSpcm</td></tr>
<tr><td>00</td><td>−9.5 dBm0</td></tr>
<tr><td>01</td><td>−12 dBm0</td></tr>
<tr><td>10</td><td>−15 dBm0</td></tr>
<tr><td>11</td><td>−18 dBm0</td></tr>
<tr><td>30:39</td><td>1111111111</td><td colspan="2">Ten ONEs</td></tr>
<tr><td>40:49</td><td>0101010101</td><td colspan="2">Bits 10:19 repeated</td></tr>
<tr><td>50:59</td><td>010P000LM1</td><td colspan="2">Bits 20:29 repeated</td></tr>
</table>

8.3.3 QC2d

Signal QC2d is a sequence of bits transmitted using V.21(H) modulation. The bits are transmitted using the signal structure defined in clause 7/V.8 *bis* and the information field structure defined in clause 8/V.8 *bis*. The digital modem shall encode the identification field as defined in Table 12.

Table 12/V.92 – Definition of identification field in QC2d

Bit position	Content	Definition
0:3	1011	Message type
4:7	VVVV	V.8 *bis* revision number (Note)
8:9	LM	Level of ANSpcm from Table 11
10:12	000	Reserved for the ITU
13	P	Set to 1 calls for LAPM protocol according to ITU-T V.42 (see 9.2.5)
14	0	QC identifier
15	1	Digital modem
NOTE – At the time of publication the V.8 *bis* revision number is 0100. The receiving modem shall ignore this field.		

8.3.4 QCA1d

Signal QCA1d is a sequence of bits transmitted using V.21(H) modulation. The sequence consists of 10-bit frames using V.8-type formatting as defined in Table 13. QCA1d is transmitted once.

Table 13/V.92 – Definition of QCA1d

<table>
<tr><th>Bit position</th><th>Content</th><th colspan="2">Definition</th></tr>
<tr><td>0:9</td><td>1111111111</td><td colspan="2">Ten ONEs</td></tr>
<tr><td>10:19</td><td>0101010101</td><td colspan="2">Synchronization sequence</td></tr>
<tr><td>20</td><td>0</td><td colspan="2">Start bit</td></tr>
<tr><td>21</td><td>1</td><td colspan="2">Indication for digital modem</td></tr>
<tr><td>22</td><td>1</td><td colspan="2">Indication for QCA</td></tr>
<tr><td>23</td><td>P</td><td colspan="2">Set to 1 calls for LAPM protocol according to ITU-T V.42 (see 9.2.5)</td></tr>
<tr><td rowspan="5">24:29</td><td rowspan="5">000LM1</td><td>LM</td><td>Level of ANSpcm</td></tr>
<tr><td>00</td><td>−9.5 dBm0</td></tr>
<tr><td>01</td><td>−12 dBm0</td></tr>
<tr><td>10</td><td>−15 dBm0</td></tr>
<tr><td>11</td><td>−18 dBm0</td></tr>
<tr><td>30:39</td><td>1111111111</td><td colspan="2">Ten ONEs</td></tr>
<tr><td>40:49</td><td>0101010101</td><td colspan="2">Bits 10:19 repeated</td></tr>
<tr><td>50:59</td><td>011P000LM1</td><td colspan="2">Bits 20:29 repeated</td></tr>
<tr><td>60:69</td><td>1111111111</td><td colspan="2">Ten ONEs</td></tr>
</table>

8.3.5 QCA2d

Signal QCA2d is a sequence of bits transmitted using V.21(L) modulation. The bits are transmitted using the signal structure defined in clause 7/V.8 *bis* and the information field structure defined in clause 8/V.8 *bis*. The analogue modem shall encode the identification field as defined in Table 14.

Table 14/V.92 – Definition of identification field in QCA2d

Bit position	Content	Definition
0:3	1011	Message type
4:7	VVVV	V.8 *bis* revision number (Note)
8:9	LM	Level of ANSpcm from Table 11
10:12	000	Reserved for the ITU
13	P	Set to 1 calls for LAPM protocol according to ITU-T V.42 (see 9.2.5)
14	1	QCA identifier
15	1	Digital modem
NOTE – At the time of publication the V.8 *bis* revision number is 0100. The receiving modem shall ignore this field.		

8.3.6 QTS

Signal QTS consists of 128 repetitions of the sequence {+V, +0, +V, −V, −0, −V} where V is defined to be the PCM codeword whose Ucode is U_{QTS} and 0 is the PCM codeword with Ucode 0. QTS\ consists of 8 repetitions of the sequence {−V, −0, −V, +V, +0, +V}.

The first symbol of QTS is defined to be transmitted in data frame interval 0. The digital modem shall keep data frame alignment from this point on.

8.4 Full and short Phase 2 signals and sequences

All full and short Phase 2 signals and sequences are defined in ITU-T V.90.

8.4.1 INFO information bits

The CRC generator used is described in 10.1.2.3.2/V.34.

Table 15 defines the bits in the $INFO_{0d}$ sequence. Bit 0 is transmitted first in time.

Table 15/V.92 – Definition of bits in $INFO_{0d}$

$INFO_{0d}$ bits LSB:MSB	Definition
0:3	Fill bits: 1111
4:11	Frame sync: 01110010, where the left-most bit is first in time
12	Set to 1 indicates symbol rate 2743 is supported in V.34 mode
13	Set to 1 indicates symbol rate 2800 is supported in V.34 mode
14	Set to 1 indicates symbol rate 3429 is supported in V.34 mode
15	Set to 1 indicates the ability to transmit at the low carrier frequency with a symbol rate of 3000
16	Set to 1 indicates the ability to transmit at the high carrier frequency with a symbol rate of 3000
17	Set to 1 indicates the ability to transmit at the low carrier frequency with a symbol rate of 3200
18	Set to 1 indicates the ability to transmit at the high carrier frequency with a symbol rate of 3200
19	Set to 0 indicates that transmission with a symbol rate of 3429 is disallowed
20	Set to 1 indicates the ability to reduce transmit power to a value lower than the nominal setting in V.34 mode
21:23	Maximum allowed difference in symbol rates in the transmit and receive directions in V.34 mode. With the symbol rates labelled in increasing order, where 0 represents 2400 and 5 represents 3429, an integer between 0 and 5 indicates the difference allowed in number of symbol rate steps
24	Set to 1 in an $INFO_{0d}$ sequence transmitted from a CME modem
25	Set to 1 indicates the ability to support up to 1664-point signal constellations
26	Set to 1 requests short Phase 2 to be used
27	V.92 capability: 1
28	Set to 1 to acknowledge correct reception of an $INFO_{0a}$ frame during error recovery

Table 15/V.92 – Definition of bits in $INFO_{0d}$ *(concluded)*

$INFO_{0d}$ bits LSB:MSB	Definition
29:32	Digital modem nominal transmit power for Phase 2. This is represented in −1 dBm0 steps where 0 represents −6 dBm0 and 15 represents −21 dBm0
33:37	Maximum digital modem transmit power. This is represented in −0.5 dBm0 steps where 0 represents −0.5 dBm0 and 31 represents −16 dBm0
38	Set to 1 indicates the digital modem's power shall be measured at the output of the codec. Otherwise the digital modem's power shall be measured at its terminals
39	PCM coding in use by the digital modem: 0 = μ-law, 1 = A-law
40	Set to 1 indicates ability to operate V.90 with an upstream symbol rate of 3429
41	Reserved for the ITU: This bit is set to 0 by the digital modem and not interpreted by the analogue modem
42:57	CRC
58:61	Fill bits: 1111
NOTE 1 – Bits 12, 13, 14 and 40 are used to indicate the modem's capabilities and/or configuration. The values of bits 15 to 20 depend upon regulatory requirements and apply only to the modem's transmitter. NOTE 2 – Bit 24 may be used in conjunction with the PSTN access category octet defined in ITU-T V.8 to determine the optimum parameters for the signal converters and error-control functions in the analogue and digital modem and any intervening CME.	

Table 16 defines the bits in the $INFO_{0a}$ sequence. Bit 0 is transmitted first in time.

Table 16/V.92 – Definition of bits in $INFO_{0a}$

$INFO_{0a}$ bits LSB:MSB	Definition
0:3	Fill bits: 1111
4:11	Frame sync: 01110010, where the left-most bit is first in time
12	Set to 1 indicates symbol rate 2743 is supported in V.34 mode
13	Set to 1 indicates symbol rate 2800 is supported in V.34 mode
14	Set to 1 indicates symbol rate 3429 is supported in V.34 mode
15	Set to 1 indicates the ability to transmit at the low carrier frequency with a symbol rate of 3000
16	Set to 1 indicates the ability to transmit at the high carrier frequency with a symbol rate of 3000
17	Set to 1 indicates the ability to transmit at the low carrier frequency with a symbol rate of 3200
18	Set to 1 indicates the ability to transmit at the high carrier frequency with a symbol rate of 3200
19	Set to 0 indicates that transmission with a symbol rate of 3429 is disallowed
20	Set to 1 indicates the ability to reduce transmit power to a value lower than the nominal setting in V.34 mode or in V.90 mode

Table 16/V.92 – Definition of bits in $INFO_{0a}$ *(concluded)*

$INFO_{0a}$ bits LSB:MSB	Definition
21:23	Maximum allowed difference in symbol rates in the transmit and receive directions in V.34 mode. With the symbol rates labelled in increasing order, where 0 represents 2400 and 5 represents 3429, an integer between 0 and 5 indicates the difference allowed in number of symbol rate steps
24	Set to 1 in an $INFO_{0a}$ sequence transmitted from a CME modem
25	Set to 1 indicates the ability to support up to 1664-point signal constellations
26	V.92 capability: 1
27	Set to 1 requests short Phase 2 to be used
28	Set to 1 to acknowledge correct reception of an $INFO_{0d}$ frame during error recovery
29:44	CRC
45:48	Fill bits: 1111
NOTE 1 – Bits 12 to 14 are used to indicate the modem's capabilities and/or configuration. The values of bits 15 to 20 depend upon regulatory requirements and apply only to the modem's transmitter. NOTE 2 – Bit 24 may be used in conjunction with the PSTN access category octet defined in ITU-T V.8 to determine the optimum parameters for the signal converters and error-control functions in the analogue and digital modem and any intervening CME.	

Table 17 defines the bits in the $INFO_{1d}$ sequence. Bit 0 is transmitted first in time.

Table 17/V.92 – Definition of bits in $INFO_{1d}$

$INFO_{1d}$ bits LSB:MSB	Definition
0:3	Fill bits: 1111
4:11	Frame sync: 01110010, where the left-most bit is first in time
12:14	Minimum power reduction to be implemented by the analogue modem transmitter. An integer between 0 and 7 gives the recommended power reduction in dB. These bits shall indicate 0 if $INFO_{0a}$ indicated that the analogue modem transmitter cannot reduce its power
15:17	Additional power reduction, below that indicated by bits 12:14, which can be tolerated by the digital modem receiver. An integer between 0 and 7 gives the additional power reduction in dB. These bits shall indicate 0 if $INFO_{0a}$ indicated that the analogue modem transmitter cannot reduce its power
18:24	Length of MD to be transmitted by the digital modem during Phase 3. An integer between 0 and 127 gives the length of this sequence in 35-ms increments
25	Set to 1 indicates that the high carrier frequency is to be used in transmitting from the analogue modem to the digital modem for a symbol rate of 2400

Table 17/V.92 – Definition of bits in $INFO_{1d}$ *(concluded)*

$INFO_{1d}$ bits LSB:MSB	Definition
26:29	Pre-emphasis filter to be used in transmitting from the analogue modem to the digital modem for a symbol rate of 2400. These bits form an integer between 0 and 10 which represents the pre-emphasis filter index (see Tables 3/V.34 and 4/V.34)
30:33	Projected maximum data rate for a symbol rate of 2400. These bits form an integer between 0 and 14 which gives the projected data rate as a multiple of 2400 bits/s. A 0 indicates the symbol rate cannot be used
34:42	Probing results pertaining to a final symbol rate selection of 2743 symbols per second. The coding of these 9 bits is identical to that for bits 25-33
43:51	Probing results pertaining to a final symbol rate selection of 2800 symbols per second. The coding of these 9 bits is identical to that for bits 25-33
52:60	Probing results pertaining to a final symbol rate selection of 3000 symbols per second. The coding of these 9 bits is identical to that for bits 25-33. Information in this field shall be consistent with the analogue modem capabilities indicated in $INFO_{0a}$
61:69	Probing results pertaining to a final symbol rate selection of 3200 symbols per second. The coding of these 9 bits is identical to that for bits 25-33. Information in this field shall be consistent with the analogue modem capabilities indicated in $INFO_{0a}$
70	Set to 0 indicates that the channel does not support PCM upstream
71:78	Probing results pertaining to a final symbol rate selection of 3429 symbols per second. The coding of these 8 bits is identical to that for bits 26-33. Information in this field shall be consistent with the analogue modem capabilities indicated in $INFO_{0a}$
79:88	Frequency offset of the probing tones as measured by the digital modem receiver. The frequency offset number shall be the difference between the nominal 1050 Hz line probing signal tone received and the 1050 Hz tone transmitted, f(received) – f(transmitted). A two's complement signed integer between –511 and 511 gives the measured offset in 0.02 Hz increments. Bit 88 is the sign bit of this integer. The frequency offset measurement shall be accurate to 0.25 Hz. Under conditions where this accuracy cannot be achieved, the integer shall be set to –512 indicating that this field is to be ignored
89:104	CRC
105:108	Fill bits: 1111

NOTE 1 – Projected maximum data rates greater than 12 in bits 30:33 shall only be indicated when the analogue modem supports up to 1664-point signal constellations.

NOTE 2 – The analogue modem may be able to achieve a higher downstream data signalling rate in V.90 mode if the digital modem indicates that the analogue modem may transmit at a lower power in bits 15:17.

Table 18 defines the bits in the $INFO_{1a}$ sequence that an analogue modem uses to indicate that PCM upstream operation is desired. The analogue modem shall not use this sequence if bit 70 of $INFO_{1d}$ is clear. Bit 0 is transmitted first in time.

Table 18/V.92 – Definition of bits in $INFO_{1a}$ if PCM upstream is selected

$INFO_{1a}$ bits LSB:MSB	Definition
0:3	Fill bits: 1111
4:11	Frame sync: 01110010, where the left-most bit is first in time
12:13	Number of filter sections in precoder and prefilter 0 = $p_1(i)$ and $z_2(i)$ are supported 1 = $z_1(i)$, $p_1(i)$ and $z_2(i)$ are supported 2 = $p_1(i)$, $p_2(i)$ and $z_2(i)$ are supported 3 = $z_1(i)$, $p_1(i)$, $p_2(i)$ and $z_2(i)$ are supported
14:15	Integer number indicating the maximum number of coefficients supported by analogue modem in multiples of 64 starting at 192 $L_{tot} = LZ_1 + LP_1 + LZ_2 + LP_2$ 0 = 192; 1 = 256; 2 = 320; 3 = 384
16:17	Integer number indicating the maximum number of coefficients supported by analogue modem for each filter section in multiples of 64 starting at 128 $L_{max} = \max \{LZ_1, LP_1, LZ_2, LP_2\}$ 0 = 128; 1 = 192; 2 = 256; 3 = 320
18:24	Length of MD to be transmitted by the analogue modem during Phase 3. An integer between 0 and 127 gives the length of this sequence in 276 symbol (34.5 ms) increments
25:31	U_{INFO}: Ucode of the PCM codeword to be used by the digital modem for the 2-point train. The power of this point shall not exceed the maximum digital modem transmit power. U_{INFO} shall be greater than 66
32:33	Reserved for the ITU: These bits are set to 0 by the analogue modem and are not interpreted by the digital modem
34:36	Symbol rate of 8000 to be used by the analogue modem: The integer 6
37:39	Symbol rate of 8000 to be used by the digital modem: The integer 6
40:49	Reserved for the ITU: These bits are set to 1 by the analogue modem and are not interpreted by the digital modem (Note)
50:65	CRC
66:69	Fill bits: 1111
NOTE – These bits are set to 1 to avoid generating a tone.	

Table 19 defines the bits in the $INFO_{1a}$ sequence that an analogue modem uses during short Phase 2 to indicate that V.34 upstream operation is desired. Bit 0 is transmitted first in time.

Table 19/V.92 – Definition of bits in $INFO_{1a}$ if V.34 upstream is selected during short Phase 2

$INFO_{1a}$ bits LSB:MSB	Definition
0:3	Fill bits: 1111
4:11	Frame sync: 01110010, where the left-most bit is first in time
12:17	Reserved for the ITU: These bits are set to 0 by the analogue modem and are not interpreted by the digital modem
18:24	Length of MD to be transmitted by the analogue modem during Phase 3. An integer between 0 and 127 gives the length of this sequence in 35-ms increments
25:31	U_{INFO}: Ucode of the PCM codeword to be used by the digital modem for the 2-point train. The power of this point shall not exceed the maximum digital modem transmit power. U_{INFO} shall be greater than 66
32	Reserved for the ITU: This bit is set to 0 by the analogue modem and is not interpreted by the digital modem
33	Set to 1 indicates that the high carrier frequency is to be used in transmitting from the analogue modem to the digital modem
34:36	Symbol rate to be used in transmitting from the analogue modem to the digital modem. An integer between 3 and 5 gives the symbol rate, where 3 represents 3000 and 5 represents 3429
37:39	Symbol rate of 8000 to be used by the digital modem: The integer 6
40:49	Frequency offset of the probing tones as measured by the analogue modem receiver. The frequency offset number shall be the difference between the nominal 1050 Hz line probing signal tone received and the 1050 Hz tone transmitted, f(received) – f(transmitted). A two's complement signed integer between –511 and 511 gives the measured offset in 0.02-Hz increments. Bit 49 is the sign bit of this integer. The frequency offset measurement shall be accurate to 0.25 Hz. Under conditions where this accuracy cannot be achieved, the integer shall be set to –512 indicating that this field is to be ignored
50:65	CRC
66:69	Fill bits: 1111

8.5 Phase 3 signals for the analogue modem

8.5.1 CP_t

CP_t contains modulation parameters for use by the digital modem during training. CP_t is transmitted using the same modulation as TRN_{1u}. CP_t is scrambled and differentially encoded by modulo 2 addition of the present bit with the previously transmitted bit. The differential encoder memory shall be initialized with the final symbol of the preceding TRN_{1u} and 24 differentially encoded binary ones shall be transmitted prior to transmitting the first CP_t in a series of CP_t sequences. Bit fields for CP_t sequences are defined in Table 23. Bit 0 is transmitted first.

CP_t sequences are defined to be of variable length. A constellation mask consists of 128 bits where a bit set to 1 indicates that the constellation includes the PCM code represented by the corresponding Ucode. Constellations that are identical in two or more data frame intervals only need to be included once in a CP sequence. The constellations that are sent are indexed from 0 (in bits 136:271) to a maximum of 5 (in bits 816:951). If the constellations at the digital modem's transmitter differ from those at the output to the codec's D/A converter, then bit 128 shall be set and the constellation at the output to the codec's D/A converter corresponding to each transmit constellation shall be sent. Due to the variability in the number of constellations, a parameter γ is defined to be 136 × (the maximum constellation index given in bits 103:127) and a parameter δ is defined to be $(2 \times \gamma) + 136$ if bit 128 is set and γ if bit 128 is clear.

The CRC generator used is described in 10.1.2.3.2/V.34.

When multiple CP_t sequences are transmitted as a group, they shall all contain identical information.

8.5.2 E_{1u}

E_{1u} is a data frame of scrambled, differentially encoded zeroes used to signal the end of CP_t. It is transmitted using the same modulation as CP_t.

8.5.3 MD

As defined in 10.1.3.5/V.34.

8.5.4 J_a

Sequence J_a consists of 24 binary ones followed by repetitions of the DIL descriptor detailed in Table 20. When N = 0, the DIL descriptor is 276 bits long. The modulation used for transmitting J_a is as defined for TRN_{1u}. J_a is scrambled and differentially encoded by modulo 2 addition of the present bit with the previously transmitted bit. The differential encoder memory shall be initialized with the final symbol of the preceding TRN_{1u} at the start of J_a. Transmission of sequence J_a may be terminated without completing the final DIL descriptor. J_a shall be an integer multiple of 12 bits long.

The CRC generator used is described in 10.1.2.3.2/V.34.

Table 20/V.92 – Definition of bits in the DIL descriptor

LSB:MSB	Definition
$0:187 + \beta + \lceil N/2 \rceil \times 17$	As defined in 8.3.1/V.90
$188 + \beta + \lceil N/2 \rceil \times 17$: $203 + \beta + \lceil N/2 \rceil \times 17$	Data signalling rate capability mask Bit $188 + \beta + \lceil N/2 \rceil \times 17$: 24 000; bit $189 + \beta + \lceil N/2 \rceil \times 17$: 25 333; …; bit $203 + \beta + \lceil N/2 \rceil \times 17$: 44 000. Bits set to 1 indicate data signalling rates supported and enabled in the transmitter of the analogue modem
$204 + \beta + \lceil N/2 \rceil \times 17$	Start bit: 0
$205 + \beta + \lceil N/2 \rceil \times 17$: $220 + \beta + \lceil N/2 \rceil \times 17$	Data signalling rate capability mask (continued) Bit $205 + \beta + \lceil N/2 \rceil \times 17$: 45 333; bit $206 + \beta + \lceil N/2 \rceil \times 17$: 46 666; bit $207 + \beta + \lceil N/2 \rceil \times 17$; 48 000; bits $208 + \beta + \lceil N/2 \rceil \times 17$ to $220 + \beta + \lceil N/2 \rceil \times 17$: Reserved for the ITU. (These bits are set to 0 by the analogue modem and are not interpreted by the digital modem.) Bits set to 1 indicate data signalling rates supported and enabled in the transmitter of the analogue modem
$221 + \beta + \lceil N/2 \rceil \times 17$	Start bit: 0
$222 + \beta + \lceil N/2 \rceil \times 17$: $237 + \beta + \lceil N/2 \rceil \times 17$	CRC
$238 + \beta + \lceil N/2 \rceil \times 17$	Fill bit: 0
$239 + \beta + \lceil N/2 \rceil \times 17$…	Fill bits: 0s to extend the J_a sequence length to the next multiple of 12 bits

8.5.5 R_u

Signal R_u is transmitted by repeating the 6-symbol sequence $\{+L_U, +L_U, +L_U, -L_U, -L_U, -L_U\}$. Signal $\overline{R_u}$ is transmitted by repeating the 6-symbol sequence $\{-L_U, -L_U, -L_U, +L_U, +L_U, +L_U\}$.

The analogue modem shall bypass the precoder and prefilter structure whenever transmitting signal R_u and $\overline{R_u}$. It shall use the same structure used while transmitting 2 point TRN_{1u} signal.

8.5.6 S_u

Signal S_u is transmitted by repeating the 6-symbol sequence $\{+\sqrt{(3/2)} \times L_U, 0, +\sqrt{(3/2)} \times L_U, -\sqrt{(3/2)} \times L_U, 0, -\sqrt{(3/2)} \times L_U\}$. Signal $\overline{S_u}$ is transmitted by repeating the 6-symbol sequence $\{-\sqrt{(3/2)} \times L_U, 0, -\sqrt{(3/2)} \times L_U, +\sqrt{(3/2)} \times L_U, 0, +\sqrt{(3/2)} \times L_U\}$. Signals S_u and $\overline{S_u}$ shall be an integer multiple of 12 symbols in length.

8.5.7 TRN_{1u}

Signal TRN_{1u} is a sequence of $\pm L_U$ values. The signs of TRN_{1u} are generated by applying binary ones to the input of the scrambler described in 6.3. A scrambler output of 0 represents a positive voltage; a scrambler output of 1 represents a negative voltage.

The scrambler shall be initialized to zero prior to the transmission of TRN_{1u}.

TRN_{1u} segments shall be an integer multiple of 12 symbols in length. The digital modem shall keep data frame interval alignment from the first symbol of the second TRN_{1u} signal.

8.6 Phase 3, signals for the digital modem

The digital modem shall use the polynomial, GPC, in equation 7-1/V.34 when generating signals J_d, J_p, J_p', SCR and TRN_{1d}. Signals transmitted by the digital modem during Phase 3 are not spectrally shaped.

8.6.1 DIL

As defined in 8.4.1/V.90.

8.6.2 J_d

Sequence J_d consists of a whole number of repetitions of the bit pattern given in Table 21. Bit 0 is transmitted first. The bits are scrambled and differentially encoded and then transmitted as the sign of the PCM codeword whose Ucode is U_{INFO}. A sign of 0 represents a negative voltage; a sign of 1 represents a positive voltage. The differential encoder shall be initialized with the final symbol of the transmitted TRN_{1d}.

The CRC generator used is described in 10.1.2.3.2/V.34.

Table 21/V.92 – Definition of bits in J_d

J_d bits LSB:MSB	Definition
0:16	Frame Sync: 11111111111111111
17	Start bit: 0
18:33	Data signalling rate capability mask. Bit 18:28 000; bit 19:29 333; bit 20:30 666; …; bit 33:48 000. Bits set to 1 indicate data signalling rates supported and enabled in the transmitter of the digital modem
34	Start bit: 0
35:40	Data signalling rate capability mask (continued). Bit 35:49 333; bit 36:50 666; …; bit 39:54 666; bit 40:56 000. Bits set to 1 indicate data signalling rates supported and enabled in the transmitter of the digital modem
41:46	Reserved for the ITU: These bits are set to 0 by the digital modem and are not interpreted by the analogue modem
47	J_d/J_p identifier: 0 = J_d, 1 = J_p
48	Reserved for the ITU: This bit is set to 0 by the digital modem and is not interpreted by the analogue modem
49:50	A number between 1 and 3 indicating the digital modem's maximum look-ahead for spectral shaping
51	Start bit: 0
52:67	CRC
68:71	Fill bits: 0000

8.6.3 J_p

Sequence J_p consists of a whole number of repetitions of the bit pattern given in Table 22. Bit 0 is transmitted first. The bits are scrambled and differentially encoded and then transmitted as the sign of the PCM codeword whose Ucode is U_{INFO}. A sign of 0 represents a negative voltage, a sign of 1 represents a positive voltage. The differential encoder shall be initialized with the final symbol of the transmitted J_d.

The digital modem is not capable of changing the sampling phase of the central office A/D. Hence, it shall use signal J_p to indicate its desire to the analogue modem to adjust its transmitter phase from [0, 1) symbol or [0, T) seconds.

The CRC generator used is described in 10.1.2.3.2/V.34.

Table 22/V.92 – Definition of bits in J_p

J_p bits LSB:MSB	Definition
0:16	Frame Sync: 11111111111111111
17	Start bit: 0
18:33	Fractional amount that signal $\overline{S_u}$ corresponding to signal J_p to J_p' transition needs to be extended. 16-bit unsigned integer covering the range [0, 1) symbol or [0, T) seconds
34	Start bit: 0
35:46	Reserved for the ITU: These bits are set to 0 by the digital modem and are not interpreted by the analogue modem
47	J_d/J_p identifier: 0 = J_d, 1 = J_p
48	Size of constellation used to transmit CP_u, E_{2u}, SUV_u and TRN_{2u} during training sequences: 0 = 4-point constellation; 1 = 8-point constellation
49	Size of constellation used to transmit CP_u, E_{2u}, SUV_u and TRN_{2u} during rate renegotiation procedures: 0 = 4-point constellation; 1 = 8-point constellation
50	Reserved for the ITU: This bit is set to 0 by the digital modem and is not interpreted by the analogue modem
51	Start bit: 0
52:67	CRC
68:71	Fill bits: 0000

8.6.4 J_p'

J_p' is used to terminate J_p. J_p' consists of 12 binary zeroes. The bits are scrambled and differentially encoded and then transmitted as the sign of the PCM codeword whose Ucode is U_{INFO}. A sign of 0 represents a negative voltage, a sign of 1 represents a positive voltage. The differential encoder shall be initialized with the final symbol of the transmitted J_p.

8.6.5 R_i

As defined in 8.6.4/V.90.

8.6.6 SCR

SCR is a sequence of the PCM codeword whose Ucode is U_{INFO} with signs generated by applying binary ones to the input of the scrambler. The scrambler does not need to be initialized at the beginning of SCR. A sign of 0 represents a negative voltage; a sign of 1 represents a positive voltage. SCR shall be an integer multiple of 6 symbols long.

8.6.7 S_d

As defined in 8.4.4/V.90.

8.6.8 TRN_{1d}

As defined in 8.4.5/V.90.

8.7 Phase 4, Rate Renegotiation and Fast Parameter Exchange signals for the analogue modem

8.7.1 $B1_u$

$B1_u$ is 48 data frames of scrambled binary ones transmitted using the data mode constellation parameters from the preceding CP_d. The first transmitter output symbol in the first data frame corresponds to n = 0 in the prefilter and precoder filter output equations in 6.4.2. A data frame in the upstream direction is 12 symbols long. The first symbol of $B1_u$ shall begin data frame interval 0. The scrambler, modulus encoder, convolutional encoder, precoder and prefilter memories are initialized to zero prior to transmitting $B1_u$.

8.7.2 E_{2u}

E_{2u} is a data frame of scrambled, differentially encoded zeroes. It is transmitted using the corresponding TRN_{2u} modulation during Training and Rate Renegotiation. During Fast Parameter Exchange it is transmitted using the preceding data mode modulation. E_{2u} shall be extended by a single symbol if bit 29 of CP_d is set.

8.7.3 CP_u

There are 2 types of CP_u sequences: a long one and a short one.

The long CP_u sequence contains modulation parameters for use by the digital modem in data mode. The long CP_u sequence is transmitted using the corresponding TRN_{2u} modulation during training and rate renegotiation procedures and it is transmitted using the same modulation parameters as data mode during fast parameter exchange procedures. For training and rate renegotiation, the differential encoder is initialized using the last transmitted sign bit of the preceding sequence. A CP_u with the acknowledge bit set is denoted CP_u'. Bit fields for CP_u sequences are defined in Table 23. Bit 0 is transmitted first.

Table 23/V.92 – Definition of bits in CP_u and CP_t

CP_u and CP_t bits LSB:MSB	Definition
0:16	Frame Sync: 11111111111111111
17	Start bit: 0
18	CP: 0
19:20	Type: CP_t denoted by 0; CP_u denoted by 1
21:25	Selected digital modem to analogue modem data signalling rate, an integer, drn, between 0 and 22. drn = 0 indicates cleardown. Data signalling rate = (drn + 20) × 8000/6 in CP_u and (drn + 8) × 8000/6 in CP_t
26:30	Reserved for the ITU: These bits are set to 0 by the analogue modem and are not interpreted by the digital modem
31:32	S_r: The number of sign bits used as redundancy for spectral shaping
33	Acknowledge bit: 0 = modem has not received CP_d from the digital modem, 1 = received CP_d from the digital modem
34	Start bit: 0

Table 23/V.92 – Definition of bits in CP_u and CP_t *(continued)*

CP_u and CP_t bits LSB:MSB	Definition
35	Codec type: 0 = μ-law; 1 = A-law
36:48	Reserved for the ITU: These bits are set to 0 by the analogue modem and are not interpreted by the digital modem
49:50	ld: Number of look-ahead frames requested during spectral shaping. This shall be consistent with the capabilities of the digital modem indicated in J_d
51	Start bit: 0
52:67	The RMS value of TRN_{1d} at the transmitter output divided by the RMS value of TRN_{1d} at the output to the codec's D/A converter expressed in unsigned Q3.13 format (xxx.xxxxxxxxxxxxx)
68	Start bit: 0
69:76	Parameter a_1 of the spectral shaping filter in signed Q1.6 format (sx.xxxxxx)
77:84	Parameter a_2 of the spectral shaping filter in signed Q1.6 format (sx.xxxxxx)
85	Start bit: 0
86:93	Parameter b_1 of the spectral shaping filter in signed Q1.6 format (sx.xxxxxx)
94:101	Parameter b_2 of the spectral shaping filter in signed Q1.6 format (sx.xxxxxx)
102	Start bit: 0
103:106	An integer between 0 and 5 denoting the index of the constellation to be used in data frame interval 0
107:110	An integer between 0 and 5 denoting the index of the constellation to be used in data frame interval 1
111:114	An integer between 0 and 5 denoting the index of the constellation to be used in data frame interval 2
115:118	An integer between 0 and 5 denoting the index of the constellation to be used in data frame interval 3
119	Start bit: 0
120:123	An integer between 0 and 5 denoting the index of the constellation to be used in data frame interval 4
124:127	An integer between 0 and 5 denoting the index of the constellation to be used in data frame interval 5
128	Set to 1 if the constellations at the transmitter differ from those at the output to the codec's D/A converter
129:135	Reserved for ITU: These bits are set to 0 by the analogue modem and are not interpreted by the digital modem
136	Start bit: 0
137:152	Constellation mask for $Uchord_1$ (bit 137 corresponds to Ucode 0)
153	Start bit: 0
154:169	Constellation mask for $Uchord_2$ (bit 154 corresponds to Ucode 16)

Table 23/V.92 – Definition of bits in CP_u and CP_t *(concluded)*

CP_u and CP_t bits LSB:MSB	Definition
170	Start bit: 0
171:186	Constellation mask for $Uchord_3$ (bit 171 corresponds to Ucode 32)
187	Start bit: 0
188:203	Constellation mask for $Uchord_4$ (bit 188 corresponds to Ucode 48)
204	Start bit: 0
205:220	Constellation mask for $Uchord_5$ (bit 205 corresponds to Ucode 64)
221	Start bit: 0
222:237	Constellation mask for $Uchord_6$ (bit 222 corresponds to Ucode 80)
238	Start bit: 0
239:254	Constellation mask for $Uchord_7$ (bit 239 corresponds to Ucode 96)
255	Start bit: 0
256:271	Constellation mask for $Uchord_8$ (bit 256 corresponds to Ucode 112)
$272:271 + \gamma$	Possibly more constellations in same format as bits 136:271
$272 + \gamma:271 + \delta$	Corresponding codec constellations in same format as bits 136:271
$272 + \delta$	Start bit: 0
$273 + \delta:288 + \delta$	CRC
$289 + \delta$	Fill bit: 0
$289 + \delta:\ldots$	Fill bits: 0s to extend the CP sequence length to the next multiple of 12 symbols

The long CP_u sequences are defined to be of variable length. A constellation mask consists of 128 bits where a bit set to 1 indicates that the constellation includes the PCM code represented by the corresponding Ucode. Constellations that are identical in two or more data frame intervals only need to be included once in a CP sequence. The constellations that are sent are indexed from 0 (in bits 136:271) to a maximum of 5 (in bits 816:951). If the constellations at the digital modem's transmitter differ from those at the output to the codec's D/A converter, then bit 128 shall be set and the constellation at the output to the codec's D/A converter corresponding to each transmit constellation shall be sent. Due to the variability in the number of constellations, a parameter γ is defined to be 136×(the maximum constellation index given in bits 103:127) and a parameter δ is defined to be $(2 \times \gamma) + 136$ if bit 128 is set and γ if bit 128 is clear.

CP_{us} denotes a short CP_u sequence used in rate renegotiation and fast parameter exchange procedures when the digital modem's modulation parameters are not changed. CP_{us} is transmitted using the same modulation parameters as TRN_{2u} during rate renegotiation procedures and it is transmitted using the same modulation as data mode during fast parameter exchange procedures. For rate renegotiation, the differential encoder is initialized using the last transmitted sign bit of the preceding sequence. Bit fields for CP_{us} sequences are defined in Table 24. Bit 0 is transmitted first.

The CRC generator used is described in 10.1.2.3.2/V.34.

When multiple CP_u and CP_u' sequences are transmitted as a group, they shall all contain identical information.

Table 24/V.92 – Definition of bits in CP_{us}

CP_{us} bits LSB:MSB	Definition
0:16	Frame Sync: 11111111111111111
17	Start bit: 0
18	CP: 0
19:20	CP_{us}: 2
21:25	Selected digital modem to analogue modem data signalling rate, an integer, drn, between 0 and 22. drn = 0 indicates cleardown. Data signalling rate = (drn + 20)*8000/6
26:32	Reserved for the ITU: These bits are set to 0 by the analogue modem and are not interpreted by the digital modem
33	Acknowledge bit: 0 = modem has not received CP_d from the digital modem, 1 = received CP_d from the digital modem
34	Start bit: 0
35:50	CRC
51	Fill bit: 0
52:…	Fill bits: 0s to extend the CP_{us} sequence length to the next multiple of 12 symbols

8.7.4 R_M

R_M is transmitted by repeating the 12-symbol pattern as defined in Table 25.

Table 25/V.92 – Symbol pattern for signal R_M

Data Frame Interval, i	Modulus Encoder output K_i
0	$K_0 = M_0 - 1$
1	$K_1 = M_1 - 1$
2	$K_2 = 0$
3	$K_3 = 0$
4	$K_4 = M_4 - 1$
5	$K_5 = M_5 - 1$
6	$K_6 = 0$
7	$K_7 = 0$
8	$K_8 = M_8 - 1$
9	$K_9 = M_9 - 1$
10	$K_{10} = 0$
11	$u_{11} = 0$

$R_M{}'$ is transmitted by repeating the 12-symbol pattern as defined in Table 26.

Table 26/V.92 – Symbol pattern for signal R_M'

Data Frame Interval, i	Modulus Encoder output K_i
0	$K_0 = 0$
1	$K_1 = 0$
2	$K_2 = M_2 – 1$
3	$K_3 = M_3 – 1$
4	$K_4 = 0$
5	$K_5 = 0$
6	$K_6 = M_6 – 1$
7	$K_7 = M_7 – 1$
8	$K_8 = 0$
9	$K_9 = 0$
10	$K_{10} = M_{10} – 1$
11	$k_{11} = M_{11} – 1$

Sequences R_M and R_M' are transmitted using the constellation parameters used for the data mode. The analogue modem shall use the same precoder and prefilter structure used in the latest data mode. Sequences R_M and R_M' shall be trellis encoded.

8.7.5 SUV_u

SUV_u is a short information sequence. SUV_u is scrambled and transmitted using the corresponding TRN_{2u} modulation during Training and Rate Renegotiation. During Fast Parameter Exchange it is transmitted using preceding data mode modulation. The differential encoder is initialized using the last transmitted sign bit of the preceding sequence. An SUV_u with the acknowledge bit set is denoted SUV_u'. Bit fields for SUV_u sequences are defined in Table 27. Bit 0 is transmitted first.

The CRC generator used is described in 10.1.2.3.2/V.34.

When multiple SUV_u and SUV_u' sequences are transmitted as a group, they shall all contain identical information.

Table 27/V.92 – Definition of bits in SUV_u

SUV_u bits LSB:MSB	Definition
0:16	Frame Sync: 11111111111111111
17	Start bit: 0
18	SUVu: 1
19:25	Reserved for the ITU: These bits are set to 0 by the analogue modem and are not interpreted by the digital modem
26	Set to 1 indicates that the analogue modem wishes the digital modem to wait for a CP_u before sending a CP_d. The digital modem is not required to comply with this request

Table 27/V.92 – Definition of bits in SUV_u *(concluded)*

SUV_u bits LSB:MSB	Definition
27:31	20 × log10(L) where L is the measured RMS level of the prefilter output multiplied by G . This result is expressed in signed Q2.2 format (sxx.xx). The value 16 (−4.00) indicates that no measurement has been taken
32	Set to 1 indicates that a silent period is requested. This may be used during rate renegotiation (see 9.8.2.1)
33	Acknowledge bit: 0 = modem has not received CP_d from the digital modem, 1 = received CP_d from the digital modem
34	Start bit: 0
35:50	CRC
51	Fill bit: 0
52:…	Fill bits: 0s to extend the SUV_u sequence length to the next multiple of 12 symbols

8.7.6 TRN_{2u}

TRN_{2u} is a 4- or 8-point constellation signal as requested by the digital modem via J_p bits 48 and 49.

TRN_{2u} consists of scrambled binary ones. The mapping of the scrambler output to symbols shall be done according to the rules defined in Tables 28 and 29. The scrambler shall be reset at the beginning of TRN_{2u}. The sign bit of TRN_{2u} is differentially encoded by modulo 2 addition of the present sign bit with the previously transmitted sign bit. The differential encoder memory shall be initialized with the last transmitted sign bit of the preceding E_{1u} sequence. TRN_{2u} shall be an integer multiple of 12 symbols in length. TRN_{2u} maybe used to estimate the analogue channel for upstream.

Table 28/V.92 – Mapping of bits to symbols for 4-point TRN_{2u}

MSB:LSB	Linear value
00	$(1/\sqrt{5}) \times L_U$
01	$(3/\sqrt{5}) \times L_U$
10	$-(1/\sqrt{5}) \times L_U$
11	$-(3/\sqrt{5}) \times L_U$

Table 29/V.92 – Mapping of bits to symbols for 8-point TRN_{2u}

MSB:LSB	Linear value
000	$(1/\sqrt{21}) \times LU$
001	$(3/\sqrt{21}) \times LU$
010	$(5/\sqrt{21}) \times LU$
011	$(7/\sqrt{21}) \times LU$
100	$-(1/\sqrt{21}) \times LU$
101	$-(3/\sqrt{21}) \times LU$
110	$-(5/\sqrt{21}) \times LU$
111	$-(7/\sqrt{21}) \times LU$

8.7.7 $FB1_u$

$FB1_u$ is 48 data frames of scrambled, differentially encoded binary ones. It is transmitted using the preceding data mode modulation.

8.8 Phase 4, Rate Renegotiation and Fast Parameter Exchange signals for the digital modem

8.8.1 $B1_d$

As defined in 8.6.1/V.90.

8.8.2 E_d

E_d consists of 2 data frames of scrambled binary zeros. It is transmitted using corresponding TRN_{2d} modulation during Training and Rate Renegotiation. During Fast Parameter Exchange it is transmitted using the preceding data mode modulation.

8.8.3 CP_d

CP_d contains modulation parameters for use by the analogue modem in data mode. There are four parts to a CP_d sequence. The first part, occupying bits 0 to 50, is always sent. The other three parts are optional and their presence is indicated by bits 19 to 21. These parts contain the modulus encoder parameters, the prefilter and precoder coefficients and the constellation sets respectively. All the bits contained in a part are removed from the CP_d sequence when it is indicated that the part is not present. All CP_d sequences end with a CRC field followed by at least one fill bit. CP_d is scrambled and transmitted using the corresponding TRN_{2d} modulation during Training and Rate Renegotiation. During Fast Parameter Exchange it is transmitted using the preceding data mode modulation. For training and rate renegotiation, the differential encoder is initialized using the last transmitted sign bit of the preceding sequence. A CP_d with the acknowledge bit set is denoted CP_d'. Bit fields for CP_d sequences are defined in Table 30. Bit 0 is transmitted first.

The bit positions given in Table 30 assume that all parts of CP_d are present. The precoder and prefilter coefficients and the constellation sets in the CP_d sequences are defined to be of variable length. Due to this variability a parameter α is defined to be $17 \times (LZ_1 + LP_1 + LZ_2 + LP_2)$ and a parameter β is defined to be $17 \times (LC_1 + LC_2 + LC_3 + LC_4 + LC_5 + LC_6)$. The bit positions of the actual CP_d that is transmitted will depend on which parts are present. The modulus encoder parameters, if present, are transmitted using 6 words. The precoder and prefilter coefficients, if present, are transmitted using $4 + LZ_1 + LP_1 + LZ_2 + LP_2$ words, where $LZ_1 + LP_1 + LZ_2 + LP_2$

shall not exceed L_{tot} given in bits 14:15 of $INFO_{1a}$. The constellation sets, if present, are transmitted using 5 + LC_1 + LC_2 + LC_3 + LC_4 + LC_5 + LC_6 words. Constellations shall not contain the zero point. All of the constellation sets with non-zero size shall be listed first. The number of points in a constellation set shall not exceed 128.

The digital modem shall design the modulation parameters assuming that, when the prefilter output multiplied by G has a mean-square value of 1, the analogue modem will transmit at the desired power.

The CRC generator used is described in 10.1.2.3.2/V.34.

When multiple CP_d and CP_d' sequences are transmitted as a group, they shall all contain identical information.

NOTE – The digital modem should design the precoder coefficients under the assumption that the analogue modem minimizes the power at the precoder output on a symbol-by-symbol basis.

Table 30/V.92 – Definition of bits in CP_d

CP_d bits LSB:MSB	Definition
0:16	Frame Sync: 11111111111111111
17	Start bit: 0
18	CP_d: 0
19	Set to 1 indicates modulus encoder parameters are present
20	Set to 1 indicates prefilter and precoder coefficients are present
21	Set to 1 indicates constellation sets are present
22:26	Selected analogue modem to digital modem data signalling rate, an integer, drn, between 0 and 19. drn = 0 shall indicate cleardown. Data signalling rate = (drn + 17) × 8000/6
27:28	Trellis encoder select bits in analogue modem to digital modem direction: 0 = 16 state, 1 = 32 state, 2 = 64 state, 3 = Reserved for the ITU. The digital modem receiver requires the analogue modem transmitter to use the selected trellis encoder
29	Extend the length of the E_{2u} sequence: 0 = don't extend; 1 = extend by 1 symbol. This bit shall be set to zero during rate renegotiation and fast parameter exchange procedures
30:32	Reserved for the ITU: These bits are set to 0 by the digital modem and are not interpreted by the analogue modem
33	Acknowledge bit: 0 = modem has not received CP_u from the analogue modem, 1 = received CP_u from the analogue modem
34	Start bit: 0
35:50	4 × G > 0 : Four times the gain used at the output of the prefilter in unsigned Q0.16 format (.xxxxxxxxxxxxxxxx)
	Modulus encoder parameters
51	Start bit: 0
52:59	Modulus encoder parameter M_0
60:67	Modulus encoder parameter M_1

Table 30/V.92 – Definition of bits in CP_d *(continued)*

CP_d bits LSB:MSB	Definition
68	Start bit: 0
69:76	Modulus encoder parameter M_2
77:84	Modulus encoder parameter M_3
85	Start bit: 0
86:93	Modulus encoder parameter M_4
94:101	Modulus encoder parameter M_5
102	Start bit: 0
103:110	Modulus encoder parameter M_6
111:118	Modulus encoder parameter M_7
119	Start bit: 0
120:127	Modulus encoder parameter M_8
128:135	Modulus encoder parameter M_9
136	Start bit: 0
137:144	Modulus encoder parameter M_{10}
145:152	Modulus encoder parameter M_{11}
	Precoder and prefilter coefficients
153	Start bit: 0
154:162	LZ_1: Number of taps for feed-forward section of precoder. Up to L_{max} given in bits 16:17 of $INFO_{1a}$
163:169	Reserved for ITU: These bits are set to 0 by the digital modem and are not interpreted by the analogue modem
170	Start bit: 0
171:179	LP_1: Number of taps for feedback section of precoder. Up to L_{max} given in bits 16:17 of $INFO_{1a}$
180:186	Reserved for ITU: These bits are set to 0 by the digital modem and are not interpreted by the analogue modem
187	Start bit: 0
188:196	LZ_2: Number of taps for feed-forward section of prefilter. Up to L_{max} given in bits 16:17 of $INFO_{1a}$
197:203	Reserved for ITU: These bits are set to 0 by the digital modem and are not interpreted by the analogue modem
204	Start bit: 0
205:213	LP_2: Number of taps for feedback section of prefilter. Up to L_{max} given in bits 16:17 of $INFO_{1a}$
214:220	Reserved for ITU: These bits are set to 0 by the digital modem and are not interpreted by the analogue modem
221	Start bit: 0

Table 30/V.92 – Definition of bits in CP_d *(continued)*

CP_d bits LSB:MSB	Definition
222:237	1st precoder feed-forward filter coefficient in signed Q0.15 (s.xxxxxxxxxxxxxxx), $z_1(1)$ (if $LZ_1 > 0$)
...	Remaining precoder feed-forward filter coefficients, $z_1(2) : z_1(LZ_1)$
$221 + 17 \times LZ1$	Start bit: 0
$222 + 17 \times LZ1$: $237 + 17 \times LZ1$	1st precoder feedback filter coefficient in signed Q1.14 (sx.xxxxxxxxxxxxxx), $p_1(1)$
...	Remaining precoder feedback filter coefficients, $p_1(2) : p_1(LP_1)$
$221 + 17 \times (LZ1 + LP1)$	Start bit: 0
...	Prefilter feed-forward filter coefficients in signed Q0.15 (s.xxxxxxxxxxxxxxx), $z_2(0) : z_2(LZ_2 - 1)$
$221 + 17 \times (LZ1 + LP1 + LZ2)$	Start bit: 0
…	Prefilter feedback filter coefficients in signed Q1.14 (sx.xxxxxxxxxxxxxx), $p_2(1) : p_2(LP_2)$ (if $LP_2 > 0$)
	Constellation sets
$221 + \alpha$	Start bit: 0
$222 + \alpha$: $225 + \alpha$	An integer between 0 and 5 denoting the index of the constellation to be used in data frame intervals 0 and 6
$226 + \alpha$: $229 + \alpha$	An integer between 0 and 5 denoting the index of the constellation to be used in data frame intervals 1 and 7
$230 + \alpha$: $233 + \alpha$	An integer between 0 and 5 denoting the index of the constellation to be used in data frame intervals 2 and 8
$234 + \alpha$: $237 + \alpha$	An integer between 0 and 5 denoting the index of the constellation to be used in data frame intervals 3 and 9
$238 + \alpha$	Start bit: 0
$239 + \alpha$: $242 + \alpha$	An integer between 0 and 5 denoting the index of the constellation to be used in data frame intervals 4 and 10
$243 + \alpha$: $246 + \alpha$	An integer between 0 and 5 denoting the index of the constellation to be used in data frame intervals 5 and 11
$247 + \alpha$: $254 + \alpha$	Reserved for the ITU: These bits are set to 0 by the digital modem and are not interpreted by the analogue modem
$255 + \alpha$	Start bit: 0
$256 + \alpha$: $263 + \alpha$	Number of positive points in the 1st constellation set, LC_1.
$264 + \alpha$: $271 + \alpha$	Number of positive points in the 2nd constellation set, LC_2 (possibly zero)
$272 + \alpha$	Start bit: 0
$273 + \alpha$: $280 + \alpha$	Number of positive points in the 3rd constellation set, LC_3 (possibly zero)
$281 + \alpha$: $288 + \alpha$	Number of positive points in the 4th constellation set, LC_4 (possibly zero)

Table 30/V.92 – Definition of bits in CP_d *(concluded)*

CP_d bits LSB:MSB	Definition
$289 + \alpha$	Start bit: 0
$290 + \alpha$: $297 + \alpha$	Number of positive points in the 5th constellation set, LC_5 (possibly zero)
$298 + \alpha$: $305 + \alpha$	Number of positive points in the 6th constellation set, LC_6 (possibly zero)
$306 + \alpha$	Start bit: 0
$307 + \alpha$: $322 + \alpha$	Linear value of 1st (smallest magnitude) constellation point in the 1st constellation set
$323 + \alpha$	Start bit: 0
…	…
	Linear value of last (largest magnitude) constellation point in the 1st constellation set
$306 + \alpha + 17 \times LC1$	Start bit: 0
	Possibly more constellations in same format (for any non-zero size constellation set).
	End of CP_d sequence
$306 + \alpha + \beta$	Start bit: 0
$307 + \alpha + \beta$: $322 + \alpha + \beta$	CRC
$323 + \alpha + \beta$	Fill bit: 0
$324 + \alpha + \beta$: …	Fill bits: 0s to extend the CP_d sequence length to the next multiple of 6 symbols

8.8.4 R

R_d and R_t are defined in 8.6.4/V.90.

R_f is transmitted by 0 repeating the 12-symbol sequence containing the PCM codewords with the sign pattern + + − − + + − − + + − − where the left-most sign is transmitted first. $\overline{R_f}$ consists of 2 repetitions of the 12-symbol sequence containing the same PCM codewords with the sign pattern − − + + − − + + − − + + where the left-most sign is transmitted first. The PCM codewords used are the highest power PCM codeword from the data mode constellation of each data frame interval as passed in CP_u.

8.8.5 SUV_d

SUV_d is a short information sequence. SUV_d is scrambled and transmitted using the corresponding TRN_{2d} modulation during Training and Rate Renegotiation. During Fast Parameter Exchange it is transmitted using the preceding data mode modulation. The differential encoder is initialized using the last transmitted sign bit of the preceding sequence. An SUV_d with the acknowledge bit set is denoted SUV_d'. Bit fields for SUV_d sequences are defined in Table 31. Bit 0 is transmitted first.

The CRC generator used is described in 10.1.2.3.2/V.34.

When multiple SUV_d and SUV_d' sequences are transmitted as a group, they shall all contain identical information.

Table 31/V.92 – Definition of bits in SUV_d

SUV_d bits LSB:MSB	Definition
0:16	Frame Sync: 11111111111111111
17	Start bit: 0
18	SUV_d: 1
19:31	Reserved for the ITU: These bits are set to 0 by the analogue modem and are not interpreted by the digital modem
32	Set to 1 indicates that a silent period is requested. This may be used during rate renegotiation (see 9.8.1.1)
33	Acknowledge bit: 0 = modem has not received CP_u from the analogue modem, 1 = received CP_u from the analogue modem
34	Start bit: 0
35:50	CRC
51	Fill bit: 0
52:…	Fill bits: 0s to extend the SUV_d sequence length to the next multiple of 6 symbols

8.8.6 TRN_{2d}

As defined in 8.6.5/V.90.

8.9 Modem-on-hold

8.9.1 RT

Tone RT is either Tone A or Tone B as defined in 8.2/V.90. If the modem transmits Tone A during retrain procedures the modem shall transmit RT as Tone A and detect Tone B during modem-on-hold procedures. If the modem transmits Tone B during retrain procedures the modem shall transmit RT as Tone B and detect Tone A during modem-on-hold procedures.

8.9.2 MH sequences

MH sequences are used to exchange information during modem-on-hold procedures. They use the same modulation as Phase 2 INFO sequences as defined in 8.2.3.1/V.90. The CRC generator used is described in 10.1.2.3.2/V.34.

Table 32 defines the bits in the MH sequences. Bit 0 is transmitted first in time.

Table 32/V.92 – Definition of bits in MH sequences

<table>
<tr><th>MH bits LSB:MSB</th><th></th></tr>
<tr><td>0:3</td><td>Fill bits: 1111</td></tr>
<tr><td>4:11</td><td>Frame sync: 01110010, where the left-most bit is first in time</td></tr>
<tr><td>12:15</td><td>Signal indication bits:
0011 MHreq Request remote modem to go on-hold
0101 MHack Indicate agreement to go on hold and timeout
0111 MHnack Deny on-hold, request cleardown or fast reconnect
1001 MHclrd Request cleardown
1011 MHcda Acknowledge cleardown
1101 MHfrr Request fast reconnect</td></tr>
<tr><td>16:19</td><td>Information bits:
For signals MHreq, MHnack, MHcda and MHfrr repeat signal indication bits
For MHack:
16:19 T1 – Timeout period for on-hold
For MHclrd:
16:19 0101 Cleardown due to incoming call
0110 Cleardown due to outgoing call
1010 Cleardown due to other reason</td></tr>
<tr><td>20:35</td><td>CRC</td></tr>
<tr><td>36:39</td><td>Fill bits: 1111</td></tr>
<tr><td colspan="2">NOTE 1 – Bit combinations not defined in bits 12-15 are reserved for the ITU. MH sequences with undefined bit combinations should be ignored.
NOTE 2 – Bit combinations not defined in bits 16-19 for MHclrd are reserved for the ITU and should not be interpreted by the receiving modem.</td></tr>
</table>

The encoding of timeout period T1 is defined in Table 33.

Table 33/V.92 – Encoding of timeout period T1

Bits 16:19	T1
0000	Reserved for the ITU
0001	10 s
0010	20 s
0011	30 s
0100	40 s
0101	1 min
0110	2 min
0111	3 min
1000	4 min
1001	6 min
1010	8 min

Table 33/V.92 – Encoding of timeout period T1 *(concluded)*

Bits 16:19	T1
1011	12 min
1100	16 min
1101	no limit
1110	Reserved for the ITU
1111	Reserved for the ITU

9 Operating procedures

The start-up procedure carried out after establishing a dialled connection between the two modems consists of four distinct phases:

– Phase 1, network interaction;

– Phase 2, channel probing and ranging;

– Phase 3, equalizer and echo canceller training and digital impairment learning;

– Phase 4, final training.

Both Phase 1 and Phase 2 have a full and a short procedure.

9.1 Full Phase 1 – Network interaction

The operating procedures for full Phase 1 are identical to those for Phase 1 of ITU-T V.90.

NOTE – There is no means in V.8 to exclusively indicate that a modem can do V.92 so that decision must wait.

9.2 Short Phase 1 – Network interaction

The operating procedures for short Phase 1 are given below and are illustrated in Figures 3 to 8.

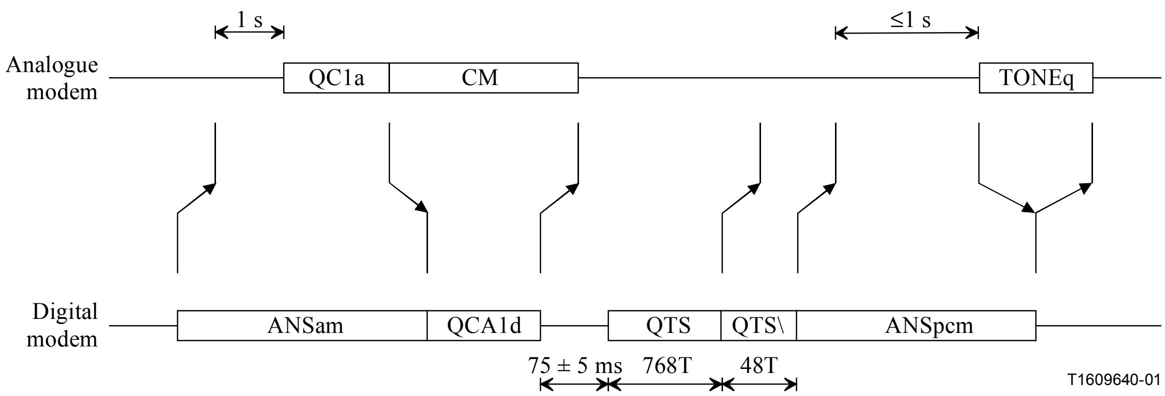

Figure 3/V.92 – Short Phase 1 when calling modem is analogue modem and answering modem transmits ANSam

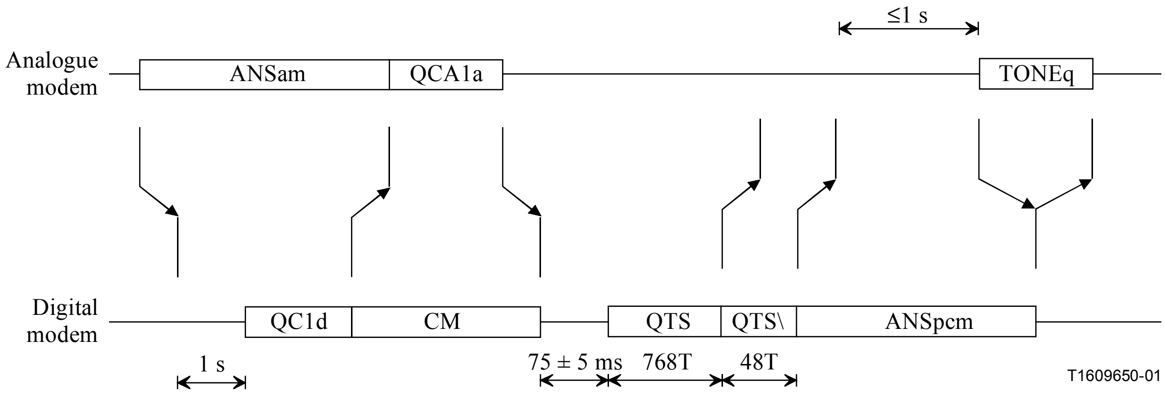

Figure 4/V.92 – Short Phase 1 when calling modem is digital modem and answering modem transmits ANSam

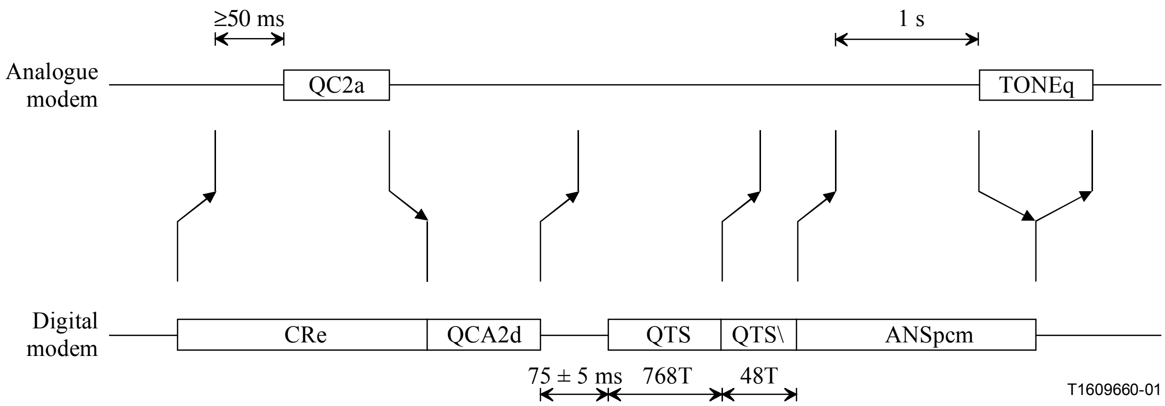

Figure 5/V.92 – Short Phase 1 when calling modem is analogue modem and answering modem transmits CRe

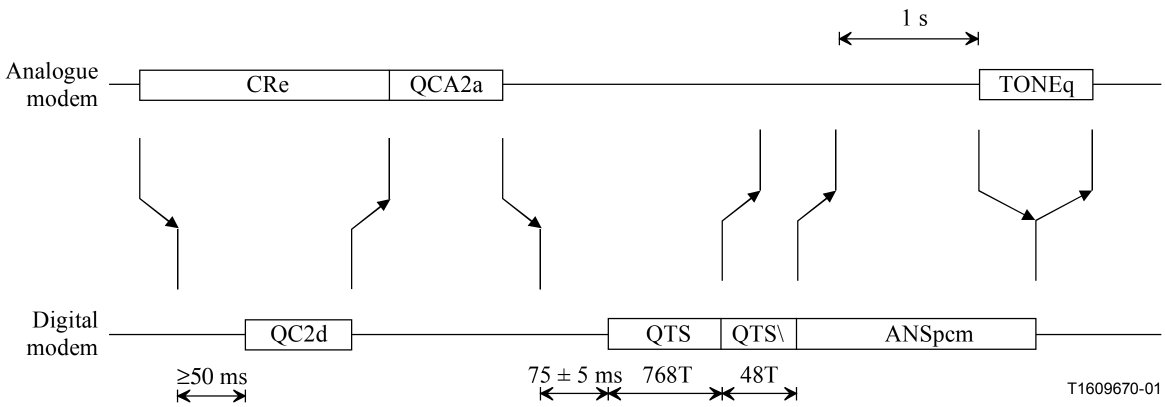

Figure 6/V.92 – Short Phase 1 when calling modem is digital modem and answering modem transmits CRe

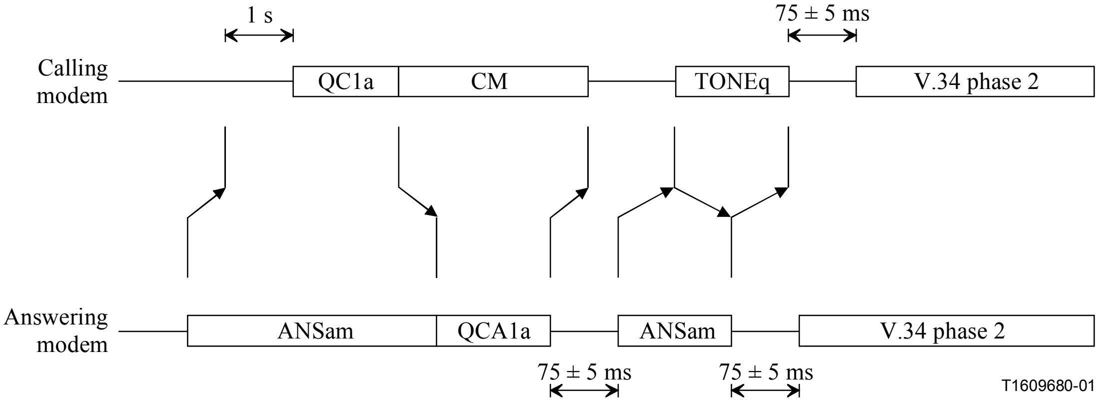

Figure 7/V.92 – Short Phase 1 when both modems are analogue modems and answering modem transmits ANSam

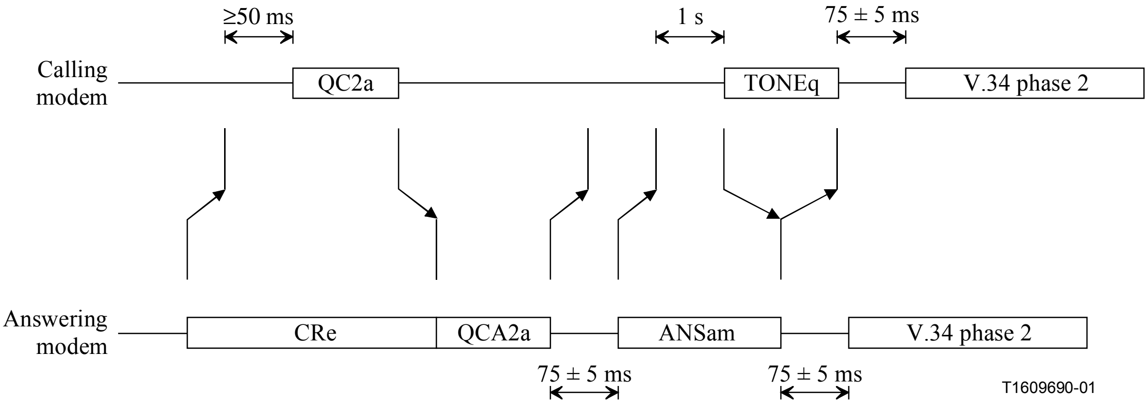

Figure 8/V.92 – Short Phase 1 when both modems are analogue modems and answering modem transmits CRe

9.2.1 Call modem is analogue modem

Initially, the call modem shall condition its receiver to detect signal ANSam as defined in ITU-T V.8 and optionally signal CRe as defined in ITU-T V.8 *bis*.

9.2.1.1 If signal ANSam is detected for 1 s, the analogue modem shall transmit signal QC1a followed by CM and condition its receiver to detect QCA1d, QCA1a and JM. If QCA1d is detected, the modem shall stop transmitting CM without completing the current octet and transmit silence and condition itself to detect QTS and QTS\ followed by ANSpcm and proceed in accordance with 9.2.1.3. If QCA1a is detected, the modem shall stop transmitting CM without completing the current octet and transmit silence until ANSam is detected, then transmit TONEq and proceed according to 9.2.1.4. If JM is detected, the analogue modem shall proceed according to ITU-T V.8.

9.2.1.2 If the initial 50 ms of signal CRe is detected, the analogue modem shall transmit signal QC2a followed by silence and condition its receiver to detect QCA2d, QCA2a, ANSam and ANS. If QCA2d is detected, the modem shall condition itself to detect QTS and QTS\ followed by ANSpcm and proceed according to 9.2.1.3. If QCA2a is detected, the modem shall condition itself to detect ANSam and when ANSam is detected for 1 s, transmit TONEq and proceed in accordance with 9.2.1.4. If ANSam is detected the modem shall proceed according to 9.2.1.1. If ANS is detected for 3 s after sending QC2a, the analogue modem shall proceed according to ITU-T V.8. If neither

QCA2d nor QCA2a is detected 1 s after transmitting QC2a the modem shall proceed in accordance with ITU-T V.8 *bis*.

9.2.1.3 When ANSpcm has been detected for 1 s the modem shall transmit TONEq for a minimum of 50 ms; however, if ANSam was already detected for 1 s in 9.2.1.1, TONEq may be transmitted upon detection of ANSpcm. When ANSpcm is no longer detected, the modem shall terminate TONEq and transmit silence for 75 ± 5 ms and proceed to Phase 2 of the start-up procedure.

9.2.1.4 When ANSam is no longer detected the modem shall terminate TONEq and transmit silence for 75 ± 5 ms and proceed to Phase 2 of ITU-T V.34.

9.2.2 Call modem is digital modem

Initially, the call modem shall condition its receiver to detect signal ANSam as defined in ITU-T V.8 and optionally signal CRe as defined in ITU-T V.8 *bis*.

9.2.2.1 If signal ANSam is detected for 1 s, the digital modem shall transmit signal QC1d followed by CM and condition its receiver to detect QCA1a, JM and ANSam. If QCA1a is detected, the modem shall stop transmitting CM without completing the current octet and transmit silence for 75 ± 5 ms followed by QTS and QTS\ and then ANSpcm. The digital modem shall then proceed according to 9.2.2.3. If ANSam is detected for 1 s after sending QC1d, or JM is detected, the digital modem shall proceed according to ITU-T V.8.

9.2.2.2 If the initial 50 ms of signal CRe is detected, the digital modem shall transmit signal QC2d followed by silence and condition its receiver to detect QCA2a, ANSam and ANS. If QCA2a is detected, the modem shall transmit silence for 75 ± 5 ms followed by QTS, QTS\ and then ANSpcm and proceed according to 9.2.2.3. If ANSam is detected the modem shall proceed according to 9.2.2.1. If ANS is detected for 3 s after sending QC2d, the digital modem shall proceed according to ITU-T V.8. If QCA2a has not been detected 1 s after transmitting QC2a, the modem shall proceed in accordance with ITU-T V.8 *bis*.

9.2.2.3 When ANSpcm is transmitted, the modem shall condition its receiver to detect TONEq. When TONEq is detected, the modem shall transmit silence for 75 ± 5 ms and proceed to Phase 2 of the start-up procedure.

9.2.3 Answer modem is analogue modem

Upon connection to line, the modem shall initially remain silent for a minimum of 200 ms and then transmit signal ANSam according to the procedure specified in ITU-T V.8 or CRe according to the procedure specified in ITU-T V.8 *bis*.

9.2.3.1 If ANSam is transmitted, even when a previous V.8 *bis* session has timed out, the modem shall condition its receiver to detect either QC1d, QC1a or CM. If QC1d is detected, the modem shall transmit QCA1a followed by silence, and condition itself to detect QTS and QTS\ followed by ANSpcm and then proceed according to 9.2.3.3. If QC1a is detected, the modem may transmit QCA1a followed by silence for 75 ± 5 ms and then ANSam and proceed according to 9.2.3.4. If CM is detected, the modem shall proceed with normal V.8 procedures.

9.2.3.2 If CRe is transmitted, the modem shall condition its receiver to detect QC2d and V.8 *bis* signals. If QC2d is detected, the modem shall terminate transmission of CRe and shall transmit QCA2a followed by silence, and condition itself to detect QTS and QTS\ followed by ANSpcm and then proceed according to 9.2.3.3. If QC2a is detected, the modem may transmit QCA2a followed by silence for 75 ± 5 ms and then ANSam and proceed according to 9.2.3.4. If a V.8 *bis* signal other than QC2d or QC2a is detected, the modem shall proceed with normal V.8 *bis* procedures. If no V.8 *bis* signals nor QC2d or QC2a are detected 3 s after transmission of CRe, the analogue modem shall transmit ANSam and proceed according to 9.2.3.1.

9.2.3.3 When ANSpcm has been detected for 1 s, the modem shall transmit TONEq for a minimum of 50 ms; however, if ANSam was transmitted in 9.2.3.1 TONEq may be transmitted upon detection of ANSpcm. When ANSpcm is no longer detected, the modem shall terminate TONEq and transmit silence for 75 ± 5 ms and proceed to Phase 2 of the start-up procedure. If ANSpcm is not detected during the 2 s following transmission of QCA1a, the analogue modem shall transmit ANSam and proceed according to ITU-T V.8. If ANSpcm is not detected during the 2 s following transmission of QCA2a, the analogue modem shall transmit ANSam and proceed according to 9.2.3.1.

9.2.3.4 While transmitting ANSam, the modem shall condition its receiver to detect TONEq and CM. If CM is detected, the modem shall proceed according to ITU-T V.8. If TONEq is detected, the modem shall terminate ANSam, transmit silence for 75 ± 5 ms and proceed to Phase 2 of the start-up procedure.

9.2.4 Answer modem is digital modem

Upon connection to line, the modem shall initially remain silent for a minimum of 200 ms and then transmit signal ANSam according to the procedure specified in ITU-T V.8 or CRe according to the procedure specified in ITU-T V.8 *bis*.

9.2.4.1 If ANSam is transmitted, even when a previous V.8 *bis* session has timed out, the modem shall condition its receiver to detect QC1a, QC1d or CM. If QC1a is detected, the modem shall transmit QCA1d followed by silence for 75 ± 5 ms and then QTS, QTS\ and ANSpcm and proceed according to 9.2.4.3. If QC1d is detected, the modem may take on the role of the analogue modem and proceed according to 9.2.3.1. If CM is detected, the modem shall proceed with normal V.8 procedures.

9.2.4.2 If CRe is transmitted the modem shall condition its receiver to detect QC2a, QC2d and V.8 *bis* signals. If QC2a is detected, the modem shall terminate transmission of CRe and shall transmit QCA2d followed by silence for 75 ± 5 ms and then QTS, QTS\ and ANSpcm and proceed according to 9.2.4.3. If QC2d is detected, the modem may take on the role of the analogue modem and proceed according to 9.2.3.2. If a V.8 *bis* signal other than QC2a or QC2d is detected, the modem shall proceed with normal V.8 *bis* procedures. If no V.8 *bis* signals or QC2a or QC2d are detected 3 s after transmission of CRe, the digital modem shall transmit ANSam and proceed according to 9.2.4.1.

9.2.4.3 While ANSpcm is transmitted, the modem shall condition its receiver to detect TONEq. If TONEq is detected, the modem shall transmit silence for 75 ± 5 ms and proceed to Phase 2 of the start-up procedure. If TONEq is not detected during the 2 s following transmission of QCA1d, the digital modem shall transmit ANSam and proceed according to ITU-T V.8. If TONEq is not detected during the 2 s following transmission of QCA2d, the digital modem shall transmit ANSam and proceed according to 9.2.4.1.

9.2.5 ODP/ADP bypass

If both modems have indicated LAPM capability, the V.42 ODP/ADP exchange shall be bypassed.

9.3 Full Phase 2 – Probing/ranging

The operating procedures for full Phase 2 and the associated recovery procedures are identical to those for Phase 2 of ITU-T V.90. The information bits to be used for V.92 operation are defined in 8.4.1. If both the digital and analogue modems indicate V.92 capability using bit 27 of $INFO_{0d}$ and bit 26 of $INFO_{0a}$ respectively, then the digital modem shall use the information bits defined for $INFO_{1d}$ in 8.4.1. In this case, the analogue modem may select PCM upstream operation by using the information bits defined for $INFO_{1a}$ in Table 18. If either modem does not indicate V.92 capability, then the digital modem and analogue modem shall use the information bits defined in 8.2.3.2 of ITU-T V.90.

If both the digital and analogue modems indicate V.92 capability, any subsequent retrains shall use Phase 2 of ITU-T V.92.

9.3.1 ODP/ADP bypass

If both modems indicate V.92 capability as well as indicating LAPM protocol in ITU-T V.8 or ITU-T V.8 *bis*, then the V.42 ODP/ADP exchange shall be bypassed.

9.4 Short Phase 2 – Ranging

If both the digital and analogue modems indicate V.92 capability and the desire to shorten Phase 2 by using bit 26 of $INFO_{0d}$ and bit 27 of $INFO_{0a}$ respectively, then the modems shall proceed as described below. The analogue modem shall only indicate the desire to use a short Phase 2 if it intends to connect in either PCM upstream or V.90 data mode.

The error-free operation of short Phase 2 is illustrated in Figure 9.

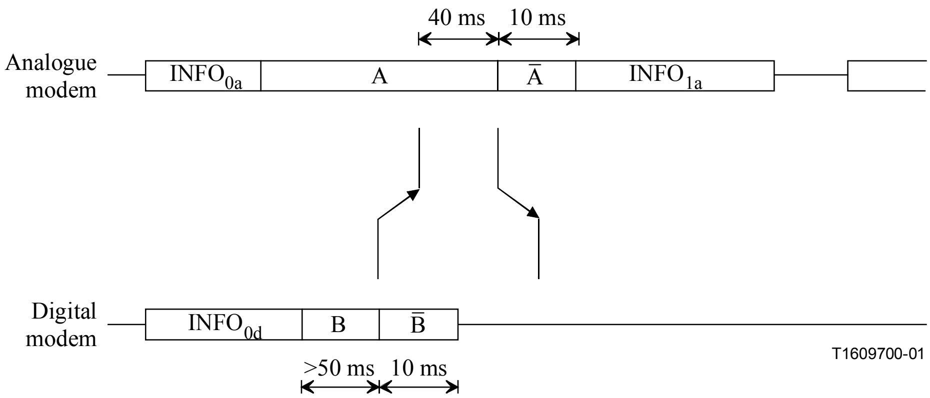

Figure 9/V.92 – Short Phase 2 – Ranging

9.4.1 Digital modem

9.4.1.1 Error-free procedures

9.4.1.1.1 During the 75 ± 5 ms silent period ending Phase 1, the digital modem shall condition its receiver to receive $INFO_{0a}$ and detect Tone A. After the 75 ± 5 ms silent period, the digital modem shall send $INFO_{0d}$ with bit 28 set to 0, followed by Tone B.

9.4.1.1.2 After receiving $INFO_{0a}$, the digital modem shall condition its receiver to detect Tone A and receive $INFO_{0a}$ (see 9.4.1.2).

9.4.1.1.3 After Tone A has been detected and Tone B has been transmitted for at least 50 ms, the digital modem shall transmit a Tone B phase reversal. Tone B shall be transmitted for another 10 ms after the phase reversal. The digital modem shall then transmit silence and condition its receiver to detect a Tone A phase reversal.

9.4.1.1.4 After detecting the Tone A phase reversal, the digital modem has the information required to calculate the round-trip delay. The round-trip delay estimate, RTDEd, is the time interval between the appearance of the Tone B phase reversal at the digital modem line terminals and receiving the Tone A phase reversal at the line terminals minus 40 ms. The digital modem shall then transmit silence and condition its receiver to receive $INFO_{1a}$.

9.4.1.1.5 After receiving $INFO_{1a}$, the digital modem shall proceed in accordance with the appropriate Phase 3 as signalled in $INFO_{1a}$.

9.4.1.2 Recovery procedures

9.4.1.2.1 If, in 9.4.1.1.2 or in 9.4.1.1.3, the digital modem detects Tone A before correctly receiving $INFO_{0a}$, or if it receives repeated $INFO_{0a}$ sequences, the digital modem shall repeatedly send $INFO_{0d}$ sequences. The digital modem shall set bit 28 of the $INFO_{0d}$ sequence to 1 after correctly receiving $INFO_{0a}$. If the digital modem receives $INFO_{0a}$ with bit 28 set to 1, it shall condition its receiver to detect Tone A and a subsequent Tone A phase reversal, complete sending the current $INFO_{0d}$ sequence, and then transmit Tone B. Alternatively, if the digital modem detects Tone A and has correctly received $INFO_{0a}$, it shall condition its receiver to detect Tone A phase reversal, complete sending the current $INFO_{0d}$ sequence, and then transmit Tone B. In both cases, the digital modem shall then proceed according to 9.4.1.1.3.

9.4.1.2.2 If, in 9.4.1.1.4, the digital modem does not detect a Tone A phase reversal within 2500 ms from transmission of the Tone B phase reversal in 9.4.1.1.3, the digital modem shall condition its receiver to detect Tone A. Upon detection of Tone A, the digital modem shall transmit Tone B and condition its receiver to detect Tone A phase reversal. The digital modem shall then proceed with the full Phase 2 procedure.

9.4.1.2.3 If, in 9.4.1.1.5, the digital modem does not receive $INFO_{1a}$ within 2500 ms from the transmission of Tone B phase reversal in 9.4.1.1.3, the digital modem shall send Tone B and condition its receiver to detect Tone A. Upon detection of Tone A, the digital modem shall condition its receiver to detect the Tone A phase reversal and proceed with the full Phase 2 procedure.

9.4.2 Analogue modem

9.4.2.1 Error-free procedures

9.4.2.1.1 During the 75 ± 5 ms silent period ending Phase 1, the analogue modem shall condition its receiver to receive $INFO_{0d}$ and detect Tone B. After the 75 ± 5 ms silent period, the analogue modem shall send $INFO_{0a}$ with bit 28 set to 0, followed by Tone A.

9.4.2.1.2 After receiving $INFO_{0d}$, the analogue modem shall condition its receiver to detect Tone B and receive $INFO_{0d}$ (see 9.4.2.2) and detect the subsequent Tone B phase reversal.

9.4.2.1.3 After detecting the Tone B phase reversal, the analogue modem shall transmit a Tone A phase reversal. The Tone A phase reversal shall be delayed so that the time duration between receiving the Tone B phase reversal at the line terminals and the appearance of the Tone A phase reversal at the line terminals is 40 ± 1 ms. Tone A shall be transmitted for 10 ms after the phase reversal.

9.4.2.1.4 Then, the analogue modem shall send $INFO_{1a}$ and proceed in accordance with the appropriate Phase 3 as signalled in $INFO_{1a}$.

9.4.2.2 Recovery procedures

9.4.2.2.1 If, in 9.4.2.1.2 or in 9.4.2.1.3, the analogue modem detects Tone B before correctly receiving $INFO_{0d}$, or if it receives repeated $INFO_{0d}$ sequences, the analogue modem shall repeatedly send $INFO_{0a}$ sequences. The analogue modem shall set bit 28 of the $INFO_{0a}$ sequence to 1 after correctly receiving $INFO_{0d}$. If the analogue modem receives $INFO_{0d}$ with bit 28 set to 1, it shall condition its receiver to detect Tone B, complete sending the current $INFO_{0a}$ sequence, and then transmit Tone A. Alternatively, if the analogue modem detects Tone B and has correctly received $INFO_{0d}$, it shall complete sending the current $INFO_{0a}$ sequence, and transmit Tone A. In both cases, the analogue modem shall then proceed according to 9.4.2.1.3.

9.4.2.2.2 If, in 9.4.2.1.3, the analogue modem does not detect the Tone B phase reversal within 2500 ms from the end of $INFO_{0a}$ transmission, the analogue modem shall initiate a retrain according to 9.7.2.1.

9.5 Phase 3 – Equalizer and echo canceller training and digital impairment learning

See Figures 10 and 11.

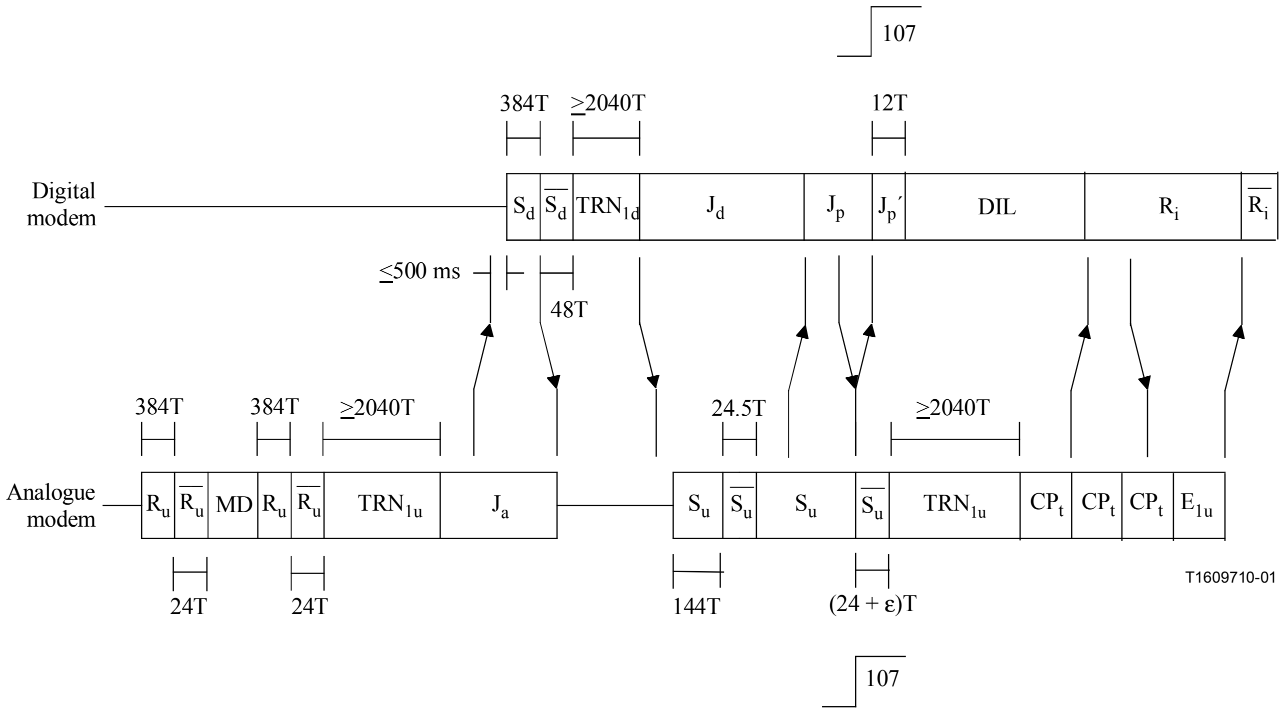

Figure 10/V.92 – Phase 3 – Equalizer and echo canceller training and digital impairment learning

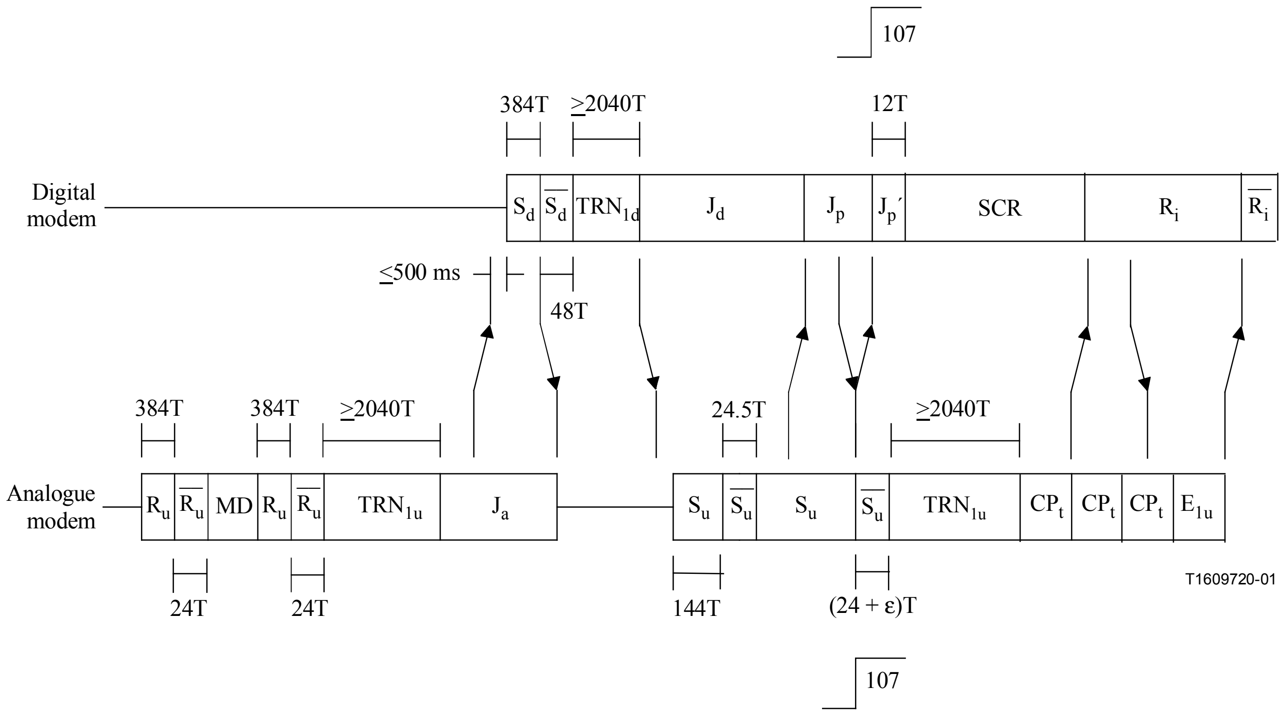

Figure 11/V.92 – Phase 3 – Equalizer and echo canceller training when no DIL has been requested

9.5.1 Digital modem

9.5.1.1 Error-free procedures

9.5.1.1.1 The digital modem shall be initially silent and condition its receiver to detect R_u and the subsequent $\overline{R_u}$. If the duration of signal MD indicated by $INFO_{1a}$ is zero, the digital modem shall proceed according to 9.5.1.1.2. Otherwise, after detecting the R_u-to-$\overline{R_u}$ transition, the digital modem shall wait for the duration of signal MD as indicated by $INFO_{1a}$ and then shall condition its receiver to receive signal R_u and the subsequent R_u-to-$\overline{R_u}$ transition.

9.5.1.1.2 After detecting signal R_u and the R_u-to-$\overline{R_u}$ transition, the digital modem shall condition its receiver to begin training its equalizer using signal TRN_{1u}.

9.5.1.1.3 After receiving the first 2040T of signal TRN_{1u}, the digital modem shall condition its receiver to receive sequence J_a. After receiving a DIL descriptor of J_a, the digital modem may wait for up to 500 ms and shall then transmit signal S_d for 384T and signal $\overline{S_d}$ for 48T.

9.5.1.1.4 The digital modem shall then transmit TRN_{1d} for a minimum of 2040T. Within 4000 ms of starting to transmit TRN_{1d} the digital modem shall transmit J_d and condition its receiver to detect signal S_u.

9.5.1.1.5 The digital modem shall continue to repeat the J_d sequence.

9.5.1.1.6 Upon detection of S_u digital modem shall condition its receiver to detect the S_u-to-$\overline{S_u}$ transition. It should use signal S_u to measure the phase information.

9.5.1.1.7 Upon detection of S_u-to-$\overline{S_u}$ the digital modem shall condition its receiver to continue receiving signal S_u and should continue to measure the phase information.

9.5.1.1.8 Once the digital modem has determined the proper phase adjustment it shall complete the current J_d sequence and then transmit the J_p sequence and condition its receiver to detect the S_u-to-$\overline{S_u}$ transition.

9.5.1.1.9 Upon detection of the S_u-to-$\overline{S_u}$ transition, the digital modem shall complete the current J_p sequence, assert circuit 107 and then transmit J_p'.

9.5.1.1.10 The digital modem shall then receive TRN_{1u}. The digital modem shall keep a modulo 12 data frame interval count from the first symbol of TRN_{1u}.

9.5.1.1.11 After sending J_p', the digital modem shall send the DIL requested by the analogue modem and condition its receiver to receive CP_t. If the analogue modem requested a DIL of zero length then the digital modem shall send SCR instead of DIL and proceed according to 9.5.1.1.13.

9.5.1.1.12 Upon receiving CP_t, the digital modem shall transmit R_i. Upon receiving the E_{1u} terminating the CP_t sequences, the digital modem shall transmit $\overline{R_i}$ and then proceed to Phase 4 of the start-up procedure.

9.5.1.1.13 When the digital modem is sufficiently trained, it shall transmit R_i and condition its receiver to receive CP_t. Upon receiving CP_t, the digital modem shall transmit $\overline{R_i}$ and then proceed to Phase 4 of the start-up procedure.

9.5.1.2 Recovery procedures

The digital modem may initiate a retrain at any time during Phase 3 according to 9.7.1.1. If Tone A is detected during Phase 3, the digital modem shall respond to retrain according to 9.7.1.2.

9.5.1.2.1 If, in 9.5.1.1.3, the digital modem does not detect J_a within 4500 ms plus a round-trip delay from the end of $INFO_{1a}$ the digital modem shall initiate a retrain according to 9.7.1.1

9.5.1.2.2 If, in 9.5.1.1.9, the digital modem does not detect S_u within 5100 ms plus a round-trip delay from the start of TRN_{1d}, the digital modem shall initiate a retrain according to 9.7.1.1.

9.5.2 Analogue modem

9.5.2.1 Error-free procedures

9.5.2.1.1 After sending sequence $INFO_{1a}$, the analogue modem shall transmit silence for 70 ± 5 ms, signal R_u for 384T and signal $\overline{R_u}$ for 24T. If the duration of the analogue modem's MD signal, as indicated in the $INFO_{1a}$, is zero, the modem shall proceed according to 9.5.2.1.2. Otherwise, the modem shall transmit signal MD for the duration indicated in $INFO_{1a}$, signal R_u for 384T and signal $\overline{R_u}$ for 24T.

9.5.2.1.2 The analogue modem shall then transmit signal TRN_{1u}. Signal TRN_{1u} shall be transmitted for at least 2040T. The total time from the beginning of transmission of signal MD to the end of signal TRN_{1u} shall not exceed one round-trip delay plus 4000 ms.

9.5.2.1.3 After transmitting signal TRN_{1u}, the modem shall send sequence J_a and condition its receiver to detect signal S_d and the S_d-to-$\overline{S_d}$ transition. After detecting the S_d-to-$\overline{S_d}$ transition, the modem shall terminate J_a at the next 12 bit boundary and transmit silence.

9.5.2.1.4 The modem shall condition its receiver to begin its equalizer training using the first 2040T of signal TRN_{1d}.

9.5.2.1.5 After receiving 2040T of signal TRN_{1d}, the analogue modem shall condition its receiver to receive sequence J_d.

9.5.2.1.6 After receiving J_d, the analogue modem may wait for up to 5000 ms from having begun to transmit silence as required in the procedure in 9.5.2.1.3 and shall then transmit signal S_u for 144T.

9.5.2.1.7 After transmitting 144T of signal S_u the analogue modem shall transmit signal $\overline{S_u}$ for length of 24.5T followed by signal S_u and condition its receiver to detect J_p.

9.5.2.1.8 After detecting J_p, the analogue modem shall assert circuit 107 and transmit $\overline{S_u}$ for 24T plus any fractional amount from 0 to 1 symbol as specified in J_p and shall condition its receiver to detect J_p'.

9.5.2.1.9 After detecting J_p' the analogue modem shall then condition its receiver to receive the DIL sequence it requested in J_a or SCR if it requested a DIL of zero length. During the reception of DIL or SCR the analogue modem shall transmit TRN_{1u}. The length for this segment of TRN_{1u} shall be in multiple of 12 symbols and shall be at least 2040T long if a non-zero DIL was requested.

9.5.2.1.10 If the analogue modem has requested a zero length DIL, it shall wait until it receives R_i and then transmit CP_t sequences. Upon receiving $\overline{R_i}$, the analogue modem shall complete sending the current CP_t, transmit E_{1u} and then proceed to Phase 4 of the start-up procedure.

9.5.2.1.11 If the analogue modem requested a non-zero length DIL, it shall transmit at least 2040T of TRN_{1u} followed by CP_t within 5000 ms of transmitting $\overline{S_u}$ in 9.5.2.1.8. This indicates to the digital modem that the analogue modem has received enough of the DIL sequence. The analogue modem shall continue to send CP_t sequences until it receives R_i. Upon receiving R_i, the analogue modem shall complete sending the current CP_t, transmit E_{1u} and then proceed to Phase 4 of the start-up procedure.

9.5.2.2 Recovery procedures

The analogue modem may initiate a retrain at any time during Phase 3 according to 9.7.2.1. If Tone B is detected during Phase 3, the analogue modem shall respond to retrain according to 9.7.2.2.

9.5.2.2.1 If, in 9.5.2.1.3, the analogue modem does not detect the S_d-to-$\overline{S_d}$ transition within 1500 ms from the start of J_a, the analogue modem shall initiate a retrain according to 9.7.2.1.

9.5.2.2.2 If, in 9.5.2.1.6, the analogue modem does not receive J_d within 4500 ms from the end of J_a, the analogue modem shall initiate a retrain according to 9.7.2.1.

9.6 Phase 4 – Final training

See Figures 12 to 14.

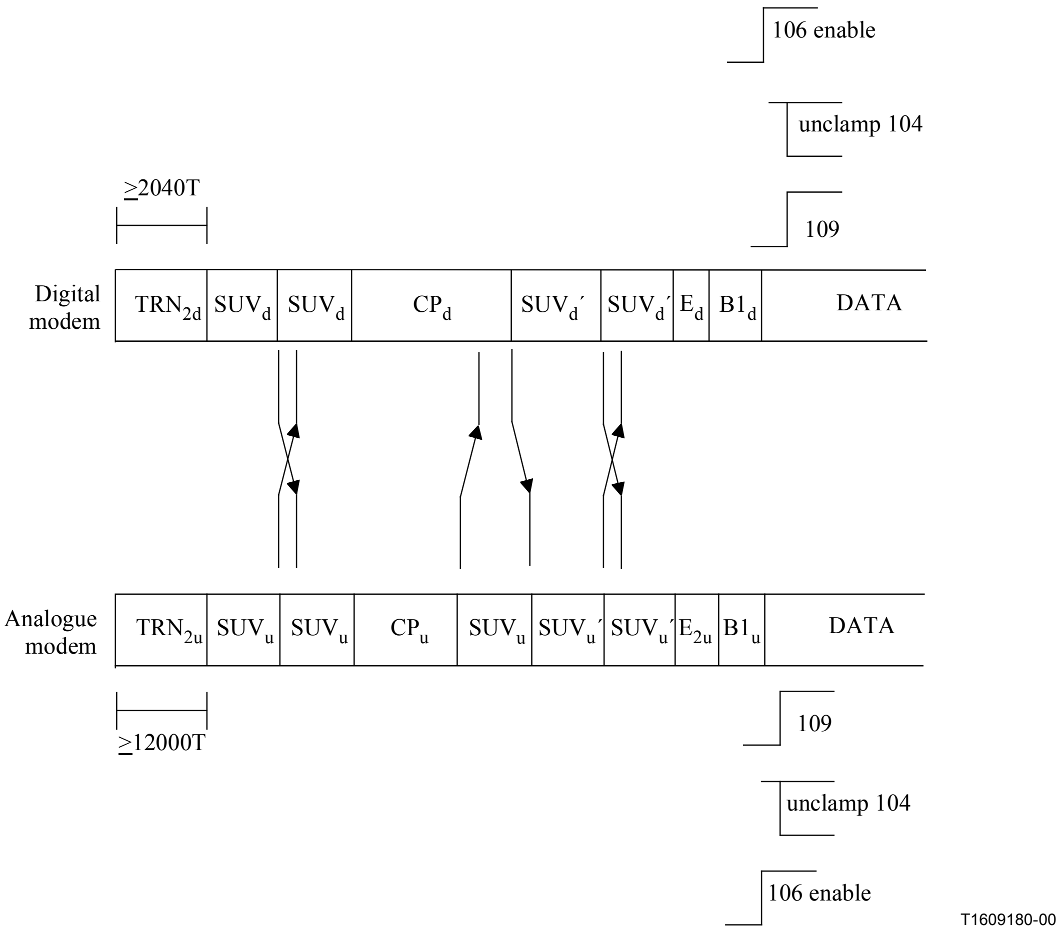

Figure 12/V.92 – Phase 4 – Final training where the two CP sequences occur at about the same time

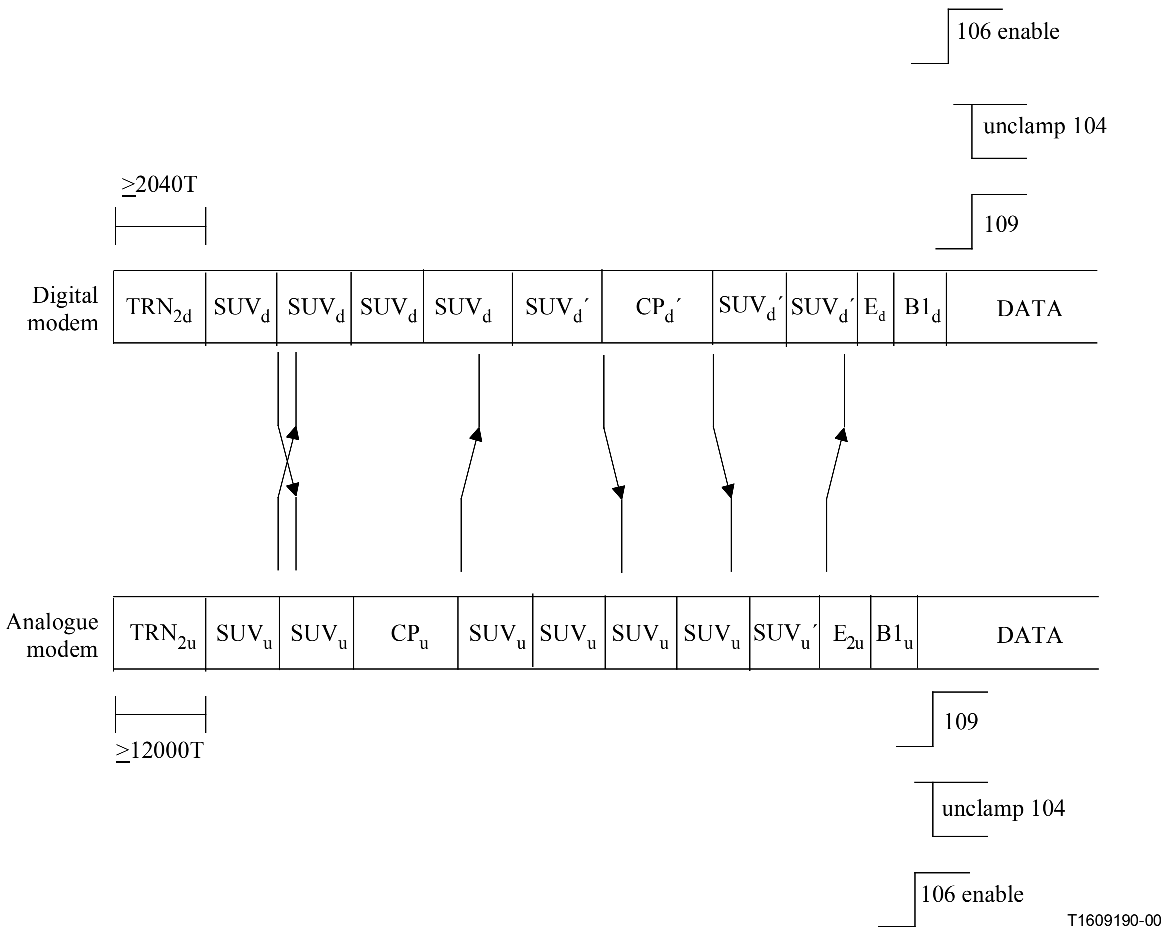

Figure 13/V.92 – Phase 4 – Final training where CP_u is sent earlier than CP_d

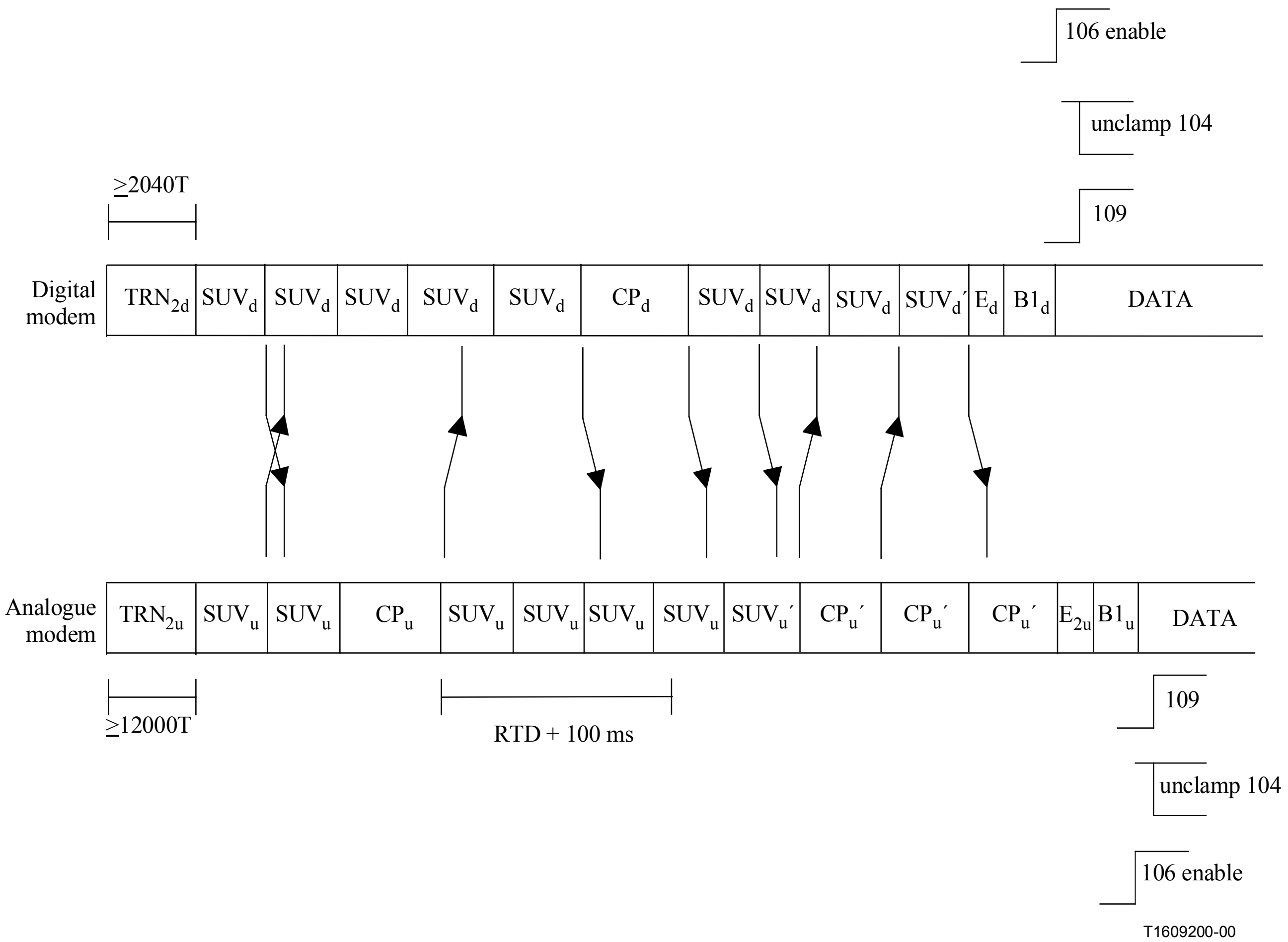

Figure 14/V.92 – Phase 4 – Final training where the first CP_u is not received by the digital modem

9.6.1 Digital modem

9.6.1.1 Error-free procedures

9.6.1.1.1 The digital modem shall transmit TRN_{2d} for at least 2040T. When the digital modem is ready to receive a CP_u sequence, it shall condition its receiver to receive an SUV_u sequence and it shall transmit SUV_d sequences.

9.6.1.1.2 After receiving an SUV_u sequence, the digital modem shall transmit a single CP_d sequence followed by more SUV_d sequences. After receiving a CP_u sequence, the digital modem shall transmit subsequent CP_d and SUV_d sequences with the acknowledgement bit set.

9.6.1.1.3 If the acknowledgement bit is not set in any of the CP_u or SUV_u sequences received by the digital modem up to and including the entire CP_u or SUV_u sequence that is received after 100 ms plus a round-trip delay from the end of its CP_d, the digital modem shall send repeated CP_d sequences.

9.6.1.1.4 After the digital modem has sent a CP_d or SUV_d sequence with the acknowledgement bit set and it has received a CP_u or SUV_u sequence with the acknowledgement bit set or E_{2u}, the digital modem shall complete sending the current CP_d or SUV_d sequence and transmit E_d.

9.6.1.1.5 After sending the E_d sequence, the digital modem shall send $B1_d$ at the negotiated data signalling rate using the data mode constellation parameters it received in CP_u. The modem shall then enable circuit 106 to respond to the condition of circuit 105 and begin data transmission using the modulation procedures of clause 5.

9.6.1.1.6 After receiving E_{2u}, the digital modem shall condition its receiver to receive $B1_u$, or for a Fast Parameter Exchange, condition its receiver to receive $FB1_u$ followed by $B1_u$. After receiving $B1_u$, the digital modem shall unclamp circuit 104, turn on circuit 109, and begin demodulating data.

9.6.1.2 Recovery procedures

The digital modem may initiate a retrain at any time during Phase 4 according to 9.7.1.1. If Tone A is detected during Phase 4, the digital modem shall respond to retrain according to 9.7.1.2.

9.6.1.2.1 If the digital modem does not receive $B1_u$ within 20 s plus 6 round-trip delays from the end of $INFO_{1a}$, the digital modem shall initiate a retrain according to 9.7.1.1.

9.6.2 Analogue modem

9.6.2.1 Error-free procedures

9.6.2.1.1 The analogue modem shall condition its receiver to receive an SUV_d sequence and transmit TRN_{2u}. When the analogue modem is ready to receive a CP_d sequence and it has transmitted TRN_{2u} for at least 12000T or received an SUV_d sequence, it shall transmit SUV_u sequences.

9.6.2.1.2 After receiving an SUV_d sequence, the analogue modem shall transmit a single CP_u sequence followed by more SUV_u sequences. After receiving a CP_d sequence, the analogue modem shall transmit subsequent CP_u and SUV_u sequences with the acknowledgement bit set.

9.6.2.1.3 If the acknowledgement bit is not set in any of the CP_d or SUV_d sequences received by the analogue modem up to and including the entire CP_d or SUV_d sequence that is received after 100 ms plus a round-trip delay from the end of its CP_u, the analogue modem shall send repeated CP_u sequences.

9.6.2.1.4 After the analogue modem has sent a CP_u or SUV_u sequence with the acknowledgement bit set and it has received a CP_d or SUV_d sequence with the acknowledgement bit set or E_d, the analogue modem shall complete sending the current CP_u sequence and transmit E_{2u}.

9.6.2.1.5 After sending the E_{2u} sequence, the analogue modem shall send either $B1_u$, or, for Fast Parameter Exchange, $FB1_u$ followed by $B1_u$. The modem shall then enable circuit 106 to respond to the condition of circuit 105 and begin data transmission using the modulation procedures of 6.4.

9.6.2.1.6 After receiving E_d, the analogue modem shall condition its receiver to receive $B1_d$. After receiving $B1_d$, the analogue modem shall unclamp circuit 104, turn on circuit 109, and begin demodulating data.

9.6.2.2 Recovery procedures

The analogue modem may initiate a retrain at any time during Phase 4 according to 9.7.2.1. If Tone B is detected during Phase 4, the analogue modem shall respond to retrain according to 9.7.2.2.

9.6.2.2.1 If the analogue modem does not receive $B1_d$,within 20 s plus 6 round-trip delays from the end of sending $INFO_{1a}$, the analogue modem shall initiate a retrain according to 9.7.2.1.

9.7 Retrains

9.7.1 Digital modem

9.7.1.1 Initiating retrain

To initiate a retrain, the digital modem shall turn OFF circuit 106, clamp circuit 104 to binary one and transmit silence for 70 ± 5 ms. The digital modem shall then transmit Tone B and condition its receiver to detect Tone A. After detecting Tone A, the digital modem shall condition its receiver to detect a Tone A phase reversal and proceed in accordance with the full Phase 2 start-up procedure.

9.7.1.2 Responding to retrain

After detecting Tone A for more than 50 ms, the digital modem shall turn OFF circuit 106, clamp circuit 104 to binary one and transmit silence for 70 ± 5 ms. The digital modem shall then transmit Tone B, condition its receiver to detect a Tone A phase reversal, and proceed in accordance with the full Phase 2 start-up procedure.

9.7.2 Analogue modem

9.7.2.1 Initiating retrain

To initiate a retrain, the analogue modem shall turn OFF circuit 106, clamp circuit 104 to binary one and transmit silence for 70 ± 5 ms. The analogue modem shall then transmit Tone A and condition its receiver to detect Tone B. After detecting Tone B and when Tone A has been transmitted for at least 50 ms, the analogue modem shall transmit a Tone A phase reversal, condition its receiver to detect a Tone B phase reversal and proceed in accordance with the full Phase 2 start-up procedure.

9.7.2.2 Responding to retrain

After detecting Tone B for more than 50 ms, the analogue modem shall turn OFF circuit 106, clamp circuit 104 to binary one and transmit silence for 70 ± 5 ms. The analogue modem shall then transmit Tone A and proceed in accordance with the full Phase 2 start-up procedure.

9.8 Rate renegotiation

The rate renegotiation procedure can be initiated at any time during data mode (see Figures 15 to 18). Data signalling rate and other parameters may change as a result of rate renegotiation. This procedure can also be used to retrain the analogue modem's echo canceller or the precoder and prefilter without going through a complete retrain.

The digital modem and the analogue modem shall maintain data frame synchronization during rate renegotiation. Rate renegotiation shall be initiated only on the boundary of a data frame. Similarly, a modem shall only respond to a rate renegotiation on the boundary of a data frame.

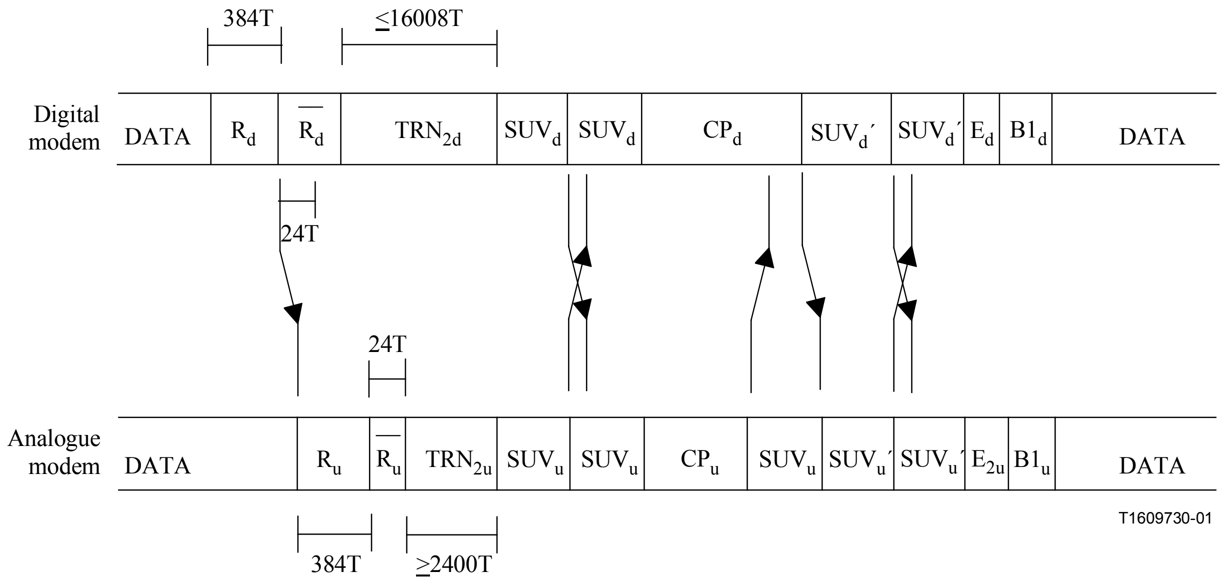

Figure 15/V.92 – Rate renegotiation with no silence initiated by the digital modem

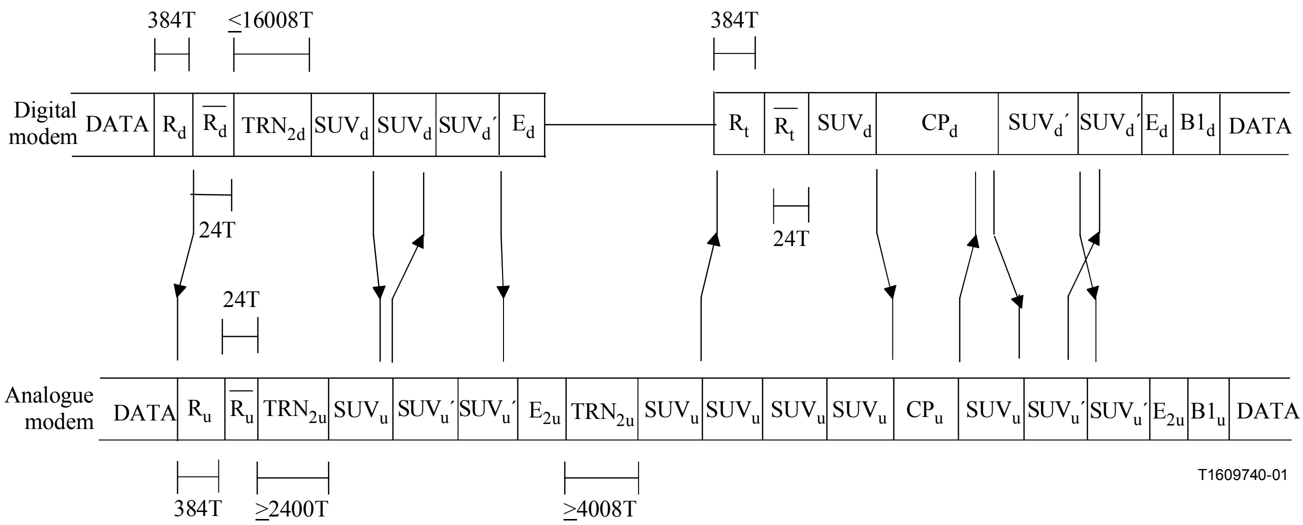

Figure 16/V.92 – Rate renegotiation with silence requested by the digital modem and sustained for the maximum length

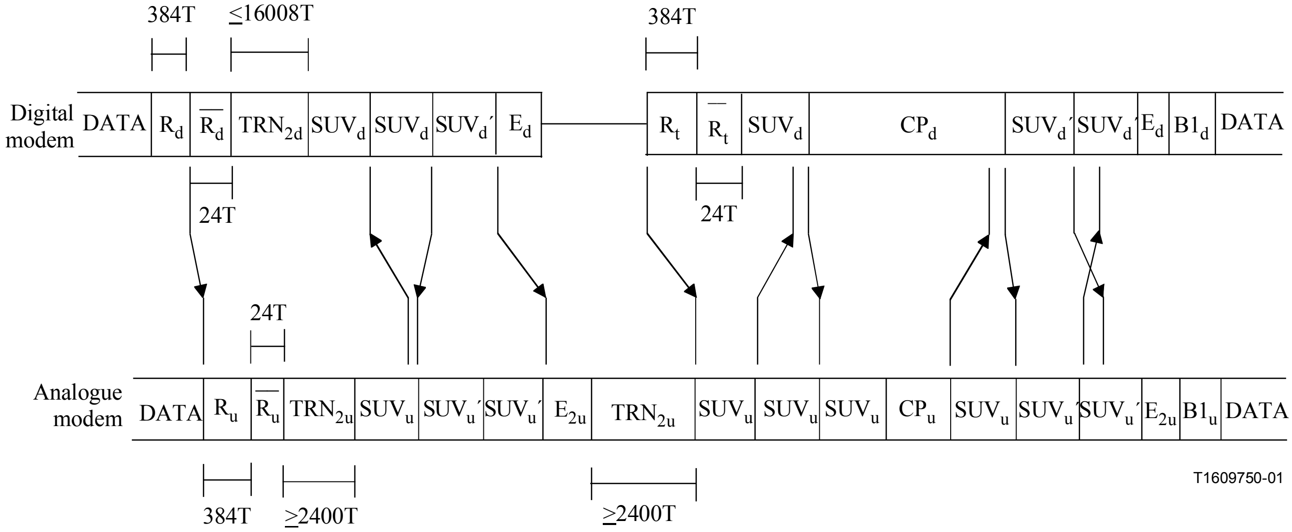

Figure 17/V.92 – Rate renegotiation with silence requested by the digital modem and terminated before maximum length

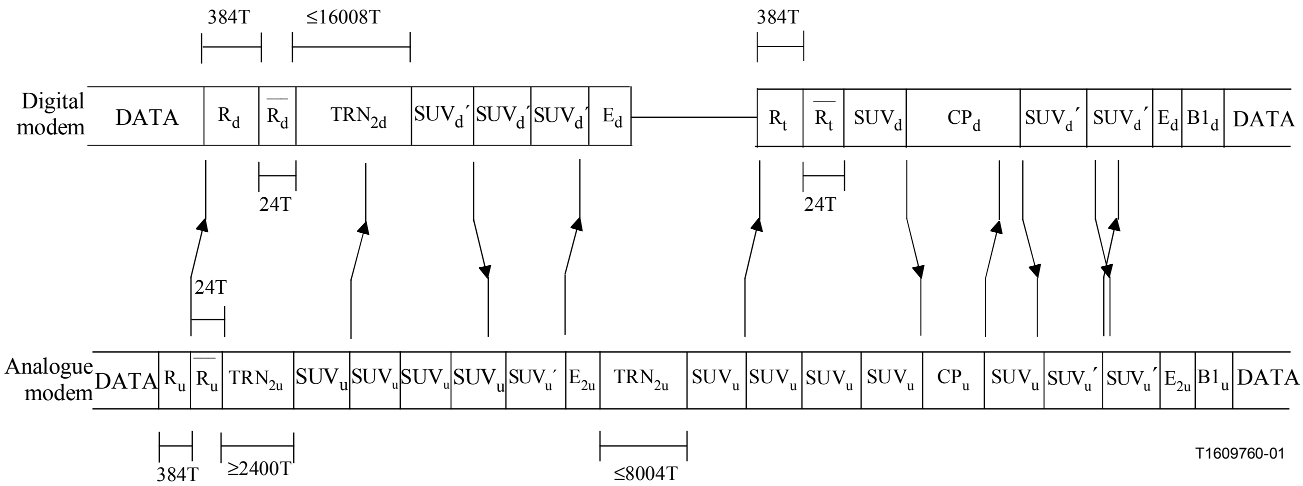

Figure 18/V.92 – Rate renegotiation with silence requested by the analogue modem

9.8.1 Digital modem

9.8.1.1 Initiating a rate renegotiation

9.8.1.1.1 The digital modem shall turn OFF circuit 106, condition its receiver to detect R_u, $\overline{R_u}$, and SUV_u and transmit signal R_d for 384T and then $\overline{R_d}$ for 24T. The signal R_d shall begin on the boundary of a data frame.

9.8.1.1.2 The digital modem shall then transmit TRN_{2d} for up to 16008T followed by SUV_d sequences. Upon receiving an SUV_u sequence, the digital modem shall proceed according to 9.6.1.1.2 unless bit 32 is set in either SUV_d or SUV_u.

9.8.1.1.3 The digital modem shall then transmit SUV_d sequences with bit 33 set. After receiving an SUV_u sequence with bit 33 set or E_{2u}, the digital modem shall complete sending the current SUV_d and then transmit E_d followed by silence. The digital modem shall generate silence by sending PCM codewords with magnitudes represented by Ucode 0. It shall retain data frame alignment during this period of silence.

9.8.1.1.4 If bit 32 of SUV_u was set, the digital modem shall wait to receive SUV_u with bit 32 clear. After receiving SUV_u with bit 32 clear, the digital modem shall transmit R_t for 384T followed by $\overline{R_t}$ for 24T and SUV_d. The digital modem shall then proceed according to 9.6.1.1.2.

9.8.1.1.5 If bit 32 of SUV_u was clear, the digital modem may transmit R_t for 384T followed by $\overline{R_t}$ for 24T and SUV_d sequences or wait to receive another SUV_u. The digital modem shall then proceed according to 9.6.1.1.2.

9.8.1.2 Responding to a rate renegotiation

9.8.1.2.1 After detecting R_u, the digital modem shall clamp circuit 104 to binary one and condition its receiver to detect the R_u-to-$\overline{R_u}$ transition.

9.8.1.2.2 After detecting the R_u-to-$\overline{R_u}$ transition, the digital modem shall transmit signal R_d for 384T and then $\overline{R_d}$ for 24T. The signal R_d shall begin on the boundary of a data frame.

9.8.1.2.3 The digital modem shall then proceed according to 9.8.1.1.2.

9.8.2 Analogue modem

9.8.2.1 Initiating a rate renegotiation

9.8.2.1.1 The analogue modem shall turn OFF circuit 106, transmit signal R_u for 384T followed by $\overline{R_u}$ for 24T. The signal R_u shall begin on the boundary of a data frame.

9.8.2.1.2 The analogue modem shall condition its receiver to receive an SUV_d sequence. The analogue modem shall transmit TRN_{2u} for up to 16008T, but it may terminate the transmission of TRN_{2u} after 2400T or when SUV_d is received.

9.8.2.1.3 The analogue modem shall then transmit SUV_u sequences. After transmitting an SUV_u sequence and receiving an SUV_d sequence the analogue modem shall proceed according to 9.6.2.1.2 unless bit 32 is set in either SUV_u or SUV_d.

9.8.2.1.4 The analogue modem shall then transmit SUV_u sequences with bit 33 set. After receiving an SUV_d sequence with bit 33 set or E_d, the analogue modem shall complete sending the current SUV_u and then transmit E_{2u} followed by TRN_{2u}.

9.8.2.1.5 If bit 32 of SUV_d was clear, the analogue modem shall transmit TRN_{2u} for up to 8004T followed by SUV_u with bit 32 clear. The analogue modem shall then proceed according to 9.6.2.1.2.

9.8.2.1.6 If bit 32 of SUV_d was set, the analogue modem shall condition its receiver to receive R_t. Upon receiving R_t or after transmitting 8004T of TRN_{2u}, the analogue modem shall transmit SUV_u sequences with bit 32 clear and wait to receive an SUV_d. The analogue modem shall then proceed according to 9.6.2.1.2.

9.8.2.2 Responding to a rate renegotiation

9.8.2.2.1 After receiving R_d, the analogue modem shall clamp circuit 104 to binary one and shall condition its receiver to detect the R_d-to-$\overline{R_d}$ transition.

9.8.2.2.2 After receiving the R_d-to-$\overline{R_d}$ transition, the analogue modem transmit R_u for 384T and $\overline{R_u}$ for 24T. The signal R_u shall begin on the boundary of a data frame.

9.8.2.2.3 The analogue modem shall condition its receiver to receive an SUV_d sequence. The analogue modem shall transmit TRN_{2u} for up to 16008T, but it may terminate the transmission of TRN_{2u} after 2400T or when SUV_d is received and proceed according to 9.8.2.1.3.

9.9 Fast parameter exchange

The fast parameter exchange procedure can be initiated at any time during data mode (see Figure 19). Data signalling rate and other parameters may change as a result of a fast parameter exchange.

The digital modem and the analogue modem shall maintain data frame synchronization during a fast parameter exchange. A fast parameter exchange shall be initiated only on the boundary of a data frame. Similarly, a modem shall only respond to a fast parameter exchange on the boundary of a data frame.

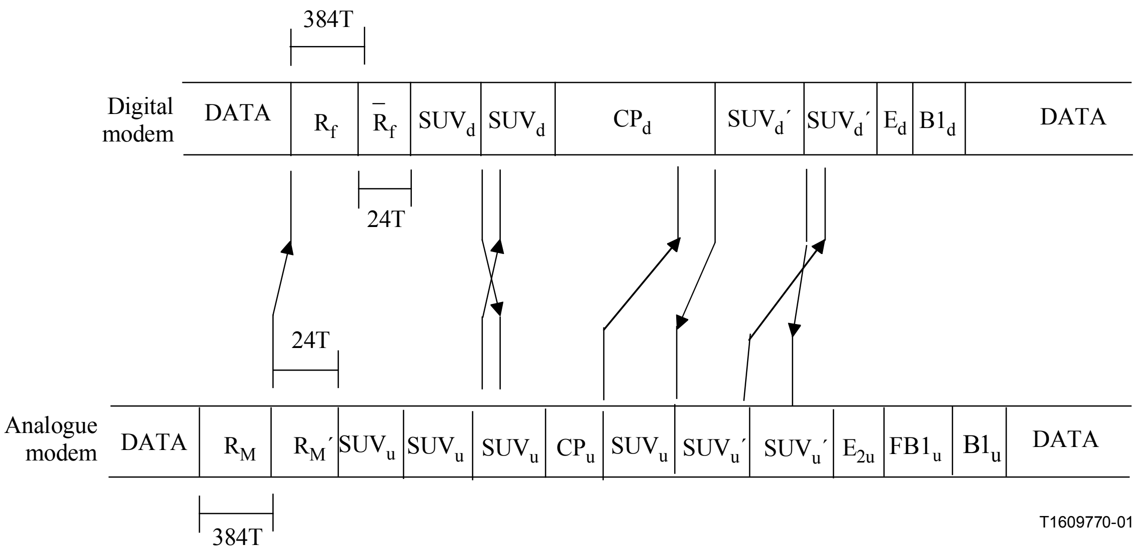

Figure 19/V.92 – Fast parameter exchange initiated by the analogue modem

9.9.1 Digital modem

9.9.1.1 Initiating a fast parameter exchange

9.9.1.1.1 The digital modem shall turn OFF circuit 106, condition its receiver to detect R_M, R_M' and SUV_u and transmit signal R_f for 384T followed by $\overline{R_f}$ for 24T. The signal R_f shall begin on the boundary of a data frame.

9.9.1.1.2 The digital modem shall then initialize the scrambler, differential encoder and spectral shaping filter memory to zero and transmit SUV_d sequences with bit 32 clear and, after detecting R_M, R_M', condition its receiver to receive an SUV_u sequence and proceed according to 9.6.1.1.2. If signal R_u is detected the modem shall proceed according to 9.8.1.2.1.

9.9.1.2 Responding to a fast parameter exchange

9.9.1.2.1 After detecting R_M, the digital modem shall clamp circuit 104 to binary one and condition its receiver to detect the R_M-to-R_M' transition.

9.9.1.2.2 After detecting the R_M-to-R_M' transition, the digital modem shall transmit signal R_f for 384T and then $\overline{R_f}$ for 24T. The signal R_f shall begin on the boundary of a data frame.

9.9.1.2.3 The digital modem shall then initialize the scrambler, differential encoder and spectral shaping filter memory to zero and transmit SUV_d sequences with bit 32 clear and proceed according to 9.6.1.1.2.

9.9.2 Analogue modem

9.9.2.1 Initiating a fast parameter exchange

9.9.2.1.1 The analogue modem shall turn OFF circuit 106, condition its receiver to detect R_f, $\overline{R_f}$ and SUV_d and transmit signal R_M for 384T followed by R_M' for 24T. The signal R_M shall begin on the boundary of a data frame.

9.9.2.1.2 The analogue modem shall then initialize the scrambler and differential encoder to zero and transmit SUV_u sequences with bit 32 clear and, after detecting R_f, R_f', condition its receiver to receive an SUV_d sequence and proceed according to 9.6.2.1.2. If signal R_d is detected, the modem shall proceed according to 9.8.2.2.1.

9.9.2.2 Responding to a fast parameter exchange

9.9.2.2.1 After detecting R_f, the analogue modem shall clamp circuit 104 to binary one and condition its receiver to detect the R_f-to-$\overline{R_f}$ transition.

9.9.2.2.2 After detecting the R_f-to-$\overline{R_f}$ transition, the analogue modem shall transmit signal R_M for 384T and then R_M' for 24T. The signal R_M shall begin on the boundary of a data frame.

9.9.2.2.3 The analogue modem shall then initialize the scrambler and differential encoder to zero and transmit SUV_u sequences with bit 32 clear and proceed according to 9.6.2.1.2.

9.10 Modem-on-hold

The MH sequences defined in 8.9.2 may be used to initiate modem-on-hold procedures when network interruptions occur due to call-waiting and related services. If an MH sequence is received, an appropriate MH sequence shall be transmitted in response.

9.10.1 Transmission of MH sequences

If Tone RT is transmitted before an MH sequence its duration shall be at least 20 ms if the tone was preceded by another MH sequence, or at least 50 ms otherwise. MH sequences shall be transmitted repeatedly, with the first 4 fill bits immediately following the last 4 fill bits of the preceding sequence. Each transmitted sequence shall be completed before transmitting other signals.

9.10.1.1 Initiating sequences

MH sequences MHreq, MHclrd and MHfrr may be transmitted to initiate a modem-on-hold transaction after circuit 107 has been asserted and either Tone RT is received or an MH response sequence is detected. MHnack may be transmitted to initiate a second transaction in response to MHreq. The initiating sequence shall be transmitted until the appropriate response is detected. If the appropriate response is not detected after 2 s plus a round-trip delay the modem shall complete the current sequence and either initiate a retrain or disconnect.

The beginning of a modem-on-hold transaction may be indistinguishable from the beginning of a retrain. Therefore, when a modem-on-hold transaction is initiated by transmitting Tone B, the responding modem may initiate a retrain by transmitting a Tone A phase reversal. In that case, the initiating modem will normally ignore the phase reversal and proceed with the modem-on-hold transaction. Correspondingly, the responding modem shall condition its receiver to detect both a Tone B phase reversal and an initiating MH sequence.

9.10.1.2 Response sequences

If one of the initiating sequences is detected the modem shall transmit the appropriate response shown in Table 34. The response sequence shall be transmitted repeatedly until either ANSam or silence is detected or the initiating sequence is not detected for 200 ms.

Table 34/V.92 – Initiating and response MH sequences

Initiating MH sequence	Response MH sequence
MHreq	MHack or MHnack
MHnack	MHcda or MHfrr
MHclrd	MHcda
MHfrr	ANSam

9.10.2 Modem-on-hold transactions

9.10.2.1 Modem-on-hold request

Sequence MHreq is transmitted to request the remote modem to enter an on-hold state (see Figures 20 to 22). If MHack is received, the modem may continue sending MHreq for a maximum of 30 s or send Tone RT or silence. If MHnack is received, the modem shall respond by transmitting either MHcda or MHfrr within 10 s.

If sequence MHreq is received, the modem shall transmit MHack to grant the on-hold request or MHnack to deny the request. If MHack is transmitted, the modem shall enter an on-hold state and when Tone RT is detected for 100 ms or silence is detected for 2 s, stop transmitting MHack and then transmit ANSam within 80 ms. Once in the on-hold state, a modem shall continue sending ANSam for time T1 and condition its receiver to detect signals from Phase 1 of the start-up procedure. If no such signals are detected after time T1 from the end of the first MHack, the modem shall exit the on-hold state and disconnect. If signal QC or signal CM are received, the modem shall proceed with Phase 1 of the start-up procedure, assuming the role of an answer modem and disregarding information received in previous phase 1 signals. If signal QC is detected with the U_{QTS} code set to 1111, cleardown from on-hold state, the modem shall disconnect. If a CM is detected with no PCM modem availability category and zeros for all modulation category modulation modes, the modem shall transmit a JM with no PCM modem availability category and zeros for all modulation category modulation modes. The modem shall then disconnect after reception of CJ.

If MHnack is transmitted in response to MHreq and MHcda is detected, the modem shall disconnect. If MHfrr is detected in response to MHnack, the modem shall transmit silence for up to 80 ms, transmit ANSam and proceed with Phase 1 of the start-up procedure, assuming the role of an answer modem and disregarding information received in previous phase 1 signals.

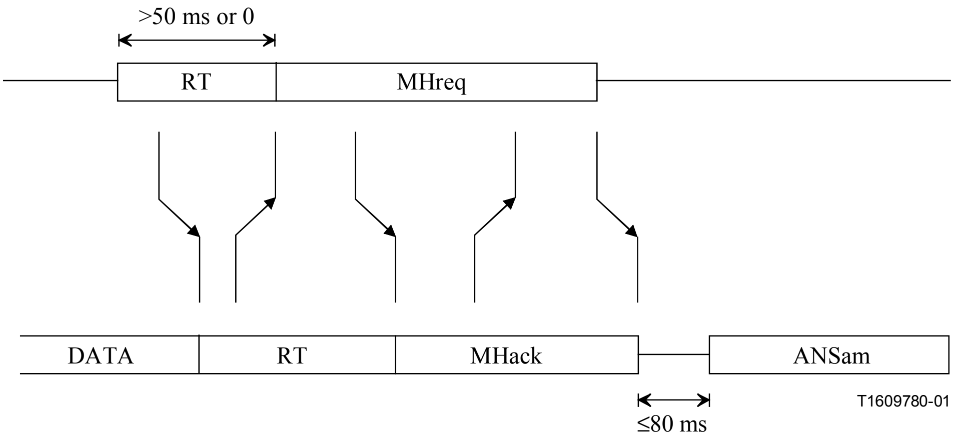

Figure 20/V.92 – Modem-on-hold request acknowledged

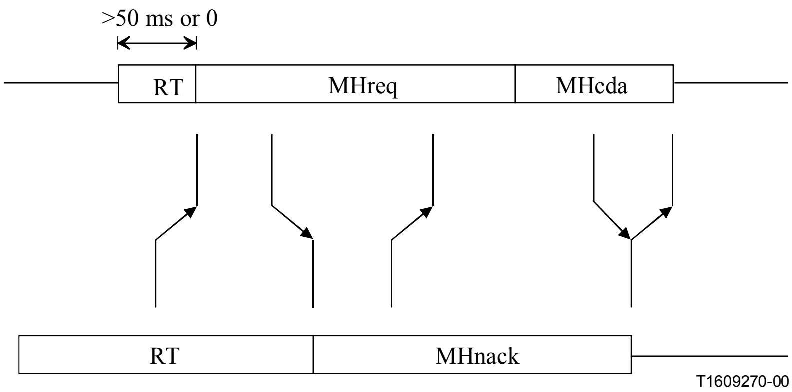

Figure 21/V.92 – Modem-on-hold request denied followed by cleardown request

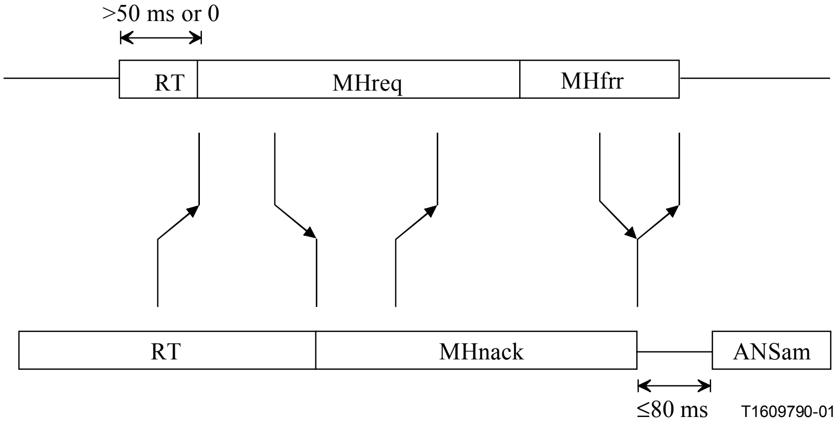

Figure 22/V.92 – Modem-on-hold request denied followed by fast reconnect request

9.10.2.2 Cleardown request

Sequence MHclrd is transmitted to request a cleardown (see Figure 23). The reason for the cleardown request shall be indicated in the information field of MHclrd as described in Table 32. When MHcda is received, the modem shall disconnect.

If MHclrd is received, the modem shall transmit MHcda. When either Tone RT or silence is detected or MHclrd is not detected for 200 ms, the modem shall disconnect.

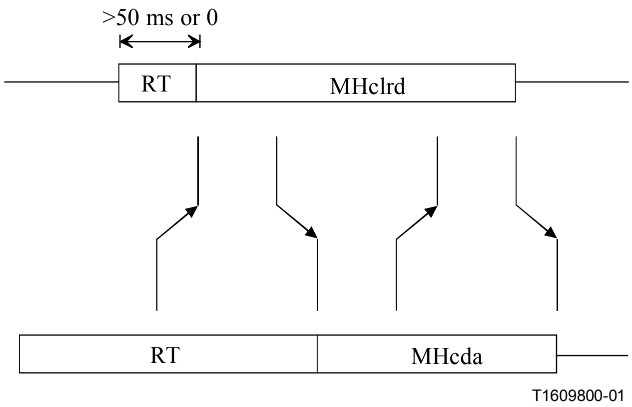

Figure 23/V.92 – Cleardown request

9.10.2.3 Fast reconnect request

Sequence MHfrr is transmitted to request a fast reconnect (see Figure 24). When ANSam has been detected for 1 s, the modem shall proceed according to Phase 1 of the start-up procedure.

If sequence MHfrr is detected, the modem shall transmit silence for up to 80 ms, transmit ANSam and proceed according to Phase 1 of the start-up procedure.

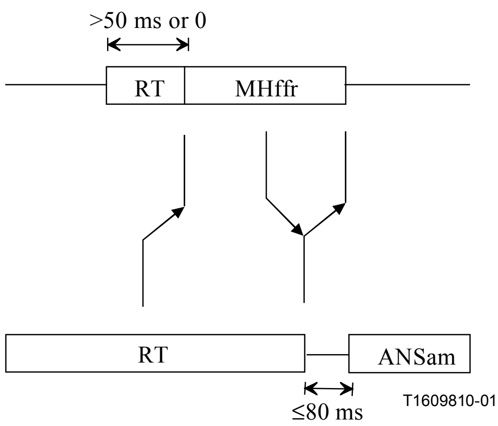

Figure 24/V.92 – Fast reconnect request

9.11 Cleardown

The cleardown procedure shall be used to terminate a connection. Cleardown is indicated by setting drn to 0 in either SUV_u by the analogue modem or SUV_d by the digital modem. This may be signalled at any time that a modem sends a rate sequence. To cleardown from data mode, a modem shall initiate either a rate renegotiation or a fast parameter exchange in order to send a rate sequence with drn = 0.

10 Testing facilities

Testing facilities as specified in other V-series modem Recommendations cannot be used for this Recommendation. Appropriate testing facilities are for further study.

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Geneva, 2001