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SERIES J: TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

Digital transmission of television signals

Distribution of digital multi-programme signals for television, sound and data services through SMATV networks

ITU-T Recommendation J.84

(Previously CCITT Recommendation)

ITU-T J-SERIES RECOMMENDATIONS

TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

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

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Geneva, October 1996).

This second edition of ITU-T Recommendation J.84 was prepared by ITU-T Study Group 9 (1997-2000) and incorporates Amendment 1 and Amendment 2 approved under the WTSC Resolution No. 1 procedure on the 17th of October 1996 and the 22nd of April 1997 respectively.

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NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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SUMMARY

This Recommendation: "Distribution of digital multi-programme signals for television, sound and data services through SMATV networks" covers the definition of the framing structure, channel coding and modulation for digital multi-programme signals for television, sound and data services received from a satellite system and distributed in a transparent way through Satellite Master Antenna Television (SMATV) networks.

This Recommendation defines the required network architecture for SMATV systems and is closely related to ITU-R Recommendation BO.1211 (applicable to the satellite path) and to Recommendation J.83 (applicable to the cable path).

This Recommendation has four Annexes (A, B, C and D) that provide the specifications for the digital television SMATV systems submitted to the ITU-T. This reflects the fact that standardization of digital SMATV television systems is being addressed for the first time by the ITU-T and that a number of systems had been developed and provisionally implemented when this standardization effort was undertaken by the ITU.

This Recommendation recommends that those implementing new digital multi-programme services on existing and future SMATV networks should use one of the systems whose framing structure, channel coding and modulation are specified in Annexes A, B, C and D.

INTRODUCTION

The development of new digital technologies is now reaching the point at which it is evident that they enable digital systems to offer significant advantages, in comparison with conventional analogue techniques, in terms of vision and sound quality, spectrum and power efficiency, service flexibility, multimedia convergence and potentially lower equipment costs. Moreover, the use of SMATV distribution for the delivery of video and audio signals to individual viewers and listeners is continually growing, and has already become a significant form of distribution in some parts of the world. It is also evident that these potential benefits can best be achieved through the economies of scale resulting from the widespread adoption of digital systems designed to be easily implementable on existing infrastructure and to take advantage of the many possible synergies with related audiovisual systems.

Common features of SMATV networks are the use of consumer-type equipment and the lack of regular maintenance, and therefore the system ruggedness is a primary consideration. In particular, the SMATV head-end should be transparent to the digital TV multiplex, without any baseband interfacing, thus permitting the use of simple and cost-effective consumer-type head-end equipment.

This Recommendation has four Annexes (A, B, C and D) that provide the specifications for the digital SMATV systems submitted to the ITU-T. This reflects the fact that standardization of digital SMATV systems is being addressed for the first time by ITU-T and that a number of systems had been developed and provisionally implemented when this standardization effort was undertaken by the ITU.

Administrations and private operators planning the introduction of SMATV systems are encouraged to consider the use of one of the systems described in Annexes A, B, C and D, and to seek opportunities for further convergence, rather than developing a different system based on the same technologies.

This second version of this Recommendation incorporates Amendment 1 and Amendment 2. These amendments brought the following changes with respect to the first edition of this Recommendation:

    a)   Annex C has now full text. In the first edition it was stated that Annex C was under study.

    b)   Annex D takes into account additional VSB modes which are specified in the second edition of Recommendation J.83.

    c)   A new Table 1/J.84 is added to show the comparison of the digital multi-programme SMATV systems.

Recommendation J.84

DISTRIBUTION OF DIGITAL MULTI-PROGRAMME SIGNALS FOR TELEVISION, SOUND AND DATA SERVICES THROUGH SMATV NETWORKS

(Geneva, 1995; revised in 1997)

1   Scope

The scope of this Recommendation is the definition of the framing structure, channel coding and modulation for digital multi-programme signals distributed by SMATV networks, possibly in frequency-division multiplex with existing analogue television signals.

> NOTE – It should be noted that requirements for some ancillary data capacity in the forward channel, related to the needs of interactive services, can be accommodated in the MPEG-2 transport layer, which is specified for all the systems described in the Annexes to this Recommendation (a description of the provision and characteristics of the return channel is outside the scope of this Recommendation).

> It should also be noted that the specified MEPG-2 transport layer allows the delivery of a number of digital sound channels, at various possible levels of quality; the content of those channels can be either related or unrelated to the video signal content.

This Recommendation is intended to ensure that the designers and installers of SMATV networks carrying digital multi-programme signals, will have the information they need to be able to establish and maintain fully satisfactory networks. It also provides the information needed by the designers and manufacturers of equipment (including receivers) for digital multi-programme signals distributed by SMATV networks.

It is to be noted that this Recommendation is complementary to other Recommendations which define the transmission characteristics for digital multi-programme signals distributed by satellite and cable networks (see References).

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; all 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.

[1]   ITU-T Recommendation J.83 (1997), *Digital multi-programme systems for television, sound and data services for cable distribution*.

[2]   ITU-R Recommendation BO.1211 (1995), *Digital multi-programme emission systems for television, sound and data services for satellites operating in the 11/12 GHz frequency range*.

[3]   ITU-T Recommendation H.222.0 (1995) | ISO/IEC 13818-1:1996, *Information technology – Generic coding of moving pictures and associated audio information: Systems*.

[4]   FORNEY (G.D.): Burst-correcting codes for the classic bursty channel, *IEEE Trans. Comm. Tech., COM-19*, pp. 772-781, October 1971.

3   Definitions

This Recommendation defines the following terms.

3.1   satellite master antenna television (SMATV) network: A broadband network intended for the distribution of television, sound and data signals received directly from one or more satellites, possibly in frequency-division multiplex with similar terrestrial UHF or VHF signals, to households located in one or more adjacent buildings. Where intended also for the distribution of new digital multi-programme television, sound and data services, such networks are known as "Digital SMATV networks", and the digital configuration made for this purpose is known as a "Digital multi-programme SMATV system".

4 Symbols and abbreviations

4.1 Symbols

This Recommendation uses the following symbols:

α	Roll-off factor
f_0	Channel centre frequency
R_s	Symbol rate corresponding to the bilateral Nyquist bandwidth of the modulated signal
R_u	Useful bit rate after MPEG-2 transport multiplexer
$R_{u'}$	Bit rate after RS outer coder
T	Number of bytes which can be corrected in RS error protected packet
T_s	Symbol period

4.2 Abbreviations

This Recommendation uses the following abbreviations:

BB	BaseBand
BER	Bit Error Ratio
BW	BandWidth
DTVC	Digital Television by Cable
EBU	European Broadcasting Union
ETS	European Telecommunication Standard
FEC	Forward Error Correction
FIR	Finite Impulse Response
IF	Intermediate Frequency
IRD	Integrated Receiver Decoder
LNB	Low Noise Block
LSB	Least Significant Bit
MPEG	Motion Picture Experts Group
MSB	Most Significant Bit
MUX	Multiplex
PDH	Plesiochronous Digital Hierarchy
PRBS	PseudoRandom Binary Sequence
QAM	Quadrature Amplitude Modulation
QEF	Quasi Error Free
QPSK	Quaternary Phase Shift Keying
RF	Radio Frequency
RS	Reed-Solomon
SMATV	Satellite Master Antenna Television
SMATV-DTM	SMATV system based on Digital TransModulation
SMATV-IF	SMATV system based on distribution at IF
SMATV-S	SMATV system based on distribution at extended Super Band
TDL	Tapped Delay Line
TDM	Time Division Multiplex

TDT	Transparent Digital Transmodulator
TV	Television
UHF	Ultra High Frequency
VHF	Very High Frequency
VSB	Vestigial SideBand

5 Digital multi-programme SMATV systems

It is recommended that those wishing to distribute new digital multi-programme services on existing and future SMATV networks should use one of the systems whose framing structure, channel coding and modulation are specified in the Annexes A, B, C and D. The specifications are compared in Table 1, indicating common features.

Table 1/J.84 – Comparison of digital multi-programme SMATV systems

Item	Annex A	Annex C	Annex D
Satellite modulation	QPSK	QPSK	QPSK
QPSK distribution excluding frequency conversion	Yes System A2 (SMATV-IF)	Yes System C(I)	Not considered
QPSK distribution including frequency conversion	Yes System A2 (SMATV-IF) Yes System A2 (SMATV-S) (VHF/UHF typical 230-470 MHz)	Yes System C(II)	Not considered
Transmodulation at the head-end	QPSK to QAM (System A1)	QPSK to QAM [System C(III)]	QPSK, 2-VSB, 4-VSB, 8-VSB, 16-VSB, 8-VSB (trellis coded)
Simplified implementation of TDT	Yes (simplified System A1)	Yes	Not applicable
Baseband processing at the head-end	No	No	Yes (possible reconfiguration of MPEG-2 TS)
Receiver (IRD)	QPSK for Systems A2 and C(I), C(II) QAM for Systems A1 and C(III)		2-VSB, 4-VSB, 8-VSB, 16-VSB, 8-VSB (trellis coded)
MPEG-2 transport layer	Yes	Yes	Yes
Compatibility with cable systems (Rec. J.83)	Annex A	Annex C	Annex D
Channel model	As indicated in Appendix A.I (Annex A)	Not provided	Not provided
Equalization requirements	Not necessary for QPSK Simple equaliser for 64-QAM	Not identified	Not identified
SMATV channel bandwidth	Not constrained	Systems C(I), C(II): not constrained: System C(III): 6 MHz	6 MHz

Annex A

Digital multi-programme SMATV System A

A.1   Scope

This Annex describes a transmission system, known as System A for digital multi-programme television suitable for distribution in Satellite Master Antenna Television (SMATV) systems. This Annex describes the SMATV network architecture, is complementary to Annex A/J.83 [1] and it is aligned with [2]. System A described in this Annex is compatible with the modulation and channel coding systems used for digital multi-programme television by cable and satellite transmissions (see [1] and [2], respectively). System A is based on the MPEG-2 System Layer [3], with the addition of appropriate Forward Error Correction (FEC) technique. System A allows for further evolution as technology advances as described in [1] (see also the Bibliography in Appendix A.IV to this Annex) and is capable of starting a reliable service as of now.

A.2   References

This Annex incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed in clause 2 as References [1] to [4].

A.3   SMATV distribution system concepts

A Satellite Master Antenna Television (SMATV) system is defined as a system which is intended for the distribution of television and sound signals to households located in one or more adjacent buildings. These signals are received by a satellite receiving antenna and may be combined with terrestrial TV signals. SMATV distribution systems are also known as community antenna installations or domestic TV cable networks. A SMATV system represents a means for sharing the same resources among several users for satellite and terrestrial reception.

The SMATV System is designed to perform the adaptation of the satellite TV signals to the SMATV channel characteristics. The primary consideration of the SMATV System is the transparency of the SMATV head-end to the digital TV multiplex from a satellite reception without baseband interfacing, delivering that signal to the user home Integrated Receiver Decoder (IRD); thus permitting a simple and cost effective head-end as required for the consumer profile of SMATV equipment.

This Annex considers two main SMATV System approaches for distribution of digital TV signals in SMATV installations, as follows:

SMATV System A1: This System approach consists of the transmodulation from satellite Quaternary Phase Shift Keying (QPSK) signals as defined in [2] to a Quadrature Amplitude Modulation (QAM) scheme (16-QAM, 32-QAM or 64-QAM) using either a full implementation of the System described in Annex A/J.83 [1] (see A.4.1 below), or a simplified transmodulation process as described in A.4.2 below. This process of transmodulation without baseband interfacing is also known as Transparent Transmodulation.

SMATV System A2: Direct distribution of QPSK satellite signals as defined in [2] using frequency conversion of the received satellite signal to a frequency band appropriate to the characteristics of the distribution network.

The use of one of the System A1 or System A2 approaches depends on the technical performance and cost trade-offs in each particular situation.

> NOTE – Digital terrestrial specification is not the subject of this Annex.

A.4   SMATV System A1

SMATV System A1 is based on the use of the transmodulation from satellite QPSK signals to a QAM modulation scheme (see Figure A.1). This system is also known as SMATV-DTM.

The System comprises the following elements:

–   **Head-end transmodulation unit**: This performs the required decoding and adapts the signal modulation coding to the cable distribution network. This unit is also known as the Transparent Digital Transmodulator (TDT).

–   **SMATV UHF distribution network**: This is a physical cable structure for distribution of the signal to several users. The reference channel response of SMATV distribution network is given in Appendix A.I.

–   **User IRD**: This unit performs the required equalization to compensate the channel distortion as well as demodulating and decoding the QAM signal.

A.4.1   Full implementation of SMATV System A1

A full implementation of the QAM System shall be performed according to Annex A/J.83 [1] and to [2] with a transparent interface between them. To this end, the full implementation of SMATV System A1 shall make use of the MPEG-2 transport layer, the framing structure, the channel coding, the byte-to-symbol mapping and modulation consistent with Annex A/J.83 [1] and with [2]. The channel coding shall include the randomization for spectrum shaping, the Reed-Solomon (RS) coding and the convolutional interleaving according to Forney [4]. This configuration is shown in Figure A.2.

A.4.2   Simplified implementation of SMATV System A1

In the complete implementation architecture of SMATV System A1, outer error protection (i.e. Reed-Solomon and convolutional interleaving) is performed twice, i.e. independently for the satellite link and the cable link. Therefore, the cable link is fed by a Quasi Error Free (QEF) bit stream. In cases when an adequate satellite link margin is achieved, one Reed-Solomon decoder-encoder and de-interleaving-interleaving process could be eliminated from the System. In such cases, a single RS decoder at the user IRD is capable of correcting errors generated in the cable link added to the remaining bursty errors after Viterbi decoding. This configuration is shown in Figure A.2 when removing the dashed line blocks.

        NOTE – This simplified configuration may imply a non-negligible saving in terms of the number of gates and thus in the total equipment cost. Due to consumer type character of SMATV head-ends, this saving is important when an economy of scale is achieved. Consequently, manufacturers could decide whether to adopt the simplified SMATV System A1 architecture.

A.5   SMATV System A2

SMATV System A2 is based on the use of QPSK modulation (see Figure A.3). The SMATV System A2 concept allows a direct reception of digital satellite signals by the user IRD connected to a SMATV distribution network. The functional elements of this system are given in [2]. Two configurations of SMATV System A2 are considered as follows:

–   SMATV-IF;

–   SMATV-S.

In the SMATV-IF configuration, QPSK signals are distributed directly at the Intermediate Frequency (IF) as delivered by the Low Noise Block (LNB) [see Figure A.3 a)]. In the SMATV-S configuration, QPSK signals are frequency converted to S-band [see Figure A.3 b)]. In both configurations, the satellite signal reaches the user IRD without being subject to any demodulation and transmodulation process at the head-end. Thus, the modulation characteristics of the satellite link are retained.
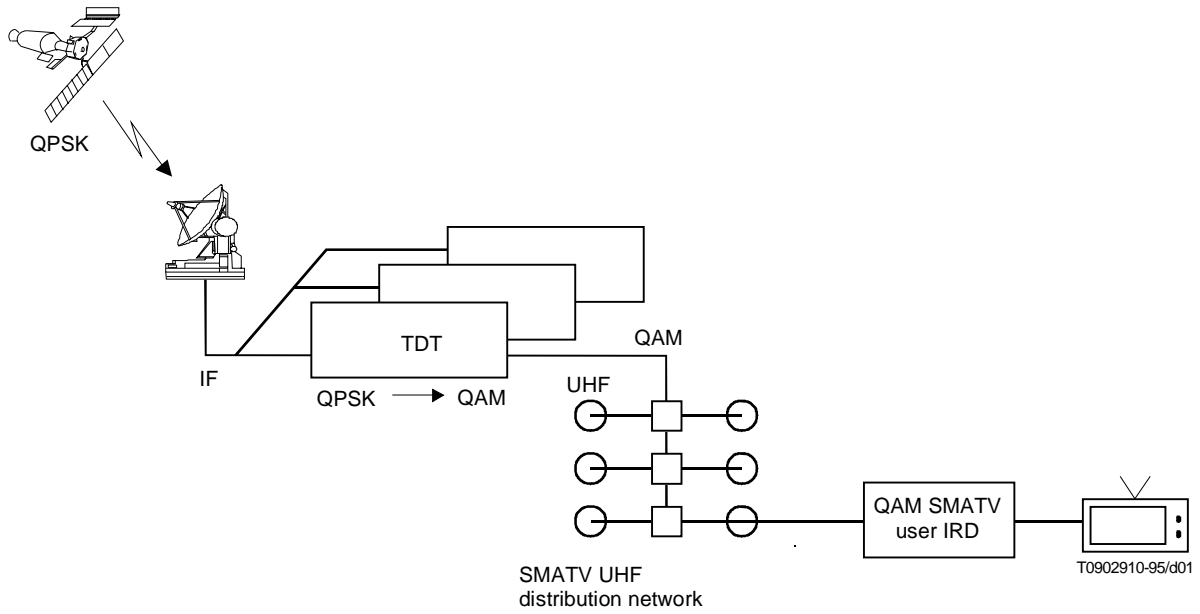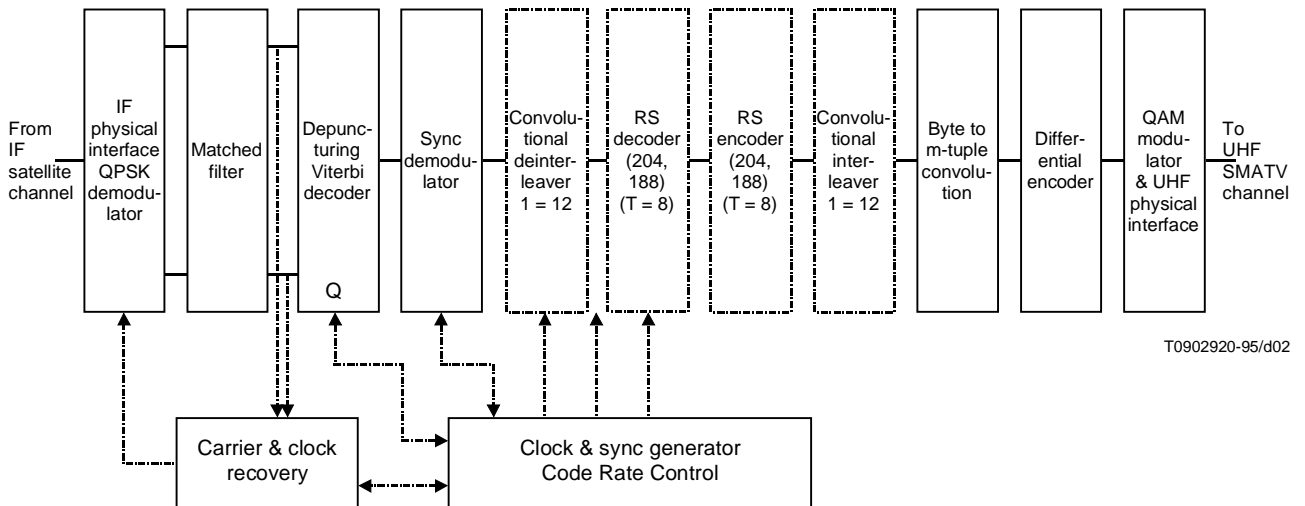
Figure A.1/J.84 – SMATV System A1 configuration

Figure A.2/J.84 – Functional diagram of a SMATV System A1
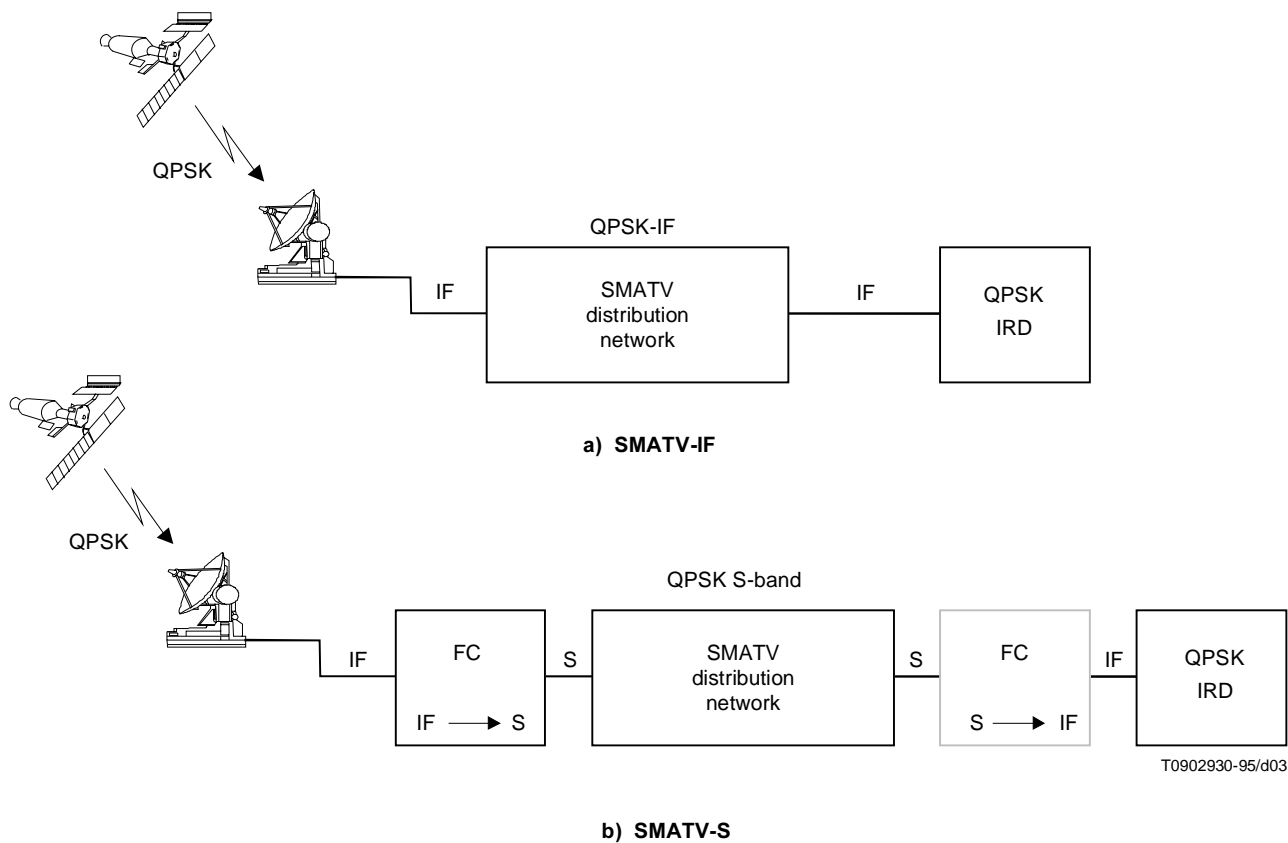
a) SMATV-IF

b) SMATV-S

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Figure A.3/J.84 – SMATV System A2 configuration, SMATV-IF and SMATV-S

A.5.1   SMATV-IF

This configuration allows the direct distribution of the QPSK signal received from the satellite to the SMATV-IF distribution network in the extended IF band (above 950 MHz).

The user IRD should be able to tune all the channels in the extended IF band to demodulate and to decode the signal.

The functional elements of SMATV-IF are given in [2].

A.5.2   SMATV-S

This configuration requires the frequency conversion of the satellite signals from extended IF band (above 950 MHz) to a part of the VHF/UHF band [for example: extended S-band (230 MHz to 470 MHz)].

> NOTE – An inverse frequency conversion process (e.g. from extended S-band to IF) may be required at user IRD equipped with IF tuner.

The user IRD performs similar functions as for the satellite reception (see [2]). In order to compensate for the channel linear distortions, the matched filter may include equalization capabilities.

The S-band channel model is similar to that of the UHF band; it is given in Appendix A.I.

A.6   MPEG-2 transport layer

The SMATV System shall use the MPEG-2 transport layer which is defined in [3]. The Transport Layer for MPEG-2 data is comprised of packets having 188 bytes, with one byte for synchronization purposes, three bytes of header containing service identification, scrambling and control information, followed by 184 bytes of MPEG-2 or auxiliary data.

A.7   Framing structure

The framing organization of the SMATV System shall be based on the MPEG-2 transport packet structure (see [1], [2] and [3]).

Appendix A.I

Channel model of SMATV distribution systems

(to Annex A of Recommendation J.84)

A.I.1   Channel model response

In order to test SMATV Systems and to evaluate the need for equalization, an RF channel model response has been obtained for SMATV distribution network. The model is based on measurements and computer simulations. The model is significantly simplified in order to take into account only the relevant aspects for the equalization definition. It applies to UHF band as well as S-band SMATV networks.

The RF channel model is split into four models; they are presented in Figures A.I.1 to A.I.4:

– model A: for microreflections between devices in consecutive floors (Figure A.I.1);

– model B: for microreflections between head-end and first device (Figure A.I.2);

– model C: for microreflections between tap-off and user outlet (Figure A.I.3);

– model D: combined microreflections model (Figure A.I.4).

Real SMATV networks usually combine features from all models depending on the concrete structure, and mainly the cable length and mismatching degree in each connection. It has been concluded that:

– microreflections delay depends on cable lengths;

– microreflections attenuation depends on the level of mismatching among components (return losses).

These models are based on assumptions derived from a survey on the most extended SMATV structures, see [5] in Appendix A.IV. The following configuration has been considered as a reference:

– a range of 3 m to 3.5 m cable length between cascade user outlets;

– a range of 6 m to 12 m cable length between tap-off and user outlet for parallel structures;

– a range of 10 m to 20 m cable length between head-end amplifiers and first passive elements;

– approximately a 10-storey building, in order to include representative echoes generated in several floors.

In Figures A.I.1 to A.I.4 microreflection distribution can be observed for the 4 models. The X-axis in the diagrams represents the microreflection delay in nanoseconds. The Y-axis gives microreflection attenuation in dB. Taking the above considerations into account, the echo delay ranges can be noted.

The reference channel model for most practical installations is given in Figures A.I.1 to A.I.4 marked with "3 sigma" and is represented in dark colour. The upper level refers to the worst case.

A.I.2   Definition of adaptive equalization requirements

QAM demodulator at the user IRD should include an adaptive equalizer to compensate the channel distortion introduced by SMATV in the UHF band. An equalizer may also be included at the user IRD for QPSK demodulation in the S-band. Equalization should be blind, since the baseline systems do not include any training sequence. Referring to the reference RF channel model of Figures A.I.1 to A.I.4 for the 3 sigma case, state of the art implementations of equalizers can provide less than 1 dB implementation margin at a BER of 2×10^{-4}, and less than 100 ms acquisition time.
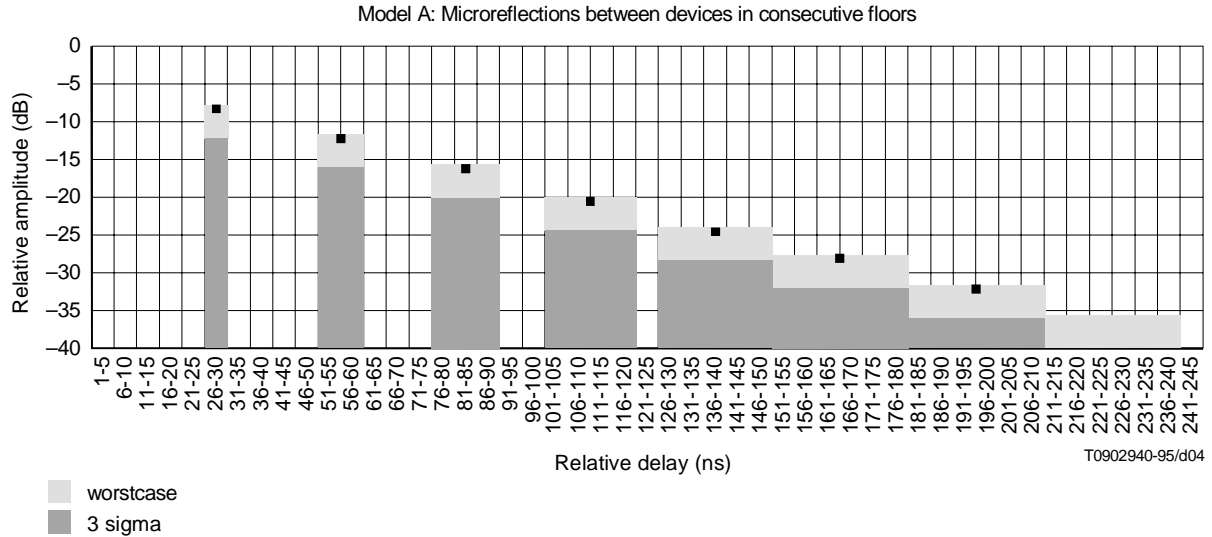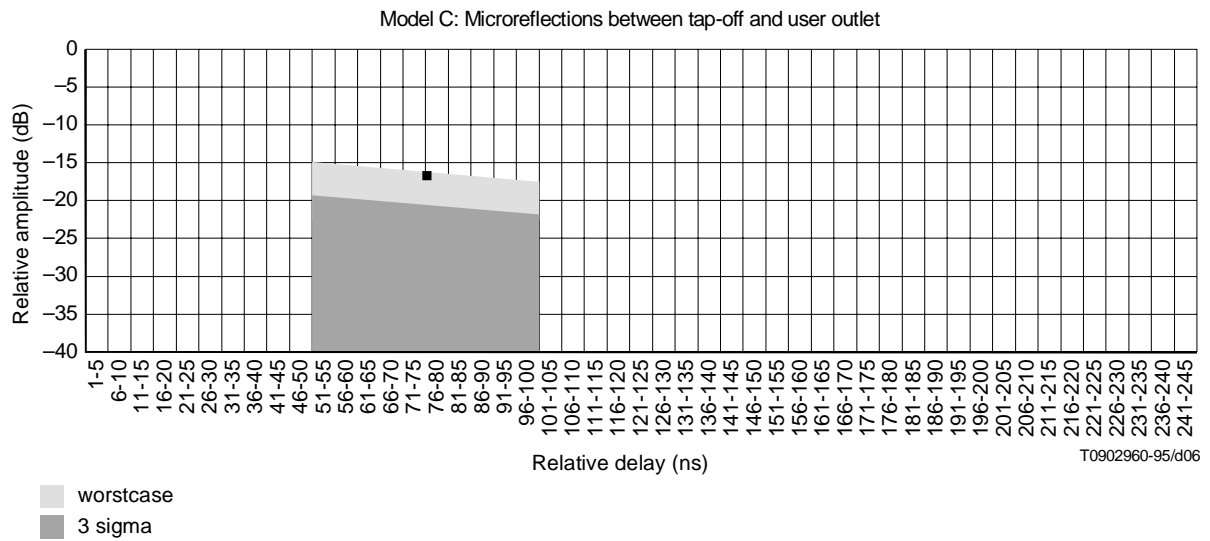
**Figure A.I.1/J.84 – RF channel model A response of UHF
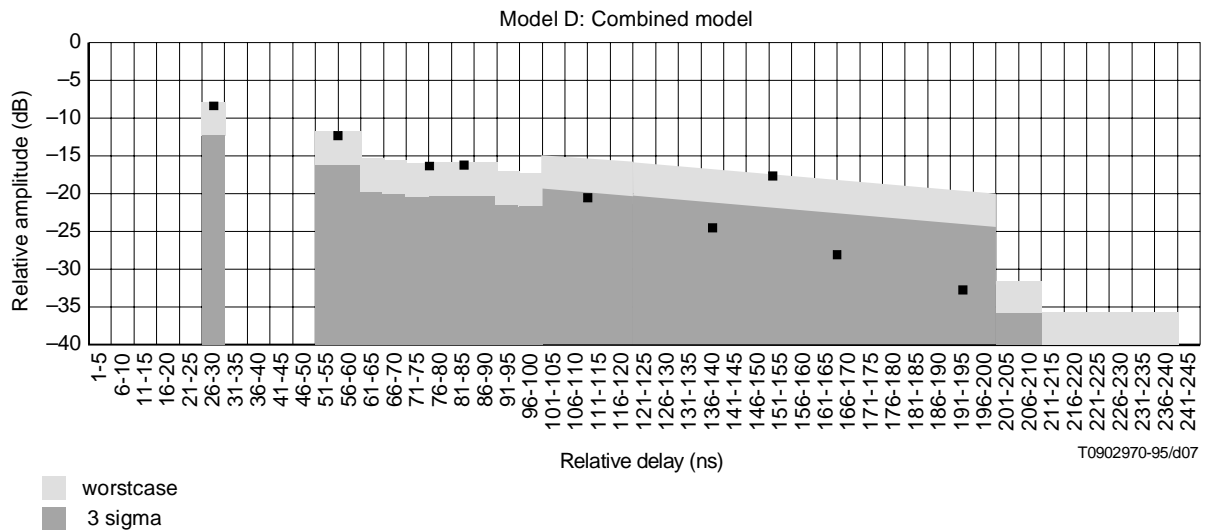and S-bands SMATV distribution network**

FIGURE A.I.1/J.84...[D04] =   CM
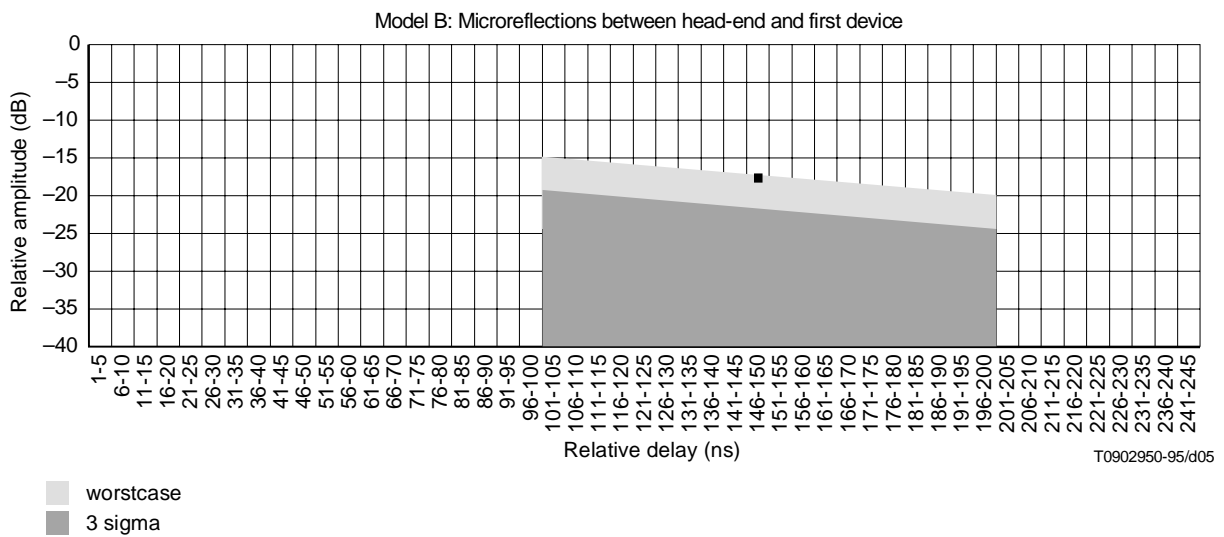
Figure A.I.2/J.84 – RF channel model B response of UHF and S-bands SMATV distribution network

Model C: Microreflections between tap-off and user outlet

**Figure A.I.3/J.84 – RF channel model C response of UHF
and S-bands SMATV distribution network**

Model D: Combined model

Figure A.I.4/J.84 – RF channel model D response of UHF and S-bands SMATV distribution network

Appendix A.II

Examples of 64-QAM and QPSK performance with equalizers

(to Annex A of Recommendation J.84)

In the following, performance of two possible examples of SMATV systems are investigated by computer simulations:

SMATV System A1: Transmodulation from QPSK to 64-QAM, symbol rate R_s = 6.9 MBaud in 8 MHz channels, useful bit rate of 38 Mbit/s at the MPEG multiplex output.

SMATV System A2: QPSK modulation with rate 3/4 convolutional coding, symbol rate R_s = 25.8 MBaud and useful bit rate of 35.6 Mbit/s at the MPEG multiplex output.

To overcome the linear distortions introduced by the SMATV network, an adaptive "blind" equalizer (see [4] in Appendix A.IV), composed by a symbol-spaced complex transversal filter Finite Impulse Response (FIR), has been introduced in the receiver. The second tap of the equalizer was set to "1", since the presence of anticipated echoes can generally be excluded in SMATV installations. The results assume steady state of the equalizer, after the end of the blind lock-in phase.

Some critical examples of SMATV channels have been considered in the simulations, as measured on a hardware-simulated SMATV network for a 5-floor building (see [3] in Appendix A.IV). The channel amplitude and group delay characteristics are reported in Figures A.II.1 to A.II.6. The first case (Response – 1) refers to a 40 MHz channel, suitable for System A2, while the others (i.e. Response – 2, to, Response – 6) refer to 8 MHz channels, suitable for System A1.

A.II.1   SMATV System A1 – Simulation results

With System A1 the signal is regenerated at the SMATV network input, therefore the noise generator in the simulations was put at the 64-QAM demodulator input, after the SMATV network. Very high degradation levels have been obtained without equalization. In the presence of adaptive equalization with 6 symbol-spaced taps, the signal-to-noise ratio degradation for BER equal to 2×10^{-4} (before Reed-Solomon correction) was lower than 1.5 dB in all the five analysed network responses [2]. These results refer to the value of 23.8 dB in a bandwidth of 7 MHz in an ideal linear Gaussian channel; they do not however include possible additional impairments due to amplifier non-linearity in the cable head-end.

It is therefore possible to conclude that with SMATV System A1 (in the 64-QAM configuration), the use of adaptive equalizers is mandatory to overcome typical SMATV network degradations. However, in the case of old cable installations with very poor performance (e.g. echo levels of about 8 dB to 12 dB, as given in Figures A.I.1 to A.I.4), the use of the equalizer might be insufficient to guarantee 100% service availability when 64-QAM modulation is adopted. Nevertheless, in the case of new installations complying with [8] in Appendix A.IV, the service availability with 64-QAM can be guaranteed by a suitable equalizer.

Hardware tests with a 16-QAM modem including blind equalization have demonstrated good performance on the above described SMATV network, see [3].

As regards the required number of equalization (symbol-spaced) taps N, the echo delay spread T_e to be considered on typical SMATV networks is of the order of 220 ns, as indicated in Figures A.I.1 to A.I.4 (64-QAM requires C/I levels of the order of 35 dB). Assuming that the second tap of the equalizer is set to "1", to achieve good performance with 64-QAM and high echo levels, N should be larger than $2 + 2\,T_e/T_s$. Therefore, for a symbol duration T_s = 143 ns, the minimum equalizer length should be of about 6 taps, while 8 to 10 taps could offer an additional margin to cope with longer echoes.

A.II.2 SMATV System A.2 – Simulation results

Since in a well-designed SMATV network adopting SMATV System A2 the main noise source should be in the satellite downlink path, the noise source in the simulations has been put before the SMATV network. The SMATV network transfer function, which has been used in the simulations, is "Response – 1" of Figure A.II.1.

For BER equal to 10^{-4} before Reed-Solomon correction, the SMATV network introduced a degradation on the required C/N (calculated in a bandwidth of 26.8 MHz) for the satellite of about 1.4 dB on the system without equalizer, while the degradation was reduced to 0.4 dB with the equalizer [2]. These results refer to the value of 6.1 dB in an ideal linear Gaussian channel; no implementation margin is included. Therefore also for SMATV System A2, based on the rugged QPSK modulation, the use of an adaptive equalizer in the receiver seems important, allowing to utilize current SMATV installations with very low additional C/N degradation with respect to direct satellite reception.

Hardware tests with a QPSK modulator including rate 3/4 convolutional coding, without equalizer, confirmed the simulation results on the above SMATV network.

As regards the number of equalizer (symbol-spaced) taps N, assuming that the second tap of the equalizer is set to "1", good QPSK performance can be achieved for $N > 2 + (T_e/T_s)$, where T_e is the echo delay spread to be considered. For $T_e = 220$ ns, as indicated in Figure A.I.1, and a symbol duration of $T_s = 30$ ns, the minimum equalizer length should be of about 10 taps.
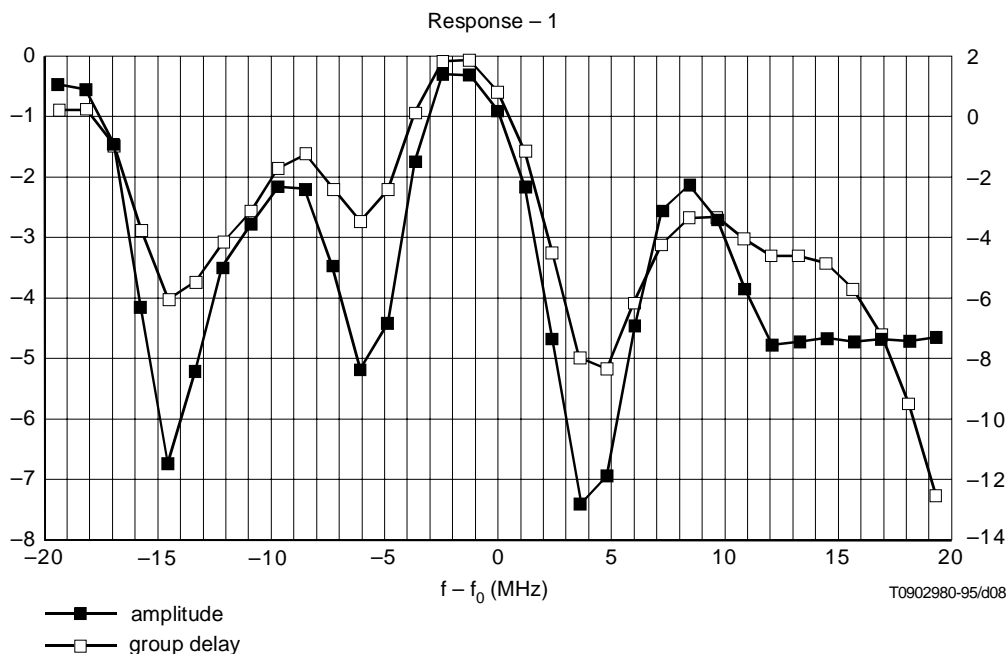
**Figure A.II.1/J.84 – Significant example of the measured transfer function
for the considered SMATV network**

Response – 2
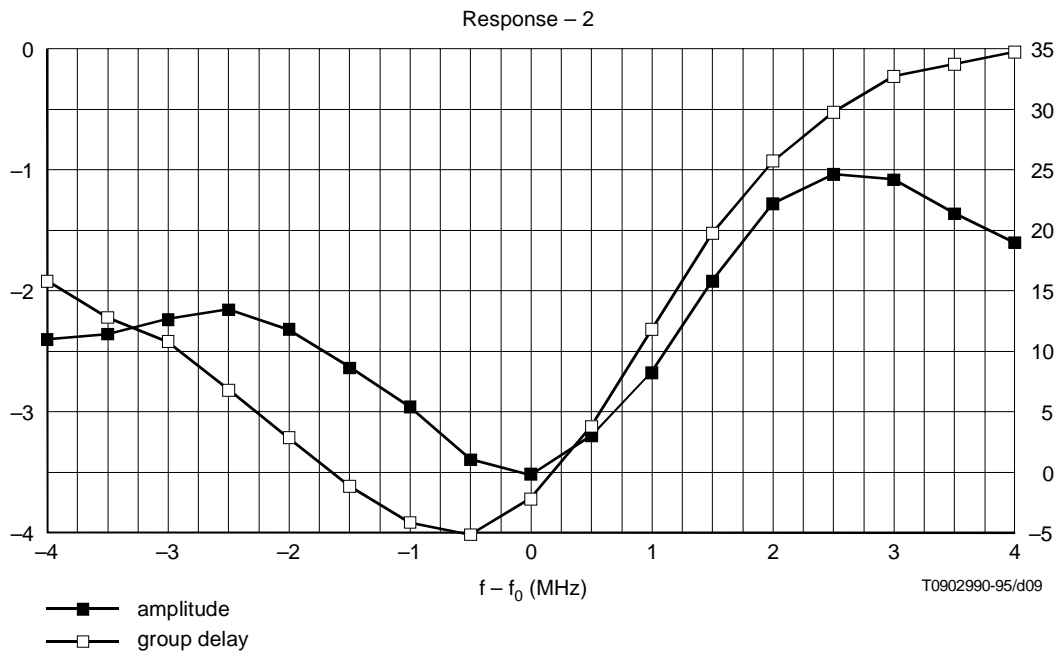
**Figure A.II.2/J.84 – Significant example of the measured transfer function
for the considered SMATV network**

Response – 3
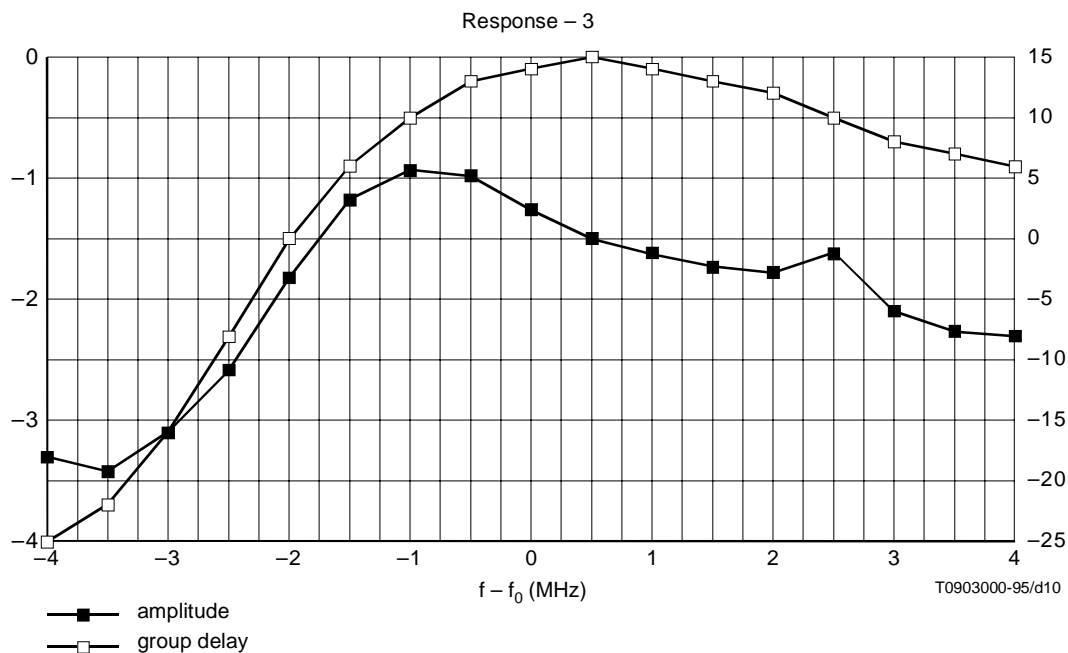
**Figure A.II.3/J.84 – Significant example of the measured transfer function
for the considered SMATV network**

Response – 4

**Figure A.II.4/J.84 – Significant example of the measured transfer function
for the considered SMATV network**
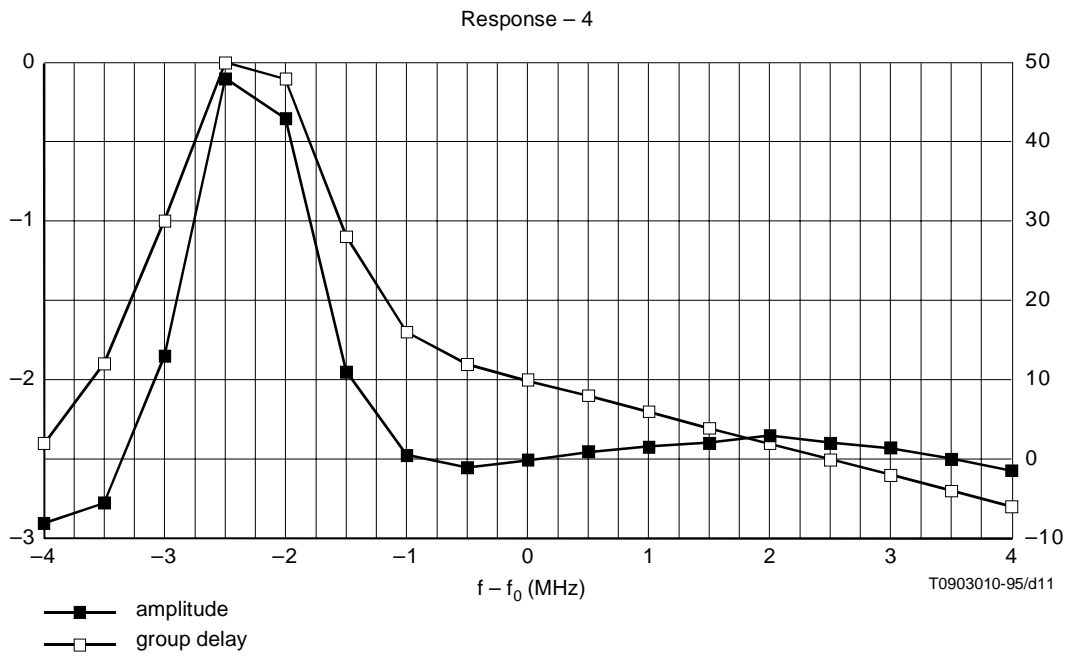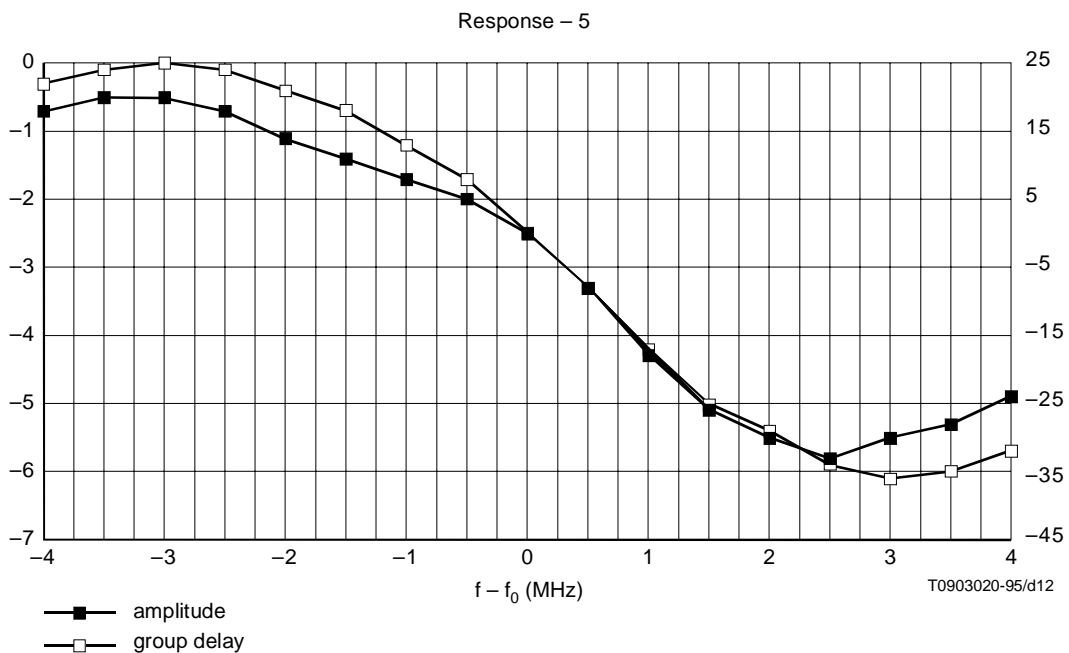
Response – 5

**Figure A.II.5/J.84 – Significant example of the measured transfer function
for the considered SMATV network**

**Figure A.II.6/J.84 – Significant example of the measured transfer function
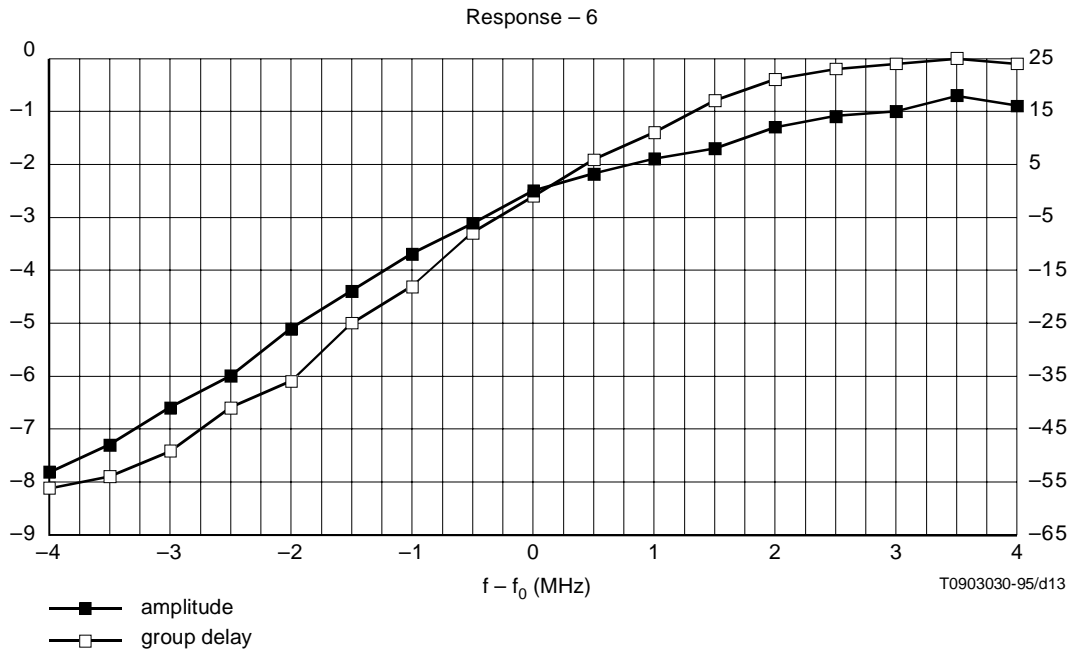for the considered SMATV network**

Appendix A.III

Bit rate consideration for SMATV distribution systems

(to Annex A of Recommendation J.84)

In order to achieve a transparent re-transmission of satellite services on SMATV systems, it is necessary to take into account the limitations imposed by the SMATV System A1 in the 8 MHz cable channel bandwidth.

Table A.III.1 gives figures, showing the possible ranges of SMATV symbol rates and occupied bandwidths for different useful bit rates on the satellite. The 16-QAM, 32-QAM and 64-QAM constellations of the SMATV System A1 are considered.

For full transparency, the same useful bit rate (excluding RS coding) should be used in the satellite and the SMATV cable network.

The theoretical maximum symbol rate in an 8 MHz SMATV channel is 6.96 MBaud with a roll-off factor of 0.15. In Table A.III.1 indicative useful bit rates are provided.

Channel bandwidth constraints exist in a number of high loaded SMATV networks, which limit the useful bandwidth to 7 MHz. For such existing high loaded networks, transmission of symbol rates about 6 MBaud are feasible with acceptable signal degradation. Symbol rates given above the upper highlighted line support the simplified transparent transmodulation concept, facilitating the satellite link operation at BER ratios above threshold (before RS) for a given antenna size. However, future upgrading of current single channel amplifiers may clear such limitations.

Table A.III.2 shows the indicative SMATV capacity in case of QPSK channels distributed in the existing extended super-band or in the existing extended IF band for the symbol rates referred in [2]. Other symbol rates and channel spacing are possible.

Table A.III.1/J.84 – Examples of transparent re-transmission of satellite TV on SMATV networks using the same useful bit rate R_u (excluding RS)

Examples of satellite R_u for BW (–3 dB)/Rs = 1.27 (after MPEG-2 MUX) (Mbit/s)	16-QAM		32-QAM		64-QAM	
	Symbol rate (MBaud)	Occupied BW (MHz)	Symbol rate (MBaud)	Occupied BW (MHz)	Symbol rate (MBaud)	Occupied BW (MHz)
18.9	5.13	5.90	4.10	4.72	3.42	3.93
19.6	5.32	6.11	4.25	4.89	3.54	4.07
21.7	5.88	6.77	4.70	5.41	3.92	4.51
24.0	6.51	7.49	5.21	5.99	4.34	4.99
25.2	6.84	7.86	5.47	6.29	4.56	5.24
26.1			5.66	6.51	4.72	5.43
26.2			5.68	6.54	4.74	5.45
28.3			6.14	7.06	5.12	5.88
29.0			6.29	7.24	5.24	6.03
29.4			6.38	7.34	5.32	6.11
31.5			6.84	7.86	5.70	6.55
31.9			6.92	7.96	5.77	6.63
32.6					5.89	6.78
32.7					5.91	6.80
33.1					5.99	6.88
33.4					6.04	6.95
34.4					6.22	7.15
34.8					6.29	7.24
35.9					6.49	7.47
36.2					6.55	7.53
38.1					6.89	7.92
31.672 (PDH)			6.87	7.90	5.73	6.59

7 MHz Cable channel Bandwidth (BW)

8 MHz Cable channel Bandwidth (BW)

Table A.III.2/J.84 – SMATV-S and SMATV-IF capacity

RS (MBaud)	Minimum channel spacing (MHz)	Number of channels		Total
		Extended super-band (230-470 MHz) (Note)	Satellite first IF band (0.95-2.05 GHz) (Note)	
42.2	57.0	4	19	23
35.9	48.5	4	22	26
31.5	42.5	5	25	30
28.1	37.9	6	28	34
25.8	34.8	6	31	37
23.4	31.6	7	34	41
21.1	28.5	8	38	46
20.3	27.4	8	40	48

NOTE – The frequency ranges in parenthesis are only indicative. Wider ranges may be possible in some circumstances.

Appendix A.IV

(to Annex A of Recommendation J.84)

Bibliography

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[2]   MASENTO (A.), MIGNONE (V.), MORELLO (A.): Performance of 64-QAM and QPSK in SMATV installations – Simulation results, *Report No. 94/xx/E.*

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Annex B

Digital multi-programme SMATV System B

System B of Recommendation J.83 has no companion SMATV system.

Annex C

Digital multi-programme SMATV System C

C.1   Scope

This Annex describes a System C transmission system that distributes digital multiple-programme television suitable for distribution in Satellite Master Antenna Television (SMATV) systems. The SMATV network architecture is described and is complementary to Annex C/J.83 [1]. System C is based on the MPEG-2 system layer [3], with the addition of an appropriate Forward Error Correction (FEC) technique.

C.2   SMATV distribution system concept

The aim of SMATV is to distribute television and sound programme signals broadcast from satellites to several households in a neighbourhood and/or within households located in one building or in several adjacent buildings. These signals are received by a satellite receiving antenna and are distributed together with other broadcast signals. SMATV subscribers share a common satellite antenna, which transmits satellite signals to Integrated Receiver Decoders (IRDs) in homes transparently and without baseband processing.

This Annex describes three options for SMATV systems for distributing digital television signals:

    a)   *SMATV system C(I)*

        This system receives satellite broadcast signals with a satellite receiving antenna. The signals, which are Quadrature Phase Shift Keying (QPSK) signals as defined in [2], are distributed at the intermediate frequency delivered by the Low Noise Block (LNB) of the receiving antenna. The signals are received with IRDs designed for receiving satellite broadcasts.

    b)   *SMATV system C(II)*

        This system receives satellite broadcast QPSK signals with a satellite receiving antenna and converts the frequencies of the output signals of the LNB to a frequency band appropriate for the distribution network. The frequency re-allocated signals are received with IRDs designed for receiving satellite broadcasts.

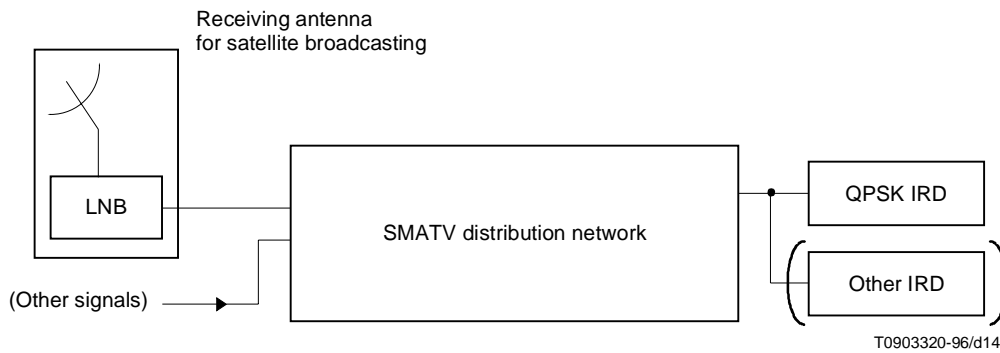   c)   *SMATV system C(III)*

        This system receives satellite broadcast QPSK signals with a satellite receiving antenna, demodulates them to remove some of error correction bits, and then remodulates them as 64-QAM signals as defined in Annex C/J.83 [1] for distribution. This system remodulates signals transparently without baseband interfacing. The signals are received with IRDs designed for receiving cable television rather than ones for satellite broadcasts.

C.3   SMATV system C(I)

SMATV System C(I) is a distribution network using QPSK-modulated signals. The QPSK-modulated signals from a satellite are received by a satellite receiving antenna, and the LNB output signals are led directly to an SMATV distribution network, where they may be multiplexed and distributed with other signals. They are received with QPSK IRDs for satellite broadcasts.

As shown in Figure C.1, the satellite signals reach satellite-broadcast IRDs without any demodulation or remodulation.
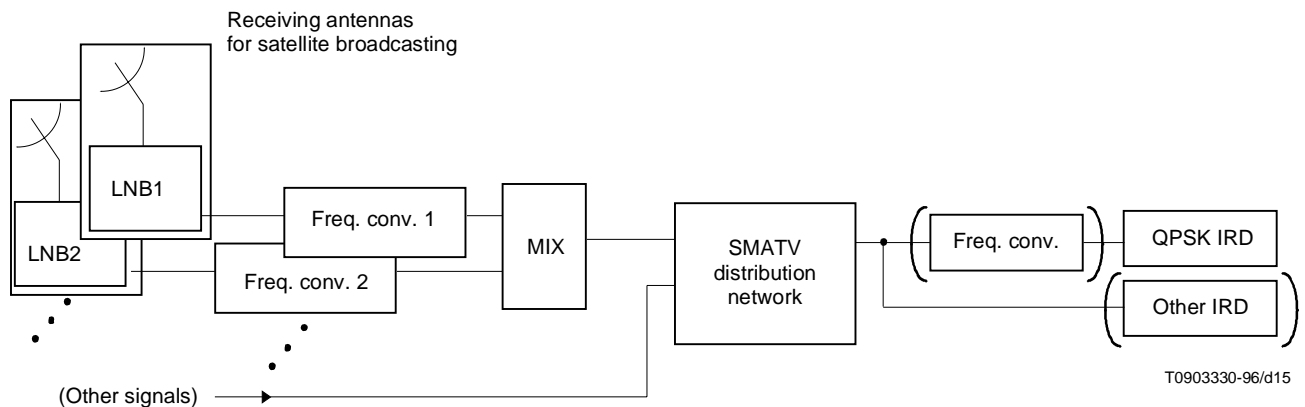
Figure C.1/J.84 – SMATV System C(I)

C.4   SMATV system C(II)

SMATV System C(II) is a distribution network using QPSK-modulated signals. The QPSK-modulated signals from satellites are received with satellite antennas. One or more outputs of the LNB are frequency-converted and frequency re-allocated, and are then fed into an SMATV distribution network, where they may be multiplexed and distributed with other signals. They are received with QPSK IRDs designed for satellite broadcasts. Frequency converters may be used with the IRDs if necessary. This system is applicable to a distribution network that cannot handle the frequency band of the LNB output.

As shown in Figure C.2, the satellite signals reach satellite-broadcast IRDs after frequency-conversion without any demodulation or remodulation.
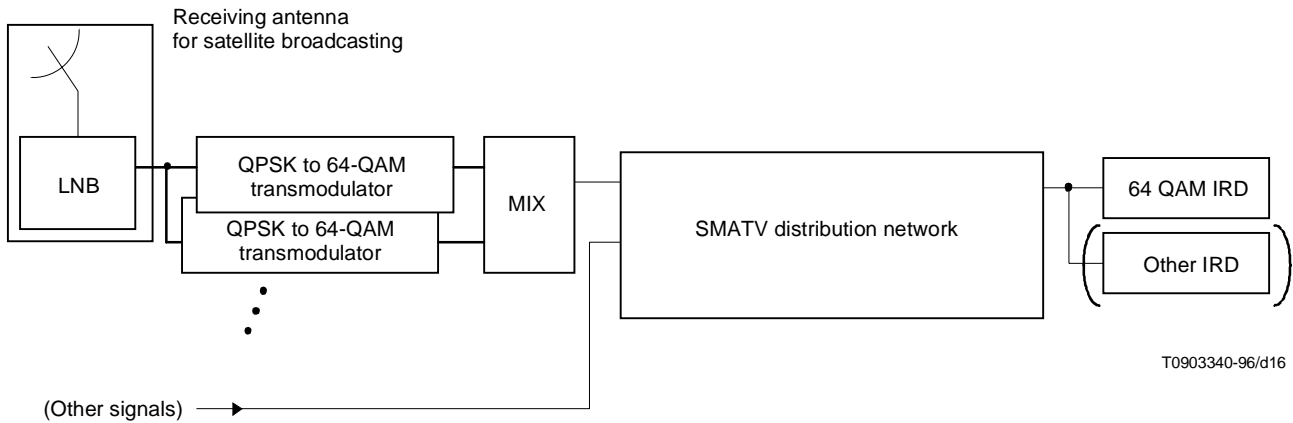

Figure C.2/J.84 – SMATV System C(II)

C.5   SMATV system C(III)

SMATV System C(III) is a distribution network using 64 QAM-modulated signals. The QPSK-modulated signals from a satellite are received with a satellite antenna and are remodulated as 64 QAM signals for distribution in an SMATV distribution network. QPSK-to 64 QAM transmodulators at the head-end convert the QPSK-demodulated bit streams

into 64-QAM signals, which are described in Annex C/J.83. The channel coding shall include RS coding and interleaving but not convolutional coding. The signals are transmitted to a distribution network, where they may be multiplexed and distributed with other signals. The 64-QAM signals are received with 64 QAM IRDs conforming to Annex C/J.83.

As shown in Figure C.3, the satellite signals reach 64 QAM IRDs after demodulation and remodulation.

Figure C.3/J.84 – SMATV System C(III)

C.6   MPEG-2 Transport layer

The SMATV System shall use the MPEG-2 transport layer, which is defined in [3]. The Transport Layer for MPEG-2 data is comprised of packets having 188 bytes, with one byte for sysnchronization purposes, three bytes of header containing service identification, scrambling and control information, followed by 184 bytes of MPEG-2 or auxiliary data.

C.7   Framing structure

The framing organization of the SMATV system shall be based on the structure of MPEG-2 transport packets (see [1], [2] and [3]).

Annex D

Digital multi-programme SMATV System D

D.1   Introduction

This Annex describes the head-end processing and equipment configuration suitable for SMATV systems by the use of the 16-VSB cable mode of the VSB (Vestigial SideBand) digital transmission system. The architecture of the SMATV network is indicated in Figure D.1. The system is coherent with the description in Annex D/J.83.

D.2 SMATV VSB system concept

A possible configuration of head-end equipment suitable for SMATV systems (as well as cable distribution head-ends) is shown in Figure D.1. Although the signal path is pointed out for the satellite reception and insertion into an SMATV network, there are other possibilities to feed the system (such as terrestrial).

Shown at the top of Figure D.1 is a satellite received source of MPEG-2/188 byte packets provided by appropriate demodulator and interface circuitry.

The MPEG-2/188 byte packet sources are shown combined in Figure D.1 by an Interface/Buffer and fed to a 16-VSB cable head-end transmitter (described in [1]), the output of which may be combined with other RF signal sources. As shown, the payload bit rate of 16-VSB, which is a nominal 38.78 Mbit/s (for a 6 MHz channel), is partially provided by the satellite source and partly by other digital sources. In the event that the satellite source provides a data rate equal to the capability of one 16-VSB channel, an additional 16-VSB head-end transmitter can process other digital sources (terrestrial or satellite).

Other VSB modes are available as defined in D.8/J.83.

D.3 SMATV head-end commonalities

SMATV installations are typically used in private cable systems of multiple dwellings where the head-end is unattended and makes use of consumer grade equipment. The configuration shown in Figure D.1 is expected to meet that requirement, in as much as the components, such as integrated circuits, are those expected to be used in digital terrestrial receivers.

D.4 Conclusion

An SMATV head-end configuration for satellite reception has been described which presents commonalities with other digital delivered signals, and is affordable and rugged to meet requirements of typical SMATV head-ends.
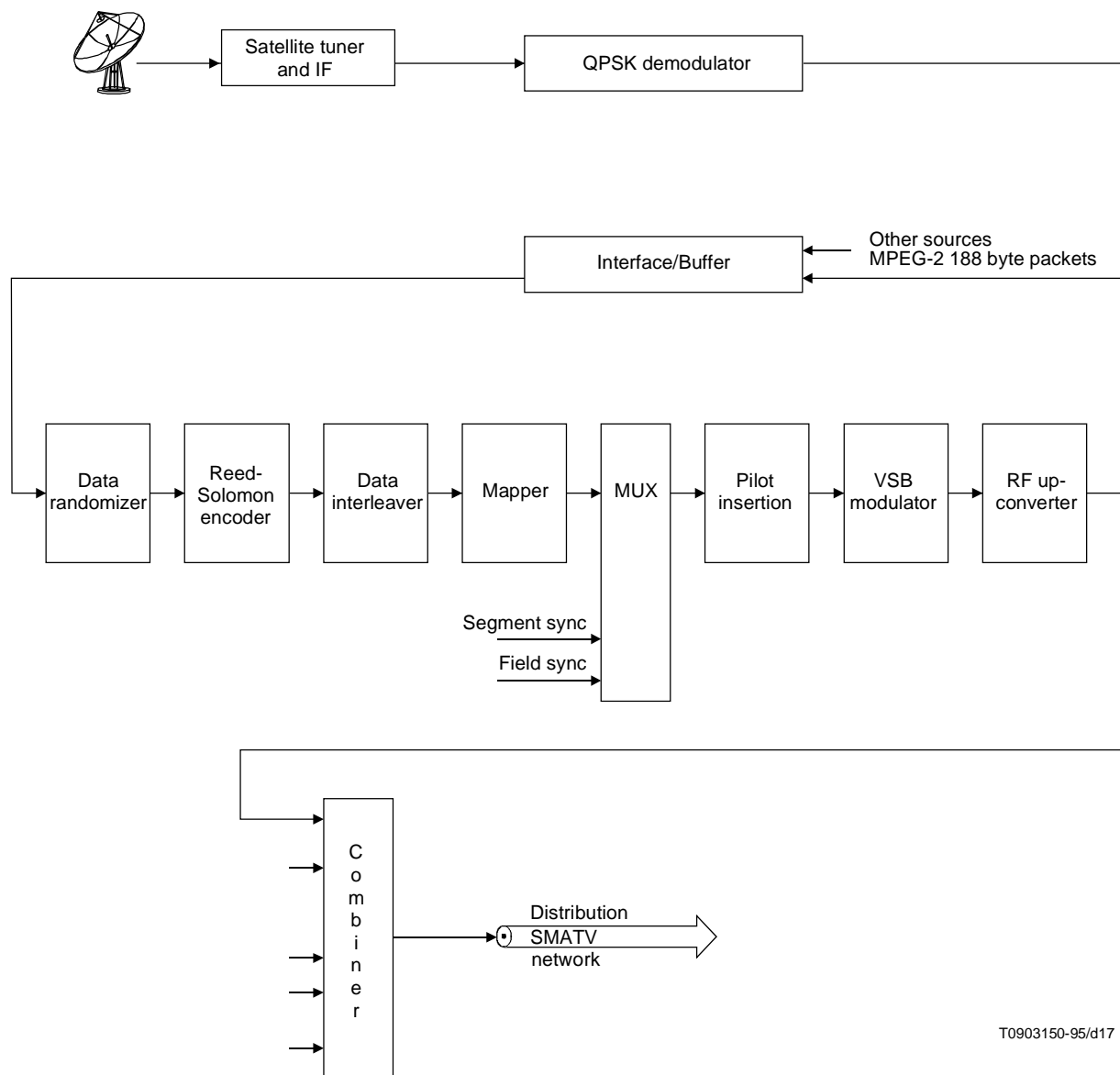
Figure D.1/J.84 – SMATV head-end equipment configuration

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